INTRODUCTION

Changes in the geo-political security environment have resulted in significant adjustments in the methodology of warfare. Conflict scenarios are expected to vary in severity and intensity, with the level of violence likely to remain at the lower end of the conflict scale although the possibility of a large scale conventional conflict does remain. Conflict will become increasingly complex due to the asymmetric threat, the use of complex terrain and the increase in the size of areas of operations. This demanding battlespace will encompass the realms of land, sea air and space as well as the electro-magnetic spectrum and the cybernetic domain.

The above paraphrase is from the Army's final draft of the Force Employment Concept Paper and outlines the current operating environment and describes how it is being affected by the revolution in military of affairs (RMA). Much of the current discussion revolving around the RMA has focused on effects-based operations and network-centric warfare. This is only natural, as technologies in communications and precision-delivered weaponry have progressed significantly in the last two decades to allow for capability increases that have had tremendous military applications.[1] In Canadian military circles there has been a great deal of discussion on how the COMMAND function will be affected and what technologies the military will need to acquire. However, there has been very little in debate on how these technological advancements will affect how we are organized to fight and how the operational functions of SENSE and ACT will be affected. Admittedly there has been much discussion on force structures and Army transformation; but this debate has mostly been

[1] Sean J. A. Edwards, "Military History of Swarming," http://www.comdig.de/Conf/C4ISR/Edwards.ppt; Internet; accessed 5 February 2005, xi.

inspired by budgetary constraints[2] and not by improvements in technology and dramatic changes in war fighting philosophies. This is unfortunate and some serious thought and debate needs to occur in order to determine how to best harness philosophies on EBO network-centric warfare theories and take advantage of technologies so that the Canadian Armed Forces will be better able to meet its requirements and the demands of the future. If the Canadian military doesn't give serious consideration on how best to structure the forces to utilize these emerging capabilities, it runs the risk of becoming irrelevant. More specifically, the Canadian Army needs to examine traditional force structures and determine how they will be able to best utilize these technologies. To date the Army has put a great deal of effort into transforming its command and control capability and how it will generate forces to meet its operational demands, but it continues to think in terms of traditional force structures and has not focused on whether these force structures will actually maximize emerging technologies and be able to best fulfill its roles.

THESIS STATEMENT

The Army needs to amend force structures to meet emerging threats and to best leverage new technologies.

BACKGROUND

The potential exists for a dramatic change in our force structures. Canada's military budget will not likely ever support a large conventional force capable of a wide spectrum of conflict, as Canadian governments balance the requirements of competing

[2] General (R) M. Jeffrey, presentation at Simonds Theatre, January 2005.

demands.[3] Therefore, a strategy that envisions smaller, cheaper force structures which have units that are still capable of accomplishing their missions during stability operations, crisis and war should be advantageous. These units would be by their very structure, more easily deployable; and would capitalize on emerging warfighting theories and technologies that are spawning concepts such as Effects Based Operations (EBO) and Network-centric Warfare (NCW). Additionally these force structures should be based on joint capabilities that would be able to utilize the ability of the navy and the air force to delivery precision guided munitions thereby reducing redundancy and duplication within the Armed Forces. By basing the Forces' structure on joint effects and not on systems or platforms, there should be significant savings that could be reinvested in technologies and equipment that will allow the military to structure itself to meet the future threat.

ROAD MAP

This paper will examine and define new technologies and theories. It will first examine and define effects based operations (EBO) and network-centric warfare (NCW) as these new developments form the basis that is causing the revolution in military affairs. More importantly EBO and NCW form the foundation of swarming doctrine or philosophy and provide the arguments to why it will be able to function in the 21st century. Once EBO and NCW are understood and how they give credence to a possible doctrine of swarming, the paper will then examine in detail the theory of swarming, and how EBO, NCW and swarming enable and support each other. Together these phenomenons may revolutionize military operations. The paper will then determine the

[3] General (R) M. Jeffrey, presentation at Simonds Theatre, January 2005.

practicality of swarming and whether it has applications in warfare and the current threat environment. It will then focus on the advantages to the Canadian Army should it adopt swarming, and whether they outweigh the disadvantages. Next the structures required to implement swarming will be explained and the paper will propose amendments to the current "task force" generation model. Throughout the paper the synergies to be gained by true joint force involvement as well as other capabilities will be outlined.

EFFECTS BASED OPERATIONS (EBO)

Effects-based operations are coordinated sets of actions directed at shaping the behavior of friends, foes, and neutrals in peace, crisis, and war.[4] This shift to EBO is a departure form the traditional attrition based approach of warfare and instead looks toward targeting an enemy's will to fight. There are three ongoing technological revolutions that support this shift; one is in sensors, another is in information technology, and one is in weapons. These three technologies are capable, especially when employed in concert with each other, of achieving significant improvements in force effectiveness. But to do only this would miss their real potential. These technologies can also enable a change in how forces organize and fight.

Network-centric warfare or operations supports the doctrine or philosophy of EBO by providing the command, control, communications, coordination and information framework that enables effective EBO.[5] But this is not enough and network-centric operations are only a means to an end or a system that enables more efficient operations.

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[4] Edward A. Smith, *Effects Based Operations: Applying Network-centric Warfare in Peace, Crisis, and War* (Center for Advanced Concepts and Technology, 2002), 104.

[5] United States, Department of Defense, *Network-centric Warfare* Report to Congress (Washington, D.C.: July 27, 2001), i.

Their true impact derives from how they are applied. When narrowly applied, they can produce more efficient attrition, yet they clearly can do much more when combined with the systems of systems approach espoused by EBO. EBO enables the application of the power of the network-centric operations to the human dimension of war and to military operations across the spectrum of conflict from peace, to crisis, to war, which a new strategic deterrence demands.

The appreciation of the effectiveness of EBO is growing. EBO is a holistic approach to warfare and takes into consideration the entire spectrum of resources to achieve the end state. Because EBO is focused on actions and their links to behavior, rather than on targets and the infliction of damage, it naturally considers all resources to achieve the effects desired. In addition to military resources, EBO considers the application of diplomatic, informational and economical resources. EBO is applicable not only to traditional or conventional warfare, but also to military operations short of combat such as stability or peace support operations. Effects based operations are not new and good generals and statesmen have always focused on outcomes and on the human dimension of war. Indeed Sun Tzu recommended a sort of EBO approach to operations when he lauded the concept of defeating your enemy without meeting them in battle.[6]

The concept of EBO focuses sets of coordinated actions which are applied to achieve objectives defined in terms of human behavior in multiple dimensions and on multiple levels. Success is measured in terms of the behavior produced.[7] The actions include all facets of military and other national power that might shape the decisions of friends, in addition to foes, and neutrals. As noted earlier the spectrum of possible actions

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[6] Edward A. Smith, *Effects Based Operations…*, 103.
[7] *Ibid*., 104.

