Defence Research and Development Canada | Recherche et développement pour la défense Canada

DRDC | RDDC
technologysciencetechnologie

2015-10-27

DRDC-RDDC-2015-L376

Produced for: Canadian Army Land Warfare Centre (CALWC) and Directorate of Land Requirements (DLR) 7

Scientific Letter

Unmanned Systems Study for the Canadian Army

Introduction

The use of unmanned systems by militaries worldwide has increased dramatically in the past few decades, mostly in the roles of reconnaissance and explosive defeat and disposal. Currently, unmanned systems are employed in limited numbers in niche roles by the Canadian Army. However, it is expected that the application of unmanned systems technologies will continue to grow to provide benefits to other operational functions in the future. As these systems expand their capability and achieve wider acceptance within the CAF they have the potential to greatly improve the effectiveness of various operations.

This Scientific Letter summarizes the results of comprehensive study conducted by DRDC on the potential applications of adopting autonomous and unmanned systems in the Canadian Army [1]. The goal of this report is to inform the Army of the current state-of-the-art in unmanned systems, to evaluate the technical feasibility of their application in the future, and to provide an expectation of the level of effort required to realize their impact. This study provides a significant first step towards producing a roadmap for how, when, and why unmanned systems will be employed in the future Canadian Army.

Statement of Results

The report analyzes the potential employment of unmanned systems in Armies of Today, Tomorrow and the Future within the Adaptive Dispersed Operations (ADO) context. Specifically, this study focuses on the potential applications of all classes of Unmanned Ground Vehicles (UGV) and Unmanned Air Vehicles (UAV) up to tactical applications and is organized by operational functions (Command, Sense, Act, Shield, Sustain). This study does not attempt to provide an analysis of the application of unmanned systems across all tasks within the Army but attempts to group the relevant tasks into a subset of important capabilities.

All work was performed as part of a direct client request through the DRDC Army project Manoeuvre through Adaptive Dispersed Operations (ManADO). The client Canadian Army Land Warfare Centre (CALWC) requested guidance on the technical feasibility of unmanned systems to support future Army endeavours in developing an unmanned systems strategy. Work was accomplished by the authors over a 6-month period primarily through market and literature surveys, table top author discussions, based on their subject matter expertise, as well as direct client engagement.

Canada

This study relied on the Director General Land Capability Development (DGLCD) Army Task List and the Army Hard Problems list to produce 25 potential applications of unmanned systems that have the greatest potential to impact the Canadian Army across all operational functions. This analysis discusses the advantages and impact of using unmanned systems in each role, the enabling technologies, and the potential of government, academia and industry to jointly deliver the impact to the CAF. From this analysis, it is apparent that many operational functions could be leveraging unmanned systems today, using current technology, but there are still technical hurdles to overcome before widespread adoption of unmanned systems is a feasible option.

The criteria used to analyse the 25 potential capabilities were:

- **Technical Feasibility (Army of Tomorrow (AoT)):** The technological hurdles needed to successfully field unmanned systems in the manner described will be overcome within the 0–10 year time frame given current funding and research levels (i.e. TRL 7[1]). A low Technical Feasibility for AoT (See Table 1) indicates a low likelihood of the technological hurdles being overcome in the 0–10 year time frame.
- **Technical Feasibility (Army of the Future (AoF)):** The technological hurdles needed to successfully field unmanned systems in the manner described will be overcome within the 10–25 year time frame given current funding and research levels (TRL 7). A low Technical Feasibility for AoF (See Table 1) indicates a low likelihood of the technological hurdles being overcome in the 0–10 year time frame.
- **DRDC Capability:** DRDC has past or current research and development capability in the technology areas related to the potential unmanned task. A low DRDC capability (See Table 1) indicates that DRDC has little to no R&D capability in the technology area.
- **Partner Capability:** The general capability of Canadian and NATO allies to deliver the capability through a combination of industry, academia, and government funding given current research interest and funding levels. A low partner capability (See Table 1) indicates that the CAF currently has little interest from industrial, academic, and government allies to pursue R&D in a particular technology area.
- **Level of R&D Investment Required:** The degree of investment including non-recurring engineering costs required to bring a system to a TRL of 7. A low R&D investment required (See Table 1) indicates that very little additional R&D investment is required to bring a system to a TRL of 7.
- **System Cost and Complexity:** The expected cost and complexity (in broad terms) of a system once it has reached a TRL of 7. This is evaluated against the cost of current systems employed. A low system cost and complexity (See Table 1) indicates that very little additional costs would be associated with deploying unmanned systems for a potential capability compared to how the capability is currently carried out.
- **Potential for PY Reduction:** The use of unmanned systems for a certain task, could potentially reduce the manpower necessary to complete the task for the indicated Army of the Future capability in the 10–25 year time frame. A low potential for PY reduction (See Table 1) indicates that there is little potential for PY reduction to be gained by using unmanned systems in a certain task.

