DLCD Sensor Mix Study

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Technical Memorandum
DRDC CORA TM 2008-043
November 2008

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Abstract

This Technical Memorandum describes the first phase of the DLCD Sensor Mix Study which was conducted in February 2008. The objective of this study was to evaluate how sensor mixes contribute to mission success in a number of vignettes across a range of formation levels (from Section to Battle Group).

In February 2008, a brainstorming seminar was held at DLCD in Kingston with members from the 2nd Electronic Warfare Squadron. During the seminar, the subject matter experts discussed the utility of various sensor types for each vignette, and brainstormed a number of sensors that would be useful in each situation. The main themes that emerged from the seminar included the desire for extensive use of UAVs with electro-optical and infrared imagers as well as the potential to use aerostats as sensor platforms on more static missions (e.g. Forward Operating Base defence). Perhaps owing to their expertise in the field, the SMEs discussed the potential use of electronic warfare sensors for each vignette.

It was decided that a second brainstorming phase was required with subject matter experts from other intelligence, surveillance, and reconnaissance communities to get a holistic view of the sensors. Following this, a more in-depth study involving sensor suites and virtual wargaming will provide more information to military decision makers.

Résumé

Ce Mémorandum Technique décrit la première phase de l'étude sur les combinaisons de senseurs menée par la DCSFT en février 2008. L'objectif de l'étude était d'évaluer comment différentes combinaisons de senseurs contribuent au succès d'une mission, et ce pour des niveaux de formation allant de la section au groupement tactique.

Une séance de brain-storming a été tenue par la DCSFT en février 2008, à Kingston, avec les membres du 2ième Escadron de guerre électronique. Au cours de ce séminaire, des experts en la matière (EM) ont discuté de l'utilité de divers types de senseurs pour chacune des vignettes, et lancé des idées au sujet des senseurs qui seraient utiles dans chaque situation. Les principaux thèmes qui ont émergé de ce séminaire ont été le souhait d'une utilisation soutenue d'UAVs dotés de senseurs électro-optiques et d'imageurs infra-rouges ainsi que la possibilité d'utiliser des aérostats comme plates-formes de senseurs dans le cas de missions plus immobiles (ex. défense des bases d'opération avancées). Probablement à cause de leur expérience dans le domaine, les experts participant ont discuté de l'utilisation potentielle de senseurs de guerre électronique pour chacune des vignettes.

Il a été décidé qu'une seconde séance de brain-storming serait nécessaire avec des experts provenant d'autres communautés reliées au renseignement, la surveillance et la reconnaissance afin d'obtenir une perspective holistique des senseurs. À la suite de cette seconde séance, une étude plus en profondeur incluant différentes combinaisons de senseurs et l'utilisation de jeux de guerre virtuels pourra fournir davantage d'information aux décideurs militaires.

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Executive summary

DLCD Sensor Mix Study:

Ian Chapman; DRDC CORA TM 2008-043; Defence R&D Canada – CORA; November 2008.

Introduction: Owing to the rapid pace of technological development in the sensor field, military decision makers face a myriad of sensor technologies to select from when considering equipment requirements. To obtain a better understanding of the contributions of sensors to mission success, Directorate of Land Concepts and Designs (DLCD) – Concepts 3 requested a sensor mix study.

The Land Capability Development Operational Research Team (LCDORT) assisted in the definition of questions for the study, and planned an Information Preparation of the Battlefield (IPB) activity to assess the utility of a variety of sensors in a number of vignettes with formation levels ranging from Section to Battle Group (BG). Owing to staffing constraints, this activity was reduced in scope to a brainstorming session with several Subject Matter Experts (SMEs) from 2nd Electronic Warfare Squadron (2 EW Sqn) from Canadian Forces Base Kingston.

Results: During the brainstorming session, the SMEs discussed eight vignettes which were believed by the sponsor to be representative of a broad spectrum of military operations. Most of the vignettes had a basis in a Counter Insurgency (COIN) scenario, with the final vignette focused on a conventional force-on-force battle. Maps of urban and rural areas from Iraq, Afghanistan, and Southeastern Ontario were used to stimulate the discussions and focus the SMEs on the strengths and limitations of sensors.

As they had recent operational experience with EW sensors, the SMEs discussed how these could be used in many of the scenarios. This was not surprising, given their occupational bias toward EW sensors. Among the other main themes from the session, the SMEs felt that the addition of micro and mini Unmanned Aerial Vehicles (UAVs) to the lower level formations would be very useful. The SMEs were also enthusiastic about the use of aerostats for surveillance when missions were relatively non-kinetic. The use of Unmanned Ground Vehicles (UGVs) was also interesting, as these assets could function as beyond-line-of-sight sensors and weapons systems.

Future plans: At the conclusion of the activity, the value of the brainstorming session was apparent, and a follow-on session with a broader community of Intelligence Surveillance and Reconnaissance (ISR) SMEs will be planned. Following this, a more rigorous examination of sensor capabilities will be conducted through an IPB activity and wargaming.

Sommaire

DLCD Sensor Mix Study:

Ian Chapman; DRDC CORA TM 2008-043; R & D pour la défense Canada – CORA; Novembre 2008.

