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Cover image: A soldier from 9th Regiment, Royal Australian Artillery launches an AeroVironment RQ-20 Puma hand-launched unmanned aircraft during Exercise Autonomous Warrior 2022 at Jervis Bay Airfield in Jervis Bay Territory.

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Book Reviews

/ FOREWORD

Luisa Powell

It is unsurprising that successive Chiefs of Army have devoted considerable effort to articulating, refining and championing the value of land power and the Army profession to the nation's defence. Throughout his tenure, the Chief of Army, Lieutenant General Simon Stuart, has been particularly consistent in this regard. He has framed land power through five enduring and distinctive value propositions—**presence, persistence, asymmetry, versatility and value.**[1] As Lieutenant General Stuart noted in his opening address at the Chief of Army Symposium in 2023, these propositions extend Dr Jack Watling's analysis of the UK's post–Integrated Review conception of land power.[2] Importantly, Stuart's articulation remains both relevant and resonant in the context of the 2023 Defence Strategic Review and the 2024 National Defence Strategy, and in anticipation of the forthcoming 2026 National Defence Strategy.

The Australian Army sustains these value propositions through continual adaptation: adopting emerging technologies, critically reviewing training needs, managing the tensions between sustaining current capabilities and introducing new ones, understanding changes to the strategic environment and faithfully implementing government direction. Underpinning all of this is a commitment to evidenceinformed decisionmaking at every level: strategic, operational and tactical. For over seven decades, the *Australian Army Journal* (*AAJ*) has been the Army's flagship platform for disseminating such evidencebased research to military professionals. Since its first issue in July 1948, the journal's mission has remained constant: to convey the latest trends in military thought and development, both domestically and internationally; to support professional military education; to stimulate intellectual engagement with the military art; and to build an Australian body of military literature equal in diversity and dignity to that of other nations.[3]

After 329 issues, through to 1976, the *AAJ* had achieved what it set out to do. From October of that year, seeking closer alignment with the other services,[4] the journal was merged into the *Australian Defence Force Journal* (1975–2018)[5] and subsequently the *Australian Defence Journal of Strategic Studies* (2019–2023). Across these iterations, scholarship continued, ensuring sustained debate, analysis, and advocacy for the land domain. When the AAJ was reinstated in 2003, it returned to its original mission—an undertaking its contributors continue to uphold today.[6]

This edition of the *AAJ* offers a rich collection of evidencebased research across technical, historical, conceptual and social domains. A suite of technical papers advances the *AAJ*'s longstanding commitment to leadingedge research. Contributions examine the future of quantum squeezing technologies and their potential applications for Army; emerging sensor systems capable of detecting underground structures; and a framework for scaling robotics and autonomous systems capabilities. These articles collectively expand the reader's understanding of how rapidly evolving technologies can shape future land force design and practice.

Furthering the theme of adaptation, this edition also presents research on supply chain resilience and the gamification of human–machine teaming. Each offers insights for practitioners to assess risk in an increasingly disrupted global environment.

Several contributions extend the discussion initiated in last year's themed *AAJ* edition (vol. 21, no. 3) on the state of the Army profession, which was published following Lieutenant General Stuart's request for a review across the pillars of jurisdiction, selfregulation and expertise. The profession's introspection must remain an enduring effort, and this edition continues that conversation.

Other contributors variously provide thoughtful pieces exploring how Army can harness the advantages of artificial intelligence without compromising the virtues that define the soldier; case studies on how Defence personnel have intersected with politics; the role of reservists within the Army profession; and how rigorous scholarship can shape institutional advocacy to set conditions for robust, respectful debate.

I also commend to readers the collection of book reviews examining works of contemporary relevance to the Australian Army. Assessment of these titles through the lens of a military professional highlights important lessons and insights for practitioners, which is one of the strengths of the Australian Army Research Centre's book reviews.

The Editorial Advisory Board (EAB) supports the *AAJ* through advocacy and engagement with domestic and international partners, while providing expert advice for the ongoing development of the journal and professional gravitas. There have been some recent changes in membership of the EAB, and it is my pleasure to welcome the new members: Brigadier (Dr) Jodie Lording, Colonel (Dr) Lauren Sanders, Professor Joanne Wallis, Associate Professor Shannon Ryan and Dr Troy Lee-Brown. They join Professor Peter Dean, Dr Rhys Crawley, Ms Katherine Mansted and Professor Andrew Phillips to advise Army on journal content and direction.

One of the longstanding members of the board, Professor John Blaxland, concluded his term at the end of 2025. John has been a valued board member since 2012, having overseen 30 issues and more than 200 articles of the *AAJ*. I wish him the very best in his future endeavours and know that he remains an avid supporter and advocate for land power, the Army and the *AAJ*.

I extend my sincere thanks to all contributors to this edition. As the editor of the first *AAJ*, Colonel Eustace Keogh, wrote in 1948, ‘the aims of the journal will not be fulfilled if all the articles are written by the editorial staff. The journal, therefore, invites contributions from all ranks’.[7] That invitation remains open. I encourage you to engage with the material before you. Learn, experiment, research, debate, and contribute to the growing body of evidence-based knowledge that will inform and guide the Army now and into the future.

> ‘If I have seen further it is by standing on the shoulders of Giants.’
>
> Isaac Newton (1642–1727)

Luisa Powell
Director
Australian Army Research Centre

ENDNOTES

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/ SOLUTIONS FOR SCALABLE SITUATIONAL AWARENESS IN REMOTE AUTONOMOUS SYSTEMS[1]

Kanaka Sai Jagarlamudi, Kevin Lee,
Arkady Zaslavsky and Shaine Christmas

Introduction

The Australian Army's robotics and automation strategy provides that the Army will adopt robotic and autonomous systems to maintain a competitive advantage in war.[2] The strategy proposes to enhance (refine existing capabilities), augment (add new functionalities) and replace (introduce entirely new platforms and capabilities) existing technologies with robotic and autonomous systems. This outcome is to be achieved through a process of collaboration with industry, academia and international partners.

Remote autonomous systems (RAS) are designed to operate independently of their controllers in remote, hazardous or inaccessible environments. They are able to execute complex missions with minimal human control. RAS have the potential to reduce the physical and cognitive demands on Australian soldiers. For example, autonomous systems such as unmanned aerial vehicles (UAVs) can carry heavy equipment, monitor soldiers' health and performance, and provide real-time surveillance capabilities. RAS offer Army the opportunity to scale operations by increasing firepower, protecting the force and providing operational reach. Accordingly, RAS have the potential to both boost the effectiveness of individual soldiers and strengthen the overall capabilities of the military force.

The United States and China are using advanced technologies to enhance their autonomous systems and achieve a strategic edge in the Indo-Pacific region. By integrating RAS into its military capabilities, the Australian Army can ensure it remains competitive, capable and ready to defend Australia's national interests in a technologically advanced global landscape.

For RAS to operate effectively in support of military operations, these systems must have situational awareness. Situational awareness[3] refers to the systems' ability to perceive, understand, predict and respond to elements within their environment[4] and is essential for enabling RAS to navigate and respond to dynamic environmental and mission conditions. Attaining situational awareness involves rapid acquisition and processing of diverse data attributes that relate to operational environments and missions. This data typically stems from advanced sensor integration, ground control or peer RAS. Network technologies carry the data, which is then processed by artificial intelligence (AI) and other technologies to create situational awareness.

Scalability of situational awareness refers to the ability of RAS to expand situational awareness without compromising mission functionalities. It is achieved by acquiring and processing larger volumes of data. Scalability is necessary to achieve better situational awareness and is therefore essential in efforts to optimise the use of RAS in modern warfare.

To date, only limited research and development has been conducted on the issue of RAS scalability. To address this gap, this article provides insights into how the Australian Defence Force (ADF), and the Australian Army in particular, can effectively incorporate RAS that have the critical attribute of scalable situational awareness. To achieve this, the article:

1. reflects on existing data acquisition, network and processing enhancement solutions relevant to enhancing situational awareness in RAS
2. analyses the reviewed solutions to identify their limitations in remote and challenging environments
3. based on the limitations identified, and the technical characteristics of RAS, recommends effective approaches to augment situation awareness.

Use of Remote Autonomous Systems by Prominent Military Forces

Autonomous systems are used by several countries with advanced defence capabilities, as well as by other less technologically advanced nations that are currently engaged in conflict. Below are a few representative examples; a comprehensive list is beyond the scope of this article.

United States of America

The primary motivation for US efforts to acquire RAS is to achieve operational superiority. In this regard, the focus is on mitigating risks to soldiers, reducing their workload and enhancing the situational awareness of the force to support both offensive and defensive actions.[5] To this end, the US Army is progressing through a phased program of developing and integrating RAS. In the far term (2031–2040), the US aims to replace older autonomous systems with advanced RAS that will be fully integrated into military capabilities. This goal suggests that the US intends to achieve full-scale deployment of RAS within Army operations soon. Indeed, a military review published by the US Army[6] emphasises the immediate need for AI integration into military systems to enhance operational decision-making. The achievement of AI integration aims to create a more accurate and detailed common operational picture across various echelons, as well as enabling faster and more informed decision-making within multi-domain battle environments.

China

China's motivation for deploying autonomous systems in military operations is rooted in its desire to surpass the US as a global superpower by 2049.[7] To achieve this, China has implemented a military–civil fusion policy that aims to integrate civilian technological advancements with military applications. This Chinese policy has driven significant investment in emerging and disruptive technologies, including AI and military robotics. Other notable developments include the production of cutting-edge UAVs like the GJ-11 and a significant increase in the acquisition market for military robotics.

Russia

Russia is motivated to deploy autonomous systems in military operations to counter its adversaries.[8] To this end, Russia has invested in the development and deployment of various autonomous platforms across aerial, ground and maritime domains. One of its most advanced autonomous systems is the S-70 Okhotnik unmanned combat aerial vehicle, which is designed for long-range strike missions with a range of up to 6,000 kilometres. Another notable system is the Orion UAV, which performs intelligence, surveillance and reconnaissance (ISR) and combat roles with a range of 250 kilometres. Despite such advances, most Russian autonomous systems still operate under significant human control, with aims to achieve greater autonomy in the future.

Ukraine

Ukraine uses a variety of autonomous systems in its ongoing conflict with Russia. It has deployed both military-grade drones (like the Turkish Bayraktar TB2) and commercially available off-the-shelf (COTS) drones.[9] The Bayraktar TB2, equipped with AI-driven targeting systems, has been successful in precision strikes. Ukraine has also adopted more cost-effective COTS drones for artillery spotting and direct attacks. One of the most notable developments is Ukraine's use of swarm tactics where large numbers of COTS drones are deployed simultaneously to overwhelm enemy defences. These systems are not fully autonomous and still require significant human input.

From this analysis, it is evident that several nations are actively seeking to incorporate RAS into their military arsenals. Most systems still require significant human control.

Current Solutions for Scaling Situational Awareness

To better understand how to solve the issue of scalable situational awareness in RAS, it is useful to first consider the data sources, as well as the hardware and software components, that combine to make scalability possible.

Situational awareness is achieved through the interaction of various modules in RAS, such as data sources (e.g. onboard sensors, remote operators, cloud databases and peer RAS units), networks, data processing units, and actuation mechanisms. These components are not exclusive to RAS used in the military sector; RAS from civilian industry, including autonomous cabs,[10] space flights,[11] and robots used in supply chains,[12] possess similar attributes and operate on the same principles. As an element of situational awareness, data sources provide contextual information (or context)[8] to RAS. Contextual information refers to data related to a place, person or object. In a military context, RAS use contextual information to infer relevant states of the target and to build situational awareness.

Context exchange between RAS and data sources occurs via networks. The inbuilt data sources in RAS use internal communication channels (data cables) to communicate with processing components. RAS also rely on external data sources, which require low-latency communication. Autonomous mobile robots exchange sensor data and task information with cloud processors and human operators. These robots use 5G networks or dedicated high-bandwidth links such as gigabit multimedia serial link (GMSL), which supports up to 6 gigabits of sensor data and low bit-error rates. Bandwidth describes the maximum rate per second at which data can be transmitted over a network, indicating how much data can pass through the network at any given moment. RAS process the acquired context from networks to infer environmental situations using AI and machine learning (ML) algorithms which run on various processors. These data inputs, and network and processing components, enable RAS to take necessary actions (actuation).

An example of non-military use of RAS is Waymo's current-generation autonomous cabs. These cabs were introduced into service in Arizona's metropolitan Phoenix area in 2017 and were being rolled out in greater Arizona, San Francisco and Los Angeles from 2024. Supported by RAS, Waymo cabs identify their surroundings using numerous lidars mounted to them. The cab's 'brain' is an onboard computing system with central processing units and graphics processing units (GPUs) that process sensor data in real time to identify objects and plan safe driving paths. When these autonomous cabs encounter unusual situations that are beyond their inbuilt AI models' capabilities, they relay those situations to remote human operators to assume control. The entire process occurs through ultra-reliable low-latency communication.[13] Another example of the commercial use of RAS is in factory settings where autonomous mobility robots keep human workers safe from hazardous machines and chemicals using lidar to navigate dynamic environments.

In the government sector, NASA's Ingenuity Marks helicopter is supported by RAS technology. This helicopter has been designed to test if powered flight is possible on Mars. It uses a laser range finder and a navigation camera to realise altitude and velocity. It also relies on multi-processor architecture which supports the functioning of rotor blades based on the environmental conditions presented by the sensors.

While there are successful examples of RAS in the military, commercial, industry and government sectors, further improvements across context acquisition, networking and processing are necessary to achieve and maintain scalable situational awareness. RAS need the capacity to consistently acquire and process data generated in diverse contexts and from varying sources. However, deficiencies in contemporary technology mean that RAS are currently limited by the need to rely on fixed sources of context, so they are unable to achieve seamless context source discovery. Situational awareness is also compromised by limitations in networking and processing performance. The quality of service (QoS) of networks (usually represented by metrics such as bandwidth and delay[14]) and the QoS of processing (including metrics like reliability and interoperability) also significantly impact overall situational awareness.

A further problem is that few RAS can effectively process contextual information obtained from diverse sources. Instead, they are generally limited to a fixed set of sources, predefined at the time of their deployment. Efforts are being made, however, to overcome this limitation. For example, the Defense Advanced Research Projects Agency (DARPA) OFFensive[15] program envisions up to 250 UAVs and ground systems supporting defence missions in urban environments. These UAVs enable information-sharing, acting as context information sources for one another. Still, they cannot discover new sources, and data acquisition remains limited by the predefined data sources in their software stack.

There are several available methods to enhance situational awareness in RAS. However, limitations still exist. The following section provides further explanation.

Context Management Platforms

Context management platforms (CMPs)[16] [17] offer the potential to enhance the data acquisition capabilities of RAS. CMPs facilitate context acquisition from diverse sources by bridging applications and sources. As outlined below, CMPs can be categorised into three types: domain specific, open ecosystem centralised, and open ecosystem distributed.

Domain-Specific CMPs

The primary characteristics of domain-specific CMPs are that they incorporate a fixed set of contextual information sources and that they are bound to specific domains. BDCAM[18] and CoCaMAAL[19] are two examples related to assisted living and patient monitoring; these systems data-share between related sensors and applications. These types of CMPs are useful for applications with certain contextual information needs but they are incompatible with RAS, which require context from far more diverse and dynamic sources.

Open Ecosystem Centralised CMPs

These types of CMPs coordinate and deliver relevant contextual information to applications based on updates received from various sources. Accordingly, they enable applications to acquire diverse contextual information by acting as a central server. Examples are context-as-a-service (CoaaS)[20] and FIWARE CMPs.[21] The main limitation is that the centralised nature of these types of CMPs can slow down their response times when there is limited network connectivity or if one platform is attempting to serve multiple RAS. As the load from context sources and applications increases, the CMPs' processing times may also rise. Except for the CoaaS CMP, most advanced CMPs of this type also lack the functionality to deliver contextual information with quality of context (QoC) metrics such as timeliness and accuracy. This article discusses the attributes of QoC in more depth in a later section.

Open Ecosystem Distributed CMPs

This type of CMP is currently under development in the form of a distributed version of CoaaS CMP.[22] In these ecosystems, the context sources and applications are interconnected with a distributed network of CMPs. Distributed CMPs have the potential to provide faster context responses compared to centralised CMPs. They therefore allow for far faster access to contextual information than can be achieved by either domain-specific CMPs or open ecosystem centralised CMPs.

While open ecosystem distributed CMPs represent a promising technological development, they still have characteristics of centralisation. This can lead to inconsistencies in QoC compliance when operating under unstable network conditions. Moreover, as the number of context sources and applications increases, ensuring synchronisation across distributed nodes becomes complex.

Enhancing Networks (Communication)

There are several methods available to enhance networks that may help to improve the situational awareness achievable by RAS. These include scheduling algorithms, heterogeneous network switching, relay nodes and ML. These methods span a range of military use cases, such as improving communication between military vehicles, providing navigation support for UAVs in GPS-denied environments, and enabling surveillance for search and rescue operations. Other use cases include autonomous decision-making and enhanced long-distance data transmission. The methods are outlined in further detail below.

Scheduling Algorithms[23] [24] [25]

Scheduling algorithms can be used to prioritise data in transmission to ensure efficient and timely delivery in bandwidth-constrained environments. The main limitation of this method is that it cannot be used effectively in environments with varying bandwidths. Instead, scheduling algorithms are generally designed for specific bandwidth conditions and may not be flexible enough to adjust to fluctuations in bandwidths. Combining these scheduling techniques with relay node based approaches (discussed below) could address this limitation.

Heterogeneous Network Switching[26] [27]

This method is used to seamlessly switch between different network technologies (e.g. wi-fi, 5G, satellite), based on the availability and performance of the network, to maintain optimal connectivity. Many commercial drones, such as the DJI Matrice 300, use this technology. It switches between different communication channels such as long-term evolution (LTE), wi-fi, or private radiofrequency links, ensuring that connectivity is maintained even in remote areas or challenging environments. The difficulty here lies in the varying speeds and performance of these different networks. Wi-fi and 5G typically provide faster speeds but have limited ranges, while satellite internet offers long-range connectivity at slower speeds. The slower speed of satellite networks can hinder RAS performance in dynamic environments. Equally, the remoteness of RAS operations often makes wi-fi or cellular networks inaccessible.

Relay Nodes[28] [29]

These are intermediate nodes (also known as hopper nodes) used to extend network coverage or boost signal strength. In real-word deployments of RAS, using relay or hopper nodes is common for extending network connectivity. For example, the Parrot ANAFI[30] drone uses relay nodes (4G network nodes) for long-range communication. Military drones often employ mesh networks with intermediary nodes to maintain communication in remote areas.

Static nodes, such as those used in typical GSM networks, are the most common types of relay nodes. The problem is that static nodes may be ineffectual for maintaining the connectivity of RAS. This is because static nodes cannot reposition to accommodate environmental factors that can disrupt signal strength and reliability, such as high terrain or tides. Mobile relay nodes, such as network-carrying drones or vehicles, can be used to overcome these challenges. This method allows the nodes to adjust dynamically to the changing environments, but it introduces unpredictability in terms of costs and resource requirements.

Machine Learning for Data Prediction [31]

ML uses AI-based techniques to predict and reconstruct missing or corrupted data. The accuracy of ML predictions, however, is heavily dependent on the quality of the input data. If the data is incomplete or ‘noisy’, the predictions become less reliable. While ML can help predict missing data in continuous data streams, this method will inevitably struggle to accommodate new or unrelated inputs, limiting its utility in RAS.

Enhanced Processing

Processing high volumes of real-time data requires significant computational power. Military-grade drones like the MQ-9 Reaper[32] are equipped with powerful onboard computing systems such as field programmable gate arrays (FPGAs) and system-on-chip architectures. These systems enable faster data processing and offer energy efficiency to handle complex tasks.

RAS with scalable mission objectives often face varying data rates and mission demands. When RAS are engaged in missions with constant and predictable data volumes, onboard computing resources are generally adequate for data processing. However, if RAS are responding to fluctuating data loads, more flexible processing capabilities are needed than are generally built in. There are several available ways to improve the data processing capacity of RAS. These methods are outlined below.

Edge and Fog Computing for Distributed Data Processing

Edge computing refers to the idea of bringing computation closer to devices that need it in order to minimise latency. Fog computing is more specifically a layer between the edge and the cloud to provide additional computing resources to the edge. In this method, additional processing components are deployed closer to RAS. This reduces the load on the inbuilt processing resources of RAS and the latencies associated with carrying data to ground stations.

An example of a system that uses edge and fog computing is the US Army's Advanced Battle Management System.[33] It distributes command and control to multiple resources instead of relying on a central system. Another example is the US military's F-35 fighter jet, which uses edge computing principles to process vast amounts of data directly on the aircraft. In this way, sensor data is collected and fused with information from other F-35s in the same squadron, and a unified picture of the battlefield is generated.[34]

While processing data on edge devices is beneficial for real-time responses, limited computational capabilities may mean that it is unable to handle all of the incoming data from diverse sources. For example, problems can arise when the processing power of edge devices does not match the capabilities of central servers or cloud-based systems. As a result, data synchronisation issues can occur.

Data Offloading to Ground Stations or Cloud Systems

When the edge nodes, fog nodes (if deployed) and onboard capabilities in RAS reach their processing limits, data is transmitted (offloaded) to ground stations or cloud resources for processing. For example, the US Army has multiple legacy and state-of-the-art applications where data is offloaded to ground stations.

An example of a ground station is the Air Force Distributed Common Ground System.[35] It has the capacity to gather and process data gathered by various ISR platforms. Similarly, the Tactical Intelligence Targeting Access Node (TITAN)[36] system processes data collected by multiple sensors, including space, aerial and ground-based platforms.

While offloading can free up local resources, it also introduces dependencies on communication links. If those links have limited availability or are jammed by adversaries, the offloaded service may become unavailable. Latency issues and network dropouts are also significant challenges when processing is reliant on ground stations or cloud systems. In remote or contested areas, communication channels may not be fast enough to support continuous data transmission to these systems. As a result, there may be delays in data transfer.

Data Balancing Across Multiple RAS

Data balancing involves distribution of data with peer RAS, nodes and multiple servers for processing so that no single component is overwhelmed. When multiple RAS work collaboratively,[37] processing resources can be shared between collaborating RAS. When the computational load is spread across a drone swarm, the entire swarm can dynamically balance tasks and resources to achieve mission objectives. For example, under the US Army's Project Convergence, drone swarms work together to engage targets.[38] The US Army Research Laboratory has also been working on enhancing swarm capabilities.[39] While swarm capabilities offer an advantage over less coordinated RAS, their limited individual processing capacity and environmental constraints (such as distance) make sharing resources inefficient.

Data Compression or Prioritisation Techniques

These techniques involve compressing data at the source and sending it to RAS processing units. When received by the RAS, the data is prioritised for processing based on mission conditions. These techniques considerably lower processing demands at the receiving end. For example, military UAVs, such as RQ-4 Global Hawk,[40] compress large datasets collected by onboard sensors and then transmit only the essential information back to mission command and control.[41]

The main limitation with this method is that the time and resources required for data compression are directly proportionate to the volume of data collected. Data prioritisation relies on predefined rules or AI-based systems to rank the importance of incoming data. This method may therefore falter if a system is unable to establish data priority. This might occur when all data possess similar significance or when data compression is performed (e.g. when the data is end-to-end encrypted). Also, because data volumes can vary significantly depending on mission conditions, important data may be overlooked when the data volume is high, compromising situational awareness.

AI and ML for Adaptive Data Processing

This process involves using AI and ML algorithms to automatically process relevant data. Platforms that use this technology autonomously detect and classify targets without the need to transmit large volumes of raw data back to a ground station. An example of a military application is FIRESTORM AI, which is part of US Army's Project Convergence.[42] This system analyses sensor data from UAVs and recommends the best weapons systems to engage identified targets. Another AI-driven platform is Maven Smart System,[43] which uses ML algorithms to process full-motion videos in UAVs.

To effectively process the data generated by AI and ML algorithms, reliable communication links are necessary between the UAV and the ground station. This is a major constraint, as communication networks in remote or contested environments can be unstable. Also, most RAS lack sufficient onboard processing power to process large datasets; they must instead rely on external systems, a situation which again reinforces the need for reliable communication links.

Further, if the data received by the UAV is not part of the AI system's training dataset, the system may not be able to respond effectively. One concern is that if the AI encounters novel data patterns or scenarios that were not used in training, the system might misclassify their importance. When faced with novel data patterns, AI- and ML-based adaptive data processing systems may struggle to prioritise tasks effectively, which can degrade performance and increase adaptation time.

Using Scalable Hardware Architectures

Processing hardware architectures like FPGAs and GPUs are designed to accommodate surges in processing demands. RQ-4 Global Hawk[44] uses FPGAs to enhance processing abilities, allowing faster data conditioning and more efficient transmission of data.

The issue with both FPGAs and GPUs is that they consume a significant amount of power, limiting their utility in RAS with limited power supplies. They also generate substantial heat, requiring effective cooling systems. Integrating additional cooling mechanisms within lightweight RAS is impractical due to size, weight and design constraints. Further, if networks cannot transfer data quickly enough to match the processing speeds of the hardware, the performance gains can be diminished.

Caching and Data Preprocessing

Caching and data preprocessing methods are employed to temporarily store data, making it accessible when onboard processing resources are constrained. The US Army is using this method in efforts to implement full-motion video capabilities in the MQ-1C Gray Eagle UAV, including caching critical video data on board. This capability will enable the platform to access previously captured information during surveillance operations.

Data caching has limitations in dynamic and unpredictable combat environments. Specifically, relying on data caching and preprocessing will be less effective in evolving mission scenarios or missions requiring data processing from multiple sources: as new variables and threats emerge, cached data may rapidly become irrelevant.

Recommendations for Enhancing the Situation Awareness in Remote Autonomous Systems

The preceding analysis has demonstrated that situational awareness in RAS depends on the performance and coordination of data acquisition, network and processing components. It has also shown that existing methods to scale these components have their limitations when applied to RAS.

This section contends that RAS need to incorporate CMPs or similar technologies that allow for the acquisition of diverse contextual information within compliant QoC standards. It argues that QoS metrics (related to processing and network performance) are key requirements for scalable RAS. This section conceptualises how to incorporate CMPs with RAS. It also explores how network and processing solutions can be integrated into RAS, including recommendations based on whether the solution is compatible with QoS metrics.

Incorporation of CMPs with RAS for the Effective Acquisition of Contextual Information

Most CMPs share common functionalities.[45] Potential therefore exists to generate a standardised conceptual method for integrating RAS with CMPs. QoC metrics represent how usable contextual information is for RAS across identified mission conditions. Table 1 presents the different QoC metrics and their definitions.[46] For the purposes of the table, the term 'contextual information attribute' refers to a piece of information (e.g. temperature).[47]

Table 1: Quality of context metrics and their definitions

QoC metric	Definition
Timeliness	The level of validity of a contextual information attribute based on time
Accuracy	The level of alignment of a contextual information attribute compared to the ground truth
Resolution	The level of detail in a contextual information attribute
Completeness	The extent of availability of relevant metadata in a contextual information attribute (this metadata is required for computing QoC metrics)
Significance	The level of a contextual information attribute's importance to the application
Representation consistency	The level of data format compliance of a contextual information attribute and its metadata
Sensitiveness	The degree to which access to a contextual information attribute and its metadata is preserved

Not all CMPs can acquire QoC-compliant context. Most of them locate data sources that produce the required context without ensuring QoC compliance. Some CMPs, such as CoaaS[48], are equipped with advanced components like the context cost and quality engine (ConCQeng).[49] These components ensure RAS acquires QoC-compliant context.

CMPs typically connect with applications, such as RAS, and contextual information sources through application programming interfaces (APIs). QoC managers, such as ConCQeng, can either connect to CMPs via APIs or be incorporated internally. Figure 1 illustrates the process flow of RAS integration with a CMP that is capable of delivering QoC-compliant contextual information (or context).

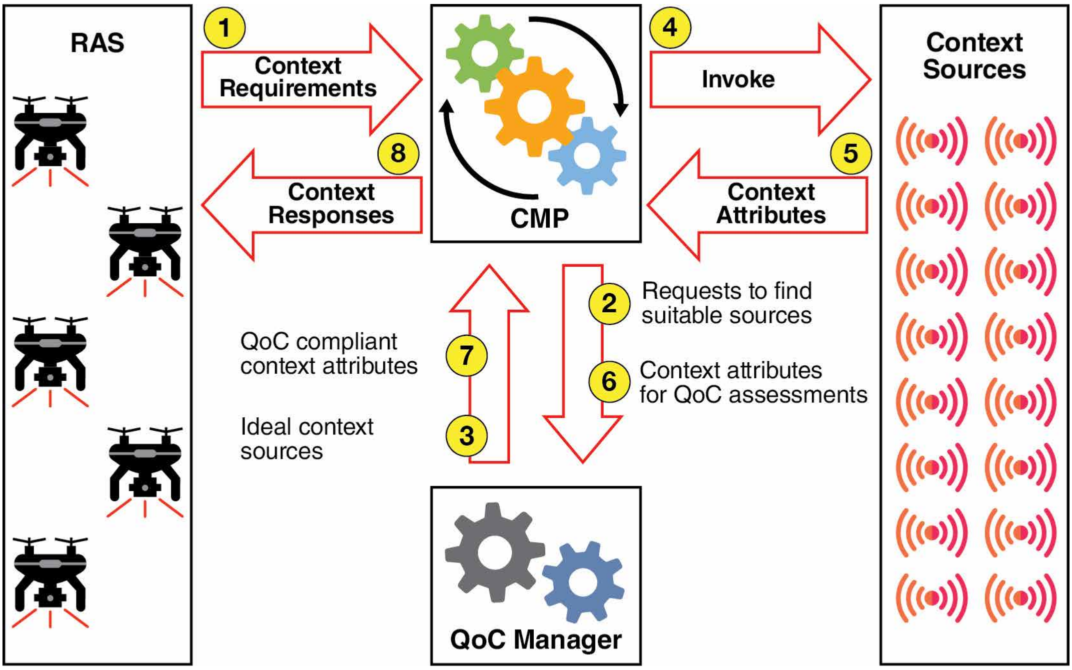

Figure 1: Conceptual integration of CMP with QoC-compliant context retrieval capabilities in RAS

The following steps explain the process illustrated in Figure 1.

- **Step 1:** RAS initiate queries for contextual information (each query contains the required context attributes and respective QoC requirements). Queries are typically expressed in languages like SPARQL or those specific to context managers, such as the context definition query language (CDQL).[50]
- **Step 2:** Upon receiving a query, the CMP requests the QoC manager to identify context sources capable of meeting the query's requirements.
- **Step 3:** The QoC manager identifies and sends back the information of the most suitable sources. This is possible as the QoC manager evaluates the QoC delivery rate of context sources over time by validating their context attributes.[51]
- **Step 4:** The CMP invokes the identified context sources.
- **Step 5:** The context sources deliver the requested attributes to the CMP.
- **Step 6:** The QoC manager validates the received context attributes for QoC compliance, and updates the QoC delivery rate of the context sources.
- **Step 7:** The QoC manager forwards the valid context attributes to the CMP.[52]
- **Step 8:** The CMP delivers the validated context attributes to the RAS.

The process described in Figure 1 enables RAS to be incorporated with a CMP that is integrated with a QoC manager. This relationship ensures that RAS acquire QoC-compliant context attributes and can achieve diverse contextual acquisition to enhance situational awareness.

Figure 1 specifically pertains to a centralised CMP ecosystem. In a distributed CMP ecosystem, the local functionalities of each CMP, its associated RAS and its context sources remain the same. The key difference is the cross-exchange of contextual information between CMPs when required, where each CMP acts as a context source for the others.

Mapping Network Quality of Service Metrics to Relevant Methods for Scalable Situational Awareness

Figure 2 maps QoS metrics to the network enhancement methods that potentially attain them (indicated in green boxes), those that conditionally attain them (indicated in orange boxes) and those that may not attain them (indicated in red boxes). This mapping is based on the definitions of QoS metrics and the functionality of the enhancement methods to align with these definitions. The use of these methods, as well as their influence on the given metrics, can be seen in many defence-related applications.

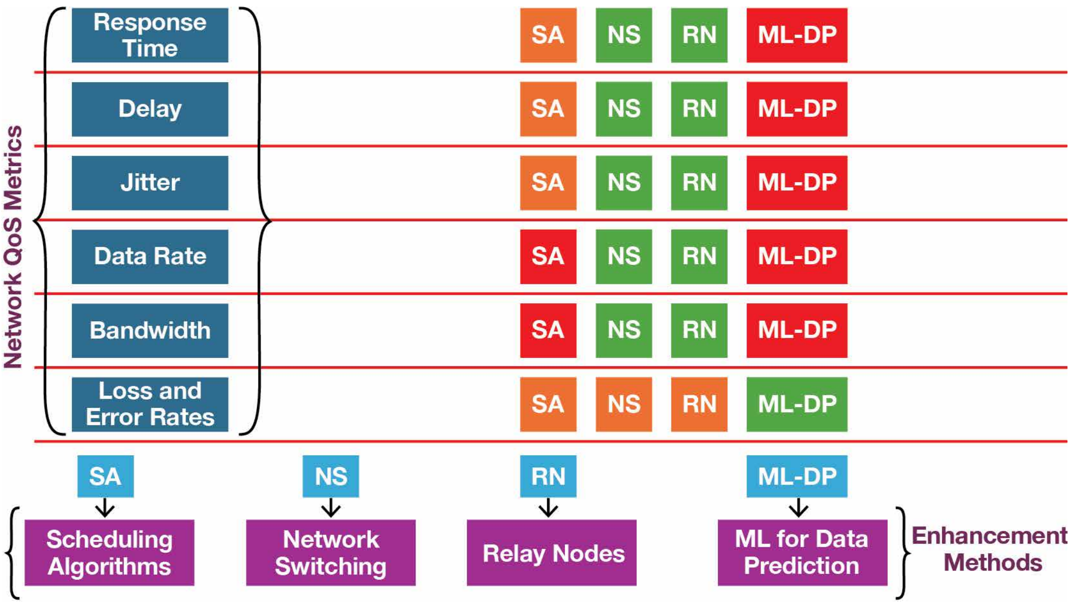

Figure 2: Network QoS metrics and level of suitability of enhancements methods for their attainment—green, orange and red, respectively, range from most suitable to least suitable

The following QoS metrics are related to networks[53] and play a crucial role in determining network performance.

- **Response time** refers to the turnaround time—the time taken for a message to leave the source, reach the destination and receive a response back.
- **Delay** (also called **latency**) indicates the total time it takes for a data packet to travel from the source to the destination.
- **Jitter** refers to the variance in delay—how much the data packet delivery times vary between transmissions.

The metrics described above can be attained through *network technology switching*, such as by moving from cellular networks to satellite networks, to maintain connectivity. For example, Honeywell's JetWaveX[54] offers satellite communication systems for military use that enable network technology switching to ensure that a reliable communications path is always available. This avoids spikes in delay and jitter, which in turn improves the capacity of RAS to respond quickly to dynamic data inputs. Despite this benefit, network technology switching cannot improve the underlying network connection or increase the network's capacity.

Another method for sustaining these metrics is by the use of *relay nodes*. Relay nodes enhance both connectivity and speed by distributing network traffic over multiple paths. For example, the Battlefield Airborne Communications Node[55] is a US Air Force-led program designed to improve communications and data-sharing across different military forces and platforms in network-constrained environments. Here, a high-altitude aircraft carries communication payloads, acting as a relay node. This approach helps overcome the difficulties caused by mountains or distance, reducing the jitter that may be caused by dynamic operational conditions.

Scheduling algorithms also contribute to preserving the metrics described in Figure 2. They do this by prioritising smaller or high-priority messages based on network capacity. These algorithms ensure that critical data is transmitted efficiently, optimising the use of available resources. However, scheduling algorithms only optimise existing data flows within the constraints of network capacity; they cannot enhance the network's overall ability to accommodate or carry larger volumes of data.

According to an article published in the US Army's *Cyber Defense Review*,[56] QoS can be preserved in network-constrained environments by *graceful degradation*. That is, when resources are insufficient to meet the demands, the system adaptively degrades service (or scheduled services) in a controlled and prioritised way to maintain an optimal QoS. However, the overall capacity of the network still depends on the capacity of the network's links. So the QoS requirement may not be met if the network capacity is inadequate.

As discussed in the previous section, ML techniques predict and reconstruct missing or corrupted data once it reaches its destination. So ML can be useful in efforts to manage loss and error rates. Such rates often represent missing or corrupted data, which can affect the integrity of the entire dataset. However, ML cannot improve the underlying network connection or increase the network's capacity. Further, if the network suffers from high jitter or latency, ML-based recovery cannot compensate for the disruptions caused by poor network performance. Therefore, ML-based methods are not well suited to maintaining data rate and bandwidth.

Loss and error rates can be conditionally preserved through *scheduling algorithms*, *network switching* and *relay nodes*. Loss rate is the percentage of data packets sent but never received at the destination. Error rate is the frequency of corrupted or altered packets during a transmission. Scheduling algorithms help by optimally aligning the transmission of messages with available resources. Network switching contributes by selecting the strongest available technology to reduce data loss and transmission errors. Further, relay nodes reduce loss and error rates by diverting data through the most suitable channels. However, these methods are not always foolproof. Relay node malfunctions—or failures in the available networks—can increase the loss and errors rates in relay node and network switching methods. If the data must be transmitted in a specific sequence, scheduling methods may not work.

Note: The perspective presented on the usability of relay nodes and network switching assumes the availability of relay nodes and alternative network technologies to handle varying data loads.

Mapping Processing QoS Metrics to Relevant Methods for Scalable Situational Awareness

Table 2 lists and defines the QoS metrics related to processing and contains both general metrics (applicable to all technological systems) and metrics exclusive to context- and situation-aware systems[57] (such as RAS).

Table 2: Definitions of QoS metrics relevant to processing, including general metrics and exclusive metrics for context- and situation-aware systems

QoS metric	Definition
Availability	The degree of the processing resource's accessibility within a given timeframe
Reliability	The processing resource's ability to perform its functions without failure over a specific period
Scalability	The processing resource's ability to handle increasing workloads without performance degradation
Interoperability	The processing resource's ability to seamlessly exchange information with other systems or processes
Security and privacy	The level of access protection, confidentiality and integrity of data
Service adaptation time (exclusive to context- and situation-aware systems)	The time taken by a system to adjust or switch between services based on changing conditions
QoC (exclusive to context- and situation-aware systems)	The aggregate of quality metrics associated with contextual information

The performance of processing modules is generally judged based on considerations of *availability*, *reliability*, *scalability*, *interoperability* and *security and privacy*. Additional metrics like *service adaptation time* and *QoC* are also relevant in situationally aware systems like RAS. This is because RAS are time-sensitive applications that are heavily reliant on contextual information. Therefore, maintaining high-quality contextual data and faster service times is essential for enhancing their performance.

As Figure 3 depicts, determining whether an application has achieved the QoS metrics (availability; reliability; scalability; interoperability; security and privacy) and QoC is a subjective assessment. Unlike network QoS metrics (where metrics can be predicted based on the methods' functionalities and metric definitions), maintaining processing metrics depends on several factors. These include hardware configurations, external conditions and data loads.

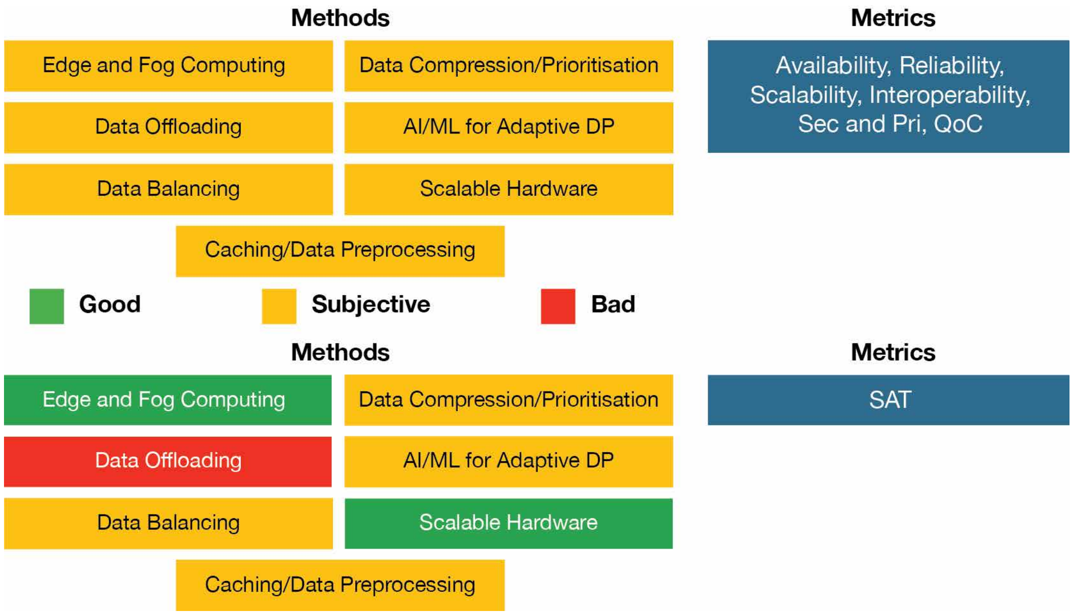

Figure 3: QoS metrics related to processing and level of suitability of processing enhancement methods

The methods outlined in Figure 3 can be described as follows.

Enhancing QoS Through Edge and Fog Computing

In edge and fog computing, resources are connected through secure links that support data processing at edge servers rather than relying entirely on the cloud. The processing module is thereby more resilient because its dependency on central servers is reduced. Because optimal data distribution is achieved by eliminating any single point of failure, this approach supports the achievement of most QoS metrics.

One vulnerability, however, is that edge and fog systems depend on the proper functioning of both hardware and software within these systems. Any discrepancies can negatively affect QoS. For example, failures in fog nodes can reduce reliability and scalability, while software error—or the introduction of systems with new communication protocols—can compromise interoperability. If some edge nodes become interoperable or break down, the entire QoS can collapse.

To ensure interoperability, NATO's framework recommends the adoption of common standards across distributed systems.[58] Even when edge nodes belong to different domains or allied forces, they must speak the same language. To this end, the US Joint Interoperability Test Command certifies systems and tools for their compliance with NATO common standards.

Enhancing QoS Through Data Offloading

Data offloading involves transferring processing tasks from the local (edge) system to ground stations or cloud servers. For example, the US project Maven[59] offloads video feeds from ISR assets to ground stations, and this approach has reportedly reduced the real-time latency.

Data offloading is not ideal, however, as remote environments typically introduce significant latency. Further, data offloading is only viable when there is more than one available ground station or cloud system to which the data can be offloaded. Relying on a single high-capacity offload path can create a single point of failure —if that path goes down, the processing cannot be performed at all.

Enhancing QoS Through Data Balancing

By enhancing data balance, the QoS scalability metric of the system will support more RAS in the field. Achieving a perfect balance of data processing, however, requires continuous inter-system monitoring and communication among nodes about their status. The problem is that this requirement can increase service adaptation time as data loads grow. Further, if coordination fails (e.g. if a node silently fails and tasks are not rebalanced because others did not know in time), the data or processing task may become unavailable. This compromises the QoS metrics availability, reliability and scalability. Also, data balancing may become inconsistent with scalability; if every RAS processes data locally, their resources may become unavailable for additional loads.

Data Compression and Prioritisation Techniques

Data compression and prioritisation techniques allow for large amounts of data to be compressed and prioritised for processing. These techniques can help RAS to maintain QoS, particularly in resource-constrained environments. For example, the VAST platform[60] uses these methods to carry high-quality videos from tactical scenarios, which can then be carried by the networks under 50 kilobits per second (very low bandwidth for HD streaming). However, the effectiveness of data compression and prioritisation depends on system interoperability. If compression rules are not standardised across systems—or if priority levels do not align with the operational context—these techniques can fail to function as intended.

AI- and ML-Based Adaptive Data Processing

AI- and ML-based adaptive data processing can dynamically reroute processing tasks and reallocate available resources. This advanced processing capability can assist RAS to achieve QoS metrics, particularly in circumstances with large amounts of image or video processing which are resource intensive.

The reliability of AI-based systems depends on the quality of their training and algorithms. Even scalable hardware architectures, such as GPUs, may struggle with complex algorithms that require simultaneous instructions. Achieving security and privacy metrics when using hardware architectures such as GPUs relies heavily on manufacturer support and deployment processes such as secure key distribution. Meanwhile, QoC is contingent on the quality and context of the data sources.

As can be seen by this overview, it is difficult to single out one method that can consistently preserve all QoS metrics; multiple dynamics are in play. Nevertheless, based on the analysis presented, this article proposes that QoS can be best preserved if processing latency is reduced. This outcome is most effectively achieved through edge and fog computing, where data is processed closer to the RAS, and scalable hardware (such as GPUs) is used to execute instructions more quickly. Despite the conceptual benefits of this proposal, however, selecting the most suitable method will ultimately depend on available resources, budgetary constraints and environmental conditions.

Putting It Together: What Is Needed to Enhance Situational Awareness in Remote Autonomous Systems

A key characteristic of RAS is their need for enhanced situational awareness in order to perceive, infer and act based on the environmental conditions.[61] RAS infer situational awareness from contextual information (or context), representing the relevant environmental data.[62] RAS must dynamically discover relevant contextual information sources that produce quality-compliant context (represented by QoC metrics). Many core capabilities of RAS—including data-acquisition technologies and network and processing functionalities—significantly affect the achievable levels of situational awareness. For example, network and processing resources need to be sufficiently adaptable to transfer varying loads of context and to access them promptly to ensure that the system is sufficiently situationally aware to support real-time operational decision-making.

Existing RAS lack technologies to discover relevant contextual information sources at the standard required to produce quality-compliant contextual information. No single solution can comprehensively achieve scalability while attaining all QoS metrics. Existing solutions typically optimise specific QoS metrics under certain conditions. Attempting to implement a single best solution for scalability presents several challenges. These include limited fit and lack of fail-safety. Limited fit refers to the fact that any single solution may have the capacity to address only a subset of QoS metrics effectively. Lack of fail-safety means that some solutions perform well under ideal conditions but degrade significantly when environmental factors change. Other limitations are also relevant. For example, due to their remote deployment, RAS often face limited network connectivity, and both power and space limitations can constrain onboard processing capacity.

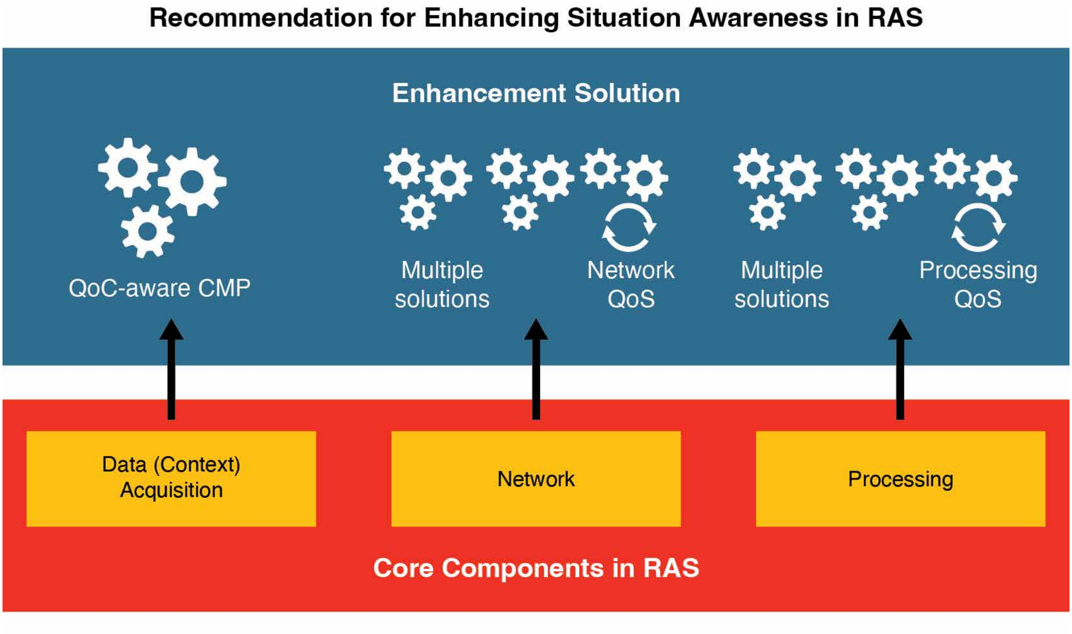

Figure 4: Enhancements recommend in context acquisition, network and processing components in RAS for enhancing overall situation awareness.

Figure 4 depicts a method to enhance situational awareness in RAS that involves a combination of methods: improved data (context) acquisition, enhanced network performance and increased processing capacity. Improving *data acquisition* relies on the integration of QoC-aware CMPs, such as CoaaS[63] powered with QoC manager ConCQeng.[64] Such CMPs will enable RAS to discover and acquire relevant and quality-compliant context from diverse sources. During exchange, transfer and processing of various loads of context, the *network performance* must be optimised to meet the required QoS metrics. In this regard, network switching and relay nodes are an effective way to maintain most QoS metrics. No single solution exists for improving *processing capacity* across all QoS metrics. Instead, a mix of processing solutions should be adopted that balance the performance, budget, available resources and operational constraints relevant to the circumstances. To minimise service adaptation time, priority should be given to edge- and fog-based solutions and to scalable hardware. To mitigate loss and error rates, we recommend the integration of ML-based methods.

Based on the analysis conducted in this article, Table 3 below indicates how methods can be most effectively prioritised based on whether the use case of RAS has time dominance, has accuracy dominance, or has both.

Table 3: Network and processing enhancement methods to prioritise in RAS based on their operational focus (time dominance or accuracy dominance) to best meet the corresponding QoS metrics

Category	Relevant QoS metrics (network and processing)	Method to prioritise (network and processing enhancements)
Time dominance (e.g. rapid coordination, swarm control, strike synchronisation)	**Network:** delay, jitter, response time **Processing:** service adaptation time	**Network:** relay nodes (e.g. air/vehicular), heterogeneous network switching, scheduling algorithms **Processing:** edge and fog computing, scalable hardware (GPU/FPGA)
Accuracy dominance (e.g. ISR validation, coalition data fusion, intelligence analysis)	**Network:** loss rate, error rate **Processing:** security and privacy, interoperability	**Network:** ML-based prediction and reconstruction **Processing:** systems and network security measures, CMPs
Has both time and accuracy dominance (e.g. coordinated ISR, decision support and mission autonomy) *This category excludes the metrics identified above*	**Network:** data rate, bandwidth **Processing:** QoC, scalability, reliability, availability	**Network:** network switching, relay nodes **Processing:** QoC-aware CMP integration, selection of other appropriate method based on time and resource constraints

To see how the considerations outlined in Table 3 can assist in enhancing the situational awareness of RAS, consider a coordinated ISR mission involving multiple drones deployed across a wide operational area. During target detection and live coordination, they operate under a time-dominant condition. In this phase, it is essential to achieve low delay, to reduce jitter, and to maximise service adaptation time to ensure continuous situational updates. To achieve this, relay nodes and heterogeneous network switching maintain uninterrupted links, while edge/fog processing and GPU acceleration support rapid local processing.

When transmitting collected imagery and other data to remote or coalition command units, the scenario transitions to being accuracy dominant. Now, maintaining low loss and error rates, achieving interoperability and preserving security become critical. In this scenario, ML-based reconstruction restores corrupted or missing packets, maintaining data accuracy during its transfer. Interoperability is enhanced by establishing compatible network links that are managed at the network level, considering all layers of the open systems interconnection (OSI) model. Incorporating CMPs that facilitate consistent and structured data communication ensures that data exchange occurs in standardised formats so that information can be shared seamlessly between heterogeneous systems. Data security is preserved by incorporating common methods such as access control and identity and access management (a detailed discussion of these mechanisms is beyond the scope of this paper).

As operations progress, the mission may evolve into a combined time- and accuracy-dominant phase. In this case, it becomes particularly important to preserve network bandwidth and data rate in order to support timely and accurate response. While these metrics are emphasised here, the other QoS metrics discussed earlier remain applicable (but are not reiterated to avoid repetition). Bandwidth and data rate are enhanced through network switching and the use of relay nodes, ensuring sustained communication performance under varying operational conditions. While processing performance can be preserved through most of the methods discussed above, selecting the optimal method will depend on time constraints, environmental factors, available expertise and resource availability. These will differ depending on the mission context.

By integrating CMPs with complementary network and processing strategies, RAS can achieve enhanced situational awareness and operational scalability. However, to move beyond theory, field exploration and validation trials will be needed. The purpose will be to:

- explicitly test the recommended methods for data acquisition, networking and processing to determine how effectively each approach improves the relevant QoC or QoS metrics based on the mission use case
- develop and incorporate methods to improve situational awareness in RAS through coordinated enhancement across data-acquisition, network and processing layers
- establish evaluation frameworks that measure performance under varied operational conditions (e.g. bandwidth constraints, latency fluctuations and environmental interference) to inform robust defence-grade deployments.

Conclusion

Australia's defence strategy emphasises the use of autonomous systems to attain a strategic advantage in complex and high-risk operational environments. The ADF, and the Australian Army in particular, is committed to incorporating RAS into its capabilities to more effectively achieve mission objectives.[65] Able to execute missions when the deployment of soldiers is impractical or dangerous, RAS can perceive, interpret and autonomously adapt to mission conditions, making them invaluable assets in modern military operations. However, their utility depends on their capacity to achieve high levels of situational awareness, a characteristic which depends heavily on technologies that support data acquisition, network connectivity and information processing. Limitations in data discovery methods, the impact of remote operations on network performance, and constraints in computational power hinder the effectiveness of these systems.

In response to these limitations, this article has presented the key challenges affecting situational awareness in RAS, explored potential technological solutions and provided recommendations to enable the effective deployment of RAS by the ADF in support of Australia's defence strategy. Collectively, the recommendations made and the pathways proposed in this article provide a strategic roadmap for the ADF to transition a concept for enhancing situational awareness in RAS into operational practice. Systematically testing and integrating the proposed methods across all system layers will enable future RAS deployments to achieve seamless, scalable situational awareness and greater mission readiness in dynamic and resource-constrained environments.

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ENDNOTES

1 This paper draws on material covered in John Blaxland, *The Australian Army from Whitlam to Howard* (CUP, 2014). The author wishes to acknowledge the constructive feedback from the blind reviewers. Readers interested in exploring this issue further should also examine the contributions by a range of authors in Russell Glenn (ed.) *Trust and Leadership: The Australian Army Approach to Mission Command* (University of North Georgia Press, 2020). This includes contributions by Russell Glenn (mission command overview), Peter Pedersen (AIF), Peter Dean (Pacific War), Meghan Fitzpatrick (Korean War), Bob Hall (Vietnam War), John Caligari (1 RAR Group in Somalia), John Blaxland (East Timor in 1999), John Frewen (Solomon Islands in 2003), Ian Langford (Special Forces) and Chris Field (Queensland national emergency in 2010–11). See also Russell Glenn, 'Mission Command in the Australian Army: A Contrast in Detail', *Parameters: The US Army War College Quarterly* 47, no. 1 (2017), DOI:10.55540/0031-1723.2833.

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/ RESILIENT SUPPLY CHAINS FOR DEFENCE ENERGY SECURITY IN THE ERA OF SUSTAINABLE ENERGY TRANSITION

Khalil Gholami, Ali Azizivahed, Li Li and Dylan Lu

Abstract

This article explores the critical structure and resilience of supply chains within the defence and energy sectors. It begins with an overview of key supply chains supporting defence capabilities and identifies vulnerabilities that may pose strategic risks. In the context of the energy sector, the analysis covers the characteristics of energy-related supply chains, including mining, material production, and production lead times. Regional capacity for mineral resources and technology manufacturing is assessed in relation to strategic energy needs. A methodology for managing disruption risks specific to military microgrids is presented, recognising their importance in defence infrastructure. Finally, the article examines the emerging global hydrogen economy, with a focus on production geography, renewable resource deployment, and international trade flows. The findings provide a foundation for improving resilience and security across critical supply chain networks that support national defence and energy objectives.

1. Introduction

The global shift toward sustainable energy represents a profound transformation driven by climate imperatives, technological innovation, and evolving societal expectations. While the civilian sector has made notable progress in renewable energy adoption, electrification, and decarbonisation, defence energy systems face distinct and complex challenges. Military operations demand energy solutions that guarantee mission-critical reliability, rapid deployment, and high resilience under extreme or contested conditions—requirements that often exceed the capabilities of current civilian green technologies. Many low-carbon alternatives lack the energy density, logistical flexibility, and robustness needed for defence platforms operating in remote or hostile environments. Furthermore, defence applications require rigorous validation and long-term reliability before new technologies can be fielded, leading to slower adoption rates.[1] [2]

In light of these constraints, independent energy systems have emerged as a promising approach to enhance energy resilience within defence operations. These systems, which include solar arrays, battery storage, and advanced control technologies, enable localised energy generation. They play a critical role in ensuring the continued operation of essential infrastructure during disruptions caused by natural disasters, cyber attacks, or armed conflict. Beyond resilience, such systems can also reduce long-term operational costs, improve energy efficiency and contribute to sustainability goals through the integration of renewable resources.[3] [4]

The implementation of independent energy systems brings significant benefits but also introduces critical challenges, particularly in terms of supply chain dependencies. Defence forces rely on complex and globally interconnected supply networks to obtain the specialised components and materials required for advanced energy technologies.[5] [6] These include rare earth elements, precision-manufactured parts, fuel supply chain, and high-performance storage and control systems.[7] [8] Such dependence exposes defence energy infrastructure to a range of risks, including geopolitical tensions, market volatility, logistical disruptions, and cyber threats.[9] In the absence of a secure and resilient supply chain, even the most advanced systems can fail to deliver during emergencies. Therefore, assessing supply chains in the context of sustainable energy is essential and warrants detailed investigation, as outlined below.