[1] TRL – Technology Readiness Level as described in “Assistant Secretary for Defense Research and Engineering (2011), Technology Readiness Assessment Guidance, Federal Department of Defense, USA”.

- **Improvement to CAF Safety:** The use of an unmanned system in this application could reduce the chance of soldiers being harmed in the line of duty. A low improvement to CAF safety (See Table 1) would indicate that there is little potential for improvement to CAF safety to be gained by employing unmanned systems in a certain task.

The table produced on the following page summarizes the 25 capabilities across the evaluation criteria and attempts to convey the weaknesses and strengths each capability must address before it can be more successfully employed.

Table 1: *Analysis of potential unmanned applications. Please reference the previous page for a description of the evaluation criteria and there interpretation in this table. NOTE: AoT (Army of Tomorrow), AoF (Army of the Future).*

Name	Technical Feasibility for AoT	Technical Feasibility for AoF	DRDC Capability	Partner Capability	R&D Investment Required	System Cost/ Complexity	Potential for PY Reduction	Improvement to CAF Safety
Command								
Network Relay	High	Medium	Medium	Low	Low	High	Low	Medium
Sense								
Reconnaissance	High	Medium	Medium	High	Medium	Medium	Medium	Medium
Surveillance	High	Medium	Medium	High	Medium	Medium	Medium	Medium
Counter Sniper/Counter Battery	Low	Medium	Medium	Low	High	High	Low	Medium
Act								
Tactical Breaching	High	High	High	Medium	Low	Medium	Low	High
Construction/Demolition	High	Medium	Medium	Medium	Low	Low	Low	Low
Direct Fire Support (Small Arms)	High	Medium	Low	High	Medium	Low	Low	High
Armoured Indirect Fire Support	High	High	Low	High	Low	Low	Low	High
Target Acquisition/Designation	Low	Medium	Medium	Low	High	High	Low	Medium
Vanguard	Medium	Low	Medium	Medium	High	Medium	Low	High
Shield								
Demining	High	High	High	High	Low	Medium	Low	Medium
CBRN	High	High	High	High	Low	Medium	Low	High
CIED: Clearance	High	High	Medium	High	Medium	Medium	Low	High
CIED: Advanced Search	High	High	Medium	High	Medium	Low	Low	Medium
CIED: Route Opening	High	High	High	High	Medium	High	Low	High
Checkpoint Vehicle Inspection	Medium	High	Low	Medium	Medium	Low	Low	Medium
Decoy/Decep/Electronic Warfare	Low	Medium	High	Medium	Medium	High	Low	Medium
Physical Security	High	High	Medium	High	Low	High	High	Low
Convoy Overwatch	Medium	High	High	Medium	Low	High	Low	High
Sustain								
Tactical Training	High	Medium	Medium	Medium	Low	Medium	Low	Low
Tactical Resupply	High	High	High	High	Medium	Medium	High	High
Vehicle Convoys	High	High	Medium	High	Low	Low	High	High
Material Handling	Medium	Medium	Low	Medium	Medium	Medium	High	Low
Search and Rescue	High	Medium	Medium	Medium	High	Medium	Low	Low
Dismounted Mule	Low	Low	Medium	Medium	High	High	Low	Low

Discussion of Results

In the analysis of these applications, a number of key trends can be observed. A significant number of capabilities have the technical feasibility to be employed in the Army of Tomorrow (16 of 25) and a relatively high number of capabilities have the technical feasibility to be employed in the Army of the Future (12 of 25).[2] While the potential for PY reduction is relatively