Introduction ou contexte: Avec la progression rapide des technologies dans le domaine des senseurs, les décideurs militaires font face à une myriade de choix lorsque vient le temps de déterminer les besoins en équipement. Afin d'obtenir une meilleure compréhension de la contribution des senseurs au succès d'une mission, la Direction des Concepts et Schémas de la Force Terrestre (DCSFT) - Concepts 3 a demandé la réalisation d'une étude sur les combinaisons de senseurs.

L'équipe de recherche opérationnelle du développement des capacités de la Force Terrestre (LCDORT) a fourni son aide pour définir les questions de l'étude et a planifié une session de préparation d'organigraphes du champ de bataille pour le renseignement (IPB) afin d'évaluer l'utilité d'une variété de senseurs dans une série de vignette couvrant les niveaux de formation allant de la section au groupement tactique. À cause de restrictions de personnel, cette activité fût réduite en champ à une séance de brain-storming avec des experts en la matière provenant du 2ième escadron de guerre électronique, situé à la Base des Forces Canadiennes de Kingston.

Résultats: Au cours de la séance de brain-storming, les experts ont discuté de huit vignettes qui représentaient, selon le commanditaire, un spectre suffisamment large d'opérations militaires. La plupart des vignettes étaient basées sur des scénarios d'opérations contre-insurectionnelles, à l'exception de la vignette finale qui était basée sur une bataille conventionnelle à forces égales. Des cartes de zones urbaines d'Irak, d'Afghanistan et du sud-est de l'Ontario ont été utilisées afin d'animer les discussions et focaliser l'attention des experts sur les forces et les limites des senseurs.

À cause de leur expérience récente avec des senseurs de guerre électronique, les experts ont souvent discuté de leur utilisation dans les divers scénarios fournis. Il ne s'agissait pas là d'une surprise étant donné leurs prédispositions professionnelles. Parmi les autres thèmes majeurs abordés au cours de la séance, les experts ont exprimé que l'ajout de véhicules aériens sans pilote (UAV) de tailles micro et mini serait très utile. Les experts ont aussi montré de l'enthousiasme pour l'utilisation d'aérostats pour la surveillance dans le cas de missions relativement immobiles. L'utilisation de véhicules terrestres sans pilote (UGV) a aussi été considérée intéressante puisque ces ressources pourraient être utilisées comme senseurs et armes en dehors des zones sous visibilité directe.

Activités futures: À la conclusion de l'activité la valeur de la séance de brain-storming est apparue évidente. Une seconde séance, avec la communauté plus large du renseignement, de la surveillance et de la reconnaissance (ISR), sera planifiée. À la suite de cela, un examen plus rigoureux des capacités des senseurs sera menée au moyen d'une activité d'IPB et de simulation par jeu de guerre.

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Acknowledgements

The author wishes to acknowledge the contribution of Mr Fred Cameron, LCDORT team leader for his advice in developing the activity. Thanks also go to Major Jim Terfry and Major Thomas Burke for their guidance and inputs as sponsors of the study. Finally, the author wishes to thank the participating members of the 2 EW Sqn for their opinions and insights, which will serve to further guide this project in the future.

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1 Introduction

1.1 Background

As discussed in *Land Operations 2021*[1], technological development is continuing at a frenzied pace in the early 21st century. Electronics manufacturers continue to develop innovative ways to condense components on circuit boards. This has led to increasingly capable computers as well as to increasingly small computational powerhouses (witness the spectacle of 2007's buzz technology: Apple's iPhone™).

Technological progression has also led to the development of novel and improved sensors. Many of these sensors can be seen in consumer life, for example: RFID (Radio Frequency Identification) tags are becoming an increasingly prevalent means of tracking inventory, and solid state accelerometers and infrared detectors are being incorporated into video-game hardware (e.g. Nintendo Wii™ [2]).

As novel sensors continue to be introduced, the maturation of other sensor technology has led to reductions in costs and resulted in an explosion in the number of surveillance cameras in use. London, England is believed to be the city with the most security cameras in the world, and it is estimated that an average person can expect to be "seen" by over three hundred Closed Circuit Television (CCTV) cameras per day [3]. Surveillance cameras are now nearly ubiquitous, installed in shopping malls, in parking lots, in public transportation depots, on street corners, etc. While the main impetus for the installation of these cameras is to prevent or solve crimes, cameras have also been used to automatically monitor traffic and punish speed and stop-light infractions. A result of all of this persistent surveillance is a pervasive sense that "Big Brother is watching."

In addition to affecting civilian lifestyles, the increasingly sophisticated sensor and computing technology can be put to use in a military setting where it will provide future soldiers with unprecedented situational awareness. According to the Army of Tomorrow concept, these sensors will allow soldiers to dominate the information battlespace, providing vital information for the full spectrum of operations (from Peacetime Military Engagement to Major Combat).

1.2 Sensor Mix Study

The Directorate of Land Concepts and Designs (DLCD) – Concepts 3 requested an operational research study to determine the level of success (or failure) of different combinations of sensors throughout the continuum of operations. The study was to look at sensor mixes from the company level up to battle group level under a variety of mission and terrain requirements. Since DLCD is responsible for the development of the Army of Tomorrow (AoT) concept [1], the study was to have a near-future focus, considering sensor systems that could be available in the next five years through commercial or Defence Research and Development Canada (DRDC) sources.

