Army

Robotic & Autonomous Systems Strategy

October 2018

Serving our Nation

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Foreword

"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"[1]

Foreword

The use of advanced and networked technologies on the battlefield is increasing and future warfighting is expected to centre on human-machine teams both in the physical and virtual sense. Army's Robotic and Autonomous Systems (RAS) strategy articulates how Army aspires to ethically leverage emerging technology such as Artificial Intelligence (AI), autonomy and robotics as they mature to gain asymmetric advantage.

RAS covers a wide range of inter-connected technologies including un-crewed ground systems, aerial systems, AI, self-learning machines, and systems more able to make sense of their environment. The increased use of RAS capabilities will fundamentally change the way the Army fights by: increasing situational awareness, reducing the soldier's physical and cognitive workloads, improving sustainment, facilitating movement and manoeuvre, increasing reach and range and force protection. In turn, this will afford Joint Force commander's new opportunities and, potentially, replace soldiers in some of the most dangerous tasks in the battlespace. RAS technology will also provide significant opportunity in the training and education of Army to improve learning and provide cost-effective and realistic training.

[1] Paul D Scharre, The Opportunities and Challenges of Autonomous Systems paper within "Autonomous Systems, Issues for Policymakers" HQ SACT, NATO 2017.

“We tend to overestimate the effect of technology in the short run and under estimate the effect in the long run.”[2]

To ensure Army can maintain a capability advantage and meet future threats, we must start thinking about how Army can best use RAS capabilities, determine what human-machine teaming could look and operate like, and consider how we could operate with and alongside machines. Of particular importance will be considering the impact of systems that can improve the speed and accuracy of the human decision-making cycle to create tempo. This will require imagination and appropriate risk taking. By starting this thinking now, Army can ‘future proof’ legacy and new systems. This will inform future iterations of the Defence White Paper and Integrated Investment Program (IIP); including divestment of legacy platforms that are no longer fit for role and may impact on anticipated life of type (LOT) of those capabilities currently under development.

The purpose of the RAS Strategy is to set the path to realising a RAS enabled future Army that can rapidly deploy, concentrate at a point of effort and disperse to survive – through a robust and resilient network, leveraging superior decision-making to win in future conflict that can utilise game changing technology whilst simultaneously ensuring it can defeat advanced technologies used by potential adversaries.

“The question is not whether the future of warfare will be filled with autonomous, AI-driven robots, but when and in what form.”

Ilachinski, “AI, Robots and Swarms”, P231, CNA 2017

In addition to exploring what RAS capabilities can offer, Army needs to consider what changes will need to occur to doctrine, concepts and force design to support the use of RAS capabilities. This will include adapting current acquisition processes to be more agile to ensure Army can keep up with the rapid rate of technology development and improvement. Army should support innovation through prototyping, experimentation, and tapping into the technical knowledge of

[2] Amara’s Law stated by Rodney Brooks – The Seven Deadly Sins of AI Predictions, MIT Review 6 Oct 2017

the existing workforce. In this context it will take time to learn, refine and adapt to fighting with and through RAS.

A principal outcome of this strategy is to harness emerging technological opportunities by creating a focus for learning through doing, experimentation, collaboration with allies, industry, science and academia. This strategy will evolve and be adapted as we learn and gain experience of this technology.

RM Burr AO, DSC, MVO
Lieutenant General
Chief of Army
December 2018

Introduction

"Human-machine teaming….offer a potential revolutionary shift in how ground forces plan, train and fight"[3]

War, by nature, remains an intense human activity and the use of armed force to compel change remains at its heart. The character of war is changing with the adoption of emerging and disruptive technologies.[4] As these technologies become more available and affordable, the gap between well-equipped militaries and the motivated individual or group with a cause is closing.[5] Therefore, sustaining and maintaining a technological edge over potential adversaries is becoming more challenging. An area where we can maintain an edge is in the large scale integration, synchronisation and coordinated employment of these technologies, coupled with superior training and decision-making.

