Challenge and opportunity: robotics and autonomy as part of future land warfare

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The use of advanced and networked technologies on the battlefield is increasing and future warfighting is expected to focus on human-machine teams both in the physical and virtual sense. Army is examining how robotic and autonomous systems can be ethically exploited, leveraging emerging robotic and autonomous systems to gain asymmetric advantage. This paper explores both the opportunities and the challenges.

Key words: artificial intelligence; autonomy; digital systems; ethics; human-machine teams; networked technologies; robotics; robotic and autonomous systems.

"… understanding the best use of autonomous systems will ultimately be what separates militaries that capitalize on the advantage of autonomous systems from those that do not …" (Scharre 2017)

We live in a world of rapid and accelerating change. These words have become so commonplace that it is easy to forget how true they are – from politics, to social attitudes, to potential shifts in the geopolitical order and to technology. Consider this: the telephone took 75 years to reach 50 million users; the radio, 38 years; TV, 13 years; the internet, four years; Facebook, three and a half years; and Angry Birds, only 35 days! While the development and use of technology are accelerating at an unprecedented rate, technology should be viewed through the lens of Amara's Law, which asserts that: *"We tend to overestimate the effect of technology in the short run and underestimate the effect in the long run"* (Ratcliffe 2016).

With this in mind, Army has started the journey towards the ethical use of robotics and autonomous systems in the future. We anticipate that this will raise challenging operational, strategic and policy issues, the full scope of which cannot yet be seen.

This paper discusses some of the things Army is doing to realise the possibilities around robotics and autonomous systems. Potentially, a disruptive set of technologies, they will be a key component of the competitive advantage that Army will need to generate in the future land-forces operating environment. The paper will cover the key advantages Army sees in our development of robotics, artificial intelligence and autonomous systems, some of the challenges, and how we will seek to realise our goals.

Potential Opportunities of Robotics and Autonomous Systems

Advanced digital systems, robotics and autonomy are already with us. For example, if in the United States, a customer orders a product on Amazon, the product can arrive at the customer's door within hours[2]. While Australia has not yet reached this speed of service, one can shop online and expect to receive a product on the same day[3]. Underpinning this is a digital profile that knows the customer, their preferences, and where they like to send products. Algorithms – predictive behaviour analysis software – increasingly called artificial intelligence, mines data about us, refines them and then mixes them to predict and influence all aspects of our digital presence. Artificial intelligence, combined with robotics and automation, pervades our everyday outcomes. This is exciting, challenging and full of opportunity, which means it is an opportunity for Army too.

But we recognise that our mission is very different to that of the commercial sector. That means that as Army considers its use of autonomous systems and robotics, we have to think about the problem differently from our colleagues in the private sector. We have to be at once more creative, and more careful. It is not so much that Army is slow in this field. We are not. We are instead purposeful in reflecting on for what uses we will want automation and robotics. In our line of work, the "so-what?" is the key question for any discussion of strategic or operational advantage when new technologies are in reach. For that reason, Army is developing a strategy for how Army will integrate the emerging capabilities of robotics and autonomy.

We will use a strategy to guide us because our Defence Force sees the potential opportunity these systems offer, and the change they can bring about. To paraphrase David Kilcullen at the Land Warfare Conference at the Royal United Services Institute London in June 2018, "… *the ability for small squads to apply vertical systems, rivals, in importance, the introduction of the light machine-gun into the squad 100 years ago. In terms of reach and envelope, small- and medium-size drones significantly transform what they can do* …"

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[2]https://www.amazon.com/Prime-FREE-Same-Day-Delivery/b?ie=UTF8&node=8729023011

[3]https://www.finder.com.au/same-day-delivery-melbourne

(Kilcullen 2018). Army's nascent robotic and autonomous systems strategy outlines benefits for Army in the future.