include diplomatic, informational, military and, economic or D.I.M.E. Military actions, for example, might include air strikes, but also include a host of other military actions such as maneouver, which can have a serious non-kenetic effect and is often a major aspect of crisis operations. Looking closely at real world crisis and combat operations, some rules of thumb for effects-based operations quickly emerge. Actions create effects not just on the foe but also on anyone who can observe them.[8] Effects can occur simultaneously on the tactical, operational, military-strategic, and grand-strategic levels of military operations, as well as in the arenas of domestic and international politics, and in economics as well. When planning an EBO campaign it is important to note that effects cannot be isolated. All effects, at each level and in each arena, are interrelated and are cumulative over time. And lastly, effects are both physical and psychological in nature.[9]

Effects-based operations can be described as operations in the cognitive domain because that is where human beings react to stimuli, assess a situation, and then decide on a response. To create an effect, an action first must be seen by an observer who will then interpret it and understand it against the backdrop of his or her prior experience, mental models, culture, and institutional ties, and translate this perception into an idea of the situation.[10] Finally, this sense will be balanced against the options perceived to be available to produce a set of decisions and the reactions that constitute a response or behaviour. This cycle of actions and reactions will be repeated many times at multiple levels during the course of a crisis, a war, or even a peacetime interaction. The cognitive cycle suggests three levels of complexity in effects-based operations. First, actions must

[8] *Ibid*., 186.
[9] *Ibid*., 111.
[10] *Ibid*., 186.

be crafted to have an impact on a node, that will effect how the observer sees something. Nodes include political, military, economical, social, informational, and infrastructure or PMESII. However, the observer will see not only what is done but also how it is done such as the scale of our action, its Geographic and operational scope, its timing, speed, duration and synchronicity. Second, there must be an identifiable link between a particular action or set of actions and the effect that was sought to create. But cognitive processes contain so many vaecitrlesct thaff

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how an observer will think or predict exact outcomes. Since this is assessed as being unlikely, the object is to identify a series of the most likely outcomes and actions that will likely create these.

Given this knowledge, an estimate can be made on how the various aspects of the actions might be perceived and plan for what options might be considered in response although forces employed in EBO must be structured with the capability to adapt agilely to changing situations.[14] Additionally, in order to determine whether criteria have been met to transition to subsequent actions, feedback will be required as to whether the actions had the direct effect intended, and as to any change in behaviour created. Clearly, there are many parts of the cognitive process we will not be able to observe although there should be observables we can exploit. If an action involves destruction then damage assessment is an index of whether the direct effect sought was achieved. Similarly, a system's physical performance can provide an index of direct effect. Likewise, assessment of an organization's performance can provide an index of its reaction to the stimulus.

Despite its complexity, EBO is not an impossible task and has proven effective in dealing with these challenges on an ad hoc basis throughout history. The difference now is that EBO can tap into the technologies and concepts of network-centric operations to provide the four key ingredients of successful effects-based operations: options, agility, coordination, and knowledge mobilization.[15]

NETWORK CENTRIC WARFARE

[14] *Ibid*., 290.
[15] *Ibid*., 531.

The ability to link diverse and dispersed capabilities, both military and non-military offers decision makers a wide range of options to tailor their actions precisely to a situation. In order to best decide on the appropriate action, decision makers will require superior situational awareness which is facilitated by NCW. To achieve this superior situational awareness, commanders will need sensors across the battle space or area of operations. Swarming units dispersed across the battlefield might provide much of the HUMINT sense capability in many situations.

The responsiveness of networked forces with shared awareness and speed of command provides the agility to adapt to an intelligent adversary's actions by enabling us to shape and reshape our options and actions amid the give-and-take of battle and crisis operations.[16] Swarming units based on EBO concepts would provide an inherently agile and lethal capability that will keep a commander's options open. Shared situational awareness and understanding of command intent, coupled with the capacity for synchronization, enable the coordination of complex actions and effects that will produce a unity of effect across levels and arenas in which diverse actions build on each other synergistically.[17]

Most importantly, success in EBO will hinge on how well we mobilize knowledge and expertise to bear so as to provide timely and relevant support to decision makers at all levels. Flexible, responsive networking can bring this breadth of knowledge to bear to provide a means to an end, and effects-based operations are that end. As noted earlier network-centric warfare is not a type of warfare but is instead a command, control, communications, coordination and information system (C4I) that provides a force with

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[16] *Ibid*., 531.
[17] *Ibid*., 532.

access to a new, previously unreachable region of the information domain.[18] The ability to wage war in this region provides armed forces with a new type of information advantage that has been enabled by networking of the improved information. With this information advantage, a warfighting force can achieve dramatically improved shared situational awareness and knowledge which ultimately supports a commander's ability to make better decisions faster than his adversary.[19] The concept of network-centric warfare is about improving situational awareness on the battlefield. By achieving and maintaining information superiority a force can defeat or deter the enemy by getting the right information to the right place in the right format at the right level of precision and accuracy at the right time.[20] Commanders at all levels can obviously benefit from this shared awareness which is maximized by making it available to all levels. NCW can be employed to provide information for the benefit of the military, thus having applications during both peacetime and wartime.[21]

The ability to achieve a heightened state of shared situational awareness and knowledge among all elements of a joint force, in conjunction with allied and coalition partners, is increasingly viewed as a cornerstone of transformation.[22] Emerging evidence from recent military operations and a broad range of experimentation supports the relationship between shared situational awareness and knowledge enabled by NCW concepts and increased combat power.[23] During operations it will be important for

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[18] United States, Department of Defense, *Network-centric Warfare*…, iv.

[19] Department of National Defence, DAD *Force Employment Concept Paper* (DND Canada, 2003) 4.

[20] *Ibid.,* 20.

[21] The Mitre Digest, "Network-Centric Warfare: More Than Just Technology," http://www.mitre.org/news/digest/defense_intelligence/09_03/di_ncw.html; Internet; accessed 5 February 2005.

[22] United States, Department of Defense, *Network-centric Warfare* …, iv.

[23] *Ibid*., i.

units on the ground leveraging airpower are powerful. We learned the linkage of intelligence operations with military operations is very powerful." Most importantly, commanders had superior situational or battlefield awareness and were better able to envision strategies and out maneouvre and out fight the enemy. With new technology, commanders were better able to see in real time where the enemy is and where their own forces were as well. Satellites, drones, radar planes, and other surveillance resources spied constantly on Iraqi forces, while transponders with each American unit signalled their location. Both enemy and friendly units were represented on digital screens that were constantly updated giving commanders a real time picture of the battlefield.

Another extremely important criterion for successful network-centric warfare is information management. The network provides shared situation awareness which builds a shared repository of data for different people to draw on. However this data bank of information must be tailored to each user's needs.[26] This requires an information management system, otherwise the system or commanders will likely be overwhelmed. For instance, a Special Ops detachment or a swarm unit has different needs than an aircraft commander. Depending on the situation, some warfighters need local sensors to judge their environment, while others need network or global information such as, in order to see the big picture. There is value in both local and network information if it gets to the right person at the right time.

NCW requires a strategic focus on interoperability and interoperability must not be sacrificed for near-term considerations. Battle space entities such as platforms, units, sensors, and shooters must be capable of being interoperable with the net. Increased

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[26] Department of National Defence, DAD *Force Employment Concept Paper*…, 20.

emphasis must be placed upon research in developing awareness, shared situational awareness, and new organizational approaches to achieving synchronization.