This can be achieved through robotics and manipulation of data through advanced networks (or system of networks) that can improve the speed and accuracy of information sharing. These networks can connect soldiers to other combatants (both human and machine), the broader Army, the Joint Force and partner nations; improving situational awareness, survivability and lethality. However, adoption of emerging technologies should be considered objectively prior to acquisition to confirm the capability offered by the technology is justified and cost effective. Risk, informed through future casting, modelling, simulation and experimentation, should also be considered to ensure the right technology is adopted at the right time.

[3] Human-Machine Teaming For Future Ground Forces by MAJGEN Mick Ryan, Center for Strategic and Budgetary Assessments, April 2018.

[4] *'artificial intelligence is the future…whoever becomes the leader in this sphere will become the ruler of the world*" Vladimir Putin 01 Sep 17.

[5] *"There is evidence that the world is now in the midst of a 4th Industrial revolution".* Human-Machine Teaming For Future Ground Forces by MAJGEN Mick Ryan, Center for Strategic and Budgetary Assessments, April 2018.

In this context RAS can be viewed as the application of software, artificial intelligence and advanced robotics to perform tasks as directed by humans. Simply *“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”.*[6] The term autonomy can be a barrier to understanding as it is, generally, specific to a system or sub-system. Therefore, it can be misleading to refer to an autonomous platform if the entire system of systems is not autonomous. It can be helpful to consider the level of human input, how much discretion the machine has with regard to the task and what aspect of the system has been automated.

Within this strategy, RAS will span the full spectrum of human input from remote control through to full autonomy – the level of autonomy required will be determined by the role and also the maturity of the underpinning technologies such as AI.

Therefore RAS is a lens through which to describe a system, hardware and software, which has varying elements of autonomy and/or robotics and commonly both.

[6] Paul D Scharre. The Opportunity and Challenge of Autonomous Systems. NATO ACT publication 2017.

Outcomes

Many of the emergent capabilities entering service over the next decade will be impacted by RAS technology. As such, Army should remain cognisant of how RAS technology can be inserted into new and legacy systems and how rapidly the technology will change. Army should also start to experiment with and prototype emerging technology to appreciate the value that it may bring, how it may alter the way we fight and integrate;[7] and most importantly to shape future procurement activity to generate a modern Army for the future Joint operational environment.

There are five fields Army will seek to gain advantage and harness the range of technologies that are expected to emerge in the immediate and intermediate future:

- 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.

[7] *"..how a future land force might fight is as important, and potentially more so, than the new technology employed by its people"* Human-Machine Teaming For Future Ground Forces by MAJGEN Mick Ryan, Center for Strategic and Budgetary Assessments, April 2018.

Maximising Soldier Performance. Army will seek to reduce the physical and cognitive burden on the soldier through the use of smart materials, situational awareness tools, and improving power management (including generation). In the future, machines will accompany the soldier on their mission, offering the opportunity to unburden the soldier of equipment and enhance their performance, through reducing fatigue and increasing endurance. Burden sharing machine technology includes systems such as a load carriage platform and exoskeleton. RAS technologies will also be used to rapidly collect, process, transfer, task and present information in a usable and intuitive way to the soldier. These systems will seamlessly integrate different sources of information and intelligence to alert, communicate, and/or suggest courses of actions to dismounted soldiers or vehicles via robust and configurable user interface. This reduces the cognitive burden on soldiers, improves situational awareness and speeds up decision-making, which in the future congested and contested environment will be vital for success.

Potential capabilities that might be developed in this area include:

Improved load carriage such as 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.

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.

Fused sensors – boosting local area awareness – intuitively presented to the soldier through glasses/visor/head-up display/sights. This could include location of blue force, red force, sensors cueing the soldier to a target or threat with scalable information. The interface being app driven and intuitive to ensure it doesn’t distract.

Individual ‘guardian angel’ UAV to improve survivability and cue protective measures.

"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."[8]

Improving Decision-Making. Advances in AI, big data, cloud computing and the proliferation and miniaturisation of sensors all combine to create a previously unattainable degree of situational understanding across the battlespace. AI enabled decision-making tools have the ability to create greater clarity and can sense and respond faster than humans. This speed, coupled with reliability and accuracy, creating periods of 'decision advantage', will enable commanders at all levels to make faster, better decisions underpinned by comprehensive analysis. The ability to understand and act more quickly provides a competitive edge over an adversary, even if there is incomplete information. As these AI driven tools improve, decision-making could be decentralised which would stop growth in the size of HQ[9] ensuring they remain agile and more mobile, and thus more survivable.