2. Overview of Supply Chains and Key Products in the Defence Sector

The foundation of complex global supply chains was laid in the 1970s, when industries such as apparel began outsourcing certain production stages to Asia. Over the decades, global supply chains have evolved into the dominant industrial model across a wide range of sectors, particularly within high-tech industries reliant on specialised skills and expertise.[10] As a result, supply chains have become the principal industrial framework in the defence sector, driven by the technological sophistication of contemporary military platforms.[11]

Global defence corporations, commonly referred to as ‘primes’ in Australia, are central to the defence procurement process. They manage and coordinate a diverse array of defence supply chains on behalf of governments under procurement contracts. Furthermore, small and medium-sized enterprises in Australia have developed significant capabilities and established their own supply chains within the defence industry.[12]

While the term 'supply chain' typically conjures an image of a straightforward flow of goods across borders—starting with raw materials, progressing through stages of production, and culminating in finished products delivered to consumers—it oversimplifies the intricate dynamics at play. Global supply chains are far more complex, involving three key and interdependent flows:[13]

1. **Material flows**—the movement of commodities as they progress through various stages of production across multiple countries.
2. **Capital flows**—the commercial relationships between firms within the supply chain, including investments and contractual agreements that govern their interactions.
3. **Knowledge flows**—the transfer of intellectual property and expertise between firms, either shared directly or embedded within goods and services.

These interconnected flows forge relationships of interdependence among supply chain participants. Nations and firms do not merely exchange goods; they build long-term, institutionalised commercial relationships that integrate the various components of the system. While a final product may be labelled 'made in' a particular country or 'made by' a particular company, its production relies on a globally coordinated network, with numerous countries and firms playing crucial roles. Understanding the structure of these networks is vital for assessing and enhancing the security of supply for modern products. Moreover, supply chains should not be conceived as linear sequences of relationships. Instead, they are better characterised as complex webs, with multiple participants at each production stage and overlapping connections between them.[14]

3. Supply Chain Configuration Models

Supply chains can take various structural forms, each with distinct implications for resilience and vulnerability. Below are some examples of chain configuration models; the 'critical' nodes are highlighted in red.[15]

Branching supply chains (Figure 1) are considered highly robust, as downstream users source inputs from multiple suppliers, each with their own networks. This competitive structure minimises reliance on any single participant, thereby reducing the risk of disruption at critical points.

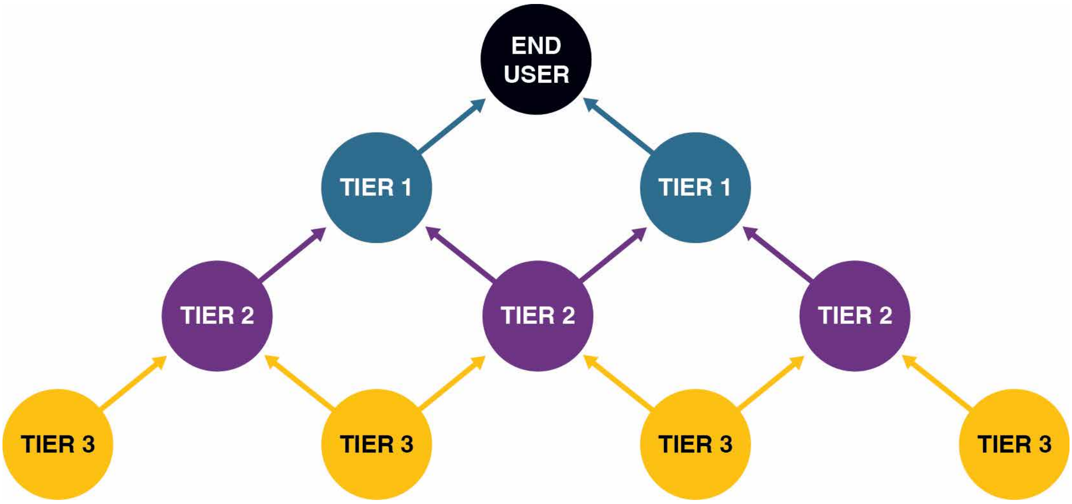


Figure 1. Branching supply chains

In contrast, diamond supply chains (Figure 2) feature diversified suppliers at the downstream level, but these suppliers ultimately rely on a single upstream source. While appearing resilient at first glance, this model creates a strategic vulnerability at the upstream node, where any failure can impact the entire chain.

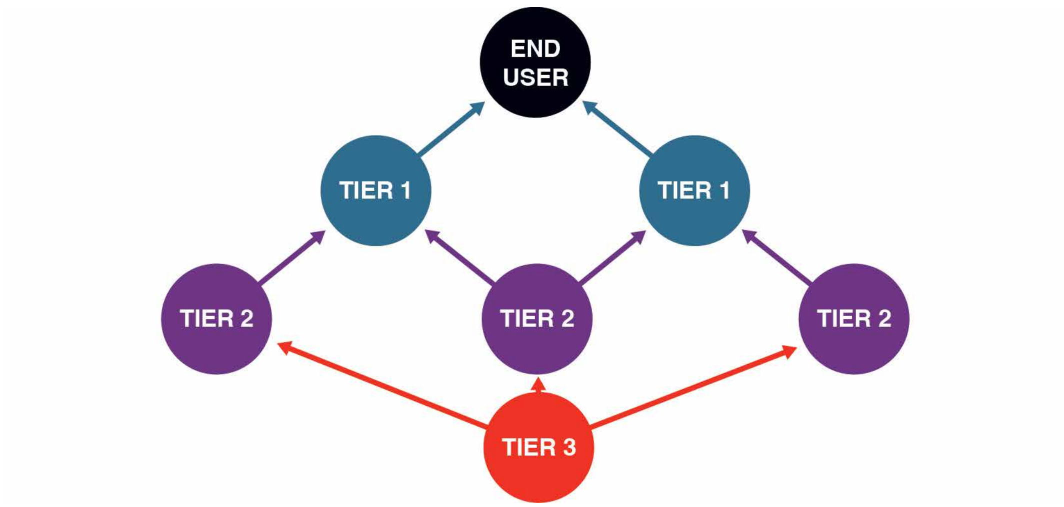


Figure 2. Diamond supply chains

Hourglass supply chains (Figure 3) involve numerous upstream suppliers and downstream users, but they converge around a single critical midstream entity. This centralisation makes the entire system dependent on the uninterrupted function of that midstream player.

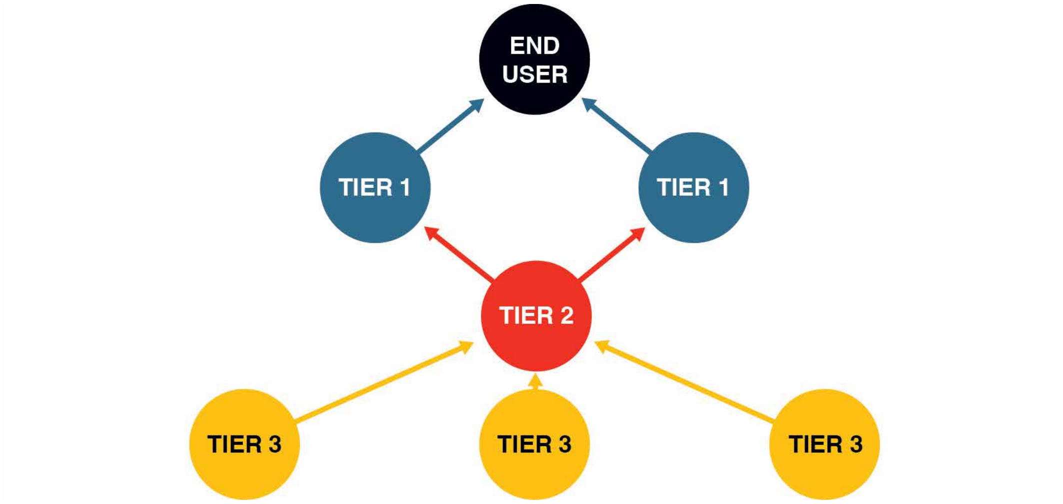


Figure 3. Hourglass supply chains

Finally, linear supply chains (Figure 4) represent a more fragile structure in which each downstream user manages its own sequential chain of midstream and upstream suppliers, with each link acting as a critical node. This model is rare. It is typically associated with highly specialised products where tight control is essential, but it offers the least resilience to disruption.

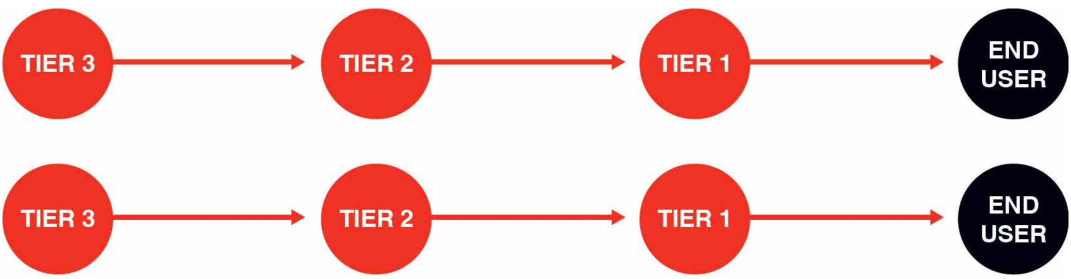


Figure 4. Linear supply chains

Criticality serves as the pivotal factor that governs the resilience of global supply chains. Supply chains containing critical nodes—such as those with a diamond or hourglass structure—are less adaptable to external disruptions. In contrast, supply chains that lack critical nodes, such as branching models, are inherently more flexible and capable of adjusting to shocks. Importantly, the existence of critical nodes is often hidden from those further along the chain. In hourglass or diamond-shaped supply chains, downstream users with multiple tier-1 suppliers may remain unaware of the critical nodes that exist further upstream. A clear example of this 'hidden' criticality can be seen in the global battery production supply chain, which exhibits an hourglass shape, with China controlling the production of vital midstream components (see Table 1). Despite having diverse suppliers at both the upstream (mining) and downstream (battery assembly) stages, both ends are heavily reliant on China for materials processing and refining. For instance, lithium mined in Australia and used in batteries assembled in Japan must undergo processing in China. This concentration gives China far greater leverage over the global battery market than its relatively small share of final product sales (around 20 per cent) would suggest. Understanding the entire global supply chain is crucial, as it reveals critical nodes that would otherwise remain obscured when viewed from either the upstream or downstream perspective alone.[16]

Defence supply chains present unique and more complex challenges when it comes to managing criticality. Compared to civilian supply chains, those in the defence sector typically feature a higher number of critical nodes due to several key factors:[17]

1. **High economic importance:** Defence products are often essential for national security and operational effectiveness, with strict requirements that leave limited room for substitution with similar alternatives.
2. **Increased concentration:** Defence supply chains tend to be more concentrated due to stringent design specifications and security compliance needs, which limits the number of firms capable of participating.
3. **Reliance on imports:** Smaller nations often find it economically unfeasible to produce all the necessary defence capabilities locally, making them more reliant on imported goods and services.
4. **Intellectual property:** Defence products frequently contain high levels of intellectual property, necessitating long-term relationships between manufacturers and customers for ongoing support and services post delivery.
5. **Geopolitical risks:** The strategic nature of the defence sector exposes these supply chains to heightened risks of geopolitical interruptions, which can disrupt the flow of critical components.
6. **Longer supply chains:** Modern defence platforms often require advanced technology, which results in supply chains that can extend over 10 or more tiers.

These factors make defence supply chains more intricate and prone to risk than those in most other sectors. Given the complexity, the multitude of potential risk points and the higher expectations for continuity, defence supply chains require much more focused attention on risk management. The approaches used in civilian sectors are insufficient, as the defence sector's specific risks must be understood and mitigated through tailored strategies that go beyond standard commercial practices.

Table 1. Approximate distribution of country shares in the battery value chain across different production stages in 2017

Countries	Up stream	Mid stream		Down stream	
	Raw materials	Refining	Active materials	Cell manufacturing	Battery pack assembly
Australia	50%	0%	0%	0%	0%
Chile	29%	11%	0%	0%	0%
China	6%	89%	64%	50%	20%
Japan	0%	0%	11%	20%	50%
Korea	0%	0%	10%	20%	20%
USA	1%	0%	0%	8%	9%
Others	14%	0%	17%	2%	1%

4. Assessing and Managing Supply Chain Risks in the Defence Sector

Mapping a supply chain's framework is an essential initial step in pinpointing potential risks, particularly when identifying crucial nodes that could lead to disruptions. The next phase involves assessing the probability of these risks resulting in actual interruptions. Various factors can trigger such disruptions, which can be divided into two broad categories: traditional and strategic supply chain risks. Traditional supply chain risks have long been present and affect industries universally, as follows:[18]

- **Economic disruptions:** Sudden changes in market demand or rapid technological developments can lead to short-term shortages of essential components. A well-known example is the global semiconductor shortage,[19] which caused production stoppages in the automotive sector and contributed to a worldwide scarcity of vehicles.

- **Infrastructure and transport disruptions:** Delays in logistics networks, including customs procedures and transportation routes, can severely impact the movement of goods. Notable cases include the six-day blockage of the Suez Canal in 2021,[20] ongoing congestion at major US ports, and COVID-19 related delays at key Chinese shipping hubs.[21]
- **Environmental and health-related hazards:** Natural events such as wildfires, floods, droughts and pandemics can significantly disrupt routine business operations. The COVID-19 pandemic,[22] along with natural disasters in Taiwan and Japan—both major centres of semiconductor production—further intensified the global chip shortage.
- **Social and political instability:** Mass protests, civil unrest, and industrial action can disrupt supply chains, particularly in resource-based sectors. For example, civil unrest in Kazakhstan affected oil and uranium exports,[23] while strikes at Fremantle Ports in Western Australia threatened construction sector supply flows.

These types of risks are recurring and embedded within the fabric of the global economy. Businesses across all sectors typically address them through well-established measures such as inventory management, multi-sourcing, and supplier diversification. While these disruptions can be severe, they are not exclusive to the defence sector and are largely characterised as unpredictable events that companies must be ready to manage as they occur.

In contrast, strategic supply chain risks have become increasingly prominent in recent years, particularly within the defence industry. These risks stem from evolving geopolitical dynamics, which include the following:[24]

- **Geopolitical intervention risks:** These occur when governments intentionally disrupt supply chains for political or strategic purposes. Measures such as trade sanctions, export controls and embargoes fall into this category. For instance, China's trade restrictions imposed amid diplomatic tensions with Australia, and the United States' national security related bans on Chinese technology firms, exemplify such interventions.
- **Geopolitical demand shocks:** Supply chain demands can change rapidly in response to geopolitical developments. This may involve the exclusion of certain suppliers due to international conflict or a sudden increase in demand for military equipment during periods of heightened geopolitical tension.
- **Security threats to intangible assets:** These risks involve cyber attacks, theft of intellectual property, and breaches of classified or sensitive data. Rather than targeting physical goods, these threats compromise the exchange of knowledge, designs and proprietary information across the supply chain.

Strategic risks differ fundamentally from traditional operational risks in that they are deliberate, politically motivated, and often intended to compromise the stability and integrity of supply chains. Although such risks can affect any sector, they are particularly critical in defence-related industries, which are frequent targets of geopolitical interference. The increasing digitalisation of global supply networks and heightened international tensions have contributed to the growing prevalence of these threats.

To address these challenges, organisations operating within global industries typically adopt supply chain management approaches that fall along a continuum between efficiency and resilience:[25]

- **Efficiency-focused models** aim to reduce costs and optimise speed to maintain a competitive advantage. Common strategies include offshoring and just-in-time production, which minimise inventory and streamline operations.
- **Resilience-oriented models** prioritise adaptability and risk mitigation, often accepting higher costs to safeguard against disruptions. An example is the just-in-case approach, which involves maintaining surplus inventory to cushion against unexpected interruptions.

These models are not mutually exclusive; rather, businesses select their position on this spectrum based on the nature, frequency and potential impact of risks in their operating environment. In relatively stable industries, where disruptions are infrequent or low impact, efficiency strategies tend to dominate. In contrast, sectors exposed to significant uncertainty or strategic threats increasingly favour resilience-based approaches.

To enhance resilience, firms may adopt a range of risk mitigation measures, each with distinct trade-offs in terms of cost, complexity and effectiveness:[26]

- **Strategic stockpiling** involves holding buffer inventories to bridge temporary supply gaps. This approach is suitable for products with stable demand and longer shelf life, but less effective for perishable or rapidly obsolete items.
- **Supplier diversification** reduces reliance on single sources by engaging multiple suppliers, ideally across different geographic regions. This lessens exposure to disruptions linked to national-level political or logistical issues.
- **Friend-shoring** refers to sourcing critical inputs from trusted nations or corporate partners with shared strategic interests. While not always feasible for replacing key supply chain nodes, it can significantly enhance security and reliability where substitution is difficult.
- **Onshoring or in-house production** involves relocating or internalising the manufacture of essential components to improve control and reduce external dependencies. Although often resource intensive, this strategy offers the highest level of oversight and security for critical supply chain elements.

While these strategies can improve resilience, they come at a considerable cost. Businesses typically implement them when the risks justify the expenses. Even in the defence sector, where resilience is crucial, these strategies are applied selectively to the most vulnerable areas. Therefore, effective supply chain risk management requires a tailored approach, where managers assess the criticality of risk points and implement proportionate mitigation measures to maintain business continuity while avoiding unnecessary costs.

5. Key Strategies for Defence Supply Chain Security

The current global geopolitical situation has led to a heightened risk of strategic disruptions to supply chains, a concern that was not as pronounced in the past. Although it is unclear when traditional supply chain disruptions will return to normal levels, there are strong indications that the increased level of strategic risks is likely to be a permanent feature of the defence sector for the foreseeable future. The 2020 Defence Strategic Update[27] highlighted the critical need for Australia's defence sector to modernise its supply chain security strategies. However, no single approach can be universally applied to defence supply chain security, as these supply chains vary widely. They differ in structure, reliance on key components, and exposure to both conventional and emerging risks. There are various methods available to manage these challenges, ranging from cost-effective, scalable solutions such as diversification and stockpiling, to more resource-intensive strategies like developing trusted or sovereign capabilities. Given the limited resources available to strengthen supply chain security, the focus should be on effective risk management. This involves not only identifying and evaluating risks but also taking targeted, proportionate actions where necessary. Securing supply chains is a collective responsibility that involves all parts of the defence sector. While the federal government, particularly the Department of Defence, plays a vital role in purchasing, managing and using defence materials, the defence industry also plays a crucial part due to its deep expertise in managing supply chains. This responsibility extends beyond just the primary contractors to include other important players throughout the upper tiers of the supply chain. Security initiatives must involve the entire defence industry ecosystem, working collaboratively to create more resilient and reliable global supply chains. To guide these efforts, a set of core 'framework principles' are proposed to assist in shaping defence supply chain security initiatives between the government and defence industry. As shown in Figure 5, four key principles—concerning information sharing, risk assignment, appropriate interventions, and government–industry collaboration—are fundamental to effective supply chain security practices. While the application of these principles will vary across different defence supply chains, they provide a strong framework for future policy development.[28]

Informational resources	• Map supply chain geometry to identify critical nodes • Assess current and future flexibility requirements • Include supply chain at start of project life cycle
Assigning risk	• Identify nodes facing above-normal traditional risks • Assess likelihood and impact of strategic risks • Forecast risk assessments over project life
Calibrating interventions	• Analyse and assess interventions: stockpiling or diversification strategies • Build trusted capability networks • Develop sovereign capability
Government – industry collaboration	• Agree definitions and shared understanding of supply chain concepts • Establish governance and mechanisms for information sharing • Incorporate supply chain security into contracting

Figure 5. Principles for ensuring the security of defence supply chains[29]

The first principle focuses on enhancing information resources. At present, information about defence supply chains is fragmented and inconsistent, lacking the detail necessary to fully identify vulnerabilities. Mapping the supply chain is the first step in identifying critical nodes. Given the complexity of defence supply chains, this process must go beyond traditional methods and utilise more efficient automated tools, which can provide a clearer, more detailed picture than earlier manual approaches. It is also important to assess both current operational needs and future flexibility. Defence supply chains must meet present requirements while being adaptable to future demands. The mapping process should therefore account for both current and potential future needs. Supply chain considerations should be incorporated early in the project life cycle, as decisions made during the early acquisition stages often determine which suppliers are chosen, influencing the entire supply chain structure.[30]

The second principle focuses on assigning risk to the critical nodes identified during mapping. While mapping helps identify where critical nodes are located, it does not assess the risks associated with these points. Further risk assessments are necessary to determine the likelihood of disruptions and understand the potential impacts on supply chain resilience. These assessments will require human judgement and cannot be fully automated. Risk assessments should aim to:[31]

- identify nodes facing higher-than-average traditional risks, such as components with specific technical requirements that are difficult to substitute or those that compete with civilian markets
- assess the possibility and implications of strategic risks. Although strategic risks have not yet affected defence supply chains directly, changes in the global political landscape make it likely that such risks may arise in the future. These assessments should factor in the potential for political or geopolitical events to disrupt supply chains
- forecast risks over the entire project life cycle. Given the long-term nature of many defence capabilities, risk assessments should not be static but should predict emerging risks throughout the life of a project, not just in the present.

The third principle involves matching supply chain interventions to the level of risk identified. Various resilience-building interventions are available, but their costs vary, so it is essential to tailor the response to the level of risk. For moderate risks, low-cost measures such as stockpiling or diversification should be prioritised, while more significant risks may require higher-cost interventions like building trusted capability networks or establishing sovereign capabilities. Key interventions include:[32]

- stockpiling and diversification, which are often the most cost-effective methods; these should be used to mitigate short-term risks or reduce dependence on a narrow set of suppliers
- building trusted capability networks, which can provide a balanced approach for securing critical components without the need for complete self-reliance. Working with trusted partners helps spread resources across multiple risks
- developing sovereign capabilities, which offer the highest level of security but come with higher initial costs and a longer time frame for implementation. Sovereign capabilities should only be pursued after thoroughly evaluating the associated risks, particularly those related to strategic factors.

The fourth principle stresses the importance of strong collaboration between the government and the defence industry. Supply chain resilience is a shared responsibility, with both parties playing essential roles. The government sets policy and handles procurement, but the defence industry is key in identifying risks and executing resilience strategies. Effective collaboration is necessary for success, and this involves:[33]

- ensuring both the government and defence industry have aligned definitions of critical nodes and agree on the levels of information needed for meaningful collaboration
- developing robust governance and information-sharing frameworks, particularly for the management of commercial and security-sensitive data, to support cooperation across both sectors. Initiatives like the Office of Supply Chain Resilience provide a foundation for this kind of collaboration
- addressing supply chain security early in the procurement process. Many defence procurement decisions made early on in a project will have significant consequences for supply chain security. Supply chain security must be integrated into the procurement process from the beginning, with clear contracts outlining the roles and responsibilities of both the government and the defence industry contractor.

In conclusion, strengthening defence supply chain security requires a coordinated, collective effort between the government and industry. By focusing on risk management, implementing tailored interventions and fostering strong collaboration, the defence sector can build supply chains that are resilient enough to handle both existing and emerging risks.

6. Defining Features of Supply Chains in the Energy Sector

Figure 6 highlights the integrated nature of energy and technology supply chains, each comprising distinct yet interconnected processes essential for delivering modern energy services and technologies to end users. The energy supply chain involves a sequence of operations—from energy generation and conversion to transportation and distribution—often incorporating cross-border trade. Meanwhile, the technology supply chain encompasses the full life cycle of technological products, beginning with the extraction of mineral resources, followed by material refinement and component fabrication, and culminating in the deployment, maintenance and eventual recycling or repurposing of equipment. These systems are mutually dependent: technological infrastructure is critical for producing and distributing energy, while energy is a fundamental input across all stages of technology development and deployment.[34]

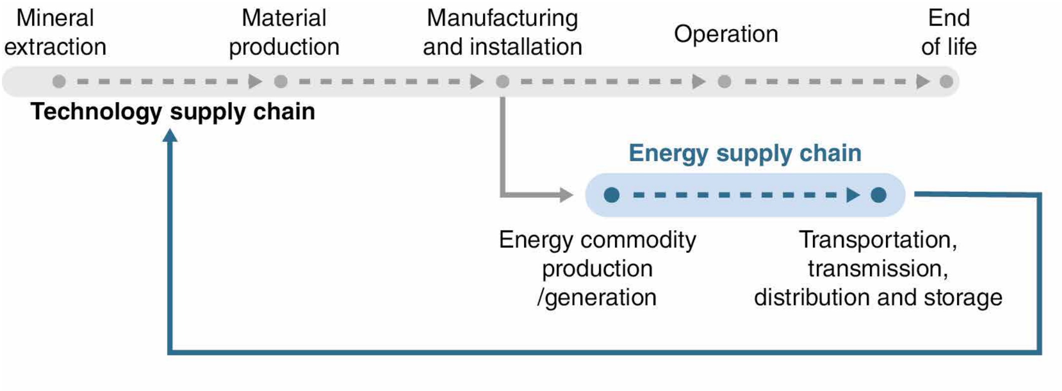


Figure 6. Stages of and connections between technology and energy supply chains[35]

It is essential to understand that each category of equipment within the energy and technology sectors is supported by a distinct and complex supply chain, extending from the extraction of raw materials to the delivery of the final product. This is clearly depicted in Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11, which outline the specific supply chains associated with various technologies, including low-emission electricity generation, low-emission hydrogen production, battery electric vehicles, heat pumps, and fuel cell trucks. Each of these technologies follows its own developmental pathway, involving tailored processes such as the extraction and refinement of critical minerals, the manufacture and assembly of specialised components, and the deployment and operational integration of the final equipment. Furthermore, these supply chains do not operate in isolation. They are often interlinked, with shared materials, technologies and services flowing across different sectors. This interconnection highlights the inherent complexity and mutual dependence that characterise today's energy and technology systems.[36]

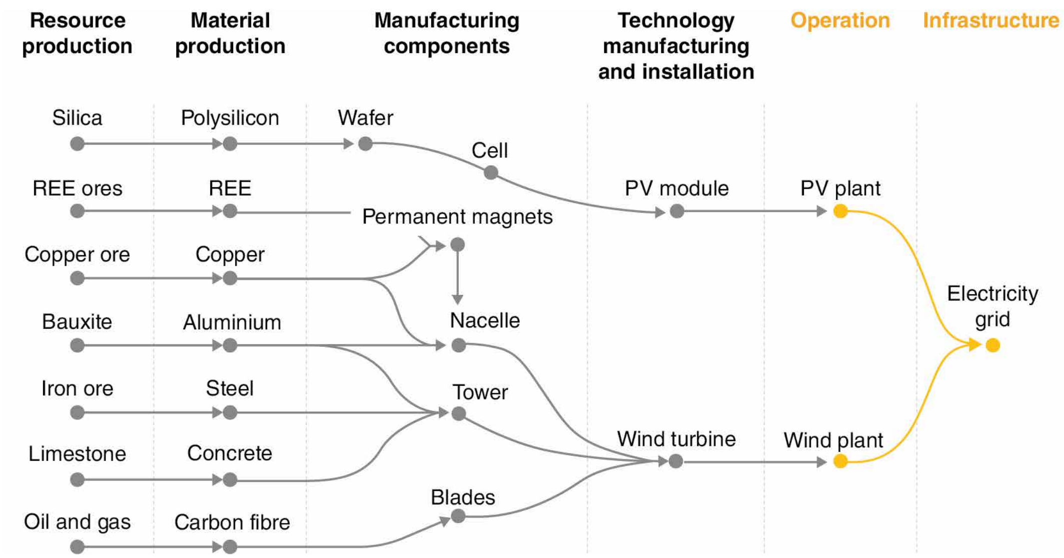


Figure 7. Key components of the supply chain for low-emission electricity[37]

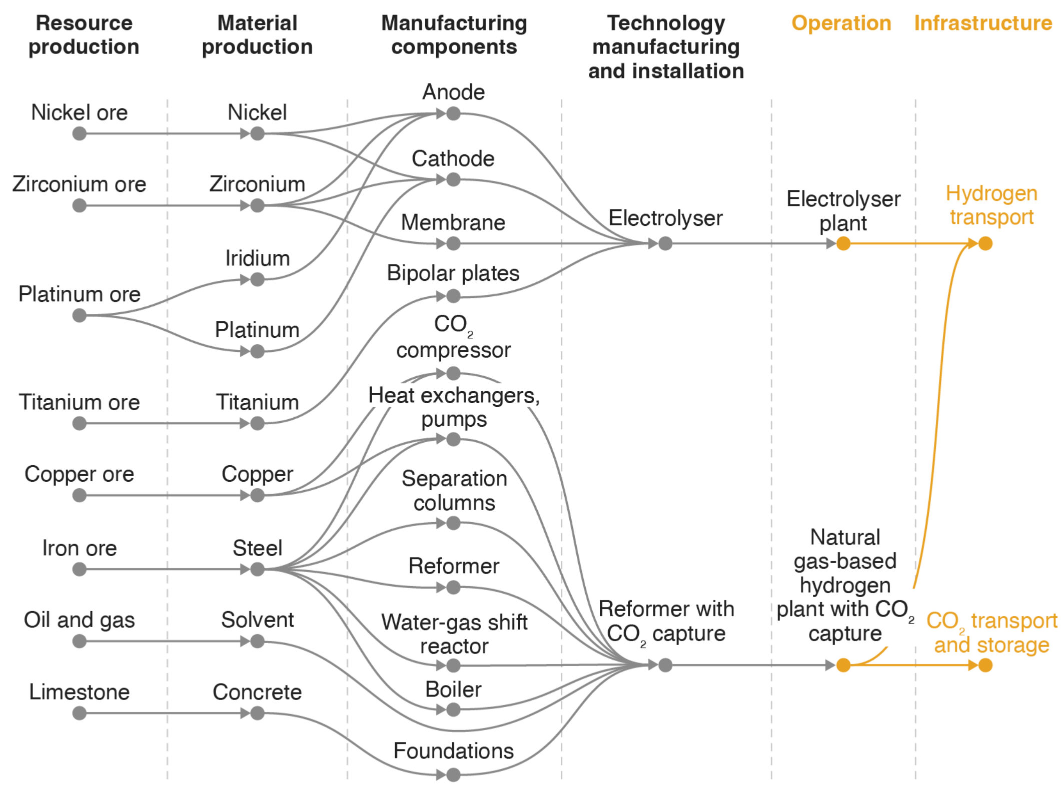


Figure 8. Key components of the supply chain for low-emission hydrogen[38]

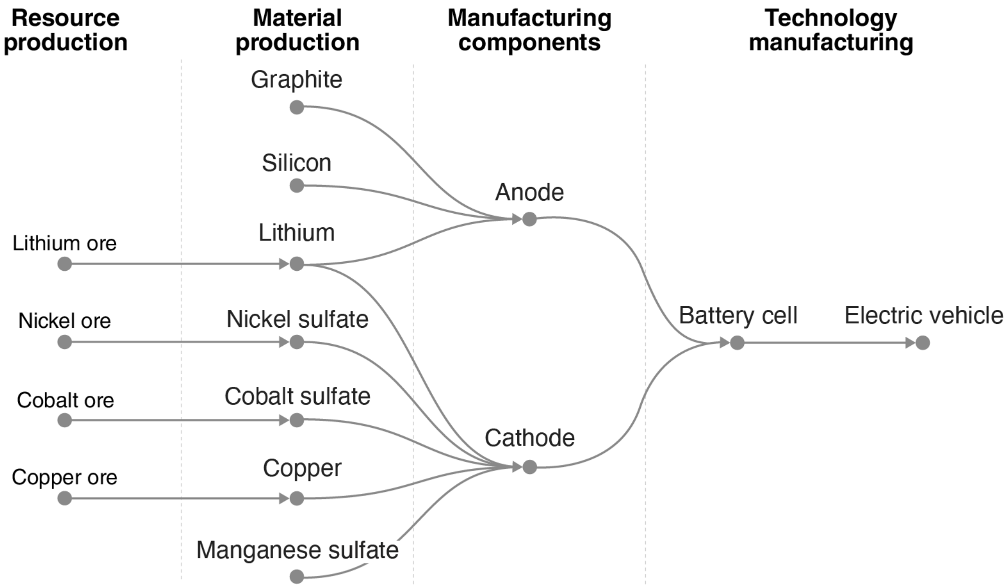


Figure 9. Key components of the supply chain for battery electric vehicles[39]

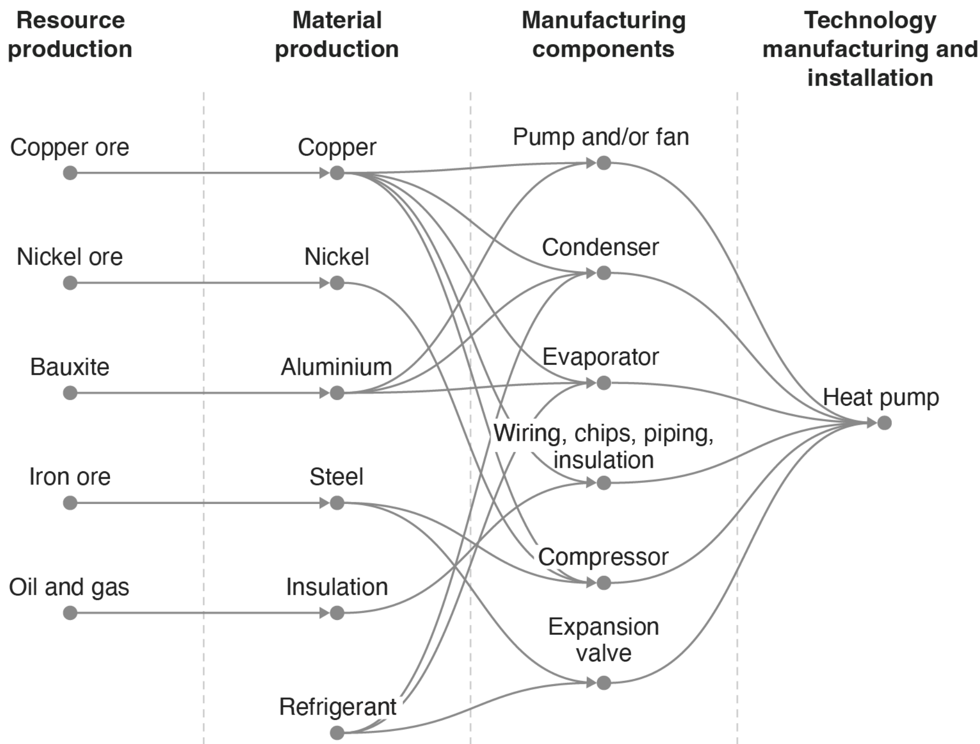


Figure 10. Key components of the supply chain for heat pumps[40]

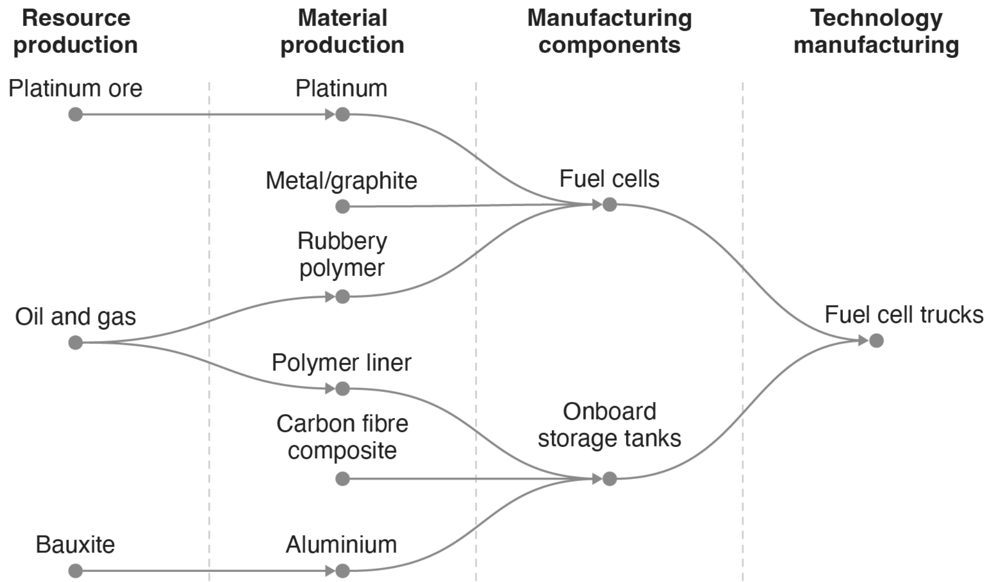


Figure 11. Key components of the supply chain for fuel cell trucks[41]

7. Geographic Distribution of Mineral Resources, Technology Manufacturing Capacity, and Fuel Supply Chains

Here we examine the supply chains of various components in the energy sector, including minerals, manufacturing and fuel.[42]

7.1. Mining and Material Production

Figure 12 provides an overview of regional mining capacities and material reserves. It highlights the distribution of mining activities across various regions, showing which areas have the largest reserves and the capacity to extract critical materials. The data reveal key global players in resource availability, with some regions holding more significant reserves and mining capabilities than others. Of these, the Asia-Pacific region and Central and South America have the largest shares of mining capacities and reserves.

Figure 13 presents an overview of regional production capacities for critical raw materials, illustrating the ability of various regions to supply essential inputs such as copper, lithium and other key resources required across multiple industries. The data clearly highlight China's dominant position as the leading global producer of many of these critical materials, underscoring its strategic influence within global supply chains.

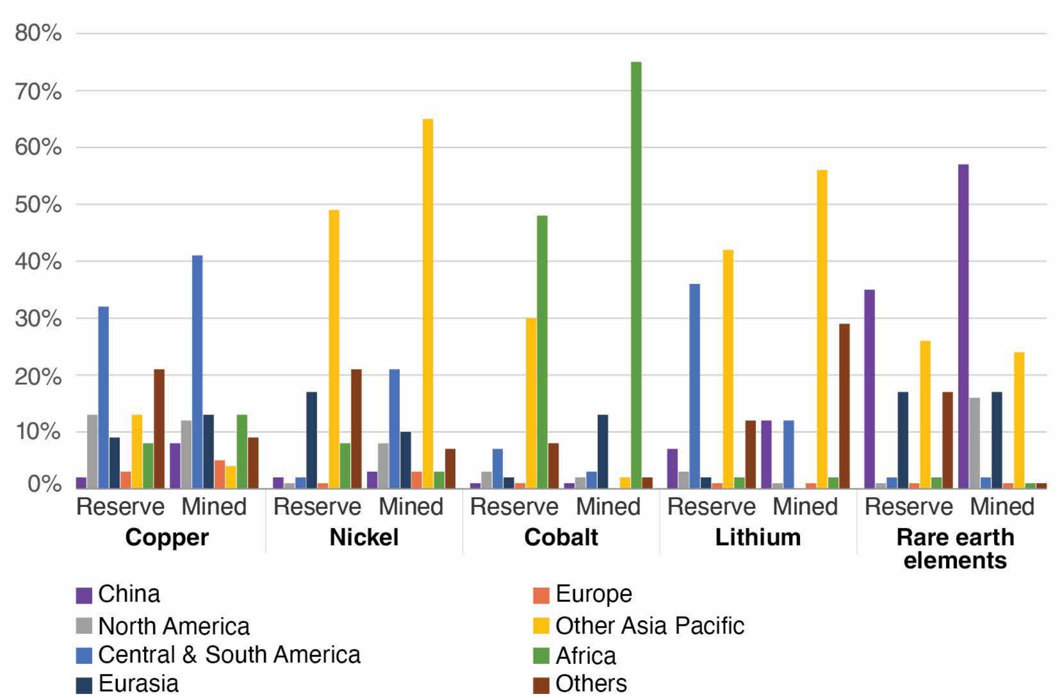


Figure 12. Regional capacities for mining and reserves in 2021[43]

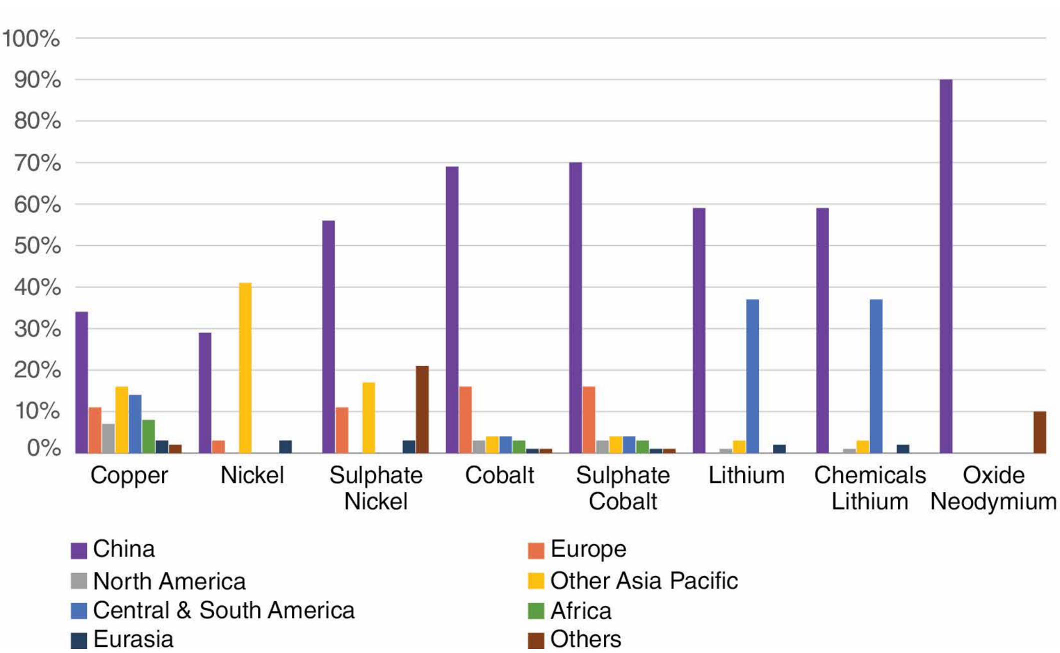


Figure 13. Regional capacities for producing critical materials in 2021[44]

Figure 14 illustrates the distribution of electrolyser production capacity across different regions. China emerges as the dominant global manufacturer, reflecting its strong industrial base and leadership in clean energy technologies. Europe ranks second, driven by substantial investment in green hydrogen and renewable energy infrastructure. North America and the broader Asia-Pacific region also contribute to global electrolyser production, though at a more limited scale. The data underscore China's pivotal position in the electrolyser market, while highlighting ongoing efforts in Europe and North America to expand domestic manufacturing in response to the growing demand for green hydrogen technologies.

Figure 15 presents a summary of wind turbine component production capacities by country. China clearly leads the global market, holding a commanding share of manufacturing output. Europe and North America maintain substantial production capabilities, but on a comparatively small scale. This highlights China's prominent role and competitive advantage in the manufacture of wind turbine technology.

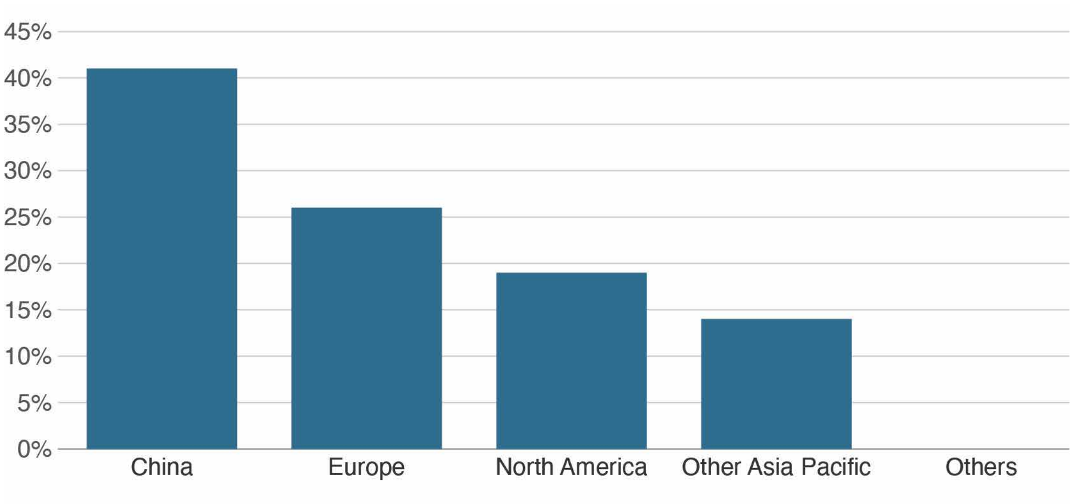


Figure 14. Regional electrolyser manufacturing capacity in 2022[45]

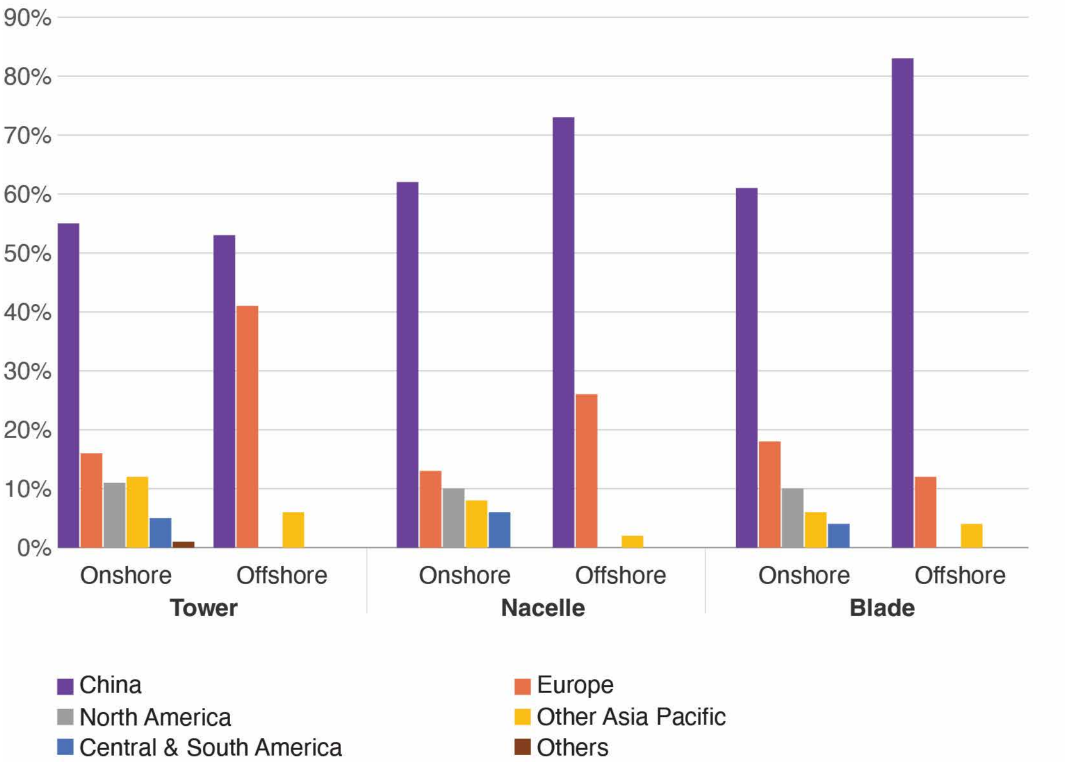


Figure 15. Regional capacities for manufacturing wind turbine technology components in 2021[46]

Figure 16 illustrates the production capacities for photovoltaic (PV) components across various countries. China emerges as the clear leader in PV component manufacturing, with other nations exhibiting minimal or negligible production capabilities in comparison.

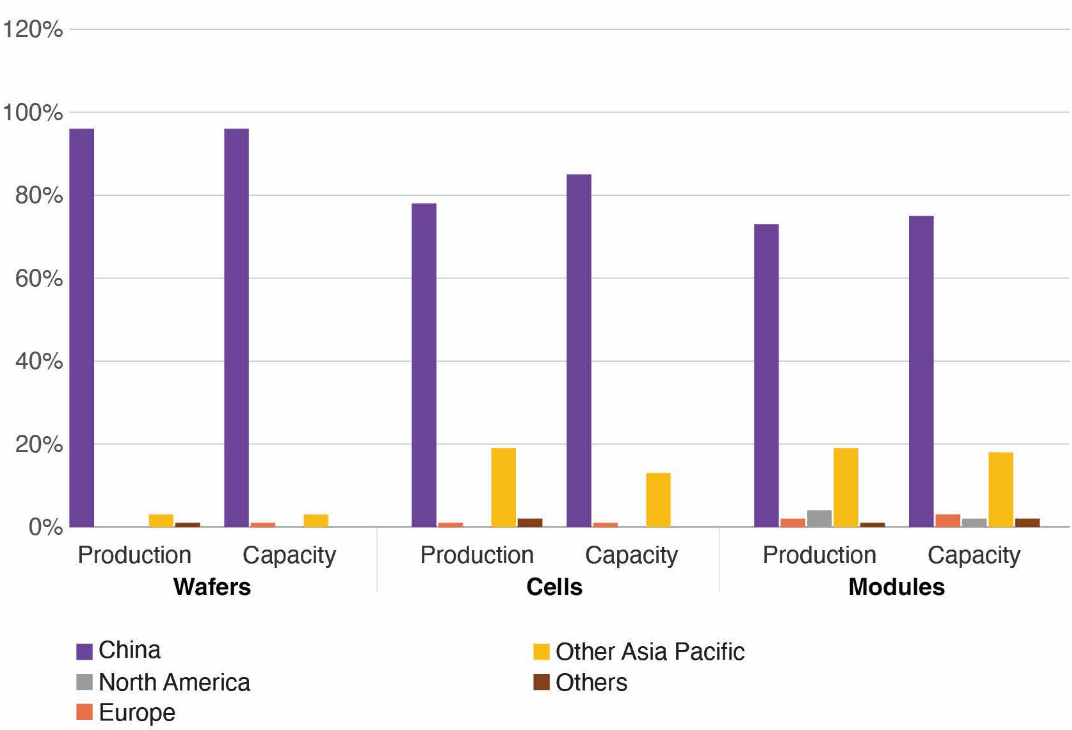


Figure 16. Regional capacities and production levels for solar PV components in 2021[47]

Figure 17 highlights a critical obstacle facing the Department of Defence in securing reliable battery supplies: the overwhelming dominance of China within the global battery supply network. China controls the production of essential materials and components such as anodes and cathodes, as well as precursor substances. Even supply chains based domestically often depend on Chinese-sourced inputs, exposing them to significant vulnerabilities. With the anticipated surge in electrification by 2030, dependence on Chinese battery production is expected to intensify, with China's leading position projected to persist.[48]

The manufacturing of heat pumps is heavily influenced by regional production capacity and capabilities. Figure 18 illustrates that China holds the largest share of production capacity for heat pump components, with North America and Europe ranking second and third, respectively.

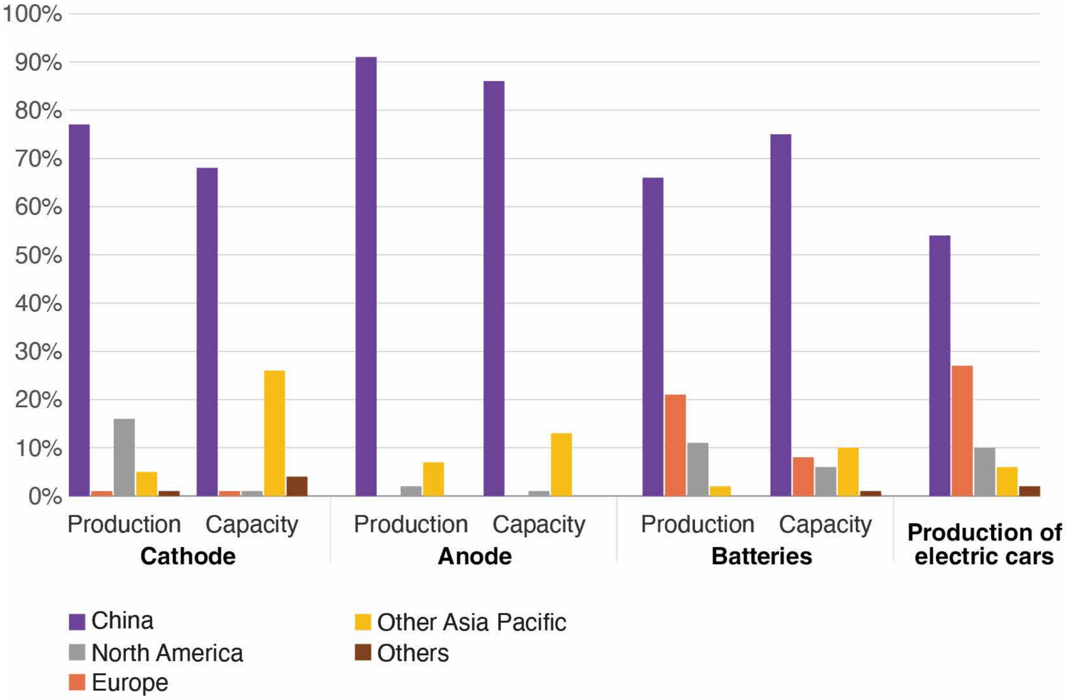


Figure 17. Regional capacities and production levels for electric vehicle and battery storage components in 2021[49]

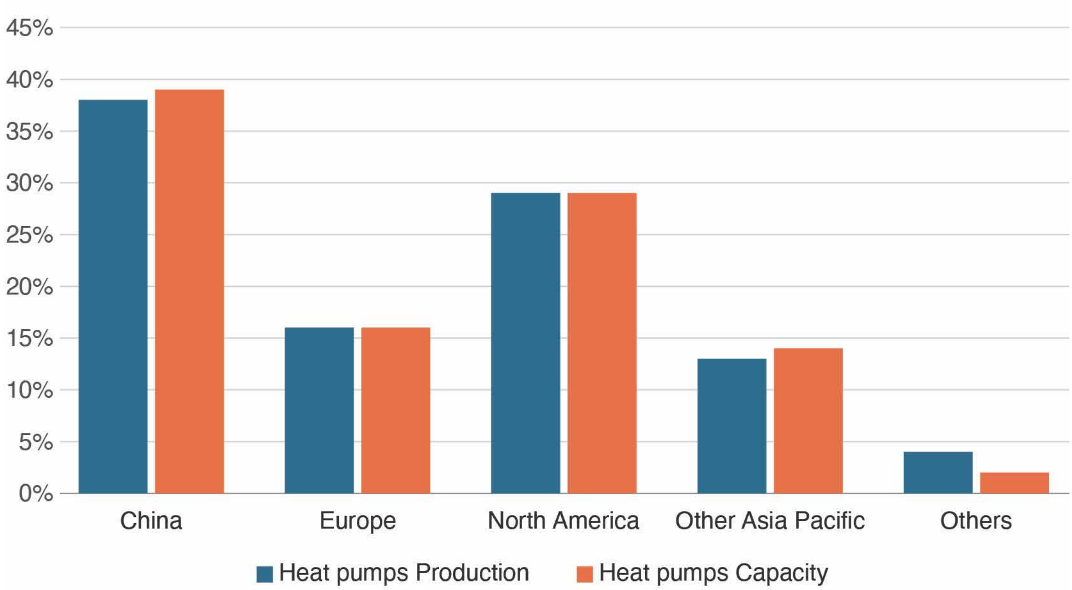


Figure 18. Regional capacities and production levels for heat pump components in 2021[50]

Regional production capacity and capabilities play a vital role in the manufacture of components for fuel cell heavy-duty trucks. As depicted in Figure 19, China leads in production capacity, supported by its advanced infrastructure and technological expertise.