Through refinement of the study objectives, a list of sub-questions was created in order to give focus to the study activity. The proposed sub-questions fell into three general categories: sensor mix composition, sensor use, and data fusion and accessibility. These questions are discussed below.

1.2.1 Sensor Mix Composition

1.2.1.1 For each vignette and force size, what sensors should be used?

This is the main question raised in the project definition form. In each vignette and force size, different threats will be presented. In conjunction with the sponsors, several sensor suites, or treatments, will be developed and it will be up to an expert to use each of these suites in an Intelligence Preparation of the Battlefield (IPB) to counter the threat.

Using a Geographical Information System (GIS), such as ESRI Canada's ArcGIS™, sensors of various types can be emplaced on virtual terrain and fields of view calculated using operational parameters of the sensors. Once this is complete, the maps will be presented to an impartial expert who will critique the sensor coverage and provide judgements and insights on the utility of the sensor suite.

Sensors in the suites should be based on current or near-future systems, and should have well known operational parameters. Also, as with all current and future procurement, the sensor suites should address the Army of Tomorrow capability requirements. It is also important to obtain detailed terrain maps for the vignettes, as elevation data is essential to constructing accurate fields of view.

1.2.1.2 How can broad coverage across sensor families and across the electromagnetic spectrum be achieved with a minimum overhead to operators?

Broad-based sensor coverage is highly desirable, as it can provide a "safety net" to protect against enemies camouflaging themselves in one spectrum. However, it is difficult for users to look at data from many types of sensors at once. It may be expensive to provide many types of sensors to cover a single area, but benefits from sensor complementarities and common use of sensor platforms could be worth the cost.

A cost-benefit analysis is required to balance both monetary and personnel costs against the benefits of using multi-tiered sensor coverage. Also, data fusion and analysis systems need to be investigated in order to make sense of a potential deluge of data from a well-covered area.

1.2.2 Sensor Use

1.2.2.1 Where and how should sensors be emplaced?

As they will work with a broad range of sensors, Tactics, Techniques, and Procedures (TTPs) are required to instruct operators on appropriate locations to emplace sensors. Certainly, some sensors will be limited by their capabilities (e.g. seismic sensors can only be placed on the ground), but when a sensor can be used in a variety of locations, doctrine will be needed to provide guidance as to the most effective positioning.

A related topic to emplacement is whether or not the sensors should be camouflaged. In some cases, surreptitious surveillance is desirable, and concealing sensors is vital. However, it may occasionally be beneficial to place sensors in prominent locations as this may have a deterrent effect on hostile behaviour.

1.2.2.2 What software is needed/available to plan the emplacement?

Another topic related to the positioning of sensors is the use of software to plan sensor network coverage. An examination of current tools should be undertaken to determine if it will be effective with an increasing number of sensors of various types. Some requirements for so-called “expert software” can be derived from the deficiencies, if any, of current software.

1.2.3 Data Fusion and Accessibility

1.2.3.1 What fusion should be done?

Trends in the development of sensor technology indicate that there will be an explosion in the number and type of sensors collecting data, leading to “ubiquitous sensing” in the decades to come. If the current, human-centric methods of handling data continue to be used, this wealth of data will actually hinder the soldiers’ ability to find and use information relevant to their operations.

A study into the process of data fusion (both how it is done and how data is reduced) is required to plan for the oncoming data increase. It is particularly important to determine how much of the fusion process can be undertaken by intelligent software and how much will still be required of humans (intelligence officers).

In addition to the study on the process of fusion itself, an investigation into emerging methods of effectively sharing information is required. The emergence of a number of information-centric programs on the internet may provide inspiration for what can be achieved in the field. With the shrinking size and continued proliferation of computers, soldiers may be able to use software such as Google Earth, Wikipedia, and MySpace as an effective means to share information on operations (although this might require the installation of surrogates inside the Department of National Defence/Canadian Forces firewall). A study into the art of the possible with these types of programs could lead to the adoption of this type of technology if it is found to be effective.

1.2.3.2 How should fusion be incorporated into Army structure?

As the process of fusion changes with the development of sensor technology, it is important to determine its place in the overall structure of operational units. With increasing amounts of data, there may be a large staff required to conduct fusion. In this case, fusion may need to move upward in the organizational chain of the Army. Conversely, if new software emerges that is capable of handling most fusion activities with no human intervention, fusion centres may shrink and disperse into smaller operational units.

A study of the impacts of both increasing data and increasingly capable software is required to determine what workload fusion will place on staff. An analysis of this information may result in recommendations to change current intelligence (INT) organizations.

1.2.3.3 Who should see what intelligence products?

One of the functional concepts of the Army of Tomorrow is that it must be Network-Enabled [1]. In essence, each soldier and piece of equipment becomes a node in an Army-wide network, and uses the interconnection to dominate the information battlespace. As soldiers down to the lowest levels of the organization become connected to the network, it is necessary to study who should see information, and how much of it, from the sensors.

The study should review the types of products that are available from current INT cells, including different levels of fused data. An assessment of each product should be made for various levels of soldier organization (e.g. single soldier, fire team, platoon, company, etc.) with regard to the utility of the information towards mission success. The study should also assess the security issues with the various products. The study should identify what types of data need to be restricted for what levels, and should discuss the implications of connecting to an international ally's network.