The networking and integration of a Joint Force generates huge volumes of data that will require analysis, processing and dissemination across the Force and Allied networks. This is a complicated endeavour that will require a suite of highly capable and resilient networks that can share appropriate and timely information, and AI systems that can interpret the mass of data. These networks must be able to operate in a highly contested, jammed, denied and electromagnetically rich environment. As such robust and adaptive communication solutions underpinned by a highly developed sense of mission command is required. Autonomous platforms that can make sensible and trustworthy decisions in the absence of the network could be used to perform this function. However, although use of autonomous systems is expected to reduce the demand on the network, in the short term they are likely to increase demand and the need for greater resilience of networks.

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[8] Human-Machine Teaming For Future Ground Forces by MAJGEN Mick Ryan, Center for Strategic and Budgetary Assessments, April 2018.

[9] UK DCDC, Joint Concept Note 1/18. Human-Machine Teaming.

Potential capabilities that might be developed in this area include:

Fused picture/common operating picture (COP) through increased feeds from multiple sources including facial recognition, gait analysis, biometrics and Joint sources.

This will reinforce and support decision-making recommendations or confirmations through the big data analytics, AI and visualisation tools especially in Fires/Log/GIS and Med Int. This in turn will improve targeting and increase the speed of decision cycle.

Survivability could be improved through distributed HQ and decision-making – 'virtual' HQ and use of avatars drawing on cloud based information. Reducing incidents of mistakes in targeting and more moral algorithms.

Development of micro-networks within wider networks – reducing signature and demand on bandwidth.

"The use of human-robot teams during operations offers a solution to an enduring challenge for ground forces – the building of mass."[10]

Generating Mass and Scalable Effects.

Noting Army's relatively modest size, teaming humans with RAS machines can significantly increase combat effect and mass without the need to grow the human workforce.[11] RAS systems can improve firepower, force protection, and manoeuvre, enable sustained missions and identify threats and targets on the battlefield. RAS systems can also provide defences against inbound missiles and aircraft, and provide intelligence surveillance reconnaissance (ISR) and electronic warfare capabilities (e.g. act as a decoy, deceive and provide sequenced and persistent ISR). They can also be used in RAS teams and sub-teams to swarm a target, delivering different payloads and effects, providing scalable and flexible options to the commander. Human-machine teams, therefore, allow greater dispersion, reach and effect on the battlefield, across all

[10] Human-Machine Teaming For Future Ground Forces by MAJGEN Mick Ryan, Center for Strategic and Budgetary Assessments, April 2018.
[11] Acknowledging that increased numbers of systems will increase, at least initially, the demand on sustainment, maintenance, C2 architecture and bandwidth.

corps and at all levels. For example, Combat Service Support (CSS), un-crewed and autonomous platforms could deliver combat supplies through self-cueing resupply and automated platform delivery. As such, Force Design needs to consider the impact of human-machine teaming on the future battlefield.

Swarming offers an additional opportunity and warrants particular mention. Heterogeneous swarming could allow for the pursuit of alternative methods of effects delivery on the battlefield. Individual swarm members should be able to perform autonomously or as part of a team; integrating with other swarms and segment into sub-swarms, providing scalable and flexible effects. This teaming will enable greater dispersion, reach and effect on the battlefield of the future.

Potential capabilities that might be developed in this area include:

Human-Machine teaming to create wingman or team slaved to crewed platform in both the ground and air domain (remote control operator initially with autonomy later – possibly avatar), scalable to grow radius of effect of the team increasing the mass and endurance on task over the current combat organisations.

Swarming offers significant opportunity and may, in time, replace indirect fire and allow scalable 'fires' effects to be delivered in a different way, 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.

The multispectral aspects are particularly appealing – the ability to generate EW, create radar cross section and spoof opponents in particular and the proliferation of UxV allow a degree of persistence that is currently unattainable. Combining these capabilities into a swarm would enable the systems to identify and track a target, confuse its defences and strike with variable effect based on mission context.

