Army

Robotic & Autonomous Systems Strategy v2.0

August 2022

Serving the Nation

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Foreword

‘Understanding the best use of autonomous systems will ultimately be what separates militaries that capitalise [sic] on the advantage of autonomous systems from those that do not.’[1]

The use of advanced and networked technologies on the battlefield is increasing, and future warfighting is expected to centre on human-machine teams in both the physical and virtual sense. Army’s Robotic and Autonomous Systems (RAS) Strategy V2.0 articulates how Army aspires to leverage emerging technology such as Artificial Intelligence (AI), autonomy, and robotics to gain operational advantage. This document builds on the first iteration of the Strategy in 2018 which led to rapid acceleration in both knowledge and demand for RAS across Army.

RAS covers a wide range of interconnected technologies, including uncrewed systems, AI, self-learning machines, and systems more able to make sense of their environment. The increased use of RAS capabilities will continue to evolve the way Army trains and fights – enabling increased tempo, decision-making and reducing risk. In turn, this will afford commanders new opportunities in achieving competitive advantage in some of the most dangerous tasks in the future operating environment. RAS technologies also provide significant opportunities to improve the way in which we learn, adapt and train.

The purpose of the RAS Strategy is to ensure Army can generate and maintain a combat advantage. By optimising the use of RAS capabilities, we can determine the best ways to team with machines and systems. Of particular importance will be systems that can improve the speed and accuracy of decision-making to generate tempo.

This will require imagination and a clear understanding of risk. Our modernisation processes will need to be more agile to best leverage the velocity and scale of technological developments. This presents a range of options to *enhance*, *augment*, or *replace* those capabilities currently in service or under development. Army will need to continue managing the productive tension between being simultaneously *Ready Now* and *Future Ready*. RAS will create opportunity to influence concepts, doctrine and force design.

This version of Army's RAS Strategy aims to identify and harness emerging opportunities through an applied focus that emphasises a 'learn by doing' approach, taps the knowledge, skills and potential of our people in partnership with industry, academia, allies and partners.

LTGEN Simon Stuart, AO, DSC
Chief of Army

August 2022

CAPABILITY CONTEXT

Introduction

'Human-machine teaming… offer a potential revolutionary shift in how ground forces plan, train, and fight.'[2]

The character of warfare is changing[3] unlike its nature which remains an intense human-centric undertaking. Armed forces continue to adapt their methods of operation, exploiting emerging and disruptive technologies as they continue to embrace the digital era. From these technologies, rapidly developing RAS potentially present one of the most significant paradigm shifts for the future battlespace. In this capacity, RAS stands to remove the reliance on humans and human intelligence from some warfighting activities that were once considered solely a 'human' activity, fundamentally reshaping the character of future warfare. As RAS technologies become more advanced, available, and affordable, the capability of potential adversaries will also continue to expand, becoming more intelligent and agile. This reduces the capability gap between well-equipped militaries and the motivated individual or group with a cause[4], representing new and significant threats in future conflict.

As technological sophistication continues to evolve, so too does Australia's strategic context, further influencing future opportunities and threats posed by RAS. As highlighted in the *2020 Defence Strategic Update* (DSU)[5], Australia now resides in a highly dynamic strategic environment. The accelerated militarisation in the Indo-Pacific, greater prevalence of grey zone activities, and increased utilisation of disruptive and emerging technology by potential adversaries has contributed to increased regional competition. This has fostered an increased focus within the flexibility, scalability, and decision advantage opportunities offered by RAS to enhance the Joint Force. This focus is continued within Army's *Accelerated Warfare*[6] intent, highlighting the importance of RAS and emerging technology in enabling a continuously adaptive and *Future Ready* Land Force and providing a potential offset[7] in future operations. This is further emphasised by the late 2020 release of the ADF Concept for RAS, which this strategy both draws on and is nested.

Force Structure Plan 2020: RAS will be a key enabling element of the Future Land Force. The Force Structure Plan (FSP) allocates A$7-11b for brigades with uncrewed platforms within the next decade.

This emphasis on RAS is prevalent throughout the broader Defence community as demonstrated through Royal Australian Navy's RAS/AI Strategy[8], Royal Australian Air Force's Jericho Disruptive Innovation (JDI)[9], the ADF RAS Concept[10], and Defence Science and Technology Group (DSTG) STaR Shots program.[11] Hence, the RAS-enabled technological change within the future Land Force must be underpinned by a joint warfighting philosophy to fully address future challenges. In achieving this technological change, the Army presents the revised Army RAS Strategy, which aims to create and maintain competitive advantage for the future Land Force through RAS.

Army RAS Strategy Vision: To create and maintain competitive advantage for the Future Land Force through RAS.

Example RAS capabilities in the future Land Force include Human-machine teams of autonomous agents, swarms, and platforms across the cyber-physical. RAS will improve situational awareness, survivability, and lethality through high-speed information analysis and distribution. This will create intelligence, recommended courses of action to drive advantage.

Establishing and maintaining such a competitive advantage is a complex endeavour requiring a coordinated effort across Army and wider Defence.

Australia no longer assumes a 10-year strategic warning time for defence planning, Army must work quickly to address these challenges in implementing future RAS capability. This includes the inherent difficulty of rapid technology development and insertion, an increasing sovereign Science, Technology, Engineering and Mathematics (STEM) workforce, resource constraints, and navigating policy and laws. The Army RAS Strategy V2.0 is an opportunity to identify and consider these challenges to guide a cohesive Army effort toward harnessing the true potential of robotics, AI, and autonomy for the future Land Force for the Joint Force.

Defining RAS Terminology

Artificial Intelligence

AI is a critical technology for many RAS realisations. While many definitions are presented within the Australian Defence Glossary, this strategy fuses key definitions from the DTSG[12], CSIRO Data61[13], and Stanford.[14] Within this strategy, AI is defined as:

> *A collection of techniques and technologies that demonstrate behaviour and automate functions that are typically associated with, or exceed the capacity of, human intelligence.*

In this sense, AI provides a range of techniques that can be used for advanced decision-making and reasoning capabilities. Prominent AI techniques include deep learning and machine learning (ML), which use data to predict or classify future information. These techniques are then used in a number of technology applications.[15] These techniques are presented in *Figure 1*.

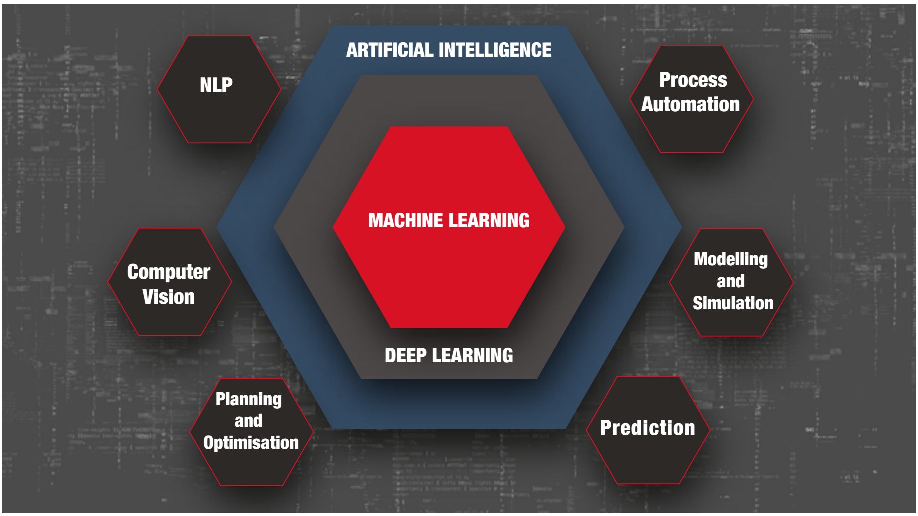


FIGURE 1 Artificial Intelligence Technologies

Robotic and Autonomous Systems

RAS are viewed as the application of software, AI, and advanced robotics to create systems capable of achieving tasks and goals as directed by humans. Notably, RAS encompasses both robotics *and* autonomous systems that can be deployed across a range of cyber and physical applications. In this context:

'Autonomy is the ability of a machine to perform a task without human input. Thus, an autonomous system is a machine, whether hardware or software, once activated performs some task or function on its own.'[16]

A systems level of autonomy is defined by considering the level of independence a whole system has in achieving its goal. Hence, while individual sub-systems within a platform may be autonomous, such as parking assist systems on modern vehicles, this does not make the whole platform fully autonomous in its own right. Full platform autonomy is only achieved when all constituent sub-systems are autonomous and controlled by an autonomous supervisory system. For instance, a fully autonomous car must decide when to use its autonomous parking system. Hence, platform autonomy naturally sits on a spectrum.

RAS Autonomy Spectrum

The RAS Autonomy Spectrum describes the range of possible intelligent decision-making capabilities demonstrated by RAS. This is best considered through the level of human input required to operate the system and the level of technical ability of the system. This strategy adopts the RAS Autonomy Spectrum from the ADF RAS Concept[17], as summarised in Table 1. In general, higher levels of platform autonomy will require more sophisticated AI technology to collect, analyse and reason with and achieve assigned goals.

Level of Autonomy	Human Role	Agent Role	Autonomous Capability
Remotely Operated	Full human control	Human dependant	**Actuate platform sub-systems:** Move steering wheel, push brake
Automatic	Monitor-intervene (human in the loop)	Self-operating	**Complete actions:** Pre-programmed movements in sub-system
Autonomic	Supervise-task (human on the loop)	Self-managing	**Achieve tasks:** Interpret information to dynamically achieve individual tasks (autonomous sub-systems)
Autonomous	Collaborate-rely (human starts the loop)	Self-governing	**Achieve goals:** Plan and achieve multiple tasks to reach final objective

TABLE 1 RAS Autonomy Spectrum

GENERATING COMPETITIVE ADVANTAGE

Capability Offset Areas

Many of the emergent capabilities entering service over the next decade will be impacted by RAS technology. As such, Army should remain aware of the potential opportunities afforded by RAS technology when inserted into new and legacy systems. More importantly, Army must fully explore and appreciate how RAS-enhanced capabilities can be integrated into the existing and future force to achieve the greatest impact.[18] This will inform and shape research, experimentation, prototyping, and procurement activity to generate a RAS-enabled Army for the future Joint operational environment.

There are five key capability offset areas in which Army will seek to gain advantage through harnessing technologies expected to emerge in the immediate and intermediate future.[19] These are:

MAXIMISING SOLDIER PERFORMANCE through reducing their physical and cognitive loads

IMPROVING DECISION-MAKING at all levels

GENERATING MASS AND SCALABLE EFFECTS through Human-machine teaming

PROTECTING THE FORCE

EFFICIENCY

Maximising Soldier Performance

Army will seek to reduce the physical and cognitive burden on the soldier through robotic platforms, smart materiels, situational awareness tools, and improved power generation and management.

Physical Performance

In the future, machines will accompany the soldier on their mission, offering the opportunity to unburden the soldier of equipment and enhance their performance. This will reduce fatigue and increase endurance, sustaining soldier performance and enabling concentration on more critical tasks. Burden-sharing machine technology includes systems such as load carriage platforms, personal transportation platforms and exoskeletons. Autonomous systems may also be able to measure and evaluate a soldier's critical signs and bio-chemistry state to ensure optimal health while on operation.

Cognitive Performance

RAS technologies will also rapidly collect, process, transfer, task and present information in a usable and intuitive way to the soldier. Additionally, these systems will seamlessly fuse different sources of data and intelligence to alert, communicate, and suggest courses of action to dismounted soldiers, vehicles, and command and control nodes via robust and configurable user interface. This will reduce the soldier's cognitive burden, improve situational awareness, and speed up decision-making.

IIn addition, information management tools will 'link' the team into a fully cohesive group, allowing future units to collaborate more efficiently to improve the effectiveness of team missions. RAS, AI and mixed reality will also enhance overall solider performance and enhance training opportunities. These technologies will allow soldiers to fully prepare for combat in a more efficient and effective manner in highly realistic settings.

POTENTIAL CAPABILITIES THAT MIGHT BE DEVELOPED IN THIS AREA INCLUDE:

Modular autonomous platform with charging station/dock, a common platform with a range of uses such as load carriage, close-fire support platform, mortar carrying platform, AT system carrying platform or ISR platform.

Augmented reality via glasses/visor/head-up display/sights used to intuitively present fused sensor data and information to enhance local area awareness. This could include location of blue force, red force, sensors cueing the soldier to a target a threat with scalable information.

Improved load carrying capacity through exoskeleton or alternative load carriage options enabling the soldier to better cope with the rigours of operations. This could also extend to supporting tasks such as moving heavy ammunition or logistic loads.

Improving Decision-making

'The slowest element in decision-making is becoming the human decision-maker. In the competitive environment of war, the race truly does go to the swift.'[20]

As the Joint Force progresses towards a fully networked and integrated future and embraces hierarchal command and agile control[21], larger volumes of data will have to be analysed, processed and distributed. This is a complex endeavour requiring a suite of highly capable and resilient networks that can share appropriate and timely information, including to AI systems for interpretation. RAS and AI will provide the foundation for this complex and flexible networking and C2 structure, facilitating rapid and robust decision-making. These networks must operate in a highly contested, denied and EM-rich environment. As such, robust and adaptive communication and processing solutions, underpinned by a highly developed system of mission command, will be required. Paradoxically, although autonomous systems are expected to reduce the demand on the network, in the shorter term, they are likely to increase demand and necessitate greater network resilience.

Advances in AI, big data and cloud computing, combined with the proliferation and miniaturisation of sensing technology, create a previously unattainable degree of situational understanding across the battlespace. AI-enabled decision-making tools can enhance overall clarity and respond significantly faster than humans. This speed, coupled with greater reliability and accuracy, can create periods of 'decision advantage' and enable commanders at all levels to make faster, more informed decisions underpinned by comprehensive analysis. Understanding and acting faster than an adversary provides a competitive edge, even with incomplete information. These AI-driven tools enable the operationalisation of agile control within the Land Domain. This may enable as reduction in the size of HQ[22] through automation of data fusion and analytics, ensuring enhanced agility, mobility and thus survivability.

POTENTIAL CAPABILITIES THAT MIGHT BE DEVELOPED IN THIS AREA INCLUDE:

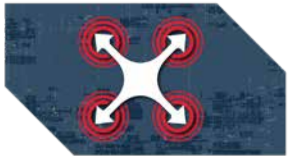
Autonomous Fused Common Operating Picture (COP) and visualisation tools through using AI and ML to fuse data feeds from multiple sources in a single point of common situational understanding able to be filtered and shared at all levels.

Big data processing, analytics powered using state-of-the-art AI will transform this fused data into actionable information and predictive assessments. This will significantly reinforce decision-making recommendations, notably in Fires/Targeting/Log/GIS and Med Int.

Mixed reality, such as a 'virtual' HQ combined with cloud-based computation and storage and advanced networking solutions will enhance overall survivability through a distributed HQ.