1.3 Study Plan

After a review of the study questions, it was decided that the focus of the study should be on 1.2.1.1 (sensor mix composition for the various missions and force sizes), 1.2.1.2 (ensuring broad coverage across the available sensor families), and 1.2.2.1 (sensor emplacement issues). The scope of the remaining sub-questions was judged to be large enough that separate, related studies would be required to provide answers.

In consultation with the sponsor, an IPB variation on a seminar wargame was planned. A number of vignettes requiring the employment of sensors were generated for the various force sizes. The vignettes had a basis in the Future Security Environment [4] and mainly had Counter Insurgency (COIN) characteristics, although there were several "traditional" combat vignettes included.

A number of Subject Matter Experts (SMEs) were invited to participate in the activity, but constraints on staffing meant that only Electronic Warfare (EW) SMEs were available for the chosen dates. As EW is but one discipline concerned with surveillance, it was decided to implement the study in phases, with SMEs from different Intelligence, Surveillance, and Reconnaissance (ISR) trades participating in subsequent IPB wargames. This paper discusses only the first phase of the study, with the participation of the EW SMEs.

The original intent of the wargame was to have a set of sensor mixes for each force level, and allow the SMEs to deploy these as dictated by the vignettes and terrain chosen. The terrain and vignettes were all modelled using the Joint Conflict and Tactical Simulation (JCATS) as a static mapping application. This procedure was modified during the actual execution phase, and the

SMEs participated in a brainstorming seminar that focused on providing ideas for appropriate sensor mixes for each of the vignettes.

The remainder of this paper discusses a number of trends in the development of sensor technology, a plan of the seminar wargame activity, and results from the execution of the seminar.

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2 Sensor Technology: Key Trends and Upcoming Developments

2.1 Sensor Family Taxonomy

Previous work in the sensor realm [5] has led to a division of sensor technologies into distinct "families." Individual sensor models in a single family share characteristics derived from the underlying sensor technology, but may vary in terms of operational parameters, usage methods, and output. Listed below are several main sensor families with brief explanations of their general capabilities. Any of these sensor families may be leveraged for use in a sensor mix and breadth both within and across the families is considered important in providing a robust capability for force protection.

2.1.1 Electro-Optical Systems

This family is made up of passive, camera-type devices that capture images of areas of interest. They operate in various regions of the electromagnetic spectrum including visible, infrared, and thermal infrared. These sensors typically present a user with a video feed or still image of the field of view of the sensor. Depending on the spectral region being presented, it may require special training for an operator to detect or recognize targets.

2.1.2 Seismic

Seismic sensors are specialized accelerometers that are planted in the ground to detect vibrations caused by the movement of vehicles and people. Seismic sensors may be networked in order to reduce false alarms and to facilitate localization of targets through multiple detections. These sensors tend to have short ranges (~100 meters) and may be used to cue other sensors in order to identify targets.

2.1.3 Acoustic

Acoustic sensors are microphones that are used to detect sound waves travelling through the air and may be used for a number of purposes. When specially configured, acoustic sensors may be used to locate snipers from the signature of their gunfire. Acoustic sensors may also be used in a detection role, programmed to trigger alarms or cross cue other sensors upon detection of specific sounds (footsteps, voices, gunfire, engine sounds, etc.).

2.1.4 Radar/LiDAR

Radar systems are active sensors that generate radio waves to "illuminate" targets and determine their locations from radio reflections. Radar systems can be used either in air defence or ground defence roles. Although the detection of hostile aircraft was not considered for this study, radar can be used to detect incoming subsonic munitions, such as rockets or mortars, and provide probable locations for points of origin. As a ground defence system, radar can be used to track vehicle and human movement near a vital location.

Light Detection And Ranging (LiDAR) systems are similar to radar, but use lasers as the illumination. LiDARs can be used for a number purposes including generating three-dimensional maps of terrain and buildings, detecting and identifying targets, and are used in various spectral remote sensing applications.

2.1.5 Passive Infrared Detectors

Passive Infrared (PIR) sensors are closely related to thermal infrared sensors in the electro-optical family. However, instead of providing an image to the user, these systems detect changes in an infrared scene and can be used to trigger alarms or cue other sensors once motion or temperature changes are detected.

2.1.6 Wireless Sensor Networks

Wireless sensor networks are made up of sensors from various families linked together using radio frequency communication. The sensors in these networks are typically small and inexpensive, but derive much of their value by using intelligent analysis software and cross cueing. These systems are one of the first steps toward the realization of ubiquitous sensing.

2.1.7 Electronic Warfare Sensors

Electronic warfare sensors are designed to intercept and locate enemy radio or radar transmissions. These systems can be used to cue other sensors, or to cue Electronic Attack and jamming capabilities.

EW sensors are currently being used in new ways: detecting cell phone communications and wireless network auras. These applications are particularly useful as these types of technology are being used by insurgents in the Contemporary Operating Environment (COE) as a method to detonate Improvised Explosive Devices (IEDs).

2.2 Technology Trends

2.2.1 Sensor Trends

As mentioned in Section 1.1, sensors continue to develop along with other electronic technologies. One of the main trends being seen in sensor technology is miniaturization. With the rise of nanotechnology, certain types of sensors are shrinking to the size of dust particles [6], which may be spread around an area of interest in order to monitor it.