Major impediments to NCW progress are technical, cultural, organizational, and administrative and include:

- Technological or budget restraints that prevent secure, robust connectivity and interoperability,
- Military cultural intolerance of disruptive innovation, and
- Lack of understanding of key aspects of human and organizational behaviours.[27]

These impediments will slow progress and limit the ability to achieve the full potential of NCW thereby sacrificing a potential military advantage. An adequate information structure will promote information sharing, analysis, and enable new approaches to command and control. The creation of an environment that supports disruptive innovation will allow NCW to move beyond sustaining innovations and reap the full potential of NCW.[28]

The evidence indicates that forces employing NCW concepts have significant advantages because of situational awareness and knowledge that result in dramatically increased survivability, lethality, speed, timeliness, and responsiveness.[29] This evidence also points to the fact that the source of the transformational combat power enabled by NCW concepts can better be understood by focusing on the relationships in warfare that take place simultaneously in and

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[27] United States, Department of Defense, *Network-centric Warfare* …, iii.
[28] *Ibid*., iii.

[29] *Ibid*., iv.

among the physical, the information, and the cognitive domains,[30] in much the same way that EBO does.

The physical domain is the domain of warfare as it is where strike, protect, and maneouver take place across the ground, sea, air, and space environments. It is the domain where platforms and the communications networks that connect them reside. Comparatively, the elements of this domain are the easiest to measure, and consequently, combat power has traditionally been measured primarily in this domain.[31] The adoption of a swarming doctrine would dramatically alter this domain, and therefore a new system of measurement of combat power will be required in order to compare and contrast tactics, techniques and procedures.

The information domain is the domain where information resides and where information is created, manipulated, and shared. It is the domain that facilitates the communication of information among forces employed on the battlefield. It is the domain where the command and control of modern military forces is communicated, where commander's intent is conveyed.[32] Consequently, it is the information domain that must be protected and defended to ensure operational security and to enable a force to generate combat power in the face of offensive actions taken by an adversary.[33] It is developments in this domain that has increased the odds of success for swarming.

The cognitive domain is the domain of the mind of the warfighter and the warfighter's supporting populace and as such speaks a great deal to EBO. Many battles

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[30] *Ibid.,* iv.
[31] *Ibid*., iv.

[32] *Ibid*., iv.

[33] *Ibid*., iv.

and wars are won or lost in the cognitive domain. Intangibles such as leadership, morale, unit cohesion, level of training and experience, situational awareness, and public opinion are elements of this domain. This is the domain of commander's intent, mission command. This domain is relatively well developed in the Canadian Army and consequently could be exploited to develop swarming doctrine.

Network-centric warfare has typically focused on the tactical and operational levels of warfare, but it can impact all levels of military activity from the tactical to the strategic. At the operational level, NCW provides commanders with the capability to generate precise effects at an unprecedented operational tempo, creating conditions for rapid victory.[34] At the strategic level, NCW will have a dramatic effect on force structure, employment and force generation.[35] Changes in force structure may require changes in training and equipment requirements. So the potential impact of NCW supported swarm EBO may be significant.

SWARMING

Both EBO and NCW allow for swarming to increase its effectiveness and chances of success in modern warfare. EBO is the philosophy of warfighting and NCW is the technical framework and related thought processes that enables commanders to achieve their end state. Swarming is how these strategies and frameworks may be best applied in operations.

There are a number of definitions of swarming; one definition of swarming is a useful self organization of multiple entities that continuously amends or changes through

[34] Department of National Defence, DAD *Force Employment Concept Paper*…, 4.

[35] United States, Department of Defense, *Network-centric Warfare* …, v.

local interactions. This organization is most useful in military problems that are diverse, distributed, decentralized, and dynamic. In one such use, a collection of decentralized, often-diverse units converge on an objective (or a problem) from multiple directions, affect the objective and then re-disperse for future action.[36] Swarming suggests the agility to rapidly concentrate the power of a highly networked force in any domain or dimension of warfare to dominate an adversary. Many of the most innovative ideas for military transformation relate in significant ways to this class of concepts. However, potential adversaries are much more dangerous when they adopt even crude forms of swarming. As a result, a comprehensive understanding of both the use of and defense against swarming is critical to an effective defense policy and military doctrine.[37]

The dictionary defines the noun swarm as "a large number of things massed together and usually in motion" or "an aggregation of free-floating or free swimming unicellular organisms" and the verb swarm "to beset or surround in a swarm." Refining the schoolbook characterizations, the two main schools of thought present are one inspired by history, while the other is inspired by observations of social insects. One theorist says that "swarming occurs when the scheme of maneouver is a convergent attack of several semi-autonomous (or autonomous) units on a target." Another says "swarm intelligence is a mindset rather than a technology. It is a bottom up approach to controlling and optimizing distributed systems, using resilient, decentralized, self-organized techniques, initially inspired by how social insects operate."[38]

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[36] Jeff Vail, "Swarming, Open-Source Warfare and the Black Block," http://www.jeffvail.net/2005/01/swarming-open-source-warfare-and-black.html; Internet; accessed 26 March 2005, 1.

[37] John Arqilla and David Ronfeldt, "Swarming and the Future of Conflict," http://www/rand.org/publications/DB/DB311/; Internet; accessed 16 December 2004, 2.

[38] Arqilla and Ronfeldt, "Swarming and the Future…," 2.

Still another definition describes swarming as "the seemingly amorphous, but deliberately structured, coordinated, and strategic way to strike from all directions, by means of a sustainable pulsing force and/or fire, close-in as well as from standoff positions. It will work best, and perhaps only work, if it is designed mainly around the deployment of myriad small dispersed, networked manoeuvre units."[39] This definition keys on an important aspect of swarming and NCW and that is the concept of firepower employed from stand-off positions to overwhelm a target or objective. What swarming is not, is a siege because a siege although it surrounds an objective doesn't have the effect of continuous converging and dispersing.

The keys to the success of swarming forces have always been elusiveness, which entails mobility or concealment; situational awareness, and standoff firepower.[40] In history, ancient horse archers had two of the criteria; that of elusiveness and standoff firepower. In the Battle of the North Atlantic (1939-1942), swarming U-boats possessed only one of these keys; that of elusiveness. In the Battle of Mogadishu (1993), the Somalis had two; that of elusiveness and situational awareness.[41]

Swarming has occurred throughout military history and the lessons of the past may offer insight into a possible future application of swarming. Very little historical research has been conducted with a sole focus on swarming, yet a close reading of military history shows certain swarming patterns. Historical examples of swarming indicate that not only has it been a successful doctrine but also that it has been employed at the tactical and operational levels, both defensively and offensively, in cities, deserts,

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[39] *Ibid*., 45.
[40] Vail, "Swarming and Open-Source Warfare…," 3.
[41] Sean J.A. Edwards, "Swarming on the Battlefield: Past, Present, and Future," http://www.rand.org/publications/MR/MR1100/; Internet; accessed 16 December 2004, 10.

jungles and oceans, by conventional and unconventional forces.[42] Modern militaries can learn from history and realize that swarming is applicable in all operations of war, the entire spectrum of conflict and in all environments. Consequently swarming would seem a logical alternative force structure that might very well have applications to the Canadian Army and should be researched.

