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ROBOTIC ENHANCEMENTS TO INFANTRY CAPABILITIES

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JCSP 45

Service Paper

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PCEMI 45

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Canada

CANADIAN FORCES COLLEGE/COLLÈGE DES FORCES CANADIENNES
JCSP 45/PCEMI 45
15 October 2018/15 octobre 2018

DS545 Component Capabilities/DS545 Capacités des composantes

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Word Count: 2,345

Nombre de mots : 2 345

ROBOTIC ENHANCEMENTS TO INFANTRY CAPABILITIES

AIM

1. The aim of this service paper is to illustrate practical applications of robotic capabilities to the 21st Century infantry soldier. Specifically this paper will discuss what sorts of robotic technology can be worn to improve mobility and load carriage for individual soldiers in order to increase their capabilities to fight on land. It will also highlight potential applications of unmanned ground vehicles (UGV) to enhance combat support and combat service support domains as they pertain to the infantry, and finally it will discuss the potential for robotic enhancements to existing weapon platforms to optimize their use by infantry soldiers.

INTRODUCTION

2. Context. Bearing loads of up to 40-60 kgs of personal protective equipment, communications electronics, weapons, ammunition, section-level mission equipment, and a horrendously wide assortment of typically non-interchangeable batteries, soldiers today are far too heavy.[1] Studies of US forces operating in Iraq and Afghanistan have shown that medical evacuations stemming from musculoskeletal injuries outpaced those caused by combat related injuries by a ratio of 2:1, and remain the primary cause of medical discharge among all US service personnel.[2] This is clearly a problem, but it is hardly a new one. While technology has evolved significantly, the essential functions of contemporary infantry soldiers have not changed dramatically from their forebears. Modern soldiers would have little difficulty recognizing the essential equipment of Assyrian soldiers from 700 BC: "iron scale armour, helmet, iron shinned boots, shield, sword, and spear."[3] Certainly with an average weight of this equipment ranging from 27.5-36.5 kg, there would be a common appreciation of shared hardship in the occupation.[4]

3. Scope. Technological advances in robotics offer potential solutions for the modern army on many fronts, and it is therefore important to bound the scope of this paper. For the purposes of this paper, this discussion is limited to equipment where a soldier is still in full control either through direct or remote operation, or through a programmed sequence of commands. It will examine technology that is currently available, or already in development that reasonably has the potential to come to market within the next decade. It does not venture into the realms of autonomous systems, artificial intelligence, or machine learning, which pose their own unique philosophical and ethical questions beyond the scope of this paper.

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[1] Australian Defence Science and Technology Organisation, *A Review of the Soldier's Equipment Burden,* (Edinburgh, South Australia: Government of Australia, 2011), 1-2.
[2] Jeremy Hsu, "The Weight of War," *Popular Science 285* (November 2014): 62.
[3] Robert Orr, "The history of the soldier's load," *Australian Army Journal* 7, no. 2 (Winter 2010): 68.
[4] Ibid.

DISCUSSION

3. Wearable Robotic Technology. The title *Robotic Enhancements to Infantry Capabilities* evokes images of Mobile Infantry in powered suits. While technology has not yet caught up with the imagination of author Robert Heinlein, there have been significant advances in development. There are three types of wearable robots (hereafter used interchangeably with exoskeleton/exosuit) of primary interest to the modern infantry soldier: full body, lower body, and energy scavenging exoskeletons.[5]

4. A full-body exoskeleton consists of one contiguous wearable robot. These systems are designed to directly address the equipment burden placed on soldiers today by dramatically increasing a soldier's ability to lift heavy objects, carry heavy loads, and provide additional strength to break through obstacles. Starting in 2001, the US Defense Advanced Research Projects Agency (DARPA) began investing in developing an exoskeleton for the military.[6] Over the ensuing decade, several designs were trialed, but only two made it all the way to functional prototypes: Raytheon's XOS2 and Lockheed Martin's Human Universal Load Carrier (HULC). While the designs were hailed with much fanfare in the media around 2010, they were both limited by their size and power consumption. The XOS2, weighing in at 95 kg, actually needed to be powered by a gasoline engine to sustain the system untethered from a power source.[7] While both of these projects have met with success in applications in other fields such as orthopaedic medicine, their unsuitability for military applications led to the withdrawal of DARPA interest in 2010. While full-body suits would greatly decrease the weight borne by infantry soldiers in the field, the technology is not yet sufficiently developed for serious application in a combat role.