Load reduction

Firstly, every soldier knows what it is to carry a pack. Today, the kit and the weight carried by soldiers, especially the infantry, has increased significantly as greater technology has been pushed forward. The range of equipment, including body armour, helmets, radios, batteries and electronic counter-measures, on top of water, ammunition and food, continues to grow. This increasing burden risks undermining the performance of soldiers, reducing their effectiveness on task, increasing their exposure to risk and reducing their endurance. We would seek to halt this and reduce the physical load on the soldier. Advances in systems such as exoskeletons and autonomous ground vehicles (mules) may help us do this.

Coupled with the physical demands of soldiering is the large mental load imposed by maintaining situational awareness – mentally fusing the feeds such as threat, navigation, timings, terrain, and mission. Each one of these is a complex information thread that can change rapidly and without warning. This is "cognitive load" (and at times, overload); the burden placed on a human when they are required to think through multiple challenges simultaneously.

In Army, we like to think that we are good at managing this load because we think in terms of teams and sharing the load. We think better as a group than we do on our own. Autonomous systems have the ability to be part of the team by taking the load off in the cognitive space. Fusing together multiple information feeds, creating a rich shared picture conveyed directly to each soldier, can help soldiers, teams and units gain enhanced understanding of their environment and focus on what requires human judgement.

For example, if a patrol comes into contact with the enemy, a machine could give timings, distances, direction of threat and enemy numbers. Beyond that, automated systems could actually conduct our team's resupply, allowing soldiers to depart on task with a reduced physical load. Autonomous ammunition resupply of tactical units, through integrated data-feeds, is not beyond our reach. If a printer can order resupplies before they run out, then, surely, we can do the same for our combat supplies *e.g.* ammunition ordered direct from the weapon system delivered by unmanned platforms at the right time.

Decision-making

Secondly, automated systems, robotics and artificial intelligence could speed up decision-making in headquarters. Headquarters are loaded with complexity – bureaucratic, political, social and tactical. Converging them effectively is an art – indeed, the "art of war" – and it is an art machines probably cannot master. But we can master how to get machines take some of the cognitive load off a headquarters. Certainly, we can get machines to undertake the routine, predictable or backroom-type tasks. The quantity of remote sensor feeds into an operational headquarters will need rapid mass-fusion into a high-quality common operating picture – real-time information with 'low latency'. That means better decision-making opportunities, more often and with greater support. Our real challenge here may not be the autonomy or artificial intelligence. It might be allowing the war-fighter on the ground to continue to do his or her job without second-guessing their judgement in the field.

Additionally, through automated and artificial intelligence-enhanced networks we can develop the ability to distribute headquarters physically (*i.e.* disperse its elements across the terrain). This will reduce the profile and signature of the headquarters. At the moment, our headquarters are vulnerable given their increased physical and electronic signature, making them targets for electronic or kinetic attack. A distributed design could reduce this risk.

Human and machine teaming presents some of the greatest opportunities for headquarters and the complex decision-making environments they embody. The vision here is of a "Centaur" concept, where humans partner with machines to produce a better outcome than just a human or a machine on their own[4]. Operational and strategic headquarters have the potential to explore human-machine teaming like this, to develop the best relationship between human empathy and judgement, and aggregation of data; combining the best of the art and science of war. These concepts and their development are already well-advanced in the civilian world. Army believes we will be best positioned if we explore these developments early, and seriously consider how we might integrate them into our future. We are simply talking about putting machines to use – artificial intelligence, robotics, and software-based automation – directed by skilful, intelligent humans to serve clearly-identified operational ends.

Mass generation

Thirdly, for a modestly-sized force such as the Australian Army, the opportunity to generate greater mass is very appealing. Mass can allow a commander greater reach, influence and effect on the battlefield. Potentially, teaming crewed platforms with autonomous systems could improve the ability for Army to sense and strike at greater range with greater lethality. Along the way, the opportunity to 'optionally' crew platforms may allow us to conduct operations in a different way, helping us reimagine our concepts for the employment of platforms. We consider we may be able to 'dial up' and 'dial down' the autonomy levels in a platform depending on the mission and the risk profile with which we are presented.