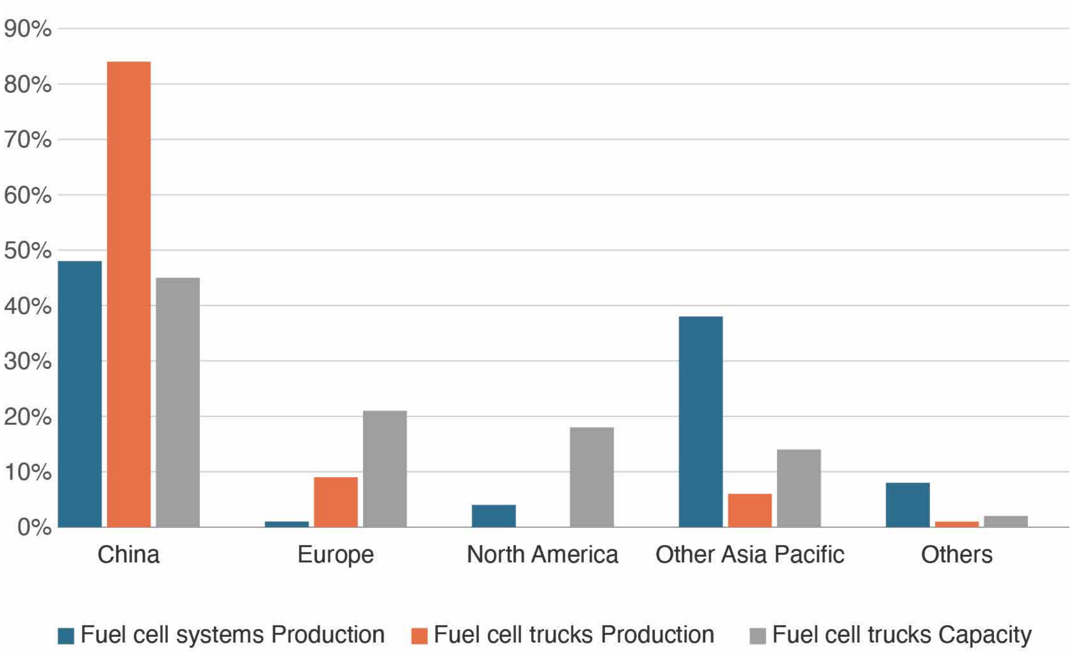


Figure 19. Regional capacities and production levels for manufacturing fuel cell truck components in 2021[51]

7.2. Production Lead Times for Mass-Manufacturing Facilities

The transition to mass production of equipment within the energy sector demands considerable lead times, reflecting the complexity of the technologies involved, the challenges of scaling manufacturing processes, and the integration of sophisticated systems. Table 2 details the lead times associated with producing various critical pieces of equipment, covering a broad spectrum of technologies including renewable energy assets such as solar panels and wind turbines, hydrogen electrolysers, and other emerging innovations. By outlining these production timelines, the table offers valuable insight into the scale-up challenges faced in meeting the growing demand for sustainable energy solutions.[52]

Table 2. Production lead times for mass-manufacturing facilities[53]

Technology		Year
Solar photovoltaic	Polysilicon	1–3.5
	Wafers	0.5–2
	Solar cells	0.5–2
	Solar modules	0.5–2
Wind turbines	Blade	1–2
	Tower	1.5–2.5
	Nacelle	1.5–2
Electrolysers		2–3
Electric vehicles	Anode	2–5
	Cathode	2–5
	Battery	0.5–4.5
Heat pumps		1–3
Fuel cell trucks	Fuel cell stacks	1.5–2.5
	Fuel cell trucks	0.5–1.5

7.3. Australian Defence Fuel Supply Chain Activities

The ongoing global energy transition, coupled with the evolving and increasingly diverse energy needs of the Australian Defence Force (ADF), is set to significantly reshape the structure and operations of the defence fuel supply chain. Traditionally focused on the procurement, storage, handling and distribution of conventional fossil fuels powering ADF vehicles, aircraft, naval vessels and installations, this supply chain must now expand its scope and complexity to incorporate lower-carbon alternatives such as biofuels, synthetic fuels and other renewable energy sources. This multifaceted system involves a wide array of activities, technologies, infrastructure and organisations, all working to ensure that fuel is delivered safely, efficiently and reliably to support mission-critical operations. Effective coordination across procurement channels, storage facilities, transportation networks and real-time fuel management is essential, with oversight and strategic direction provided by the Commander of Joint Logistics, who is responsible for maintaining the supply chain's safety, efficiency, integration and cost-effectiveness.[54] As the ADF advances toward sustainable energy adoption, the supply chain must adapt to accommodate new fuel types and energy carriers, each with unique handling, storage and distribution requirements. The supply chain framework illustrated in Figure 20 provides a critical blueprint for managing this transition, emphasising pathways and checkpoints that are vital for maintaining operational readiness. Furthermore, integrating emerging energy sources presents challenges related to supply security, logistical complexity and infrastructure adaptation. Successfully addressing these issues will be crucial not only for achieving Australia's defence sustainability goals but also for preserving the resilience and effectiveness of the ADF's energy supply under all conditions.

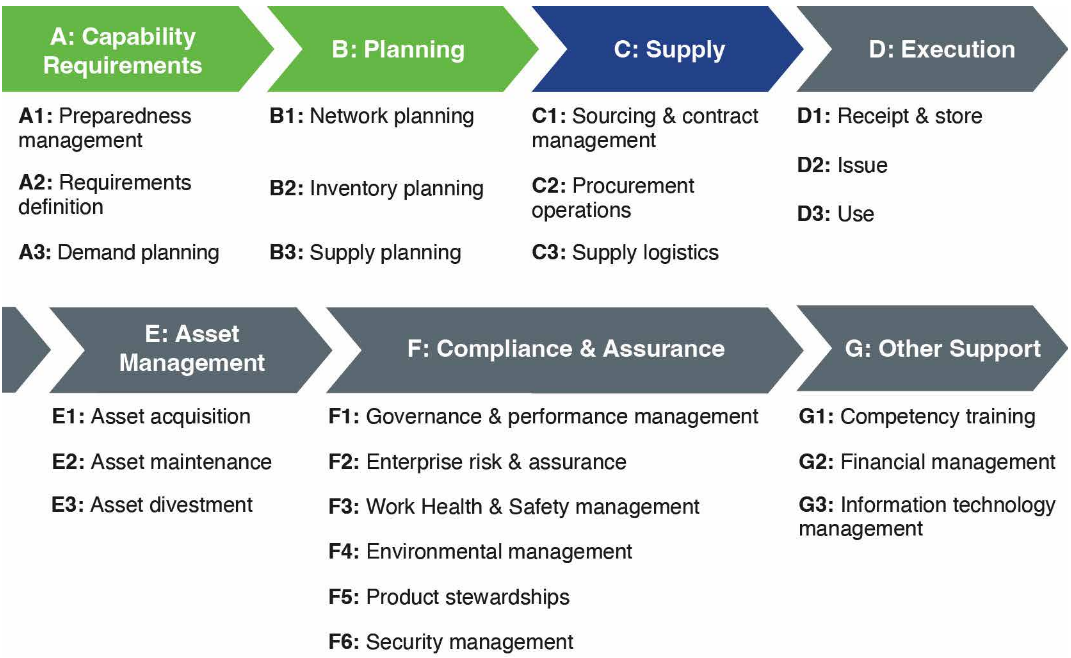


Figure 20. Fuel supply chain in Australian defence[55]

8. The Future of Hydrogen Generation and Distribution

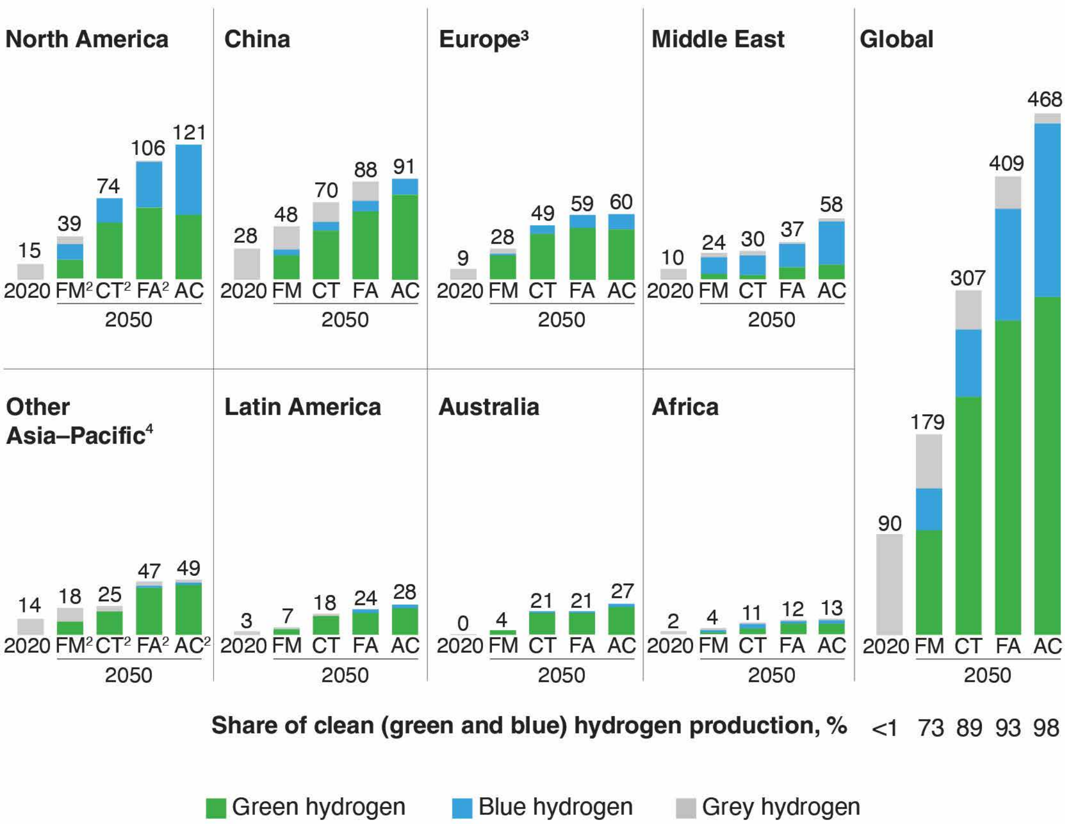
This part explores the application of hydrogen prospects worldwide.

8.1. Geographical Distribution of Clean Hydrogen Production

Hydrogen generation in different regions by 2050 has been forecasted in Figure 21. As shown, green hydrogen is anticipated to lead the global hydrogen supply, making up 50 to 65 per cent of the total, due to decreasing costs of renewable energy and electrolysers. This production will be centred in regions rich in renewable resources, like Australia and Iberia. However, production might be limited by the availability of renewable energy, requiring substantial investments in electrolysers and large-scale manufacturing capabilities. Blue hydrogen is expected to account for 20 to 35 per cent of the supply, mainly in areas with affordable natural gas and carbon capture infrastructure, such as the Middle East and North America. Producing blue hydrogen will necessitate about 500 billion cubic metres of natural gas and the capacity to capture and store 750 to 1,000 megatonnes of CO_2. The regional distribution of blue and green hydrogen production will vary based on local cost factors, with green hydrogen flourishing in renewable-rich areas and blue hydrogen in regions abundant in natural gas. Expanding hydrogen production successfully will depend on overcoming challenges related to renewable energy availability, technological progress and infrastructure development.[56]

Hydrogen production by region, 2050,

Mt per year of hydrogen equivalent



Note: Upside for power not considered.
[1]Includes supply for exports.
[2]FM = Fading Momentum; CT = Current Trajectory; FA = Further Acceleration; AC = Achieved Commitments.
[3]Includes EU27, Norway, and United Kingdom.
[4]Includes economic regions: ASEAN, Hong Kong, Other Asia and India, and Taiwan.
Source: McKinsey Energy Solutions' Global Energy Perspective 2023

Figure 21. Hydrogen production in different regions by 2050[57]

8.2. Global Deployment of Renewable Resources for Hydrogen Generation

The deployment of renewable resources for hydrogen generation across various regions in 2027 is depicted in Figure 22. From this, an estimated 50 gigawatts (GW) of renewable energy capacity will be dedicated to hydrogen production, representing approximately 2 per cent of total renewable capacity growth. Leading this expansion is China, with significant contributions also coming from Australia, Chile and the United States, which together account for around two-thirds of the new capacity. This additional capacity will be evenly distributed globally between solar PV and onshore wind, depending on regional resource availability. China aims to increase its renewable capacity by more than 18 GW by 2027, driven by national decarbonisation goals and local policies. For example, the province of Inner Mongolia, known for its abundant solar and wind resources, aims to produce 500,000 tonnes of renewable hydrogen annually, supported by accessible financing and industrial development. Meanwhile, Europe plans to add 7 GW of renewable capacity for hydrogen production by 2027, motivated by decarbonisation targets and the need to enhance energy security, particularly by reducing dependence on Russian gas. Spain leads this initiative, followed by Germany, Sweden, Denmark and the Netherlands, all pursuing ambitious goals for deploying electrolysis technology, supported by financial incentives such as those provided by the Important Projects of Common European Interest program.[58]

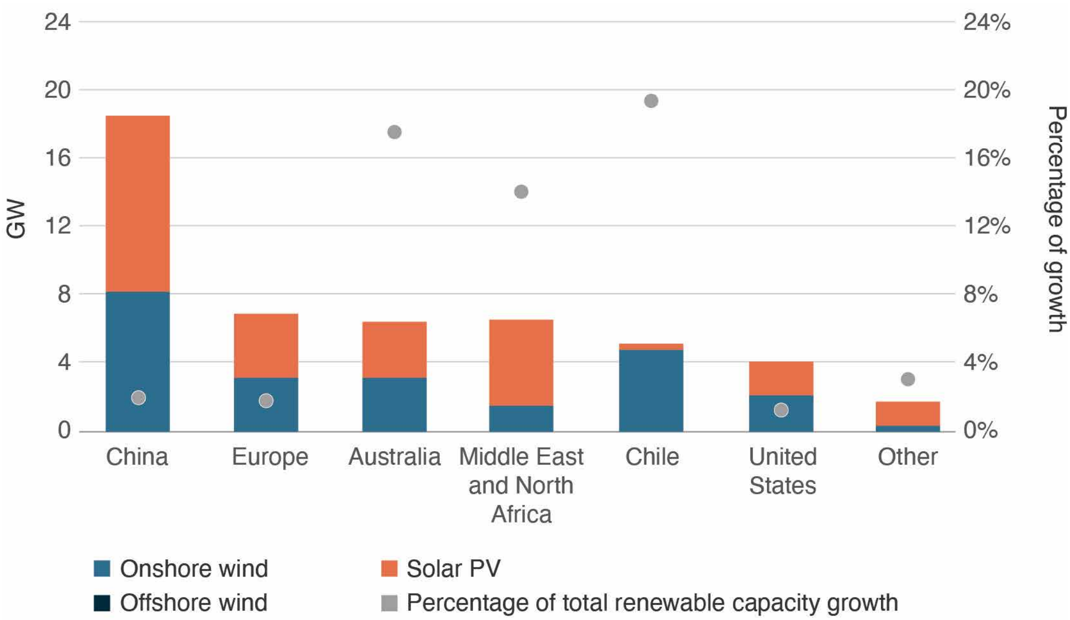


Figure 22. Designated renewable capacity for hydrogen production across regions by 2027[59]

8.3. Worldwide Mapping of Hydrogen Trading

The global hydrogen trade in 2050 is anticipated in Figure 23, driven by strategically located export hubs near abundant renewable energy sources or natural gas reserves, linking with key demand centres in Asia and Europe. Europe aims to meet a substantial part of its hydrogen demand domestically, leveraging regions like Iberia and the Nordic area for their competitive gas prices and robust renewable energy capabilities. Additional supply sources may include the Middle East, North Africa and North America. Conversely, Asia looks to import hydrogen from diverse regions such as Australia, Latin America, the Middle East and North America. Certain regions are expected to emerge as pivotal hydrogen production hubs, benefiting from efficient market access via pipelines or adapted natural gas infrastructure. Europe's trade routes are likely to heavily rely on pipelines, while international shipping could play a vital role, potentially involving hydrogen conversion into synfuels like ammonia or methanol at export terminals. Liquid hydrogen shipments are anticipated to grow post-2030, potentially reaching around 20 million metric tonnes annually by 2050, reflecting historical growth patterns observed in liquefied natural gas development.[60]

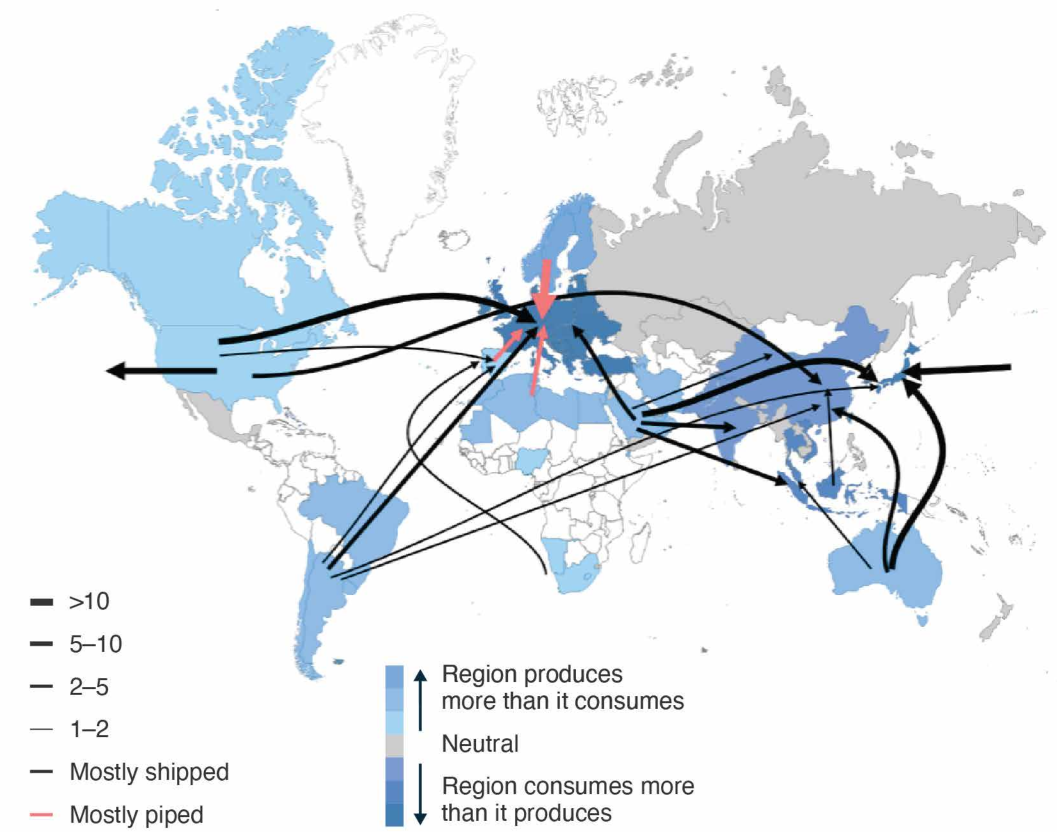


Figure 23. Global hydrogen trade linking demand centres and export regions[61]

9. Methodology for Managing Supply Chain Disruption Risks in Military Microgrids

In this section, we introduce an approach for identifying and managing risks associated with supply chain disruptions in military microgrids, using the proposed energy resilience impact metric. This methodology combines multiple techniques into a unified analysis tool designed to reduce the impact on mission effectiveness. The steps outlined in Figure 24 guide the process, with the option to customise the approach based on local installation protocols.[62]

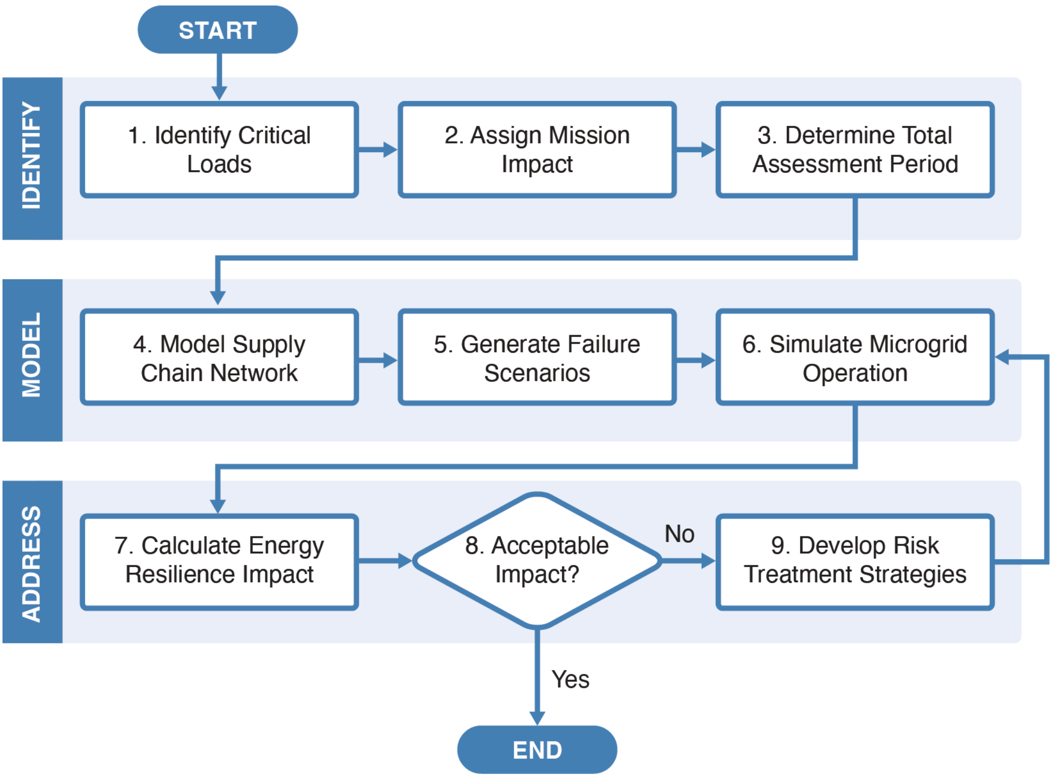


Figure 24. Methodology for assessing and mitigating supply chain disruptions in military microgrids

Step 1: Identify Essential Loads

The first task for the installation energy manager (IEM) is to pinpoint the critical loads that are necessary for mission success. This is most effectively achieved by dividing the installation into its individual facilities and determining which ones require uninterrupted power. While further classification at the subsystem or component level is possible, it is typically not needed. We recommend illustrating these facilities in an electrical one-line diagram to create a comprehensive view of the microgrid. This approach will help clarify the problem space and, crucially, define the power flow requirements for future simulations.

Step 2: Assign Mission Impact Ratings

The next step involves assigning a mission impact score to each facility, using a scale from 0 to 100. This is a unitless value that reflects the importance of each facility to the mission's success. This stage addresses key considerations, such as:

- How long can the facility operate without compromising the mission?
- How much of the mission can continue if a facility becomes non-operational?
- Does the disruption lead to cascading failures across the installation?
- Are there any redundancies, or can functions be transferred to another facility?

These scores should be verified by relevant stakeholders to inform emergency management decisions and guide prioritisation of funding for improvements.

Step 3: Determine the Total Evaluation Period

The IEM must now decide on the total evaluation period (T) for subsequent calculations and simulations. This period should cover the 'days of autonomy' required by the relevant armed service, although it can be extended to assess alternative system configurations. If the duration is too long, additional factors such as equipment reliability and maintainability need to be considered. We recommend setting T to at least two refuelling cycles or 14 days, whichever is longer. This will provide enough time to observe the impact of supply chain disruptions while complying with the Ministry of Defence policy.

Step 4: Model the Supply Chain Network

The next step involves using a discrete-time Markov chain / dynamic Bayesian network approach to model the energy supply chain network. Starting from the installation and working backwards, the IEM will account for all entities influencing the value stream. Each node in the network will be represented by a discrete-time Markov chain to model operational states, with conditional probability tables added where dependencies exist.

Collaborating with logistics specialists is crucial to ensure accurate representation of transitions and probabilities. The analysis should be limited to the short-term sustainability of the islanded microgrid, guided by the defined evaluation period (T). The longer the evaluation period, the greater the likelihood that upstream disruptions will affect the installation.

Step 5: Generate Disruption Scenarios

Once the network model is developed, the IEM must create a set of disruption scenarios that could affect the supply chain. Since there is no universal method for identifying risks, each node's specific conditions must be considered. Historical data can offer valuable insights, and localised threats (such as weather conditions, waterborne risks or proximity to population centres) and the current geopolitical situation should also be factored in. Suggested scenarios include:

- Baseline scenario: Normal supply chain network operation with no disruptions throughout T.
- Worst-case scenario: Complete disruption to the energy supply chain network for the entire duration of T.
- Single-node scenario: Disruption affecting a key node essential to the supply chain network operation.
- Multiple-node scenario: Disruption affecting several nodes simultaneously.

Step 6: Simulate Microgrid Performance

With the failure scenarios in place, the IEM can simulate the operation of the islanded microgrid. Key inputs for the simulation include generator sizing, refuelling schedules, specifications for photovoltaic arrays, energy storage system capacities, and load profiles. The simulation should focus on stress periods, such as peak demand or low sunlight, to reveal potential vulnerabilities. Power-flow analysis will be used to calculate power generation, consumption and unmet demand, with particular attention paid to unmet demand.

Step 7: Assess Energy Resilience Impact

Energy resilience impact can now be calculated for critical loads or the entire microgrid, depending on the scope of the analysis. These calculations treat each load equally, but this may not fully reflect their relative importance. To adjust for this, the most affected critical load sets the baseline energy resilience impact score, which is then modified by the mission impact scores for other loads.

Step 8: Determine Acceptable Impact Levels

At this point, the calculated energy resilience metric is compared to predetermined threshold values. Rather than choosing an arbitrary cut-off, the IEM can use a percentage of the total impact modifier (for example, 5 per cent of the total impact modifier) to define an acceptable level of impact. If the calculated impact falls within acceptable limits, the microgrid is considered sufficiently resilient, and no further action is required. If the impact exceeds the threshold, the IEM proceeds to Step 9 for further analysis.

Step 9: Develop Risk Mitigation Strategies

The IEM reviews the simulation results to identify the primary causes of mission degradation. If multiple issues are identified, the supply chain vulnerabilities should be addressed in order of their impact. Microgrid improvements, such as system configuration changes or updates to operational policies, should be tested through Steps 6 to 8 to reduce the energy resilience impact. Once a satisfactory solution is found, the IEM submits design recommendations to the installation commander for final approval.

10. Key Recommendations to Enhance Supply Chain Resilience in Australia

As outlined in the previous subsections, Australia's energy supply chain faces notable vulnerabilities; hence, Table 3 presents several proposed alternatives to strengthen the country's energy sector supply chain.

Table 3. Suggestions for strengthening the resilience of the energy sector supply chain

Risk	Description	Suggestion	Effects
High dependency on imported fuels	• Australia depends heavily on international sources for liquid fuels.	• Create strategic fuel stockpiles and diversify import origins and transit routes.	• Boosts national resilience against global supply disruptions or geopolitical constraints.
Vulnerable defence energy logistics	• Energy delivery to remote or deployed defence operations relies on lengthy and fragile supply chains.	• Integrate hybrid power solutions (solar, battery, diesel) at operational bases.	• Increases operational independence and reduces exposure to supply chain disruptions.
Lack of domestic processing capabilities	• Critical energy infrastructure components, such as refineries and tech production, are predominantly located abroad.	• Support investment in local manufacturing and scalable processing technologies.	• Enhances sovereign control over essential infrastructure and reduces international dependency.
Centralised and exposed power infrastructure	• Core energy infrastructure is susceptible to physical, cyber, and environmental threats.	• Strengthen central systems and implement microgrids for key facilities.	• Improves system robustness and ensures energy continuity during crises.
Inconsistent use of resilient technologies	• Modern, decentralised energy solutions are unevenly implemented across sectors.	• Promote widespread adoption of distributed energy systems in critical areas.	• Expands national energy flexibility and strengthens sector-wide resilience.
Over-reliance on global technology supply chains	• Many energy-related technologies rely on overseas manufacturing hubs and logistics networks.	• Invest in domestic innovation, R&D and high-tech manufacturing capabilities.	• Lowers vulnerability to international trade disruptions and supply shortages.
External processing of critical minerals	• Essential minerals for energy systems are mostly refined or processed outside Australia.	• Develop onshore refining capacity and secure long-term resource partnerships.	• Secures reliable access to vital inputs for energy and defence applications.

11. Conclusion

Secure and resilient supply chains are essential for maintaining national defence readiness and supporting the transition to sustainable energy systems. The defence sector depends on complex global supply networks that are increasingly vulnerable to geopolitical and operational risks. Addressing these vulnerabilities requires a proactive approach that includes identifying critical dependencies, enhancing regional production capabilities and adopting robust risk management methodologies. In the energy sector, similar challenges exist, particularly in the sourcing of raw materials, skilled labour and technological infrastructure. The transition to clean energy, including the development of a global hydrogen economy, adds new layers of complexity that must be addressed through coordinated policy, investment and innovation. Strengthening the capacity to manage disruptions, especially in sensitive areas such as military microgrids, is crucial for ensuring continuity of operations.

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/ THE PROFESSION OF ARMS IN AN AI-ENABLED WORLD

Matthew LM Jones

Abstract

This article explores how artificial intelligence (AI) is poised to reshape multiple aspects of military practice—tempo, teaming, and decision cycles—and how that may affect the profession of arms. Drawing on contemporary Australian and international military doctrine, recent conflicts, and academic literature, it reassesses four professional dimensions in an AI context: expertise; ethics and accountability; identity and culture; and self-regulation. The article argues that while AI may disrupt aspects of the character of war, it does not alter its fundamental nature: war remains a human endeavour. Military professionals must now integrate technical fluency with traditional judgement, maintain ethical accountability amid algorithmic opacity, preserve trust and cohesion within hybrid human–machine teams, and lead in testing and establishing doctrinal and moral boundaries for AI use. It contends that adapting to AI is not merely a technical challenge but a test for the profession itself. The enduring values of Defence (service, courage, respect, integrity, excellence) remain essential and must evolve to guide the profession through this period of rapid technological change. Ultimately, the article asserts that the profession of arms must shape, not be shaped by, the rise of AI.

Introduction

> The advent of Artificial Intelligence in warfare may usher in a new age, as for the first time non-human entities may make decisions about the application of political violence.[1]
>
> Lieutenant General Simon Stuart, Chief of Army

Modern warfare stands on the cusp of a disruptive transformation driven by AI. This prospect raises profound questions about the future of the profession of arms—the vocation of military service and expertise in the ethical application of force on behalf of society. The profession of arms has long been grounded in human judgement, expertise and moral responsibility in war. Yet AI-enabled systems from autonomous drones to decision-support algorithms are rapidly changing how militaries fight and make decisions. What, then, does the profession of arms look like in an AI-enabled world?

This article examines that question by reviewing the traditional foundations of the profession of arms and analysing how AI-driven technological disruption is altering warfare and military decision-making. This analysis revisits four core dimensions of the military profession in light of AI: expertise (the changing nature of military knowledge and decision processes, such as AI-enabled planning); ethics and accountability (new challenges from autonomous systems and 'black-box' algorithms, and preserving human responsibility); identity and culture (maintaining trust, cohesion and purpose in human–machine teams); and self-regulation (how the profession can set ethical and doctrinal boundaries for AI use). Finally, the discussion appraises the implications of these changes for the Australian Army's future professional identity and its relationship with Australian society.

This review aims to critically assess how AI might reshape (but not replace) the profession of arms. In doing so, this paper draws on contemporary sources, including emerging national strategies, allied initiatives like AUKUS and Project Convergence, and scholarly perspectives, alongside insights from Australian Army research on the profession itself.

Definitions and Scope

In this article, **artificial intelligence (AI)** refers to computational systems that sense, process and generate outputs that support or take decisions—covering both **machine-learning** (data-trained) and **rules-based** approaches. **Autonomy** is the ability of a system to select and execute actions towards commander's intent **without continuous human direction**, within constraints and with **override**. **Decision support** is used to mean AI that assists a human commander, and **decision delegation** when a system executes actions once authorised.

Background: the Profession of Arms

The term 'profession of arms' encapsulates the military vocation as a specialised field akin to medicine or law, distinguished by unique expertise, ethical responsibilities and an ethos of service. Within the Australian Defence Force (ADF), formal recognition of this concept has only recently crystallised. *Australian Military Power* (2021, revised 2024) defines the profession of arms as comprising personnel skilled in 'the ethical application and exercise of lethal force to defend the rights and interests of the nation'.[2] This definition underscores the profession's core elements: ethical conduct, expertise in controlled violence, and national duty.

Historical thinkers have long shaped our understanding of military professionalism. Lieutenant General Sir John Hackett characterised soldiering as possessing a distinct body of technical knowledge, institutional cohesion, specialised education and a unique societal role.[3] Similarly, Samuel Huntington identified the military profession through its expertise in warfare, a profound societal responsibility, and distinct institutional culture.[4] Both thinkers highlight the profession's uniqueness in expertly wielding force with the objective of resolving societal problems.

Within the Australian Army, Chief of Army Lieutenant General Simon Stuart has described the profession as resting on three pillars: jurisdiction, expertise and self-regulation.[5] Jurisdiction signifies the Army's unique service—applying land combat power to advance national interests. Expertise represents the specialised knowledge embodied in the 'art and science of war', encompassing tactics, doctrine and advanced military skills. Self-regulation underscores the military's ability to govern its ethical and disciplinary standards internally, even amid the chaos of warfare. Collectively, these pillars align closely with Hackett's and Huntington's principles, affirming the Army's professional autonomy, distinct knowledge base and ethical obligations.

The core ethos binding these elements together is the notion of 'unlimited liability', where soldiers willingly risk their (and take others') lives. This commitment creates a profound societal contract: in return for their sacrifice, society grants the military professional autonomy, esteem and trust, contingent upon maintaining high standards of integrity, ethical conduct and competence.[6] Military professionals undergo extensive education and rigorous training, developing expertise progressively throughout their careers.

Past technologies—aviation, nuclear weapons, cyber, and precision munitions—reshaped tactics and force design but kept humans clearly in charge of decision-making. AI is different in kind: it invites delegation of decision steps to non-human systems, often via opaque models that act at speed and at scale, which creates new pressures on judgement, accountability and training. Furthermore, AI's rapid advancement poses pressing questions against the established backdrop: does AI alter the required professional expertise? Does it introduce new ethical challenges and accountability gaps? How must military training evolve to ensure continued mastery of warfare? Will the Army's identity and cohesion change as humans increasingly partner with autonomous systems? Crucially, how can the profession effectively regulate AI usage to maintain societal trust?

The questions raised by this contemporary technological context provide the opportunity for the Army to assess the full effects AI may have on its professional identity. This reassessment is urgent as militaries worldwide integrate AI systems into operations, requiring the profession to evolve without compromising its core ethical and societal commitments. The Australian Army stands at a critical juncture, challenged to maintain its professional integrity and re-examine its values against the emerging realities of AI-enabled warfare.

Technological Disruption: AI's Impact on Warfare and Decision-Making

AI's technological disruption of warfare has been described in some analysis as a 'third revolution'. It has been compared in impact to gunpowder and nuclear arms, with claims that AI cuts through the fog of war and enables new ways of fighting.[7] However, while AI is reshaping tempo and tactics, the evidence from recent conflicts indicates an evolution of warfare rather than a revolution; true 'revolution' requires parallel organisational, doctrinal and cultural transformation—not only new kit.[8] This article therefore treats AI as a catalyst for professional adaptation more than a fait accompli of revolution. Regardless, AI is fundamentally altering both operational and strategic paradigms, prompting militaries worldwide to adapt swiftly.

Autonomous systems such as drones, robotic vehicles and intelligent munitions are already changing battlefields. In practice, most systems fielded today are remotely piloted or operate with bounded (narrow) autonomy within prescribed envelopes (e.g. waypoint navigation, target tracking, terminal guidance) and with human authorisation for effects against persons. Recent conflicts, including the war in Ukraine, illustrate how AI-guided drones and autonomous systems are being employed extensively, providing decisive tactical advantages.[9] These technologies allow for unprecedented speed, precision and operational tempo, fundamentally altering force structures and battlefield tactics. Smaller AI-enabled drones can neutralise larger, expensive crewed platforms, dramatically shifting cost-effectiveness ratios and strategic calculus.[10]

Beyond physical platforms, AI's most profound impact is arguably in decision-making. Warfare today generates enormous volumes of data, from surveillance feeds to intelligence reports, exceeding human cognitive capacities.[11] Through advanced machine-learning algorithms, AI rapidly processes and interprets this data, significantly compressing the observe–orient–decide–act (OODA) loop, which is essential to military superiority.[12] The Australian Army's decision-making and planning process (DMPP) exemplifies an area ripe for AI integration, with potential to accelerate decision-making cycles and provide commanders enhanced situational awareness and tactical agility.

International experiments such as the US Army's Project Convergence highlight AI's operational potential.[13] Using systems like FIRESTORM, these trials demonstrate AI's capacity to streamline targeting and coordination processes from minutes to mere seconds, dramatically improving lethality and survivability.[14] Likewise, the multinational AUKUS trials have shown how AI-enabled sensor-to-shooter networks can drastically reduce the time from target identification to engagement.[15] However, these trials emphasise that speed only helps if it rides on quality assurance: fast loops can amplify 'hallucination' (confidently presented, plausible but unfounded outputs)[16] or 'slop' (large volumes of low-quality content that floods systems).[17] Critically, these trials emphasise the need to retain human oversight, introducing roles like the 'AI officer' to ensure accountability.

Despite technological enthusiasm, AI's strategic implications remain contentious. Critics like AI ethicist Toby Walsh argue that current defence strategies inadequately address AI's transformative potential, leaving militaries vulnerable to sudden disruptive shifts.[18] Conversely, senior ADF leadership emphasises that while technology changes the conduct of war, the fundamental nature of warfare remains human-centric.[19] Human factors such as leadership, judgement and moral courage remain irreplaceable elements in combat.

While AI may reshape war, the weight of evidence still points to evolution rather than revolution.[20] Autonomous systems are shifting force design and cost curves, as small, cheap, smart platforms become available. The most profound change is in decision-making: machine-learning tools ingest intelligence, surveillance and reconnaissance (ISR) at scale and compress the OODA loop; the Army's DMPP is primed for this. Strategically, views diverge—some warn that policy and doctrine lag technology; senior ADF voices emphasise that war's human nature endures. Ultimately, technological disruption via AI provides the Australian Army a significant opportunity to redefine and reinforce its professional identity, ensuring its continued relevance and effectiveness in the emerging AI-enabled era of warfare.

Expertise: AI and the Changing Nature of Military Knowledge

Traditionally, military expertise has encompassed mastery of tactics, strategy, leadership and operational planning, built upon deep, experiential understanding of warfare. However, AI introduces a dramatic shift, demanding that military professionals acquire not only conventional military knowledge but also proficiency in AI technologies, data science and algorithmic calculations.

The Australian Army now acknowledges technical literacy as an essential requirement of modern soldiering, emphasising the importance of understanding AI-driven systems in warfare. Some industry voices push further, as seen in assertions like Shyam Sankar's provocative statement that 'warfighters need to know how to code'.[21] His claim underscores an exaggeration of an evolving reality—however, code doesn't kill; people do. What AI may offer is efficiency and decision advantage, not a substitute for responsibility for lethality or judgement. In this way, software and algorithms are becoming central to military effectiveness, requiring soldiers to understand and manipulate these tools effectively in operational contexts.

Yet integrating technical expertise with traditional military judgement poses significant challenges. Some, like Johnson, highlight that while AI is powerful in handling vast datasets and generating rapid tactical recommendations, it lacks the intuitive grasp of battlefield complexity inherent in human commanders.[22] Military professionals risk 'deskilling' if overly dependent on AI-generated solutions, potentially losing their ability to independently analyse, judge and creatively respond to unpredictable battlefield situations. This phenomenon, termed the 'ironies of automation', highlights how the use of automation, while enhancing efficiency, can inadvertently erode crucial human skills.[23]

A key approach to mitigating these risks is 'centaur warfighting', a model blending human strategic insight with AI's analytical capabilities.[24] Rather than replacing human decision-makers, AI systems serve as cognitive augmentations, enhancing commanders' situational awareness and decision-making speed. Experts advocate preserving human judgement as the ultimate arbiter, cautioning against fully delegating strategic decisions to machines.[25] Effective human–machine teaming thus requires military professionals to develop nuanced judgement in leveraging AI, critically evaluating algorithmic outputs and maintaining overall control.

Practical examples underscore this evolving expertise. Initiatives such as the multinational AUKUS trials introduced the 'AI officer' role, dedicated to supervising algorithmic decisions within operational contexts. Similarly, research conducted by institutions like the National Defence University of Finland highlights the necessity for specialised officers proficient in AI, supported by broader AI literacy among all military leaders.[26] These developments illustrate how military expertise is shifting towards dual competence: retaining foundational strategic and ethical understanding while incorporating deep familiarity with advanced technological tools.

The Australian Army's DMPP epitomises this dual expertise requirement. AI applications in DMPP can swiftly generate and evaluate multiple operational scenarios, offering commanders enhanced strategic insight.[27] However, maintaining human oversight and cultivating critical judgement remains paramount in AI-enabled military environments.[28] Military professionals must be adept at interrogating AI-generated recommendations, understanding algorithmic assumptions and identifying potential errors or biases. Education and training must actively develop scepticism and critical-thinking skills, enabling commanders to avoid passively accepting AI outputs. Deliberate exposure to AI limitations through training scenarios where algorithms make plausible yet flawed recommendations is essential for developing this critical judgement.

In summary, the above evidence suggests AI is expanding the skill set that constitutes military expertise, rather than replacing its core. While new technical competencies will matter, they should be developed without eroding the profession's strategic, tactical and ethical foundations. The Australian Army has the opportunity to cultivate leaders who employ AI judiciously while maintaining independent judgement and critical thinking, informed by military history, ethics and human psychology.[29] Framed this way, AI resembles a transformative tool that enhances (rather than substitutes for or replaces) human strategic ingenuity.

Ethics and Accountability: Autonomy, 'Explainability Paradox' and Preserving Human Responsibility

Like earlier disruptive technologies—from aircraft to nuclear weapons—AI pressures the profession's ethical foundations, but its distinct challenge is the shift of agency from humans to autonomous systems. As machines increasingly participate in battlefield decisions, military professionals must confront new questions. Can a machine ever be trusted to make life-and-death choices? Who is accountable when an algorithm causes harm? How do we preserve human responsibility in a world of autonomous systems and black-box decision-making?

At the heart of military ethics is accountability: humans, not machines, must remain responsible for the use of force.[30] Yet as AI systems become more autonomous, the foundational principle of accountability is under pressure. Close-in defensive systems (e.g. CIWS/Phalanx, SeaRAM) can search, detect, track and intercept incoming materiel threats at machine speed within pre-authorised envelopes with minimal human input.[31] It therefore remains important to separate defensive, object-target autonomy from offensive, person-target autonomy.

The ethical dilemma is stark: can responsibility for offensive, lethal decisions be shared with, or even ceded to, software? Delegating those decisions to software is categorically different: only humans possess moral agency and can bear command responsibility;[32] opaque models cannot evidence compliance with distinction, proportionality and precautions; machines lack reason-responsive judgement (mercy, restraint);[33] and non-person killing erodes public trust, lowering the threshold for force.[34] Furthermore, modern AI systems, particularly those based on machine learning, often operate as black boxes, a factor dubbed the 'explainability paradox'.[35] Hence, meaningful human control at the point of lethal effect is non-negotiable.

Democratic militaries have attempted to draw a line through the principle of 'meaningful human control'. But enforcing this is complex.[36] If an AI system recommends a strike, and a human commander rubber-stamps it without understanding the rationale, then that is not truly meaningful control. Under these conditions, humans risk becoming mere supervisors of decisions they cannot fully audit. This is the 'moral crumple zone' problem, where human operators absorb blame for outcomes they did not truly control.[37] A better model is risk-aware delegation with independent checks. For example, Australian artillery has chosen to cede some decision-making to computer-generated firing data in order to speed up its OODA loop; however, it requires an independent manual verification against maps and safety traces before execution—retaining command accountability while harvesting efficiency.[38]

It is clear that ethical and legal responsibility cannot be outsourced. The commander remains accountable, regardless of how automated the system. The US Department of Defense's AI principles reinforce this: personnel remain responsible for all AI use.[39] Commanders must remain in the loop for lethal decisions even as many systems move human involvement to on the loop and, if not governed, carry the risk of humans drifting out of the loop.[40] The ADF should adopt the same uncompromising stance, beyond its current technical analysis.[41] The profession of arms demands ownership of decision-making, and accountability for consequences, especially when life is at stake.

Designing AI systems with traceability and governability is essential. Traceability means commanders and operators must understand how decisions are made, what data was used and what assumptions were applied. Governability means systems must be interruptible, and if an AI behaves unexpectedly, soldiers must have the ability to override it or shut it down. NATO's AI principles and the US Department of Defense's AI ethics both require the ability to deactivate systems that show unintended behaviour,[42] and the International Committee of the Red Cross (ICRC) urges timely intervention and deactivation as a legal/ethical safeguard.[43] Reports on the Israel Defense Forces' 'Lavender' show how thin human verification over AI-generated target lists can fuel controversy about accountability and civilian harm,[44] underlining why auditable logs, real overrides, and enforceable decision rights are non-negotiable at the point of lethal effect. Doing this demands complex, critical thinking[45]—professional scepticism, creative red-teaming, and wargaming that forces failures to happen in training, not in contact.

Beyond technical safeguards, the military must actively resist the dehumanisation of war. As AI increases stand-off capabilities and removes soldiers from physical danger, the temptation to use force may grow. Psychological distance is known to reduce empathetic concern and increase abstraction, which can weaken restraint when risk to one's own force is low.[46] When there is no risk to one's own troops, the political and emotional barriers to initiating conflict can erode.[47] This moral distancing, war by algorithm, threatens the very restraint that underpins ethical military conduct.[48] [49] Here, the role of military professionals as ethical stewards becomes even more critical. Soldiers must internalise that AI is a tool, not a moral agent. It cannot be blamed and it cannot absolve. Ethics education must evolve to cover AI scenarios explicitly, training leaders to challenge AI recommendations when they conflict with values or law.

Training environments also present risks. If trainees use AI-enabled planning tools without oversight, they may fail to engage critically with ethical trade-offs. Simulations that optimise for victory without considering collateral damage can desensitise leaders to moral consequences. Training must be deliberately structured to include ethical considerations, requiring students to exercise moral judgement, not just tactical and technical competence.

The Australian Army must also articulate ethical boundaries for AI, and codify its use in doctrine, policy and practice. This includes specifying where human decision-making is non-negotiable and defining acceptable levels of autonomy. The profession must lead, not wait for, policymakers. This is part of self-regulation: imposing standards on oneself to retain legitimacy and societal trust.

In summary, the rise of AI makes ethics and accountability more, not less, central to the profession of arms. Military professionals must ensure that human judgement remains at the core of every lethal decision, that AI systems are used transparently and responsibly, and that the ethos of service, courage and integrity is not diluted by automation. If AI is to serve the military, it must do so within the moral framework that defines the profession—not outside or above it.

Identity and Culture: Trust, Cohesion and Purpose in Human–Machine Teams

AI is changing how armies fight and how soldiers work in teams—but the profession remains human at its core. The military profession has always been defined not only by its expertise and ethics but also by a strong identity and culture. Trust, cohesion and purpose bind military units together. Human–machine teaming now tests all three.

First—trust. Human teams rely on mutual confidence built through shared hardship and demonstrated reliability. Now trust must extend to AI tools and autonomous systems to function reliably in combat.[50] Just as with new team members, this trust must be earned, and AI systems must prove themselves in training and operations. Studies have noted that ‘soldiers can develop a readiness to trust the AI systems soon to be integrated with warfighting teams’ by leveraging concepts of trust from human team cohesion.[51] However, any failure, whether it is an autonomous system varying from its input directives or a decision-support system producing an imprecise course of action (COA), can erode that trust quickly. Building trust in AI requires rigorous, transparent testing and realistic training. AI is fallible and its recommendations must be interrogated, not followed without question. Military culture must reinforce the point that responsibility always rests with the human. The danger is overconfidence in technology, not being aware of other options available or merely assuming the algorithm knows best. That path may lead to further unintended consequences. A countermeasure to this would be human skilling. This could see leaders generate and compare independent COAs and practise ‘AI-off’ drills, red-team challenges and cognitive-forcing checks so that questioning, overriding, and choosing the human-owned option becomes trained behaviour—not an act of courage.

Second—cohesion. Traditionally, soldiers bond through shared experiences: field exercises, deployments, danger. As AI takes over some tasks, especially in logistics, ISR and targeting, the structure of human teams may change. Soldiers may operate more independently or alongside autonomous systems rather than with fellow humans. This risks weakening traditional bonds of trust and mutual dependence. Military leaders must find new ways to build cohesion in hybrid human–machine teams.[52] This may include integrating systems into team routines and roles (i.e. giving names to autonomous systems or running man–machine competitions) so that they are treated as accountable team assets, not faceless black boxes. This limited 'operational anthropomorphism'—the sort we already use with military working dogs—may aid care, protection and recovery. This might seem trivial, but organisation culture is built on symbols and shared stories.[53]

Humanising the machines or decision-making algorithms helps reinforce that they are part of the mission; but at the same time, a balance should be found against over-anthropomorphising machines. Like aircraft individualised through tail numbers, these systems remain equipment, not moral subjects—valued for mission contribution, and replaceable without the rituals reserved for people. It is therefore important to treat anthropomorphism as a tool, not a truth: allow it in a bounded way to cue efficiency, coordination and teamwork, while measuring and calibrating it through training (trust checks, question–verify–override drills) so that attachment never overrides judgement or accountability.

Third—purpose. The Australian Army's ethos is built on the Defence values of service, courage, respect, integrity and excellence. These values are forged in adversity and tested in combat. But what happens when AI systems carry out the most dangerous missions? Does the role of the human soldier diminish? Some fear that the profession will lose its soul—that remote warfare and AI-driven operations will hollow out the sense of service and sacrifice.[54] But this future is not preordained. The military can and must adapt its concept of soldier identity. Courage in the AI era may mean taking moral risks, challenging an AI recommendation under pressure, or leading human–machine teams into uncertain operational environments. Honour remains in making hard decisions, bearing responsibility and protecting civilians. The profession endures when its values adapt to new contexts. Military culture has evolved before. The rises of aviation, cyber, and remote warfare all brought cultural challenges.[55] Uncrewed aerial vehicle operators and cyber soldiers don't fit the mud-and-blood archetype, yet they have been integrated into the profession. The same can happen with AI-era roles like 'AI officers'—so long as the core values are preserved.

Leadership styles may also need to adapt to account for the further integration of people with technology. A concept emerging is ‘AI command’ or ‘centaur leadership’, where a commander effectively commands both human subordinates and autonomous systems as part of the unit.[56] This requires clear communication of intent that both humans and AI can understand, possibly more standardised, data-driven command intent so that AI decision-support tools align with the commander’s goals.

The integration of AI also has implications for the civil–military relationship and societal trust, which are part of the profession’s broader identity. The Australian Army has a proud identity tied to values like mateship, courage, and loyalty, and it is keenly aware of serving the democratic society’s interests. As AI-driven warfare emerges, the Army will need to ensure the public understands that the Army’s values and human accountability remain paramount.[57] If the public perceives that the military is becoming a faceless force of robots that might act without human control, trust will be undermined. Thus, the Army’s culture of transparency and adherence to law must be clearly communicated. The Chief of Army’s initiative to focus on ‘the Army in society’ and clarify the Army’s purpose suggests recognition that societal licence for the Army’s actions might hinge on showing that even as the force modernises with AI, it remains firmly under ethical, human control.[58]

In summary, AI may reshape certain facets of military identity—teaming, tempo and decision cycles—but need not erode it. With deliberate leadership, adaptive culture and a firm hold on core values, the profession of arms can remain a human vocation. What remains to set professionals apart is not their hardware but their judgement, responsibility and commitment to each other and the society they serve.

Self-Regulation: Setting Ethical AI Boundaries

Professions are characterised not only by their expertise and service but by their ability to self-regulate—to set standards of conduct, enforce accountability and adapt norms as their practice evolves. For the Australian military profession, self-regulation operates within the framework of civilian control, but there remains a domain of professional autonomy in matters of discipline, doctrine and ethical guidelines.[59] In the face of AI-enabled warfare, how the Australian profession of arms establishes and enforces boundaries for AI use will be a critical test of its professionalism. It must ensure that this powerful technology is harnessed in ways consistent with military virtue, legal obligations and strategic prudence.

Firstly, the military can incorporate AI usage guidelines directly into doctrine and rules of engagement (RoE). Just as there are RoE and targeting directives shaped by context and mission, law and policy will need to codify limits on autonomous systems. Or it might prohibit deploying certain AI capabilities unless they meet reliability thresholds under realistic conditions (aligning with reliable and tested AI principles). The ADF could produce doctrine specifically on human–machine teaming, outlining best practices and required oversight. Self-regulation will involve the Army (and Defence enterprise) writing the ‘rulebook’ for AI in military operations before crises force ad hoc decisions. This internal rule-making reflects professional autonomy: military experts devising the tactics, techniques and procedures that both exploit AI and keep it within acceptable bounds.

The ADF needs AI-specific ethical principles. Modelling a first effort on the US Department of Defense’s clear commitments to traceability, reliability and governability is a reasonable starting point.[60] But before committing to new principles the Army should first test the current system: deliberate assessment and wargaming is needed to confirm where existing values, law of armed conflict obligations, the DMPP and acquisition gates already accommodate AI, and to identify genuine gaps. Where gaps persist, it may be necessary to integrate an AI employment code within doctrine so it is trained, planned and audited like any other obligation. For instance, a principle might state: ‘Commanders must be able to explain, challenge, and override AI decisions’. Another might be: ‘Lethal force will not be delegated to AI without human decision-making’. Service doctrine should specify contexts, decision rights and safeguards, ensuring a single professional standard expressed through different modes of control. The Australian Army profession’s moral licence to operate with AI depends on demonstrably ethical AI employment; ethics is therefore a governing requirement, not an add-on.

Other self-regulatory tools include internal advisory boards, ethical review processes for acquisitions, and pre-deployment testing standards for AI tools. These mechanisms ensure that new technologies are not fielded without adequate scrutiny.

The Australian Army has a strong foundation to build on. Chief of Army has framed professionalism through jurisdiction, expertise and self-regulation;[61] this article argues for extending the same frame to AI. The near-term task is to test current doctrine, RoE, and values against AI use, identify genuine gaps, and then embed updates where necessary. Self-regulation in the AI era is not about slowing down innovation—it is about ensuring that innovation serves, rather than subverts, the values that define the military profession. When the public see that the Army uses AI responsibly, ethically and transparently, it is hoped they will continue to grant Army the trust and autonomy it needs to operate.[62] That trust is earned, not assumed.

In summary, if the Australian Army wishes to exploit AI technology, it must also lead in setting rules for its use. That is the essence of self-regulation: using authority not for self-interest but in service of higher standards. The Australian Army must be seen as a capable and principled user of AI. Anything less puts the profession’s lasting and unwavering social contract at risk.

Implications for the Australian Army: the Future Professional Identity

For the Australian Army, the challenge posed by the rise of AI is not simply to adopt new technologies but also to test and adapt the institution's identity, values and practices to an AI-enabled battlespace. The following six action areas represent priority lines of 'AI' effort:

1. **Institutionalise AI literacy and technical fluency**
   Make AI literacy a foundational requirement across all ranks by embedding AI principles, data reasoning, and automation awareness into all tiers of training and professional military education (PME). Introduce AI-enabled decision-support tools in scenario-based exercises, and establish formal AI-functional specialisations (i.e. 'AI officers'). Partner with academic institutions to offer targeted postgraduate education in machine learning, data ethics and operational AI systems.
2. **Modernise doctrine and reinforce mission command**
   Update doctrine to reflect AI–human teaming, clearly defining where human decision-making is non-negotiable. Build AI systems that reinforce, not undermine, mission command—prioritising decentralised, context-sensitive tools that enhance junior leader autonomy. Use AI to compress decision loops, not to centralise control.
3. **Integrate AI ethics into Army culture and policy**
   Codify AI-specific ethical principles—such as traceability, overridability and meaningful human control—into doctrine, RoE, and command responsibilities. Train leaders to interrogate AI outputs and model ethical use. Establish internal ethics boards to review and audit AI tool deployment and procurement.
4. **Transform PME and career development pathways**
   Integrate AI tools into PME curriculum and exercises. Shift the focus of PME to critical analysis of AI-enabled operations. Create and support new career pathways for AI/data professionals in service. Encourage and sponsor exchange programs with technology partners and Defence science units.
5. **Strengthen public trust through transparency and engagement**
   Develop a strategic communications plan that explains how AI is used lawfully, ethically and with human oversight. Be open about constraints and safeguards. Engage broader society, academia and media to co-shape Australia's AI defence narrative.
6. **Lead professionally on policy and self-regulation**
   Take proactive ownership of setting internal standards for AI testing, validation, deployment and accountability. Develop doctrine before crises occur, and represent Australia's military values in shaping international norms around responsible AI use in warfare.

Conclusion

AI's inexorable advancement seems set to change many aspects of military operations, but it need not undermine the fundamental nature of the profession of arms. Rather, it should prompt a renaissance of professional reflection and adaptation. An AI-enabled world challenges the premise that only humans should decide who is killed, and when. The Australian profession of arms must recommit to its values and adapt to this technological evolution.

The thesis of this article has been that while AI will change how military professionals carry out their missions, it does not change why or to what end they serve; nor does it absolve them of the responsibility for those missions. Military expertise is expanding to encompass new technological domains, but the essence of that expertise endures. Ethical and accountable conduct faces new tests from autonomy and opaque algorithms. Even this profession's own moral compass, honed over centuries, shows a record of strengths and failures, which is why its ethics must be applied, tested and audited, and why authorisation of lethal force must remain a human decision with accountable ownership. The identity and the culture of soldiers are evolving to include technical prowess and human–machine trust, but the camaraderie, courage and honour that define military units remain as vital as ever. And the profession's capacity for self-regulation is being exercised vigorously to set boundaries on AI use consistent with laws and values, thereby maintaining public trust in an era of fast-paced change.