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.

Protecting the Force. With a proliferation of uninhabited platforms, improved sensors and AI the future battlespace will require the ability to operate at range, in a dispersed manner and in CBR (N) contaminated environments. This will be achieved by using RAS technology to conduct highly dangerous activities; removing the human from the immediate danger and hence increasing force protection.[12] The use of automated ISR systems to provide over-watch can also enhance force protection by neutralising threats before they manifest. As such, these systems will enable Army to conduct 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 – such as driving.

Within protecting the force, Army must understand and consider countering the threat of adversarial RAS systems. These are expected to rise in prominence as technology matures and as threat actors capitalise on the dual use nature of much of this technology. Furthermore, any perceived weakness of Army's technology or limitations on use may be exploited by potential adversaries.

[12] May include obstacle breaching, obstacle crossing, choke point clearance, IEDD, EOD disposal, battlefield clearance, CBR detection, CBR decontamination, search, route proving, and route clearing.

Potential capabilities that might be developed in this area include:

A number of programs that are already underway in the EOD and C-IED fields. Having identified the highly dangerous environment that these tasks are undertaken.

Breaching and obstacle crossing should maximise the opportunities to create remote control and/or autonomous technology. This allows the removal of soldiers from a highly dangerous task.

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 whilst on other tasks or resting.

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

Efficiency. RAS affords the opportunity to 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."*[13] RAS capabilities, particularly if enabled by AI, can create efficiencies in a number of Army processes, including:

- logistics – rationalise stockholdings, improve ordering, speed up delivery, and deliver 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 the advanced medical facility to receive the casualty, and
- maintenance – advanced health and usage monitoring systems (HUMS) to enable timely and accurate fault diagnosis, drive down the length of time that platforms

[13] UK DCDC, Joint Concept Note 1/18. Human-Machine Teaming.

are out of action for maintenance, and repair and inform risk taking with platform performance.

Emerging transport technologies, such as fully autonomous delivery, offer the opportunity to fundamentally redesign future platforms to enable autonomous replenishment from uninhabited systems. 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. RAS systems could also ensure stocks can be dispersed and protected through a network of delivery and ‘virtual’ warehouse design. This would afford greater agility, reduction of logistics footprint and signatures to be managed.

Potential capabilities that might be developed in this area include:

AI enabled 'Aware Logistics' – this is a situation where a rich logistics operating picture enables directed logistic support accuracy, reducing demand and stockpiling. In this construct immediate replenishment of the fighting echelon is completed autonomously with limited human direction. Enabled by AI and enabling capability to be restocked with combat supplies through improved design (such as UGV/UAV to platform replenishment).

This will be reinforced by alternative distribution means (cued, un-inhabited or crewed, air and ground depending on situation) including over the shore support.

Untethered trailers, leader-follower convoys, will enable greater reach and lift capability of bulk.

Power and Energy is a key enabler in this area and the provision of alternative power means and energy banks will grow endurance in the deployed force.

Stockpiling and warehousing could be more distributed, improving survivability, with AI enabled tools and alternative delivery means. A 'virtual' warehouse (potentially uninhabited) consisting of multiple stock locations interconnected by rapid UxV.

HUMS will enable directed maintenance, enabling surging of maintenance assets at appropriate times, informed by AI to understand risk of platform failure.

In the medical domain, smart clothing and personnel monitoring cueing medical intervention, including casualty collection, preparing the advanced medical facility to receive the casualty. Casevac could be through crewed or un-crewed means, with on-board medical capability and without.

Enabling Technologies

The realisation of RAS relies on a number of supporting factors and technologies that will enable RAS to have the endurance and robustness that engenders trust from the user, wider Defence, and Government. Users must be able to trust that RAS capabilities will function as intended, not behave unexpectedly, can operate in contested and congested environments, and can operate when there is limited network availability. This includes the ability to continue to operate or shut down at times where there is no network and where a human has no back up controls. This will require RAS capabilities that are flexible and adaptable to changes in the communication environment (whether degraded or denied), and a wide range of platforms that can connect to the network. These systems will, therefore, require an open and extensible communications architecture.