Types of swarming cases can be broken into two broad categories, massed and dispersed. Most historical examples of military swarming are massed swarm cases from the ancient world and the Middle Ages. A massed swarm is where a swarming army begins as a single massed body then disassembles and conducts a convergent attack. The key distinction here is that the army arrives as a single mass. Most historical cases are of this type because of limitations of command and control which didn't allow for swarm units to converge from dispersed locations on the battlefield. In general, unit commanders had to see all of their units although the Mongols were able to use an early mission command philosophy and dispatch riders to operate separate formations while campaigning that were capable of converging from different areas to join battle. For the most part however, before about 1800 AD, the technological limitations of command normally prevented commanders from controlling more than one body of soldiers.

Dispersed Swarm cases occur when the swarming army is initially dispersed but then it converges on the battlefield without ever forming a single mass. An example from history of dispersed swarming would be the Somalis, North American Indians, U-boats in the North Atlantic, and the Hezbollah. It has only been recently in the modern mechanized age with the advent of the wireless radio that dispersed swarming has become more of a possibility as it allows commanders to communicate orders over

[42] Arqilla and Ronfeldt, "Swarming and the Future…," 78.

distances. Examples of dispersed swarming are much rarer because it is a new phenomenon, although it has occurred in Chechnya and Somalia to good effect. Dispersed swarming is of interest to modern armies because on future battlefields, concentrations of mass will be vulnerable to the growing lethality of modern munitions and therefore dispersion is advantageous to avoid casualties.[43]

By following historical trends to their logical conclusion, the future battlefield environment will be more conducive to swarming operations. Communication trends and the necessary dispersion to achieve protection would seem to indicate both the possibility and the need. It is not surprising therefore that much of the current discussion about future warfare focuses on dispersed yet integrated operations, operating in nonlinear and noncontiguous environments with networking, small autonomous units operating independently, placing a greater reliance on firepower.[44] In this kind of environment, current linear warfighting techniques will find it difficult to fulfill the missions successfully.

There has been much thought on new ways of fighting. Many of the proposed American operational concepts for light and medium forces beyond the 2015 timeframe involve friendly forces that usually wait for an enemy to penetrate their defensive area, rely upon stealth or mobility to survive, and then unleash an ambush of massive simultaneous fires from close in and from afar.[45] In order to assess whether swarming has applications in modern militaries and the Canadian Army in particular, a better understanding is needed of this kind of environment and how swarming doctrine can be incorporated.

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[43] Edwards, "Swarming on the Battlefield…," 69.
[44] *Ibid.,* 69.
[45] *Ibid.,* 14.

Swarming can be broken into four stages: Locate; converge; attack and; disperse.[46] Pulsing is another term often encountered with these tactics. Pulsing in this sense is the converging of units onto the target and then re-dispersing.[47] Sustained pulsing is the real effect sought in swarming, and this is the ability to continuously converge on a target and disperse again. Pulsing can also refer to the concentration of fire on a target that is used to overwhelm it producing the effects of physical destruction or psychological confusion. It also must be sustainable.[48] This pulsing of swarm units on a target ideally should happen simultaneously in order to enhance the chaos or confusion effect required. Logically, small units are vulnerable on their own, but if these small units are coordinated into a swarm with other combat enablers, the overall lethality is multiplied because the phenomenon of the swarm effect is greater than the sum of its parts.[49] These converging tactics of relatively small units from dispersed dispositions also has the added benefit of defeating or nullifying modern battlefield capabilities such as airpower and weapons of mass destruction.

Throughout history, with the increased lethality of munitions have come more and more dispersed operations, or formations. The density of soldiers on the battlefield has decreased substantially over time and the last three decades have proven no different, as weapon technology has progressed. This has also proven beneficial to swarming as it has created more and more gaps on the battlefield that has allowed small units operating space.

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[46] Sean J.A. Edwards, "Swarming on the Battlefield…," 68.
[47] *Ibid.,* 68.
[48] Arqilla and Ronfeldt, "Swarming and the Future…," 46.
[49] Edwards, "Swarming on the Battlefield…," 69.

Today, precision guided weapons and warheads that have increased yield (lethality) have forced formations to disperse to avoid casualties. These very same capabilities have also enabled smaller dispersed formations on the battlefield to have greater lethality. The weapons that enhance the capability of these small units or swarm units can either be organic to the small unit, or as is increasingly happening, non-organic. This is to say that the swarm units can affect targets by calling on remote assets not integral to the unit. These reach back assets can be indirect such as artillery, rockets or even offshore naval gunfire. Air delivered precision warheads can also be called on and ultimately space-based delivered weaponry may be employed. Because of this ability to apply force against an objective or target with assets located far away and not integral to the swarm unit, these light units will have capabilities out of proportion to their size and integral weapons. This link to reach back firepower is called the sensor-shooter link. The shift to reach back weaponry has also increased individual unit mobility and has also increased elusiveness as the swarm has reduced its signature.[50] This also means that more shooters can be engaged, more of the time, and that a higher level of engagement can be sustained throughout a campaign.[51] With the capability to call on overwhelming firepower, experiments have indicated that light forces, if well informed and armed with standoff guided weapons can indeed perform capably even against heavy adversaries.[52] In many respects, Special Forces have been utilizing this capability for some time. During recent simulation exercises, Special Forces achieved astonishing results, routinely defeating heavily armoured opponents.[53]

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[50] Edwards, "Swarming on the Battlefield…," 70.
[51] Arqilla and Ronfeldt, "Swarming and the Future…," 78.
[52] *Ibid*., 81.
[53] *Ibid.,* 82.

In order to maximize the synergistic effects of EBO and NCW, swarms must be interoperable with other military systems. This means that swarming must exploit, or contribute to, the portfolio of network-enabled C4ISR capabilities in order to achieve its full potential. By its very nature, swarming dovetails into NCW; with one theory very much enabling the other. Swarm units flooding a battle area provide observers or sensors that feed the information network while with the superior situational awareness picture obtained through NCW, swarm units can attack when in the most advantageous position and time, coordinated with other swarm units.

NCW also potentially increases agility and command effectiveness to the lowest tactical level. In order to be the most effective, swarm units must be able to rapidly assess a situation and make quick decisions. Rapid decision-making requires situational awareness and fused information at the right place and time. Information is used to improve traditional, common operational pictures and databases that are subsequently used by swarms to improve their common operational picture, which allows for the coordination of efforts laterally between swarm units.