Research into materials is leading to new types of detectors that have more capabilities than their predecessors. One example of this is the invention of high-temperature infrared detector focal planes, allowing infrared imaging without the need for a cooling medium [7]. By eliminating the need for coolant, this development has allowed a substantial reduction in size for many infrared systems.

As the sensor technologies mature, they will become less expensive. As a result of this, many futurists predict the rise of "ubiquitous sensing." The concept is that sensors, shrunken to the point of being invisible to the human eye, will surround us as a "smart dust" that will be capable of measuring a number of useful parameters.

2.2.2 Data Processing

It is currently possible to collect a large amount of data from sensors, but it requires a great deal of human intervention to make sense of what is collected. It is up to human operators to link related sensor detections and to report on their findings. This will soon begin to change as more powerful computers and programs become available to the users of sensor networks.

There are a number of emerging trends in computing and software that are pointing to changes in the way sensor data will be processed. A good deal of work is going into networking systems of sensors together to gain a more complete picture of the targets they detect. Through intelligent cross-cueing, false alarm rates drop, and multiple sensor types are used to monitor areas of interest.

Another interesting trend in data processing involves recognition software. Computers are currently able to match facial images to databases in order to recognize who they are "looking at" under controlled conditions [8]. Expected developments in this field include the ability for computers to recognize suspicious activities from the actions of humans in front of the camera. With these abilities, the requirement for human supervision of security cameras is greatly reduced, leaving this activity to intelligent processing software.

2.2.3 Power

With a proliferation of sensors comes a requirement for portable power options capable of powering the sensors for long periods of time. This can be achieved in one of two ways: reducing power requirements and increasing battery life.

Reduced power requirements are being achieved through developments in electronic materials and design. Using miniaturized components built from higher-efficiency materials, it is possible to build sensors that use less power, but provide the same level of service as before. It is also possible to use algorithms in the software architecture to "intelligently" power these sensors [9]. Thus, when little or no activity is occurring, the sensor can be put into a sleep mode that uses less power. Also, if a sensor can predict activity patterns of targets, it can draw enough power to perform its duties until the target is out of range.

Increased battery life is being achieved through research into new types of batteries, and is actually benefiting from recent interest in creating electric/hybrid vehicles. Miniaturized versions of fuel cells provide an increased lifetime over standard batteries [9], microcombustion is being used to release energy in small cells [11], and super capacitors can be used to store and release large amounts of energy in short time spans. Other power options being researched include nuclear powered cells and vibration powered cells. These options provide long-lived batteries and would dramatically increase the lifespan of equipment in the field.

Further technological developments such as polymer batteries and power paper provide options in battery shapes and sizes. These trends will allow the development of sensor platforms and cases that need not be restricted by standard battery shapes and sizes.

2.2.4 Networking and Communications

Another technology that has seen explosive growth is wireless communication. Cellular phones are now an all-pervasive technology, with many subscribers in some of the least likely places on Earth (e.g. Iraq, Afghanistan). In highly industrialized nations, many people use wireless networking in their homes to link computers to local networks and to the internet. In fact, a number of cities have begun constructing city-wide wireless networks that enable citizens to connect with no need to use land-line access points.

One of the major trends in this technological area is the increasing data rate that can be achieved by the progressive wireless standards. One such wireless standard, 802.11, has seen several iterations that have increased maximum data rates from 11 Mbit/s (802.11b) to 54 Mbit/s (802.11g). The next iteration in the standard, 802.11n, which will be formally released in 2009, has a maximum data rate of 248 Mbit/s. Early 802.11n devices are already being sold at popular retail outlets in anticipation of this standard.

Alongside increased maximum data rates, wireless network ranges continue to grow. Devices using the 802.11b standard can communicate over distances of ~40 feet indoors and ~150 feet outdoors. When the 802.11n standard arrives, it will achieve communication ranges of ~220 feet indoors and ~500 feet outdoors. Other standards, such as 802.16e (WiMAX), can achieve long range communication (>10 km) and have been used to link remote subscribers to the internet.

Sensors, particularly wireless sensor networks, have begun using intelligent networking to overcome a number of challenges in the field. Sensors in these networks must be capable of self-discovery and creating ad-hoc networks with their neighbours. In this manner, it is possible to use low-energy antennae to communicate through the network with more distant sensors. It is also possible to use this technique in urban areas to get sensors to talk to each other “around corners.” Another useful feature of self-networking is that it can be used for triangulation in order to locate sensors in the field.

2.2.5 Platforms

The Canadian soldier is currently heavily burdened both with the amount of kit he has to carry with him into the field and with the tasks he must perform while he is there. As such, it is highly undesirable to add weight to the soldier as a platform for sensors. As they are added to mission equipment, sensors will need to be carried about in other ways.

One of the first ways that new sensors will enter areas of operations is attached to the vehicles that soldiers use. In order to not distract soldiers from their already busy routines, these sensors will be smart, requiring little to no supervision from the soldiers. Instead, data processors will feed information to the soldiers if it is deemed important enough.