Advanced networking solutions, such as flexible, adaptable, and self-healing meshed network layouts, will aid in reducing overall signature and required bandwidths.

Generating Mass and Scalable Effects



'The use of human-robot teams during operations offers a solution to an enduring challenge for ground forces – the building of mass.'[23]

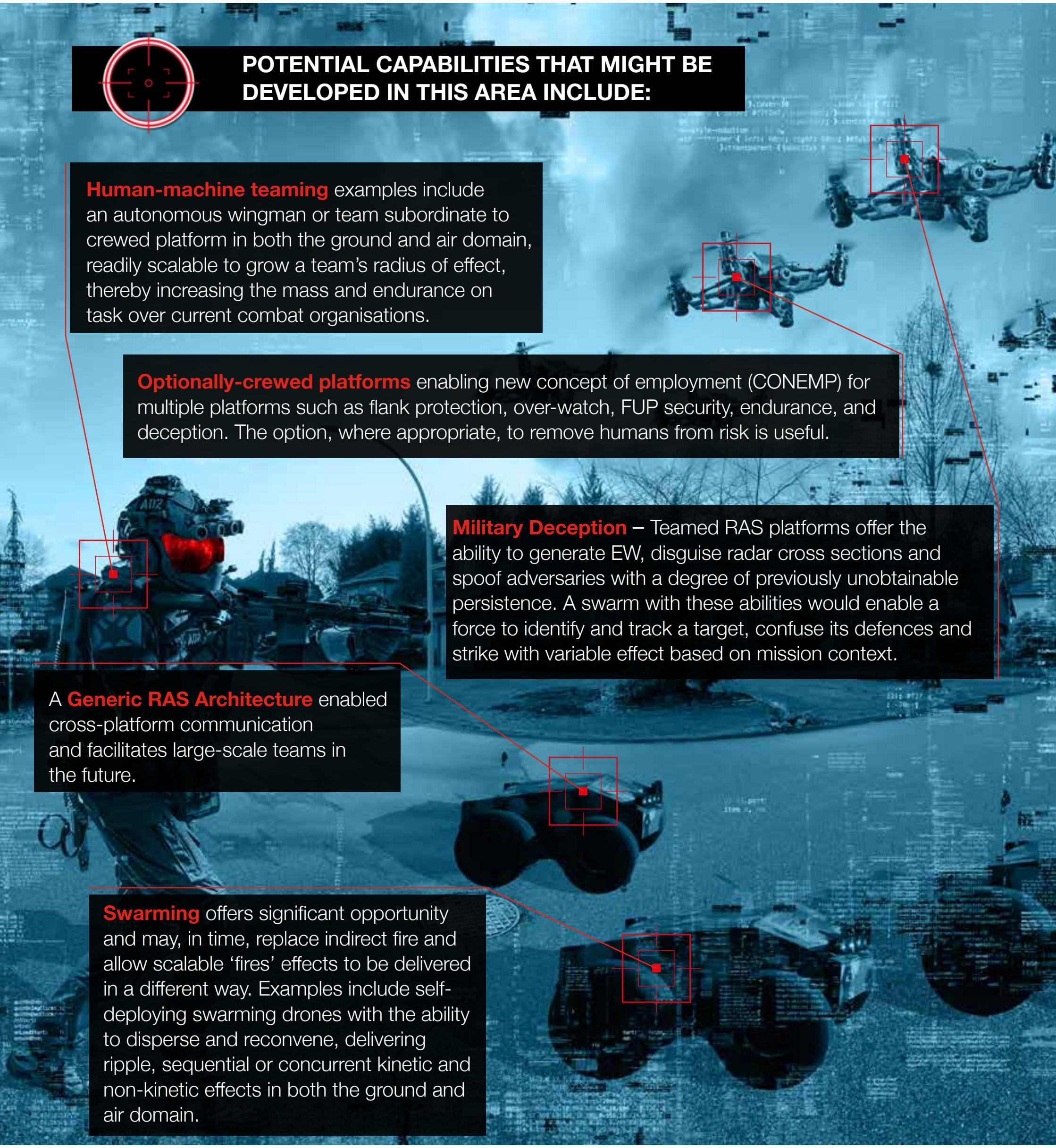
Noting Army's relatively modest size, Human-machine teaming (HMT) can partner human intelligence with RAS to significantly increase Army's combat mass and effect without the concomitant growth in the human workforce.[24] HMT merges the soldier's strategy, expertise and creativity with the overall mass and effects delivery of RAS to create a significant force multiplier.

RAS can directly improve firepower, force protection, and manoeuvrability while enabling sustained missions and rapid targeting on the battlefield. Other RAS effects could include providing defences against threat missiles; aircraft; intelligence, surveillance and reconnaissance (ISR); and electronic warfare (EW) capabilities (e.g. act as a decoy, deceive and provide sequenced and persistent ISR).

RAS could also be deployed in cooperative teams to swarm a target and deliver varied effects throughout the cyber and physical domains, providing scalable and flexible options to the commander. Heterogeneous swarming could allow for the pursuit of alternative methods of effects delivery on the battlefield. Individual swarm members would be able to perform autonomously or as part of a team, integrating into variably sized swarms and providing scalable and flexible effects. This teaming will enable robust and flexible options with greater dispersion, reach and effect on the future battlefield.[25]

Human-machine teams would also allow greater dispersion, reach and effect on the battlefield. For example, in Combat Service Support, uncrewed and autonomous platforms could deliver combat supplies through self-cueing resupply and automated platform delivery.

Notably, these effects do not necessarily require advanced autonomy capabilities. Optionally, crewed platforms represent a significant opportunity for rapid mass generation, allowing for flexible operational concepts with relatively low *enhancement* or *augmentation* to in-service platforms.



POTENTIAL CAPABILITIES THAT MIGHT BE DEVELOPED IN THIS AREA INCLUDE:

Human-machine teaming examples include an autonomous wingman or team subordinate to crewed platform in both the ground and air domain, readily scalable to grow a team's radius of effect, thereby increasing the mass and endurance on task over current combat organisations.

Optionally-crewed platforms enabling new concept of employment (CONEMP) for multiple platforms such as flank protection, over-watch, FUP security, endurance, and deception. The option, where appropriate, to remove humans from risk is useful.

Military Deception – Teamed RAS platforms offer the ability to generate EW, disguise radar cross sections and spoof adversaries with a degree of previously unobtainable persistence. A swarm with these abilities would enable a force to identify and track a target, confuse its defences and strike with variable effect based on mission context.

A **Generic RAS Architecture** enabled cross-platform communication and facilitates large-scale teams in the future.

Swarming offers significant opportunity and may, in time, replace indirect fire and allow scalable 'fires' effects to be delivered in a different way. Examples include self-deploying swarming drones with the ability to disperse and reconvene, delivering ripple, sequential or concurrent kinetic and non-kinetic effects in both the ground and air domain.

Protecting the Force

Range

RAS offer numerous opportunities to reduce and remove danger to Army personnel. Human exposure to high-risk situations will be reduced in the future battlespace through increased range of operations enabled by uncrewed platforms, improved sensors and AI. This will be achieved by using RAS technology to conduct highly dangerous activities, such as operations in CBR(N), highly contested environments, or in the deep operational environment, removing the human from the immediate danger and increasing force protection.[26]

Physical Protection

Automated ISR systems can also provide overwatch and enhance force protection, neutralising threats before they manifest. These systems will enable Army operations in areas that were previously not possible, or only at extreme risk, and free up human resources to complete other tasks (thereby acting as a force multiplier). In the short term this could be achieved by reworking current fleets into optionally-crewed platforms, where appropriate functions within the combat system could be automated or available for automation. RAS also provide the opportunity to enhance Army's application of deception effects through advanced and intelligent decoys to conceal and protect other operations.