It has already been said that swarming can be conceptually broken into four stages, locate, converge, attack, and disperse and that technology has enabled the modern swarm to operate more effectively than ever before in history. NCW has enabled military units to operate with superior situational awareness and a common operating picture, but NCW requires constant updating of information, and this in part requires sensors. Sensors on the battlefield have become more and more man portable, cheap and effective. Even if the swarm unit cannot carry all the necessary sensors, it can still tie into the network to access the required information. New lightweight and secure communications devices

Similarities between swarming and guerrilla tactics are interesting because of their non-linear and dispersed nature. Swarming units and guerrillas do not maintain a linear front nor do they rely on major lines of communications; they fight a war without fronts. They both disperse and move in small groups so that they may remain undetected and avoid direct confrontation with superior concentrations of enemy forces. They both use harassment, raids, and ambushes to attack enemy lines of supply and isolated detachments. With swarm units, rapid concentration is followed by equally rapid dispersion. Surprise attacks are followed by immediate retreat in the case of he guerrillas, and dispersion in the case of the swarm units. These similarities may very well give swarm units the edge when conducting operations against guerrillas.

Elements of swarms interact primarily with their neighbors to facilitate the randomness, diversity, competition, and adaptation that are essential to self-organization. This may place less of a burden on the communications architecture. Interestingly, the number of elements or entities in a swarm must be sufficient to support self-organization. Dispersion enables the force to explore and adapt to the battle- or problem-space as necessary. And, after part of the swarm discovers a promising solution, recruitment, reinforcement or pulsing by the rest of the swarm occurs. All of the above characteristics are necessary in varying degrees, depending on the specific application, to produce the effects of flexibility and robustness, multiple and surprising lines of attack, speed that are characteristic of swarming systems.

ADVANTAGES OF ADOPTING A SWARMING DOCTRINE

There a great many reasons for the Canadian Army to consider adopting a swarm like doctrine. First, the tremendous increase in accuracy of precision-guided munitions and weapons of mass destruction has made large military formations and the logistics required to support them, increasingly vulnerable.[56] Therefore the force structures the Army adopts should reflect a need for dispersion. This will increase the difficulty of sustainment if the Army retains traditional force structures that are heavy consumers of commodities like fuel. Since swarming involves smaller and lighter more mobile units, a swarming doctrine would likely require less in the way of sustainment and therefore allow for easier dispersion and ultimately survival. Techniques for re-supply across dispersed battlefield will need to be developed, however in many respects they have already been utilized in special operation missions.

Historically the trend towards dispersion on the battlefield is undeniable. Dispersion has been an undeniable result with each new improvement of weaponry. Dispersion in today's conflicts has also been a factor in the viability of swarming, since modern weapons have forced armies to disperse in order to avoid destruction, swarming has become more feasible since it allows for greater freedom of movement for the small mobile swarm units that can move amongst dispersed enemy forces.

Secondly, the fielding and maintenance of conventional units is costly, and grows more so all the time. Aside from the natural growth in costs of manpower and materials, a great deal of time, money, and effort is being dedicated to improving protection of armoured vehicles. Ultimately, this is a futile effort, as firepower will always improve to defeat any new increase in armour protection.[57] Defence policy analysis should turn

[56] Arqilla and Ronfeldt, "Swarming and the Future…," 76.
[57] Arqilla and Ronfeldt, "Swarming and the Future…," 76.

instead to studying alternative force structures that may reduce vulnerabilities and increase capabilities. Units that are agile and present a less valuable target present one option that can be pursued. Smaller, more mobile and lethal swarm units may in fact provide a cost savings, while still being able to fulfill the Army's current roles and providing a flexible framework to adopt to future threats and requirements.

The adoption of light swarming forces and the subsequent doctrine would likely provide Canada with many of the same capabilities, at a lesser cost. In fact Canada might be able to increase its military capabilities without increasing the Armed Forces budget. Given the limited moneys available and the competing priorities, this reason should be attractive to any sitting Canadian government who could be made to see the "more bang for the buck" argument. This fact coupled with the realization that such a force would be more easily deployable, and requires fewer, and less large, strategic assets, should also prove to be convincing to a middle power government who is interested in projecting influence around the world.

Current force structures were conceived of, and formulated to fight large similar forces in a high intensity conventional conflict. The reality is that things have changed. There are precious few militaries in the world that continue to present Canada and its allies this sort of threat and even these few could be dealt with by light swarming type units were Canada to adopt them. The last two decades have shown that Canada is more likely to become involved in low or mid intensity conflicts against an enemy who is technologically backward and lacking sophisticated weaponry and command control capabilities. Swarming is enhanced by jointness and Canada has had a history of intra service operations. Therefore, even a small step in the direction of adopting a swarming

doctrine should give Canadian military forces a marked edge against many of its likely adversaries, or opposing forces in a PSO. Much of the world and many of the likely

The command and control (C2) characteristics of swarming systems are similar to principles essential to Canadian Army C2 doctrine.[60] Commander's intent and end state are expressed in, mission type orders and this has promoted relative autonomy, low-level initiative and self-organization. Mission command, coupled with NCW and agile, lethal swarm units would appear to be a path for success that the Canadian Army has already begun to walk down and for which it has laid the foundations for a successful transition.

Additionally, the Canadian Army has been blessed with a professional NCO corps, who because of long-service careers develops wide-ranging skills and knowledge. Given the nature of the operations we have been involved with over the past two decades, they have also developed a confidence to made decisions. In fact, Junior Leadership training has become more and more focused on making quick decisions in difficult situations. One might conclude then that the leadership required for swarming is also in place and continues to develop.

All these factors would seem to indicate that a transition to swarm-like doctrine wouldn't be a significant leap for the Canadian Army. The degree of professionalism and competence at the junior leadership level exists that would permit this change in doctrine that would see small units deployed dispersed. In fact, without any dramatic change in the order of battle (ORBAT) and weapon and equipment scales, a swarming doctrine could be adopted. This assumption is further reinforced by the proposed light infantry ORBAT at the platoon and company level where very capable support weapons elements are built into these organizations in order to support missions at the lowest level and to allow for the decentralizing of operations. This ability to operate at low tactical level in small units is especially necessary for light infantry who are expected to generally operate in

[60] Department of National Defence, DAD *Force Employment Concept Paper*…, 7.

complex terrain. Because of this ORBAT, these units would seem to be ideally suited to adopting a swarming philosophy with minimal changes in their existing structure.

As eluded to earlier in the paper, much of the experience in the last 15 years has been operations where it has been a "section commander's war." With new technology and advances in weaponry and communications, wedded to a military that is replete with capable junior leaders, the environment that would seem to be ripe for adopting a "swarming" doctrine. Practically, much of the training, doctrine, and equipment that would support swarming are in place already. Some capabilities would need to be acquired and perhaps more significant, our philosophy on how the Canadian Army is prepared to fight and how it is structured would need to be refocused.