For the Australian Army, answering 'What does the profession of arms look like in an AI-enabled world?' has practical urgency. It looks like an Army that is smarter, faster and more integrated, that leverages AI for superiority yet also anchors innovation in ethics and expertise. It is, ultimately, an Army that harnesses the strengths of AI without surrendering the virtues of the soldier. The enduring value of the profession, in the face of disruptive change, is that it provides the human judgement, ethical restraint and institutional wisdom that ensure new technology is used wisely and justly in the nation's service. In that sense, the more things change, the more the core ideals of the profession of arms must stay the same—and indeed, they remain essential for navigating the uncharted terrain of AI-enabled warfare.

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SUBTERRANEAN INFORMATION FROM GRAVITY: DETECTING MASS AT A DISTANCE

Samuel Legge

This article is a deep dive into measuring gravity as a form of remote sensing and its potential applications in land warfare. It includes a tutorial on gravitational signals and an overview and projection of existing and future sensing technologies.

Introduction

Warfare has always involved a significant element of utilising underground infrastructure as a tactical asset. The resilience of the Ukraine forces entrenched in the extensive tunnel network of the Azovstal steelworks in Mariupol[1] is a recent example of the strength of subterranean complexes; the Ukraine troops defended their position for months against a significant asymmetrical force. The most striking advantage afforded by subterranean structures, beyond the physical protection of layers of earth and rock safeguarding them against ordnance and direct assault, is their resistance to external observation. These structures are resilient to scans across the electromagnetic spectrum, which includes our most commonly used remote sensing methods such as radar, thermal imaging and multispectral analysis. This leads directly to our problem statement:

How do we remotely detect and gain information about subsurface operations and infrastructure?

This question becomes increasingly relevant as global urbanisation continues to shift the landscape of conflicts closer to cities and their associated subsurfaces. Below-ground tunnels in modern cities are complex networks of transport infrastructure (pedestrian, road and rail); piping and channels (supply, sewerage and stormwater); electrical and telecommunication utilities; mining tunnels; catacombs; and abandoned sub-infrastructure. The development of large tunnel-boring machines has continued to advance since the 1950s, with machines and tunnels both reaching diameters of over

10 metres; and globally an estimated 5,200 kilometres of tunnels are built every year.[2] Even where well-documented subsurface maps of an area exist, their reliability will rapidly deteriorate if the area is subjected to conflict and bombing, with previously connected tunnels collapsing and alternative pathways being constructed.

One potential way of addressing the subsurface detection problem is by utilising gravity as a detectable signal. On Earth, we are very familiar with the strong gravitational attraction we experience; we are constantly pulled towards the planet's centre at an acceleration of 9.8 $m.s^2$. Gravity is a fundamental physical force that is different from the electromagnetic force, and all mass produces a gravitational attraction that transmits through all known materials. Utilising this property, gravity can be used to 'see' changes in mass through the ground by detecting subtle variations in the gravitational field.

This technique, known as gravimetry, represents a unique sensing modality. It cannot be blocked, jammed or easily spoofed, making it particularly resilient in contested environments, and it is entirely passive, allowing silent detection in covert situations. Gravimetry is performed using a specialised sensor called a gravimeter, a highly sensitive type of accelerometer. While gravimetry remains a niche technology, it is widely used in geophysical resource exploration—typically in conjunction with other subsurface detection methods such as magnetometers, ground-penetrating radar and exploratory borehole drilling—to map geological structures.

There are no documented examples of gravimetry being employed as a subsurface detection tool in active warfare. However, even existing commercial gravimetry technology holds potential relevance for military applications. For instance, a gravimeter could be deployed on the surface to detect the absence of mass caused by a tunnel or concealed bunker in a strategically important area, as illustrated in Figure 1.

Although these concepts can be tested using commercially available devices, their high cost and fragility may limit their suitability for use in active conflict scenarios. Nevertheless, ongoing advancements in gravimeter technology, particularly in the field of quantum sensing, are expected to produce next-generation devices that are smaller, more accurate, more robust and easier to operate.[3] The following discussion investigates gravimetry in a device-agnostic manner and addresses its limitations, which are often hidden behind a 'quantum complexity' shield that allows new technology to avoid scrutiny of sensor performance and applicability to a particular use case.

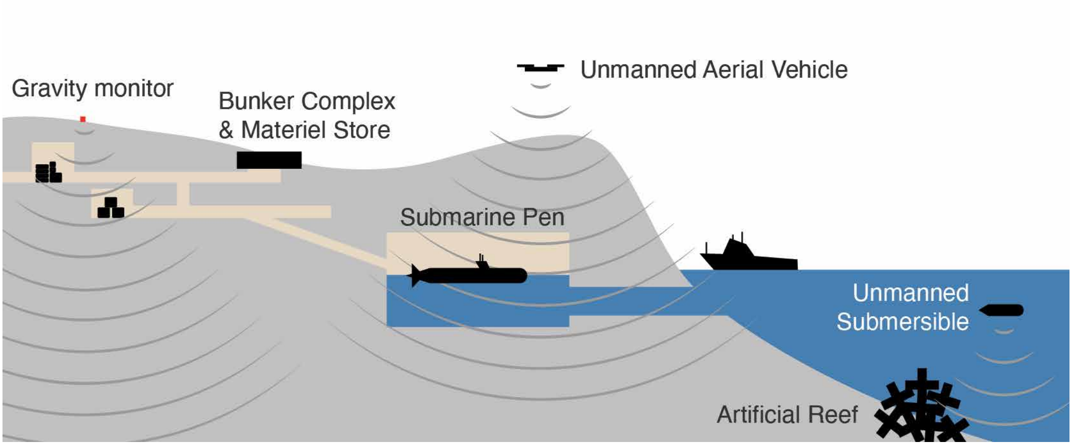

Figure 1: Cross-sectional diagram demonstrating potential use cases of gravimetry in subsurface detection. From left to right, a surface-mounted gravimeter is used to map/observe near subsurface structures (detection and mapping achievable with current technology;, monitoring requires further technological development); a gravimeter-equipped airborne survey drone senses larger subterranean structures (requires further technological development); and an autonomous underwater vehicle silently measures local gravity to infer detailed ocean topography (requires further technological development). Conical grey lines show the vision cone from each gravimeter.

This article will explore the application of gravimetry to the subsurface information problem through the following sections:

- Gravimetry Applications: a discussion of current and future applications of gravimetry relevant in both the defence and the civilian spaces
- Measuring Gravity: a tutorial on the mechanism of gravity, with an investigation of the generated signals from basic structures and the physical limitations of the method
- Gravimeter Technologies: an overview of gravity sensing technologies with a focus on the strengths, weaknesses and preferred applications of each, followed by a projection of future technologies
- Conclusion: the recommended future path for defence in this space.

Gravimetry Applications

The idea of gravity detection is always the same: using the gravimetric signals generated by a nearby density variation to infer information about that structure or materiel below the surface. The technical capability required to achieve this is not insignificant, and will be discussed in greater detail in the following section. But for now, we will assume that we have a gravimeter above the area of interest and are looking to gather information, as depicted in Figure 1.

Subsurface Detection

The simplest form of detection is a detection test—that is, using a gravity signal to confirm or deny the existence of a subsurface asset. An example might be when information is received that there may be an underground bunker in a particular area. In this case, if the area directly above this bunker is accessible, a gravimeter could do a two-point measurement to assess the likelihood of the structure's existence. First, a nearby measurement would be made to establish the background gravitational field for that area, followed by a second measurement above the expected substructure. This kind of measurement can be visualised in Figure 2, which shows the measured gravitational signal generated by the Acton Tunnel from the surface.

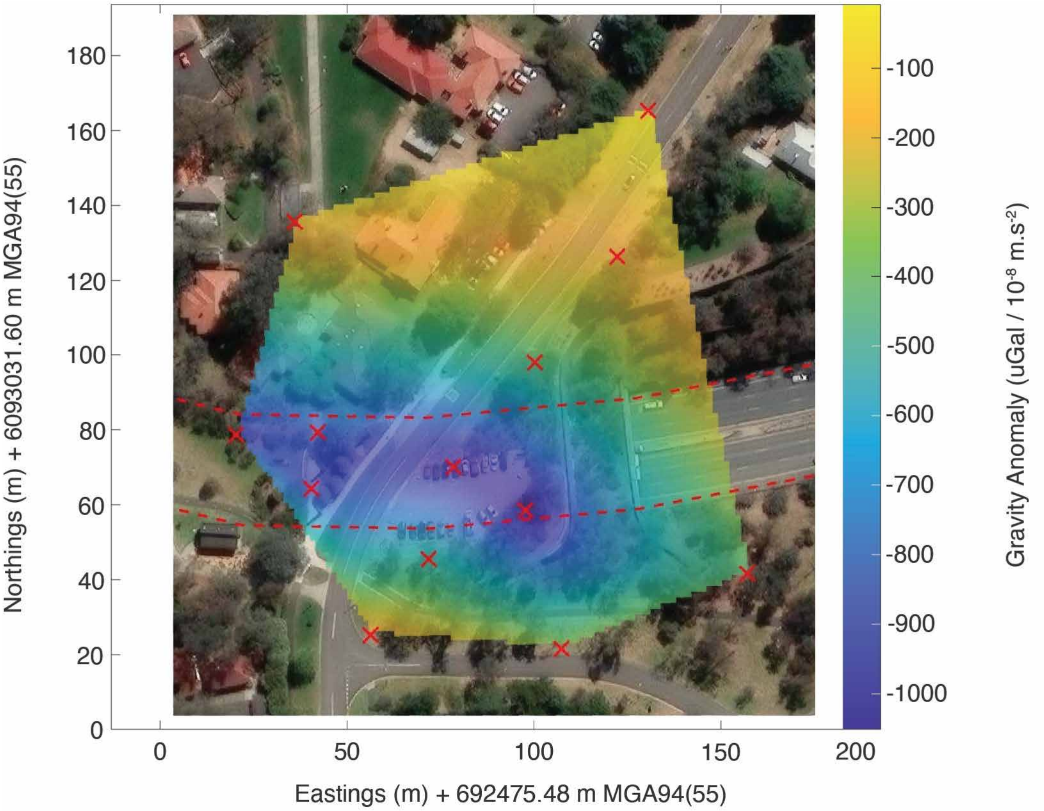

Figure 2: Ground-level measurement of the gravity anomaly generated by the Acton Tunnel (entry at 70 m northing, 130 m easting) below Liversidge Street, Acton, ACT. This data was taken over two hours using a CG6 gravimeter[4] and an Emlid RTK GPS.[5] Red crosses indicate individual measurement points, and the interpolated colour map is generated from these points. Dashed red lines are indicative of tunnel/road position. Imagery data is provided by Maxar. The blurred gradient nature of the data is the expected result of this gravitational signal. The resolution of a gravitational 'image' is roughly equal to the depth of the signal, hence the highest possible resolution in this case is limited by the 20-metre depth of the tunnel.

Here, numerous surface data points were taken over the area to generate a rough map of the subsurface tunnel, with measurements directly above the tunnel, showing a decline in the expected value of local gravity of approximately 10^{5} $m.s^{2}$ (this is a large signal for this kind of survey). For the CG6 gravimeter used to take this data in this scenario, a signal-to-noise ratio (SNR) of ~500 is achievable in a one-minute measurement.[6] Verification of the tunnel's presence via gravity could be done with only two measurements: first, a reference measurement on the road north of the tunnel to establish a baseline gravitational signal in that area; second, a measurement above the tunnel that would show the gravitational anomaly of the tunnel, confirming its presence. This application of gravimetry for land forces would be the simplest to implement; it's fast and reliable, and can easily confirm or deny the existence of large subsurface infrastructure. However, difficulties arise if there is inconsistent subsurface geography, as changes in rock and soil types can mimic these signals. Additionally, if the chosen points are both directly above bunkers or voids, the signals may give a false reading. Because of these limitations, gravity is unlikely ever to be the single solution to a subsurface problem; instead, it is likely to be one sensing modality used in a broad-spectrum approach to detection.

Subsurface Mapping

Extending on the two-point measurement discussed above, greater knowledge of the subsurface structure can be gained by recording gravity at multiple sites above the site of interest. In this case, the gravimeter data is used to map out the area, as has been done in Figure 2.

In Figure 2, the continuation of the tunnel can be seen in the westerly direction (indicated by the blue shaded area), following its path as it traverses under the ridge. The resolution of this data is limited as the ground level is approximately 20 metres above the tunnel, effectively setting a 20-metre resolution of the subsurface structure. The strength of gravimetry for mapping is most effective when the gravimeter can be physically closer to the source. The actual detection limits of current gravimeters are dependent on the size, depth and density contrast of the subsurface structure but, as a rough estimate, in common rock/soil, at 1 metre below the surface, commercially available devices could detect a roughly 0.6 cubic metre void. Detection limits will be discussed in further detail in the 'Measuring Gravity' section.

Figure 3: Operating a GC-6 gravimeter in the field. RTK GPS is attached to the back of the device.

If we reconsider the drone deployment case shown in Figure 1, this distance limitation indicates the first clear physical constraint of this technology: the higher the drone is flown above the signal of interest, the lower the resolution of the signal that it can measure will become. It is not like a camera: there is no gravitational lens that can be used to image gravity at a distance. In addition, the signal strength decreases with distance, and the motion of the drone itself can severely degrade the gravity signal. These gravity sensing issues are intrinsic to the physical nature of gravity itself; they cannot be solved or sidestepped by any level of technological advancement or quantum sensing development. In almost all cases, the optimal solution would be for the drone to act like a grasshopper, flying and landing to make a gravity measurement grid of the area on the ground. Currently, such surveys are done using human-carried gravimeters similar to the Figure 3 example. Airborne gravimetry is possible, and actively performed using human-piloted, light fixed-wing aircraft in the geophysical surveying space, and drone deployment is an expected future development as gravimeters reduce in weight and size.

Subsurface Monitoring

The final subsurface detection modality is active area monitoring. This can be thought of as using gravimetry to monitor a single point or an area for changes over time. In the examples discussed so far, the data has directly measured Earth’s gravity over the points of interest. These measurements show the data at a single time. However, if data were taken periodically over these areas as a differential measurement, any significant mass changes in the subsurface would become visible. This differential measurement method highlights changes between scans and would, for example, reveal any new tunnels that have been dug in the area since the previous dataset was taken. One could also imagine static gravity monitoring above a known cache where, if the materiel were sufficiently massive and close enough to the surface, its gravitational signal could be used to assess movements and cache levels as depicted in Figure 4. What is detectable via gravity is, again, dependent on the distance between the gravimeter and the target of interest, and the total mass of the target.

For current gravimeters, a good rule of thumb is the inverse square law (discussed in the ‘Measuring Gravity’ section) and the 100 kilograms at 1 metre distance rule—that is, if the object is 1 metre away, it should weigh at least 100 kilograms to be detectable. It follows then that if the object is 10 metres away it would need to weigh 10,000 kilograms to be detectable, and at 100 metres away it would need to weigh 1,000,000 kilograms to have a detectable gravity signal. These mass and distance constraints impose significant limitations when it comes to the kinds of materiel that could be monitored with gravity.

A significant limitation of the current gravimeters for this application is their lack of long-term stability. Commonly used commercial devices are based on a spring-type measurement that can drift at 2×10^{7} $m.s^{-2}$/day,[7] which would appear like a change in mass of 300,000 kilograms at a depth of 10 metres. In this case, the long-term stability of quantum sensors could be a significant improvement for this application. A gravimeter that has this long-term stability is typically known as an absolute gravimeter and can be thought of as a calibration-free device, measuring with atomically reference definitions of the second and the metre.

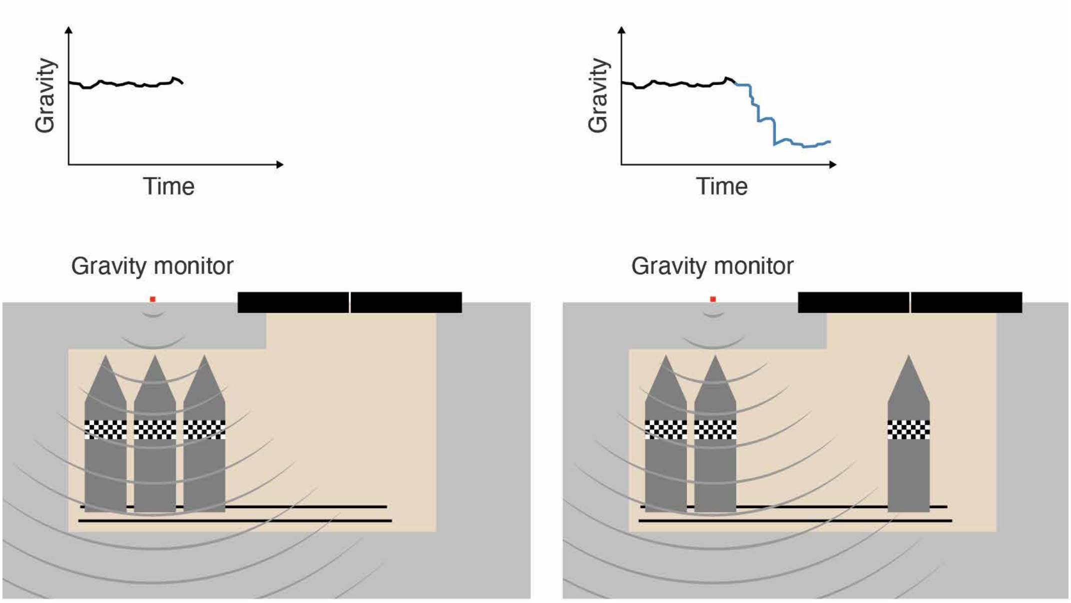

Figure 4: Diagram depicting the change in gravity signal over a long time as materiel is moved within a subsurface cache

Navigation and Mapping

Of interest to combined land and naval forces, especially for littoral operations, is the ability of gravity signals to elucidate information about the ocean floor. Our current deep ocean floor maps are generated from gravitational data measured by airborne gravimetry and orbiting satellites (inferred through orbital changes, which have much worse resolution than terrestrial surveys).[8] However, on a smaller scale, there is a strong focus following the 2023 Defence Strategic Review[9] on the Indonesian archipelago and littoral operations. While not the only option for mapping the ocean floor, gravimetry is well suited to an uncrewed submersible that can passively detect the ocean topography with no active sonar or noise. It would be especially well suited to the detection of changes in ocean floor structure through differential measurement of an area over time. An example of this is depicted in Figure 1, where a submersible is used to identify the presence of an artificial reef, which might indicate pre-conflict effort to secure a beachhead area or secure a key asset from littoral invasion.

Another essential aspect of gravimetry to the defence forces is the necessity of a local gravitational map or model to remove local acceleration in the inertial navigation (IN) equation. The current reliance of all Australian forces on the global navigation satellite system is a known vulnerability, and the reliability of IN is an alternative to outside-in positioning. However, IN has a drift problem, whereby the longer you operate only on IN, the greater the circle of uncertainty as to where you actually are becomes. The advent of better gravimeters may also allow new techniques that solve this issue through gravitational map matching[10]—that is, using pre-known gravitational anomaly signposts to correct to a known position.

This technique is comparable to the age-old method of positioning with a compass bearing and visible landmarks. By using known gravitational anomalies in the earth's fields, they can act as landmark signals or 'signposts' to zero your position. This is particularly well suited to a submersible craft where there are minimal other signals to reference off. The impact of this technique has high value to naval and air platforms, but the direct applicability to land forces is lower, as there are typically easier to observe and measure sources of navigation signposts (such as local topography) when operating on land.

Table 1 summarises the defence applications of this technology, listing the technical requirements and difficulties of each and their likely impact on land forces. The technical difficulties are given for existing technologies; these will be more fully explained in the 'Measuring Gravity' section of this article.

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Table 1: Overview of defence applications for gravimetry.

Application	Measurement time/ constraints	Technical difficulty/principal factor/requirements	Impact/value
Subsurface detection	~5 minutes	Easy Portable gravimeter with short-term (two-point) stability. Single axis. Precision requirement set by target mass and depth. *Achievable with current technology*	Medium Validation of existing data
Subsurface mapping	~1 hour per 100 m^2 (resolution dependent)	Hard Portable/drone-deployable gravimeter with short-term (survey-length) stability. Single axis. Precision requirement set by target mass and depth. *Achievable with current technology*	High Generation of new data
Subsurface monitoring	Long-term stability required	Very hard Gravimeter with long-term (absolute) stability. Precision requirement set by target mass and depth. *5–10-year technology horizon*	High Generation of real-time data
Ocean floor mapping	~1 hour per 100 $m^{\wedge 2}$ (resolution dependent)	Hard Gravimeter with long-term (absolute) stability. Full tensor gravity/gradient measurement desirable. *10-year technology horizon*	Medium Generation of new data for littoral areas
Gravity map matching	Detailed pre-existing gravity maps required	Very hard Gravimeter with long-term (absolute) stability. Full tensor gravity/gradient measurement desirable. *10-year technology horizon*	High Particularly for submersible platforms

The following sections discuss civilian and commercial use cases of gravimetry, both established and emerging, and are included so that the reader knows the dual-use avenues of this technology and the areas where it is likely to be advanced outside military applications.

Mineral Exploration

Mineral and mining exploration surveys (geophysical surveying) are currently the largest established market for gravimeters. Gravity signals are generated by density variations in large subsurface ore deposits and are measured either by airborne gravimetry with fixed-wing aircraft close to the ground, or by ground surveys with human operators. The gravity data is typically used with other detection modalities, such as magnetic sensors and seismic reflectometry, to find potential deposits. This modality is very similar to the previously discussed subsurface detection and mapping applications; however, it typically looks at much deeper and volumetrically larger density variations than would be of interest to Army. The existing knowledge in this field of combining detection modalities and calculating the mass density inversion could be adapted for smaller-scale subsurface structures of interest in defence applications. Another application in this field involves using gravimetry to monitor deposits over time, a method that is often used for oil and gas reservoirs where the gravity over the field changes as the resources are pumped out and depleted. Again, this is an analogue to the subsurface monitoring application at larger scales and depths.

Construction/Archaeology

Analogous to subsurface detection and mapping, gravimetry has applications in civilian construction for areas with unknown subsurface structures. Underground voids, both naturally occurring or from historic structures, are a significant problem in the construction industry, often causing delays and, at worst, structural instability. As the cost and capabilities of gravimeters improve, gravimetry is likely to see more significant utilisation as a tool to detect and mitigate the risk in this field; gravity is particularly well suited to detecting possible sinkholes.[11] Similarly, discovering buried voids in historical structures has archaeological applications where gravity is appealing as a detection modality, as it can passively identify substructures without disturbing the potentially fragile structures.

Groundwater/Volcanology

Measuring and tracking the use of groundwater as a resource is a difficult task, typically done by digging boreholes in the areas of interest. However, boreholes only provide a single data point for that particular location. The idea to utilise gravity as a catch-all mass sensor for near-surface groundwater is still being researched[12]—its greatest challenge being the requirement of absolute gravimeters (gravimeters with long-term stability) to measure the groundwater signals over timeframes ranging from months to multiple years. At a deeper and larger scale, gravimeters have also been used in research to monitor active seismic areas such as volcanoes, where researchers use gravimeters to track changes in the subsurface magma environment over time.[13]

Measuring Gravity

This section of the article will discuss the nature of gravimetric signals in detail, especially their limitations and constraints—which, given our current understanding of physics, restrict the potential applications regardless of sensor types or technological developments. By necessity, it is written at a higher technical level and gives a brief introduction to the underlying physics of gravimetry and precision measurement. The detail of this section will enable readers to make their own assessment about potential gravimetric signals in specific applications.

Fundamentals of Gravity

As previously discussed, a key property of gravity is that the signal (or field) travels unimpeded through all known material as well as the vacuum of space. This property makes it ideal for subsurface detection. However, it also means that there is no conceivable technology that allows us to manipulate gravity in a way that would let us refocus the signal at a distance, as we are accustomed to with optical technology. In the electromagnetic spectrum, where a lens or antenna can be used to manipulate light or radio, it is possible to image something at a distance, as is done in a typical camera. With gravity, there is no known technical pathway or physical possibility of creating a gravity lens, and therefore there is no way to focus the signal into a sharp image of what is underground. Instead, we measure a blurred signal from all nearby gravity sources. It is like having a camera that is always out of focus: you can't see the image of what is in front of you, but it is still possible to detect the presence and relative brightness of different light sources. This is the primary reason why the gravitational signal of the tunnel in Figure 2 does not have sharp, well-defined edges. Even if more data points were taken, since the tunnel is 20 metres below the surface, the resolution will be limited to the distance of the signal from the sensor. This is a generally applicable rule of thumb for gravity mapping: the resolution limit will be the same as the distance between the source and the sensor.

The strength of a gravitational signal can be estimated by using the point mass approximation (where an object is approximated to its total weight located at its centre of mass). The acceleration due to gravity, g_z (or vertical gravitational signal), where the sensor is directly above the source, is given by $g_z = \frac{GM}{r^2}$ where *G* is the gravitational constant (6.67×10^{-11} $N.m^2.kg^{-2}$), *M* is the object's mass (*kg*), and *r* is the distance (*m*) of that object from the sensor. The SI unit for acceleration and, therefore, gravity is metres per second squared ($m.s^{-2}$). Another popular unit in literature is the *Gal* (short for *Galileo*), where 1 *Gal* = 0.01 $m.s^{-2}$, often used with SI prefixes with milli or micro (e.g. 1 $\mu Gal = 10^{-8}$ $m.s^{-2}$).

The total gravitational signal can be calculated as the sum of individual mass sources, such that the gravitational force measured by a gravimeter is the total sum of all sources in their respective directions. Spherical sources of gravity can be perfectly modelled with the point mass approximation (this is known as Gauss's law). These properties mean that we can calculate Earth's gravity as a large, constant signal (spherical source at a distance) and estimate local changes in gravity as the sum of nearby signals of significance causing slight perturbations in the gravity field.

By this logic, the absence of mass can generate a local gravitational signal—that is, the presence of an underground room could be detected from the surface due to the reduction in local gravity caused by the removal of materiel, as shown in Figure 1. For example, if we assume a homogenous ground density of 2,700 kg^{-3}, and a 20 m^3 room 4 *m* below the surface, we can approximate this room as an effective negative mass of –54,000 *kg*, and if we use the above equation we get a signal of -2.3×10^{-7} $m.s^{-2}$, indicating we expect a reduction of local gravity by this magnitude on the surface.

So far, we have only discussed the concept of gravity as attracting downwards, towards the centre of the earth. However, gravity is a three-dimensional vector field that has a component in all three orthogonal directions. For example, a vector gravimeter can measure acceleration in all three orthogonal directions (typically denoted g_x, g_y and g_z as the accelerations in the north, east and down directions) and could, for example, measure the attraction of a large mass such a mountain pulling you sideways very slightly. One of the biggest advantages of a vector gravimeter is the removal of the requirement to level the sensor so that the single measurement axis is aligned with the direction of the desired measurement. Currently, all commercially available gravimeters only measure in one axis (g_z, vertical), and require levelling at each measurement site.

Gravity Gradients

Gravity gradients are a commonly used extension to traditional gravity measurements, and operate on many of the same principles. The primary advantage of a gradient measurement is immunity to platform motion, but it also enables a slightly higher resolution detection of shallow density variations. However, the gradient signals are typically weaker and less useful in finding larger or deeper structures compared to a standard gravity survey.

By measuring gravity at multiple locations (either in sequence or simultaneously), it is possible to calculate the spatial rate of change of gravity, known as the gravitational gradient. There is a gradient of all three orthogonal vector components of gravity in all three orthogonal directions, totalling nine total values.[14] The gravity gradient is typically denoted as G_{**} with subscripts indicating the gravity direction and the gradient direction; e.g., G_{zz} is the rate of change of g_z in the z or vertical direction, whereas G_{zx} is the rate of change of g_z in the x direction.

The simplest gravity gradient to consider is the vertical gravity gradient in the vertical direction, G_{zz}. The gradiometer sensor can be thought of as two gravimeters stacked vertically, one above the other, and the measurement is the difference in gravity between the sensors divided by the distance between them. The equation for the vertical gravity gradient signal with the sensor directly above the source is given by $G_{zz} = \frac{2GM}{r^3}$ where *G* is the gravitational constant (6.67×10^{11} $N.m^2.kg^2$), *M* is the object's mass (*kg*), and *r* is the distance (*m*) of that object from the sensor. It should be noted here that the gravitational constant *G* (italicised) is different from the gradient G_{zz}. The units of a gravity gradient signal are accelerations per metre. This equates to units of $m.s^2.m^1 = s^2$ where the metre cancels such that the final unit is per second squared. The gravity gradient is commonly measured in Eötvös (*E*) where $1\ E = 10^9\ s^2$.

If the gradiometer is fixed to a moving platform, any platform motion is common to both sensors and will be cancelled out of the final measurement. This is a key advantage of a gravity gradiometer and the primary reason why they are typically deployed on airborne surveys.

While gravity gradient measurements are inherently immune to platform motion, the signal of the gravitational gradient is typically much weaker than the direct gravity signal; the power falls with the inverse cube of the distance instead of the inverse square, resulting in lower measurement sensitivity. In addition, as the device is effectively two gravimeters, the complexity is increased and user operation is more difficult. Because of these factors, gradiometers are rarely used in land-based surveys.

Estimating Gravity Signals

It is interesting to consider what kinds of gravitational signals can be generated from various structures. As mentioned, Gauss's law means that any spherical source is equivalent to a point mass source, and for objects whose average radius is further away than their distance, this becomes an excellent approximation of the gravity signal that the object generates. For objects with a radius larger than their distance to the sensor, the gravitational signals become more complex but can often be approximated as a disk-like source, and the gravitational attraction is constant with distance until the spherical approximation can again be made. Figure 5 shows the gravitational and vertical gravity gradient signals for spherical sources of different mass and disks of various sizes. Here, the gravity response is flat close to the disk and then falls off with the inverse square law above the disk radius.

Another feature in Figure 5 is the flat gravitational signal generated by an infinite plane, as shown by the black dot-dashed line. Here, the gravity signal is limited by the density variation and thickness of the plane, and it is a more realistic representation of expected signals of any subsurface structures that are larger than they are deep.

The grey area at the bottom of the plots in Figure 5 is known as the sea of problems—systematic and random errors.[15] Effectively, this is the expected lower floor of terrestrial gravity signal, where one of the limiting factors for earth-based measurements is the earth noise floor. The inherent noise of the ground (effectively the vibrations of the planet, known as the microseism) begins to limit the ability of sensors to measure below 10^{-10} $m.s^{-2}$.

A gravity signal larger than 10^{-7} $m.s^{-2}$ is detectable with commercially available gravimeters (CG6 with SNR of 10), shown as a horizontal dashed black line on the plots in Figure 5, and a gravity gradient signal larger than 10^{8} s^{-2} is detectable with commercially available gravity gradiometers.

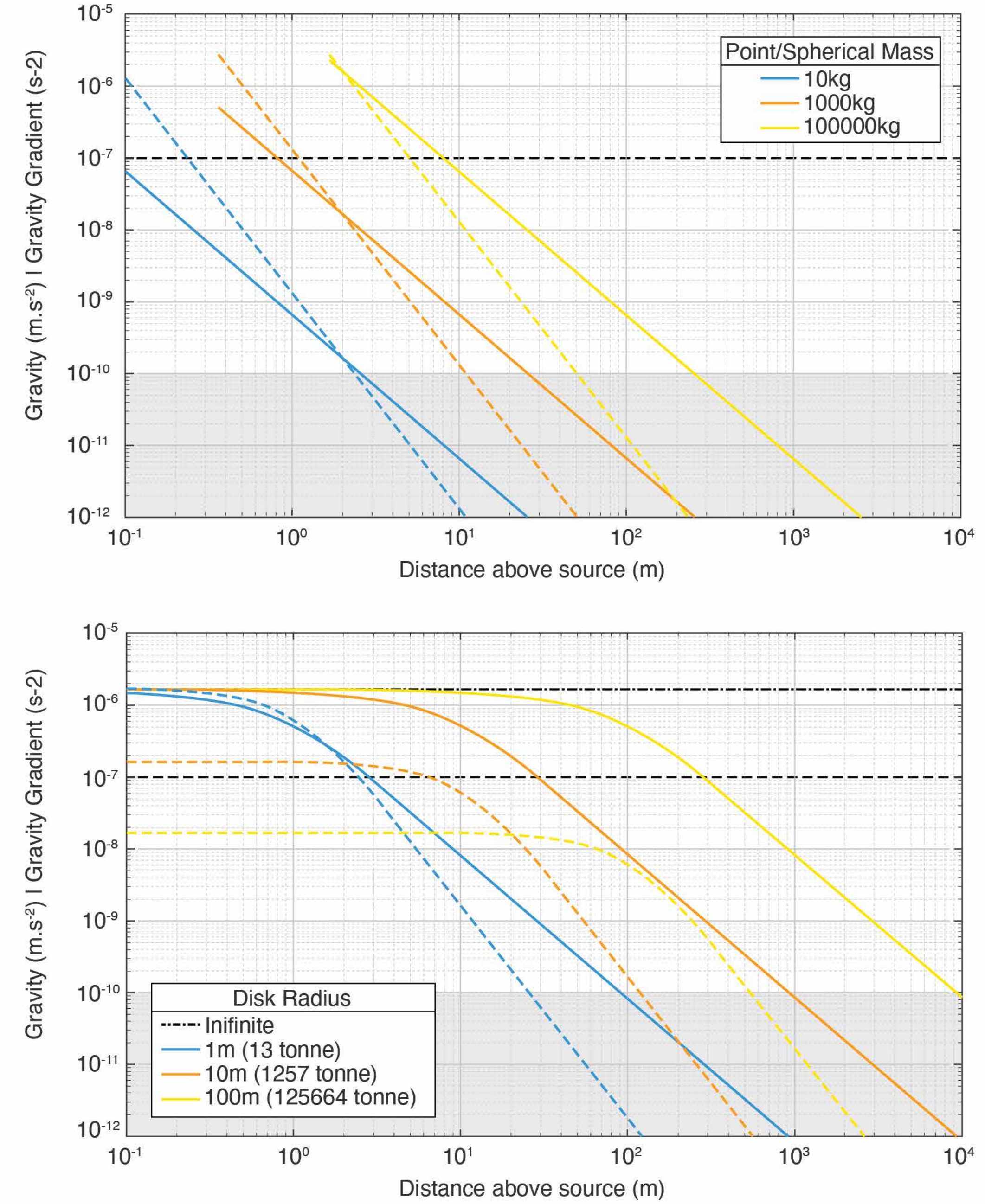

Figure 5: Magnitude of gravity (solid lines) and gravity gradient (dashed lines) signals for a point/spherical void/mass (top) and a 2-metre-high disk-shaped room with a surrounding rock density of 2,000 kg.m^{-3} (bottom).

Total mass delta from the substructure difference of the disk void is shown in the legend. The horizontal dashed line at 10^{-7} is indicative of the precision achievable with a commercial gravimeter, and the grey area below 10^{-10} represents the limit where microseismic noise will limit measurements. Spherical mass plots are truncated at densities of 5,000 kg.m^{-3}.

Assessing Gravimeter Specifications

Now that it is clear how to make an estimate of a gravitational signal, the question becomes, 'Does a gravimeter capable of measuring that signal exist?' The most important specifications for gravimeters, and the ones used to answer this question, are their precision and accuracy. The terms *precision*, *stability*, *accuracy*, *sensitivity* and *uncertainty* are often confused or misused when discussing measurements and are explicitly clarified here. When reading about or discussing weak signals such as gravity, it is important to check or clarify the intended message and ensure that the difference between accuracy and precision has not been lost.

Precision is synonymous with stability, sensitivity or variance, and can be thought of as the ability to make repeated measurements and get the same results reliably. An example is the grouping of shots when aiming at the same point, as demonstrated in Figure 6.

Accuracy is synonymous with uncertainty or drift, and can be thought of as the confidence that the values measured are correct. To use the same example, this is the average distance of shots from the point of aim or centre of target from an incorrect zero in the sights.

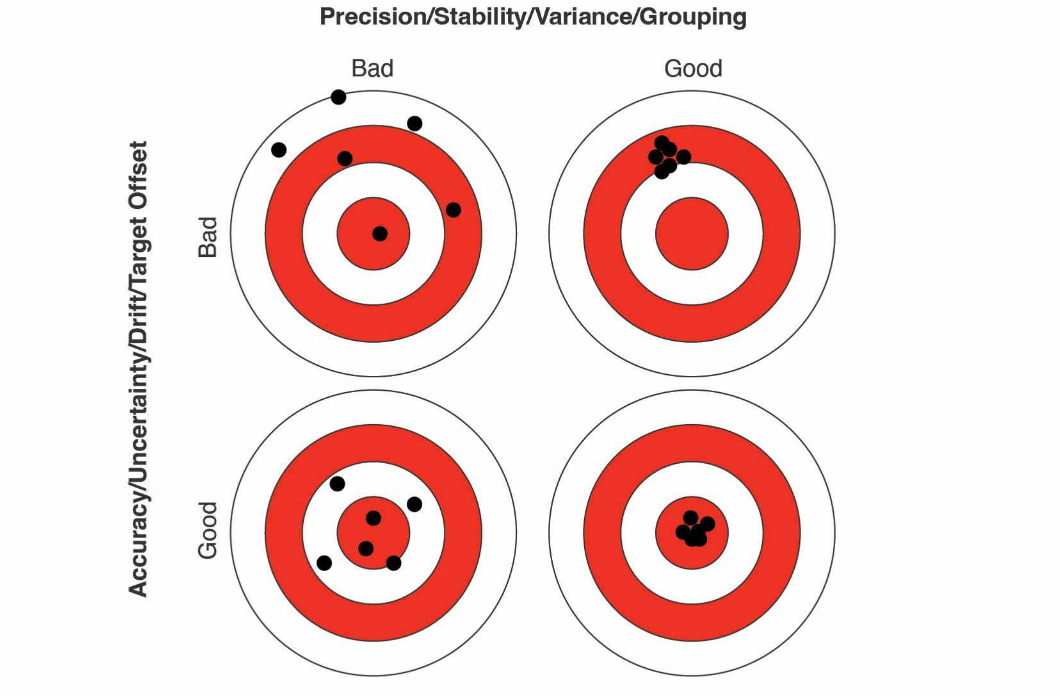

Figure 6: Six shots at a target, demonstrating the difference between accuracy and precision, with common synonyms included for each axis. The aim is fixed at the centre of the target for all shots.

It is common to find gravimeters that have excellent precision and can make sensitive measurements of gravity over a short time but with bad accuracy. This typically manifests as a drift in the sensor over multiple hours and days. While this may sound detrimental, there are many scenarios where the long-term accuracy of a measurement is unimportant. For example, there is no need for long-term stability to map the presence of a small tunnel system. The measurements in Figure 2 were made with a device with excellent precision but no inherent accuracy. However, for the use case of monitoring the movement of mass underground, such as the levels of a concealed stockpile, it is essential to have a stable, accurate device so that any observed long-term changes can be attributed to a change in the stockpile level and are not just the drift of the sensor over time. This drift is demonstrated in Figure 7 (purple signal), where the gravimeter with random drift would be able to identify a mass change of 1,000 kilograms at a depth of 2 metres in a few minutes. However, it would be unable to track that change over hours due to the inherent drift of the sensor, which generates fictitious signals that mimic the subsurface mass change. To use the previous target shooting example, this is the zero of the sights drifting over time.

This leads to the question, 'What is the minimum accuracy of a sensor?' and, more precisely, 'When is the minimum accuracy for a sensor achieved?'[16] In this article, devices will be quantified by how well they can perform in a 100-second measurement. This gives a typical real-world survey precision and is a typical time needed to reach optimal precision of the CG6 gravimeter (the best precision commercial gravimeter). The best-in-class performance for different gravimeter technologies is shown in Table 2.

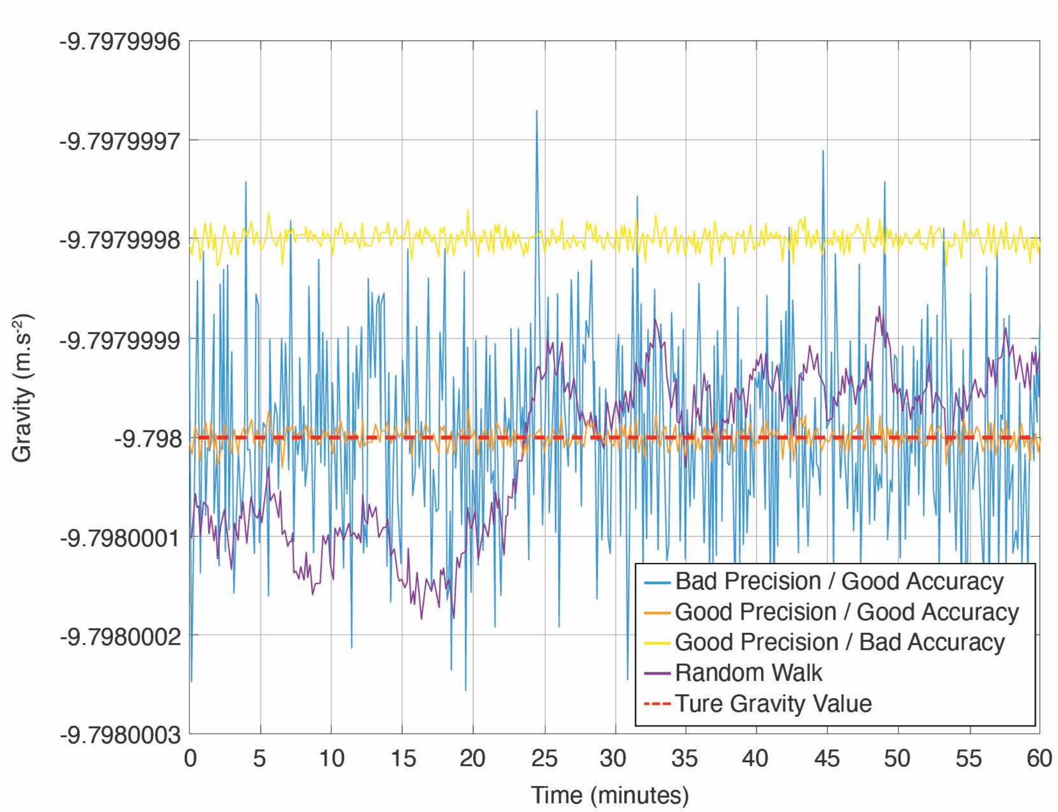

Figure 7: Various simulated gravimeter measurements over an hour. The purple data shows a random walk typical of relative gravimeters with good precision but a long-term accuracy drift. Such a sensor would, over a short time, be capable of identifying a mass void as small as 1,000 kilograms at 2 metres deep, but it would not be able to track changes over time.

Additional Challenges in Measuring Gravity

Simply because a gravimeter's specifications might meet requirements, it does not mean that there are not other potential problems. There are three other critical limitations: firstly, the contamination of the gravity signal with motion of the platform or vehicle it is mounted on; secondly, the levelling requirements for a single-axis gravimeter; and finally, the altitude of the gravimeter as it moves through Earth's gravity gradient.

The motion of the measurement platform matters; that is, if the gravimeter is mounted in a moving system such as an uncrewed aerial vehicle, movement of that vehicle will influence the gravity measurement. Physically, there is no way to differentiate between the acceleration signal of the sensor platform caused by its motion and that of the gravity signal from any surrounding density variations. This is why internal navigation calculations require a model of local gravity. This problem can often be overcome either through filtering of the signal, through use of a gravity gradiometer to reject the platform motion, or through an external position correction using a source such as GPS or lidar.

For a single-axis gravimeter, the device needs to be well aligned with local gravity, or the tilt will show as a reduction in gravity. For example, to measure a 10^{-7} $m.s^{-2}$ signal, a single-axis gravimeter needs to be levelled to less than 0.01 degrees from vertical. This challenge can be overcome with level sensors but typically requires human involvement or complex active levelling systems.

The final challenge in measuring gravity is knowing the sensor altitude sufficiently well to remove the earth's background gravitational gradient. The vertical gravitation gradient signal generated by the earth is approximately -3×10^{-6} s^{-2}, meaning that for every metre of altitude a gravimeter gains, its measured gravity signal changes by -3×10^{-6} $m.s^{-2}$ and therefore the measured signal needs to be compensated for this altitude shift. This puts a requirement on the necessary altitude measurement needed to resolve a specific gravitational signal. For example, if a device takes measurements over an area with a 0.1 *m* uncertainty in altitude, it will be unable to differentiate a gravitational signal below 3×10^{-7} $m.s^{-2}$. To achieve measurements of gravity below 10^{-8} $m.s^{-2}$, altitude must be known to a precision of 3 *mm*. The requirement to track altitude changes is the reason why an RTK GPS was used to take the data in Figure 2, and meeting the required altitude precision for the expected signal is needed in all gravimetric surveys. In commercial gravimetry surveys, this is commonly solved with GPS or a total station.

Gravimeter Technologies

This section will break down the types of gravimeters by their underlying technology, using real-world examples in the commercial and research spaces. There is some historical uncertainty around the first measurements of gravity but the best known is the measurement made by Galileo Galilei, who measured gravity in the 16th century using a ball rolling down an inclined plane. Further measurements were performed by Eötvös using torsion pendulum-based devices in the early 20th century[17] with demonstrations of detecting the gravitational pull of nearby mountains. Each technology will be described in the following subsections, and the best-in-class device specifications will be listed in Table 2.

Relative Gravimeter (Mass on a Spring)

Based on the solution to a university homework problem, Romberg and LaCoste developed spring-based gravimeters in 1931.[18] These devices formed the basis for the modern relative gravimeter. The underlying principle of operation for these devices is that of a mass on a spring.[19] Under the influence of earth gravity, the mass will pull on the spring and stretch it to a set displacement. If the acceleration of gravity changes, this displacement will change based on the known spring constant. Spring-based gravimeters are the most commonly used portable gravimeters and can typically be carried and operated by a single person, as seen in Figure 3. They can have incredible precision but lack accuracy and typically have bad long-term drifts. This makes them ideal for performing detection and mapping surveys, such as the work done with the CG6 gravimeter[20] in Figure 2, but unsuitable for long-term subsurface monitoring applications.

Superconducting Gravimeter

Superconducting gravimeters, developed in the 1960s by Pothero and Goodkind, utilise the magnetic levitation of a spherical superconducting test mass.[21] This design is an effective iteration of the classical spring-based gravimeter; however, the spring force is provided by a lossless superconducting electromagnet holding the superconducting sphere against gravity. The incredibly low loss of these systems means that they are the most sensitive of all gravimeter types ever built.

However, these devices have some severe disadvantages. Firstly, they must operate cooled by liquid helium (4 Kelvin) and cannot be allowed to move above their critical temperature. Secondly, they are relative devices that can only measure changes in gravity. Lastly, they cannot be moved or altered in any way without fundamentally changing their operation set points. These limitations mean that superconducting gravimeters, while capable of reaching the necessary sensitivities for all applications, are unlikely to be of use in an Army context and there are no obvious technological pathways that would enable this technology type to become a portable sensor in the future.

Falling Corner Cube Gravimeter

The next technology to discuss is that of the ballistic free fall gravimeter. This was first developed by Faller in the 1950s[22] and is based on the principle of dropping an object in a vacuum and measuring its position while undergoing free fall. To achieve world-class accuracy and precision, these devices require the position to be measured with an optical interferometer, where the falling object is a mirror that makes up part of the optical system. Niebauer developed the current generation of these devices,[23] which have been the gold standard of gravimetry since the 1990s. The advantage of this technology is that it is inherently accurate, measuring the free fall of an object with reference to atomic clocks and atomically locked laser wavelengths. However, the devices are not easily portable, weigh over 100 kilograms and require technical expertise to set up and operate.

These devices meet both the precision and accuracy requirements for all discussed gravimetry applications. However, the existing commercial devices are bulky and difficult to use. They operate more like a small portable laboratory than a robust self-contained sensor. However, as discussed in literature,[24] there are still possible improvements to be made in this technology space.

Cold Atom Interferometer Gravimeter

In the 1990s, when falling corner cube gravimeters were commercialised, the cold atom interferometer (CAI) gravimeter was pioneered by Kasevich and Chu.[25] Using the experimental realisation of atoms that could be cooled down to near absolute zero, Kasevich and Chu demonstrated that these small clouds of cold atoms could be used as the test mass for a gravimetric sensor. It should be noted that cold atoms provide no inherent advantage in measuring gravity, as the universality of free fall means that any dropped mass will accelerate equally.

This type of gravimeter has been one of the primary focuses of quantum sensor research. However, there are many parallels between the cold atom gravimeters and the falling corner cube gravimeters. Both commercial offerings of these devices are large portable laboratory type devices, reaching similar levels of precision and accuracy. The quantum nature of these devices has not yet shown a significant improvement over the previous technology for a commercial device.

One area where cold atoms have a clear technological advantage is in the construction of a gravity gradiometer, where a single interferometer laser can operate on multiple atomic clouds to remove systematic effects.[26]

Much of today's gravimetry focus is on this technology, and it is considered a favourable competitor for pushing the field forward. However, it should be noted that the complexity overhead of laser cooling atoms should not be underestimated. Until a commercial entity can show a maintenance-free portable sensor, they are unlikely to see use in the land forces.

Micromechanical Gravimeters

Lastly, it would be remiss not to discuss the fields of micromechanical devices. Encompassing optical resonator readouts, mass on springs, optically levitated nanoparticles and micro-electromechanical systems (MEMS), this is the most widely varying field of gravimeter/accelerometer. Your smartphones contain a three-axis MEMS accelerometer capable of measuring gravity; however, it is neither accurate nor precise enough to measure subsurface signals like the ones discussed in this article.

Recent work in this field suggests that these micromechanical devices may be able to compete with the mass-on-a-spring gravimeters discussed earlier. This is a potentially fruitful field that could leverage the existing silicone processing chain to manufacture smaller and cheaper devices.[27]

Table 2: Specifications for each gravimeter technology that is the current best in class, to the nearest order of magnitude (published data).

Technology	Type	Precision at 100 s ($m.s^{-2}$)	Long-term survey	Weight / portable
Spring[28]	Relative	10^{-8}	No	8 kg / yes
Falling corner cube[29]	Absolute	10^{-8}	Yes	100 kg / with setup
Superconducting[30]	Relative	10^{-10}	Yes*	100 kg / no
Atom interferometer[31]	Absolute	10^{-8}	Yes	100 kg / with setup
Micromechanical[32]	Relative	10^{-7}	No	5 kg / yes

*Superconducting gravimeters are only capable of long-term surveys in a single measurement run.

Table 2 shows the current state of the art for these gravimeter technology types, and should be considered in conjunction with Figure 8. It can be seen that for most technology types, a limit of about 10^{-8} $m.s^{-2}$ in a 100-second integration has not yet been beaten. Part of this probably relates to the fundamental microseism noise and the sea of problems around 10^{-10} $m.s^{-2}$. However, there is no fundamental science limiting these devices, and in existing applications, measuring at this level of precision and timeframe is adequate.

The other factor here is the size, weight and power (SWaP) of gravimeters. Looking at Figure 8, one might think that emerging technologies like CAI and MEMS gravimeters hold no benefit, but of course precision, while critical, is only part of the story. Some of the biggest gains to be made in gravimeter technology are in reducing the weight, size and complexity of these devices. Today, all commercial absolute gravimeters are effectively small portable laboratories that require a skilled operator. This will change with improved technology, and one of the key development areas for Army will be in the reduced form factor and ease of use that future devices will bring.

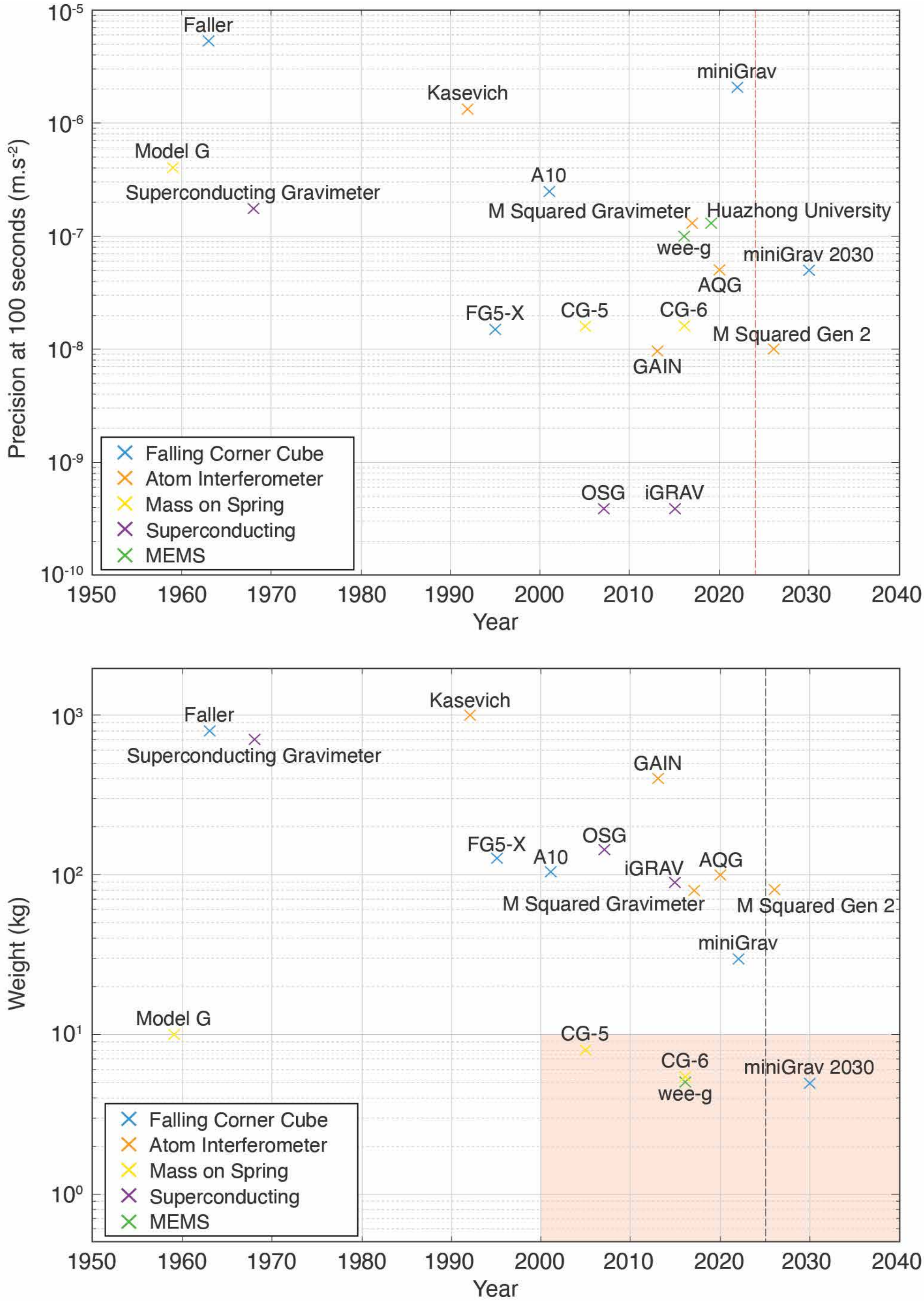

Figure 8: Development timelines of gravimeters in precision (top) and weight (bottom).

All gravimeter technologies except for superconducting types begin to hit a limit of around 10^{-8} m.s^{-2}. While further work could be done to push this precision, the applied use cases for these small signals are questionable and any sensor capable of short-term precision below 10^{-6} $m.s^2$ is of potential use. The more telling development factor is the improvement in weight and inherent portability. The red-shaded area indicates the ideal ground for sensor development, where the reduced form factor would be a key enabler for potential Army use cases. Some weights are estimated based on materials and photographs. References: Faller,[33] FG5X,[34] A10,[35] MiniGrav,[36] Kasevich,[37] GAIN,[38] M Squared,[39] AQG,[40] Model G,[41] CG5,[42] CG6,[43] Superconducting Gravimeter,[44] OSG,[45] iGrav,[46] weeg,[47] Huazhong University.[48]

Conclusion

This article has demonstrated applications for which gravimetry could be used in Army and has identified subsurface detection and monitoring as the best candidate for success. Impact and real-world measurements were taken to demonstrate this application utilising existing commercial sensors. Gravity detection is a unique sensing modality that cannot be blocked or jammed and is very difficult to fake. Its addition could be a valuable tool to augment existing subsurface detection methods, enhancing the utility of magnetometers, ground-penetrating radar and exploratory digging.

The underlying physical principles behind gravity measurements were explored, showing the expected signal strengths for various subsurface anomalies, and sensible limits were put on what could be physically achieved. Finally, various technology streams for different gravimeter types and their ongoing development have been investigated, showing a common trend where precision plateaus at the useful limit, but newer technology is making significant advances in reducing the SWaP of these sensors.

The most effective way to progress this technology within Army is to begin testing and using the current-day technology in field trials of the various applications. Commercial industry has already done the development work to build commercially available gravimeters capable of these applications. What is lacking is knowledge and experience in defence to apply and test these applications. Once clear use cases and applications are established, Army can feed back into the research and development pipeline with more explicit problem statements and specifications to refine particular use cases.

About the Author

Dr Samuel Legge is an experimental research physicist and Australian Army Research Centre Fellow (2023) working in the Research School of Physics at the Australian National University. He is part of the quantum sensors research group and specialises in lasers, quantum sensor development, experimental design, and fabrication.