Counter-RAS

The potential capability offsets RAS present will also be exploited by potential adversaries. Army must understand and consider the threat of adversarial RAS systems. These systems are expected to rise in prominence as RAS technologies mature and threat actors capitalise on their dual-use nature. Counter-RAS technologies will need to be developed to address this. Friendly RAS technologies will present new and efficient methods of conducting counter-RAS activities to protect the force directly. However, Army must also remain open to new perspectives to consider alternate counter-RAS options.

Notably, this also presents opportunities to exploit RAS-reliance within adversarial forces. Examples include using adversarial AI and EW methods to disrupt, degrade and deny adversarial RAS systems to reduce the adversary's situational awareness and capability. Conversely, the potential exploitation of Army's RAS should be fully understood and countered to reduce possible risk.

POTENTIAL CAPABILITIES THAT MIGHT BE DEVELOPED IN THIS AREA INCLUDE:

Sentry and patrolling capability to build endurance and persistence. Autonomous systems can provide resilience and endurance that humans cannot. In this role as a sentry the system could act as an early warning or self-cueing system to protect soldiers while on other tasks or resting.

Individual 'guardian angel' UxV to improve survivability and cue protective measures.

Adversarial AI technology provides a means of protecting the force from an adversary's AI technologies. This could work to disrupt enemy RAS platforms or limit the predictive abilities of enemy algorithms.

CRBN and EOD/ C-IED RAS directly removes personnel from danger. Several programs are underway in these fields. This technology is directly applicable to breaching and obstacle crossing.

Counter swarming and counter UxV are key capability requirements. In addition to exploiting these capabilities for internal use, Army seeks to develop countermeasures to these capabilities.

Efficiency

RAS can streamline a significant number of processes, drive down stockholding and drive up precision and accuracy in the provision of materiel.

'Sustainment will be improved… by improved stock and platform monitoring and anticipation; but also by automated logistic delivery.'[27]

RAS capabilities, particularly if enabled by AI, can create efficiencies in many processes, including:

- **Logistics:** Predictive data analytics allow the rationalisation of stockholdings, anticipate ordering, autonomously pre-positions stores and speed delivery to exact point of need.
- **Medical:** Delivering a greater range of medical interventions forward, and speeding up the casualty evacuation chain through casualty collection and preparing an advanced medical facility to receive the casualty.
- **Maintenance:** Advanced health and usage monitoring systems (HUMS) to enable timely and accurate fault diagnosis, drive down the length of time platforms are out of action for maintenance, and repair and inform engineering risk-taking. Electric drive vehicles may offer the ability to further reduce maintenance burdens through the overall reduction of maintenance requirements in comparison to internal combustion engines.

AI systems can also be used to enable a 'sense and respond' logistic structure, changing to an 'as needed' basis rather than a 'just-in-case' basis.[28] RAS could also ensure stocks can be dispersed and protected through a delivery network and 'virtual' warehouse design. This would afford greater agility, reduced logistics footprint and signatures to be managed.

Emerging transport technologies, such as leader-follower vehicles, and fully autonomous delivery, offer the opportunity to fundamentally redesign future platforms to enable autonomous replenishment from uncrewed systems. The automation of the drive functions may reduce or remove the factor of human fatigue as a determinant on logistic or transport rates of efforts and improve efficiency through reduction of stationary time for vehicles.

POTENTIAL CAPABILITIES THAT MIGHT BE DEVELOPED IN THIS AREA INCLUDE:

AI enabled 'Aware Logistics' – AI enables a fused logistics operating picture facilitating predictive logistic support accuracy and reduced demand and stockpiling. Immediate autonomous replenishment of the fighting echelon would be completed with limited human direction. Platforms such as UGV/UAV would contribute to automated replenishment of combat supplies and would be reinforced by alternative distribution means (cued, uninhabited or crewed, air and ground depending on situation) including over the shore support.

Predictive medical logistics – smart clothing and personnel health monitoring systems could enable intelligent medical intervention – including autonomous casualty collection and predictive preparation of a medical facility to receive the casualty. CASEVAC could be through crewed or uncrewed means, either with or without on-board medical capability.

Distributed and virtual stockpiling and warehousing – the dispersion of stores to an AI-enabled distributed 'virtual' warehouse (potentially uncrewed) consisting of multiple stock locations interconnected by rapid UxV. This improves resilience and flexibility in the logistic lines of communications and can apply 'Aware Logistics' to predict and autonomously reposition stores at the expected points of need.

Power and Energy – power generation, supply and storage will need to match the needs of the force. Increasing the power efficiency of the force through operationally renewable means will reduce the amount of logistics lines of communications dedicated to bulk fuels, and improve the protection to the force.

Enabling Factors

The future vision relies on a number of key enabling factors, including Technology, Innovation Ecosystem (Innovation Ecosystem), Sovereign Capability and Capacity, Legal, Ethical, Moral and Policy Considerations, and Force Design.

Technology

Technology will play the primary role in the realisation of RAS, with robotics, communications infrastructure, sensors, propulsion and energy, and AI all foundational to future RAS capabilities. Enduring and robust RAS will be achieved through proven and reliable robotics, advances in AI and AI architectures, computation and communications infrastructure technology. General robotics design, including effective and reliable actuation, sensing, materiels, propulsion and energy generation solutions, will be key to enabling future physical platforms. Propulsion and energy generation will be explored across the application spectrum, as explored in the Army's Power and Energy Paper, given the predicted diversity of future RAS platforms. Quantum technology also provides significant potential opportunity in future RAS applications through revolutionary sensing, communications and processing applications. Army's Quantum Technology Roadmap[29] further details the plans for exploration into quantum technology and will need to be considered extensively for integration into future RAS platforms.

These technologies will need to engender trust from the user, wider Defence, and the Australian Government. Users must be able to trust that RAS capabilities will function as intended, not behave unexpectedly, and can operate in contested and congested environments often with limited network availability. This includes the ability to selectively operate when there is no network and where a human has no backup controls. Open and extensible architectures will enable a wide range of interconnected RAS capabilities that are flexible and adaptable to changes in the communication environment (whether degraded or denied).

In addition, software such as AI underpins the realisation of true autonomy of RAS. Without it, RAS will reach autonomony limits quickly, remaining remote controlled and automatic at best. Extending AI to facilitate truly intelligent and adaptable machines and capable Human-machine and Machine-machine teams will be critical to future RAS capabilities. AI tools will also be foundational in decision support, providing RAS with the ability to rapidly analyse significant volumes of data, see patterns and make observations and recommendations.

As responsibility for the behaviour of Army RAS technology remains with the Australian Government, it is a critical requirement that Army has trust and confidence in the systems that they are fielding, particularly those which incorporate AI. The need to understand the design parameters of AI technology and algorithms embedded in the fielded capability may require Australian-derived verifiable-by-design AI, rather than a 'black box' solution. This is a fundamental change from other technologies and reinforced by the UK '… *establishing assurance over the behaviour of such systems will be very difficult. Buying constituent elements of platforms from foreign suppliers will be increasingly risky'.*[30] This supports the Australian Government declaration of RAS and AI as a Sovereign Industry Capability Priority (SICP).[31]

Innovation Ecosystem

Given that RAS and AI introduces new potential capabilities, it will be necessary to utilise and enhance the broader Innovation Ecosystem to ensure efficient division and allocation of effort and resources. In this context, the Innovation Ecosystem is the complete collection of internal Defence RAS stakeholders, such as members of the Defence innovation system, including the services and their respective innovation programs; the Defence Innovation Hub (DIH); and DSTG. External RAS collaborators include those from other government agencies, academia, industry and international partners, including the AUKUS Autonomy and AI working groups. This ecosystem represents the collective effort towards developing future RAS and facilitates the rapid research, development, integration, and deployment of RAS capabilities.