Another factor that will influence the size of a RAS capability and how it will be used is the provision of power including for propulsion, which in turn is reliant on power density, endurance of batteries and alternative fuel sources. For example, a small ISR robot should run near silent with long endurance whereas a larger fire support platform or 'trusted wingman' RAS may use a hybrid solution. In the future, the demand for power will increase significantly and future platforms must be enabled to provide power to the multitude of deployed systems. Army's nascent Power & Energy Strategy seeks to explore this technology further; on the soldier, for infrastructure and for platform propulsion.

AI is key to underpinning the realisation of true autonomy of RAS. Without it, RAS will reach autonomous limits quickly; remaining remote controlled and automatic at best. AI tools are also key to the decision support space, with machines able to rapidly analyse huge volumes of data, see patterns and make observations and recommendations.

Fundamental Inputs to Capability will also need to be reviewed as more autonomous systems are introduced. For instance, the proliferation of autonomous systems will prompt a review of how these systems are supported within the current equipment support arrangements and 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, and require a larger portion of the workforce to be skilled in Science, Technology, Engineering and Mathematics.

Realisation

"understanding the best use of autonomous systems will ultimately be what separates militaries that capitalize [sic] on the advantage of autonomous systems from those that do not"[14]

In order to leverage the opportunity that RAS technology brings, coordination through multiple lines of effort (LOE) will be undertaken to organise Army's RAS efforts. The LOE represent the focus areas that together will enable the realisation of the RAS potential to Army (see Figure 1).

Research	Research into autonomy, network resilience, IIP Program S&T plans, common architecture, Academia, Master Question List, ARDR
Experiment & Prototype	AID propositions, Future Soldier Lab, Autonomous Warrior 18, Land Autonomous Warrior, FLW Experimentation campaign
Collaboration	Coalition Assured Autonomous Resupply, collaborative programs (such as TORVICE), Allied Programs (such as Last Mile Delivery)
Influence	TAS-DCRC, AID Process, Defence Innovation Hub, DSTG, JOAD, Joint Force Design, Force Structure Reviews, Defence White Papers
Force Design	Force Design Experimentation, Prototype Force structures, Modelling & Simulation, Land Warfare Lab, Joint Land Force CONOP, CONEMP, Workforce Plans
Education	Tech Podcast, AARC, COMADC, trade schools, Army Knowledge Group, Social Media
Policy/ Law	Strategic Policy Branch, WHS, CDLE, DFAT

Figure 1. RAS Implementation Lines of Effort & Current Stakeholder Activity

Many RAS technologies are relatively new and still evolving. Army will, therefore, need to invest in virtual and in the field

[14] Paul D Scharre, The Opportunities and Challenges of Autonomous Systems paper within "Autonomous Systems, Issues for Policymakers" HQ SACT, NATO 2017.

experimentation, supported with simulation and modelling, to identify and pursue promising technologies that offer the best capability edge. This will include developing tools, methods and technologies capable of countering the emerging RAS enabled threats, and potentially technologies that will not be useful in highly contested environment but may be suitable in other types of operations, such as Humanitarian Assistance and Disaster Relief (HADR).

As Industry is likely to lead the development of many of these technologies, Army will remain alert to such developments, both as RAS threats and opportunities, through partnering with the scientific, industrial and academic communities. Army will also take the opportunity to collaborate with Allies and other areas of Defence to minimise duplication of effort, through existing projects and others as they emerge.

The adoption of many of these technologies will be evolutionary as they begin to be embedded into force design, new concepts of employment, TTP and trust is developed with the user. To support the incremental growth in the RAS arena, platforms currently being developed should be shaped/designed to allow the future incorporation of RAS technologies. In addition, procurement decisions should remain cognisant, and due consideration should be given to the opportunity to insert RAS technology in the future.

Initially, the emerging technology is likely to enhance performance and capability options available to the Army through *automatic* and *autonomic* control before full *autonomy* will be available. As the degree of autonomy is scalable and flexible, and given the range of tasks and environment that Army operates in, it is likely that full autonomy may not always be the optimal solution. This will require further research and modelling to better understand the level of appropriate autonomy for each platform.