Other platforms for sensors will be provided by unmanned vehicles, as they are developed to assist soldiers in a number of ways. Unmanned Aerial Vehicles (UAVs) will carry various sensor packages to provide situational awareness. Unmanned Ground Vehicles (UGVs) will likely fulfill a number of roles, including logistical support, reconnaissance, and combat. Each of these types of UGV will carry sensors to support their primary function, as well as to provide information to soldiers.

Finally, sensors are currently being connected in wireless networks on platforms called “motes.” These are typically small circuit-boards that can integrate a number of sensor types. These networks are placed in areas of interest, and benefit from the increased intelligence made possible by multiple sensor coverage in a network.

2.3 In Development: Future Canadian Sensor Systems and Platforms

Defence Research and Development Canada (DRDC), the scientific arm of the Department of National Defence (DND), is responsible for developing a number of technologies to assist Canadian Forces in their tasks.

DRDC has partnered with the Army through a number of Thrust Advisory Groups (TAGs) that mirror the operational functions that drive Army capability development (Command, Sense, Act, Shield, Sustain). The following is a brief overview of the Technology Demonstration Projects (TDPs) in progress in the Sense TAG.

2.3.1 Novel Sensors and Sensor Technology

A few projects within the Sense TAG are centred around the development and testing of novel sensors. Recently, much focus has gone to the development of EW sensors in projects such as the Integrated Communications EW Analysis and RF Sensor (ICEWARS) TDP and the KLONDIKE TDP. Other sensor development projects include work on a Through-Wall Synthetic Aperture Radar (TWSAR) and a LiDAR system. While the TWSAR will allow operators to detect targets through walls, the LiDAR is used to generate 3D data that can be manipulated to reveal targets under concealment (e.g. beneath a canopy or under vegetation).

2.3.2 Novel Sensor Platforms

Another focus in the Sense TAG projects is the development of novel platforms for sensors to operate on. One platform, wireless sensor network nodes, is under development in the Self-healing Autonomous Sensor Network (SASNet) Technology Demonstration Project (TDP). The potential for Unmanned Ground Vehicles to carry and/or use sensors is being investigated by the COHORT TDP, which is currently focussing on creating intelligent movement of robots through a complex environment. The Extreme Agility Micro-Air Vehicle is another project that is investigating unmanned vehicles (aerial, this time) for use as sensor platforms in a complex environment.

While the focus of these projects is not necessarily on the sensors themselves, they are developing technology that will be essential to using sensors effectively in the operational environment.

2.3.3 Novel Data Analysis Software

A number of Sense TAG projects deal with data analysis and visualization, as these functions become increasingly important as increasing volumes of data become available from the sensors. Two projects are investigating methods to display 3-dimensional sensor data to users in an intuitive manner, to facilitate easier and faster analysis by operators of sensors (especially LiDAR and SAR). A suite of intelligent software to incorporate sensor feeds in an urban environment, SCIPIO, is being developed to assist both commander decision making and route planning. The ALERT TDP provides new analysis capabilities for the Coyote sensor suite, allowing monitoring of scenes for changes, data fusion and visualization, and automated sensor cueing. Another TDP, Soldier Information Requirements (SIREQ) investigated methods to provide information to dismounted soldiers from various sensor sources.

While the novel sensor technologies and platforms will provide soldiers with more data, intelligent software packages will allow them to understand those data better and to make better decisions. It is this capability that will allow an increase in the number of sensors (and sensor types) on the battlefield, as it will reduce the issue of data overload for sensor operators.

3 Brainstorm Seminar

3.1 Seminar Plan

The original intent for this study was to conduct an Intelligence Preparation of the Battlefield for a number of vignettes using a variety of sensor suites for each. After an evaluation of where this plan would lead the study, and the types of evaluation that would be possible in a seminar wargame activity, the study plan was adapted into a brainstorming seminar with the participation of SMEs. It was felt that this type of activity would provide useful initial results that would lead to a better understanding of the issue of sensors on the battlefield, and thus allow the study sponsors to design potential sensor suites from a more informed position. Furthermore, owing to restrictions on staffing, the only available SMEs for the chosen period of activity were from the EW community, and thus surveillance and reconnaissance SMEs from the infantry and armour communities were not represented. Since the brainstorm activity is easily repeatable, a phased approach would allow follow-on brainstorming seminars to capture these additional SME opinions at a later date.

The brainstorm seminar was scheduled for February 14 to 15, 2008 in one of the DLCD conference rooms. The first day was to consist of a briefing on the goals of the study and some general discussion of Intelligence, Surveillance, Target Acquisition, and Reconnaissance (ISTAR) issues, followed by brainstorming useful sensors and employment methods for several of the vignettes. The second day would resume with brainstorming for the remainder of the vignettes, followed by a hotwash summarizing the main points brought out for each of the vignettes.

To focus the brainstorming sessions, a JCATS workstation was used to map out the vignettes. From the DLSE terrain catalogue, several locations were chosen to represent vignette locales. The data used included terrain from Afghanistan and Iraq, a map of the city of Fallujah, and terrain from Southeastern Ontario. The data used to represent each vignette are described in Section 3.2, and an attempt at varying terrain was made so that the focus did not centre too much on the current theatres of operations. An operational research analyst operated JCATS to position and orient units in accordance with the guidance of the SMEs.