Much of what has been done in Army Transformation is supportive of a change to swarming doctrine and is indicative that the Army has been progressing in this direction anyhow. The Army has been pursuing a knowledge base, command centric force for some time.[61] This doctrine has required that information be available to those who require it. This has necessitated acquiring communications and information management systems in pursuit of the "Big Head, Small Body" Army. In many ways this has benefited the concept of moving toward a swarming doctrine, however, many of the concepts of how battlefield information or situational awareness of this system is to be generated revolves around technological means. In theory, this is sound enough however, in practice, attempts at acquiring battlefield intelligence through technological means only have proven inadequate. Some of the reasons for this are technological, but some are simply because the enemy, knowing that the West has a vast technological edge, has resorted to tactics that nullify the West's technology. These tactics have been as simple as

[61] BGen D. Benjamin, presentation at Simonds Theatre, 31 January 2005.

retreating into urban areas, or into thickly forested areas where technology is unable to find them or distinguish combatants from noncombatants. The obvious counter tactic is to refocus to human intelligence. Swarming type units would provide exactly what is needed for this sort of tactic. By flooding an area with small, highly capable units a commander would gain a number of options with the same force. Swarm units could be used to gather information, dominate the area of operations or, ultimately destroy enemy units by swarming. Most after-action reviews from recent conflicts as well as theorists on military doctrine admit that technology is not meeting the need of building good situational awareness.[62] In fact many professional publications state that although technology may in the future be capable of building a complete situational picture, it is still many years before this technology is available.[63] Current technology is however, capable of linking human sensors across the battlefield and synthesizing this information into a comprehensive operating picture. This linking and information management technology is where the Canadian Army should be exploring its options and spending its money. A model that may prove beneficial is one based on the concept of swarming. As noted previously, a swarming model could easily form a framework which a knowledge based system could be built upon. Currently this is especially critical as any model primarily based on technological means to gather information is doomed to failure.

Swarming doctrine offers tremendous flexibility and employability to the Canadian Army. Although swarm units will be capable of engaging heavier forces in high intensity conflict across all terrains,[64] they will also be ideally suited to low intensity conflicts. The logic is that a force comprised of small units capable of concentrating

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[62] Edwards, "Swarming on the Battlefield…," 76.
[63] *Ibid.,* 83.
[64] Arqilla and Ronfeldt, "Swarming and the Future…," 78.

against a heavier opponent, can vary the degree of massing required to counter opponents such as guerrillas and unconventional forces. In other words, swarming units easily allow for the flexibility to adapt to any situation including the worst-case scenario. For Canada, this is ideal as these forces would inherently be cheaper. The fact that swarming units, by their very nature, would be comprised of smaller pods or patrols would make them invaluable to peacekeeping or humanitarian missions. A swarming force would likely tend to have increased contact and better relations with humanitarian agencies and non-governmental organizations (NGOs) because of their smaller size, less threatening appearance, and increased presence.[65] An additional benefit of swarming forces is that their smaller size would also tend to cause less resentment with the local population, which again reinforces the idea that coordination with NGOs will be easier. Considering the predisposition that Canadian governments have had in the last forty years to international peace and stability commitments, a force structure based to some degree on swarming would not only fulfill the governments desire to be seen to be committing to these sorts of missions, but would also provide the Army with a highly trained, lethal war fighting force structure in theatre should the situation escalate.

Another role for the military and especially the Army is domestic operations. Here again a force structure based on swarming units would prove valuable. Any number of domestic operation scenarios could be capably addressed by swarming units. Search and rescue missions would prove ideal for the dispersed, communication linked patrols or swarms. They could more easily be transported to the search area, flood the area with patrols, amend their dispositions as new information becomes available and concentrate when the object of the search is located. Forest fires, floods, civil unrest and

[65] *Ibid*., 79.

environmentally hazardous spills are just a few additional examples of domestic operations that swarm units would be ably suited to handle.

Arguments outlined above to adopt a swarming force structure are specific to Canada's situation, and these arguments for adopting swarming would seem very compelling. Although swarming is not a new phenomenon, its applications to modern warfare have increased dramatically in the past decade because of advancements in technology. Historically, swarming units were able to function because of visual or audio signals. Now swarm units can remain widely dispersed because of new abilities to communicate securely over increased distances. They can also strike with extreme precision and lethality while remaining concealed. Advances in precision-guided munitions such as laser-guided warheads and JDAMS allow very small teams or patrols to destroy or neutralize high value targets, or much bigger targets without exposing themselves.[66] This means that swarm units can take on heavily armoured formations in high intensity conflict. Because they will be interlinked with other patrols and higher command posts, they would have superior situational awareness so their efforts can be coordinated and the results achieved on their objective selected for efficiency and effect. In theory the existing four-man rifle group from a Canadian Army infantry section could form a patrol and be equipped in such a way that it could affect a much superior force and still provide itself with good self-protection. Man-portable radios with digital band transmission are available today, man-portable laser designators are rapidly becoming available, and laser range-finding binoculars that can obtain target grid information are already in service in the Canadian Army. The Defence Research and Development Centre

[66] Chris W. Cox, "Findings Released on Hunter Warrior Advanced Warfighting Experiment," http://www.fas.org/irp/news/1997/usmc_970822c.htm; Internet; accessed 5 February 2005, 2.

has conducted trials on personal situational awareness monitors. The United States Army has fielded the Blue Force Tracker system in most of its vehicles and the 4th Infantry Division has been digitalized. Precision-guided munitions, whether they are air, rocket, missile or cannon delivered have achieved such accuracy and dependability that it is generally accepted that if a target is located, it can be destroyed. All the above technology, along with the weapons integral to a rifle group, could be fielded or employed by the rifle group. This would mean that a four-man infantry team would be capable of destroying or neutralizing vastly more than it was traditionally accepted it could. By employing joint effects and joint fires this four-man team in the right circumstances could neutralize more than a company without exposing themselves and becoming endangered. Should they be exposed to risk of being located, they could break contact and quickly be replaced by another four-man sensor team who could continue the targeting process. This pulsing of effects and fire on a target provides a synergistic effect that overwhelms a target and soon causes it to be neutralized.

Technology advances have made it possible for a relatively small team to sense a target, locate it accurately, communicate its location to a shooter system and destroy that target. These newer systems allow for the sensor to remain hidden, to detect a target in conditions of battlefield operation and communicate this information over long distances. Perhaps, most importantly all these new systems are relatively light and man-portable. This technology therefore allows for very small teams, which because of their small size are inherently stealthy. As this new equipment is compact and light, these teams maintain mobility while still being capable and lethal. Additionally, because of the lack of weight and bulkiness, these teams are able to operate in complex terrain such as the urban

environment, mountainous areas, and as well as thick forests or jungle. In areas where vehicles are employable, the vehicle size can be much reduced because of these modern technologies, making them more easily strategically transportable as well as tactically attractive given their small size and mobility.

All this technology is currently available. In order to truly become swarm capable the Canadian Army should pursue the acquisition of such technology as laser designators, improved target grid determiners, improved sensors such as lightweight thermal and infrared imagers, and communication equipment that is compatible with shooter systems. Additionally the Canadian Forces will need to improve its capability of delivering PGMs in the Navy, Army and Air force. Because it is likely that Canadian Army units will be deployed as part of a coalition, and it is likely that this coalition will be led by the United States, it would therefore be advisable that the equipment acquired should be compatible with systems fielded by the United States. A four-man rifle group could easily carry target designating equipment, communications equipment, and sensing equipment while still being able to protect itself and be mobile. There is also potential to specialize to a degree to take advantage of these new technologies while at the same time leveraging the Canadian Army's traditional superiority in small unit tactics. Given that swarming doctrine achieves its maximum potential when the sensor team is tied into an information based command and control system that links it to a shooter, the opportunity exists to fill a niche of providing highly capable sensor teams, or swarming units that provide situational awareness to the command and control systems, and target data to the shooters. Additionally the Army, if it were employed in a coalition could take advantage

of coalition shooters that currently are lacking in technology and capability in the Canadian Army.