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/ THE BOOK THAT NEVER WAS: ARMY'S CHANGED APPROACH TO THINKING ABOUT THE FUTURE, 1998–2000

David Connery

Looks Can Be Deceiving

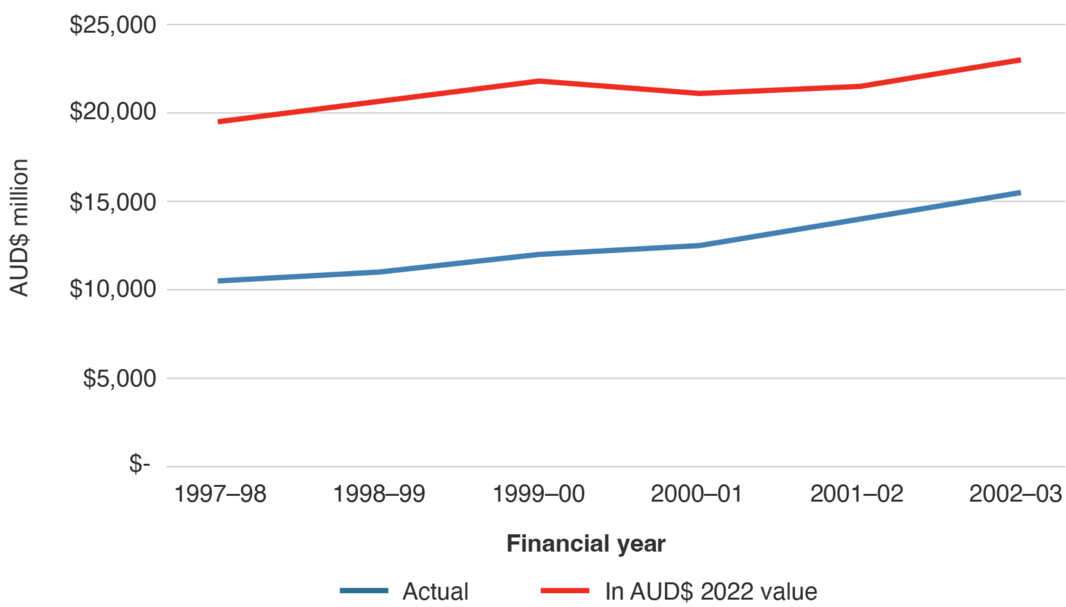
By early 2000, the Australian Army had just completed the most successful peace enforcement operation in modern history to date. The troops were welcomed home with a parade in Sydney that April; none of the angst or protest experienced during Vietnam War parades was on show. Public support for the Army was at an all-time high and political support, naturally, followed. However successful, this operation downplayed significant flaws and weaknesses that had been building in Army as a whole over the previous two decades. Change was needed, and it was up to the Army's leaders to provide a rationale for investment at a time when naval and air forces were the priority for Australian governments, whose strategic policy had been based on defending Australia since the 1970s.

This case study examines the period 1998–2000, when Army sought to influence strategic policy towards an 'expeditionary' posture and away from the 1970–80s priorities for defending continental Australia. In particular, this case study describes how then-Chief of Army Lieutenant General Frank Hickling, together with his deputy Major General Peter Abigail, prepared foundations for a future army while still meeting government expectations for combat-ready forces. These efforts were conducted within a rapidly evolving strategic and policy setting, which included significant global instability after the Cold War, major operations in the near region, and a nascent 'revolution in military affairs' based on emerging information and communications technology.

Hickling met the challenges of his day by using a two-pronged effort to create a new narrative for Army. While Hickling led an external effort to describe the Army's role in the nation, Abigail led the internal effort to develop a 'concept led–capability based' framework to describe Army's strategic role and guide its future development. As with all bold efforts within a large bureaucracy, this work featured progress, dead ends and setbacks, including 'the book that never was', *Future Land Warfare 2030*. Ultimately, this obscure work about possible future land force roles and technology was positive for Army because it provided a coherent story to influence policy, created new ways of thinking in a joint force context, provided support to an emerging experimentation function, and established a role for futures studies in the heart of Army Headquarters.

Army Must Deal with Two Strategic Environments

Events of the day usually dominate headlines and political attention. However, armed forces must think beyond the present, because planning large-scale expenditure to deliver equipment—and ultimately trained forces—takes years and the products stay in service for decades. This means armies must deal with a continuum of strategic environments: from the past to the immediate and into the distant future, often with waypoints in between. In practical terms, armies must divide their spending between maintaining the current force (described below by the shorthand of 'preparedness') and investing in a future force (known as 'capability development'[1]). They must do both, but the proportion spent on each might change due to priorities or policy. Coming to a decision on apportionment is an art that is especially complicated when budget allocations are falling (see Figure 1).



Source: Australian Strategic Policy Institute, The Cost of Defence Public Database

Figure 1: Defence funding (1997–98 to 2002–03)

Instability close to Australia and examples of modern warfare across the globe dominated the immediate strategic environment of 1998–2000. Of most concern was instability in Indonesia and the South Pacific. Major events included a 1987 coup in Fiji, which saw the ADF prepare—with inadequate capability—to evacuate Australian citizens from the island nation by sea and air. Further instability, triggered by the 1998 Asian Economic Crisis, prompted the political transition in Indonesia and ultimately the independence referendum in the Indonesian province of Timor Timur (East Timor). This instability led to the deployment of INTERFET, an 11,000-strong multinational force, for six months from September 1999. Papua New Guinea also remained troubled, even as a measure of peace was coming to the conflict-torn island of Bougainville. On top of this, Solomon Islands was experiencing violence that would ultimately lead to an Australian-led intervention in 2003. This situation saw Australian commentators refer to an 'arc of instability' that would come to be a major factor in Australian strategic policy and Army's employment over the next two decades.[2]

The South-West Pacific was not the only area of instability at that time. Brutal, low-tech local wars were raging in places such as Somalia, Cambodia, Afghanistan, Sudan and Rwanda. In Europe, Yugoslavia began disintegrating in 1991, leading to international interventions in 1995 and again in early 1999—this time based on a US-led air campaign in Kosovo. Taken together, the experience of warfare and the unstable strategic environment was broadly congruent with the existing Australian policy settings. These settings did not see a major power attempting to invade Australia, but did see a role for military force to conduct 'short warning conflict' (1994) or 'defend Australia's regional interests' (1997). Neither setting completely discounted conventional conflict. However, both were designed—in practical terms—to cope with the low levels of military capability possessed by regional nations and militias (albeit that some had increasing access to modern technologies).[3] Yet Australian guidance of the time ignored the importance of power projection over distances and the clear benefits of truly joint warfare.[4]

Even while these events were occurring, some military planners had their minds elsewhere: on assessments about the future strategic environment. The key features of the anticipated, and perhaps emergent, strategic environment were going through what some termed a 'revolution in military affairs' based on computers and information.[5] The 1990–91 Gulf War gave these 'futurists' glimpses of how information, precision firepower and manoeuvre would be decisive in conventional conflict, while the end of the Cold War two years before had made the existing strategic settings for many major nations redundant. This was especially so for the United States, and both the US Marines and the US Army launched major initiatives to conceptualise this strategic and technological change.[6] Their work influenced Australian thinking and provided some conceptual support for emerging policy change.

Australia's Defence Policy Changed Significantly over the 1990s

Given the lack of direct threats to the nation, Australian governments had since 1976, and especially after 1987, made the defence of Australia and denial in the 'sea and air gap' the main strategic priority. Added to this, successive governments were unwilling to send land combat formations overseas except on peacekeeping operations. This focus and its limits achieved political consensus within the governing Australian Labor Party and framed the 1994 Defence White Paper.[7]

The 'Defence of Australia' policy also meant the Army's main role was to defeat small and limited raids on the Australian mainland, with the lodging forces likely to have been either reduced by maritime forces or limited to small raiding parties. Given both the importance of interdiction as far as possible from Australia and the low likelihood that Australia would even experience raids, the Hawke-Keating government (1983–1996) prioritised investment in forces required in the 'sea-air gap', especially command and control, intelligence and surveillance, and maritime forces including fighter aircraft, frigates and submarines.[8] Investment in land combat and logistics would be restricted to creating and supporting light forces for overseas deployment, and forces for operations in northern Australia. The government also decided to move much of Army's combat force to northern Australia. This included moving key units of the 1st Brigade from Sydney to Darwin, starting in 1992.

Then-Chief of Army Lieutenant General John Sanderson knew further change was needed to meet the government's expectations. So he initiated the Army 21 (A21) review of 1995 and the subsequent Restructure the Army program, or RTA, starting in 1997.[9] RTA was an innovative yet highly controversial and indeed opposed initiative. The central feature of RTA was a new structure based on permanently organised, combined-arms, battalion-sized task forces suited to protection operations in northern Australia. It recognised the vast distances involved in the task of defeating raids, and the need for high degrees of independence for each. This was concerning to many—including a number of Army's senior officers. The key objections to the RTA approach were that it reduced Army's ability to concentrate forces, mobilise into large formations and have sufficient heavy forces ready to conduct high-end conventional warfighting.[10] RTA was also criticised because it only held a small, light-scales force for deployment into low-threat environments.[11] Further, RTA was described as being an 'end-point' for development with no concept for how the force would change over time.[12] The plan itself was 'resisted' and this impeded implementation.[13]

More important to the next stage of Army's development—vastly more than all the internal criticism of RTA—was a change in defence policy. The first defence policy statement of the Howard government (1996–2007) attempted to differentiate the new from the old, and presented a caricature of the previous government as narrow isolationists. The new policy headline was 'a secure country in a secure region', which significantly broadened the focus of defence policy from defending Australia.[14] Now 'our defence planning recognises that the Government may decide that such a commitment (to defending regional interests) is warranted' and made developing suitable capability its second priority.[15] This was a significant change from 1994, although land forces remained a low priority and Army remained focused on developing the RTA task forces.[16]

RTA was still in progress in 1998 when Lieutenant General Frank Hickling was appointed as Chief of Army. Hickling was a highly experienced commander. He began his career in 1960 and, after graduation from Officer Cadet School Portsea, was allocated to the Royal Australian Engineers. Subsequent postings and promotions saw him appointed as second in command of an engineer squadron in Vietnam. Later postings and commands included 2nd Field Engineer Regiment in 1979–80 and 1st Brigade in 1988–89; joint roles in Northern Command and the Australian Defence Force Academy; and commander of Army's Training Command and then Land Command.

Hickling's first tasks on becoming Chief of Army would include defining Army's situation; increasing ministerial, Defence and public understanding of what that meant for Australia; and making the case for why change was needed. He would marshal some very useful resources, including his deputy, his own headquarters and an internal 'think tank' called the Land Warfare Studies Centre (LWSC), which had been established in July 1997 by Lieutenant General Sanderson.

Hickling Saw the Need to Change Army's Direction

The effects of strategic change in the region—particularly in Indonesia—were hard for Hickling to foresee in 1998, but he already understood one new factor: the coalition government under John Howard wanted to take a different view of the role of military forces in promoting Australia's interests. In Hickling's view, the Howard government's more 'outward looking' policies required an 'expeditionary' capability that could deploy large-scale combat forces overseas.[17]

Yet Hickling took command of an Army that was far from ready for that kind of commitment. Urgent change was needed, but the Army lacked a narrative that could counter the powerful and entrenched logic of the 'Defence of Australia'.[18] So one of his first moves was to task Future Land Warfare Branch (FLW Branch) and the LWSC to develop a new narrative about the strategic role of land forces.

Within three months of his appointment as Chief of Army, Hickling asked Dr Michael Evans, a former officer in the Rhodesian Army and then a research historian at the LWSC, to produce a short explanation of the Army's role in a maritime strategy. Evans's paper pointed to the gap between the coalition government's declared maritime strategy and the Army's force structure for defending the continent. At the same time, Evans argued that the existing maritime strategy was too 'navalist' and failed to make use of highly mobile and flexible land forces. He urged Hickling to 'seek a more proactive role' within the maritime strategy and develop a structure that could conduct a range of missions, including 'littoral-expeditionary operations'.[19] Evans would have discussed these ideas with senior Army leaders, for these were soon to become central and controversial features of the next stage of Hickling's efforts to reframe the narrative.

The development of new capstone doctrine, Land Warfare Doctrine 1: *The Fundamentals of Land Warfare* (1998), took only a few months longer to produce.[20] A product of FLW Branch, this new doctrine was both intentionally forward looking and controversial. The former characteristic came from the interaction of the idea of 'concept led, capability based' force development with a significant elaboration of the 'revolution in military affairs' and its implications for Army.[21]

While retaining congruence with the 1994 edition of *The Fundamentals of Land Warfare* in the way it defined war, the 1998 edition was far more aggressive in tone. The explicit references to 'warfighting' and its description as 'the unique and critical function that the ADF provides to the Government' attempted to break the view that armies should focus on less violent tasks like peacekeeping and protective operations. Yet the real difference from the 1994 edition was the idea foreshadowed in Evans's paper of the Australian Army as an 'expeditionary force' and the reconceptualisation of the 'air and sea gap' as a 'littoral' space that was available for manoeuvre. This new narrative would, in defence bureaucratic terms, be the framework for Hickling's efforts to convince external audiences to support his vision for the force.

Army's new doctrine attracted controversy. One academic criticised the warfighting emphasis, describing it as 'highly selective' in terms of roles, as providing 'inadequate guidance' for leaders, and as 'unreflective of the Army's contemporary experience'.[22] It was also subtly damned by the architect of the 'Defence of Australia' policy, Paul Dibb, who noted the Army lacked the budget to implement its doctrine.[23] Still, *The Fundamentals of Land Warfare* was launched with some fanfare within Army and was a clear attempt to officially reframe the Army's strategic narrative, even if details (and budget) were lacking.

A High-Risk Play

Hickling's next step was to make a public case for change. In a combative and direct speech to Canberra's National Press Club on 14 April 1999, Hickling attempted to completely change the narrative about the role of, and need for, a combat-oriented Army.[24] His speech ranged broadly, including over the pace and direction of technological change, regional stability, using Reserves, and Army's commitment to a maritime strategy. As part of this strategic approach, Hickling reminded his audience that the Army existed to defend both continental Australia and the nation's interests, wherever they might be:

> A maritime strategy also recognises the need to defend Australia's interests in the region and globally, as well as direct defence of our sovereignty. And it also means that we must be able to exert influence, by adding weight to diplomacy, particularly in our region.[25]

The addition of 'national interests' was seemingly uncontroversial but it had important implications. To defend Australia's global and regional interests, its Army needed to be capable of more than just protecting vital assets at home. It would need to be deployable, bring real firepower and be able to survive in combat. While his warnings about the changing strategic circumstances, his comments on the inadequate funding assigned to Defence and his relentless focus on warfighting attracted the most attention, it was the concept of an expeditionary army that would have the most influence on subsequent work within Army Headquarters.

While partially covered by recent government decisions to raise the readiness of 1st Brigade and by the increasing concern about violence in East Timor, Hickling's approach was very risky on two fronts. Firstly, his speech placed Army outside Defence's consensus-based decision process of the day. While his position reflected an analysis of policy that was arguably ahead of the rest of the department, his direct appeal to public opinion challenged the 'Defence of Australia' orthodoxy and a decade's worth of investment planning. Consequently (and according to Hickling), the speech was not well received by others:

> There was a good deal of internal friction resulting from what I had said. This was because I was taking the Army in a different direction without going through the committee processes.[26]

Placing himself outside the established policy process effectively repudiated the consensus-making norm that dominated Defence. At best, such an approach might shape a new consensus by highlighting the flaws in current policy. At the worst, this approach could have extensive implications for Army across all areas of bureaucratic activity as others might seek to 'rein in' the non-conformer by opposing other proposals. After all, bureaucratic processes can be hard to work at the best of times—added friction makes simple tasks hard.

Hickling added to the risk by not gaining clearance for his speech beforehand. This challenged the 'no surprises' norm associated with high-level policymaking:

> This was very much a 'crash through or crash' policy! Of course, the Minister was furious but I had nothing to lose. Even if I was sacked, I still would have achieved my purpose; and I assessed, correctly, that CDF Barrie wouldn't stand in my way.[27]

There is no indication that such a dramatic move was contemplated, and his speech was vindicated by the intervention into East Timor five months later and subsequent operations after the 9/11 terrorist attacks on the US. Nor was the speech a 'standalone' effort. The work done within Army Headquarters to prepare the ideas and logic meant that Hickling was well positioned to argue his case in other forums, including a parliamentary inquiry which started a month later.

Looking to Parliament

The 'Phantom to Force' inquiry, which started in May 1999 and reported in September 2000, provided a more expansive outlet for Hickling to make Army's case. Care and thought were needed because this kind of engagement is fraught with downside. Parliamentary inquiries are largely public and often contested, so they can go in unanticipated directions. This meant Hickling needed to balance competing tensions through the narrative he presented. On one hand, Hickling needed to present the facts as he saw them and present a forceful statement. Yet he also needed to protect the Army's reputation and deterrent potential, and avoid accusations that the significant amount of money spent on Army was wasted.

This tension was resolved through a narrative that was nuanced in its presentation. While Army was not willing to write off its ability to fight altogether, its existing capability was described to the parliamentary committee in June 2000 as (author's italics):

> The Army presently has *some* capability for warfighting in a *medium to high-threat* environment. Australia would be able to offer a brigade-sized contingent for a warfighting contingency in a coalition setting, but with *considerable risk*, and it is likely that the contingent would be *deficient* in aspects of firepower, manoeuvre and force protection. Examples of areas that suffer capability limitations include ground-based air defence systems; rotary wing assets and indirect firepower assets; and nuclear, chemical and biological defences.[28]

The caveats are worth highlighting: 'some capability', 'considerable risk', 'deficient in aspects'. Any of these would be concerning for Defence leaders, but when issued together they were alarming. This passage should not be disregarded because it was written to influence a parliamentary committee. It was cleared by Hickling, and (this time) was briefed to the Chief of the Defence Force, the Secretary of the Department of Defence and the Minister for Defence. That the bipartisan Joint Standing Committee on Foreign Affairs, Defence and Trade agreed with the assessment shows that Army's dire self-assessment was generally accepted by others without a vested interest.[29]

The caveats used in Army's submission described an Australian Army that was now really only useful for operations in low-threat environments unless a government was willing to take significant risk. To draw a contrast, the Australian Army of 44,000 that deployed for a decade during the Vietnam War was fully interoperable with the US Army. Thirty years later, the Australian Army of 24,000 was no longer able to fight in an environment that was any more threatening than that experienced in the 1960s, while the US Army had developed capability to fight massed manoeuvre warfare against the Soviets and was experimenting with leading-edge capabilities involving precision weapons and information.

While Army was presenting this argument in public, it was also preparing its internal processes to create change. Clearly, keeping pace with technology was a priority but the resources available were needed to sustain the force in East Timor, not prepare for a future high-tech war. Hickling needed to broaden the focus of effort, and this was perhaps his most important decision as a strategic leader. He delegated the task of creating a narrative about the future Army, and building coherent internal processes to realise it, to his energetic and creative deputy, Major General Peter Abigail.

New Leaders Bring New Ideas

Major General Peter Abigail enlisted in 1965 and attended Royal Military College. He saw combat in Vietnam, and later commanded the Army's parachute battalion and 3rd Brigade. He had also marked himself as an expansive thinker, which saw him promoted to be Head Strategic Policy and Plans in Defence in 1996. This positioning provided him an excellent platform for growing and maturing ideas that would become useful when he was appointed Deputy Chief of Army in June 1998.

One of Abigail's first contributions to reshaping the Army's strategic narrative was the Army Model (Figure 2).[30] This model, developed as an iterative process on Abigail's whiteboard and PowerPoint slides, helped explain that Army was more than just the force actually deployed on operations that would be drawn from the Townville-based ready deployment force. Creating that deployed and deployable force was the combined effort of a 'latent combat force', an 'enabling component' and a national and international support base. Each component had shared and specific functions, which together described what an Army did. These functions included combat operations, deployment, force generation and sustainment, and force protection.[31]

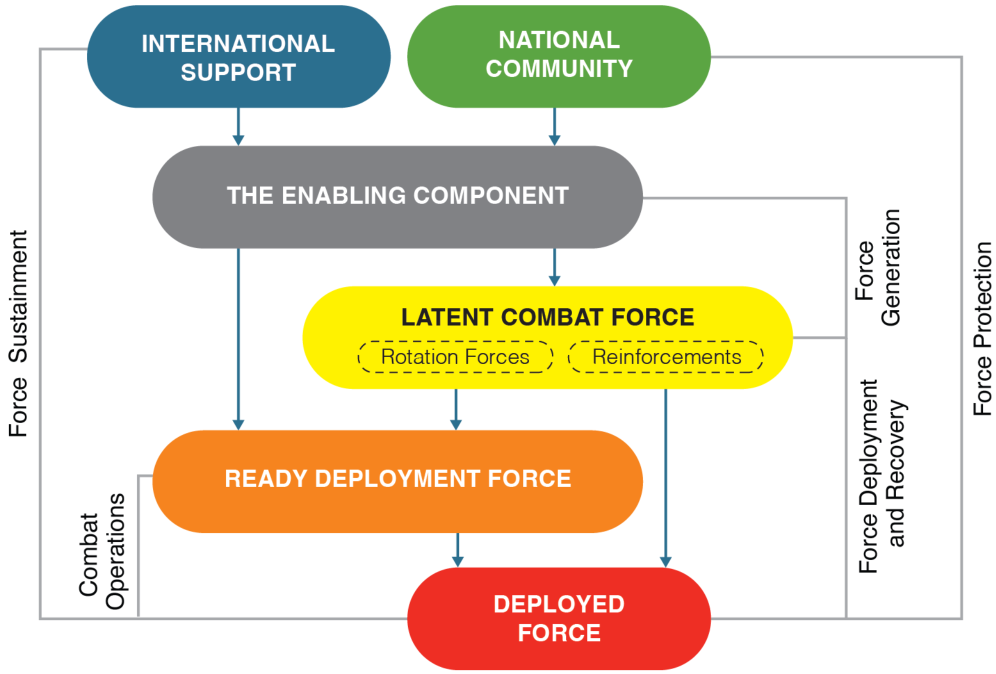


Figure 2: The Army Model (1999)

Another key set of ideas became the Army Continuous Modernisation Process (ACMP). The goal of the process was, as set by Hickling, for Army to become 'potent, versatile and modern'.[32] These characteristics would be developed over time as the existing Army, or 'Army in Being' (AIB) transitioned over the next 15 years into an 'Enhanced Combat Force' (ECF). This development process would be supported by an 'Army After Next' (AAN), which was a group of concepts and initiatives that could be 'backcast' into force development plans. This construct allowed Hickling and Abigail to show a logical path from the present to the future, using a 15-year waypoint to guide planning and potential equipment acquisitions. Together, the Army Model and continuous modernisation concept anchored the idea of Army being 'concept led and capability based'.

The 1999 ACMP started with a self-critique that cogently presented a case for change:

> Too often we have defaulted to the simple replacement of capital items when they reach life-of-type. Such an approach risks the perpetuation of outdated concepts and doctrine and a future force ill prepared for conflict.[33]

This required some change in Army's force planning practices, which had been 'uncoordinated' for too long and reluctant to think about the future.[34] This plan would help Army balance investment between preparedness for the present and future investment, and its products would be warfighting concepts and 'Army Capability Output' development plans (Figure 3).

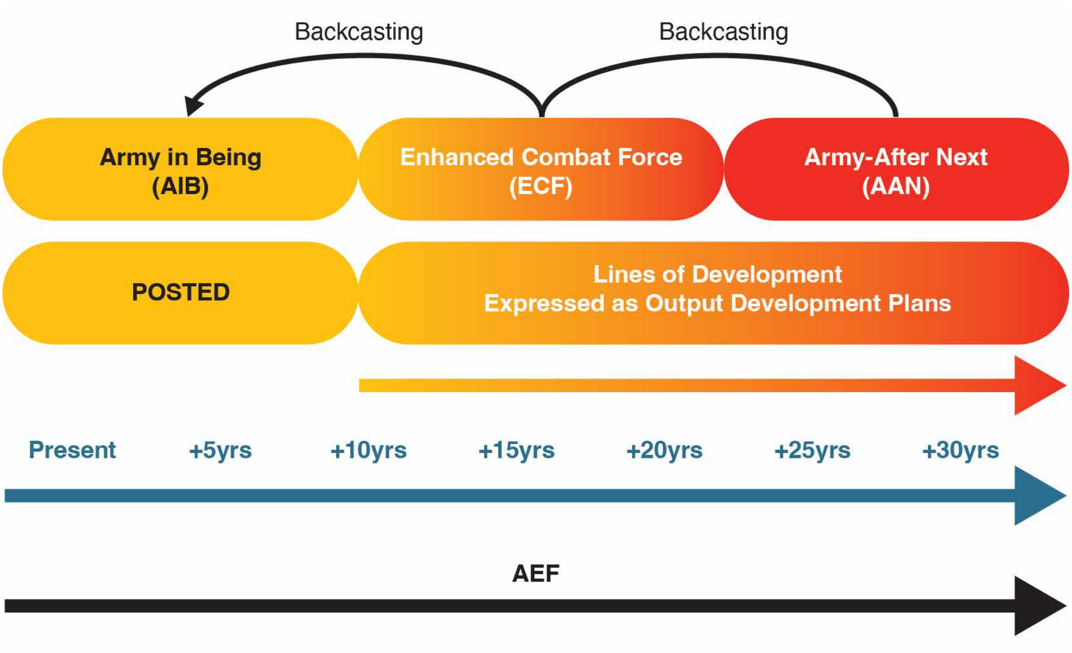


Figure 3: The AIB–ECF–AAN continuum (1999)

POSTED - inputs to capability comprising People, Organisation, Support, Training, Equipment and Doctrine (analogous to today's 'Fundamental inputs to Capability')

AEF - Army Experimentation Framework

New Leaders Bring a Supportive Leadership Climate

Key organisational activities like the ACMP reinforced Hickling's and Abigail's desire to avoid the 'slam dunk', as they perceived A21/RTA. They wanted to show Army that ideas were up for debate.[35] This type of leadership climate led to more Army elements being involved in the development process, primarily to expand the 'buy in' from its members. According to his senior officers of the time, Hickling 'had a genuine, understated way of putting out his narrative and it was OK for people to comment'.[36] This was carried through by Abigail, who 'used ACMC [Army Capability Management Committee] like a debating society' to test ideas and generate new ones. The effort would not create an end point: it would be a 'continuum' of work that would require constant effort and engagement.[37] Buy-in was also important because Hickling needed to generate more horsepower from outside Canberra after the Defence Efficiency Review and subsequent reform program limited Army Headquarters to 100 staff. Investing in FLW Branch—which grew to around a quarter of Army Headquarters by early 1999—showed the priority Hickling would give to modernisation. But most of the staff effort for planning would need to come from the newly formed, Puckapunyal-based Combined Arms Training and Development Centre (CATDC) and the Sydney-based Land Headquarters if ideas were to become a reality. Most importantly, this method sent a message that Army's approach under Hickling would be different.

This open and inquiring approach was becoming built into Army Headquarters processes. Abigail would conduct sessions with his key staff on 'big ideas', which often revolved around diagrams and dichotomies: 'his strength was his visual thinking and he loved diagrams', recalled then-Director-General FLW Branch (DGFLW) Brigadier Mike Smith.[38] Then-Colonel Justin Kelly recalled how Abigail actively drove the discussion and added to the arguments; as Kelly recalled, Abigail 'was not a passive observer'. Then-Lieutenant Colonel Andris Balmaks also remarked how Abigail 'pushed the envelope to challenge the thinking of ASP97 [Australia's Strategic Policy 1997]' that the Army was only preparing to fight as if Australia were a 'land locked nation'. This insight helped people to see the near region not as a 'sea and air gap' but as a littoral environment that was a space for manoeuvre in sea, air, land and cyber domains.[39] Abigail's 'campaign plan' for realising this approach was multifaceted; it included a framework based on 'continuous modernisation', an experimentation program, and concept development using new, forward-looking publications.

The New Climate Sought Evidence

Experimentation was a cornerstone of the ACMP, for these activities were to provide 'analytical rigour to support ongoing Army modernisation'.[40] The idea to experiment with force structures came from A21/RTA, starting with field trials based on 1st Brigade and 6th Brigade in 1997–98. The first major activity under the ACMP was named 'Headline 99', which tested the RTA Phase 2 'deliverable' of EXFOR1 (Experimental Force 1), or the initial ECF. It should be noted that the ECF of 1999 was very different in structure, combat weight and role from the independent task forces envisaged under A21/RTA and trialled in 1st Brigade.[41] Army's current leaders recognised that since ditching everything to do with A21/RTA was both bad politics and a risk to Army's credibility, it was more prudent to maintain the banner while changing the activities under it.[42]

Military experimentation was not a new idea, but modern computer technology and ideas borrowed from the United States Marine Corps added a depth of sophistication to the methods.[43] However, 'we came to experiment by accident' according to then-Colonel Steve Quinn, who was charged with closing the RTA trial. This lack of structure spurred the effort to create a better-planned and repeatable process that could be challenged logically.

The trials had shown potential to test ideas by changing variables, and key figures in Army soon saw the value in developing a more robust approach to capability development and analysis based on scientific method. Most importantly, experimentation provided quantitative evidence to support assertions by experts and move away from an argument-based approach.[44] The results of experimentation were soon found to be extremely useful in the committee environment, where the data was 'weaponised' to good effect by Army's leaders.[45] This approach also provided Army leaders with ways to test key questions and breaking points within the complex system, and so focus discussion on the places where decisions were most needed.[46] The key insights developed through this process included (in an Australian context) the ideas of close combat, littoral manoeuvre, complex terrain, 'wheels versus tracks' for certain applications, and the 'detection threshold'.[47] On the other hand, there was also a view that it took a significant period of time to produce 'confirmed' experimental results. In one view, this delay occurred because the experiments were insufficiently resourced to do them properly; in another view, the delay occurred because the Defence Science and Technology Organisation (DSTO) did not yet provide sufficient focus or clarity of objectives.[48] Despite these limitations, experimentation offered Army something new and it would continue into the future.[49]

The Headline experiments were managed under the Army Experimentation Framework (AEF), which was itself a subordinate element of the ACMP. The AEF was governed through a steering committee, master question and a five-year plan. It was also a clear partnership between Army and the DSTO, with the latter providing activity design and the analytical skills and modelling tools to make sense of the data and insights produced through the wargames and experiments. DTSO also took the lead in producing a number of supporting studies, one of which examined the definition of 'close combat'. This kind of work became a crucial element of Army's later plans to replace tanks and retain its warfighting capabilities.[50]

Experimentation Received Direction from New Concepts

Experimentation is more than just explorations of force mixes without context: successful experiments needed a guiding theme and an action to test. Concepts, which describe the military problem to be solved and approaches to be tested, provide the necessary base guidance. The concepts used by the Australian Army at this time were developed and publicised through a book that remained in draft form and was only ever officially endorsed by DGFLW. This was the book that never was: *Future Land Warfare 2030*.

Army had previously used 'concepts' in capability development, but the ACMP gave this device both a greater standing and centrality in the development process. From now, concepts would explain how the Army wanted to fight in future wars, and provide a 'clearly articulated vision' for capabilities to meet these demands.[51] Army's concepts would then be used to both influence the central Defence long-term planning process and provide a lead for Army capability output development plans.[52] These plans, once mature, would provide the guidance needed to produce capability proposals and acquisitions. Therefore, the initial concepts would need to bear significant weight if they were to withstand scrutiny and the contest associated with Defence capability development. Scrutiny would be especially challenging given that Army was now deviating from standard policy thinking.

Brigadier Mike Smith tasked Balmaks and then-Lieutenant Colonel Angus Campbell, with Major Mike Baldwin in support, to scope the concepts work in early 1999. The team quickly identified that writing credibly to influence future development will inevitably come back to today's budgets and policies. This would be a major problem, so they argued that concepts must not be constrained by today's settings at the outset. The work could be 'aspirational', which allowed them to cast the AAN as what Army 'would like to do' given their assessment of change.[53] Describing how an Army might fight was another challenge. However, this was quickly surmounted by using the established concepts of manoeuvre theory—an approach to warfare that was quickly gaining currency in Army and formally adopted in *The Fundamentals of Land Warfare*—as the philosophical basis for how the ECF and AAN would fight when using new technologies.[54]

After a pitch to Hickling in April 1999, FLW Branch and CATDC began work on two new concept books: FLW 1 *Enhanced Combat Force*, and FLW 2 *Army After Next*.[55] These books aimed to 'focus' Army's understanding of future warfare so that 'battlespace operating development plans' could be developed by the CATDC staff. Other audiences, such as the DSTO and logistics staff of Support Command Australia (Army), would also contribute to the work. Consultation with the other services and with parts of Defence was planned, but this would be an overwhelmingly Army effort at this stage.[56]

Drafting began with a working group involving Quinn and his team from CATDC's Force Development Group. While the effort would remain led by Balmaks and the FLW team, Quinn's team would provide analytical horsepower and maintain the link between the concepts and the intended outputs. The first writing group meeting, on 11 June 1999, started along those lines, and a number of broad concepts and framing devices were discussed and tested in that meeting. By the second meeting, on 23 July, it was clear that the 'two book' approach was creating duplication. While thinking about the AAN and ECF had been beneficial, the approach was also dragging the authors 'down into the weeds' and they were providing detail that was more appropriate to the subordinate output development plans. The changed approach would also undoubtedly help the project leads to maintain their very tight schedule, which required a full draft by the end of August 1999.[57]

FLW 2000—as the work was then tentatively titled—began to take its final shape in August. Its early contextual chapters were reviewed by different senior officers, with 'early feedback … that they are on the right track and informative'.[58] The second draft saw the three main warfighting concepts emerge from the outlines already provided in *The Fundamentals of Land Warfare*. These concepts were essentially geographically defined and based on existing strategic priorities, but they contained important divergences from, and extensions to, existing policy settings.

The first concept answered the 'Defence of Australia' strategic imperative that still remained a key constant in Defence thinking despite what was happening in Timor. The now-renamed 'Protective and Security Operations on Australian Territory' separated the threats to Australia into contingency operations against other military forces and homeland defence against non-state actors. This division was both prescient and different from existing policy because it downplayed the threat of raids and raised newer threats such as missile defence, cyber defence and counterterrorism to first-order concerns in the 2030 timeframe.[59]

The second concept—and where Army wanted to put its focus—was called 'Manoeuvre Operations in the Littoral Environment', or MOLE. By mid-1999, Army produced a diagram showing Australia's region divided into two sections. The first was 'the littoral', defined as 'the area from the open ocean, which must be controlled to support operations ashore, to the area inland from the shore from which that control can be contested'.[60] The littoral was depicted by coloured areas showing the ability of the expected ship-based and land-based missiles of 2010 to reach inland and seawards from the coastline (see Figure 4). The second area was the white space showing land more than sea-launched missile range from the coastline. The coloured areas displayed on the map were dominant and showed that every island in the Pacific and all of maritime South-East Asia was classed as littoral. From this, Army deduced a need to be able to project power ashore and seaward from the shore, perhaps unilaterally, to protect Australia's interests.

The yellow and red shading in Figure 4 indicates the range of ship-based land attack missiles and land-based anti-shipping missiles anticipated to be commercially available by 2010.

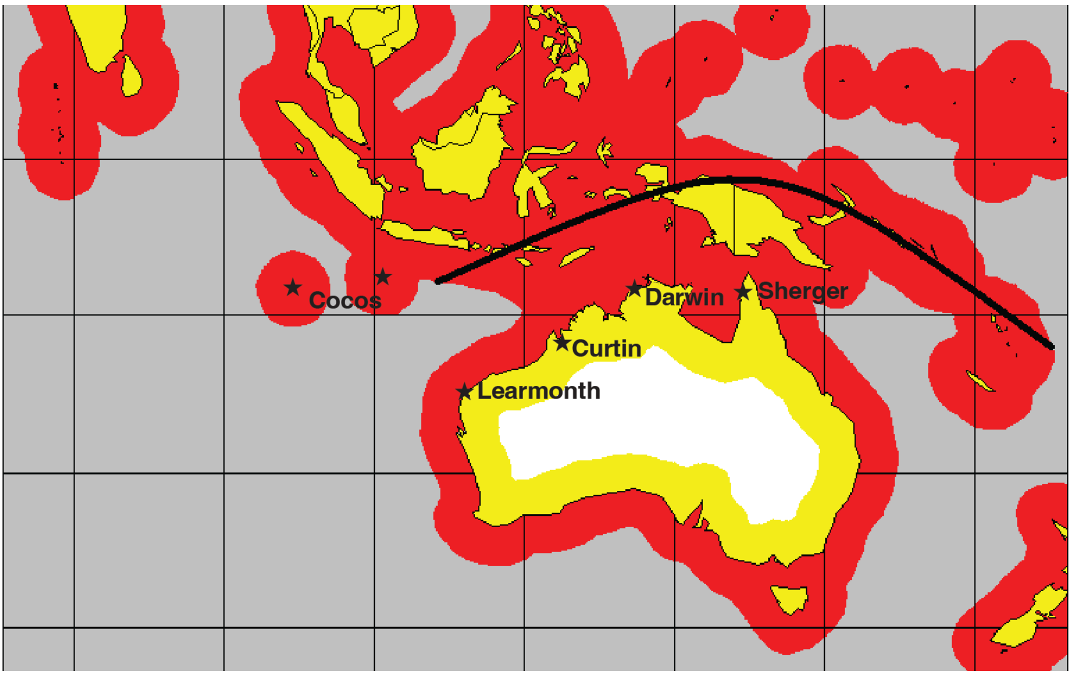


Figure 4: The littoral environment

The third concept was familiar ground for Army—providing 'contributions to coalition operations worldwide'. Dubbed 'CCOW', this concept identified the way Australia's use of armed force to protect its interests overseas had varied over time—'nevertheless, it is worth noting that unless the forces committed have the *deployability*, *lethality*, *survivability* and *interoperability* to undertake the missions assigned, they are unlikely to achieve the strategic outcomes desired'.[61] Army Headquarters thought all four characteristics were necessary to provide meaningful support to any US-led force. Without these characteristics—and without accepting an 'equitable share of the costs and risks'—the Australian contribution would not achieve the strategic objective.[62]

While *Future Land Warfare* 2030 was drafted as a staff product within Army Headquarters, the initial intention was to seek a wider range of contributions. An effort was made to bring Army's Command and Staff College into the process, with the aim of providing new ideas. This did not 'prove possible' at the time, and Steve Quinn thought the students were 'too afraid to take intellectual risks' while under the pressure of assessment.[63] The contribution by DSTO staff was considered 'really important' to the process, as they bought views about technology to the writing team.[64]

Quinn also saw a need and an opportunity to develop ideas in more detail than would be possible in a 'coherent and formal' document like *Future Land Warfare 2030*. He wanted somewhere for staff to do some 'creative risk taking'. As a result, he commissioned the 'WinNow' papers to provide an outlet for thinking about capability requirements for the future force. Quinn framed these as 'debate papers' to encourage further contributions. WinNow was a one-off production—regrettably, because it could have provided Army with an ongoing outlet for capability development thinking by junior officers and been an iterative vehicle for linking experimentation findings to the critical task of capability development.

While drafting *Future Land Warfare 2030* was hard, the task of exposing the work outside Army would prove tougher. Justin Kelly recalled the different reactions the work received when it was circulated to the wider Defence audience:

> Navy liked it, Air Force accepted it, but the Strategy people thought putting it out would muddy the waters for the White Paper. It said lots that wasn't said in the white paper like cyber and ballistic missile defence ...[65]

Balmaks agreed with Kelly on the views of the Strategy Group, and also recalled being 'hauled over the coals' in the minister's office over the draft paper. Ideas like arming the new 'unmanned aerial vehicles'—by then an existing capability but not yet employed in Australia—were considered objectionable.[66] The focus on missile defence and cyber manoeuvre was interpreted as Army 'over-reach', while the potential for non-state actors to effectively oppose Western states attracted 'you can't be serious' comments. However, Balmaks recalled the other services' views differently from Kelly. He thought Air Force—who were undertaking their own futures work, Project Oracle—were generally supportive but not all were thrilled with the idea of unmanned aircraft. Some resistance was met in Navy, as he recalled. However, then-Commander Ray Griggs, later Vice Chief of the Defence Force, supported the concept of littoral manoeuvre and so he 'he took a bit of a leap of faith on MOLE in supporting it'.[67]

Future Land Warfare 2030 ultimately foundered on the rocks of bureaucratic politics. The bad news was delivered to FLW Branch staff in mid-2000 by the Assistant Secretary Corporate Communication of the time, Ms Jenny McHenry. *Future Land Warfare 2030* would not be published, because its messages conflicted with those being developed for the forthcoming Defence White Paper. Since people could not be trusted to distinguish between policy and concept, *Future Land Warfare 2030* could only serve to distract and perhaps detract from the government's message.[68]

Consequently, the project was quietly shelved and a 'final draft' version was released, under the signature of then-DGFLW Brigadier Ian Gordon, in mid-2001. While the work did not have a lasting impact in itself, important aspects of it were revised in 2003 when the Army published its conceptual framework.

Future Land Warfare 2030, Experimentation and Other Concepts Supported Army's Narrative

It would be easy to dismiss an unpublished book, and one that some of the participants could hardly remember 20 years later, as a failure. However, they all recalled the way Army began to describe its strategic challenges and how it began to shape the case for further investment. A number also recalled how the ideas contributed to the requirements definition for Navy's future amphibious capability. This work also provided the base of argument and methodology for the next round of force development, which would become the 'Hardened and Networked Army' of 2003.[69]

The key value of *Future Land Warfare 2030* lay not in its coverage of trends and operations but in the way it helped Army form an institutional view about its desired future. Since concepts provided a way to express, debate and refine ideas, this written work helped Army create its narrative. The key elements of this narrative are expressed in concepts such as littoral manoeuvre, which described how and why the Army needed to be deployable offshore. Also, discussions about combat weight, survivability and firepower find their rationale in the CCOW concept and their expression through the ECF, which was used in experimentation and became an enduring theme for the next stage of Army's modernisation effort, which included the 'Complex Warfighting' concept and the Hardened and Networked Army initiative.[70]

Future Leaders Can Learn Much from Army's Experience of the Late 1990s

The 1998–2000 period was one in which, in some ways, events were going in the right direction for the Army's leaders. The East Timor operation averted the worst of the anticipated resource cuts to Army—indeed, the force would begin to grow from the end of 1999. The Defence White Paper of December 2000 would also provide Army with a rough formula for its preparedness levels. Still, the Army's actions and initiatives of this period provide three important lessons.

The first is the importance of understanding the strategic environment and explaining the service's role in it. In this case, Hickling reframed the debate in an uncontroversial way, by arguing the Army existed to defend the nation *and* its interests. This simple change allowed Army to shift its focus from the defence of continental Australia to a more expansive role in protecting interests, no matter where those interests lay or how they were challenged. While he was not completely successful, at least this change helped Army prosecute arguments in the ongoing competition for resources that characterises the strategic level.

The second is the value of a coherent narrative. This particular story starts with some frustration at the existing situation, and the glimpse of opportunity that came with the change in government policy. It took time and deliberate effort to build the narrative, and three elements were needed: consistency with the past, investment in idea generation, and ways to publicly expound those ideas. Hickling was careful not to 'trash' RTA, for to do that would have meant missing some good ideas and would have presented Army as a vacillating institution that could not be trusted with investment. Hickling used the LWSC—an initiative of his predecessor—to generate the ideas. That he tasked it directly to answer his most pressing problems shows how small research organisations can be used to inform and advocate. Advocacy is not just words on paper; it takes effort and a willingness to accept risk. Hickling's 'crash through or crash' approach, which was exemplified in the April 1999 National Press Club address, could have gone another way. That it did not shows that a strategic leader must have a thorough understanding of the context and of the nuances and tensions within the decision-making environment.

The third major lesson for strategic leaders is the need to create structures and a supportive command climate. No one person can come up with the ideas, let alone marshal the evidence needed to win arguments in a bureaucracy like Defence. Robust, well-channelled debate refines ideas, allows people to raise questions, and ultimately helps to create buy-in from the organisation. In some ways, Hickling was greatly assisted by the times, including by the reduction of his Headquarters staff and the changing strategic environment. But it was his leadership that counted most—and part of that leadership was allowing his deputy to run the process for him. Abigail's creative and methodical approach to building the system within Army is an example of how future strategic leaders might appropriate existing ideas for good use. In this case, Abigail used the emerging idea of futures studies, concepts and experimentation, and the broader 'revolution in military affairs' to provide the space needed to develop Army's case. In particular, the ability to situate Army's main arguments outside the budget and policy cycle—using the ECF and AAN—meant that Army's attack on the existing system was oblique and defensible. The approach was effective at the time, and it would lay the foundation for the role concept development and experimentation that remains at the heart of Army's force development work today.

About the Author

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ENDNOTES

1 'Capability' is a defence term for 'the power to achieve a desired operational effect in a nominated environment within a specified time, and to sustain that effect for a designated period' (Australian Defence Glossary). Capability is developed when essential inputs are combined and used to achieve government objectives. The inputs to capability used by Army at this time included personnel, organisation, support and facilities, training, equipment and doctrine. Army's named capabilities in 1998 were manoeuvre, fire support, intelligence and surveillance, mobility and survivability, information operations, air defence, command and control, and combat service support (Australian Army, *Land Warfare Doctrine 1: The Fundamentals of Land Warfare* (Puckapunyal: Commonwealth of Australia, 1998), Chapter 5).

2 Robert Ayson, 'The "Arc of Instability" and Australia's Strategic Policy', *Australian Journal of International Affairs* 61, no. 2 (2007).

3 See Commonwealth of Australia, *Defending Australia: Defence White Paper 1994* (Canberra: Australian Government Publishing Service, 1994), pp. 24–25; Commonwealth of Australia, *Australia's Strategic Policy* (Canberra: Commonwealth of Australia, 1997).

4 Michael Evans, *The Role of the Australian Army in a Maritime Concept of Strategy* (Canberra: Land Warfare Studies Centre, 1998), pp. 18, 24, 36–37, 40–41.

5 A 'revolution in military affairs', or RMA, occurs where new technologies or concepts change the character of warfare in fundamental ways. Past revolutions included gunpowder, powered mobility, and atomic weapons. See Lawrence Freedman, *Strategy: A History* (Oxford: Oxford University Press, 2013), Chapter 16.

6 Dan Gouré, 'Creating the Army After Next, Again', *Real Clear Defense*, 16 August 2019, at: https://www.realcleardefense.com/articles/2019/08/16/creating_the_army_after_next_again_114670.html. See also Paul E Menoher Jr, 'Force XXI: Redesigning the Army through Warfighting Experiments', *Military Intelligence Professional Bulletin*, April–June 1996, at: https://irp.fas.org/agency/army/mipb/1996-2/menoher1.htm.

7 *Defending Australia*, p. 5.

8 Ibid., pp. 32–34.

9 Renée Kidson, *Force Design in the 1990s: Lessons for Contemporary Change Management* (Canberra: Australian Army History Unit, 2017).

10 Major General (Retired) Michael Smith, interview, 2 June 2022. See also Kidson, *Force Design in the 1990s*, p. 5.

11 Brigadier (Retired) Justin Kelly, interview 12 May 2022.

12 Ibid. Michael Smith also noted that the Army Development Guide, a forerunner to A21 from the 1980s, was similarly 'flat' and had no real basis for creating change (Smith, interview, 2022).

13 Kidson, *Force Design in the 1990s*, pp. 20, 41, 44.

14 *Australia's Strategic Policy*, p. iii.

15 Ibid., pp. 32, 36.

16 Ibid., p. 65.

17 'An Interview with Lieutenant General (Retired) Francis Hickling', *Australian Army Journal* IX, no. 3 (2012): 14; Lieutenant General (Retired) Frank Hickling, interview with author, 10 August 2023.

18 Hickling, interview, 2023.

19 Evans, *The Role of the Australian Army in a Maritime Concept of Strategy*, pp. 3–4, vii.

20 *Fundamentals of Land Warfare*. This publication replaced the Manual of Land Warfare series of the same name that had seen various editions since 1977.

21 *Fundamentals of Land Warfare*, pp. 1-7 to 1-9, 4-5 to 4-18. Doctrine describes how the Army will fight its next battle, and forms the basis of training and preparation for operations.

22 And, it should be noted, it remained unreflective of the Army's experience for the next 20 years (with the exception of the special forces role in Iraq, 2003). Graeme Cheeseman, 'Army's Fundamentals of Land Warfare: A Doctrine for "New Times"?', *Australian Defence Force Journal*, November/December 1999, p. 6.

23 Paul Dibb, quote provided for rear cover of *Fundamentals of Land Warfare*.

24 'An Interview with Lieutenant General (Retired) Francis Hickling', p. 9.

25 Lieutenant General Frank Hickling, speech, National Press Club of Australia, 14 April 1999.

26 'An Interview with Lieutenant General (Retired) Francis Hickling', p. 9.

27 Hickling quoted in Nicholas Jans, *The Chiefs: A Study of Strategic Leadership* (Australian Defence College, 2013), p. 69.

28 Australian Army, Submission 47 to Joint Standing Committee on Foreign Affairs, Defence and Trade Inquiry into the Suitability of the Australian Army for Peacetime, Peacekeeping and War (2000), p. 14. Emphasis added by author.

29 Joint Standing Committee on Foreign Affairs, Defence and Trade, *From Phantom to Force: Towards a More Efficient and Effective Army* (Canberra: Parliament of Australia, 2000), pp. 5, 85–88.

30 Kelly, interview, 2022.

31 *Future Land Warfare 2030*, Chapter 1.

32 Australian Army, *Army Continuous Modernisation Plan, 1999–2004* (Army Headquarters, c. 1999), p. i.

33 Ibid., p. i.

34 Smith, interview, 2022; Brigadier (Retired) Steve Quinn, interview, 22 September 2022.

35 Hickling, interview, 2023; Frank Hickling, interview with author, 24 December 2024; Major General (Retired) Peter Abigail, interview, 2 May 2022.

36 Abigail, interview, 2022. Kelly and Smith also described Hickling's command climate in similar ways (Kelly, interview, 2022; Smith, interview, 2022).

37 Abigail, interview, 2022. ACMC was chaired by Abigail, and its members included Brigadier-level (one star) representatives of the Army's major components.

38 Smith, interview, 2022; Kelly, interview, 2022; Lieutenant Colonel (Retired) Andris Balmaks, interview with author, 11 March 2022.

39 Balmaks, interview, 2022.

40 *Army Continuous Modernisation Plan*, pp. 8, 9–13.

41 Australian Army, 'Headline 00 Interim Report (Draft)' (copy in author's possession), p. 7; Balmaks, interview, 2023.

42 Army was careful not to 'trash' A21/RTA in public. Instead, the modernisation activities under Hickling were usually portrayed as a continuation of RTA, and the ideas generated were attributed to the evidence collected through its trials and experiments. See John N Blackburn, Lee Cordner and Michael A Swan, '"Not the Size of the Dog in the Fight": RMA—The ADF Application', *Australian Defence Force Journal* 144 (2000): 68.

43 The Australian Army had some experience with experimentation and trials before, but it is difficult to argue that this methodology for decision support was embraced. More often, the Army would wait for others—such as the British with regard to mechanisation and the United States in response to the 'atomic battlefield'—to provide evidence for change through experiments. See respectively James C Morrison, *Mechanising an Army: Mechanisation and the Conversion of the Light Horse, 1920–1943* (Canberra: Land Warfare Studies Centre, 2006); John Blaxland, *Organising an Army: The Australian Experience 1957–1965*, Canberra Papers in Strategy and Defence No. 50 (Canberra: Australian National University, 1989).

44 Professor Mike Brennan, interview with author, 20 October 2022.

45 Ibid. The methods would be applied to good effect in future work covering amphibious capability requirements: see Army Experimental Framework, *The Army's Future Amphibious Requirements* (December 2002), Army file A356814.

46 Brennan, interview, 2022; Quinn, interview, 2022.

47 Ibid.

48 Balmaks, interview, 2023.

49 Senior Officer Study Period presentation, 'Headline Experiment 2000—Interim Report', 1 December 2000, copy in author's possession; Balmaks, interview, 2023.

50 Brennan, interview, 2023.

51 *Army Continuous Modernisation Plan*, p. 1.

52 Ibid., p. 1. These plans would morph into 'Objective Force Design Papers' by 2002. See FLW Branch, *Army Conceptual Framework (Draft)* (Army Headquarters, 2002), pp. 6–7.

53 *Fundamentals of Land Warfare*, pp. 1-7, 1-8; FLW Branch, *Army Conceptual Framework*, p. 4; Balmaks, interview, 2022.

54 *Future Land Warfare 2030*, Chapters 7 and 8.

55 Brief, Balmaks to Hickling, 'Future Land Warfare (FLW) 1 and 2: Warfighting in the Enhanced Combat Force and Warfighting in the Army After Next', 28 April 1999, Army file A151790.

56 'Minutes of the Meeting for the Writing of Future Land Warfare 1 Warfighting in the ECF and Future Land Warfare 2 Warfighting in the AAN, Held at the CATDC on 30 April 1999', Army file CA 98-21238.

57 Meeting notes, Baldwin and Balmaks, 'Key Points of the Meeting for the Writing of FLW 1 & 2, Held at the CATDC on 23 July 1999', Army file A151816.

58 Ibid.

59 The 2000 Defence White Paper gives only passing mention to these 'non-military' security threats and proposes no new capability to meet them. See Australian Government, *Defence 2000: Our Future Defence Force* (Canberra: Commonwealth of Australia, 2000).

60 *Future Land Warfare 2030*, Chapter 4, 26 August 1999, p. 1, Army file A151997.

61 Ibid., Chapter 6, p. 4. Emphasis in original.

62 Ibid., Chapter 6, p. 3.

63 The crowded staff college curriculum, which was designed to meet tertiary accreditation needs, is the probable reason why students could not be engaged in the writing task. Brief, Kelly to Hickling and Abigail, 'Future Land Warfare—Characteristics of Future Land Warfare (FLW)', 29 July 1999, Army file A151881; Quinn, interview, 2022.

64 Balmaks, interview, 2022.

65 Kelly, interview, 2022.

66 The 'unmanned' descriptor has been replaced by 'uncrewed' in Defence today.

67 Balmaks, interview, 2022.

68 Kelly, interview, 2022.

69 John Caligari, 'The Adaptive Army Post-Afghanistan: The Australian Army's Approach Towards Force 2030', *Security Challenges* 7, no. 2 (2011): 2.

70 Peter Leahy, 'Towards a Hardened and Networked Army', *Australian Army Journal* 2, no. 1 (2004). See also Australian Army, *Complex Warfighting* (Canberra: Department of Defence, 2004).

/ EXAMINING THE IMPORTANCE OF POLITICAL ACTIVITIES OF DEFENCE MEMBERS TO CIVIL–MILITARY RELATIONS

Dana Pham

Introduction

Defence, including Army, continues to face public scrutiny over the political activities of its personnel. In June 2024, the Chief of the Defence Force (CDF) sent a joint message to Defence personnel to remind them of their social media obligations.[1] This appeared to be a response to questions raised in Senate estimates hearings earlier that month about personnel who signed an open letter accusing Australia of 'support' for alleged acts of genocide in Gaza.[2] It was not the first time in recent years that Defence's political neutrality had come under public scrutiny.

In response to allegations that Australian Defence Force Academy (ADFA) cadets claimed they were pressured not to wear their uniforms on Wear It Purple Day in August 2023, shadow defence minister Andrew Hastie, himself a graduate of ADFA, told the media that the leadership at the academy were being 'overtly political'.[3] In November 2022, *The Canberra Times* reported that Defence members in uniform were seen attending a politically controversial Jordan Peterson event at the federal Parliament House.[4]

Based on this recent pattern, it is tempting to call for Defence to further restrict members' (private) engagement in political activities. Indeed, Sir Robert Peel once told the House of Commons that 'it would be utterly impossible to maintain the discipline of the army, if soldiers were allowed to be political partisans, correspondents of newspapers, or members of political clubs'. He thought that a standing army that would allow this 'would be in truth … [an ethical curse bidding] farewell to civil liberty' and that, because of this, 'the soldier must [have the character to] forfeit that portion of his civic right which would interfere with the discipline of the army'.[5]

But since this speech, laws and policies governing political activities in an Australian Defence context have evolved. This article will not only submit that this evolution is ethical in the contemporary sense but also examine the importance of political activities of Defence members to civil–military relations (CMR) in Australia. Ultimately, this article contests that political activities have provided an opportunity (at times a misunderstood one) for Defence members to develop skills and experience to engage in equal dialogue with unequal authorities. That is, political activities build members' capability to help the ADF, the Australian Public Service (APS), and members of parliament (MPs) and senators to mutually understand Australia's national interests in a complex world.

Defence Ethics, and Some Forgotten History of Political Activities in a Defence Context

The word 'ethics' is derived from the Greek word 'ethos', meaning character.[6] The ADF-P-0 *Military Ethics* doctrine indicates that ethical action both legitimises Defence business and ensures the support of the Australian people. Therefore, Defence members are ethically expected to apolitically follow the directions of the elected government of the day, as long as these directions are based on applicable Australian and international law.[7] The implication of this is that there are limitations to members' political activities. What these limitations are has been debated since the federation of Australia.

The Constitutional Convention debates before the turn of the 20th century discussed the issue of whether Defence members should be able to serve in parliament, leading to the wording of the final paragraph of section 44 of the new Australian Constitution.[8] The constitutional ambiguity led to an unresolved debate during World War II about whether MPs could retain their seats while serving as Defence members.