Given the vignette and the terrain, the SMEs were asked to discuss the sensor needs for each mission. The sensors that could be used in the vignettes included in-service equipment and near future sensors, although free-thinking was encouraged in case the sensors discussed in the in-brief were not sufficient for the missions. Each vignette was discussed in succession, with the study sponsor acting as a discussion moderator, and an operational research analyst acting as scribe to capture the relevant points of discussion.

3.2 Vignettes for Investigation

In the lead-up to the brainstorming seminar, the sponsor developed eight vignettes for investigation. The vignettes were deliberately chosen to be varied in scope, purpose, and mission to reflect both the COE and the operational environment predicted for the near-future in Future Security Environment [4]. Heavy focus was placed on COIN-type operations, although one of the vignettes did deal with a conventional-style conflict. The vignettes were also deliberately generic so as to not focus completely on Afghanistan.

The following subsections describe each vignette and include an indication of the type of terrain and of the OPFOR. Each vignette was matched to a piece of terrain from the DLSE catalogue, and these matches are indicated in the descriptions.

3.2.1 Section Patrol Task – Urban

A section is conducting a dismounted patrol in a dense, low-rise urban environment. The buildings are of mud-brick or cinder block construction with numerous walled compounds and back alleys. The section comes under attack by the OPFOR, which consists of 1 or 2 riflemen sniping at the dismounted section.

The terrain from the DLSE catalogue that best fit this vignette was from Fallujah, Iraq. A box approximately 1 km by 1 km was selected from an area heavily populated with buildings in the centre of town. This section was chosen to give the patrol a large challenge when attempting to locate the snipers due to the abundance of hiding places and short sightlines.

3.2.2 Platoon Convoy Escort – Rural

A platoon-sized convoy security element is escorting a Combat Service Support (CSS) convoy through a rural, desert-type environment, similar to what could be found in Helmand province, Afghanistan or the Darfur region of Sudan. The area is characterized as a semi-arid plain with shallow cut wadis (dry riverbeds) bounded by rugged mountains. Little cover is provided by the terrain, other than the mountains in the distance. The convoy is struck by an IED, which serves as the initiation of an engagement by 4 – 6 dismounted OPFOR armed with small arms (AK 47s) and RPGs.

The DLSE catalogue includes a large amount of terrain from Kandahar province, Afghanistan, much of which resembles the described features. A 5 km by 10 km area from the Kandahar terrain was selected for this vignette. Although little ground cover is available in this location, the attackers could take advantage of the wadis as hiding places, keeping them protected from line-of-sight sensors. The mountains in the distance make an excellent place to hide if the attackers are able to escape the immediate engagement by the convoy security element.

3.2.3 Section Observation Post – Rural

A "section+" (2 vehicles) has taken up position in a rural area similar to Helmand province, Afghanistan for an Observation Post (OP) tasking. The area is in a desert, with shallow cut wadis and rugged mountains in the distance. While on post, the section is under threat of attack by a standoff rocket attack from 5 – 7 km away. The OPFOR consists of a small group of attackers (2 – 3 men) who will emplace and launch the rockets at the OP.

Another area from the Kandahar province terrain was chosen for this vignette. The OP was placed near an important crossroads in an area bounded by a 10 km by 10 km box. Because of the rugged terrain in the distance and the range of the rockets, this vignette would be especially challenging for a section to manage.

3.2.4 Platoon Observation Post – Rural

This vignette involves a platoon that has set up an OP in an arid rural area, with similar terrain to that described in Section 3.2.3. The OPFOR in this vignette consist of a dismounted group of about 6 riflemen, who will probe the OP perimeter and engage in a standoff RPG attack.

Again, the Kandahar province terrain was used for this vignette, but another 10 km by 10 km area was chosen for the terrain. This time, the OP was positioned near a small compound of buildings, placing them under observation. This terrain provided little cover for any attackers who would have to make a close approach to the OP position before being within attack range.

3.2.5 Company Forward Operating Base Security – Rural

A company has established a Forward Operating Base (FOB) in an open rural setting. The FOB is located in an arid environment with little ground cover, shallow wadis, and mountains in the distance. The threat in this vignette consists of standoff rocket and mortar attacks from distances of 5 – 7 km and 3 km, respectively. Two teams of attackers, with 3 – 5 men each will emplace and launch the projectiles.

A large, open, 10 km by 10 km area in the DLSE Kandahar terrain was chosen for this vignette. Mountains and small hills in the terrain provide excellent locations for the OPFOR to launch their attacks, and will challenge Blue surveillance assets.

3.2.6 Company Cordon and Search – Complex Rural

A company has been tasked with a cordon and search operation in a complex agricultural area akin to the Panjwai district of Kandahar province. The OPFOR in this vignette is comprised of 20 OPFOR dismounts spread amongst 4 – 5 buildings in a compound complex.

A 10 km by 10 km area was chosen from the Panjwai district of the DLSE Kandahar terrain for this vignette. Although not represented in the terrain, the vignette calls for an area filled with mud-walled compounds and grape huts, which will hinder mobility and provide concealment for the OPFOR. It was up to the participants to take these features into consideration in their discussions.