LIMITATIONS TO SWARMING

There are some limitations to swarming that should be considered and may ultimately affect the degree of swarming adopted. Wars and battles are won by taking advantage of one's own strengths and using them to overcome an adversary's weaknesses. Swarming in the past has enjoyed mixed success and there are some limitations that need to be factored when considering force mix or force structure. As with any tactic or strategy, swarming will not work against all types of opponents in all situations. Even when swarm units have the advantages of superior situational awareness, elusiveness, and standoff fire, there are foreseeable missions and conditions for which swarming may not be ideal.

For example, the massed swarm maneouver used by the most conventional armies in history would present a problem today because the initial massing of forces in any proximity to the battle area would present a target (before they swarmed) and would consequently be vulnerable to modern munitions.[67] Admiral William A. Owens uses the term system of systems to represent a concept whereby weapons and systems from three technology areas—sensors, C4I, and precision guided munitions-will interact synergistically on future battlefields and destroy any target considered high pay off. [68]

The dispersed swarm maneouver avoids this disadvantage but still has limitations. Defensive swarming along a border or any area without maneouvering room could be a

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[67] Edwards, "Swarming on the Battlefield…," 77.
[68] William A. Owens, "The Emerging System of Systems," *Military Review*,(May–June 1995): 16.

problem as the essential requirement of freedom of movement would not be present. If, prior to hostilities, swarm units have to defend border areas adjacent to the enemy, they are probably not well suited to providing a fixed, linear defense. The swarmer must either be allowed to preemptively swarm on the offense and cross into enemy territory first, or the attacker must be allowed to penetrate the swarmer's home territory in order to allow defensive swarmer attacks from all directions.[69] Deliberate swarming attacks against fixed, defensive positions may not succeed when the defender has had time to fortify those positions and place effectively extensive minefields. A swarm attack that is channeled will fail as it denies the swarm unit freedom of movement. Heavily mined areas pose a problem for a swarming doctrine, which places so much emphasis on dispersion and maneouver.[70]

Swarm units may be at a disadvantage if when operating in an environment where the indigenous people are hostile to the swarm units as the swarm unit will likely loose some of the elusiveness that it requires to operate. This disadvantage may be overcome by operating at night or if the population is sparse and the swarm units are able to maintain their stealth and consequently their freedom of movement.

If the enemy is an elusive guerrilla force in difficult terrain where vehicles cannot operate, only dismounted swarm units may be feasible. Some sources argue that while dismounted swarm units will probably not have a direct standoff fire capability over their opponents (except perhaps at night). This presupposes that the swarm unit will be in close combat with guerilla units. However this need not be the case. Modern weaponry and optics allow the swarm units some standoff distance should they make contact with

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[69] Edwards, "Swarming on the Battlefield…," 78.
[70] *Ibid*., 78.

guerilla units. More importantly the swarm unit using the tactical internet workout can call for reach-back fire power to defeat any force that it make contact with.

Equally, the criticism that swarm units in the past have been unable to deliver a knockout blow rapidly is no longer true in modern times. Swarm units can now call on joint indirect fires such as fighter-bombers, C-130 and helicopter gun ships, MLRS and ATACMS, naval gunfire and perhaps in the future, space-based weaponry.[71]

ARGUMENTS FOR FORCE COMPOSITION

The lethality, mobility and, capability of very small groups employing new technologies and swarming doctrine cannot be argued. What limitations there are to swarming are far outweighed by the advantages gained. Additionally, it should be evident that these swarming groups have application in all environments, operations of war, crisis situations, and the entire spectrum of conflict. So how should the Canadian Army configure itself to maximize technology network enabled operations and swarming doctrine. Current Army employment plans are predicated on two task forces or battle groups deployed out of Canada at any one time. The current Chief of Defence Staff (CDS) has also expressed a very strong desire to deploy Canadian Brigade headquarters in conjunction with Canadian manoeuvre and combat support and combat service support units to form the basis of a coalition brigade combat team.[72]

The Canadian Army continues to move towards a command centric, knowledge-based force.[73] In its campaign design the Army strategic objective is to be "strategically relevant, tactically decisive, and sustainable." In order to do this, the Army has developed

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[71] *Ibid*., xv.
[72] Department of National Defence, DAD *Force Employment Concept Paper* …, 5.
[73] *Ibid., 2*.

a Task Force model for deployments that it believes will meet the strategic objectives. This model has two infantry companies, one reconnaissance squadron, one field artillery battery, one engineer squadron and, associated sustainment subunits and operation enablers.[74]

This model appears to be weak in a number of the operational functions. Currently, with the command center "big head" Army, Canada has been dedicating significant effort to improve COMMAND and SENSE functions at the brigade and battalion level. However the assets assigned in theory to sense, at the battalion level are wholly inadequate in complex terrain. This would seem to be contradictory considering the CDS's focus on the three-block war. If it is assumed that the Task Force will have the swarming capability as well as more traditional capabilities, it may prove to be advantageous. The current battalion task force model plans on an ISTAR squadron containing a reconnaissance platoon and a surveillance troop. Surveillance radar provides little advantage in complex terrain, as it is a line of sight sensor system, which obviously has limitations when operating in complex terrain, which by its very definition has limited line of sight. Given that the Army is being told to maximize capabilities for complex terrain, the current task force model seems to be unrealistic and inflexible.

Additionally, two infantry companies do not translate into a significant ACT capability, especially when operating in complex terrain. Traditional forces structures employ linear tactics that call for predictable massed formations. Units employing linear tactics rely almost entirely on themselves for fire support and sustainment. Two infantry companies operating in a complex terrain environment such as the urban environment would be incapable of covering a large area of operations and would have a difficult time

[74] *Ibid*., 2.

dealing with a substantial threat. Each task force should be mission tailored to meet the requirements of the operation. This is difficult to achieve however, because the Canadian Army has limited personnel and equipment. Planners at Land Forces Command have to work on assumptions, which in order to achieve long term sustainability, limit the forces available to form task forces.

But these task forces are built around forces employed in traditional roles. If swarming doctrine were adopted however, planners would have significantly more flexibility given that swarming units could fulfill SENSE functions as well as ACT functions. Instead of having a task force of one SENSE sub-unit and two ACT sub-units, a task force could in theory be comprised of three swarm sub-units, which could be employed sensing and acting concurrently or as a commander saw fit depending on a situation. The inherent flexibility of swarming doctrine would have strategic advantages for Army planners trying to regulate operational tempo with limited resources. Yet once deployed, a task force with some swarm capability also provides the tactical commander with flexibility as well as increased capability, especially when compared with a traditionally rolled task force operating in complex terrain. A task force may be called upon to sense the enemy, strike and destroy the enemy, defend and secure localities while at the same time providing command and control as well as sustainment. In order to accomplish all these missions with the limited manpower allocated, all sub-units need to be able to do more than one funcion.