The multi-disciplinary nature of RAS necessitates collaboration as key to realising fast and effective outcomes. With many internal and external partners all exploring RAS, AI, robotics and sensing technology, collaboration will expand overall RAS opportunities and reduce cumulative effort. Collaborative efforts will also need to extend to industry and academia to provide further sovereign research and development capacity.

Army must actively participate in appropriate activities within the Innovation Ecosystem to inform and shape its consideration and implementation of RAS capability, with prototyping and experimentation key to learning, especially in the *application* of the technology. Improved coordination of various RAS initiatives through the Robotics and Autonomous Systems Implementation and Coordination Office (RICO) will enhance innovation and reduce development time, by directing effort towards the most relevant goals and avoiding effort duplication. Army will actively promote and manage internal and external collaboration in the ecosystem, expediting RAS development for Land Domain RAS capability requirements. This will include work towards updating RAS and AI governance and acquisition processes to more directly align with future requirements. This most notably includes overseeing the incorporation of RAS and AI into the Defence Capability Lifecycle (CLC).

People

Training, sustaining and retaining RAS and AI skillsets within the existing and future sovereign RAS workforce will be required to build foundation RAS literacy. People with these skillsets are a core requirement throughout the RAS lifecycle, including fundamental research and development, operation, support and improvement. Technical skillsets within STEM, specifically robotics, AI and cyber, are in high demand, with overall talent in limited supply.[32] This has created a highly competitive STEM workforce market, primarily in specialist occupations within the RAS area.[33] Army will maximise its use of the Total Workforce System to ensure an appropriately skilled workforce is recruited, employed and retained in key areas of RAS development.

Sovereign Capability and Capacity

'A "sovereign capability" approach for each nation could provide a more secure approach to developing key technologies… '[34]

Army will need to ensure personnel develop sufficient RAS and AI literacy as these technologies are introduced into the force. Making soldiers and decision-makers fully appreciate RAS opportunities, limitations, and general considerations will significantly increase the probability of fast and efficient RAS implementation. Literacy is key to Army understanding what RAS and AI skillsets are developed and maintained within the service and wider Australian academia and industry to support future RAS activities and communicate the future capability needs of the Land Force.

The addition of RAS & AI as a SICP seeks to optimise Australia's access to, or control over, certain elements of critical RAS industrial capabilities, and to support or influence industry investment in these areas. Developing these capabilities will ensure Australia has access to world-leading RAS & AI capabilities that meet Defence's unique requirements and extend Australia's warfighting advantage. A strong, sovereign RAS design and manufacturing capability and capacity is critical to ensuring continued secure and reliable support and sustainment to future Army RAS capabilities. Manufacturing, testing and development industry with sovereign facilities also expedite the RAS development process and allow for faster, more efficient prototyping and operation within the Army. Through understanding the Innovation Ecosystem, Army will be able to actively focus its limited innovation resources to invest in innovation that adds value without duplicating effort already completed by allies, partners and RAS industrial base. This will reduce duplicated effort and wasted resources, while setting the conditions to inform where Australian industry may wish to invest capability and capacity to meet Army's RAS insertion requirements.

Responsible, Legal and Policy

Army will need to remain cognisant of the issues surrounding the responsible use of RAS technologies as this Strategy evolves and is implemented. The use of automation is already challenging previous paradigms on the employment of complex systems and control frameworks. The Army will need to address many challenges, especially the legal and ethical issues around the use of autonomous weapon systems and the application of force. All weapons systems developed and deployed by Army, including RAS, will be compliant with Australia's obligations under international law.

As a party to *Article 36* of *Additional Protocol I of the Geneva Convention*, Australia fully supports and undertakes a review of any proposed new weapon, means or method of warfare irrespective of autonomy. *Article 36* reviews are an essential component in ensuring compliance with international humanitarian law on the battlefield and within Australia's 'system of control'. Army will also monitor the ongoing United Nations, particularly our obligations regarding the UNESCO Recommendations on the Ethics of AI[35], and ongoing discussions on Lethal Autonomous Weapons (LAWS) (noting that the definition is not agreed). Strategic Policy (SP) Division (Counter-Proliferation and Arms Control section) remains the policy lead for Defence and address such issues in conjunction with Department of Foreign Affairs and Trade (DFAT).

More widely, there is some discussion over whether there might be a greater willingness to wage war when far fewer humans are involved in the fight. This strategy recognises this dynamic and changing environment, and the potential impacts if Army does not remain integrated and engaged. Army has and will continue to actively engage, contribute to, and inform Defence and Government policy. Furthermore, Army will formulate its position on many of the challenges in this field cognisant of the national and ADF position. There are many interconnected issues surrounding rules of engagement, responsibility in the event of failure, testing and evaluation criteria of autonomous systems; these will be explored throughout the RAS development process.

Force Design

‘Autonomous Systems raise challenging operational, strategic, and policy issues, the full scope of which cannot yet be seen. The nations and militaries that see the furthest into a dim and uncertain future to anticipate these challenges and prepare for them now will be best poised to succeed in the warfighting regime to come.’[36]

To fully appreciate the opportunities afforded by RAS within Army, RAS and AI capabilities must be carefully included and considered within operational concepts, force design and analysis activities. These activities determine the capability needs of the Land Force inclusive of potential RAS capabilities. These are then communicated through the Land Operational Concept Document (Land OCD) in consideration of the future operational environment and Shape, Deter, and Respond strategic objectives to maximise potential benefit across Army’s strategic outlook.[37] The Land OCD will guide the RAS Capability Insertion Framework and consideration of Fundamental Inputs to Capability (FIC) for the implementation of RAS capabilities into the future Army. While initial RAS activities will be exploratory, RAS concepts of employment and force structures will need to be created to evaluate the RAS options and direct future RAS technology exploration as Army looks towards investing the DCAP 2020 provision of A$7-11b for uncrewed systems for the Land Domain in the next decade.[37]

This will then be followed by RAS concept analysis activities such that Army can compare and identify the most appropriate RAS concepts while highlighting and investing in future-specific technical research directions. These activities will need to consider the rapidly developing nature of RAS technology to generate flexible concepts that can continue to fully exploit the state-of-the-art technology. In addition, it is noted that RAS technology and concept development will be symbiotic. Concepts will inform future technology exploration; however in other instances RAS technology development and maturation will inform concept development.

Fundamental Inputs to Capability (FIC) will also need to be reviewed as more autonomous systems are introduced through the replace frame. For instance, the proliferation of autonomous systems will prompt a review of how these systems are supported within the current equipment support arrangements, their evacuation from the battlefield and how the deployed force echelon system will have to adapt. It will also result in changes to personnel training and recruitment, potentially requiring a larger portion of the workforce to be skilled in STEM in addition to an increasing overall RAS and AI literacy across the force. In the immediate term, data collection and management practices to enable the development of future AI systems will also need to be considered and aligned to the Defence Data Strategy.[38]

Capability Insertion Framework

Insertion of RAS capabilities into the force will need to be flexible and adaptive to fully capitalise on opportunities that arise from future technology. The Enhance, Augment, Replace (EAR) framework for RAS capabilities provides such an approach. This framework aims to highlight potential RAS implementation options from a force element viewpoint and guide discussions on how RAS can be employed on in-service and future platforms throughout all stages of the capability lifecycle. The key is identifying the correct autonomy level for the role of the system.