5. In order to overcome some of the challenges of powering a full body suit, lower-body powered suits have seen greater investment and development in recent years. Typically a blend of rigid components and soft components, exosuits such as DARPA's Warrior Web program are less fixated on directly relieving the weight load of the infantry soldier, focussing instead on decreasing the metabolic cost to the soldier operating under the load. Several prototypes of this nature are currently being evaluated for military applications by DARPA, though many others are being tested for industrial, recreational, therapeutic, and medical purposes.[8] An interesting subset of lower-body suits are energy-scavenging exoskeletons, which are designed to harvest

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[5] Exoskeleton Report, "19 Military Exoskeletons into 5 Categories," Last accessed 11 October 2018, https://exoskeletonreport.com/2016/07/military-exoskeletons/.
[6] J.F. Jansen, "Phase I Report: DARPA Exoskeleton Program," United States, doi:10.2172/885609, https://www.osti.gov/servlets/purl/885609; and Exoskeleton Report, "19 Military Exoskeletons into 5 Categories," Last accessed 11 October 2018, https://exoskeletonreport.com/2016/07/military-exoskeletons/.
[7] Exoskeleton Report, "19 Military Exoskeletons into 5 Categories," Last accessed 11 October 2018, https://exoskeletonreport.com/2016/07/military-exoskeletons/.
[8] Forbes Media, "First Look at DARPA-Funded Exoskeleton for Super Soldiers," Last accessed 11 October 2018, https://www.forbes.com/sites/bruceupbin/2014/10/29/first-look-at-a-darpa-funded-exoskeleton-for-super-soldiers/#482d570a62a0.

energy used as a by-product of soldier movement.[9] These suits can be used to passively charge batteries while the soldier is on the move, decreasing the overall weight that a soldier must carry on extended missions. These are fast-moving technological fields with multiple stakeholders, applications, and markets. As such, some designs are expected to begin to be fielded within the next few years.

6. One step further in the conceptual applications of wearable robots is the US Special Operations Command (US SOCOM) Tactical Assault Light Operator Suit (TALOS). Rather than simply transfer weight to a lower-body system, TALOS aims to provide maximal protection for select members of special operations teams, such as door breachers.[10] Dubbed the "Iron Man Suit" project, and set to deliver a testable prototype in the summer of 2019; this is another developing technology to watch.[11] Notably, this is a US SOCOM-specific project that is not yet being considered for wide-scale use by conventional infantry units.

7. The three types of wearable robots offer unique advantages for infantry soldiers, but may also lower existing barriers for service in the infantry. It is no secret that the physical demands on infantry soldiers can be arduous, which can be a deterrent for even the most robust men.[12] Arguably, this is even more true for women.[13] As of February 2018, Regular Force (Reg F) infantry soldiers are the least gender-balanced occupation in the Canadian Armed Forces, with a mere 0.7% of all infantrymen being female.[14] This is well below the CAF-wide percentage of 13.8% Reg F non-commissioned members (NCMs) being female, and even well below comparable combat-arms occupations such as crewman (3.1%) and artilleryman (4.9%).[15] Strong, Secure, Engaged emphasizes the importance of achieving a more representative and gender-balanced force across the CAF.[16] A study done by the Israeli Defence Force (IDF) during its most recent ground campaign demonstrated that female operators of their Unmanned Ground Vehicles (UGV) outperformed their male counterparts so decisively that the IDF has re-assigned

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[9] Tandem National Security Innovations, "How Army and Marine Leaders Could Replace Batteries," Last accessed 11 October 2018, http://www.tandemnsi.com/2016/06/how-army-and-marine-leaders-could-replace-batteries/?mc_cid=d83ca179f5&mc_eid=0c3e21b983.

[10] National Defense, "'Iron Man Suit' Prototype Delivered by 2019, SOCOM Officials Vow," Last accessed 11 October 2018, http://www.nationaldefensemagazine.org/articles/2018/5/24/socom-leadership-confident-of-delivering-talos-prototype-by-2019.

[11] Ibid.