In order to compare and contrast different force structures, it will be assumed that the Canadian Task Force will be operating independently. It will also be assumed that the COMMAND, SHIELD and SUSTAIN functions remain constant. Three task force

models that would maximize the SENSE and ACT functions and consequently the task force model and the Canadian Army's ability to fulfill its role will be compared and contrasted in an effort to determine a suitable TF model.

1. Three swarm sub-units and a battery.
2. Two swarm sub-units, one infantry sub-unit and, a battery
3. One ISTAR sub-unit, One swarm sub-unit, one infantry sub-unit and, a battery

The first option gives a task force commander tremendous capability. Not only would the commander have a tremendous capability to SENSE or find the enemy, he would also have a very significant capability to ACT or fix and destroy the enemy. Three sub-units deploying four-man fire group swarm teams, or light vehicle patrols across the battlefield would be able to cover a wide area. Because the task force would be deploying three swarm sub-units, its situational awareness, even in complex terrain would be greatly enhanced. This superior situational awareness, combined with a battery firing PGMs would give the Task Force commander tremendous capability to fix and destroy an enemy as long as the swarm units could remain elusive, which may well be predicated on the indigenous population being friendly and the geographic area of operations allows for mobility. Another potential disadvantage is that the task force would have difficulty attacking any well-prepared defensive position, as swarm units are at a disadvantage in any form of sustained close combat in restricted areas where they are unable to disengage and disperse. The task force commander would, however, have an incredibly capable unit when it comes to operations other than war and low intensity conflict as well as domestic operations.

The second option balances the requirement for SENSE and ACT functions. With a traditional infantry company and all its weapons and capabilities as part of the task force, the task force commander has a better ability to attack prepared defensive positions, defend or guard perimeters and operate in an environment of a hostile indigenous population. This would be fairly limited, but nonetheless the task force commander would have a better-balanced force. The commander would still maintain a significant SENSE capability with its two swarm sub-units, however, it would increase its ability to operate in restrictive areas of operations with the infantry company.

The third option seemingly puts more emphasis on the SENSE function, with a balanced leavening of swarming and conventional sub-units to round out the task force. In reality there is a reduction in the ACT function ability with no real increase in the SENSE function when the task force is employed in complex terrain. The task force commander's ability to complete missions during operations other than war is still good but he now suffers from a greatly reduced ability to operate in restrictive areas of operation, attack strong points and defend and secure terrain.

Whatever the option when a truly SENSE only sub-unit is replaced by a multi purpose swarm sub-unit, the task force commander's capability as well as his flexibility is increased. This paper does not advocate the outright dismissal of the ISTAR squadron of the task force, however, instead of three sub-units capable of different things, perhaps, multipurpose swarm units could form a potion of the task force. If the deciding factor on force composition is available manpower, the ISTAR sub-unit would seem to offer the least reduction in capability if replaced because the swarm sub-unit would continue to do many of the SENSE function requirements. That is not to say that the ISTAR squadron

wouldn't be sorely missed, only that given the limitation of manpower; an objective assessment of what the squadron provides to the task force in comparison to the swarm sub-unit leaves one with the inevitable conclusion that in complex terrain, the swarming sub-unit is preferred. It would seem advantageous that the ISTAR sub-unit should become a swarming sub-unit as a basis of the task force, if not more of the sub-units. In theory this would mostly mean a change in doctrine and training with some changes in equipment, allocations and force structure at the tactical level.

In an ideal World, if the Director General Land Staff were able to call upon additional forces, a task force would have a ISTAR sub-unit with a force mix of swarm and conventional infantry sub-units task-tailored to the environment that the task force will be operating in. In many ways it is naïve to imagine that the "cookie cutter" task forces that the Army is currently envisioning will meet the needs of any future mission nd the Army will inevitably fid itself wanting with the current Task force structure. If force generation is the restricting factor, then greater flexibility must be built into the force structure in order to be able to meet the operational requirements of a wider range of missions. Swarming units would seem to meet the need for more flexible units.

If a decision were made to generate swarm capable units a number of changes would need to be enacted. These changes can be grouped into two categories: equipment and, training/doctrine. The actual amount of equipment required should prove to be relatively inexpensive to develop and acquire. As previously stated personal secure digital communications devices already exist; small cheap GPS systems are readily available; equipment to designate targets so that sensors can reach back to a shooter for the right effects is available and improving; precision guided munitions have developed

to a degree where they are easily employed. The indirect fire sub-unit in the task force might however, need to acquire different delivery systems as the 105mm Howitzer is currently incapable of handling PGMs. However even 120mm mortars are capable of firing PGMs and these mortars are also available to be bought without any further research and development. Additionally, air-delivered means such as laser-guided bombs and JDAMS which already exist and are being currently employed in conflicts must continue to augment the firepower of swarm units. The Navy may need to acquire a shooter system capable of precision shore bombardment, but this should prove to be simply a "bolt on" option without the need for any capital procurement project. Some improved anti-personnel and anti-material weapons may also assist the swarm teams and examples of improved sniper rifles, automatic grenade launchers, and lightweight anti-tank missiles are already being acquired by the Canadian Army. UAVs are already being deployed with task forces, but there needs to be more of them at lower tactical levels to improve situational awareness. These sorts of UAVs are available in the world today at relatively inexpensive prices.

Swarming would also affect training to some degree, although the extent may not be severe. Certainly, junior leadership courses would require some amendment, although the foundation of these courses would be unaffected. The tactics package of these courses would need to be amended and training in new communications equipment and target designating equipment would also be required. Training, especially collective, would need to become more and more joint to allow for improvement in inter-service operations that swarming would most certainly entail. Other than these adjustments to training, there would seem to be little other requirement for amendment and therefore would seem to

also provide a good argument to adopt swarming as it doesn't require a major change to existing career training.

CONCLUSION

The adoption of swarming doctrine would provide the Canadian Army and arguably the Canadian Forces with an extremely capable, highly flexible, and strategically deployable asset. The arguments for swarming far outweigh any disadvantages. Swarming would deliver more "bang for the buck" and would not entail a large expenditure of monies to adopt. In fact, the realization is that a change to swarming would not create much disturbance to force structure. The Army is already predisposed to swarming given its mission command philosophy, small unit competency and the initial steps towards transition to a network-centric based concept of warfare. Additionally the Army's strength in superior junior leaders and the individual training system that supports and produces them could ease the transition to swarming as it is already in place. Swarming can provide the Canadian Army with a force structure that is relatively inexpensive, but still very capable. Swarm units are employable across the entire spectrum of conflict and in crisis or stability operations. Swarming has applications in non-linear as well as non-contiguous environments and therefore could prove invaluable in meeting the modern asymmetric threat.

Effect-based operations supported and enabled by network-centric warfare is the stated way of the future for the Canadian Forces and swarming provides a system to prosecute these concepts. Therefore it would seem that the adoption of a swarming doctrine would prove to be very advantageous.

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