ENHANCE

Refine the Platform Capability/Functionality

How it does it

In the simplest and least invasive approach, RAS technology insertion will enhance current platforms by improving and refining existing functionality, minimising wider operational impacts. Examples of enhance include:

- improving communication and sensing system performance
- converting current platforms to enable remote operation
- developing more immersive and effective training methods through augmented and virtual reality.

These enhancements will refine and improve platform functionality. Given no functionality is added or changed, wider operational impacts are minimal. This technology insertion also requires the lowest autonomy (a minimum of remote operation), reducing development time and presenting a rapid method of RAS employment within the shorter term.

AUGMENT

Extend the Platform Capability

What it does

As system technology and trust develop, RAS can augment existing platforms by adding new functionality and capability. Examples of augment include:

- auto-recommender and tracking systems for target engagement
- autonomous operation on optionally crewed vehicles
- intelligent EW and SA capabilities
- incorporating augmented reality into soldier teams to increase SA
- additional autonomous self-defence systems.

Augment presents an effective and efficient method of RAS technology utilisation. RAS can be implemented to increase the functionality of tried and tested platforms, exploiting key RAS opportunities and future operating concepts without significant changes to force structure. Hence, *augment* will likely feature as the prominent means of RAS employment in the mid-to-long-term.

REPLACE

Replace the Platform Capability

What it is

The most advance and substantial method of RAS technology insertion is to replace existing platforms. Redesigned platforms and capabilities can depart from traditional design constraints such as on-board human control facilities or protection and survivability requirements of operators or crews when fully utilising RAS. This can increase platform capability while reducing cost. This unconstrained design ethos also allows for effects to be achieved in novel ways, improving options in the battlespace. Examples of replace include:

- uncrewed (by design) combat platforms
- distributed and scalable effect through swarm teams
- cab-less autonomous logistics platforms
- unit support platforms such as quadrupeds or micro ISR platforms.

In some cases, platforms can also replace human capability in dangerous, dirty or dull tasks, such as high-risk ISR activities or operation in the CBR(N) environment.[39] However, in this capacity, replace aims to complement and integrate within the human force, utilising novel operational concepts and HMT to maximise effect while allowing the development of unique creative skills of 'knowledge workers'[40]. Replace also includes the introduction of novel platforms which provide new capabilities not possible without RAS due to their performance characteristics, such as excessive G-force exposure.

Enhance, Augment, Replace Considerations

The insertion of RAS technologies into Army employment will combine *Enhance*, *Augment* and *Replace* technology options. *Figure 2* presents a likely distribution of *enhance*, *augment* and *replace* technology insertions over the near to far terms. The employment type for each technology on a given platform will be dictated by technology sophistication, trust in RAS and the most efficient means of technology utilisation.

Early technology insertion will likely be limited by technical capability and will focus on simple, remotely operated and automatic sub-systems employed through *enhance* and *augment* capacity.

Augment and *replace* insertions will likely require more sophisticated AI and higher levels of autonomy (autonomic and autonomous). Hence, as *technology* tends towards autonomic and autonomous capability, further *augment* and *replace* options may become feasible. It is noted that *replace* is not the final goal of RAS capability insertion. In many cases, *enhance* and *augment* will likely produce more effective and efficient results. Hence the future force will likely combine *enhance*, *augment*, and *replace* RAS insertion options to achieve sufficient autonomy to gain the best benefit from Army's resources. Autonomy levels will need to be commensurate with role, this is the most expeditious method of adopting this technology set.

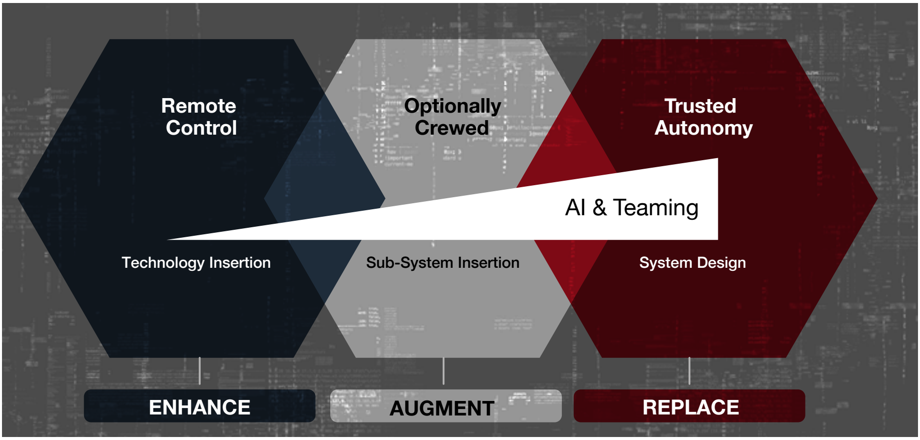


FIGURE 2 Enhance, Augment, Replace Employment through Time

Realisation

To successfully realise the potential capability offset opportunities RAS technologies offer, coordination through multiple lines of effort (LOE) will be necessary to organise Army's RAS efforts. These LOEs are directly drawn from the identified key Enabling Factors identified in the previous section and are presented in *Table 2*. Key LOE objectives guide future effort within each LOE. These objectives are perpetual, remain end-state agnostic, and represent the pursuit of continuous development given the dynamic nature of RAS technology development and Army operational requirements.

Enabling Factor	Line of Effort	Objective
Technology	Shape and Enable RAS Research	To comprehensively and responsively identify relevant gaps and opportunities and facilitate research.
	Develop, Experiment and Prototype	To understand and evidence how capability offsets can be realised by testing, evaluating, and iterating emerging and mature RAS capabilities in user environments.
Innovation Ecosystem	Shape and Influence Innovation Ecosystem	To maximise Defence efforts in pursuit of RAS innovation by eliminating innovation silos and communicating opportunities to relevant parties.
	Foster Collaboration with External Stakeholders	To establish Army as a RAS champion through effective engagement and strengthening of industry, academia, and coalition partnerships.

TABLE 2 **RAS Strategy Lines of Effort**

Enabling Factor	Line of Effort	Objective
Sovereign Capability and Capacity	Understand and stimulate Sovereign Capability and Capacity	To gauge and build RAS literacy, capacity, and expertise across both Defence and external capabilities to assure Future Army requirements are met.
Force Design	Explore and Integrate RAS Technologies within Force Design	To meaningfully advise and assure decision-making regarding introduction of fit-for-purpose capabilities into service at the right time and quantities.
Legal, Ethical, Moral and Policy	Explore and Shape RAS Policy/Law	To support development of RAS legal and ethical frameworks, doctrine, and policy.

TABLE 2 **RAS Strategy Lines of Effort**

Shape and Enable RAS Research

Research into robotics, sensors, AI and holistic RAS capabilities is a key enabler towards future RAS technology. This LOE serves to understand and identify desired research outcomes and use knowledge to shape future RAS research. Three technical themes will guide RAS research. These are:

- Intelligent Machine (autonomy [including AI and cognition], robotics, power and energy, and other related technologies)
- Human-machine teaming (Human-machine interfaces, cooperation and coordination)
- Machine-machine teaming (general machine cooperation).

This will also include developing foundational tools, methods, and technologies that enable and counter emergent RAS capabilities. This may also include technologies for use outside of adversarial operations such as

Humanitarian Assistance and Disaster Relief. Examples of initiatives that can be explored within this LOE include a RAS IS&T plan, engagement of the academic sector through partnership with the DSTG and the STaRShot program, the Next-Gen Tech Fund, DIH and other groups and services.