[2] The technical hurdles for unmanned systems in the AoT may be different than the AoF as more autonomy is expected in AoF systems (i.e. Artificial Intelligence). Therefore, a capability may have a high technical feasibility for the AoT, but may have a medium or low technical feasibility for the AoF. Assessments are based on the vision for employment within each potential task and time frame (AoT or AoF), and are described in detail in the full report.

low with only four capabilities are listed as high, it is important to note that most capabilities have the potential for increasing the safety of personnel and efficiency of the task.

Another key trend from the analysis, which is not expressed in the table, is that a number of technical limitations surfaced repeatedly that would be common to multiple capabilities and crucial to the effectiveness of these systems. These limitations will either need to be dealt with from an operational standpoint, or will require more investment in R&D to realize the potential in each application:

- **Vulnerability and Deployability:** Current systems tend to be large, heavy, noisy, and slow making them poor choices to accompany soldiers. They also tend to be vulnerable to defeat by GPS and radio jamming and small arms fire to sensors.
- **Range of Operations:** Lack of autonomy and reliance on high-bandwidth communications limits the distances that unmanned systems can be deployed. This also limits their deployment in urban areas, indoors, or underground.
- **Mobility in Complex Terrain:** Current systems do not possess the intelligence and sensing to operate in difficult terrains. Small UAVs are just starting to have capability to avoid obstacles in urban areas and indoors. UGVs cannot operate in heavy vegetation, and are stopped by low walls, doors, and water. The ability to operate among humans in traffic and pedestrians is not yet solved.
- **Power and Endurance:** Propulsion for unmanned systems is provided by either limited capacity electrical batteries with endurance on the order of minutes, or by large, noisy internal combustion engines.
- **Human Robot Interaction:** Operation of current systems is cumbersome, requiring keyboards, joysticks, video monitors and antennas. Future systems will require voice and gesture based control to be effective team members.
- **Complexity and Reliability:** As systems increase in autonomy and sophistication, there is corresponding increase in the number of sensors, computing power, and mechanical complexity. Most current systems are not robust to failure or easy to maintain.
- **Modularity, Utility, and Cost:** Current systems are expensive and tailored to one task in one type of environment. Future systems will need to provide a higher benefit to cost, have modular payloads, and have the ability to fill multiple roles within the Canadian Army.

Despite these limitations, unmanned systems are in widespread use in niche roles such as Explosives Ordnance Disposal / Counter Improvised Explosive Device (EOD/CIED), and Chemical Biological Radiological and Nuclear (CBRN) roles and several are on the cusp of being effective options to current practices. The most promising applications for near term employment are counter-IED route opening, tactical resupply, security, and vehicle convoys. These unmanned tasks have had heavy investment from industry and governments, and have yielded systems at a TRL-7 or higher.

Other applications for unmanned systems are not as obvious from a military standpoint, but could have great potential for improving operations. For example, material handling is an area that has a high potential to free up personnel for more tactical operations. Network communications relays, predominately using UAVs, have the ability to increase operational range and ensure connectivity across a widespread battlespace. This could be vital under the ADO concept where many small teams may be deployed over a large area.

Conclusion

The work captured in the Scientific Report [1] provides a detailed and comprehensive analysis of the technical feasibility of employing unmanned systems across the operational functions (Command, Sense, Act, Shield, Sustain) and through the lens of Adaptive Dispersed Operations. It also provides the framework for addressing which of these capabilities will best serve the Canadian Army in future operations.

The Canadian Army will need to conduct an in-depth operational analysis for the most promising applications of the capability and create a roadmap for industry, academia, and research communities to follow. The highest impact will occur through effective partnership of participating organizations that leverage the collective expertise.

Prepared by: J. Giesbrecht, J. Collier, B. Beckman (DRDC – Suffield Research Centre).

[1] Beckman, B., Collier, J., Giesbrecht, J. (2015), *Autonomous Systems for Adaptive Dispersed Operations*, Defence R&D Canada – Suffield Research Centre, Scientific Report (pending).