In the short term, due to a lack of maturity, the acquisition of RAS technologies will augment the current Land capability suite. They will follow a path of *enhancing* current force structures through technology insertion – *augmenting* the objective force – through to *replacing* whole equipment types as they reach life of type and the technology gains in capability and trust (shown illustratively at Figure 2).

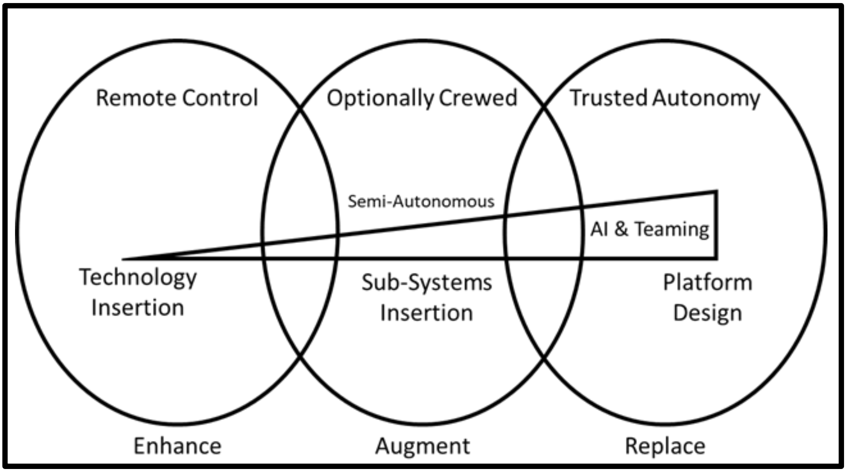


Figure 2. RAS Realisation

Implementation Roadmap

A comprehensive implementation plan will now need to be developed in support of this strategy. Implementation in the short term is likely to focus on pursuing the research effort in RAS capabilities. For example, optional crewing is being investigated, which offers much promise and identified 'game changing' options. Furthermore, opportunities to continue to collaborate with Allied programs, industry and academia will inform the future Army structures and identify the capability set required by Army.

In this phase insertion of emerging RAS technology will be on an opportunity basis to enhance Army's capability, including informing the use case and the Joint Capability Needs Statements (JCNS). Intelligent prototyping and experimentation is crucial in this phase to inform the future procurement strategy. Force design implications of the rollout of RAS technology must 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.

In the medium term, some aspects of RAS and AI are expected to mature to a suitable TRL for deployment. In this regard it is anticipated that Army will be augmented by RAS systems or sub-systems for specified purposes or effect; incorporating heterogeneous machines working together, with humans, to create scalable and flexible capability. At this stage it is anticipated that policies, TTP and CONEMP of key platforms and systems will be adjusted to take account of an increased level of autonomy with 'optionally crewed' being available. Improvements should also be realised in the CSS sphere, coupled with improvements in power provision; this provides the opportunity to redesign the support provided to deployed forces. This will also impact on the strategic base in policy and practice terms and could have Defence-wide impact. The insertion of RAS technology can also be planned to coincide with planned upgrade points in the capability life cycle.

In the longer term, it is expected that equipment will be replaced by capabilities designed for their specific purpose as opposed to being configured predominantly to protect a human. Army will see autonomous platforms replacing the crewed platforms in a number of roles. As AI technology grows in capability the ability to orientate and act will have significantly accelerated and AI will feature in many decisions taken, although it is expected that the human will remain at the heart of decision-making. At this stage trust and AI maturity will be sufficient that crewed and uninhabited teams will be formed with autonomous team-mates routinely.