Develop, Experiment and Prototype

Many RAS technologies are relatively new and still evolving. To advance these technologies into capability, experimentation and prototyping activities must be conducted to test the application of the technology and assess its potential. This LOE will test and demonstrate key capabilities in representative environments and is critical to ensuring system reliability, robustness and usability in contested environments and to inform Army's user needs. Supported by simulation and modelling, these activities will identify and explore promising technologies that offer the best capability edge. This work will also identify gaps in technological offerings and generate new research questions, furthering the RAS development cycle. The three technical themes of Intelligent Machine, Human-machine teaming and Machine-machine teaming will also guide this LOE.

Shape and Influence Innovation Ecosystem

This LOE will aim to shape and influence the Innovation Ecosystem to increase overall RAS development efficiency. This will encourage optimal coverage of investment across key research themes and technology focus areas while deconflicting unnecessary effort duplication. It will also ensure RAS-related activities align with Army's primary interests, where possible, to further increase development efficiency.

Foster Collaboration with External Stakeholders

Army will remain alert to RAS developments, as both threats and opportunities, through collaborating with the scientific, industrial and academic communities. This LOE will aim to increase the Innovation Ecosystem through collaboration and active engagement and outreach with external stakeholders. Army will also aim to collaborate with allied and internal Defence where possible to minimise duplication of effort and enhance innovation resources and relationships through existing and emergent projects. Army will continue to invest in intiatives to generate visibility of RAS developments across the ecosystem though events such as the Army Robotics Expo (ARX), Quantum Technology Challenge and Army Innovation Days to provide opportunity for collaboration with external stakeholders.

Understand and Stimulate Sovereign Capability and Capacity

A strong RAS sovereign capability and capacity is crucial to effective and sustained RAS capability. Initially, this LOE will serve to understand the current sovereign capability, its key limitations and opportunities for growth. This includes workforce and general capability related to AI, robotics, automation, perception, and data science. Following this process, targeted investment and collaboration activities can be carried out to stimulate overall capability and ensure sufficient sovereign industry for future RAS research, manufacturing and sustainment.

Explore and Shape RAS Policy/Law

Army acknowledges that RAS policy considerations are a complex topic that will require the cumulative input of many stakeholders including SP&I Div, DFAT and the ADF. Army will collaborate with these stakeholders to ensure appropriate and responsible use of RAS in the future. Under this LOE, Army will work with internal and external partners to ensure that it adheres to all relevant RAS regulations and policy while developing, testing and deploying RAS capabilities. It will also collaborate with partners to ensure that regulations are fit for purpose within the Army operational context. RAS policy and legal considerations will be developed iteratively through RAS experimentation and deployment. Hence, RAS efforts will not only be informed by policy and legal considerations, they will also actively inform policy and law in this iterative process.

Explore and Integrate RAS Technologies within Force Design

RAS concepts will need to be generated, analysed and incorporated into future force structure and design to fully realise RAS benefits. This LOE aims to stimulate RAS concept design and analysis activities to enable the consideration of future RAS capabilities into force design and structure. This will be completed through the lens of the *enhance, augment and replace* employment framework to provide clarity to, and maximise the coverage of, potential technology insertion options. This includes leveraging key capabilities from across Defence to appropriately consider RAS force options, notably operations analysis expertise within DSTG and Directorate of Land Force Design within Future Land Warfare Branch (FLWB). This LOE will also serve to explore RAS operational considerations such as adversarial RAS, interoperability and FIC.

Lines of Effort Interaction

A single, interconnected effort across all seven lines of effort will be necessary to realise the benefit of RAS technology. In realising future RAS capability, Army will coordinate these LOEs using *Innovate, Coordinate*, and *Realise* framework presented in *Figure 3*. In this framework, lines represent interaction and information flow between LOEs.

The three technical themes guide the '*Innovate* feedback loop' representing the traditional research-test-refine loop. Within this framework, innovation activities are managed and facilitated through the coordination and collaboration LOEs. Outcomes from testing in experiment and prototyping activities are then used to inform the sovereign capability requirements, signalling future RAS opportunities to industry and academia.

Coordinate serves as the primary management function for *Innovate* and *Realise*. The collaboration LOE aims to ensure that collaboration continues to grow the Innovation Ecosystem while the *Shape* and *Influence* LOE directs effort to achieve Army RAS goals.

Realise then acts as a primary output for Army's RAS development efforts, transforming the technology output from the *innovate* LOEs into integrated capability through force design activities. This force integration occurs through the *enhance*, *augment* and *replace* employment framework to provide benefit to the five primary offset areas.

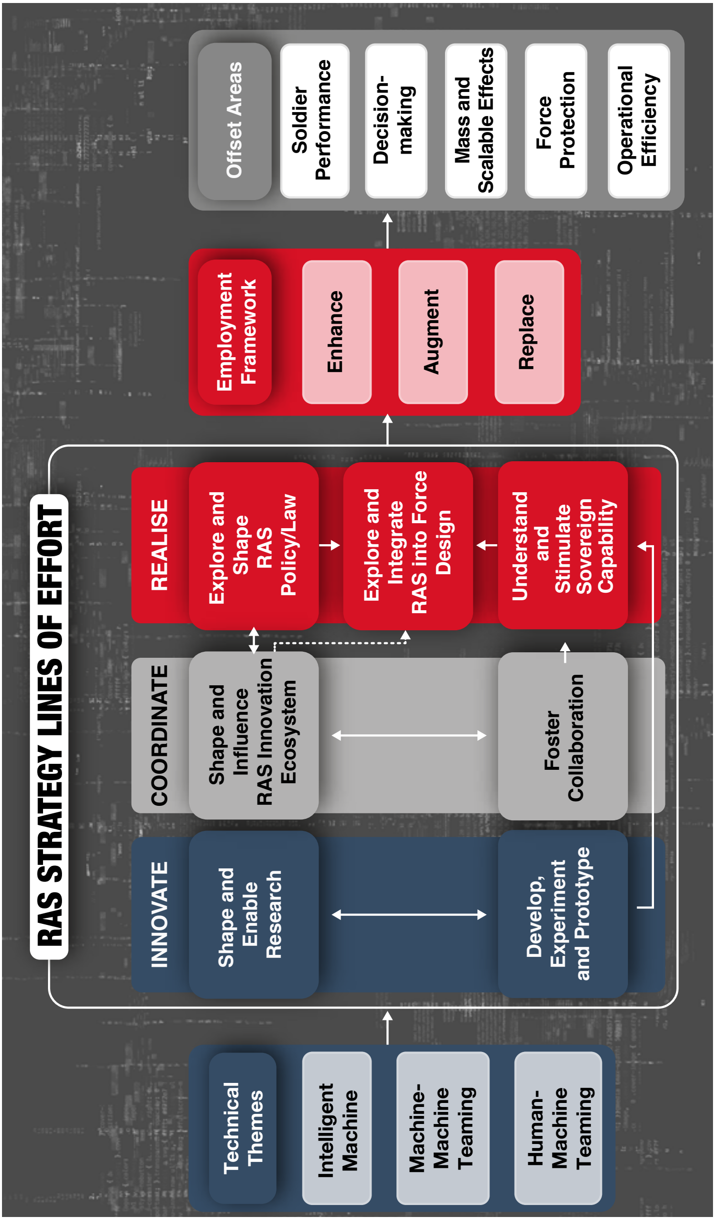


FIGURE 3 RAS Lines of Effort Interactions

Implementation

The implementation of this strategy will be led by the FLWB and executed through project LAND 135. LAND 135 forms the comprehensive implementation plan to support this strategy. LAND 135 is not a traditional capability development project; it does not seek to procure equipment or technology for immediate employment in Army. Rather, it seeks to advance RAS technologies and explore what level, configurations, and combinations RAS can be employed in Army to augment, enhance or replace capability in order to equip the future Land Force with a warfighting advantage in the future. LAND 135 is nested within the Defence innovation ecosystem, seeking to identify how RAS can be employed and integrated to achieve transformative capability effects. To progress innovation from concept to capability, LAND 135 is necessary to investigate the application of RAS technologies and the unique complexities of land domain-specific autonomy challenges in the contexts of Land Programs. It enables the Land capability programs to appreciate their user needs for their input into the Capability Lifecycle. The systems, both physical and cyber-physical, that will be procured through LAND 135 are representative systems of potential future capability and therefore lower on the TRL scale than a traditional project. They are used to identify use cases, user requirements, and safety and performance characteristics – knowledge. This knowledge is shared with the broader Defence innovation ecosystem and transferred to the extant Land Programs to progress to and shape capability acquisition along a traditional project pathway.

