EMERGING TECHNOLOGIES FOR SUSTAINMENT FOR COMMAND OF FUTURE OPERATIONS

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Abstract

Western militaries continuously consider the future of armed conflict in order to better prepare for the challenges of tomorrow. This includes intelligence organizations monitoring trends to better understand threats in the near-term, and it also includes planners extrapolating trends into "futures" documents that present potential views of the future security environment. Defining the potential military missions for the future enables capability development toward a view of future challenges. The focus of this paper is on how emerging technologies can provide new capability for combat service support for the future force, with specific focus on digital information solutions, and autonomous systems.

Introduction, Future Security Environment

At the strategic level there is general agreement among Western allies about the themes of future operations, and the need to harness technology effectively to meet future challenges. The 2018 US Defence Strategy identifies the need for enhanced global presence in the face of increasing tensions between states and declining global order, and rapid advancements in technology[1]. The United Kingdom's 2015 National Security Strategy identifies similar themes, with domestic and international threats and an increased role for technology[2]. Canada's *Strong, Secure, Engaged* also identifies similar trends, noting an evolving balance of power, the changing nature of conflict, and the rapid evolution of technology[3]. To address the complex and evolving nature of operations, commanders and decision-makers will need sufficient flexibility to address traditional state-based threats, emerging non-state groups, and the overlap between the two in politically and strategically complex regions.

New technology will likely enable new capabilities for Intelligence, Surveillance and Reconnaissance, enable greater situational awareness, extend the range of existing weapons systems, increase the precision of weapons systems, and make the future force capable of delivering greater effect over a wider area in less time than the force of today. No matter what shape the future force takes, all operations will require robust sustainment to ensure their success. This means a reliable and efficient supply chain to move material from domestic or international supply bases (including from commercial vendors) to units potentially distributed across a wide area. Regardless of the specific mission, a robust and versatile sustainment network is necessary to sustain operations across the spectrum of operations. Emerging technologies provide options for modernizing the sustainment function and providing greater supply chain flexibility to commanders. The technologies with the greatest potential to impact supply chain effectiveness and efficiency in the near and mid-term are: Internet of Things (IoT) enabled technologies and autonomous technologies. It is assumed that cyber defence and resiliency technologies will be required for all future capabilities. This paper discusses the benefits to future command and control that emerging technologies can provide.

Data Analytics and Internet-of-Things enabled technologies

The Internet of Things (IoT) concept is to connect entities to a database via the internet to provide digital awareness of physical assets. The concept is to create a digital entry for each piece of equipment in a data repository and allow human users to make sense of huge amount of data[4] and to improve the efficiency of processes[5] across an organization. IoT-enabled technologies are expected to provide decision-makers with real-time / near-real-time information about the status of assets. This concept has significant potential application for Western militaries, managing and maintaining vehicles, aircraft, weapons systems, and equipment, and maintaining a supply chain of spare parts, fuel, ammunition, rations, and water to sustain operations across oceans. Items will connect to the internet via Radio-Frequency Identification (RFID) tags, Near-Field Communication (NFC) chips, S-beam devices, Bluetooth chips, Global Positioning System (GPS) beacons, or comparable devices[6]. For supply chain applications, IoT will enable asset visibility to show users shipping manifests, the status of materials in transit, expected delivery times, etc.

IoT technology has significant potential for Adaptive Dispersed Operations where land operations are conducted by units separated by significant geographic distance, possibly in complex urban terrain, and far from their traditional supply chains[7] [8]. With IoT technology, units could submit supply orders while on the move or request delivery to a future location, all with the knowledge that the shipment can be tracked in real-time / near-real-time. This will allow sustainment decision-makers and field decision-makers to plan based on common real-time / near-real-time information in a dynamic environment. This will be especially useful in complex and urban terrain.

IoT systems will accumulate significant amounts of data: for each shipment there will be a record including things like time of order, time to process, expected delivery time, route, type of terrain traversed, location where delays occurred, time of day when delays occurred, actual deliver time, etc. Aggregating this data will enable predictive analytics to provide suggestions for filling supply orders based on the unit's previous consumption rates, and the conditions of delivery. These concepts are well understood by experienced decision makers and commanders, though IoT technology can provide specific data and visualization to a greater degree of precision and timeliness than human operators can currently provide.

IoT technologies have the potential to benefit not only supply delivery, but also mobile asset and maintenance optimization. Proprietary technology is currently being used to optimize the location and use of vehicles by utilities (public and private), shippers, aviation companies, and the mining and construction industries[9]. This has the potential to forward position supply elements based on planned deployment of ground units. This technology could also enable optimization of maintenance scheduling by scheduling regular preventative maintenance at intervals that allow the fewest number of vehicles to be down at a given time. Maintenance schedules could be linked to ordering and stockpiling of replacement parts, providing optimization on supply for maintenance.