For example, in 1943 the Commander-in-Chief of the Australian Military Forces, General Sir Thomas Blamey, complained about the potential conflict of duties of MPs serving in Defence.[9] He referred to the ethical dilemma of Captain Clarrie Martin, New South Wales Attorney-General, serving on the staff of the Port Moresby Base Sub Area. Martin was at one point granted leave during this service to deal with urgent ministerial matters; otherwise, his functions as an MP and a government minister would have been unduly restricted.

During World War II, at least 11 MPs and senators served in Defence and still received parliamentary allowances as well as their military pay and allowances. This situation went legally unchallenged. The side questions regarding the eligibility of national service conscripts to run for parliament was addressed by the *Defence (Parliamentary Candidates) Act 1969* (Cth), noting that conscription was a politically contentious issue and Australia's involvement in the Vietnam War was becoming increasingly unpopular with the public. But the 'office of profit under the Crown' issue debated during the last World War was not revisited until 1996.[10]

Because she was still an Air Force officer at the time of nomination for election, Jackie Kelly, federal MP for Lindsay, was found to have been invalidly elected. Though she transferred to the non-active reserves before the election date, this took place only after candidate nominations closed. She did not challenge the disqualification; after all, Defence members are responsible for serving the government of the day in a neutral, apolitical manner. But what of non-candidate political activities of serving Defence members?

The Evolution of CMR Study, and the Parallel Evolution of Defence Policies Governing Political Activities

Contemporary American scholar Peter Feaver defines CMR as 'the control and direction of the military by the highest civilian authorities in nation states'.[11] The study of CMR owes its foundations to the work of post-World War II American scholars Samuel Huntington and Morris Janowitz, but there has been only intermittent scholarly research on Australian CMR.[12] This is due in part to the American schools of thought nowhere near fully capturing the Australian experience, which evolved from Australia's British military heritage and predominantly Westminster-style system of government.

Australia's Mick Ryan pointed out in 2025 that there were attempts in the early 2020s to revive examination of Australian CMR and that these were attempts to pick up from where 1970s and 1980s scholarly work left off.[13] An example of this was the conclusion of Air Commodore Ray Funnell (later Vice Chief of the Defence Force) that a Huntingtonian approach would lead to an 'absolutist' ADF isolating itself professionally from society.[14]

Indeed, Huntington in *The Soldier and the State* argued that harmonious CMR could be created through 'objective control'—that is, the clear demarcation between military and civilian spheres.[15] His contemporary Janowitz counter-argued that both would eventually converge to become indistinguishable from one another.[16] Yet Australia has the longstanding practice of formulating defence policy through a formal diarchy between public servants and military officers, supervised by elected parliamentarians, thereby complicating efforts to harmonise CMR. Unsurprisingly, Hew Strachan pointed out that in the real world, politics and the military are not clearly demarcated, especially as modern warfare continues to technologically integrate.[17]

In the early days of the new diarchy, Air Commodore Funnell argued that to remain relevant in strategic policy, Australian military professionals would have to upskill for the bureaucracy, a counter-Huntingtonian point reinforced later by the likes of General Sir Phillip Bennett and Major General Stephen Day.[18] To this seemingly awkward aspect of Australian CMR, the non-candidate political activities of serving Defence members becomes an important complement.

Prior to 1981, Defence took a somewhat Peelian-Huntingtonian approach to political activities. Though Australian Military Regulation 210 did not prohibit full-time members from joining political parties, it did prohibit them from taking an active part in the affairs of any political organisation, ‘either by speaking in public or publishing or distributing literature in furtherance of the purposes of any such organisation or party, or in any other manner’.[19]

Huntington argued:

> Politics is beyond the scope of military competence, and the participation of military officers in politics undermines their professionalism … The military officer must remain neutral politically … The area of military science is subordinate to, and yet independent of, the area of politics … The military profession exists to serve the state … The superior political wisdom of the statesman must be accepted as a fact.[20]

But with a growing recognition that this approach was unsatisfactory, the regulation was repealed, and put in its place were Defence Instructions (General) Pers 21–1 *Political Activities of Defence Personnel*.[21]

The new liberalising instructions allowed Defence members to participate in political party activity, provided said participation did not involve using rank or uniform, prejudicing performance of duty, impacting Defence capability, or identifying Defence with any political activity. The timing of this coincided with Australia’s ratification of the International Covenant on Civil and Political Rights (ICCPR).[22] Since Articles 18, 19 and 21 of the ICCPR refer to the freedoms of religion or belief, opinion and expression, and assembly, the liberalisation may have been an attempt to ethically align with the ICCPR.

Perhaps it was also a Clausewitzian recognition that Defence is a branch of broader political activity and so—unsurprisingly—Defence personnel (civilian or uniformed), their elected supervisors and the electors are inexorably ‘tangled up in each other’s business’.[23] Noting that CMR is the foundation for articulating strategy—that is, the relationship between civilian and military leaders is crucial to linking use of military force to a desired policy end of government—the political activity experience and skill set of serving Defence members is a value-add to the Defence bureaucracy. Regardless of what the case was, Air Commodore Jarrod Pendlebury argued that the ADF needs first to provide an environment that feasibly enshrines individual rights, and second to be perceived as legitimate, based on the Janowitzian position that armed forces representing a liberal democracy must feasibly align to the goals of democratic political control.[24]

The current Chief of Army (CA) affirmed in 2025 that Army exists only in the context of Australians.[25] By extension, the wider Defence exists only in the context of Australians, for Defence draws its members and its legitimacy wholly from the society Defence serves. CA pointed out that during the Peloponnesian War, Athenian general and statesman Pericles extolled the virtues of Athenian society, which included democracy, celebrating the citizens who made Athens what it was. In this sense, the political activities of Defence members, if carried out without risking Defence's apolitical status, enhance CMR.

Major Cate Carter emphasised the importance of the Australian soldier as citizen, as the soldier's domain is predominantly outside of Australia, an operational domain that is subject to political debate led by the Australian community who ultimately produced the citizen who became the soldier.[26] Among other elements of unease related to this duality, the citizen soldier lives under both military and civil law, and Carter questioned: How can Army inculcate humanity in the institution that is Defence? How well can the soldier's character develop in the barracks without 'rocking the boat'? Whatever the case, she observed: 'Even those who have never worn a military uniform are now war veterans ... television has made combatants of them all.'[27]

If the soldier must ultimately be prepared to sacrifice his or her life without it being clear to himself or herself what the sacrifice is for, then is he or she a mercenary rather than a citizen soldier? Later, Carter described the reinvented citizen soldier who expressed public messages of frustration and despair, such as when Kabul fell to the Taliban in 2021. This is unsurprising, as there are now identifiable Defence members on online platforms acting as ethicists, agents for social change, humanitarian and gender activists, and leaders in creative thinking.[28] These members are living in the community and knowing why they warfight, which hopefully translates into performance on the job.[29]

Carter concluded that the citizen soldier tradition that has evolved in Australia for the past century allows for a closer relationship between Defence and the Australian public. She pointed out that recent opinion polls show that public support for Defence continues to rise, while support for Defence spending continues to fall, indicating that the reinvented citizen Defence member may be the Australian holding the public trust.[30] If this is true, it appears that the horse has legitimately bolted on Defence policy.

Later Evolution of Defence Policies Governing Political Activities, Why It Matters, and 2010s Case Studies: Major Bernard Gaynor, Captain Mona Shindy (Retired) and the 2016 Federal Elections

In 1989, the Minister for Defence Science and Personnel clarified that the policy liberalisation extended to Defence members writing letters to newspapers—but of course not *as* Defence members—to preserve Defence's impartiality.[31] The restrictions the minister outlined do not appear to have significantly changed in policy since, except for one explicit restriction:

> [M]embers are not allowed to take a leading part in the affairs of a political organization … [finding] themselves in the position of being spokesperson for their party and possibly having to espouse and support policies which are at variance with those of the Government of the day.[32]

This political leadership restriction was largely lifted by Defence Instructions (General) Personnel 21–1 (DI(G) Pers 21–1) in 2007, where it was changed to:

> Defence members on continuous full-time duty must not take a leading or publicly prominent part in the affairs of a political organisation or party where such would identify any part of Defence with a political activity and/or impair their ability to adequately fulfil their obligations to Defence.[33]

As for participation in local government elections while serving, which is not legislatively restricted like participation in state/territory and federal elections, DI(G) Pers 21–1 specifies the approval delegation to the Service Chief level, whereas the *Military Personnel Policy Manual* prescribes the delegation to a delegate without specifying who.[34]

Colonel Philip Hoglin observed that religion is particularly curious in the context of the changing demographics of both the ADF and the general Australian population, specifically because religion and belief systems in the West often sit at the intersection of other attributes that may pigeonhole an individual as conservative or progressive, or leaning left or right in political ideology.[35] Defence could be stereotyped as politically conservative, as both Huntington and Janowitz have implied, but ADF data, as provided by Hoglin, has surprisingly indicated that as of 2022, 63 per cent of the ADF membership have no religious affiliation, which will likely increase towards 75 per cent in the future.[36]

On this basis, Hoglin extrapolated that future Defence recruits may be more concerned with political causes considered progressive today, such as climate action, gender diversity and multiculturalism.[37] Whether true or untrue, this is precisely why it was important for Defence policies governing political activities to realign as described above. Despite efforts by Defence to ensure such an evolution (perhaps to enable CMR improvement), the 2010s saw Defence policies governing political activities publicly put to the test, including in the cases of Major Bernard Gaynor, Captain Mona Shindy and the 2016 federal elections.

Mr Gaynor was an intelligence officer in the Army Reserve when he was issued a termination notice in 2013. Prior to the notice, he was a member of Katter's Australia Party and had nominated to be endorsed as a Senate candidate, but naturally that was not the concern of the notice.[38] The termination decision appears to relate to certain comments Mr Gaynor made on his personal website, in press releases, on Twitter (now known as X) and on Facebook. Examples include:

- website posts titled 'Domestic betrayal a waste of soldiers' sacrifices', 'Defence's gender-bending preoccupation comes at the cost of a real equity issue: fair indexation' and 'Malcolm can't be a Cate'
- press releases titled 'Defence shows hypocrisy with gay officer', 'Australian Defence Force disciplines Reserve Intelligence Officer for discussing Islam' and 'Government and Defence blinded on Islam'.[39]

Mr Gaynor directly identified Defence with his political activities and showed that he was unable to serve the government of the day in a neutral, apolitical manner. Initially, Buchanan J in the Federal Court held that the decision was unlawful because it impermissibly infringed the constitutionally implied freedom of political communication. It should be noted at this point that the implied freedom is not an implied right—the implied freedom is a restriction on the legislative and executive powers of government.[40]

The year 2016 was a particularly busy one for Defence's senior leaders in the political activities space. The start of that year saw the media continuing to report on the @ navyislamic Twitter account run by Captain Shindy. She was appointed Chief of Navy's Strategic Advisor on Islamic Affairs in 2013.[41] The controversy appears to have started in September the year prior with tweets perceived to be critical of former Prime Minister Tony Abbott. In October 2015 Captain Shindy responded to the launch of the Australian Liberty Alliance, a party that Mr Gaynor eventually associated with, by criticising it as an 'extreme, ill-informed fringe group'.[42]

Such incidents led to complaints to Defence, including one criticising her for retweeting a post by controversial Islamic cleric Mufti Ismail Menk, who had described LGBTQ people as 'worse than animals'.[43] The Twitter account was eventually closed. Defence's final public comment on the matter was that in administering the account, 'CAPT Shindy was inundated with [certain] comments and endeavoured to ensure a balance between [these and] policy … the Chief of Navy counselled CAPT Shindy on these issues'.[44]

The @navyislamic account was problematic for the same reasons Mr Gaynor's website posts and press releases were problematic from a Defence perspective.

While appealing the Gaynor decision before the full bench of the Federal Court, Defence grappled—during an election year—with reports about its personnel straying from policies governing political activities. Then Government backbencher (formerly Captain) Andrew Hastie was eventually terminated from the standby reserve after he refused to remove photos of himself in uniform from campaign material;[45] that is, he participated in a political activity where he identified Defence with said activity. In the same election, the Labor candidate for Brisbane, (formerly Major) Pat O'Neill, was also brought to Defence's attention for similar policy breaches.

Also noteworthy was that another candidate for Brisbane, (formerly Captain) Bridget Clinch of the Veterans Party, employed election imagery of herself in civilian clothing, with service medals.[46] Defence confirmed that this was not an issue because those medals are issued to currently serving and separated veterans and are not part of uniform.

The situation in general prompted CDF to urgently write to all members, strongly reminding them to be politically neutral. He emphasised:

> [T]here is no limit on [Defence members] holding personal political opinions and expressing them as private citizens. However, to preserve the ADF's political neutrality, it is essential that members of the ADF do not associate or identify the ADF with the expression of their private opinions.[47]

From a mid-2020s perspective, the limit does not include extremist opinions that are of concern to the Australian Security Intelligence Organisation.[48]

The violent extremism issue and other security-related issues aside (these issues deserve their own article), the reminder elaborated: 'Associating the ADF with private views may give the impression to other members of the public that the ADF endorses or agrees with particular points of view.'[49] Naturally, the list of prohibited activities includes taking part in political activities on Defence establishments, and publishing imagery of Defence members in uniform on political websites and social media when referring to political activities. It was a fair and reasonable reminder from CDF—one would be tempted to think that, as a result, there would be no further incidents relating to political activities.

As the dust settled in 2017, the Full Federal Court unanimously overturned Buchanan J's Gaynor decision.[50] The Full Court held that the relevant Defence Personnel Regulations did not impermissibly infringe the implied freedom of political communication. The High Court refused Mr Gaynor's application for special leave to appeal, on the grounds that he had no reasonable prospects of success and that his case was not an appropriate vehicle to explore the implied freedom.

Lessons Learnt Since the 2010s and Their Relation to CMR

Upon termination of service, Mr Hastie explained that because he was ‘no longer under the authority of the military’, the use of photos of himself in uniform in Liberal Party election material was not problematic.[51] He further argued that those photos were ‘tasteful … in good judgment’ and that ‘the feedback [he received] from constituents has been positive so it remains in place’.[52] His further argument here is understandable to a certain extent.

The pervading assumption that a Defence member is inherently and reflexively apolitical may discourage strategic thought about Defence’s role in politics in general.[53] So in a sense, to remain non-partisan, the Defence member must be politically aware—engaging in lawful political activities can assist with this. Nevertheless, the Hastie photos created a perception during the election campaign that he was still possibly under the authority of Defence. What if a political scandal had arisen during his campaign which had directly adversely impacted Defence’s reputation? The Jaimie Abbott case demonstrates this point.

Wing Commander Abbott is a reservist public affairs officer[54] who ran as the Liberal Party candidate for the New South Wales state seat of Port Stephens in 2019. During her campaign, she was implicated in a damaging Facebook trolling scandal.[55] Fortunately, because she did not associate Defence with her political activities, Defence was not linked to said scandal. But what are the broader lessons learnt in relation to the non-candidate political activities of serving Defence members and APS employees in Defence? There still appears to be genuine uncertainty among Defence personnel about how much, or even if, they can ethically engage in political activities.

As indicated in this essay, Australia has a long and potentially forgotten history of political activities in a Defence context, a history that is both scattered over the decades and not well understood holistically. The unease around these activities coincides with intermittent Australian CMR research since the 1970s, the fact that most MPs and senators are generalists rather than specialists, and the fact that during 1901–2021 there were 56 Defence ministers, of whom only 12 served longer than three years and 19 served less than a year.[56]

Compounding the issue of the civil–military gap, it appears that Defence leaders’ occasional reminders, usually in reaction to an incident, about the organisation’s political neutrality may have unintentionally left some personnel with the impression that political activities not associated with Defence are completely banned. So how can Defence leaders ethically balance this matter?

Other than a need to reinvigorate Australian CMR research, there is an opportunity to build upon the APS Commission’s guidance to APS employees on ‘Engagement in the Voice Referendum in a Personal Capacity’.[57] The guidance was written in such a way that it could have easily been renamed ‘Employee (APS or Not) Engagement in Political Activities (Including the Voice Referendum) in a Personal Capacity’. It listed types of risks to political neutrality for management, including employee seniority, and connection of political views to employment. The articulation of these risk factors in the guidance appears to be based on lessons learnt from the 2010s.

In inviting a conversation about employee political activities, the guidance recommended that employer response to employee political activities should be proportionate to the combined risk the activities pose to reputation. It makes sense that one of the risk factors is seniority, because the public is more likely to believe more senior employees’ personal comments to be based on perceived ‘inside’ knowledge. Further, the opinions of authority figures of an organisation, especially in the public sector, may be given more weight by the public.

One can imagine that between the political activities of a junior Army officer and those of CA, the weight would be skewed heavily towards CA. The suggestion here is not that senior Defence leaders should not engage in political activities out of uniform at all; rather, it is that the risk factors in their doing so will loom larger, including connection of political views to employment. Even so, Ryan has noted that political leaders in recent times have constrained the ability of senior Defence leaders to speak freely in public, thereby socially delegitimising Defence.[58]

A Defence member engaging in political activities relating to Defence political issues—such as, in Mr Gaynor’s words, that ‘Defence’s gender-bending preoccupation comes at the cost of a real equity issue: fair indexation’[59]—is likely to cause greater concern than, for example, activities relating to immigration issues. While Mr Gaynor’s rank prior to termination would not have put him in the category of ‘senior Defence leader’, by expressing political views connected to Defence and its alleged ‘gender-bending preoccupation’, he nevertheless unethically created a perception that he had privileged access to knowledge and influence in Defence.

The relevant current Defence policies appear to have ethically developed over time, in line with the ICCPR, and assurance of this comes down to an ongoing, proactive and good-faith conversation between Defence leaders and their people on the fair and reasonable application of political activities policy. Such assurance would pave the way for Defence members with political activities experience to help fill the civil–military gap. The gap is historically not a new problem.

Conclusion

US President Abraham Lincoln had to:

> educate his generals about the purposes of the war and to remind them of its fundamental political characteristics. He had not merely to create a strategic approach to the war, but to insist that the generals adhere to it. His subordinates did not always agree with him or with one another, and indeed, he often found himself having to arbitrate disputes among general officers at odds with each other over matters weighty or trivial.[60]

Political activities have provided a sometimes misunderstood opportunity for Defence members to develop skills and experience in engaging in equal dialogue with unequal authorities, and such an opportunity should not be unreasonably restricted moving forward.

Building capability to enable ADF members, APS employees and MPs/senators to mutually understand each other should enhance Australia's national interests in a complex world. MPs and senators with a stake in Defence strive for sound political decision-making, and this depends on a taxing back-and-forth dialogue with the ADF and the Defence APS. Equal dialogue means mutual listening and productive cross-examination.[61] This dialogue contributes to strategic policy that is preferably holistic and politically contextual. Defence members with political activities experience are well positioned to help lubricate such dialogue.

This essay has explored historically ongoing public questions about the political activities of Defence personnel. Specifically, it discussed the history of this from a Defence leadership and ethics perspective. The examination of the matter included recent case studies and the lessons learnt from them, establishing that the relevant current Defence policies appear to be an ethical evolution in the management of members' political activities. On this basis, further restricting Defence member involvement in political activities would be unethical and would miss an opportunity to take advantage of said members' political capability to potentially enhance a whole-of-government approach to strategy.

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/ GAME THEORY FOR HUMAN–MACHINE TEAMING

Timothy Molloy

Abstract

Human–machine teaming (HMT) is central to the modernisation plans of militaries worldwide. A key challenge in adopting machines for HMT in Army is ensuring that they are simultaneously capable of cooperative and collaborative interactions with teammates and commanders, and noncooperative and competitive interactions with adversaries. Most existing machine technologies and artificial intelligence (AI) systems are grounded in single-agent decision-making paradigms that are unsuitable for negotiating such mixed interactions. *Game theory*, of the 'serious' or mathematical kind, is well poised to offer a conceptual, mathematical and algorithmic basis for addressing this challenge, as it is explicitly concerned with decision-making among interacting agents. This article provides an introduction to game theory and its use to conceptualise a framework for HMT in Army. Such game-theoretic frameworks offer a principled foundation for the development of technologies, training and doctrine necessary to realise effective HMT in Army.

Introduction

Machines are increasingly filling important roles on the modern battlefield.[1] Uncrewed aerial vehicles (UAVs), for example, have been employed in various roles in conflicts over the last three decades, as in the Balkans, Afghanistan, Iraq, Syria and Ukraine. Their roles have expanded from intelligence, surveillance and reconnaissance, to delivering ordnance with autonomous object recognition, tracking and homing.[2] Likewise, uncrewed ground vehicles (UGVs), whose lineage can be traced back to the early years of World War I, have come of age in the ongoing 2022 Russia–Ukraine war. Russia and Ukraine now both deploy UGVs as frontline and supporting assets, in roles ranging from casualty evacuation and resupply, to mining and demining.[3]

Despite the growing importance of machines such as UAVs and UGVs to militaries, their significant commercial potential has led to much of their advancement being driven by industry and academia.[4] Many machines for generating asymmetric military advantage are therefore likely to first appear in industry and academia before being adopted for military use.[5] This adoption pathway raises challenges associated with ensuring that new machines (and their associated technologies) meet the needs and requirements of military users. For example, machines in the private sector may be initially conceived and developed as standalone individual systems lacking robust interfaces with humans and other machines, friendly or adversarial. Their effective military use will, however, involve their deployment as members—potentially with control functions—of teams of humans and machines, subject to command by humans, and in competition and conflict with adversaries.[6]

A key challenge in adopting machines for human–machine teaming (HMT) in Army lies in ensuring that they are capable of cooperative and collaborative interactions with teammates and commanders, and noncooperative and competitive interactions with adversaries.[7] This challenge spans technology procurement and development, training, and doctrine development, since it will involve ensuring that machines (and their teams) are capable of understanding and performing real-time immediate decision-making in a manner aligned with Australian Defence Force (ADF) doctrine.[8] Within existing doctrine, such a capability entails ensuring that machines are able to form real-time *estimates* of situational aspects that enable them to formulate, assess and select courses of action for themselves (and their teammates when exercising control) that achieve command intent in the presence of adversaries.[9]

Most existing artificial intelligence (AI) systems are unsuitable for equipping machines with the requisite immediate decision-making capabilities for HMT, since they are rooted in paradigms of decision-making for single agents operating in isolation without teammates, adversaries or commanders.[10] In single-agent paradigms, effects that are not direct consequences of a machine's own actions are (implicitly) treated as artefacts of nature during decision-making, introducing significant vulnerabilities.[11] For example, a machine that attributes changes in an adversary's position to chance will fail to recognise and counter changes in their course of action. Even recent celebrated AI systems that do solve multi-agent decision-making problems, like Chess, Go and Poker, remain grounded in simplified paradigms by assuming purely competitive interactions with adversaries and no (or highly structured) collaboration and communication with teammates.[12]

This article introduces *game theory*, of the 'serious' or mathematical kind, to conceptualise a framework for HMT in Army. The conceptualised framework:

- explicitly accounts for interactions with teammates, adversaries and commanders
- is aligned with ADF doctrine on immediate decision-making
- has key steps aligned with recent fundamental technological developments, enabling early examination of the tractability of game-theoretic HMT.

Such a framework, once fully realised, will therefore offer a conceptual, mathematical, algorithmic and computational foundation for designing, analysing and simulating team dynamics, and developing the requisite machine technologies and human training for effective HMT in Army. While game-theoretic frameworks for HMT have begun to appear in the literature, none currently explicitly consider mappings to ADF doctrine or identify technologies for their implementation.[13]

The key argument of this article is that effective HMT in Army will require the development of new machine technologies and training, and potentially doctrine, that move beyond the single-agent decision-making paradigms that currently dominate AI. Game theory is well poised to offer a conceptual (as well as mathematical or algorithmic) basis for such developments due to its nature as the study of decision-making among interacting agents. In particular, it is currently possible to conceptualise a game-theoretic framework of HMT aligned with ADF doctrine on immediate decision-making that serves to highlight areas where significant future research, development and training are required.

This article proceeds by outlining motivations for the development of HMT for modern militaries and examining what is required for machines to transition from supervised tools to autonomous teammates. It then provides a brief introduction to game theory as a principled approach to studying decision-making under mixed cooperation and competition between agents (human or machine). Building on this foundation, the article conceptualises a game-theoretic framework for HMT structured around ADF doctrine on immediate decision-making, detailing observation and orientation via estimation, and decision and action via the construction and solution of games. Finally, conclusions are provided outlining future research, development, assurance and training efforts that are required to fully realise game-theoretic frameworks and implementations of HMT in practice.

Why Human–Machine Teaming?

HMT has emerged as a leading means of employing machines for military use because it seeks to leverage the strengths of both humans and machines.[14] The broad aim of HMT is to exploit Moravec's paradox, which is the empirical observation that many tasks that are difficult for humans are easy for machines, and vice versa.[15] The potential benefits of successfully exploiting Moravec's paradox to generate military advantage have recently been illustrated through the use of first-person view (FPV) drones in the 2022 Russia–Ukraine war.[16] At their core, FPV drones exploit current advantages in human intelligence, reasoning and guidance, and machine strengths of expendability, manoeuvrability, speed and increasingly autonomous target homing.

HMT is now part of plans to adopt robotic and autonomous systems for defence in the United Kingdom, the United States and Canada.[17] All three branches of the ADF—Army, Navy and Air Force—are seeking to embrace HMT.[18] For Army, HMT offers a means of generating mass and scalable effects in range, lethality, force protection and decision advantage, without equal growth of the human workforce.[19] Beyond the battlefield, HMT will generate advantage for the ADF through contributions to logistics, including warehousing, transportation, engineering and maintenance.[20]

Militaries that fail to implement effective HMT are predicted to be at a considerable disadvantage in future conflicts, including leaving them vulnerable to incurring significant (human) casualties.[21] Recent conflicts provide evidence in support of this prediction. For example, ISIS's deployment of simple remote-controlled quadrotor drones equipped with grenades in the 2016–2017 Battle of Mosul is estimated to have increased the rate of attrition of Iraqi government forces by up to 23 per cent.[22] Similarly, the introduction of loitering munitions by Russian forces in the 2022 Russia–Ukraine war corresponded to a significant spike in Ukrainian casualties.[23] In both cases, the increased casualty rates associated with the introduction of new technologies and tactics persisted until the introduction of counter tactics and technologies.

The degree and duration of a technological advantage depends on the ability of adversaries to learn from, improve upon and implement innovations.[24] Effective HMT is therefore predicted to generate significant and prolonged asymmetric advantage because of the technical complexity of the requisite machines and the necessary training of human soldiers and commanders.[25] The advantage generated by creating and understanding the technologies and doctrine required for effective HMT is likely to extend to countering HMT. Indeed, several historical examples exist in which adoption of a new sophisticated technology also provided the basis for (and dominated) initial approaches to countering it. For example, the interleaved developments in tank and anti-tank warfare over the half century beginning in World War I culminated in the United States doctrine of the 1960s essentially stating that 'the best anti-tank weapon is a tank'.[26] A more recent example is the emergence of interceptor drones as counters to large-scale offensive drones in the ongoing 2022 Russia–Ukraine war due to their cost, scalability and effectiveness being commensurate with the threat.[27]

What Is Required for Effective Human–Machine Teaming?

For Army, HMT involves transforming machines from being closely supervised 'tools' to being autonomous 'teammates' capable of coordinating and collaborating to achieve command intent.[28] It differs from past approaches to integrating humans and machines by sharing tasks that were previously only performed by humans with machines.[29]

For example, machines such as artillery have a long history of use as ‘tools’ in Army. Humans have, however, always controlled them by collecting and processing information (i.e. forming estimates) and deciding courses of action. Shifting machines to ‘teammates’ will entail enabling them to collect and process information to form their own estimates, to decide courses of action and to act independently or as part of a team to achieve command intent.[30] It will also entail empowering certain machines to exercise *control*, subject to tasking by *command* (which remains a fundamentally human function).[31]

Control, being concerned with ‘coordinating forces towards outcomes determined by Command’, requires objective, empirical and timely situational understanding and an ability to formulate courses of action for teammates.[32] Thus, machines empowered to exercise control must be capable of forming real-time estimates of situational aspects relevant to both themselves and their team, and formulating courses of action for both themselves and their team.[33] These estimates correspond to (running) *staff estimates* within existing ADF doctrine and include tangible and intangible situational aspects such as the physical configurations (e.g. locations) of friendly forces and adversaries, and their intent, goals, capabilities, strengths, training, limitations, vulnerabilities, morale, leadership and situational awareness (e.g. *higher-order* or *nested* estimates of estimates maintained by other friendly and adversary teammates and commanders).[34] In using estimates to formulate, assess and select courses of action, machines must be explicitly accounting for the vulnerabilities of—and vulnerabilities to—potential adversaries in order to be consistent with ADF doctrine.[35]

Since not all machines will exercise control, not all will strictly require estimates of all situational aspects. Similarly, not all machines will strictly need to be capable of formulating, assessing and selecting courses of action for their teammates. Instead, many machines may only need estimates of a subset of situational aspects and may only need to determine their own course of action. However, determining which machines need which estimates, and which machines are best orientated to determine which courses of action, poses a formidable challenge. At a minimum, it is likely that all machines would need to be capable of forming estimates of situational aspects that enable them to determine their own courses of action. In determining their own courses of action, they would also ideally align with, or exploit, the intent, goals, capabilities, strengths, training, limitations, vulnerabilities, morale, leadership and situational awareness of teammates, commanders and adversaries.[36] For example, while loitering munitions may strictly only require estimates of the location and appearance of adversaries to engage targets, their effectiveness is clearly improved if they have sufficient situational awareness and decision-making capabilities to prioritise agents that are most vulnerable to them.

Developing the situational-awareness and decision-making capabilities required by machines to realise effective HMT represents a considerable challenge with existing technologies.[37] The development of simpler situational-awareness capabilities, even without cooperative or competitive decision-making, has proved difficult. Indeed, several aircraft accidents have been directly attributed to autopilots forming erroneous estimates of the physical state (e.g. orientation) of aircraft.[38] Similarly, several high-profile accidents involving cars equipped with advanced perception and self-driving systems have resulted from perception systems missing important environmental cues and forming flawed estimates, leading to a loss in situational awareness and to the car's control systems selecting inappropriate courses of action.[39]

There is therefore recognition in the open literature that new technologies are required for HMT.[40] However, recent development efforts remain narrowly focused on certain technologies for specific capabilities. For example, much recent effort has been dedicated to developing technologies for realising shared mental models (i.e. synchronising estimates of situational aspects) so that machines can accurately predict and anticipate the actions of teammates to pre-emptively aid them.[41] Similarly, considerable effort has been directed towards technologies for aligning the goals of teammates in order to avoid conflicting goals and associated reductions in team performance.[42] Technologies that enable machines to use their estimates to formulate, assess and decide on appropriate courses of action have received comparatively little attention. Most existing AI technologies are unsuitable due to being grounded in single-agent decision-making and they are unable to enable machines to decide on courses of action in an explainable and transparent manner.[43] They also do not enable machines to formulate courses of action to solicit information or resolve uncertainty, such as by moving to vantage points or communicating with teammates or commanders.[44]

Game theory offers a promising foundation for developing machine technologies (and training for human teammates and commanders) required for HMT—from realising shared mental models and goal alignment through to formulating courses of action in an explainable and transparent manner.[45] The promise of game theory lies in its providing frameworks (in the form of conceptual, mathematical or algorithmic models) that account for the individual goals, estimates and decision-making processes of all agents in a tactical or operational environment.[46] These frameworks provide a basis for developing game-theoretic technologies that will enable machines to formulate, assess and decide on their own courses of action while, where necessary, considering the impact of other agents, both friendly and adversarial.[47] The role and importance of game theory in comparison to single-agent decision-making paradigms is examined in the following section and facilitates subsequent discussion of game-theoretic frameworks of HMT.

A Brief Primer on Game Theory

Game theory is the study of decision-making between multiple interacting agents, each with potentially different goals or objectives, capabilities, limitations, intentions and situational awareness.[48] It differs from the better-known concept of *optimisation* by explicitly considering the impact of multiple (other) agents and their decisions on outcomes when determining the 'best' decision or action for an agent.[49] Optimisation, in contrast, involves selecting an agent's 'best' decision or action as evaluated against their own goals or objectives without considering the impact of other agents and their decisions. Where an agent seeks to determine a sequence or course of action where the order of actions is important, optimisation branches into *optimal control* (e.g. single-agent *reinforcement learning*) and game theory branches into *dynamic* (or *differential*) *game theory* (e.g. multi-agent reinforcement learning). Decision-making paradigms are summarised in Table 1.

Table 1: Summary of decision-making paradigms

	Single agent	**Multiple agents**
Single decision or action	Optimisation	Static game theory
Sequence of decisions or course of action	Optimal control (e.g. reinforcement learning)	Dynamic or differential game theory (e.g. multi-agent reinforcement learning)

Optimisation and optimal control treat any effects that are not direct consequences of the agent's own actions as artefacts of nature.[50] Such considerations are appropriate when solving problems with outcomes that are not coupled to the decisions or actions of other agents, such as 'What is the shortest path to reach an objective?'. However, they are inappropriate when the decisions and actions of others impact what is 'best', such as determining 'What is the safest path to reach an objective?' when an adversary can render certain paths unsafe. Using optimisation or optimal control in situations with multiple agents constitutes committing the *Robinson Crusoe fallacy*, where the deliberate decisions, actions and effects of other agents are erroneously overlooked and attributed to the randomness of nature.[51]

Despite its name, game theory is not solely concerned with trivialities, entertainment or wargaming—it may be used to create strategies for such situations, but it is more broadly the mathematical (or algorithmic) study of competition, cooperation and/or conflict between multiple interacting agents.[52] A *game* in the context of game theory is a situation in which multiple agents interact with the aim of achieving their own individual or team objectives (e.g. maximising rewards or minimising costs).[53] These individual or team objectives may conflict with those of other agents in a game, and in an extreme case may simply correspond to trying to ensure that other agents receive a worst-case outcome. In contrast to optimisation, the concept of 'best' or 'worst' in game theory is ambiguous, since cooperation and conflict between agents and their objectives introduces (implicit or explicit) trade-offs as to which individual or combined objectives can be optimised when selecting decisions and actions.[54]

A classic example illustrating the differences between game theory and optimisation is the *prisoner's dilemma* game.[55] In the prisoner's dilemma game, two prisoners are each given the choice to either *remain silent* or *testify*. If both prisoners choose to remain silent, they are subject to a light sentence (e.g. one year of prison). If one prisoner chooses to remain silent but the other chooses to testify, then the silent prisoner is subject to a heavy sentence (e.g. three years of prison) while the testifying prisoner is released immediately without any sentence. If both prisoners testify, they are both subject to a moderate sentence (e.g. two years of prison). The prisoners must make their choice simultaneously without cooperating (i.e. without communicating or knowing the choice of the other prisoner and without caring about the other's sentence).

If the prisoners cooperate, their best option is to remain silent and receive only a light sentence, corresponding to a game-theoretic solution termed a *Pareto optimal solution*. More generally, Pareto optima are solutions to games when they reduce to (single-agent) optimisation problems due to agents cooperating to optimise the same objective. However, a dilemma arises when the prisoners cannot enforce or be assured of cooperation. If one prisoner remains silent, the other prisoner has an incentive to testify, which means that the silent prisoner no longer has an incentive to remain silent. This ultimately leads to both prisoners concluding that testifying is preferable to remaining silent. Said another way, a prisoner who elects to testify never has an incentive to *unilaterally* change their mind to remain silent, while a prisoner who elects to remain silent always has an incentive to *unilaterally* change their mind to testify; thus, both prisoners choose to testify. This outcome is termed the *Nash equilibrium*, which is an *equilibrium* due to both prisoners having no incentive to *unilaterally* deviate from testifying.

Nash equilibria are considered the 'best' or 'optimal' solutions to games where agents act concurrently and do not explicitly cooperate or coordinate. As the prisoner's dilemma illustrates, Nash equilibria need not correspond to Pareto optimal solutions. Agents often incur an additional cost (or inefficiency) under a Nash equilibrium as compared to a Pareto optimal solution. This additional cost is termed the *price of anarchy*. The prisoner's dilemma therefore highlights the importance of aligning (or crafting) the goals and objectives of agents such that the resulting price of anarchy is small (or bounded) and teammates do not receive bad outcomes even when they cannot explicitly coordinate or collaborate. Such considerations are especially relevant for implementing effective HMT in disrupted, disconnected, intermittent and low-bandwidth environments. They are also important when determining how to integrate standalone machines and technologies procured from industry and academia to avoid creating teaming interactions that result in large prices of anarchy.

The prisoner's dilemma is a *static game* in the sense that the agents (i.e. prisoners) only interact once. Where multiple interacting agents must select a sequence of actions and the order of actions is important (i.e. where the agents select courses of action), game theory branches into *dynamic game theory*. A *dynamic game* is therefore a situation in which multiple agents interact repeatedly (in time) with the aim of maximising their individual or team objectives and rewards, subject to constraints and limitations imposed by the (time) evolution of the states of the agents and the state of their environment.[56] It is in this dynamic form that game theory has perhaps had the most impact on machines for military affairs.[57]

Dynamic (or differential) game theory was originally developed by Rufus Isaacs in the 1950s to determine optimal guidance manoeuvres for missiles against aircraft that employ optimal evasive manoeuvres.[58] It was subsequently used to develop the US Navy's doctrine on how a surface ship should manoeuvre to keep a submarine under surveillance for the maximum period of time while the submarine seeks to escape surveillance in the minimum period of time.[59] In these dynamic games, the agents (i.e. vehicles) select their courses of action with perfect knowledge of the (immutable) capabilities and limitations of all platforms, including their maximum speeds and turn rates and the physical aspects of their situation (e.g. their time-varying dynamic physical states, including their position and heading). The agents do not cooperate and have conflicting objectives, rendering the resulting 'best' courses of action (i.e. manoeuvres or trajectories) Nash equilibria. As in static games, a unilateral deviation from a course of action that is a Nash equilibrium in a dynamic game by any agent leads to their receiving a worse outcome.[60] For example, in the case of a submarine attempting to escape surveillance by a surface ship, if the submarine deviates from a Nash equilibrium by performing a different manoeuvre (or following a different trajectory), the surface ship will be able to keep it under surveillance for a longer period of time. Conversely, if the pursuing surface ship deviates from a Nash equilibrium, the evading submarine will be able to escape more quickly.

There are now myriad *pursuit-evasion* and *surveillance-evasion* dynamic games in the literature, with various types and numbers of agents.[61] For example, by modifying the platform dynamics of the agents in the surveillance-evasion dynamic game between a surface ship and submarine, a dynamic game more closely addressing surveillance of a ground vehicle by a quadrotor drone has recently been posed and solved.[62] Such dynamic games have proved particularly suited to developing (optimal and robust) machine technologies for single-mission autonomy. However, their broader use in the development of technologies for HMT has remained limited, especially in contrast to the widespread use of (single-agent) optimisation, optimal control and reinforcement learning.

Perhaps surprisingly, game theory has played only a minor role in the development of celebrated AI systems like OpenAI Five, AlphaStar and MuZero for playing board games and computer games such as Chess, Go, Dota 2 and StarCraft II.[63] Game theory has played a more significant role in the development of subsequent AI systems like Pluribus for poker, CICERO for Diplomacy, and those developed under a variety of Defense Advanced Research Projects Agency (DARPA) challenges and academic-industry challenges.[64] However, these 'games' are simplistic in that they evolve periodically with fixed rules, have a known number of players with little difference in possible actions and facilitate easy communication between teammates. The development of AI systems in such 'games' thus introduces the potential to commit the *ludic fallacy* in applying them to real-world tasks such as HMT, where simplifications may be so drastic that any derived insights are likely to be flawed or misleading.[65]

Furthermore, the interactions between agents in the 'games' solved by celebrated AI systems are purely competitive or cooperative. Situations in which agents must negotiate a mix of competing and cooperating agents (as in HMT) pose significant unsolved challenges for the existing state-of-the-art algorithmic approaches used to train these celebrated AI systems.[66] For example, relatively simple, though technical, counterexamples exist showing that the popular multi-agent reinforcement learning technique known as self-play fails to find optimal (Nash equilibrium) solutions in games that involve conflict and cooperation.[67] These failures lead to deficiencies in AI systems that can be exploited by adversaries.[68]

Despite the limitations of existing AI systems, there exist a range of more sophisticated game-theoretic techniques and insights from across applied mathematics, engineering and economics. Indeed, game theory fundamentally generalises beyond purely cooperative or purely competitive interactions to mixed commander–subordinate and cooperative–adversarial interactions.[69] This generality has opened significant opportunities to exploit game theory in the development of effective HMT.

Frameworks for HMT grounded in game theory have begun to appear in the open literature.[70] These frameworks take the form of conceptual (or mathematical, algorithmic or computational) models in which all humans and machines in a team are considered (i.e. modelled or abstracted) as agents with their own individual characteristics, including perception sensors or systems, estimates, goals, intent, capabilities, experiences and (cognitive or computational) decision-making and action processes. They are game-theoretic in the sense that agents are considered to form their estimates and make decisions based on what enables them to best achieve their individual goals, given what they know or observe about other agents. Implicit within these frameworks is that agents may elect to synchronise their data, estimates, goals, intent, decision-making and action if it is in their interest (or the interest of their team).

Game-theoretic frameworks for HMT serve two key purposes. Firstly, they provide a conceptual (and, with further development, mathematical, algorithmic and computational) foundation for designing and analysing team dynamics and behaviours, enabling 'What if?' questions of HMT to be posed and addressed via analysis, simulation and wargaming. Secondly, they provide a foundation for developing the requisite machine technologies for HMT by providing algorithmic and computational models with which machines can formulate, assess and select courses of action by predicting and anticipating the behaviours of teammates, adversaries and commanders based on estimates of their situational and individual aspects. Existing game-theoretic frameworks for HMT have been developed without joint consideration of adversaries and hierarchical (human) command, (imperfect) situational awareness, alignment with doctrine, and technological realisation. Nevertheless, consideration of these aspects, which are of clear importance to Army, appears feasible given the generality of the underlying game theory.[71]

Conceptualising a Game-Theoretic Framework for Human–Machine Teaming in Army

A game-theoretic framework for HMT with adversaries that seek to deceive and compete can be conceptualised within the observe–orient–decide–act (OODA) loop formulation of (human) decision-making that underlies the *immediate decision-making process* (IDMP) of existing ADF doctrine.[72] To conceptualise this framework, consider a set of agents—human or machine—that may be grouped into teams and may be friendly or adversarial. Each agent is considered to (repeatedly) observe (some of) the other agents and the environment, orient itself with respect to other agents and the environment, and then decide and implement courses of action. For machines, this process could arise exactly through implementation in hardware and software through situational-awareness and decision-making technologies, forming a candidate blueprint for the development of machine technologies for HMT. For humans, this process may serve only as an abstraction or model, though it is plausibly aligned with doctrine and training through the IDMP.[73]

The steps of the OODA loop for each agent involve game-theoretic considerations and are conceptualised as follows.

Game-Theoretic Observation and Orientation

In observing and orientating itself, each agent is considered to repeatedly perform the following three key steps:

1. Scope and frame their situation, including identifying relevant situational aspects.
2. Form *estimates* of the identified relevant situational aspects.
3. Form *higher-order estimates* of other agent *estimates* (and their estimates of estimates ad infinitum).

In scoping and framing their situation, each agent is considered to first identify other observed and (potentially) unobserved agents (teammates, friendly forces, adversaries and/or commanders). It is then subsequently considered to assign a *state* to all agents (including itself) that quantifies both their tangible and intangible properties and aspects such as their goals, intent, desired end states, strengths, capabilities, limitations, training, morale and leadership. The state of the *j*-th agent from the perspective of the *i*-th agent at time *t* is thus a mathematical object denoted by $s_t(i, j)$, with $s_t(i, i)$ being the state it assigns to itself. Similarly, each agent assigns a *state* to its environment (e.g. the location of inanimate objects), with the state of the environment from the perspective of the *i*-th agent being $s_t^e(i)$. Agents may employ dynamic models to describe the time-evolution of states (e.g. computational and physics-based models of machines or cognitive behavioural and decision-making models of humans).[74]

Each agent is subsequently considered to maintain an *estimate* of the states of all agents and the environment, along with an estimate of how they may evolve in time, using observational data from their perception and/or communication systems. These estimates may be deterministic (i.e. sets of possible states) or probabilistic (i.e. probabilities assigned to different possible states). The estimate that the *i*-th agent maintains about the states of all agents and its environment at time is thus either a set or probability distribution denoted by $b_t^i(s_t(i,1), s_t(i,2), \ldots, s_t(i,N), s_t^e(i))$ where *N* is the total number of agents (this estimate is also called the agent's *belief*). For machines (or using Bayesian models of the brain), estimates of physical and tangible aspects could include those computed by *state estimation* and *sensor fusion* algorithms such as Bayesian filters and smoothers (e.g. Kalman or particle filters).[75] Estimates of more abstract aspects such as agent goals and intent could include those computed by bespoke algorithms such as those from inverse dynamic game theory concerned with computing agent objectives from observations of their decisions and actions.[76]

To support game-theoretic decision and action, agents must also maintain *higher-order estimates*—that is, estimates of estimates, and estimates of estimates of estimates, and so on—to maintain an awareness of what other agents know, and what other agents know about what others know, and so on. These higher-order estimates are necessary, to some degree, to create opportunities for, and defend against, deception. For example, an agent may need to act more cautiously if it knows that an adversary knows that it is ignorant of hazards or obstacles in its environment, or that it has only partial knowledge of an adversary's capabilities. Likewise, an agent may benefit from its teammates and commanders knowing that they do not accurately know the state of their environment. Recent *inverse filtering algorithms* have shown the tractability of computing estimates of estimates from observations of either the estimates themselves or the actions of agents that arise from such estimates.[77] These *inverse filters* are surprisingly similar to existing (forward) filters and Bayesian (state) estimation algorithms, suggesting a natural means of extending them to computing higher-order estimates.

There exists a large and growing literature on technologies and approaches that enable autonomous agents to model other agents. This literature provides insight into the practical implementation of the three key steps of game-theoretic observation and orientation, including how to select important states and how to compute estimates of them.[78] With the exception of higher-order estimates, the three key steps of game-theoretic observation and orientation are therefore likely to be tractable (at least in approximate forms) to implement on machines using modest onboard or edge computing architectures. The core challenge lies in computing higher-order estimates since, in theory, an infinite number of high-order estimates are required (i.e. estimates of estimates ad infinitum). Recent studies have, however, suggested that higher-order estimates may play a diminishing role in decision-making (i.e. past a certain order, higher-order estimates may no longer impact the selection of actions). These studies raise the important practical possibility of only needing to compute a finite number of higher-order estimates without introducing any (significant) vulnerabilities.[79] As a result, game-theoretic observation and orientation currently appears likely to impose only modest additional requirements on the actual hardware and sophistication of machines.

Game-Theoretic Decision and Action

In deciding on and taking courses of action, each agent is considered to repeatedly perform the following three key steps:

1. Construct a partial and/or incomplete information game using its estimates of other agents and the environment.
2. Solve its constructed game to formulate and evaluate potential courses of action.
3. Act to implement the course of action that best achieves its goals.

In using its estimates to construct a game, each agent is implicitly considered to decide its course of action using partial and/or incomplete information. Games with partial and/or incomplete information are well studied and, in principle, their solution can be approached mathematically or algorithmically by machines (or trained humans). Their solution (as with all games) specifically involves identifying possible equilibria (Nash or otherwise) and then selecting that which is 'best' in terms of their own goals and objectives or under a secondary criterion such as Pareto optimality, or extensions of Pareto optimality that are computed only within teams or friendly forces (e.g. against command intent).

Selecting actions by solving games formulated with estimates rather than with perfect knowledge of situational aspects implicitly accounts for the potential of agents to manipulate both their own estimates through communication or conducting reconnaissance, or those of adversaries through bluff and deception. Specifically, courses of action that solve partial and/or incomplete information games formed with potentially imperfect estimates are known to include actions whose purpose may be to only resolve or increase uncertainty, rather than to manipulate the actual underlying situation. This phenomenon is known as the *dual-control effect* in the language of stochastic optimal control theory, in recognition of the fact that actions can serve the dual purpose of both changing the underlying states of agents and the environment, and manipulating the uncertainty (or estimates) associated with them.[80]

The dual-control effect means that by selecting courses of action that solve games formulated with estimates, agents will naturally arrive at courses of action that improve their own estimates, and degrade those of adversaries, to the degree necessary to achieve their objectives. For example, an agent's optimal course of action may include actions such as moving to vantage points, actively looking for landmarks, or communicating with teammates or friendly forces Conversely, an agent's optimal course of action may include actions whose purpose is to deceive, mislead or remain hidden from an adversary (and vice versa).

By selecting courses of action through the process of solving games, each agent implicitly gives consideration to all (known or perceived) risks and opportunities. This consideration extends to examining how its own courses of action may affect or support those of teammates, exploit vulnerabilities in those of adversaries and guard against potential courses of action employed by adversaries. This game-theoretic process of deciding courses of action resembles the mission analysis and course-of-action development considerations in the IDMP of existing ADF decision-making doctrine.[81] However, rather than limiting analysis to an adversary's most likely and most dangerous courses of action, in principle this game-theoretic process entails the computation of *all possible* courses of action for adversaries, teammates and other friendly forces.

In solving games, it may be necessary (and defensible) to limit consideration to finite sets of actions and courses of action, including those most likely and most dangerous, for practical reasons of computational tractability, trust and assurance. Sets of actions and courses of action already permeate the literature on HMT for individual agents as well as for whole teams, though not in the context of being potential solutions to games.[82]

The usefulness of finite sets in reducing the computational complexity of solving games is clear since they reduce the action-space to a finite dimension. They similarly may be useful for trust and assurance purposes since by reducing the action-space to a finite dimension they render agent behaviour more predictable.[83] For similar reasons, consideration may also be limited to courses of action that an agent with bounded rationality can conceptualise; for example, consideration of courses of action may be limited to those that are easy to evaluate or understand by agents with a constrained ability to consider higher-order estimates and consequences.

The potential for agents to perform control actions (or a human agent to act as a commander) is also implicitly encoded through the selection of actions through the solution of games based on estimates. Specifically, a situational state that agents can maintain about other (friendly) agents is whether they are a commander or a controller. The role of each agent can then be considered in determining how it is treated in the solution of the game. For example, the estimated goals or intent of a commander or controller can be prioritised in the solution of an agent's game. If an agent is particularly unsure of a commander's or controller's goals or intent, the dual-control effect means that its best course of action may inherently be to take actions to resolve this uncertainty, such as by communicating with or moving to observe their commander or controller. Similarly, if an agent is exercising control (or command), its best course of action may inherently be to directly communicate or broadcast estimates and actions to others.

Summary, Variations and Extensions of the Framework

In summary, it is possible to conceptualise a game-theoretic framework of HMT that is aligned with the OODA-loop formulation of the IDMP in existing ADF doctrine. In this framework, each agent (human or machine) is considered to repeatably perform game-theoretic orientation and observation and game-theoretic decision and action.

Game-theoretic orientation and observation involves agents:

1. scoping and framing their situation, including identifying relevant tangible and intangible situational aspects already present in the IDMP
2. forming estimates of the identified relevant situational aspects, potentially through the use of Bayesian filters
3. forming higher-order estimates of other agent estimates (and their estimates of estimates ad infinitum), potentially through the use of recent inverse filters.

Game-theoretic decision and action involves agents subsequently:

1. constructing a partial and/or incomplete information game using their individual estimates of other agents and the environment
2. solving their constructed game for all equilibria of interest (Nash or otherwise)
3. acting to implement the course of action corresponding to the equilibrium that best achieves their goals (or command intent).

Importantly for Army, this framework offers a basis for the joint consideration of adversaries and hierarchical (human) command; (imperfect) situational awareness; alignment with doctrine; and technological realisation. Nevertheless, there remains the potential to expand and vary the scope of the game-theoretic framework. For example, it could be extended to include non-combatant or non-aligned agents. It could also be varied to use the act–sense–decide–adapt (ASDA) cycle or Cynefin abstractions of (human) decision-making instead of the OODA loop as a basis for ordering or prioritising the steps of game-theoretic observation and orientation, and game-theoretic decision and action.[84]

More generally, the conceptualised framework highlights that there remains a considerable amount of research and development required to realise effective HMT, particularly if the employed machines are to have high levels of autonomy. For example, new fundamental mathematical tools and algorithms are needed to construct agent estimates and solve (partial and/or incomplete information) games defined in terms of agent estimates. New machine technologies will also be required to realise scalable game-theoretic observation, orientation, decision and action—ranging from scoping and developing suitable sensors and sensor suites, to selecting appropriate computing architectures and algorithm implementations to balance tractability with game-theoretic performance (or vulnerability).

Conclusion

This article has argued that realising effective HMT in Army requires moving beyond the single-agent decision-making paradigms and technologies that dominate AI. Instead, realising effective HMT will require embracing approaches that explicitly account for both cooperative interactions with teammates and commanders, and noncooperative or competitive interactions with adversaries. Game theory, being the study of interactions between multiple agents, friend or foe, is a strong candidate approach. Indeed, it is possible now to conceptualise game-theoretic HMT frameworks in which machines reason about intent, uncertainty and adversarial behaviour in a manner consistent with ADF doctrine on immediate decision-making.

While frameworks for HMT grounded in game theory have appeared in the open literature, they only consider purely cooperative interactions between humans and machines, or do not explicitly consider game-theoretic issues associated with imperfect situational awareness such as the need for estimates or higher-order estimates. Furthermore, existing literature does not discuss how key steps in game-theoretic HMT aligned or realised with ADF doctrine. The conceptualised framework therefore provides a starting point for designing and implementing machine technologies and (human) training for HMT. With further (mathematical and technical) development, it will also provide a quantitative means of analysing and simulating HMT concepts. Significant future work is also required to examine the implications of game theory for the issues of trust, ethics, testing, evaluation, verification and validation in HMT.

For Army, game-theoretic HMT will need to be realised through a progressively staged process, given the relative immaturity of the available frameworks and technologies.

- In the short term, Army should map and relate game-theoretic concepts and terminology to existing wargaming, experimentation and doctrine (with and without HMT) in order to explicitly evaluate and develop game theory as a decision-making paradigm for warfighting.
- In the medium term, gametheoretic concepts and thinking should be applied to develop frameworks, tactics and doctrine for narrowly scoped but repeatable tasks and missions involving HMT with existing machine technologies and soldier training. This will mirror the adoption pathway of differential game theory in the US Navy.
- In the longer term, Army should seek to explicitly avoid the Robinson Crusoe fallacy by ensuring that new machine technologies, training and doctrine for HMT incorporate game-theoretic considerations from their inception.

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/ SPEECH

State of the Army Profession: A Reserve Infantry Perspective

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Introduction

Good morning Your Excellency, Sirs, Ma'ams, and colleagues. Before commencing my remarks, I would like to extend my sincerest thanks to Major General Brereton for his very kind invitation to present the Maitland Lecture to you all today. It is a privilege to follow other presenters of this lecture such as David Leece, Garth Pratten, Ron Lyons, Albert Palazzo, and Craig Stockings. I hope what I have to say today comes close to the high standard they have set. I would also like to extend my thanks to Lieutenant Colonel Tony Ang for his organisation of today's program and to my colleagues in the Australian Army Research Centre (AARC) for their support and feedback as I prepared my remarks.

I must emphasise that the content of my lecture today reflects the views only of myself as an academic researcher, and not necessarily those of the AARC, the Australian Defence Force (ADF), or the Department of Defence. My hope is that my remarks spur further discussion, research, and debate among service members of all service categories, as well as among academics and the public.

Today I will explore the state of the Army Profession, doing so though the lens of the Reserves and the reserve infantry. Almost exactly a year ago today, during the 2024 Chief of Army Symposium in Melbourne, Lieutenant General Simon Stuart noted his intent for a 'review' and reassessment of the 'Army Profession' and how it pertains to all aspects and dimensions of Army's preparation for the challenges of today and tomorrow.[1] In subsequent discussion, little exploration of the unique association between the Army Profession, the reserves, and reserve service has occurred. This is reflective of a broader theme in military studies: as Vincent Connelly and Eyal Ben-Ari attested in 2023, little research is done on reserve components of armed forces compared to regular forces.[2]

The findings from research on regular force military personnel are also regularly assumed to apply to reservists, 'despite notable differences in their employment' and context.[3]

That so little scholarly attention is given to reserve forces is additionally problematic due to their increasing importance in national force structures and defence policies globally, including in Australia. Government, society, and the Army as an institution, have long relied upon the contribution of reservists and part-time soldiers to facilitate the defence of Australia, and to meet operational demands. Indeed, apart from the period 1945–1949 when the Citizen Military Forces (CMF) underwent a post-Second World War reorganisation, it was only in 1972 that the Regular Army began to consistently surpass the numerical strength of the reserve forces.[4] Reliance upon an army largely composed of citizen soldiers was at the heart of Australian defence policy following Federation. Today, reservists serve in every part of Army, with many undertaking specialist work and giving the institution the benefit of their military and civilian expertise.[5] It is somewhat popular today to talk of the utility of the 'total defence force' concept—a move away from a focus on regular forces and towards a more holistic and collaborative use of the entire defence workforce including reserves, defence civil servants, and contractors—as the future operating concept for many Western defence forces.[6] While the adoption of such a model for the ADF is a matter for our highest leadership, I would suggest that the ADF is already some way down this road with the implementation of the Total Workforce System and the operationalisation of reserve formations in the 2nd (Australian) Division under JTF 629. It is the important nature of the tasks assigned to Army's reserve formations and members that makes it all the more essential that we explore the place of the reserves in the modern Army Profession.