DG FLW will lead the implementation of Army's RAS Strategy and coordinate Army's enduring RAS efforts through chairing the Army RAS Steering Group, incorporating the key stakeholders[41] reporting to the Land Capability Steering Group (LCSG). Direction and guidance will then flow across Army.

Responsibility for specific *innovate, coordinate* and *realise* activities across all LOEs will be shared throughout the full span of Army. *Figure 4* summarises the broad division of temporal responsibilities.

Army Future Force Epoch

The FLWB and the RICO are primarily responsible for the discovery, exploration and assessment of potential future RAS capabilities and their application within the Land Force. Activities will primarily develop the *Innovate* and *Coordinate* LOE functions, extending current RAS R&D efforts and developing a self-sustaining Innovation Ecosystem. Foremost, this will include establishing a coordination function within Army to enable oversight of RAS R&D efforts while furthering collaboration with Allied programs, industry and academia. This coordination function will bring coherence to Army's involvement in the Innovation Ecosystem.

During this period, Army-led innovation activities such as Army Innovation Day, ARX, Quantum Technology Challenges, as well as Army participation in other research opportunities such as the Centre for Advanced Defence Research in Robotics and Autonomous Systems and the Trusted Autonomous Systems Defence Cooperative Research Centre, as well as the Defence Innovation Hub, will enable Army to gain momentum. This in turn allows RICO to assess potential force design implications. RAS technology rollout must also be explored in detail, without being inhibited by perceptions, bias and human limitations – moving away from the current human-centric methods of operation. Army will look beyond the current paradigm of employment and approach this opportunity with imagination and an open mind. In this way, the full potential of RAS will be realised.

RICO is also responsible within Army for exploring overarching policy, law, and sovereign capability considerations for the insertion of RAS technologies. The output of RICO's endeavours will direct future RAS efforts and inform Land Capability Program RAS capability user needs for detailed consideration.

It is possible RICO will discover RAS technologies are emerging faster than traditional acquisition systems may allow, or which are truly disruptive. In such instances it may be recommended that tailored rapid acquisition pathways are applied. This could agilely change the scope of an existing capability program or deliver directly into the Force-In-Being in order for Army to realise the transitory capability offset or asymmetric advantage they offer.

Army Objective Force Epoch

Army's Capability Programs will take advantage of the work completed by RICO to guide their project capability user needs. This will reduce duplication in effort expended developing broad RAS knowledge by leveraging the combined efforts of the full Innovation Ecosystem. This approach empowers capability programs to focus on the developing complete understanding of the FIC requirements and detailed exploration and consideration of force structure and design will also be necessary to enable more significant RAS insertion of their respective capability to inform the acquisition of the right RAS-enabled products for the Land Force through the IIP and insertion through the capability lifecycle.

Force-In-Being Epoch

Within the Force-In-Being (FIB), responsibility for RAS innovation resides within the force. Once RAS-enabled capabilities have been introduced into service, end users are responsible for the refinement and evolution of the TTPs and SOPs to optimise their potential. The insertion of any technology will identify opportunity for development in another area, and lessons that will not only change how the FIB fights, but also inform the capability focuses of the Capability Programs and Future Land Warfare. The high level of RAS literacy and knowledge within our people must be utilised to conduct meaningfully-tactical innovation which will in turn form potential user needs for examination by LCD.

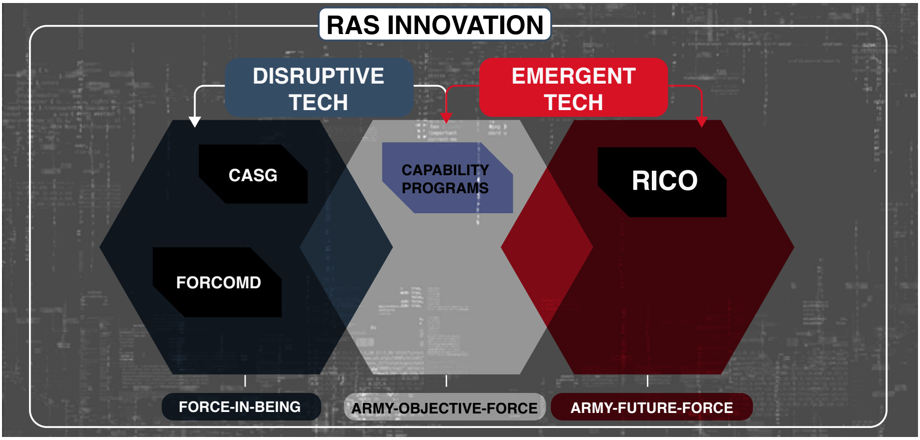


FIGURE 4 RAS Strategy Effort and Capability Goals over Short, Mid and Long Terms

Conclusion

RAS offers significant potential to the future Land Force and will fundamentally alter how the Army trains, prepares for, equips, and ultimately fights in the future. Using the Army RAS Strategy V2.0, Army aims to establish and maintain a competitive advantage for the future Land Force through RAS. This will be achieved through the combined attention to seven key LOEs encompassing the coordination of RAS activities, innovation of RAS technologies through experimentation R&D activities, and realising RAS capabilities into the Future Force.

Innovation activities will be founded on the three technical themes of ‘Intelligent machine’, ‘Machine-machine teaming’ and ‘Human-machine teaming’. These R&D efforts will explore RAS technologies and demonstrate RAS feasibility perpetually, further direct future research, and inform force design and acquisition processes.

Realisation activities will then work to incorporate RAS into the future Land Force through further investigation into sovereign capability and capacity, RAS policy, and law and force design. Developing and sustaining a sufficient sovereign RAS capability represents significant challenges and must be explored in more detail. Forward-thinking and open-minded force design will also be critical to fully exploiting RAS capabilities. In this capacity, the *Enhance*, *Augment*, and *Replace* RAS employment framework provides a method of considering various forms of RAS insertion based on technological sophistication and aims to expand traditional thinking around RAS utilisation.

This RAS insertion will then benefit the five capability offset areas within the future Land Force, aiming to enhance soldier performance, provide decision advantage, generate mass and scalable effects, protect the force and provide potentially substantial efficiency improvements. However, importantly, this Strategy remains technology agnostic. Army must take the time now to understand and decide how it wishes to use RAS technology, how to implement RAS capability most effectively within the Future Force, and then rapidly pursue its acquisition as the technology matures. In turn, this will establish competitive advantage in the future Land Force, with continued innovation critical to ensuring Army is *Future Ready*.

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