Flexibility like this holds strong promise, enabling us to think through the governance and ethical constraints that will inevitably accompany our use of force in a world where human-machine teaming may become the new operational norm. Army considers many of these opportunities to be potential 'game-changers', provided we approach them with a circumspect eye, and the ongoing commitment to the rule of law under which we deploy. Army considers that our opportunities in this field are likely to outweigh the risk. Indeed, on balance, the risk

[4]https://www.huffingtonpost.com/mike-cassidy/centaur-chess-shows-power_b_6383606.html

becomes greater to Army if we do not actively pursue these technologies given their considerably advanced state in the commercial sector and their likely development by potential adversaries.

Dull, dirty and dangerous tasks

Fourth, we have long understood that robotics and autonomous systems can remove soldiers from the dull, dirty and dangerous (Toohey 2017). Army sees a more sophisticated future where autonomous systems will be forward-deployed, undertaking the most highly dangerous tasks such as: countering improved explosive devices; obstacle breaching; minefield clearance; post-operational clearance of battlefields; and detecting chemical, biological and radiological sites, and decontaminating them. We already have experience in such activities and are seeking to develop our capabilities in this domain further.

Counter-swarming, air-defence, active protection measures can all be activated by a cue (*i.e.* 'cued') sent by autonomous sensors. These are all on our list as we explore how to use modern systems to serve the soldier and bring our soldiers home safely, faster and more often.

Each of these reflect the best tradition of Australian soldiering, such as Sir John Monash's success at the Battle of Hamel in 1918. Monash's success came not so much from the use of new and revolutionary technology, rather it was the innovative way that the effects of combined arms were synchronised that underpinned success. We believe the use and synchronisation of robotics and automation has similarly transformative potential for future battles. We believe robotics and autonomous systems offer us possibilities to enhance soldier safety and Army will step into this robotics future just as we have done for similar things in our past – with wisdom, responsibility, speed, and an eye to bringing our troops home.

Combat service support

Finally, combat service support will probably be the first area enhanced by automated systems. For supply-chains, autonomy will allow us to reimagine some foundational concepts of support to land warfare. Instead of supply-chains being long, vulnerable lines stretching out along miles of open ground or water; we envisage multiple distributed support systems that match logistical needs to operations, tracking the changing pace and intensity in real-time. Support echelons, whose core components are dispersed and fused remotely, at constantly changing locations, will be employed to reduce an enemy's ability to target our logistical heartbeat. Technology worn by soldiers will be designed to detect health issues such as biological changes, to foster preventative medicine, and to reduce diagnostic time. It will trigger medical interventions in a more directed and responsive way.

As already shown, the delivery of supplies in everything from food and ammunition to clothing can be triggered by an automatic cue from the user system ('smart cueing' in the jargon). Another potential example is automated casualty evacuation, with combat casualty-evacuation packs delivered on cue by unmanned aerial vehicles, responded to and replenished in-theatre, automatically. This is the military "internet of things" starting to move within the battlespace to enhance Australia's operational advantage, although it is worth acknowledging the challenges of networking and connectivity.

Challenges of Robotics and Autonomous Systems

These sorts of things are not as far away as we think. Building the systems to get us there must be part of Army's imagination, but it is not without its challenges. Not just the standard bureaucratic ones; there are much harder ones that will require precise judgement from Army operators on where and how to bring this technology into service.

This includes choosing when to select a quickly developing technology so as to capture it at the right time in its apex, in order to bring it quickly to the right 'technical level of readiness' for employment by soldiers. It also involves combining the enthusiasm of our young soldiers – part of a generation of 'digital natives' who will best identify the opportunities this new technology will provide – with pragmatism. We will need good judgement to identify which are truly revolutionary in this field, and which are simply evolutions. We will see automated systems impacting on the battlespace – automated resupply, for example, might remove people from the current logistics equation. But these people will be deployed elsewhere. Automated resupply will not necessarily revolutionise the battlespace, it may just make it faster and more accurate, reducing stockpiling and improving agility.