[12] Linell A. Letendre, "Women Warriors: Why the Robotics Revolution Changes the Combat Equation." *PRISM* 6, no. 1 (2016): 93-94.

[13] Ibid.

[14] National Defence and the Canadian Armed Forces, "Women in the Canadian Armed Forces," Last updated 7 March 2018, http://www.forces.gc.ca/en/news/article.page?doc=women-in-the-canadian-armed-forces/izkjqzeu.

[15] Ibid.

[16] Canada. Department of National Defence. *Strong, Secure, Engaged: Canada's Defence Policy.* (Ottawa: National Defence, 2017): 23.

all UGV operations to female IDF soldiers.[17] If wearable robotics can level the physical playing field between men and women in the infantry corps, it has the potential to break the current inertia in evolving the infantry's demographics. This could be a critical first step toward closing the gap on gender diversity, and thereby improving operational capability.

8. Unmanned Ground Vehicles. The Soviet Union was the first to attempt developing UGVs in the 1930s. By the Second World War, the British and the Germans had developed remotely controlled armoured vehicles.[18] Though these early attempts were limited by the technology of the day, their genesis as a military instrument illustrates the persistent utility for such a capability. Today, armies around the world have employed UGVs in a wide variety of roles, which can effectively be divided into three general categories: individual robots, medium sized ground combat vehicles, and medium sized logistical support vehicles.

9. While the applications of individual robots and combat vehicles are largely self-evident, the potential applications of medium-sized unmanned logistical support vehicles warrant closer consideration for the infantry. The infantry company is the smallest tactical organisation which can operate independently for up to 72 hours. Within that time, infantry companies must be able to manoeuver with or without vehicles, provide their own intelligence, surveillance, and reconnaissance (ISR), generate organic direct fire support, and conduct combat service support functions such as casualty evacuation and resupply of troops in contact. Consider each of those tasks now supported by a four-legged Boston Dynamics Legged Squad Support System (LS3), or similar UGV capable of traversing adverse terrain at pace with soldiers. Suddenly a Company Quartermaster can push ammunition resupply to multiple platoons at a time. Evacuating a single casualty, typically a task for an entire infantry section can be performed by a remotely operated UGV and a single soldier under cover without pulling combat power off the forward positions.

10. The Canadian infantry soldier is blessed with some of the best weaponry available, and yet is also cursed by the inability to effectively move these systems around the battlespace. The C16 Automatic Grenade Launcher is one such weapon. Remarkably accurate out to 2,200 m, the C16 is capable of delivering sustained direct and indirect fire onto a target. Unfortunately, even as a three-person carry, the basic load for the weapon is only two boxes of 32 rounds due to the size and weight (24.9 kg/box).[19] Such a modest combat load for this magnificent weapon system provides nearly 11 seconds of fire – a pittance considering the potential of the weapon system

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[17] Linell A. Letendre, "Women Warriors: Why the Robotics Revolution Changes the Combat Equation." *PRISM* 6, no. 1 (2016): 99-100.
[18] Liu Xin and Dai Bin, "The Latest Status and Development Trends of Military Unmanned Ground Vehicles," *2013 Chinese Automation Congress,* (November 2013): 533.
[19] Heckler & Koch, "GMG Technical Data," Last accessed 11 October 2018, https://www.heckler-koch.com/en/products/military/40-mm-systems/gmg/gmg/technical-data.html.

and the effort required to employ it. Those same three soldiers with a single LS3 UGV could carry ten times the ammunition, and move around far more efficiently.[20]

11. The application of UGVs for command and control purposes is worth exploring as well. Un-amplified dismounted radio systems suffer from line of sight and power limitations. A UGV could solve that problem for dismounted patrols by functioning as a radio-rebroadcast station, between command posts and dismounted radios. This has the simultaneous benefit of providing a redundant communications system while also allowing soldiers to carry fewer radio batteries on their person.