I will be presenting my lecture today in two parts. First I will outline what it is we mean by the Australian 'Army Profession', and how this relates to the broader Australian Profession of Arms. For those who have had the opportunity to read my introduction to the AARC's upcoming 'State of the Army Profession' themed *Army Journal*, some of what I have to say here may be familiar.[7]

In the second part we will consider the place of Army's reservists within the Australian Army Profession. There does exist substantial debate among academics, military members, and the public as to what constitutes an 'Army Professional', and there has been little analysis undertaken in Australia of whether part-time or reserve service qualifies reservists to hold such a title. Here I will make no grand declarations, but explore some of the factors that lead me to suggest that, on balance, reservists and the reserve infantry should be more readily identified as members of the profession in both the public and vocational spheres.

The Profession of Arms and the Army Profession

In the history of the Australian Army there has been no significant, holistic study of the Australian Army profession, past, present or future. There have been excellent studies and scholars of Army's unique history, its relationship to society and government, its methods of discipline, its culture, ethos, and expertise. However, these too-often siloed specialisations have not been combined to form a cohesive foundation for what constitutes the Australian Army profession. Its key characteristics and features have not been debated, how it differs from or relates to the other military professions and the broader 'profession of arms' has not been explored, and its claim for its status as a 'profession' has not been adequately proven. Together, all these factors form a *theory of the profession*—a foundation for its application on behalf of society.

Two factors account for this lack of investigation. First is the relationship between the 'army profession' and the broader 'profession of arms'. As a term, 'profession of arms' has a long history but in the 19th century it began to be used as a synonym for 'army' or 'military' or to describe the action of service in such an institution as a commissioned officer.[8] In an 1810 definition, British Major Charles James claimed the profession of arms as the domain of the officers, and noted that there was no other profession with so 'grave' a responsibility as being 'charged with defending the state', and none that required 'greater knowledge and capacity than the army'.[9] It is important to note that British Army officers of this period would scarcely meet the definition of what a modern audience would call professional: commissions and promotion were largely attained through purchase and far less often through merit; few passed through standardised officer training such as at the Royal Military College or the Royal Military Academy; pay was poor; and unless on active operations officers hardly devoted their full time to military matters, instead actively engaging in other business or aristocratic pursuits.[10] As an aside, there was one sense in which their experience is very familiar to us today, with the military administration system of the time being described as labyrinthine.[11] It was in the American context that the term 'profession of arms' became more clearly tied with a full-time force. One 1829 definition of the term 'standing army' stated that it comprised 'a body of men exclusively set apart and employed in the profession of arms, as distinguished from militia'.[12]

It is from this intellectual and linguistic heritage that the term 'profession of arms' grew in popularity in the 20th century, spurred on by individuals such as General Sir John Hackett.[13] Hackett's definition of the term became the standard one. He considered that it comprised 'the ordered application of force in the resolution of a social problem'. It was further characterised as 'an occupation with a distinguishable corpus of specific technical knowledge and doctrine', a coherent group with a complex of institutions peculiar to itself, and with an educational pattern adapted to its own needs.[14] Australia was not immune from such linguistic spread. On the eve of war in 1939, *The Cairns Post* suggested that

Army's permanent soldiers comprised 'a profession which within the Commonwealth for many years [had] been an indifferent one', though the rapid growth of the Army at this time saw it take on 'new promise'.[15] In the 1960s the profession of arms became synonymous with Army's permanent soldiers, partly due to the term's use in recruiting campaigns for the Regular Army and in post-Vietnam War discussions on military reform.[16]

The term 'army profession' has, comparatively, a much shorter lineage, both internationally and in Australia. The terms 'army' and 'profession' have often been linked and have been used for a similar length of time as 'profession of arms'—and were often synonymous with it.[17] However, the modern concept of the 'army profession' is much younger, being developed in the late 20th century. It has come to the fore as a result of the integration of Western armies, navies and air forces into unified organisations, à la the Australian Defence Force, the United States Armed Forces or the British Armed Forces. With such centralisation it is perhaps natural that the 'profession of arms' becomes a term used to bind all services into a joint 'profession' with common values or ethos. Yet fundamental differences in the expertise required, the manner of regulation and the character of war across the military domains count against such a combination, and have led some to espouse the existence of sub-professions within this broad 'profession of arms', such as the 'army profession', the 'air force profession' or the 'navy/naval profession'. While discussion of the particularities of the army profession has been evidenced in the American context since 2002, it took 22 years for the Australian Army to consider if such terminology has utility to its own practices. We should be careful, however, of assuming that international literature on the army profession or the profession of arms applies to the unique institution, and legal and cultural context, of the Australian Army. Such material should be used cautiously, as the nature of professions is such that they operate differently across national boundaries. Factors such as legal and regulatory frameworks, demographics, social and cultural attitudes, and education requirements culminate to render, for example, an Australian lawyer and an American lawyer members of unique professions, despite commonalities in the task being performed.[18]

The Three Pillars of the Profession

On multiple occasions in 2024 and 2025, Stuart has provided clear guidance on what he, as the lead steward of the Australian Army profession, views as the profession's key characteristics. Drawing upon the work of Samuel Huntington, Morris Janowitz, Hackett, and James Burk, Stuart has identified 'three pillars of the modern Army profession', namely jurisdiction, expertise and self-regulation. **Jurisdiction** comprises the unique service Army provides to society. **Expertise** refers to Army's capacity to maintain and develop new knowledge to achieve its tasks as directed by the society it serves. **Self-regulation** comprises Army's ability to uphold professional standards in its conduct in both peace and war.[19] Together, these three pillars form the foundation of Army's considerable capability as the 'integrated force's experts in land combat'.[20] Yet beyond this conception of the pillars of the profession remains a critical question that is yet to be explored—who is an 'Army Professional' and how far does this label and identity extend? While on the surface this may seem a relatively simple question, the further one digs the more nuance, exceptions, and divergence of opinion one can find. It is a thorny problem and one rendered all the more difficult, as Professor Meredith Kleykamp has stated, by the fact that '[m]odern militaries must embrace new and varied kinds of missions that stretch them beyond their [traditional] expertise in the management of violence'.[21] Let us now turn to a key facet of this question—the place of the reserves in the profession.

Reserves in the Profession—Historical Association

In Army's history, the relationship between reserve elements and the Army's full-time soldiers has been, at times, a contentious one. From Federation through to the end of the Second World War, the Army's principal force for the defence of the nation was its militia. On 9 July 1901 the Minister for Defence, Sir John Forrest, stated in parliament that Australia looked to the 'services of our citizens' to provide for its defence. This, he believed, was not only the most 'economical' and 'efficient' course for the new nation but was due to a wide-ranging belief that in the ongoing war in South Africa 'our citizen soldiers … have proved themselves worthy to fight and do their duty under difficulties and privations side by side with the trained veterans of the Empire'.[22] The *Defence Act 1903* reflected such attitudes—the Permanent Forces were limited to a small core of officers and NCOs who would carry out administrative, instructional, and technical duties, with citizen soldiers forming the Army's field force and providing its commanders.[23]

The conscious division of Army into two forces—permanent and part time—left an indelible imprint upon it. In the decades following Federation, both groups competed for scarce resources, equipment, training opportunities, the attention of the public and government, and chances to use their capabilities. This internal rivalry sometimes spilled over into the public sphere. In November 1937, Major-General Gordon Bennett (who would later command the 8th Division in Malaya and Singapore) took to the newspapers to publicly decry the fact that two of Australia's six divisions were being commanded by regular officers and not citizen soldiers. 'Experience has proved', Bennett declared, 'that citizen officers can handle our Citizen Army more efficiently than permanent officers', as it was only they that possessed 'the capacity to lead'.[24] This article, in the major Sydney paper *The Sun*, was accompanied by a second a week later where Bennett claimed that the condition of the Army made him feel 'ashamed of my Australian citizenship'.[25] Unsurprisingly, such public statements caused considerable and lasting ill will between him and many permanent officers.[26] During the Second World War, and especially while on operations, the distinction between permanent soldiers and part-timers decreased markedly. Some decisions, however, still caused friction. Prime Minister Robert Menzies's 1939 declaration, for example, that all commands of the 6th Australian Division would go to militiamen rankled many permanent officers seeking opportunities to command.[27]

Despite the creation of the Australian Regular Army in November 1947, there was still a widely acknowledged belief that Australia required a strong body of citizen soldiers. Yet, as Dayton McCarthy has shown, the years 1947–1974 were hardly happy ones for citizen soldiers in Australia, as they were faced with government apathy, military-bureaucratic disinterest, and societal ambivalence, and were unable to adapt to changing defence environments.[28] This period marked yet a further period of competition for primacy within the Army between regulars and CMF personnel. Indeed, that they competed here and previously is somewhat to be expected. According to noted sociologist Andrew Abbott, intra-professional competition—where defined groups within a profession compete for organisational, bureaucratic and status primacy—constitutes a normal aspect of professional life.[29] In this instance, and by the withdrawal of the Army from Vietnam, this was a battle which the regulars won.

It was in the 1960s that the regular Army began to adopt and use the terminology of the 'profession of arms' to support recruiting. Yet there was some attempt to broaden the utility of this term within Army. In April 1974 a committee under Thomas Millar (an academic and former permanent and CMF officer) submitted a report to parliament advising on the future of the CMF and its potential transition into an 'Army reserve'. The role of a CMF-like force to supplement regulars was articulated, and it has remained since a model that Army has employed to maximise its national defence capacity. Throughout this report the authors did identify a place within the Australian profession of arms for members of such a reserve force. The report acknowledged that not only did the CMF undertake some of the peacetime functions of the regular Army but reservists brought with them 'special skills' that the Army had not paid for, with the 'voluntary, amateur enthusiast' also able to achieve 'remarkable levels of professionalism, perhaps higher than are achieved by some people occupationally engaged in the same pursuit'.[30] Both regular and reservist needed to come to understand that they were part of a single team—'one Australian army' or a 'total force'—while acknowledging and understanding the differences in service of each. In the 30 years since the end of the Second World War, the report noted, Australia had developed a profession of arms—the 'place of the citizen soldier in the total context of this profession is different from what it was in the past, but it is still essential and honourable'.[31]

Yet such exhortation fell on barren soil. Only seven months later, in November 1974, a report on the Army by the Senate Standing Committee on Foreign Affairs and Defence ignored such rhetoric. While acknowledging that the citizen soldier remained vital to a major Army expansion, it nonetheless concluded that they would only 'complement rather than [be] a substitute for the highly trained and professional corps of regular soldiers'.[32] It is here, most plainly, that the regular Army claimed sole jurisdiction over both the title 'professional' and the profession of arms, a rhetorical ground and aspect of professional identity that it subsequently held for many years. This had many lasting consequences—in 2013 some reserve members reported they faced a 'deeply ingrained' hostility from regulars, while also accusing some of ensuring they were 'deliberately misinformed' on exercises to ensure they appeared 'unprofessional'.[33] Further research is necessary to assess, beyond anecdotes, if this is still the case. Such tensions between reservists and regulars are, as Vincent Connelly has shown in a British context, 'an enduring challenge to the [total defence force] concept'.[34] They are also a challenge to a unified Army Profession that incorporates reservists into its ranks.

Reserves in the Army Profession: Employment and Doctrine

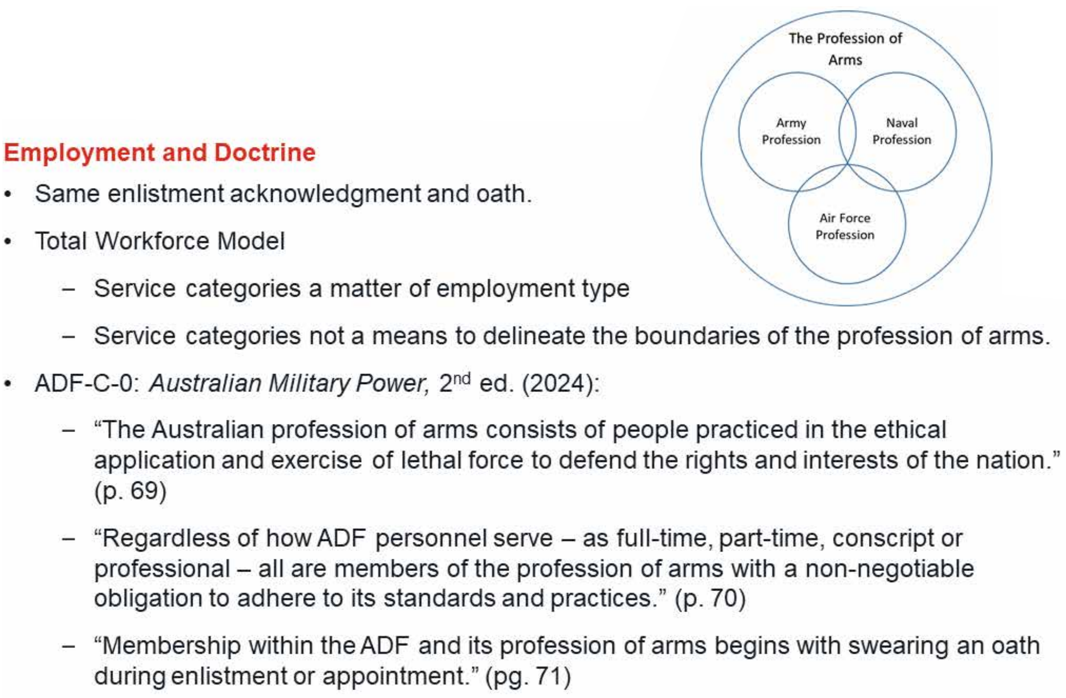

Figure 1: Slide from presentation

It is with this conceptual and historical foundation in mind that we can turn to some of the contemporary factors bearing on the place of the reserves and the reserve infantry in the Army Profession. Let us begin at the highest level, namely that of employment and doctrine. It is, I think, important to remember that individuals now joining the ADF as full-time or part-time members join the same institution, under the same oath of service, and in doing so agree to adhere to a common legislative and disciplinary framework. Both reservists and full-timers acknowledge that they may be liable to perform combat or combat-related duties, as well as peacekeeping, humanitarian assistance, or disaster relief either within or beyond Australia's territorial limits.[35] Further to this, under the Total Workforce System, individuals do not join a reserve organisation, but instead join the ADF in a specific reserve service category. This is an employment classification, not a delineator of capability, role, or professionalism. This is supported by the capstone document in the ADF's suite of doctrine—*Australian Military Power*. I will not read verbatim each of the quotes on the slide I am showing (Figure 1), but I will draw your particular attention to the second one, which attests that all ADF personnel—be they full time, part time, conscript or professional (this should be altered to 'permanent')—are members of the profession of arms. Such membership begins with the swearing of the oath during enlistment or appointment.[36] If we are to accept the model whereby the Australian Army Profession exists as a subset of the Australian profession of arms, then the suggestion that reservists belong within the Army profession is a strong one.

Reserves in the Army Profession—Perceptions of Identity, Time and Commitment

Yet despite such a sweeping declaration by this doctrine, there is the issue of perception. As Sam C Sarkesian noted in 1975, 'to be called a professional is to be qualified and perceived of as an expert. The word identifies a person as one who has more than an occupational commitment to [their] speciality'.[37] 'Time' and 'perceptions of time served' are used by many full-time professionals in many professions 'to dismiss the professionalism of those members who violate the norms of long hours [and] the blurred boundaries between work and home', and to call into question the commitment of individuals who elect to undertake part-time work regardless of their competence.[38] Indeed, the 24/7 nature of the permanent soldier's commitment is fundamental to many full-timers' identity as military professionals.[39] Many, both in the public and internally in the ADF, therefore have had a tendency to disregard the role of reservists, viewing them as non-authentic military members largely motivated by tax-free pay or the desire for a hobby.[40] This is a not altogether unexpected outcome of the dual military and civilian lives of the reservist. By positioning themselves simultaneously in both the civilian and military worlds, reservists face the unenviable situation of usually being defined by the half that differentiates them from whichever context they happen to be in.[41]

Such perceptions do not withstand scrutiny. Significant research in both Australia and Britain has shown that reservists occupy a unique form of employment, one used by many to pursue two or more careers simultaneously.[42] While we should not presume that this attitude reflects the motivation of all reserve members, I would support the contention that many Australian Army reservists take a 'professional approach' to their reserve roles and aim to be able to do their job to the same standard as the regular soldier, this being a means through which they judge their competency and professionalism.[43]

The accusations that reservists lack the commitment required of a profession are also ill founded—Defence relies upon the commitment of reservists to achieve even business-as-usual outcomes.[44] Some reservists have been reported as structuring their relationships and civilian employment around their reserve service, and not vice versa as one might expect.[45] In the UK this has led some Army Reservists, as a means to show their commitment to their service, to more actively demonstrate sacrifices made regarding their civilian career or family time while also undertaking extra hours of unpaid work.[46]

Motivations for reserve service should also not solely be reduced to a desire for tax-free pay or to play soldier. Indeed, if service to society is a fundamental aspect of modern professions, then many Army Reservists also fulfil this requirement. In a paper published this year by the Australian Army Research Centre, a survey of reservists demonstrated that the most common motivations for service are a volunteer ethic, a desire to serve the community, and a sense of patriotism.[47] Again, this is reflective of the motivations of many reservists in partner nations such as Canada.[48] As to the suggestion that reservists are motivated by financial remuneration, this cannot and should not be disregarded. We should, however, note that the recent Strategic Review into the reserves emphasised that the pay and financial benefits of reserve service were increasingly being seen as uncompetitive against alternative forms of part-time employment, with a disparity of approximately 30 per cent between SERCAT 5s and SERCAT 7s.[49] Again, further research is needed to provide additional hard data on perceptions of ADF reserve service both within and without.

Reserves in the Army Profession

We must also consider another factor that can complicate the reservists' place in the Army Profession: that is, whether reservists can attain and maintain the expertise expected of the 'Army Professional'. There is a view that the 'practice of military skills demands a degree of expertise that can only be acquired through extensive training in the highly institutionalized settings of the standing army' and therefore the reserves cannot be considered truly professional.[50] But is this necessarily true? Militaries have long struggled with the problem of generating capability from reserves and part-time soldiers, an issue particularly acute in the combat arms. Whereas the lawyer, doctor, or cyber specialist may be able to practise core aspects of their reserve role through a civilian career, the reserve infanteer cannot unless they are employed in specialised police roles related to counterterrorism or tactical response, and even here they will use different tactics, techniques, and procedures. To this, I would suggest consideration of three factors.

Firstly, we should not disregard the often impressive capability that reserve soldiers are able to generate in the limited training time and opportunities they have, *in spite of* the 'part-time army; full-time admin' burden.[51] Over the past 25 years, reservists have proven themselves fully capable of operational service, especially after the usual pre-operational training with regular counterparts.

Secondly, where a reservist may lack proficiency in a military-specific skill, they often bring into Army a wider base of skills and experience derived from their civilian employment that, some feel, can make up for less frequent military training. This is perhaps most notable in deployments involving substantial civil–military engagement. However, some British reservists have reported that regular soldiers do not value or see as relevant expertise or experience gained in a non-military context.[52] This dismissal of civilian experience is replicated in ADF bureaucracy—the *Strategic Review of the Australian Defence Force Reserves* noted that many reservists provide the ADF with 'extensive civilian or commercial experience that does not match an ADF qualification but provides a level of expertise necessary for an ADF outcome'.[53] The engineering, intelligence, medical, and technical trade skills that some reservists bring with them into service are critical to meeting ADF operational requirements, are of significant use in the application of violence in the land domain, and can be expensive to generate and maintain internally.[54]

Thirdly, the ADF has come a long way in providing opportunities for education and training to its reserve cohort. For example, there are now part-time courses at the Australian War College and reserve iterations of the Combat Officers Advanced Course. Further progress in this area is needed, however, to ensure that reservists are provided the same access to training and professional development courses as regular personnel. To ensure maximum integration, further opportunities for realistic exercises incorporating both reserve and regular formations must also be developed.

Reserves in the Army Profession—the US Army Reserve and the National Guard

We have already acknowledged that professions differ across national boundaries owing to different social, cultural, regulatory, and legislative frameworks. Notwithstanding this, it may be useful to consider how a key ally and partner, in this case the United States, conceptualises the place of its reserve forces in its military profession. In 2010 the US Army commenced its own journey of introspection into the nature of its army profession and profession of arms, acknowledging that in preceding years the institution had sometimes 'struggled' to 'maintain the highest standards of the Profession of Arms'.

One of the critical questions posed in commencing this review was this: 'What does it mean to be a professional soldier?'[55] A draft definition was provided, articulating that an American professional soldier was:

> an expert, a volunteer certified in the Profession of Arms, bonded with comrades in a shared identity and culture of sacrifice and service to the nation and the Constitution, who adheres to the highest ethical standards and is a steward of the future of the Army profession.[56]

As a definition of membership within the profession, this was not sufficient. In subsequent discussions it was rapidly identified that the multiple cohorts with a stake in the profession of arms (civilians, soldiers and officers at all levels and employment statuses) found exclusivity in membership to be 'divisive and not helpful in enabling the Army to archive its mission and exercise its core competencies', as each was an 'indispensable contributor to the Army mission'.[57] This was a point forcefully reinforced by General (ret.) Fredrick Franks in the pages of the US Army's *Military Review*. Here, Franks suggested that the operationalisation of the US Army Reserve and National Guard, and their continuing contribution to force generation for dangerous overseas deployments, fitted them to be incorporated into the profession.[58] Both justifications were embraced. Subsequently, *Army Doctrine Reference Publication No. 1—The Army Profession*, published in 2013, allowed no space for interpretation, declaring that '[t]he Profession of Arms is the uniformed members of the Army Profession. This category includes the Regular Army, Army National Guard, and Army Reserve'.[59] The National Guard and the US Army Reserves remain within the Army Profession and the Profession of Arms, each being acknowledged as a key component of the 'Total Army' construct.[60]

Reserves in the Army Profession—Additional Considerations

There do remain, however, additional considerations that must be borne in mind regarding the place of the reserves in the Army Profession. The first is a matter of an alternative categorisation. In 1990, noted US sociologist Charles Moskos suggested that, instead of just the delineation between regular and reservist, there could exist a category of 'professional reservists' or 'part time professionals' who, in terms of the capability, commitment, and time served, occupied the middle ground between the professional regular and the traditional 'weekend warrior' reservist.[61] As a model, this is a limited one, and the potential ramifications of further sub-categorising Army's soldiers based on perceived capability would be significant and negative.

Important consideration also needs to be given to the role of unlimited and limited liability in the Army Profession. Where regular soldiers use the concept of unlimited liability as a key aspect of their identity, this can marginalise the reservist. Unless subject to a call-out order from the Governor-General, reserve service is inherently more conditional, more flexible, and more easily withdrawn on the basis of a lack of fulfilment.[62] Further research and debate on how far the unlimited or limited liability concepts apply to service in the modern ADF is necessary, as this could have ramifications should some seek to ensure the Army Profession is a tightly bounded and exclusive professional body and identity.

Lastly, we must consider how far we are able to stretch the boundaries of the Army profession. Professions are, by their nature, designed and developed to deal with a particular problem or provide a certain service. Annexation by a profession of additional tasks or groups has risks. As Abbott has shown, as the boundaries of a profession expand, the central ideas unifying it necessarily become more abstract.[63] This can weaken the control of the profession over the tasks being undertaken, diminish its status and make it vulnerable to inter-professional competition. In public and vocational discussions regarding the place of the army's reserves in the army profession, commentators must be sure to highlight through rigorous and empirical arguments how their presence in the profession strengthens it.

Conclusion

As already noted, there has been little exploration in Australia of the unique association between the Army Profession, the reserves, and reserve service. For many years, the doors of the profession were held closed to reservists. Times have changed, and the role of the reserves has changed. On balance, and considering many of the factors I have discussed today, it is my hope that many reservists do conceive of themselves as members of the Army Profession, fully and wholly incorporated into its framework. This, I feel, is only reasonable—it is an acknowledgment of the very real contribution of the reserves to Australian defence and security. We must also consider the perception of any resistance to Reserve inclusion. Given the critical mission provided to Army's reserve formations under Theatre Mission One, it would not benefit Army's relationship with society if homeland defence were being seen as led by non-professionals, weekend warriors, and hobbyists who lack the expertise to fulfil their mission.

Yet there still do exist a wide variety of interpretations of what the Army Profession comprises and how far its membership extends. This can range from seeing it as a highly exclusive body solely comprising only full-time regulars of the combat corps, through to incorporating Army's entire workforce, including public servants and contractors. Understanding the boundaries to the profession will be an important area of research and discussion as we continue to review the current state of the Army profession. As with all other cohorts within the Army Profession, and in line with standard practice in other professions more generally, reservists must continue to publicly and vocationally advocate for and defend their place in the profession. Regulars, I would also suggest, also have a part to play by ensuring they acknowledge the important contributions of reservists to the profession, Army, and defence. Army will only benefit if all reservists and regulars come to feel and to understand that they are colleagues in a single profession—the Australian Army Profession—working together with other members of the Australian Profession of Arms, in service to Australian society.[64]

About the Author

Dr Jordan Beavis is an Academic Research Officer at the Australian Army Research Centre, having formally worked as a Researcher for the Australian War Memorial's Official History of Australian Operations in Iraq and Afghanistan. His research focuses on the militaries of the British Empire/Commonwealth in the interwar period (1919–1939), international engagement, professional military education, and mobilisation.

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/ BOOK REVIEW

The Race with No Finish Line: Assessing the Strategy of Regional Great Power Competition

Author: Martin Skold

Marine Corps University Press, 2023, 440 pp, ISBN 9798985340402

Reviewed by: Ping-Han Chua

It is an oft-repeated statement that we live in an era of great power competition, between the West (led by the US) and revanchist/revisionist states (led by the People's Republic of China (PRC)). This statement features prominently in the National Defence Strategy[1] and it guides Australian strategic policy, defence planning, force posture and readiness. This great power competition has become entrenched and is multidimensional. Unlike the Soviet Union in the Cold War, which was primarily a military power, the PRC represents a full-spectrum competitor that is willing to blend and use all tools at its disposal on its campaign of 'national rejuvenation'.[2]

But what is disturbingly unclear is how this competition might end: perhaps uneasy coexistence and an agreement to carve the world up into spheres of influence, perhaps the capitulation of one side and ascendance of the other or, worse still, a catastrophic war. Indeed, the avoidance of war—which is the aim of our 'strategy of denial'[3]—is in and of itself an incomplete goal. A competition for competing's sake is still inherently risky, costly and open-ended.

The Race with No Finish Line seems to answer the need to examine the nature of great power competition—how and why states compete, the dynamics at play, and how competition affects those states internally, each other, and other states. In the corpus of writing on the spectrum of conflict, there is much more commentary and speculation on a potential PRC–US war. Indeed, the title of the book (a call-back to the Cold War) promises to redress the imbalance.

This book sets forth a framework for assessing a state's competitive strategy and its prospects for prevailing in a competition for regional hegemony. The framework is easily comprehensible and mercifully free of quantitative formulae. Based on the book's date of publication, title, and cover photograph of the US 7th Fleet at sea—and the author's background as a US policy practitioner—any reader could reasonably assume the book will assess the US–PRC competition.

Instead, what follows is an overly detailed historical case study of the so-called Dreadnought race between Imperial Germany and the British Empire in the late 19th to early 20th centuries, when the former challenged the latter's dominance in capital ships in the North Sea. The author devotes no fewer than 254 of the book's 374 pages to the Dreadnought race: its origins (Chapter Four), the competition itself (Chapter Five), and strategic perspectives on the race (Chapter Six). The example is anachronistic and not mentioned on the book's cover, which felt like a literary bait-and-switch. The unfortunate result that readers, who may need a specific interest in naval history to wade through this case study, are left wishing the book had instead covered other historical examples or the current PRC–US competition.

To be fair, parts of the book are not without their usefulness to the field of statecraft. The first two chapters offer a lucid discussion on the different types of strategy states might employ to compete against other actors. These chapters are a good primer for any budding strategist. Skold outlines the nature of competition, whereby an aspirant seeks to surpass or supplant the incumbent in a zero-sum game. Applying this paradigm, a competitive strategy is one in which a decision to compete is made, finite resources are marshalled and directed, and choices are made (both deliberate and situational) on *how, when and where* to compete. Chapter One also makes a useful observation that in state competition, business strategy (rather than military strategy) is more relevant. States, like businesses, angle for competitive advantage by allocating resources and making better decisions than their competitor(s).

The third chapter then sets out the framework (summarised on pages 107–108) for assessing a state's competitive performance. The framework is strictly bounded: there must be a challenger ('beta') who has decided to compete, and a reigning hegemon ('alpha') who has decided to hold its position. Both states must compete for regional hegemony over a definable area; war could, but need not be, the end point of the competition. The success of a state will depend on how well its leader(s) formulate and execute a plan, and how well they articulate strategic intent. A state's ascendency will also turn on whether its leader(s) can make consistent decisions (especially on how to use their competitive advantage and core competencies) in pursuit of three broad goals: security, financial prosperity, and the welfare of its polity. Usefully, the author accounts for intangible goals such as national prestige and the ambitions of dominant leaders (Kaiser Wilhelm II, in this example).

Skold's framework does have utility and relevance, since it can be overlaid on the circumstances of current US–PRC competition. However, readers will need to have an extensive knowledge and nuanced understanding of both the US's and PRC's internal politics, systems of government, industrial bases and other sources of national power, and their 20th century histories, to apply the framework and produce cogent insights. It is therefore disappointing that this book falls short in that regard.

Despite the Dreadnought race having a clear winner (Great Britain), this competition was quickly surpassed by the Great War that set Europe on an irreversible path to losing its global power. Similarly, the US and PRC risk getting locked into an ever-escalating and ever-widening pattern of competition with no clear end point. A race with no finish line may tragically bring about the very war that both sides want to avoid.

The most useful chapters of this book have appeal for strategic policy and decision makers, military planners, net assessment and intelligence analysts, or mid-career officers wanting to improve their understanding of strategic competition. The example of the Dreadnought race serves as an implicit warning for our leaders to define objectives, calculate the costs and make prudent decisions.

About the Reviewer

Colonel Ping-Han Chua is a serving intelligence officer.

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/ BOOK REVIEW

Beyond Ukraine: Debating the Future of War

Editors: Tim Sweijs and Jeffrey Michaels

Hurst Publishers, 2024, 432 pp, ISBN 101911723162

Reviewed by: Jason Kirkham

Can the war in Ukraine provide us a clearer perspective on the nature and character of future war? This is precisely the question that Tim Sweijs and Jeffrey Michaels attempt to answer in *Beyond Ukraine: Debating the Future of War*, an edited collection of essays by leading scholars in the field of future war studies. The book provides a diverse range of insights into the future of war, which collectively highlight a central premise: we have not overcome the darker angels of humanity, war will continue well into the future, and only through careful examination can we hope to forecast war's evolving nature.

The book is divided into four parts which each deal with a fundamental question in the field of future war studies. Each section covers a diverse range of topics which collectively produce an extensive mosaic of perspectives on future war.

In Part One, a robust case is put forward that the so-called 'decline of war' is a delusion. Antulio Echevarria convincingly posits that the global conditions we have come to associate with the decline of war were, surprisingly, responsible for precipitating its eruption in Ukraine, and that these same factors are likely to trigger conflicts elsewhere. Frans Osinga reinforces this view by arguing that rather than receding, war is instead evolving across independent but interrelated visions. Specifically, he contends that war is likely to manifest along what Azar Gat terms 'the boundaries of the zone of peace': geographic regions where social, economic and political conditions promote conflict.[1] Part One concludes neatly by addressing the fact that the democratisation of war through cyberspace, as demonstrated in Ukraine, will inevitably attract hundreds of new cyber groups as parties to future conflicts, greatly expanding the reach and effect of future wars.

Part Two paints a gripping picture of future war that entails a multivariate struggle between state and non-state actors in which societies will play a central and expanding role. Frank Hoffman compellingly elucidates that future war will manifest non-linearly, exhibiting blends of cognitive, societal, proxy and conventional conflicts. Jan Honig complements and deepens Hoffman's view by pointing out the ever-increasing role of society in conflict, where the definition of combatant is changing and becoming muddied by the maturation of war-enabling civilian technologies. David Betz maintains Honig's people-centric focus by describing the West's inevitable descent into civil war. Betz provocatively, and at times overconfidently, asserts that the degradation of social trust and unity will fuel intercommunal violence on a grand scale. Paul van Hooft concludes the section with a view that the uneven distribution of technology will result in a strategic stalemate alterable only by the few nations rich enough to technologically innovate. While van Hooft's argument is compelling, he drifts thematically away from the main theme of Part Two, and his essay might better have been included in Part Three.

Part Three examines the evolving role of technological innovation in future war. Audrey Cronin persuasively submits that the convergence of advanced technologies into widely accessible forms will alter military innovation from a centralised top-down process to one that must draw increasingly on civilian and commercial technology sectors to remain competitive. Cronin's argument is vindicated by Lauren Gould's, Linde Aretenze's and Marjin Hoijtink's examination of how Netherland's innovative 'Military–Industrial–Commercial Complex' has generated a more efficient and integrated relationship between military and non-military technology providers. TX Hammes expands on the need for this type of innovation to generate new access-enforcing capabilities to break the defensive predominance on today's battlefields. His contribution segues well into Kenneth Payne's essay on artificial intelligence (AI), a technology he argues will deliver revolutionary effects on data aggregation, wargaming and endurance—though he stops short of asserting that AI alone will be strategically decisive.

Part Four sets out to provide a sophisticated lens through which to anticipate future war, and it succeeds to an extent. Beatrice Heuser advocates for deep historical reflection, rather than flawed presentism, to inform potential directions of future war. Collin Meisel's systems-based approach posits five factors that explain why war has been—and will remain—inherently resistant to long-term forecasts. Jeni Mitchell reminds us that the risk of apocalypse via biological, environmental and societal factors will continue to play a commanding role in all of humanity's decisions regarding war. Antoine Bousquet then concludes with a call to abandon further attempts to divine war's essence in favour of efforts to understand how and why war changes over time. All four essays combine exceptionally well to support the view that, while war is unknowable, history evidences traceable patterns and characteristics. Unfortunately, while it elucidates war's undefinable nature, Part Four leaves the reader uncertain about how to anticipate future war.

At its best, *Beyond Ukraine* successfully overcomes the implacable challenge of capturing war's complexities in written form. The diversity of subjects is so varied that even experienced war studies readers will be challenged and enlightened. *Beyond Ukraine* belongs alongside other great works on the nature of war, such as Lawrence Freedman's

The Future of War: A History, and Steven Pinker's *The Better Angels of our Nature: Why Violence Has Declined*. In my view, HR McMaster's description of the book as 'The best edited volume on war and warfare to appear in this century' is a fair one.

The reader can be misled into purchasing this book on the premise that it will feature Ukraine as a core subject matter. The image of embattled Russian tanks on the book's cover certainly invites this perception, as does the cover endorsement by Mick Ryan, who describes the book as 'one of the most detailed and forensic explorations of the war in Ukraine'.[2] These marketing ploys detract from the book's far deeper subject matter, and references to the Ukraine war sometimes appear tokenistic and forced.

The book's greatest flaw is that it leaves the reader with no clearer understanding of war's uncertain trajectory or form. In reading the book, one hopes to gain an irreducible concept or unifying model to understand future war: a reference point to plot war's perilous and uncharted trajectory. Instead, the editors acknowledge the often contradictory views of its contributors and leave readers to plot their own course and direction. In this regard, the book leaves the reader unfulfilled, presenting as many questions as it answers. In dealing with such a complex topic, the book's strength is also its weakness.

Beyond Ukraine discusses competing visions and realities about the future of war, amassing a diverse range of perspectives from war studies scholars conveyed in a compelling four-part format. Each part engages deeply and compellingly, transposing real-world events to the deep and unsolvable conundrums of the future war field. The book reminds us that the study of war and its future remains as important as ever.

In sum, *Beyond Ukraine* is an excellent book that is highly recommended to military personnel in middle-level leadership roles, industry members in defence-related fields, leaders across government, and anyone with an interest in the future of war.

About the Reviewer

Major Jason Kirkham is an officer in the Royal Australian Artillery. He has served in a variety of joint fires and targeting related roles in 8/12 Regiment, 4 Regiment, HQ 1st Australian Division, and the School of Artillery. He is currently a student of the Australian Command and Staff Course.

ENDNOTES

1 Azar Gat, 'After Russia's Invasion of Ukraine: Is the Decline of War an Illusion?', in Tim Sweijs and Jeffrey Michaels (eds), *Beyond Ukraine: Debating the Future of War* (New York: Oxford University Press, 1994).

2 Mick Ryan, cover endorsement for Tim Sweijs and Jeffrey Michaels (eds) *Beyond Ukraine: Debating the Future of War* (London: Hurst Publishers, 2024).

/ BOOK REVIEW

In the Fight: Australians and the War in Burma 1942–1945

Editors: Andrew Kilsby and Daryl Moran

Big Sky Publishing, 2024, 412 pp, ISBN 9781923144552

Reviewed by: Jean Bou

Two Victorian historians, Andrew Kilsby and Daryl Moran, have put together an edited book examining the role of Australians in the Burma Campaign of 1942–1945. By their telling, the book stemmed from researching and writing a history of the involvement of Australians in that campaign's air war. In doing so they kept stumbling across other Australians that the war had brought to India and Burma. So plentiful were these examples that Kilsby and Moran decided the subject deserved a book in its own right, and this is the result.

The collection includes a dozen chapters by a dozen authors, each on a different topic, that trace out some aspect of Australian involvement. Because there was no specific Australian military contribution to the Burma Campaign, the chapters are largely what might be described as 'incidents of the war'. That is, the ebb and flow of the war, imperial connections and a common foe led to Australians being there, either as individuals or as part of some group. So in this vein, for example, Karl James has written about special operations, Meghan Adams about women Red Cross volunteers in Ceylon, and Kama MacLean about Richard (RG) Casey's time as Governor of West Bengal as it was afflicted by famine.

In doing so, the authors have cast light into niches of what is already a niche part of Australia's war history. It is a trite habit of publishers to claim that a history book examines something 'forgotten' (all history is more or less forgotten), but in this case the claim is accurate enough. The book's main value lies in featuring these relatively obscure experiences. In this way, it gives the individuals and groups a historical legacy while also offering a valuable insight into, and reminder of, how everyone's war was different. We tend to think of wars as collective experiences, and they are that. More broadly, however, the currents of the war meant that individuals were taken to unexpected places to do unexpected things, and the kaleidoscopic range of stories in this book testifies to that variety. In doing so it also underlines how the ties of empire meant that certain Australians were drawn into a theatre of war that was of lesser importance to the rest of their compatriots.

The editors have seemingly decided to emphasise these individual stories. Their own chapter about the air war, for example, provides enough about this aspect of the campaign to give some structure but focuses mostly on the experiences of Australian individuals in it. The result is a collection of personal vignettes but little historical analysis of the institutional, military and political currents or issues. If you are wondering about the conduct of the campaign, an examination of the institutions, the links of empire or policy debates, even as they pertained to Australia and the people it provided, you will have to look elsewhere.

Moreover, the attention to personal stories gives many of the chapters a ‘bitsy’ feel. Few individuals were directly involved in the war, let alone this theatre, from beginning to end. The war drew people in, and circumstances usually took them out again at some point, be it from illness, wounding, capture or death, or the banalities of belong posted somewhere else, or their specific utility coming to an end. The result is a collection of brief mentions of individuals as they have their moment in this book’s sun. Some of them were undoubtedly noteworthy in their own way. That the famous ‘hump’ air route over the Himalayas was pioneered by an Australian, Sydney de Kantzow, flying for a Chinese airline is a small historical gem, for example. In other cases, however, the material is less rewarding. Karl James has laboured mightily to eke out a chapter about Australian special operations personnel in the theatre, but it is apparent that he had a patchy historical record to draw on.

For these reasons it is perhaps not surprising that the chapters that tend to work best are those that have a stronger collective or institutional element to them. Tom Lewis’s chapter on the Royal Australian Navy in the Indian Ocean, for example, includes personal aspects while remaining well anchored by the progress of ships and episodes of the war at sea. Meghan Adams on the women of the Australian Red Cross, and Jaqueline Dinan on the Women’s Auxiliary Service are similarly aided by having an organisation to hang the subject’s experiences from. The same can be said of David Mitchelhill-Green’s arresting chapter on pioneering and maintaining Qantas’s remarkable wartime Indian Ocean route.

The book’s emphasis on personal vignettes should not dissuade you if you have a particular interest in the Burma Campaign or in pushing your knowledge into rarely explored aspects of Australia’s war history. *In the Fight* is a collection of well researched and written chapters. It is, to this point, probably the only place where you will find a concise treatment of Australians in the campaign—something that is unlikely to change in the foreseeable future.

About the Reviewer

Jean Bou is a widely published historian and a visiting scholar at the Strategic and Defence Studies Centre at the Australian National University. He was on that centre's academic staff for more than a decade, where he convened War Studies, and taught both at the Australian War College and in undergraduate and postgraduate programs at Acton. He was previously a historian at the Australian War Memorial.

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/ BOOK REVIEW

The Other Great Game: The Opening of Korea and the Birth of Modern East Asia

Author: Sheila Miyoshi Jager

The Belknap Press of Harvard University Press, 2023, pp 624,
ISBN 9780674983397

Reviewed by: Andrew Maher

Australian defence policy clearly recognises that we are in a period of strategic competition, with reduced warning times for potential conflict. Large-scale conflict thus gains a dominant focus in Australian strategic commentary, ironically to the detriment of the broader picture of competitive statecraft.

The Other Great Game: The Opening of Korea and the Birth of Modern East Asia addresses this oversight. In an award-winning work of some 600 pages, Professor of East Asian Studies Sheila Miyoshi Jager covers two major wars—the Sino-Japanese War and the Russo-Japanese War—in the context of several decades of strategic competition for Korea, chronicling the period from the 1850s into World War I. With a title that illuminates the dominance within 19th century history of the 'Great Game' that played out between Russia and Britain over Central Asia, this book evokes the importance of a global view of competition, in which other 'games' are played.

While Army audiences will find comfort in the description of how these two large-scale wars were fought, the focus of the book is on the competitive statecraft which surrounds these events. Examination of the competition for Korea offers three key lessons for members of the Australian Defence Force and Australian Government policymakers when considering the risks of conflict.

First, the nature of competition is enduring and mirrors today's strategic challenges. There are thus lessons to be drawn from the history of north-east Asia. Second, the analysis serves to illustrate that 'hybrid warfare' is nothing new: competition for Korea involved subversion of the Korean monarchy, use of proxies, economic coercion, and orchestration of coups d'état. Competition gives rise to subversion, efforts to weaken the adversary through imposition of costs short of war. Last, Miyoshi Jager's examination of the 'Other Great Game' highlights the risks to social stability that can be caused by large-scale combat operations. The losers of the competition for Korea—Korea itself, China and Russia—all experienced revolution or the complete failure of the state because of conflict. Japan, the supposed victor, also experienced social turmoil and a certain radicalisation in its foreign policy due to the experience of competition. The history of the Korean competition illuminates and emphasises the risks of conflict to all participants. In doing so, it offers lessons that may help Australian efforts to formulate deterrence strategies and associated messaging within our nearer region.

Today, defence commentators are quick to point out Beijing's support to a Russian government that is under considerable political pressure. In the context of China's so-called 'century of humiliation', the competition for Korea suggests that Beijing might feel a certain schadenfreude regarding Russia's present humiliations. Western history doesn't emphasise Tsarist Russian exploitation of the weakened Qing dynasty through the treaties of Aigun (1858) and Peking (1860), which together won the Amur River basin area to Vladivostok—an area the size of Germany and France combined.[1] But Russian territorial ambitions were not satisfied by this achievement—appeasement does not placate autocratic regimes in competition. Instead, Russia sought to use commercial 'fronts'—the China Eastern Railway (CER) and logging concessions along the Yalu River—to subvert Peking's dominance over Manchuria and Korea respectively. Russia also fought a minor conflict for the Ili valley region of today's Xinjiang region in 1879–80, further deepening Qing distrust of Russian intentions.[2]

The Great Game shows a rhyming throughout history in the methods that states use to subvert their opponents. Seldom is this dynamic limited to a two-player competition. The Japanese, too, competed for Korea. An elite praetorian guard for King Kojong was trained by the Japanese, the so-called Pyŏlgigun (Special Skill Force). Palace politics in Seoul were ruthlessly exploited by the Japanese, with numerous coups d'état involving Japanese support or orchestration, leveraging the influence they created with King Kojong. The Koreans, however, recognised they were trapped between two fires—those of Japan and Russia. In a policy paper written by a Korean strategist in 1879, the outlook was bluntly stated as: 'Korea's position in Asia guarantees to trigger conflict'.[3] The Koreans recognised the need to block Russian expansion if there was any hope to survive. Cultivating support from China, Japan and the United States, the Korean government sought to prevent the country being 'sliced up like a cucumber'.[4] Nonetheless, elite corruption rotted away Korean resilience to external shocks. Political violence further subverted Korean strength; the Imo Uprising (1882) was an early manifestation of social discontent, followed by the Tonghak rebellion in 1894 (although a constant drumbeat of Korean popular insurrections characterised the 1880s–1890s).

As noted, *The Other Great Game* illustrates that hybrid facets of warfare are enduring. The 1894 Tonghak rebellion—a religious, anti-foreign movement strong in Korea's south—precipitated a form of hybrid warfare.[5] Specifically, links between the Tonghaks and Japanese right-wing 'patriotic organisations'—the Gen'yosha (Black Ocean Society) and the Ten'yukyo (Society for the Celestial Salvation of the Oppressed)—illuminate a proxy dynamic. Over this period, the Japanese government siphoned weapons and funding through Japanese right-wing groups to the Tonghaks.[6] Seoul requested Chinese troops to help put down the uprising; the Japanese government, feeling its influence threatened, also sent troops.[7] The Japanese government then orchestrated a coup in Korea to retain influence, in turn triggering the outbreak of the first Sino-Japanese War. This large-scale conflict between China and Japan was accompanied by a civil conflict between Koreans—the government and the Tonghaks—resulting in some 30,000 to 50,000 Korean deaths, approximately the same as the number of Chinese and Japanese casualties from the larger war.[8] Japanese victory in the Sino-Japanese War led to the so-called 'Triple Intervention' of Russia, Germany and France. Through this external involvement, Japan was forced to cede the Liaodong Peninsula as part of the Shimonoseki Peace Treaty—a deep humiliation that planted the seeds for future Japanese imperial ambitions.[9]

The Other Great Game illuminates the history of acrimonious Chinese–Russian and Japanese–Russian relations that continued into the 20th century and echoes in contemporary Asian international relations. Japan's humiliation at Shimonoseki was made more acute by Russia's exploitation of a weakened Peking. Loans were used in an early form of 'debt-trap diplomacy' to bolster Russian efforts to secure influence over Manchuria.[10] Russia's exploitative actions in Manchuria intersected with the rising discontent of the Chinese peasantry with their own government's ineptitude. The Boxer Rebellion (another anti-foreigner movement), which began in 1898, took on an anti-Russian dynamic in Manchuria.[11] Thus, the brief Sino-Russian War of July–October 1900 had a hybrid dynamic as Chinese troops, Boxer movement guerrilla attacks, and armed banditry (*honghuzi*) threatened the CER and, thus, Russian interests. Nonetheless, the Russian military prevailed, securing the CER to its Port Arthur terminus on the Yellow Sea, and directly threatening Japanese interests in Korea.

The social impact of large-scale combat operations is also explored in depth through the lens of the 1904–05 Russo-Japanese War. Following its victory in the Sino-Russian War, Russia lapsed on its pledges to Tokyo and Peking to withdraw its troops from Manchuria. Japanese patience seemingly culminated when Russian soldiers, disguised as labourers and accompanied by *honghuzi* allies, occupied Russian timber concessions along the Yalu River valley in May 1903.[12] Russia and Japan engaged in diplomatic sparring—including the idea of segregating the peninsula at the 39th parallel—before Japan launched a surprise attack against Port Arthur on 8–9 February 1904, thus triggering the Russo-Japanese War.[13] The Russo-Japanese War was thus preceded by subversive competition that leveraged social discontent within the competitor's polity.

The Japanese fought a series of successful battles on land and at sea, some of which were the largest battles yet seen in modern history. For example, the Battle of Mukden involved 275,000 Russians and 200,000 Japanese.[14] Events such as this foreshadowed a shift in the character of warfare from the offensive to the defensive—a change that manifested clearly in the opening years of World War I. The impact of telegraphic communications networks brought news of successive Russian military failures which was communicated to the civilian population within hours of the event, with deleterious consequences for an already fragile Russian social fabric. In parallel, the Japanese military attaché in St Petersburg, Colonel Motojiro Akashi, cultivated independence movements in Poland and Finland, exacerbating tensions.[15] Ultimately, on 16 January 1905, strikes by some 160,000 workers in St Petersburg paralysed the city and led to the creation of a duma (parliament). This event planted the seeds of the Bolshevik revolution of 1917.

Koreans were mobilised to both sides of the conflict. For its part, Japan used some 260,000 Ilchinhoe (Advance in Unity Society) irregular Korean troops to support its logistics and espionage efforts. Equally, Russia mobilised Korean partisans under Cossack direction to conduct raids across the border into northern Korea.[16] Over the period 1906–1910, this anti-Japanese Russian-backed guerrilla movement was known as the Ŭbiyŏng (Righteous Army). Because of these developments, Japan became increasingly embroiled in counter-guerrilla actions along the Korean-Russian border.[17] The Japanese military (which believed it had won the war) became increasingly critical of civilian policymakers who appeared to be unable to secure the peace. These tensions would plague Japanese policymaking from the Mukden incident into World War II.[18]

The 1905 Russian revolution inspired Sun Yat-sen's establishment of the Tongmenghui (Revolutionary Alliance) which ultimately overthrew the Qing dynasty during the 1911 revolution. This revolution brought to a close a long period of Qing decline and precipitated Chinese fragmentation into a feuding warlord era of civil war that lasted until the Chinese Communist Party's victory of 1949. Thus, the reverberations of conflict over Korea had profound consequences for all major stakeholders in the 'Other Great Game'.

Reading Jager's book, it is not hard to see why it was the recipient of the Duke of Wellington Medal for Military History and the Robert L. Jervis and Paul W. Schroeder Best Book Award. Complementing its rich historiography is an easy-to-follow prose. Defence scholars can benefit from consuming this work in the context of several other rich historical works referenced in this piece.

The Other Great Game is a prescient reminder that strategic competition leverages subversive divides within society and that conflict causes its own second-order effects on social cohesion. Competition and conflict thus exert a systemic dynamic that might be described as a vicious cycle: our doctrinal phased approach to competition-crisis-conflict does not well highlight this systemic dynamic. In examining competition for Korea, this book helps place contemporary strategic tensions between China, Russia, Japan, Taiwan, North Korea and South Korea within the context of longstanding political tensions that have simmered for centuries. For scholars of defence and security issues, it presents several lessons from history regarding the realities of competition, the nature of competitive statecraft, and the risks of large-scale conflict.

About the Author

Dr Andrew Maher is a Professor in Military Innovation and Adaptation at Arizona State University and a postgraduate lecturer with the University of New South Wales (UNSW), Canberra. He has lectured on 'Irregular Warfare' and the 'Theory of Special Operations' at UNSW Canberra for over five years. He is a veteran of the Australian Army with over 20 years of service, including multiple deployments to Afghanistan and Iraq. In 2021, he was a Chief of Army Scholar. This paper leverages analysis conducted in the process of writing his book *Riding Tigers: The Strategic Logic of Proxy Warfare* (London: Hurst, 2026).

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16 Jager, *The Other Great Game*, pp. 310, 331–332.

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18 Pike, *Hirohito's War*.

/ BOOK REVIEW

MacArthur Reconsidered: General Douglas MacArthur as a Wartime Commander

Author: James Ellman

Stackpole Books, 2023, 288 pp, ISBN 9780811771580

Reviewed by: Liam Kane

Of the British and US generals who led armies and army groups in the campaigns in western Europe in 1944 and 1945, the soldier and historian Reginald Thompson wrote, 'Some of them seem to cast gigantic shadows, and the shadows were mistaken for the men'.[1] MacArthur too cast a big shadow—such were his temperament, fortune, privileges, responsibilities and reputation. While it is probably impossible to separate this man from his shadow, many have tried, and thanks to their efforts we have a kaleidoscopic portrait of the man that changes depending on the biographers' interests and feelings about him. James Ellman's *MacArthur Reconsidered* adds relatively little to scholarship on MacArthur but it nonetheless raises points about his military career and the nature of military biography that are worthy of consideration.

Readers are not deprived of books about MacArthur. Even if histories of the Second World War and the Korean War in which MacArthur figures prominently are excluded, a substantial reading list remains. His memoir, *Reminiscences*, was published in 1964 (the year of his death).[2] Three years later, the Department of the Army published the administrative history of General Headquarters, South West Pacific Area (GHQ) as *Reports of General MacArthur*.[3] Of the traditional life and times style biographies of MacArthur, the best-known works are D Clayton James's *The Years of MacArthur* (its three volumes were published between 1970 and 1985) and William Manchester's popular *American Caeser* (published in 1978).[4] There are also narrower accounts of MacArthur as a commander such as Gavin Long's *MacArthur as Military Commander* and Richard Frank's *MacArthur*, published in 1969 and 2007 respectively.[5] Ellman's *MacArthur Reconsidered* falls into this last category, being a brief narrative account of MacArthur's life focusing on his higher command experiences in the Second World War and the Korean War.

Ellman describes *MacArthur Reconsidered* as a corrective to the existent 'literature on MacArthur', which in his view consists of biographies ranging from 'complementary to idolatrous' and 'a few volumes that conclude that he [MacArthur] was a brilliant but flawed leader'. Ellman emphatically argues that MacArthur was a flawed, poor commander.[6] While Ellman thus sets himself against his predecessors, he nonetheless relies heavily on their works because he appears to have done no substantial archival research of his own. The emphasis that Ellman places on his use of 'letters, transcriptions of radio messages, diary entries, and memoirs' is thus misleading.[7] It is entirely possible for fresh archival research to shed new light on MacArthur's performance as a commander, even if revelations equalling the insights provided by material concerning Japanese radio communications intercepted and exploited by GHQ—declassified in the 1970s and 1980s—are probably not on the horizon.[8]

Ellman surveys the most contentious issues in MacArthur's career, but his judgements are mostly unconvincing. He is not necessarily wrong. This reviewer strongly agrees with some of his points. For example, Ellman rightly faults MacArthur for pushing too hard to drive the Japanese entirely out of the Philippines in 1945. This approach was unwarranted and resulted in unnecessary destruction.[9] Ellman's problems are a tendency to overstate his arguments, and lack of attention to detail and context.

Take an example from the war in the Pacific. Here the Joint Chiefs of Staff maintained two area commands: the Pacific Ocean Area under Admiral Chester Nimitz and the South West Pacific Area under MacArthur. This command arrangement and the reluctance of the Joint Chiefs of Staff to clearly prioritise one theatre over the other remain controversial. Weighing in on this debate, Ellman claims that resources spent taking Dutch New Guinea in 1944 in MacArthur's theatre would have been more wisely used in Nimitz's theatre to take the Mariana Islands earlier to commence strategic bombing of Japan sooner.[10] Ellman echoes the Chief of Naval Operations and member of the Joint Chiefs of Staff Admiral Ernest King, who regarded the Marianas as a key objective for the Allies. King's agenda competed with MacArthur's agenda to get to the Philippines via Dutch New Guinea and the Bismarck Islands. In March 1944, the Joint Chiefs of Staff instructed the theatre commanders to advance both to the Marianas and into Dutch New Guinea. Ellman attributes this compromise to the success that MacArthur apparently achieved in improperly imposing his 'will' on the chiefs to shape strategy.[11] This misrepresents a complicated decision-making process in which the Joint Chiefs of Staff and their advisers considered many factors, of which MacArthur's pressure was only one consideration—albeit an important one. They opted to advance along two axes because these courses of action were not mutually exclusive. In fact, they supported one another to some extent.[12]

Most of Ellman's other points—summarised in dot-point form in the book's conclusion—feature similar carelessness.[13] Take another example: the charge that MacArthur's supposed lack of interest in training significantly contributed to the ill-preparedness of the US Eighth Army for war on the Korean Peninsula.[14] The problems in the Eighth Army were at least as much the result of institutional problems in the US Army as they were of MacArthur's leadership. Further, MacArthur, in fact, took some interest in training. An amphibious training program in Far East Command that he initiated was interrupted by the outbreak of the war.[15]

Ellman is at his most rigorous when identifying distortions of the truth in MacArthur's memoir and GHQ's infamous communiqués during the Second World War. His commentary on the Papuan campaign in 1942 and 1943 reminds readers how carefully GHQ managed the public narrative of the war in the theatre.[16] Yet MacArthur's penchant for self-aggrandisement and dishonesty is well known. Catching him or one of his staff officers in lies or half-truths does not tell us anything about him that was not already known.