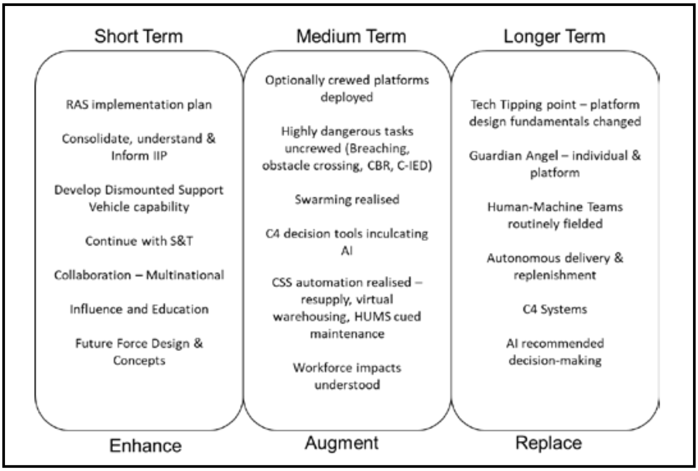


Figure 3. Army RAS Goals

Governance of RAS Acquisition

In the short-term governance will focus on close coordination to signpost and guide the Defence Capability Life Cycle (CLC) to include the potential for RAS in their acquisition deliberations. There will be a need to bring the Army and Joint efforts in this space together to identify technology goals. This may require the creation of a coordinating role to bring coherence to Army's involvement in innovation activities such as Army Innovation Days (AID), Chief of Army's Land Forces Seminar (CALFS), the Trusted Autonomous Systems Defence Cooperative Research Council (TAS-DCRC) and the Defence Innovation Hub; with a budget to invest in promising technology.

DGFLW will co-ordinate and de-conflict Army's efforts in the RAS space and convene a RAS Stakeholder Transdisciplinary Team, incorporating the key stakeholders.[15] RAS will become an agenda item at Land Capability Steering Group (LCSG) (as required) and direction and guidance can then flow across Army or issues can be taken to Chief of Army's Strategic Advisory Committee (CASAC) or Joint Warfare Council (JWC) as appropriate.

[15] Including Defence Programs, FORCOMD, SOCOMD, 1Div, RAAF, RAN, ADF HQ, JCG, DSTG, CIOG.

Ethics, Morals and Legal Aspects

Army will remain cognisant of the ethical, moral and legal issues around the use of RAS technologies as this strategy evolves and is implemented. There are many moral challenges that Army will need to address, including legal and ethical issues around the use of autonomous weapon systems and the application of force. These issues primarily revolve around where the human features in the decision cycle "*human in the loop*", "*human on the loop*" or "*human off the loop*". 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.

Article 36 reviews are an important component in ensuring compliance with international humanitarian law on the battlefield. Army will also monitor the ongoing United Nations (UN) discussions on Lethal Autonomous Weapons (LAWS) (noting that the definition is not agreed). Strategic Policy (SP) Division (Counter-Proliferation and Arms Control section) remain the policy lead and are starting to address these 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 there are far fewer humans involved in the fight. This strategy does not seek to address these issues. 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 moral 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;

some of these will require a higher classification than this Strategy will allow and will be developed in detail in the implementation plan.

Australian Industry and Academia

"A "sovereign capability" approach for each nation could provide a more secure approach to developing key technologies…."[16]

There is clear potential for an Australian RAS related technology industry, with a majority of universities already having robotic, AI or autonomy research departments. Army will, therefore, engage collaboratively with both industry and academia to understand, develop, and optimise these technologies for Army use. Army will leverage a number of extant Army and academic relationships, and foster new opportunities for cooperation. This strategy acknowledges the Australian Robotics Roadmap newly published on 18 June 2018.