12. Enhancements to Existing Weapons Platforms. A cursory review of the weapons currently fielded by the Canadian Army demonstrates the premise that as weapons systems increases in technological capability and lethality, they are also typically getting heavier and bulkier.[21] Thermal weapon sights are now standard for dismounted heavy weapon platforms on the modern battlefield, which necessitates a significant supply of batteries to operate at night and/or at optimal range bands. While most research and development today is being invested in semi-autonomous robots which can be armed, there is perhaps a more simple approach that could yield dividends without the ethical and moral deliberations necessarily associated with autonomous weapons.[22] By reversing the concept of arming robots, consideration can be given to enhancing mobility and load carriage of existing weapons in the CAF inventory through robotic solutions. Importantly, this is not an argument to develop autonomous weapons – a Canadian soldier remains in full control of the remotely operated weapon system. Consider the previous example of the C16 automatic grenade launcher; now fully stabilized with an increased ammunition capacity, operated remotely by a single soldier yet capable of fire and movement, all powered by a common source. This is a single example to demonstrate the potential. The same principles could reasonably be applied to anti-armour missile systems, heavy machine guns, and auto-loading mortars. These are high impact weapon system, all with weapons signatures commensurate with their effectiveness that makes them high priority targets for an enemy. Remotely operating these systems therefore provides an increased degree of force protection for the soldiers operating the equipment.

13. Ground-Based Intelligence Surveillance and Reconnaissance. Remotely operated systems could also produce non-kinetic effects for the modern infantry soldier. A small, remotely operated robot with the right sensors could augment or replace forward observation posts without the risk to personnel. The same robot equipped with a loud speaker could assist in broadcasting messages to populations prior to ground operations.

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[20] Jeremy Hsu, "The Weight of War," *Popular Science 285* (November 2014): 62.
[21] Canadian Army, "Weapons," Last accessed 11 October 2018, http://www.army-armee.forces.gc.ca/en/weapons/index.page.
[22] Zachary L. Morris, "Developing a Light Infantry-Robotic Company as a System," *Military Review 98.* no. 4 (July/August 2018): 20-21.

14. Risks. As with all things, the use of technology to enhance capabilities comes with the inherent requirement to shield that technology from electronic attack or other exploitation. It is worth mentioning that remotely operated systems will generate a significant electronic signature which, even if not targeted for electronic attack or exploitation, could be used to target friendly forces for conventional attack.[23] These are factors that must be considered prior to fielding any of this equipment in an operational setting.

CONCLUSION

15. The robotic technology of interest to the infantry soldier today is cutting edge, with multiple applications in a variety of domains and disciplines. Stakeholders from industry, medicine, and recreation are driving the pace of innovation. Despite the similarities in equipment weight to the Assyrian soldier of 700BC, the contemporary infantry soldier is already operating highly advanced, technologically complex equipment at a level expected of technical specialists.[24] Today, our soldiers are carrying too much kit; tomorrow, that kit could be helping to carry them. Reducing the physical burden placed on infantry soldiers in operations will decisively mitigate the differences in musculoskeletal composition between men and women, effectively lowering barriers to entry to women. In an occupation where the fundamental principals have remained essentially unchanged since 700 BC, a failure to keep pace with technological advancements could have dire consequences.

RECOMMENDATIONS

16. Three recommendations are proposed:

a. Enhancing existing weapon systems. Based on the availability of current technology, it is recommended that a detailed study of enhancing existing company-level weapon platforms to increase mobility, firepower, and force protection be prioritized. Technology to achieve this is already fielded in other domains, so the Canadian Army need only invest in engineering available technology to current weapon systems.

b. Unmanned Medium Logistic Support Vehicles. Further study of integration of unmanned ground vehicles with an infantry company to improve combat support and combat service support functions should follow. It is essential throughout this

[23] Breaking Defense, "US, UK Test Robot Breachers, Drones in Germany," Last accessed 11 October 2018, https://breakingdefense.com/2018/04/us-uk-test-robot-breachers-drones-in-germany/.

[24] Government of Canada, "Infantry Soldier," Last accessed 12 October 2018, https://www.canada.ca/en/department-national-defence/services/caf-jobs/career-options/fields-work/combat-specialists/infantry-soldier.html.

process that the end-user of the potential enhancements, specifically the technologically-capable modern infantry soldier, be involved throughout the study process to anchor the study to the true requirements on the ground.

c. Wearable Robots (Exosuits). The US DARPA is already heavily engaged in this domain with industry. It is unlikely that additional involvement or interest from the Canadian Army would entice greater innovation at this point. It is recommended that the Canadian Army continue to monitor the technological advancements in this field, but should not pursue wearable robotic technology until the technology has further progressed.

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