Future scholars of MacArthur may wish to come to their subject with a clear sense of military command as a social phenomenon. Ellman provides a sort of 'good commander checklist', including duties pertaining to preparation of forces, management of subordinates, civil–military relations and personal integrity.[17] Such lists are useful as far as they go, but others may wish to conceptually extend themselves. Carol Petillo's psychoanalysis-informed account of MacArthur's life in the Philippines remains the most forthright attempt to theorise in a biographical treatment of MacArthur.[18] While Freud may again be put to work on MacArthur, studies of military command are perhaps the more obvious place for a future writer to look for conceptual resources. The most useful study in this regard is Anthony King's study of divisional command in the 20th and 21st centuries, *Command*. This book is not without its problems (King's history is a bit patchy) and does not pertain to MacArthur's level of command in the Second World War and the Korean War. Yet King's conceptualisation of command would nonetheless provide a useful starting point.[19]

MacArthur Reconsidered would be of some interest those interested in MacArthur and his wars, and higher command in general. Seasoned readers will not find anything new here but they may find Ellman's criticisms thought-provoking. Newcomers are better off starting with Frank's *MacArthur*. The appropriate point to end this review on is not which biography of MacArthur to read but on a question: why study the man at all? The temptation to derive clean positive or negative lessons about command from MacArthur's career should be resisted because they are not there. What we see in him as a commander are flashes of different facets of high command in the 20th and 21st centuries—such as the porous boundary between political and military expertise in war and the fine line between the healthy contesting of ideas and internecine rivalries in bureaucratic decision-making. These topics are best understood with the relevant context and particulars in mind.

About the Reviewer

Dr Liam Kane is a Lecturer in Military History at Deakin University's Centre for Future Defence and National Security. His research focuses on Australian and United States military history in the era of the Second World War. His work can be found in scholarly journals such as *War in History* and the *Journal of Military History*.

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13 Ellman, *MacArthur Reconsidered*, pp. 232–236.

14 Ibid., pp. 155–157.

15 For the Eighth Army see Thomas Hanson, *Combat Ready? The Eighth U.S. Army on the Eve of the Korean War* (College Station TX: Texas A&M University Press, 2010), pp. 13–44; For amphibious training see Donald Boose, *Over the Beach: US Army Amphibious Operations in the Korean War* (Fort Leavenworth KS: Combat Studies Institute Press, 2008), pp. 81–83.

16 Ellman, *MacArthur Reconsidered*, pp. 91–95.

17 Ibid., p. 3.

18 Carol Petillo, *Douglas MacArthur: The Philippines Years* (Bloomington IN: Indiana University Press, 1981).

19 Anthony King, *Command: The Twenty-First Century General* (Cambridge: Cambridge University Press, 2019). For criticisms of *Command* see Tim Bean, Edward Flint, James Kitchen and Paul Latawski, *Orchestrating Warfighting: A History of the British Army's Corps and Divisions at War Since 1914* (New York: Routledge, 2025), p. 77.

/ BOOK REVIEW

MacArthur Reconsidered: General Douglas MacArthur as a Wartime Commander

Author: James Ellman

Stackpole Books, 2023, 288 pp, ISBN 9780811771580, RRP US$29.95

Reviewed By: Dayton McCarthy

It is said that Napoleon Bonaparte once quipped that he would ‘rather have lucky generals than good ones’. Certainly luck—or the fortune of circumstances—has played its part in any military defeat or success. Therefore, we might correctly assume that lucky generals are probably therefore successful ones. After reading James Ellman’s short and punchy book on General Douglas MacArthur, the reader will certainly conclude that this ‘American Caesar’ enjoyed inordinate amounts of good fortune repeatedly during his long career.[1] What is more, MacArthur’s luck was rarely that of a risky battlefield gambit—the Inchon landing an exception—coming up trumps. Instead, his luck was something different. Due to contemporaneous political or military circumstances, he avoided sacking or even censure on multiple occasions. This, coupled with his penchant for self-aggrandisement through spin-doctoring his actions, meant that MacArthur was not only able to survive his numerous mistakes but also to burnish his reputation further.

Australian Army Journal readers are probably aware of MacArthur’s actions in the South West Pacific Area (SWPA). This includes the machinations to sideline General Sir Thomas Blamey as the notional commander of the Allied land forces, the manipulation of Prime Minister John Curtin and the willingness to use Australian troops early on but then excluding them once he had sufficient American troops in theatre. They are less likely to know the multiple egregious overreaches MacArthur demonstrated in Korea. In *MacArthur Reconsidered’s* later chapters, Ellman illustrates that the denouement to MacArthur’s military career was one of insubordination towards higher political and military strategic leaders and fantastical post factum justifications for poor decision-making. Ellman pithily asks those who would still revere MacArthur: if a pattern of insubordination by a senior military leader of the Unites States is acceptable behaviour, what exactly would they consider to be unacceptable conduct?[2]

Ellman demonstrates that features of MacArthur's later actions and behaviours were identifiable early in his career. After service in the First World War, MacArthur enjoyed a meteoric rise up the ranks and was chief of staff of the army in 1930. He also began a long association with the Republican Party. In 1932 he courted controversy when he disobeyed President Hoover's explicit orders to not enter a camp of destitute veterans who had encamped in Washington, demanding that their retirement bonuses be paid out immediately. Instead, MacArthur entered these camps with infantry, cavalry and tanks. A riot ensued and a public relations disaster was caused. Nonetheless Hoover chose not to discipline MacArthur. Ellman writes that:

> if MacArthur learned a lesson from his actions, it was that he could safely disobey or ignore orders from superiors as long as he could produce a 'victory' and retain a large portion of [the Republican Party]. It was a path he would turn to repeatedly over his career.[3]

The next major failure covered by Ellman was MacArthur's defence of the Philippines during the Japanese invasion in December 1941. In essence, MacArthur disregarded decades of war planning—which included the caching of all important stores—and in doing so unhinged the military defence so that it was continually wrong-footed by a smaller Japanese force. This resulted in the retreat to the island fortress of Corregidor, which was slowly reduced by the encircling Japanese forces over several months. As we know, MacArthur was ordered to Australia with his headquarters staff (with MacArthur also taking his wife and child). The garrison fell and its defenders went into years of Japanese captivity. Ellman makes a point of comparing the fates of the US leaders caught by surprise at Pearl Harbor, who were summarily dismissed, with that of MacArthur, who not only lived to fight another day but was able to reinvent himself in Australia.

In retelling MacArthur's time in the SWPA, Ellman covers some well-trodden ground. This includes the dysfunctional nature of his staff, most notably his grossly incompetent intelligence chief, Charles Willoughby. We are regaled with many instances of his self-serving communiqués and his bad habit of pre-emptively declaring an operation completed (perhaps with some perfunctory 'mopping up') when it was still in its bloody throes. At the operational-strategic level, Ellman deals satisfactorily with the tension between MacArthur's preferred land-centric course of action of attacking Japan via New Guinea and the Philippines versus Admiral Chester Nimitz's and Admiral Ernest King's air- and maritime-centric advance through the central Pacific. Here we see MacArthur argue with the Joint Chiefs of Staff; again, MacArthur suffered no consequences.

Despite his age, MacArthur would initially lead the fight in the Korean War. In part, this was because President Truman, a Democrat, wanted MacArthur, who had expressed interest in being the Republican presidential nominee, as far away from the domestic political scene as possible. Ellman recounts the ebbs and flows of that war with all of MacArthur's missteps as well as his crowning glory with the Inchon landings. Ellman considers that the missteps overshadow this one success. The Korean War seemingly exacerbated all of MacArthur's extant flaws: his communiqués became increasingly riddled with falsehoods or delusional assessments; he shifted blame for his failures elsewhere and quarrelled with the Joint Chiefs of Staff often. Most notably MacArthur became more emboldened and careless in challenging the authority of the President. However, matters came to head. Truman, who had considered sacking MacArthur earlier, was left with no choice after MacArthur tried to unilaterally scuttle ceasefire talks with China. After his removal from command, his successor, General Matthew Ridgway, described MacArthur thus:

> I came to understand some traits of his complex character not generally recognised: the hunger for praise that led him on some occasions to claim or accept credit for deeds he had not performed, or to disclaim responsibility for mistakes that were clearly his own; the love of the limelight that continuously prompted him to pose before the public as the actual commander on the spot.[4]

Therefore, it comes as no surprise that Ellman's assessment of MacArthur as a wartime commander is not complimentary. In this regard, Ellman's book joins a growing body of histories that reassess MacArthur's *actual* battlefield performance against the accepted historical narrative—a narrative that MacArthur, through his post-action reports and communiqués, assiduously created himself. The question then is whether *MacArthur Reconsidered*, which covers his commands in the Second World War and the Korean War, adds much new to this revisionist school of military history.

There is a lot to commend in Ellman's book. It is readable and generally does a good job of condensing strategic and operational contexts to frame the correctness or otherwise of MacArthur's wartime performance. At times, this can come across as an oversimplification of events. This reviewer also felt that Ellman's lack of a military background was evident in some assessments of MacArthur. Likewise, in his desire to illustrate MacArthur's well-documented duplicity and self-promotion, Ellman sometimes goes too far in his condemnation of his subject. For example, he places almost the entirety of the blame for the US military's initial poor performance in Korea to MacArthur's failure to train the occupation troops in Japan. In doing so, he ignores the poor state of the forces caught in the usual postwar malaise.[5] This does not make the book wrong but it highlights that, in effect, *MacArthur Reconsidered* is a precis. Ellman does a good job in covering the key failures (and some notable successes) that characterised MacArthur's career, by referencing selected revisionist works. However, Ellman has not used primary or archival resources, so the book offers the reader no new analysis of or perspectives on MacArthur.

If *Australian Army Journal* readers are coming to MacArthur 'cold', then Ellman's *MacArthur Reconsidered* is a good start. For those that already have a working knowledge of this fabled but flawed general, this reviewer would recommend three other books instead. The first is Peter J Dean's *MacArthur's Coalition: US and Australian Military Operations in the Southwest Pacific Area, 1942–1945*.[6] The second gives a view of MacArthur from the perspective of one of his no-nonsense subordinates: Kevin C Holzimmer's *General Walter Krueger: Unsung Hero of the Pacific War*.[7] For this reviewer, the best option would be John C McManus's excellent three-volume series on the US Army in the Pacific in the Second World War.[8] Readers will find Dean's, Holzimmer's and McManus's portrayals of MacArthur far more nuanced (and contextualised) than that contained within *MacArthur Reconsidered*, and of more use in developing a balanced assessment of him as a military commander.

About the Reviewer

Colonel Dayton McCarthy CSC is the G8 (Director Force Modernisation) at Headquarters 2nd (Australian) Division. A defence analyst in his civilian career, he is the author of several books including The Once and Future Army. A History of the Citizen Military Forces, 1947-1974, The Battle of Maryang San, The Oboe Landings and The Worst of Both Worlds: an analysis of urban-littoral combat. His latest book on the history of the 2nd (Australian) Division was released in April this year.

ENDNOTES

1 William Manchester, *American Caesar* (New York: Dell Books, 1981).

2 James Ellman, *MacArthur Reconsidered: General Douglas MacArthur as a Wartime Commander* (Lanham MD: Stackpole Books, 2023), p. 236.

3 Ibid., p. 14.

4 Ibid., p. 223.

5 Ibid., pp. 156–157. For further exploration, see Brian McAllister Linn, *Real Soldiering: The US Army in the Aftermath of War, 1815–1980* (Lawrence KS: University Press of Kansas, 2023).

6 Peter J Dean, *Macarthur's Coalition: US and Australian Military Operations in the Southwest Pacific Area, 1942–1945* (Lawrence KS: University Press of Kansas, 2018).

7 Kevin C Holzimmer, *General Walter Krueger: Unsung Hero of the Pacific War* (Lawrence KS: University Press of Kansas, 2007).

8 John C McManus, *Fire and Fortitude: The US Army in the Pacific War, 1941–1943* (New York: Dutton Caliber Press, 2019); John C McManus, *Island Infernos: The US Army's Pacific War Odyssey, 1944* (New York: Dutton Caliber Press, 2021); John C McManus, *To the End of the Earth: The US Army and the Downfall of Japan*, 1945 (New York: Dutton Caliber Press, 2023).

/ BOOK REVIEW

Training for Victory: U.S Special Forces Advisory Operations from El Salvador to Afghanistan

Author: Frank K Sobchak

Naval Institute Press, 2024, 315 pp, ISBN 9781682471333

Reviewed by: Travis Peet

In early 2014, large parts of the Iraqi Army fled as the forces of the Islamic State of Iraq and Syria advanced rapidly across Northern Iraq. Despite years of training and billions of US dollars spent on training and equipment, most Iraqi Army units wilted in the face of a determined enemy. One exception was the Iraqi Counter Terrorist Service, which mounted stiff resistance and arguably prevented the collapse of the entire Iraqi government. Similar scenes unfolded in 2021 as the Afghan National Army disintegrated before a resurgent Taliban offensive, with the elite units of Afghan commandos among the last units fighting. To understand why units like these remained combat effective while others fled and failed, Frank Sobchak, a retired US Army Special Forces colonel, has undertaken a detailed study of partner forces across several modern military campaigns. In *Training for Victory* he explores the key factors in their training that underpinned their success.

In taking on this study, Sobchak embarked on an immense challenge. In the post-Cold War era, Western militaries have undertaken numerous security force assistance missions, in different countries and in different contexts. Such was the length of some of these campaigns (Iraq and Afghanistan, for example) that even within these conflicts there is large variance in the experiences of—and lessons for security force assistance based on—the different phases of the conflict. For example, the Afghan militias that the US partnered with in the early 2000s were vastly different to the hardened Afghan commandos of 20 years later. These same Afghan commandos were trained by personnel from the United Kingdom, New Zealand, many European nations and multiple US units over the course of the war, making it difficult to deduce what led to their combat effectiveness.

To make his study manageable, Sobchak has focused his efforts on the experiences of US Army Special Forces, more commonly known as the ‘Green Berets’, a force specifically selected and trained for security force assistance missions. The study is further narrowed by focusing exclusively on US Special Forces training of elite partner nation units. Across five case studies, in five separate chapters (on El Salvador, Colombia, the Philippines, Iraq and Afghanistan), Sobchak provides a background to each conflict, presents an overview of US partnering/training efforts, and analyses what he assesses to be the five key elements of the US approach in each campaign. These elements include language and cultural training, advisor-to-partner ratio, ability to organise partner forces, combat accompaniment, and consistency in advisor pairing.

In the final section of *Training for Victory*, Sobchak provides a substantial and substantive conclusion wherein he assesses the combat effectiveness of each partner nation’s respective forces. As acknowledged by Sobchak himself, this assessment is somewhat subjective. However, he utilises a consistent logic with the key determinant being battlefield performance, particularly the ability to fight during the night. Using the five elements described previously, Sobchak assesses which of them are linked to combat effectiveness, and hence which are the most important when developing a plan to ‘train for victory’. While Sobchak notes that all partner forces in his analysis were combat effective, the success of Colombian and Iraqi partner forces leads him to conclude that advisor ratios and consistency in pairing are the most critical factors for building effective partner forces. This assessment challenges common assumptions that cultural awareness and language training during pre-deployment training are the most important considerations. Given the approach that Sobchak has taken, and the subjectivity of his assessment of combat effectiveness, this conclusion is open to challenge. His points are nevertheless well argued and thought-provoking.

By narrowing his approach to focus specifically on US Army Special Forces case studies—and only their partnerships with elite partner nation forces—Sobchak somewhat limits the utility of his study. For example, one of his key conclusions is tailored to optimising the doctrine of the US Army, recommending that special forces teams should be paired with companies rather than battalion-size formations. Comparisons with other nations’ approaches to security force assistance missions (such as the British with Afghan commandos, or ‘non-elite’ partner force examples) could have added further nuance to Sobchak’s conclusions and helped further validate his findings. Furthermore, his attempt to summarise the combat effectiveness of complex partner units over extended periods risks oversimplification. This is not a criticism of Sobchak’s work but rather a reminder of the inherent tension between analytical clarity and operational complexity. Provided that Sobchak’s conclusions are acknowledged as applying predominantly to the future development of US Army Special Forces, his analysis has considerable merit.

For Australian Army readers, there is value in both Sobchak's case studies and the results of his analysis. Campaigns in Central and South America will be unfamiliar territory for many readers from Australia. However, lessons concerning jungle and urban terrain can be readily applied to the Indo-Pacific region. The case study concerning the Philippines provides valuable background understanding for those supporting the Joint Australian Training Team—Philippines (JATT-P) or any other of the increasing number of exercises the Australian Army is undertaking with its Philippines partners. The Iraq and Afghanistan chapters provide different experiences and perspectives on security force assistance missions that were undertaken by the Australian Army during the Global War on Terror. With the Australian Army's Task Group 632 also training the Iraqi Counter Terrorism Service during this same time period, Sobchak's analysis provides the opportunity to conduct a direct comparison between US and Australian approaches to security force assistance missions.

In Training for Victory, Sobchak has completed a well-researched study on US Army Special Forces campaigns, with the purpose of informing the future development of US Army Special Forces. Despite this relatively limited focus, contained within this book are insights that have far broader application. Sobchak's work forces readers to consider what factors are truly linked to combat effectiveness in security force assistance missions, while also providing a strong foundation for the history of such missions. By concluding that ratios and consistency are key determinants of success, Sobchak challenges the relevance of strategic and operational constraints related to personnel caps and personnel rotations. He also undermines conventional views that language/cultural training and the practice of accompanying partners into combat are critical to success. Whether or not the Australian Army agrees with these conclusions, *Training for Victory* encourages critical reflection in the field of security force assistance missions.

About the Reviewer

Lieutenant Colonel Travis Peet is an Australian Army Infantry Officer who is currently posted to Headquarters Joint Operations Command.

/ BOOK REVIEW

Resistance and Liberation: France at War, 1942–1945

Author: Douglas Porch

Cambridge University Press, 2024, ISBN 9781009161145, 804 pp, (AUD) $67.95 (hardback)

Reviewed by: John Nash

France's experience of World War II following its defeat in 1940 is often overlooked or reduced to the concept of the Resistance, which itself often passes through a mythologised lens. Douglas Porch's second volume on 'France at War' tackles the immensely complex topic of the French experience of war from 1942 to 1945. It covers a frantic period of time as nascent French governments in exile vied for eminence while cobbling together a military and diplomatic force that could fight for France's interests, namely the preservation of its empire—and at least appearing to contribute to the Allied cause against Nazi Germany.

The book opens with a preface that summarises the first volume, *Defeat and Division*.[1] The 10 chapters that follow trace France's role in the war in the wake of Operation Torch, the Allied invasion of North Africa. The main narrative picks up from the end of the previous volume, tracking events in Tunisia in late 1942. It begins with an examination of the key issues which had plagued French military endeavours in the preceding three years: indecisive, confused, and ineffective command and control at the highest levels. Porch's subheadings make this very clear from the start, opening with 'A Cascade of Contradictory Orders' and followed by others such as 'A Confused Chain of Command' and 'Two Commanders, Two Choices'.[2] The Commander of French Ground Forces in North Africa, General Alphonse Juin, represented this command indecision: he was described by one observer as 'commander-in-chief while avoiding behaving like one'; instead he 'issued suggestions'.[3] This dithering would have severe repercussions for the Allied campaign in North Africa. The non-decision to oppose Axis forces moving westward into French territory meant the Allies would need to slog their way through this territory. In the words of Porch, 'three lost days at Algiers and Tunis had to be redeemed at the cost of almost seven months of battle.'[4] This senior officer malaise accorded with that experienced in the resounding defeat of France in 1940, and the theme of combat effectiveness taking a back seat to French political-imperial concerns emerges throughout Porch's exploration of France's war.

This is seen in the conclusion of the Allies' North Africa campaign, where the emerging French leadership under Charles de Gaulle moved to exact retribution and forgiveness. The main determinant of what treatment was allocated boiled down to whether or not actions, including collaboration with the Axis, were done in the name of preserving the French Empire.[5] Moreover, the re-establishment of French control allowed them to crack down on dissent and squash Tunisian nationalism. On the military side of the campaign, Porch assigns blame to both US political inexperience (the Darlan deal) and plodding British progress on the battlefield under Lieutenant General Kenneth Anderson, but in the main gives the largest part of the blame to the aforementioned poor French leadership for putting the Allies in such a bad spot to begin with.[6] This segues into a necessary discussion about the state of the wider war, including the inaccurate or even duplicitous claim by Stalin that the Western Allies were merely 'fighting on the margins'.[7] Porch then does an excellent job of debunking a series of myths surrounding Roosevelt's declaration of the requirement for the 'unconditional surrender' of Germany.[8] In these ways, a reader is reminded of the wider context of the war.

With matters in North Africa (relatively) settled, the narrative turns to the organisation and rearmament of French forces. In short, this proved to be a logistical nightmare as shipping was scarce and the French had virtually no trained logistics personnel or any kind of proper organisation.[9] It also became clear that the French had learned essentially nothing from their 1940 defeat, failing to prioritise logistics, service troops and armour, while sinking limited personnel and material into rebuilding their navy, which would have no impact on the war and was done for prestige.[10] Disdaining American efforts to aid them in training, the French believed that it had been their equipment that had been deficient in 1940, not their training—though the latter was also problematic, with some 1,858 training deaths in the seven months following the Tunisia campaign.[11] Moreover, French attempts to make up their personnel shortfall with the engagement of women in the armed forces were not as successful as the US or British experiences. Porch lays bare the poor treatment of women in French service, and notes that their participation in resistance activities was more welcome and far higher.[12] In a sense, this is unsurprising. Porch is quite clear in his analysis of French war aims, which had very little to do with French forces contributing to Allied victory and everything to do with preserving the French Empire.[13]

What follows is a chapter dealing with France's largest contribution to the Allied cause, their role in the Italian campaign—though a legacy tarnished by the horrendous war crimes committed by the French forces against the civilian population. Chapter 3, 'Triumph and Dishonor in Italy', makes for difficult reading as Porch lays bare the scale of the crimes committed by French troops, and the wanton indifference and even defensiveness with which they regarded it.[14] Unfortunately, it would not be an isolated incident and would lead to French troops in Germany in 1945 being labelled 'the Russians of the West'.[15]

What follows this is an excellent chapter on the topic of French resistance in the lead-up to Operation Overlord. Porch sets the tone from the opening paragraphs, where he criticises the historiography of the 'Resistance':

> But subordinating history to *faux* and contrived patriotic analogies perpetuated a collective delusion, one that devalued the contribution of the professional soldiers and colonial subjects of the FFL [Free French Forces] and *l'armée d'Afrique*—not to mention the Allies—to France's resurrection, in favour of a spontaneous assembly of military amateurs.[16]

Porch then breaks down all of the key issues, from low resistance participation rates—lower than in Poland or Yugoslavia—through to internecine conflicts within the French movement, and unclear strategy based on a poor understanding of how ineffective resistance movements were in other countries. Driven by the romantic notions of Winston Churchill and a nascent Special Operations Executive organisation trying to make a name for itself, the reality was, as Porch illustrates, that even the worst German troops used in rear area defences 'could literally make mincemeat of the largely children's crusade, and their adult enablers, which defined the *maquis*'.[17] It is a harsh but accurate assessment of just how ineffective the resistance movement was in affecting the military situation in France prior to D-Day, with Porch also assessing that 'Resistance also created vulnerabilities—a distortion of strategic priorities and diversion of operational assets'.[18] Indeed, the Germans did not see resistance as a significant military threat, certainly not in comparison with the Eastern Front, where it was much more organised, though also had its effectiveness exaggerated.[19] The most consequential action of the resistance was the establishment of a postwar narrative of the French contributing far more to their own liberation than was actually the case.

The final three chapters of *Resistance and Liberation* deal with military efforts to retake France and participation in the invasion of Germany. It was a difficult campaign, given the need to reorganise different formations, but also due to a twisted set of priorities where revenge and score-settling against 'collaborators' was the prime concern. Much time and effort was devoted to this revenge, for all manner of perceived crimes, especially when it came to women who had been too friendly to the Germans. These 'shearings'—where the women in question had their hair shorn off as a visible indicator of their 'crimes'—were viewed with disdain by the US troops. They were seen as a sign of French insecurity at their emasculating defeat in 1940, with French men trying to regain their masculinity by targeting helpless women.[20] In addition to this, the French army had to contend with a distinct air of indifference in the liberated territories, with most French considering their war over once they had been liberated. Nevertheless, de Gaulle saw participation in the invasion of Germany—or at least a presence there—as necessary to ensure France's future role in Europe, especially in light of the view of Stalin that France's role had not been of enough to merit an occupation zone in postwar Germany.[21] As mentioned earlier, French behaviour in Germany would be appalling, with mass crimes against civilians and German prisoners of war, which were again minimised by the French command, who even went so far as to accuse the Americans of trying to tarnish French 'victories'.[22]

Taken with the fact that de Gaulle hosted five victory parades in a three-month period in 1945, it is hard to see France's participation in the latter stages of the war as a positive contribution to victory.

The final chapter is a conclusion, covering the subject matter of both volumes. Herein Porch is comprehensive in bringing together all the different strands of history that he has examined throughout both books. It starts with a theme explored in the review of book one,[23] the failure of French high command and its sluggishness compared with German *Auftragstaktik*. Porch highlights how the postwar narrative was hijacked by a collusion of Heinz Guderian and Basil Liddell-Hart to promote how their prewar ideas about mass tank warfare were correct, ignoring that the French did as much to lose the war as the 'Blitzkrieg' did to win it.[24] He also demolishes the myth that the Maginot Line was some kind of useful construct; indeed, as Porch points out, it consumed 40 French divisions at a time when there were only 19 German ones opposing them, and the main German effort was clearly underway further north, where spare French divisions could have made a difference.[25] Finally, he takes the somewhat heretical view that the Fall of France in 1940 was not some sort of 'historical hiccup'.[26] As he has carefully articulated over his two volumes, France's failures in the war, especially in 1940, can be traced to a series of political, diplomatic and military decisions. His conclusions may make for uncomfortable reading for some, but are well reasoned and backed by a mountain of evidence.

Like the first volume, *Resistance and Liberation* is not a small book. The period of history covered is also messier, with a large cast of people and various organisations and political machinations to follow. As with *Defeat and Division*, Porch is able to critically examine important events, people and ideas, and cut through seven decades worth of scholarship and myth-making around the events of 1942–1945. Anyone looking for a fuller grasp of the Second World War and of France's role after the 1940 defeat should look no further than this excellent volume.

About the Reviewer

Dr John Nash is an Academic Research Officer at the Australian Army Research Centre. Previously he was a researcher at the Australian War Memorial for The Official History of Australian Operations in Iraq and Afghanistan, and Australian Peacekeeping Operations in East Timor. He was awarded a PhD from the Australian National University in July 2019. He is also a Lieutenant in the Royal Australian Naval Reserve, having completed nine years' fulltime and ten years' reserve service as a Maritime Warfare Officer. He was the inaugural winner of The McKenzie Prize for the Australian Naval Institute and Chief of Navy Essay Competition – Open Division, 2019. His most recent publication is Rulers of the Sea Maritime Strategy and Sea Power in Ancient Greece, 550–321 BCE, Volume 8 in the series 'De Gruyter Studies in Military History'. Other publications include articles in the Australian Army Journal, Journal of Advanced Military Studies (Spring 2024), the Journal of Indo-Pacific Affairs (March-April 2022) and the US Naval War College Review (Winter 2018, Vol.71). His areas of research focus include sea power and maritime strategy, littoral warfare, land power, and strategic studies.

ENDNOTES

1 For a review of this, see John Nash, 'Book Review—Defeat and Division: France at War, 1939–1942', *Australian Army Journal* 21, no. 3 (2025): 314–318.
2 Douglas Porch, *Resistance and Liberation: France at War, 1942–1945* (Cambridge University Press, 2024), pp. 1, 11, 13.
3 Ibid., p. 22.
4 Ibid., p. 29.
5 Ibid., pp. 79–80.
6 Ibid., pp. 87–88.
7 Ibid., p. 89.
8 Ibid., pp. 94–95.
9 Ibid., p. 122. For more detail on this issue, see also David Dworak, *War of Supply: World War II Allied Logistics in the Mediterranean* (University Press of Kentucky, 2022), pp. 51–54.
10 Porch, 2024, pp. 129–132.
11 Ibid., p. 134.
12 Ibid., pp. 143–159.
13 Ibid., pp. 160–161.
14 Ibid., pp. 161–242.
15 Ibid., p. 240.
16 Ibid., p. 244.
17 Ibid., p. 323.
18 Ibid., p. 417.
19 Ibid., pp. 420–421.
20 Ibid., pp. 452–468.
21 Ibid., p. 537.
22 Ibid., p. 548.
23 See Nash, 'Book Review—Defeat and Division', pp. 314–318.
24 Porch, 2024, p. 594.
25 Ibid., pp. 611–617.
26 Ibid., p. 625.

/ BOOK REVIEW

Coalition Leadership: Lessons Learned While Commanding a NATO Brigade in Afghanistan

Author: Colonel (Rtd) James L Creighton

Marine Corps University Press, 2024, pp 282, ISBN 9798986259506

Reviewed by: Jason Blain

Few books manage to capture the intense reality, complexity and leadership demands of multinational operations at the brigade level during war quite like Colonel (retired) James Creighton's *Coalition Leadership*. As someone who had the privilege of serving alongside Colonel Creighton as his deputy during the critical 2010 campaign in Uruzgan Province, Afghanistan, I can say with confidence that this is more than just a compelling account of combat leadership; it is a doctrinal touchstone for current and future military professionals.

In *Coalition Leadership*, Creighton distils the challenges and insights gained from his tenure as the Commander of Combined Team Uruzgan (CTU), a multinational headquarters stood up during one of the most dynamic and violent phases of the Afghanistan conflict. The book delivers its most powerful lessons through the lens of experience, not theory—an experience shaped by high-intensity combat, political complexity, and the rare test of building a headquarters while in the fight.

When Colonel Creighton assumed command of CTU in mid-2010, the operational landscape in Uruzgan was undergoing rapid transformation. The Dutch were preparing to withdraw after several years of command in the province. Their transition required a new lead International Security Assistance Force nation in Uruzgan at a time when Taliban activity was surging. Into that breach stepped a United States-led but Australian-dominated headquarters—a rare construct that, to my knowledge, had not been attempted at that scale before or since.

Creighton's account does not shy away from the difficulties of this construct. Establishing a combined, multinational headquarters is a significant undertaking in any context. Doing so amid high-tempo combat operations, during a national handover and with disparate national caveats and doctrinal approaches only compounds the challenge. Yet, under Creighton's leadership, the team maintained operational momentum, ensured continuity of mission and avoided the paralysis that can so easily occur in transition.

The book is rich in lessons for officers who will one day be called upon to form, lead or serve within coalition headquarters. One of the most prominent themes is the importance of relationships. Creighton rightly emphasises that success in coalition warfare is rarely found in systems or structures alone; it is found in people—in trust built quickly across national lines, in humility to listen and in the moral courage to lead amid ambiguity. This was a central factor in the success of CTU: mutual respect between American and Australian commanders, trust at every level and an unwavering commitment to unity of purpose.

I had the honour of commanding Mentoring Task Force One (MTF-1) in Uruzgan Province at the time and then assumed the role of inaugural Deputy Commander of CTU, after handing over command of MTF-1 to Colonel Mark Jennings. To be able to remain serving alongside our fellow Australians in Uruzgan was a rare privilege, and I can attest firsthand to the pressures and uncertainty of the period. We were tasked with simultaneously mentoring the Afghan National Army's 4th Brigade, fighting a well-armed and adaptive Taliban insurgency, protecting the local population, and conducting reconstruction and development efforts—all of this while trying to knit together a newly formed headquarters drawn from multiple nations with different rules and caveats, cultural perspectives and political constraints.

Coalition Leadership provides a granular understanding of how to navigate these constraints. Creighton is candid in his treatment of national caveats, and the book's learnings on coalition cultural dynamics, both national and organisational, are superb. He offers practical advice on navigating the unspoken rules that govern international cooperation: how to manage expectations, how to avoid friction through early and respectful engagement, and how to build systems that account for difference rather than trying to erase it.

Coalition leadership is also about personal leadership. Creighton is honest and frank about his 'Just get it done' approach. His investment in conducting battlefield circulations with his Australian RSMs to conduct face-to-face interactions with the troops of all nations under his command ensured that the urgency of executing his commander's intent was understood. He is also frank about his dealings with key Afghan actors and stakeholders. His is a clear-eyed reflection on the reality of having to deal at times with unsavoury and corrupt individuals at the tactical level.

The handover from the Dutch to the US-led CTU is especially instructive. As Creighton reflects, the transition was not merely a change in flag; it was a shift in doctrine, tempo and expectations. Maintaining mission continuity required cultural awareness and both tactical and strategic acumen, understanding the Dutch approach to the conflict, recognising their hard-won local relationships, and integrating the knowledge of their commanders and soldiers before their departure. The delicate management of this transition ensured that our Afghan partners were not left disoriented or feeling abandoned—a failure that would have risked the gains made by fellow Australians and our Dutch comrades over several years.

From a leadership perspective, the book is a masterclass in coalition command. Creighton balances strategic intent with tactical reality and repeatedly returns to the principle that leadership in a coalition is not about control; it is about influence. He draws attention to the importance of personal rapport, lateral collaboration, and servant leadership in multinational teams.

For Australian Defence Force officers, *Coalition Leadership* offers particularly relevant insights. Many of our current and future operations will be conducted in coalition settings, whether in combat, peacekeeping or humanitarian assistance. Increasingly our commanders will be asked to operate in headquarters where they are not the lead nation but where their leadership, professionalism and experience will be critical to mission success. Understanding how to lead 'through others' in this context is an essential skill, and this book provides a real-world guide.

Importantly, *Coalition Leadership* is not a self-congratulatory memoir. It is reflective, honest and instructive. It captures both the promise and the peril of coalition warfare. It offers a roadmap for navigating the complex web of alliances, national interests and human dynamics that define modern conflict. And it serves as a valuable case study for how mission command, trust and unity of effort can be achieved even in the most difficult of operational environments.

In summary, this book is a must-read for any serious military professional. Its lessons are not confined to Afghanistan; they are universal to coalition operations. For those who will serve in, or lead, multinational headquarters, *Coalition Leadership* is essential reading. I commend Colonel James Creighton for his service, for his leadership during a defining period in our shared military history, and for this outstanding contribution to the profession of arms.

About the Reviewer

Major General Jason Blain, DSC, AM, CSC, is the Head of Land Systems in the Australian Defence Force, having graduated into the Royal Australian Infantry Corps in 1991 and served across a wide range of command, capability, and strategic staff roles, including secondments to the Department of the Prime Minister and Cabinet. A combat arms officer, he has commanded at all levels within the Royal Australian Regiment, including as Commanding Officer of the 6th Battalion RAR and later as Commander of the 7th Brigade, prior to promotion to Major General and appointment as Head of Armoured Vehicles. He has led Australian soldiers on operations in East Timor and Afghanistan, receiving the Distinguished Service Cross for his 2010 service in Afghanistan, and was appointed a Member of the Order of Australia in 2022. Major General Blain also serves as a director of Melbourne Legacy and is a strong advocate for the wellbeing of serving members, veterans, and their families.

/ BOOK REVIEW

Algorithms of Armageddon: The Impact of Artificial Intelligence on Future Wars

Author: George Galdorisi and Sam J Tangredi

Naval University Press, 2024, 256 pp, ISBN 9781612515410

Reviewed by: Catherine Batch

In *Algorithms of Armageddon: The Impact of Artificial Intelligence on Future Wars*, authors retired US Navy Captain (and career naval aviator) George Galdorisi and retired US Navy Captain (and former surface warfare officer) Dr Sam J Tangredi explore the looming reality of integrating artificial intelligence (AI) into military conflict and strategy. Through their meticulous research, the authors provide an in-depth look at the technological advancements driving AI and the ethical, strategic and geopolitical dilemmas they pose. The book also tackles the critical power dynamics between major global players like the US, China and Russia. In this regard, it highlights characteristics of a potential AI arms race, including how each nation approaches the development and control of AI in military contexts given the commercial realities that arise when technology is owned and controlled by different governments.

The book opens with a powerful argument: AI is not merely the future of warfare; it is the present. Galdorisi and Tangredi examine the ways in which AI is already being used in military conflicts, particularly in autonomous and semi-autonomous systems like drones and advanced missile technology. The authors reinforce the fact that AI will increasingly be used as a decision-making tool, assisting in battlefield assessments, coordinating drone attacks, and managing vast amounts of information. They emphasise that the pace of AI development is accelerating more quickly than many had anticipated, and that the ramifications of this technological shift are immense.

A central theme explores how AI will be integrated into decision-making processes in warfare. The authors introduce three distinct categories for understanding human involvement in AI-driven systems: 'in the loop', 'on the loop', and 'out of the loop'. These terms can be summarised as follows:

- **In the loop**: AI aids and recommends action but human operators retain final decision-making authority. This is the current model for most semi-autonomous systems and is generally the safest, as it allows humans to apply moral judgement.

- **On the loop**: AI operates with more autonomy but human oversight remains. In this model, humans are supervisors, stepping in only when necessary. This set-up introduces new challenges, as AI decisions might occur too quickly for effective human intervention.
- **Out of the loop**: AI operates in fully autonomous systems where it makes decisions without human oversight. The authors warn of the dangers inherent in this model, where AI could act in ways that are beyond human control, raising critical ethical concerns.

Galdorisi and Tangredi caution that as military operations become more dependent on AI, especially in autonomous systems, the level of human oversight may decrease, leading to unpredictable or unintended consequences on the battlefield.

The book delves into the geopolitical ramifications of AI, particularly focusing on China's aggressive pursuit of AI dominance. China's approach to AI is fundamentally different from that of the US, largely due to the central control exercised by the People's Republic of China over private industry. Galdorisi and Tangredi analyse how China has been able to extract algorithms and technological advancements from companies like Alibaba and ByteDance (which owns TikTok), forcing these companies to submit their AI technologies to the state. This tight integration of commercial and military AI development has allowed China to make rapid strides in deploying AI for surveillance, biometrics and military applications. The authors describe China's strategy as a holistic one: it is leveraging both state assets and private sector innovation to build an AI-driven military infrastructure.

This Chinese approach stands in stark contrast to that of the US, where there is a clear, deliberate and institutionalised separation between commercial and military applications of AI. In the US, civilian tech companies and defence agencies generally operate within distinct domains, with strict legal and ethical frameworks governing the transfer of technology between them. Policies such as export controls, defence procurement regulations, and transparency requirements are designed to maintain a clear boundary between private sector innovation and military use. This separation reflects broader democratic values of accountability, civilian oversight and market competition, aiming to prevent the concentration of power that can arise when commercial and military AI development are deeply intertwined, as seen in China's civil–military fusion model.

The authors point out that this division has sometimes worked to the disadvantage of the US military, especially when US companies have sold AI technologies to China that were subsequently reverse-engineered for military use. Galdorisi and Tangredi argue that China's ability to merge commercial AI with state-controlled assets, like surveillance systems and advanced autonomous weapons, is a game changer. China's rapid development of AI-based warfare technologies places it in direct competition with the US for global dominance, particularly as both countries race to develop autonomous military systems that can operate without human intervention.

Algorithms of Armageddon explores how demography has forced Russia—due to a reduction in population of war-fighting age—to turn to AI as a critical component of its military strategy. Specifically, AI offers the potential to fill the gap left by a diminished human workforce, allowing Russia to deploy autonomous systems, drones and AI-driven decision-making tools that can enhance its combat capabilities without relying as heavily on manpower. In response to this emerging necessity, AI has the potential to help Russia maintain its military effectiveness despite demographic issues, making AI a vital element of the country's future military strategy.

While China surges ahead with its unified strategy, the US is mired in regulatory and bureaucratic challenges that prevent some of its most innovative companies from contributing to military AI. Galdorisi and Tangredi explore the difficulties faced by under-represented startups in the US, particularly those that are at the forefront of AI innovation but cannot secure Department of Defense contracts due to complex and often prohibitive regulations. These startups may possess cutting-edge AI technologies but they are often excluded from the defence sector because they cannot meet the compliance standards designed for larger, more established defence contractors. This is a missed opportunity. By failing to nurture these smaller companies, the US risks falling behind in the AI arms race. The authors argue that the US government must revise its procurement process to enable smaller, more innovative companies to contribute to military AI development, lest it be outpaced by competitors.

Another strength of *Algorithms of Armageddon* is its examination of the ethical and strategic questions surrounding AI in warfare. The book does not shy away from the difficult moral questions posed by autonomous systems. The authors emphasise that the use of AI in warfare raises significant ethical concerns, particularly when it comes to decision-making in life-and-death situations. Trust in AI systems is fundamentally different from trust in human operators. With humans, trust is binary: either you trust the person to make the right decision, or you don't. As the authors observe, the more we rely on AI to make critical decisions, the more we must grapple with the question of accountability. If an autonomous system makes a catastrophic error, who is responsible? The authors suggest that maintaining human oversight—particularly in the 'in the loop' and 'on the loop' models—remains essential for ensuring ethical decision-making in warfare. In addition to ethical concerns, the authors address the practical challenges of AI in military use. For example, AI systems are dependent on a constant supply of electricity and are vulnerable to hacking. Moreover, the authors point out that AI's capabilities, while impressive, are often over-hyped. They caution against notions that AI can single-handedly change the outcome of wars, arguing that human judgement and strategy will remain critical components of military success.

The conclusion of *Algorithms of Armageddon* reflects on the inevitable march of AI into warfare. Galdorisi and Tangredi argue that the challenges posed by AI are both ethical and practical in nature. While AI has the potential to revolutionise military operations, it also introduces new risks that must be carefully managed. The future of AI in warfare will depend on how nations choose to integrate these technologies into their decision-making processes.

The book closes with a warning: the US must reform its approach to AI, particularly by fostering innovation among smaller startups and rethinking its regulatory frameworks. Ultimately, the authors call for a global conversation about the rules governing AI in warfare. While nations like the US might want to control their own use of AI, they cannot prevent other nations from doing the same. This is the central dilemma of the AI arms race: as AI becomes more embedded in military strategy, the risks of unintended consequences and catastrophic errors increase.

Algorithms of Armageddon: The Impact of Artificial Intelligence on Future Wars is a deeply insightful and thought-provoking examination of how AI is reshaping warfare and international security. The book offers a comprehensive analysis of the strategic, ethical and geopolitical challenges posed by AI, particularly in the context of an evolving arms race between global powers like the US, China and Russia. Galdorisi and Tangredi's exploration of AI's applications in military contexts, combined with their warnings about potential pitfalls, make this work a critical resource for understanding the future of warfare.

This book is highly recommended for several key groups within the Army and broader defence sector. First, leaders responsible for shaping military policy, strategy and doctrine should engage deeply with *Algorithms of Armageddon*. The book offers crucial insights into the role AI will play in future warfare, not only in terms of technology but also in regard to strategy. Galdorisi and Tangredi provide a sobering assessment of how AI could alter the balance of global power and the very nature of conflict. Leaders involved in long-term planning and defence innovation must understand these dynamics to make informed decisions about AI integration. Second, military technologists and AI specialist personnel involved in research and development of military technologies will benefit from the book's technical discussions on AI autonomy, decision-making and machine learning. The exploration of 'in the loop' 'on the loop' and 'out of the loop' systems is particularly valuable for those working on the ethical and practical challenges of integrating AI into military operations and the reference to a common language or framework for allies. The ethical dilemmas surrounding AI use in warfare is a key theme of the book, and of interest to Defence's ethicists and legal experts alike. They will find this work crucial in guiding policy decisions and crafting future legal frameworks around AI. Department policymakers and procurement officers will also benefit from the book's critical analysis of bureaucratic inefficiencies in the US Department of Defense.

For the broader defence community, this book is an essential read. Galdorisi and Tangredi focus not just on the technology itself but also on how AI will affect everything from battlefield tactics to long-term strategic outcomes. The notion that AI will radically transform the tempo of war, potentially outpacing human decision-making capabilities, is something that all military professionals should understand. AI is not just a tool; it will become a fundamental part of how wars are fought, won or lost.

About the Reviewer

Dr Catherine Batch is a Senior Lecturer and Director of Custom Program in QUT's Graduate School of Business. She currently teaches across Master of Business Administration, Public Sector Management Program and corporate programs. Her PhD research was on the role trust plays in AI-generated content for ASX200 companies. Catherine is a Specialist Service Officer in the Australian Army, where she provides public affairs support to military operations, exercises and activities within Australia and overseas.

/ BOOK REVIEW

Making Makers: The Past, the Present, and the Study of War

Author: Michael PM Finch

Oxford University Press, 2024, ISBN 9780192867124, 258 pp

Reviewed by: Nick Bosio

As highlighted in other reviews and works, one book is often compulsory reading at staff, war and civilian strategy colleges around the world: *The Makers of Modern Strategy*.[1] Up to its third edition, this book continues a fine tradition in strategic studies: leveraging both the history of strategic action and the history of strategic theory to inform contemporary thinking.[2] Yet this book does more than inform the strategist. *The Makers of Modern Strategy* played a significant role in shaping modern war and strategic studies.

Making Makers: The Past, the Present, and the Study of War is more than a book about a book. In *Making Makers*, Michael Finch tells the story of the first *Makers of Modern Strategy* (known as *Makers*), the attempts to write a revised version, and the successful second edition edited by Peter Paret. The book is also the story of the 20th century revolution in applied history within war studies, the development of the discipline of strategic studies, and the relevance of applied history to military and strategic art. Finch traces these developments from Hans Delbrück, Edward Earle (lead editor of the first *Makers*), Michael Howard and Paret, through to contemporaries such as Lawrence Freedman, Beatrice Heuser and Hew Strachan. Each chapter of *Making Makers* outlines both the development of *Makers* and the emergence of the structure, explicit canon, applied history methodology, and founding concepts of the disciplines of war and strategic studies. Underpinning these disciplines is the understanding that:

> since [war] is the concern of all the people, all the people must realize that it *is* their concern. In wartime this involves a total effort; in time of peace, as in time of war, it demands wide understanding.[3]

Exploring the development of contemporary war and strategic studies means that *Making Makers* is an important contribution to the professions of arms and strategic art. As the above quote implies, war is more than the clash of armed forces. War occurs within a socio-political and cultural dynamic that must be understood as much as the

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military action. Therefore, the study of war must be grounded within the study of a war's surrounding political, social and cultural elements. Although such understanding is not necessarily new, Finch's work traces the re-emergence of such thinking in the late 1800s and early 1900s through the efforts of Delbrück in Germany. However, it is in Britain that these views took root. Building on a history studies tradition that saw history as 'not only a professional discipline, but also an education for public life', British academics laid the foundation for applied history in modern thinking.[4] These academics also stated:

> Military history … is the effort to understand war, to get to know what war is and what it means. [It can only be achieved by studying] as many wars as possible, in order by comparison between them to learn what features and characteristics they have in common, whether the events which composed them happened at random, or whether they happened as they did by reason of some inherent necessity.[5]

Finch's examination demonstrates how the key tenets of war and strategic studies developed. The contemporary normalisation of many war studies concepts, such as the nature and character of war and the intrinsic links between war and politics, are grounded in the early developments that led to the first edition of *Makers*. Even Howard's guidance on the study of war and history (study it in context, depth and width) can be seen in the thinking that led to the first *Makers*.[6] Underpinning these early developments are three themes: history must be studied by all, history can be used to test one's thinking, and applied history supports decision-making. As Finch outlines, each edition of *Makers*—including the failed attempts in the 1960s and 1970s to revise the book—codifies these themes as key tenets of the disciplines of war studies and strategic studies. These two disciplines are foundational to the profession of arms.

All disciplines change over time. *Making Makers* helps illustrate these changes and who influenced them. One example is the morphing of the definition of strategy from a purely military concept to one of national import.[7] Another is how the study of military history transitioned from a parochial focus on descriptive battles and leading figures towards a broader approach that includes 'linking war to societies in which it was waged and locating itself further from the battlefield'.[8] Although such historical analysis often occurred before the 19th century, the transition back to such broader approaches enabled the growth of professional military education, war studies and strategic studies. Understanding how ideas evolve helps professionals better comprehend the contemporary challenges of their respective disciplines and professions.

Making Makers also tells of challenges that continue to plague contemporary military professionalism. Part of the story of *Makers* and the contemporary disciplines of war and strategic studies is the push and counter-push to educate military officers better. Such education should be scaffolded, structured, and grounded in the first-principle theories of the military arts—underpinned by war studies, strategic studies and the humanities. It is the study of military history, or ‘military art case studies’, that helps military officers understand the dynamic theory of war. Such study is also a key component of translating that theory into practice. While *Making Makers* reinforces the above, it also echoes many other scholars by highlighting how the counter-push against deep military education is often led by the military itself. Therefore, *Making Makers* is also the story of how those seeking to enhance the study of war must often overcome the military’s desire to insert additional training, military science or other directed topics into military education curricula at the expense of military history and theory.

By telling the story of *Makers*, Finch’s *Making Makers* shows some of the ‘behind the scenes’ development of the contemporary professions of arms and strategy. Military theory and war studies are uncodified disciplines whose concepts, structures and ideas are shaped by influential theorists, their works, and the interpretation of those works over time.[9] *Making Makers* highlights the arguments, challenges and divergent views that led to many of the founding ideas taken for granted today. Through this story, *Making Makers* gives insight into how select influential theorists and personalities have been identified, and how such selection has shaped contemporary military theory and thinking. Therefore, this work will be a valuable addition to the library of any professional with an interest in the development of the profession of arms, professional military education and the shaping of ideas over time.

About the Reviewer

Colonel Nick Bosio has held various command and staff appointments across tactical, campaign and strategic posts within Australia and on operations. His experiences include serving as Chief of Campaign Plans for a three-star Coalition Headquarters, Commanding Officer of the 6th Engineer Support Regiment, and Deputy Head/Director of Military Strategic Plans. Colonel Bosio holds a Bachelor of Engineering, three master’s degrees, and a research doctorate (PhD) focusing on military theory, strategic studies and systems thinking. He is the author of the Australian War College’s *On Strategic Art* handbook. He is currently the Director of Strategic Preparedness in the Military Strategic Plans Division.

ENDNOTES

1 Nicholas J Bosio, 'Book Review—The New Makers of Modern Strategy', *Australian Army Journal* XX, no. 1 (2024).

2 The second and third editions represent this best. As Finch highlights in the work, the editors recognised that the theory of strategy is founded as much on the practice of strategy as it is on the explicit writings of theorists. See Michael Finch, *Making Makers: The Past, the Present, and the Study of War* (New York NY: Oxford University Press, 2024), p. 184.

3 Edward Earle, *Makers of Modern Strategy: Military Thought from Machiavelli to Hitler* (Princeton: Princeton University Press, 1943), 'Introduction', cited in Finch, *Making Makers*, p. 13.

4 Hew Strachan, 'The Study of War at Oxford', in Christopher Hood, Desmond King and Gillian Peele (eds), *Forging a Discipline: A Critical Assessment of Oxford's Development of the Study of Politics and International Relations in Comparative Perspective* (Oxford: Oxford University Press, 2014), p. 208, cited in Finch, *Making Makers*, p. 26.

5 H Spenser Wilkinson, *The University and the Study of War* (Oxford: Clarendon Press, 1909), p. 9, cited in Finch, *Making Makers*, pp. 26–27.

6 See Michael Howard, 'The Use and Abuse of Military History', *Parameters* 11, no. 1 (1981).

7 Finch, *Making Makers*, pp. 187–188.

8 Ibid., p. 42.

9 Nicholas J Bosio, 'An Analysis of the Relationship between Contemporary Western Military Theory, Systems Thinking, and their Key Schools-of-Thought', PhD thesis, Australian National University, 2022), pp. 66–67, at: http://hdl.handle.net/1885/260048.

/ CALL FOR SUBMISSIONS FOR THE AUSTRALIAN ARMY JOURNAL

The *Australian Army Journal* (AAJ) focuses on the presentation of contested and evidence-based research and analysis. The Australian Army Research Centre (AARC) is looking for well written, scholarly AAJ submissions on topics related to Army and the land domain, with a particular focus on the priority research topics identified in the Army Futures Research Framework. These topics include:

State of the Australian Army Profession. The analysis of the past, present and future state of the profession of arms in an Integrated Force, including how Army needs to adapt to the enduring nature and changing character of war.

Littoral Manoeuvre. Operations and manoeuvres in the Indo-Pacific including the protection of key trade routes and maritime approaches.

Defence of Australia. Army's contribution to the Integrated Force in homeland defence.

Robotics and Autonomous Systems and Artificial Intelligence (AI) Governance. Assurance mechanisms for AI in operational settings, and systems of enabling infrastructure.

The AARC welcomes submissions from professionals of all ranks and experience, academics, industry and think-tanks. Articles should comprise structured arguments that lead to logical conclusions or recommendations that can help posture Army for future land warfare challenges in the short, medium and long term. The AARC is particularly interested in *AAJ* submissions that:

- deliver analysis based on tactical or operational level experience
- provide a perspective on issues that challenge orthodox views
- place the lessons of historical experience in a contemporary context.

Process

Authors work with the AARC's editorial team in a process of iterative review. Initially, submissions are assessed for their suitability by the AARC Academic Research team, with selected articles then subjected to a double-blind review by an academic and a subject matter expert. Articles deemed appropriate for further consideration are presented to the *AAJ* Editorial Advisory Board for consideration. The Director General, Future Land Warfare is the ultimate publication authority for all *AAJ* content.

Please note that the AARC cannot accept articles which have been published elsewhere or are currently under consideration for publication with another journal.

Word length (including endnotes)

Journal articles can be between 4,000-8,000 words in length (excl. references)
Book reviews should be between 800-1200 words (excl. references)

Author biography

A 100-word (approx.) biography should be included that outlines a summary of your educational history and professional experience.

Deadline

The AARC accepts *AAJ* submissions throughout the year with the submission deadlines for each Edition published on the AARC website (https://researchcentre.army.gov.au/about-us/contribute)

Formatting and Style

Guidance on formatting and style is available in the Submission Guidelines for AARC Publications (https://researchcentre.army.gov.au/about-us/contribute/editorial-advice-contributors).

Please make your submission using the AARC's Contribute page (https://researchcentre.army.gov.au/about-us/contribute/contribute-article-paper-or-publication).

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Are you studying towards a postgraduate degree or doctorate and writing a substantive research paper related to the land domain? If you have written an original manuscript on a priority topic identified in the Army Futures Research Framework, the Australian Army Research Centre (AARC) may be interested in publishing your work as an AARC Occasional Paper (https://researchcentre.army.gov.au/library/occasional-papers). Priority topics include:

State of the Australian Army Profession. The analysis of the past, present and future state of the profession of arms in an Integrated Force, including how Army needs to adapt to the enduring and changing character of war.

Littoral Manoeuvre. Operations and manoeuvres in the Indo-Pacific including the protection of key trade routes and maritime approaches.

Defence of Australia. Army's contribution to the Integrated Force in homeland defence.

Robotics and Autonomous Systems and Artificial Intelligence (AI) Governance. Assurance mechanisms for AI in operational settings, and systems of enabling infrastructure.

The AARC welcomes submissions from professionals of all ranks and experience, academics, industry and think-tanks. Papers should comprise structured arguments that lead to logical conclusions or recommendations that can help posture Army for future land warfare challenges in the short, medium and long term. The AARC is particularly interested in papers that:

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Please note that the AARC cannot accept articles that have been published elsewhere or are currently under consideration for publication in other formats.

Word length (including endnotes)

Occasional Paper submissions can be between 10,000 and up to 20,000+ words in length.

Author biography

A 100-word (approx.) biography should be included, that outlines a summary of your educational history and professional experience.

Paper abstract

A paper abstract should be included. The purpose of the abstract is to summarise the major aspects of a paper. A good abstract will also encourage a reader to read the entire piece. For this reason it should be an engagingly written piece of prose between 200 and 500 words that is not simply a rewrite of the introduction in shorter form.

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/ ABOUT THE AUSTRALIAN ARMY RESEARCH CENTRE

The Australian Army Research Centre (AARC) was established in mid-2016 in accordance with the wishes of the then Chief of Army Lieutenant General Angus Campbell. It is the successor to the Land Warfare Studies Centre, and sits as a Directorate within the Army's Future Land Warfare Branch in the Land Capability Division of Army Headquarters.

Role

The AARC conducts strategic studies, research and analysis, fosters debate and advocates the value of the joint land force to Government, academia and the public.

Charter

The AARC is dedicated to improving the Army's understanding of the State of the Australian Army Profession. Its purpose is to promote the contribution of the land force to integrated operations in peace and war. The AARC conducts applied research on the employment and modernisation of Army with particular reference to Australia's circumstances and interests. It raises the level of professional debate on war and its challenges within the Army, the nation and international audiences. The AARC enhances the professionalism, leadership and ethical awareness of Australian soldiers and officers.

To disseminate ideas and to promote debate, the AARC maintains a vibrant publication program. The AARC's flagship publication is the *Australian Army Journal*, now over 70 years old, on its website: https://researchcentre.army.gov.au/library/australian-army-journal. The AARC also publishes Occasional Papers, Reading Lists, the Land Power Forum and other shorter works on its website.

The AARC contributes to Army's understanding of the future character of war and the advancement of land power through a number of initiatives. These include:

- contributing to the development of strategic concepts, strategies, and force structure options
- publishing intellectual debate through the *Australian Army Journal*, Occasional Papers, and the Land Power Forum
- managing the Keogh Chair and the Staff Ride Programs
- managing the Army Research Scheme
- mentoring the work of CA Scholars and CA Honours Students.

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