We, therefore, need to be on the lookout for the genuine technological upheavals, and become a culture practised in innovation so we can speedily introduce the technological upheavals into our force design and our operational art. Technologies such as quantum cryptography and computing are but two examples. But, at the very top of this list, is human imagination, since this is where the true 'game-changers' lie as we learn to employ emergent technologies better than our opponents. When we see technologies that we believe we can and should use now, we will need to be bold and skilful enough to present our case rapidly, so quickly-emerging technologies can make us more competitive on the battlefield. Certainly, we must do this to seek to procure an advantage against potential adversaries, whom we know will also equip themselves with emergent technologies and deploy them skilfully.

Naturally, money will matter. We will not buy what we cannot afford, so we should not simply argue we need more kit; we should challenge ourselves to innovate more effectively. As Winston Churchill is reputed to have said to the British war cabinet: "Gentlemen, we have run out of money, now we must think". Creativity with concepts, and clarity with finance, must be our mantra. How wisely we use our money to turn robotics into part of Army's story will be core to our success.

Crucially, we will need to think about the impact of robotics and automation on the human workforce. Far from extinction, we believe this technology could transform the workforce positively. We may need to consider different

pay structures to capture the right people at the right rank-levels, matching pay to expertise and not just rank. An expert operator could be a highly-paid Corporal, for example, whose specialist pay reflects their ability to effectively employ or sustain an autonomous system. But they will remain different to, and differently compensated from, a commander whose military judgement and leadership skills are trained over years and instilled through lessons on operations. Both should be rewarded fairly.

The Way Ahead

Having explored the opportunities and challenges, how will Army pursue these goals? It will pursue its path to robotics and automated systems in clear, complementary and often overlapping ways.

Firstly, we will continue with our research and partnerships with industry, academia and through ongoing work with the Defence Science and Technology Group.

Next, collaboration. We are already working with the United States and the United Kingdom on a number of projects designed to sustain control over remote platforms at range in a contested environment. To this end, we are testing the ability of autonomous trucks and unmanned aerial vehicles to resupply troops anywhere, including the vital tactical last mile in contested environments[5]. We would wish to see Australian vehicles and unmanned aerial vehicles tested here too.

Funding, force-design and education are the next three pathways to generate the future of our robotics and autonomous systems . Defence has already provided pathways for Army to access this future via the $730 million Next Generation Technologies Fund, and the Defence Innovation Hub. Some of the Next Generation Fund has been allocated to the newly established Trusted Autonomous Systems Defence Co-operative Research Centre. Creating the "future Defence force after next" is this Fund's motto. Finally, education is key to where we have to go, since we need to be thinking about the use and application of robotics and automated systems in well-informed ways, across Defence, from the ground up. We seek to both inform our workforce on technology and to sharpen our own minds as we learn from and inform others where we are going in its development.

Conclusion

In conclusion, the opportunities in this field outweigh the challenges for Army by a considerable margin. Our pathways to this future are already in front us. In some cases, we are well-travelled down them. Our rate of technological change is exceeding the growth predicted by Gordon Moore, founder of the computer-chip maker "Intel". He famously stated in 1965 that the number of transistors in a microchip would double every two years, a prediction that became known as Moore's Law. The rate of current technological change, by Moore's own more recent admission, is going to exceed Moore's Law by 2025[6]. Many speculate this moment has already come and this has become the new norm.

Army has a duty to reflect on its technology differently to the way it is done in nearly all other walks of life. Our vocation in this matter is unique, because our range of missions is different. Our mission involves the use of force in ways government alone can authorise. Army is therefore determined to harness this new technology of robotics and automation thoughtfully, and turn it into a capability responsibly and ethically.

Army will do this with speed, and we will work to develop our digital reflexes competently. We will train with our developing automated systems and robotics in tactical and operational environments with our partners, friends and allies.

We stand in the foothills of a very exciting time of technology's development, and we *will* capture its momentum to our key advantage.

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