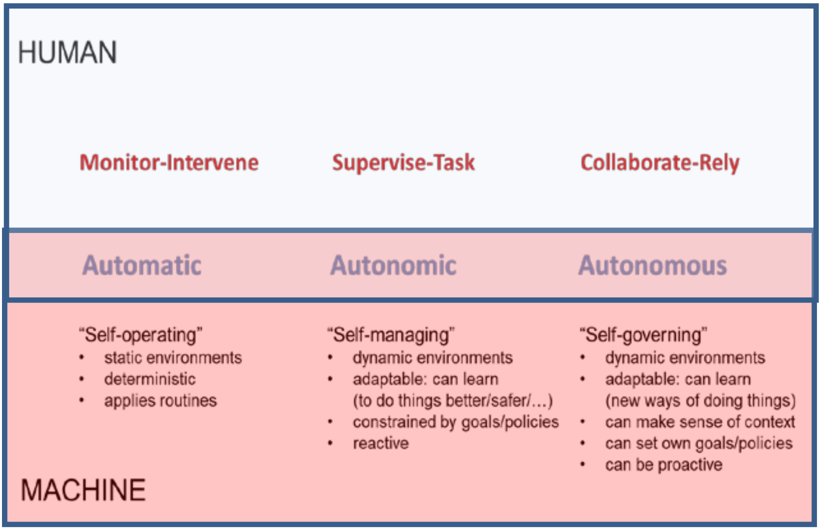
As responsibility for the behaviour of Army RAS technology remains with the Commonwealth, it is a critical requirement that Army has trust and confidence in the systems that they are fielding, particularly those which incorporate AI. The need to understand the design parameters of AI technology and algorithms embedded in the fielded capability may require Australian derived 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"*.[17]

[16] Human-Machine Teaming For Future Ground Forces by MAJGEN Mick Ryan, Center for Strategic and Budgetary Assessments, April 2018.
[17] UK DCDC, Joint Concept Note 1/18. Human-Machine Teaming.

Conclusion

RAS offers significant potential and will fundamentally alter the way the Army trains, prepares for, equips and ultimately fights in the future. The key to seizing this opportunity will be agility and open-mindedness, coupled with a forward looking force design that leverages the technology and provides direction for academia and industry. Procurement processes informed by virtual and in the field experimentation and prototyping will be essential to keep step with the accelerating rate of change of technology. Army must take the time now to understand and decide how it wishes to use the technology and then pursue its acquisition rapidly, as the technology matures.

Definitions Used in this Strategy



Abbreviations

AARC	Australian Army Research Centre
AI	Artificial Intelligence
AFA	Academic Focus Areas
AID	Army Innovation Day
AR	Augmented Reality
ARDR	Army Research and Development Requirements
AT	Anti-Tank
BMA	Brigade maintenance area
CASAC	Chief of Army's Strategic Advisory Committee
CBR(N)	Chemical, Biological, Radiological, (Nuclear)
CDLE	Centre for Defence Leadership and Ethics
C-IED	Counter Improvised Explosive Devices
COP	Common Operating Picture
CSS	Combat Service Support
CSups	Combat Supplies (Class 1,3,5)
CONEMP	Concept of Employment
DCAP	Defence Capability Acquisition Program
DFAT	Department of Foreign Affairs and Trade
DGFLW	Director General Future Land Warfare

DISC	Dismounted Infantry Support Capability
DPG	Defence Planning Guidelines
DSTG	Defence Science and Technology Group
DSV	Dismounted Support Vehicle
EMS	Electro-magnetic Spectrum
EOD	Explosive Ordnance Disposal
FORCOMD	Forces Command
FUP	Forming up Point
GIS	Geographic Information Systems
G&O	Gaps and Opportunities
HUD	Head Up Display
HUMS	Health and Usage Monitoring
IED	Improvised Explosive Device
IHL	International Humanitarian Law
IIP	Integrated Investment Plan
Int	Intelligence
ISR	Intelligence, Surveillance, Reconnaissance
JCNS	Joint Capability Needs Statement
JOAD	Joint Operational Analysis Division
JWC	Joint Warfare Council
LAWS	Lethal Autonomous Weapon Systems
LCMP	Land Capability Modernisation Plan

LCSG	Land Capability Steering Group
LFD	Land Force Design
LOE	Line of Effort
LOT	Life of Type
Log	Logistics
Med	Medical
NGTF	Next Generation Technology Fund
OS	Offensive Support (Fires)
PL	Platoon
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RAS	Robotic & Autonomous Systems
SOF	Special Operations Forces
SP	Strategic Policy
TAS-DCRC	Trusted Autonomous Systems – Defence Cooperative Research Council
TRL	Technology Readiness Level
TTP	Tactics, Techniques and Procedures
UAV	Uninhabited Aerial Vehicle
UGV	Uninhabited Ground Vehicle
UxV	Uninhabited X Vehicle (nonspecific domain)
VR	Virtual Reality
WHS	Workplace Health and Safety