Autonomous technologies

Advances in autonomous technology (both military and civilian) show potential for automating delivery using ground vehicles and helicopters. The principle benefit of autonomous technologies is that they offer the promise of replacing humans doing jobs that are dull, dirty, dangerous or dear – dear described as having an autonomous system do a discrete job a human can do, only faster and cheaper[10]. Dirty and dangerous in the military context includes tasks where there is physical risk to operators, and dull includes repetitive tasks on long endurance tasks with little deviation to plans. Depending on the nature of the threat environment, providing resupply can be dangerous, dirty, or dull, making autonomous technologies worth exploring for military application. In recent operations in Afghanistan and Iraq roughly 10% of the casualties sustained by US forces were sustained by soldiers involved in supply convoys for fuel and water[11].

The future of autonomous technology includes a wide range of land and air platforms, including: large Uninhabited Aerial Systems (UAS), small and medium unmanned helicopters, unmanned ground systems for distribution, and dismounted load carriage systems. Large UAS include helicopters that have been retrofitted to fly without a human pilot on board, and precision parachute drop systems; small and medium unmanned helicopters are mostly purpose-designed helicopters without a human pilot on-board; unmanned ground systems (like large UAS) are retrofitted trucks that drive alone or in convoy without humans (or far fewer humans) involved in driving, and; dismounted load carriage systems are small vehicles intended to follow the infantry section on dismounted operations and carry most of their equipment, significantly reducing soldiers' fatigue. Large UAS have already been successfully evaluated in Afghanistan with a K-MAX helicopter converted for autonomous flight delivering five resupply missions in one day[12].

Autonomous systems have the potential to provide two benefits for sustainment of land operations: ferrying supplies to forward storage locations with less risk to human operators than existing methods and providing direct support to soldiers in the field by carrying the bulk of their equipment. For resupply, using autonomous systems is intended to replace existing human roles. If autonomous technologies are successful, they could reduce the risk of casualties during resupply operations.

Autonomous systems will have greater endurance than human-operated systems, due to the lack of rest a machine requires. Machine endurance is limited by fuel requirements and maintenance needs – both of which are longer than the limits of human endurance. Autonomous technology therefore expands the capacity of existing platforms by reducing rest time, thereby increasing the overall sustainment capability available to commanders and decision makers. When used with an IoT-enabled system, autonomous vehicles can potentially increase the efficiency of the supply chain and provide commanders and users with greater transparency on where assets and supplies are in the supply chain. Dismounted load carriage systems provide the benefit of taking weight off of soldiers' back and extending human endurance by reducing the load carried.

Despite their potential, autonomous systems are not without limitations. The two main limitations for existing technologies are: application in complex environments, and their reliance on GPS and other external systems for navigation. Autonomous system development today is competing with the sophistication of human pilots and drivers in terms of threat identification, and then responding to the threat with appropriate action. The autonomous aircraft currently under development tend to make very deliberate landings, after they survey the landing zones with sensors to determine the best spot to land[13] [14]; the autonomous vehicles can obey basic traffic laws, avoid obstacles, and navigate to their destination – alone or in convoy – but have not been realistically tested in complex environment[15] [16] [17] [18]. This presents challenges for complex urban environments with civilian vehicle traffic, pedestrians, market spaces, and any environment with a medium to high likelihood of enemy contact. Enemies will be able to quickly identify the use of autonomous systems based on their slow deliberate movements, compared to human drivers. This could embolden them to hijack or destroy autonomous systems, once they realize there is no human on board to shoot back at them. The autonomous concept remains sound, however, the current level of sophistication is not sufficient to replace the role of humans in complex applications that require rapid decision making. For dismounted load carriage systems, the drawback is for the versatility and agility of the infantry section. Adding a vehicle to carry rucksacks and equipment will improve human endurance and performance, however it reduced the overall agility of the section, and added the need for fuel and maintenance to sustain the autonomous system.

The other limitation for autonomous systems is their reliance on sensors like GPS, Light Detection and Ranging (LIDAR), and electro-optical sensors for their positioning, navigation and timing (PNT). While LIDAR and electro-optical sensors are less likely to be jammed, foreign powers like Russia[19] and North Korea[20] have allegedly used GPS jamming technology along their borders in the past, and Russia has reportedly jammed US GPS and navigation signals to drones operating over Syria[21]. If GPS systems are jammed, the autonomous system's understanding of its location (from sensor data) will not align to the same spot in reality. This could lead to missed deliveries, crashed or damaged aircraft, and broken down or damaged vehicles. This is particularly concerning if the vision of the future is for autonomous systems to entirely replace human pilots and drivers for future logistics. Alternatives to the current GPS and PNT systems should be developed and evaluated to establish greater resilience for autonomous systems.

Autonomous systems show great conceptual potential and have been trialed in active theatres. There are definitely real-world applications for the existing technology. However, to fully replace the existing human pilots and drivers for dull, dirty, dangerous and dear jobs, the state of the art will need to be advanced further. Commanders should familiarize themselves with the current capabilities and limitations of autonomous technologies to better appreciate the role they can play in improving the efficiency and reducing the risk to sustainment operations.

Cyber defence and security

IoT-enabled systems and autonomous systems process data automatically to fulfill mission requirements. The integrity of the data is absolutely essential for all internet-enabled systems, databases, architectures, and processing capabilities for the future force. IoT-enabled systems are predicated on the idea that massive amounts of data can be collected and analyzed to provide the best decision-support possible to commanders and planners. If the data repositories are not secured, the value of the decision-support is suspect. Cyber systems should therefore have multiple redundancy points to limit the potential impacts of cyber intrusions and disruption.

Discussion

Technology development often promises to remove friction from command and control, clarify options for commanders, and make military operations simpler. There are two important elements that should be considered for how technologies should be further developed and implemented for military use; an appreciation of technology development cycles, and the challenges that need to be addressed between civilian experimentation and military operationalization.

In terms of technology development, new trends are often presented as a panacea. While new technology concepts often promise to address challenges, a measured appreciation of what can actually be delivered in the near term should be established. The *Hype Cycle*, a concept presented by Gartner[22], shows the cycle of technology development and the expectations throughout the process. It begins with an innovation trigger, followed by rapidly escalating expectations of what the technology can deliver, eventually reaching a peak. This is followed by the trough of disillusionment as weaknesses and limitations are discovered, undercutting faith that the technology will deliver. This is then followed by increasing expectations in the technology that eventually plateau once the technology becomes sufficiently stable to deliver results. This is instructive for both IoT and autonomous technologies, in terms of appreciating the limitations and opportunities for further development. IoT-enabled systems will be complex and will link millions of items into networked data repositories. This technology is not likely ready for all military applications immediately; however, there is potential for some implementation to better manage supply chain operations in the near term. Likewise, autonomous systems are currently not suitable for all resupply missions; though they may be suitable for some. Sophistication will eventually progress, however, according to the *Hype Cycle* expectations will often exceed capabilities in the near term.

For addressing military application of civilian concepts, IoT-enabled technologies and drones are illustrative examples. IoT systems are intended to provide real-time / near-real time tracking of all the 'things' that are connected to the IoT network. This assumes constant connectivity of things to the IoT network, with the implicit assumption that no one is trying to disrupt the network. Commercial logistics companies are implementing experimental drones to streamline their delivery operations. Amazon[23] [24], UPS[25] and DHL[26] are exploring the use of drones for their parcel delivery to reduce cost and reduce the time from ordering to delivery. All three have flying prototypes that can deliver a package of roughly 2.5 kg.

Both the IoT-enabled system and the delivery drone were designed assuming that the infrastructure necessary to support both will be readily available and will be robust. We know that adversaries target vulnerabilities in existing Western government networks on a regular basis. We can safely assume that any IoT-enabled network would be immediately targeted. IoT-enabled systems are intended to provide the operator with a reasonable level of net-security; however, IoT-enabled systems were not conceptualized assuming belligerent action against them. Autonomous systems were not designed to withstand impact from explosions or direct fire; though in military application this is exactly what is likely to happen. In the case of both autonomous systems and IoT-enabled systems, a PNT-permissible environment is assumed, either with cellular networks or GPS signals providing real-time data. We can assume an adversary will attempt to disrupt these during times of conflict or increased tensions. This serves to underline the point about transitioning technology conceptualized for civilian use to military use: an evaluation of the unique needs of military application should be considered when looking at any emerging technology. This observation does not mean that technologies designed for the civilian markets should not be implemented for military use; quite the contrary, if they can be proven effective. However, it is meant to reinforce that careful evaluation is necessary to determine if the technology can meet the unique needs for military service.

Conclusions

An enduring fact of armed conflict is the need to keep combat forces sustained to carry on operations. Advances in technology promise more information for commanders and decision makers through IoT technologies and reduced risk to personnel though the use of autonomous vehicles and aircraft for delivery. While these promises may be delivered over time, the current state of the art will likely only deliver on parts of the vision. However, to realize the full potential of the technology, innovation on existing concepts and applications is necessary; this is the only way to evolve the technology. IoT and autonomous technologies should be evaluated for what they can deliver in the near term and use cases should be developed for what commanders need in the medium term. By establishing objectives for what commanders need, technology advancement can be prioritized around key objectives and requirements.

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