3.2.7 Combat Team Attack – Complex Rural

In this vignette, a combat team is tasked with attacking a group of 25 OPFOR in a prepared defensive position. OPFOR is armed with small arms, mortars and recoilless rifles (SPG-9). This vignette also takes place in terrain similar to the Panjwai district of Kandahar province, with numerous compounds and grape huts providing concealment and hindering movement.

A 5 km by 5 km area in the DLSE Kandahar terrain was selected for this vignette, and again, it was up to the participants to imagine the building features in their discussions of the operation.

3.2.8 Battle Group Defensive Operation – Mixed

The final vignette is more conventional in nature, with the Blue Battle Group (BG) in a prepared defensive position with a frontage of approximately 4 km. The terrain for this vignette is a mixture of rural and urban, with battalion-sized avenues of approach to the Blue position through more close terrain. The OPFOR consists of 3 BGs of motorized infantry (BTR-70) with tank support (T-72).

A 10 km by 20 km area near Gananoque, Ontario was chosen from the DLSE terrain catalogue, as there are numerous terrain features throughout the region to challenge forces. Included in the terrain are a number of lakes, rivers, forests, farm fields, and villages, providing both open and close terrain that would affect plans of attack.

3.3 Seminar Orders of Battle and Baseline Sensor Equipment

The vignettes in Section 3.2 involve Blue formation levels from section size all the way up to BG size. This allowed the sensor requirements for a range of mission types and formation levels to be evaluated. For each formation level, an Order of Battle (orbat) was produced, based on the AoT concept. Each formation level also had a baseline sensor suite available to it, based off of the DLR in service sensors report from 28 Sep 07 (see Annex A) and the sponsor's opinion of technology that will be available in the next five years.

The following subsections describe the orbats and the baseline sensor capabilities of the formations used in the seminar.

3.3.1 Section Orbat

Figure 1: The Army of Tomorrow infantry section.

The infantry section, shown in Figure 1, is organized with a section commander and two fire teams. Each fire team consists of a team leader, grenadier, automatic rifleman, and rifleman. Each section is transported in its own Light Armoured Vehicle (LAV) with a vehicle commander, driver, and gunner.

For the purposes of this seminar, the standard sensor equipment for an AoT infantry section includes the sensors on the LAV and those carried by the dismounts. The LAV sensor suite consists of the commander's day sight, the commander's image intensifier (II) sight, the gunner's day sight, and the gunner's thermal imager (TI) sight. The dismounts' sensors include M22 binoculars, light weight binoculars, two NODLR MLIs, the C7/C9 optical sights, Night Vision Goggles (NVG) with 3rd generation II, and a Small Unmanned Ground Vehicle (SUGV) with electro-optical (EO) and infrared (IR) imagers. There is no dedicated SUGV operator in the section; rather, the commander delegates operation of the robot to one of his section members.

3.3.2 Platoon Orbat

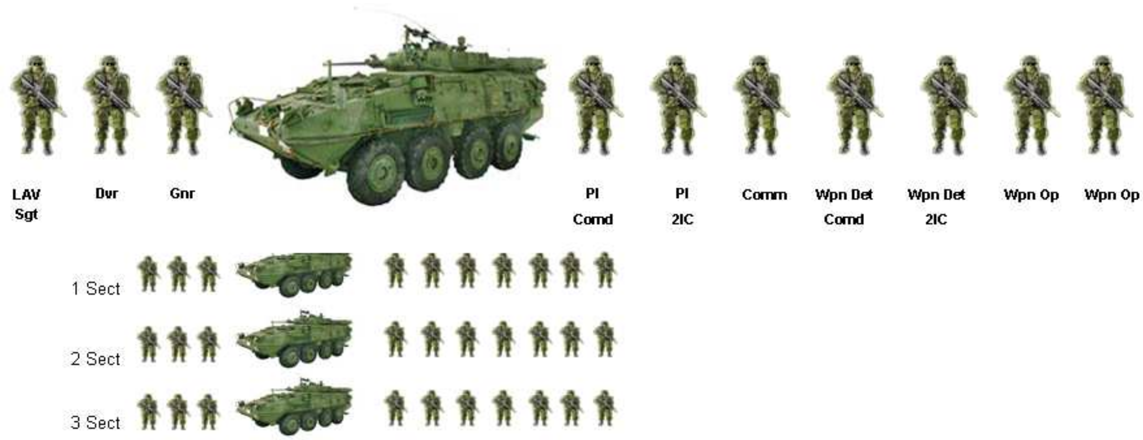

Figure 2: The Army of Tomorrow Rifle Platoon.

The rifle platoon, shown in Figure 2, is organized into a platoon headquarters (HQ) and three ten-man infantry sections. The platoon HQ consists of the platoon commander, a platoon second-in-command (2IC), a communications specialist, a weapons detachment commander, a weapons detachment second-in-command, and two weapons operators (one of whom serves as a robotics specialist), as well as a vehicle commander, driver, and gunner for the platoon HQ LAV.

The sensor suite for the platoon consists of three sets of the previously described section suites along with several platoon-level assets. The platoon sensor assets include the HQ LAV commander's day sight and II sight, the HQ LAV gunner's day sight and TI sight, a micro UAV with a charge coupled device (CCD) optical camera, an Armed Robotic Vehicle – Assault (ARV-A) with optical and IR sensors, and a Maxi-Kite night vision system.

3.3.3 Company Orbat

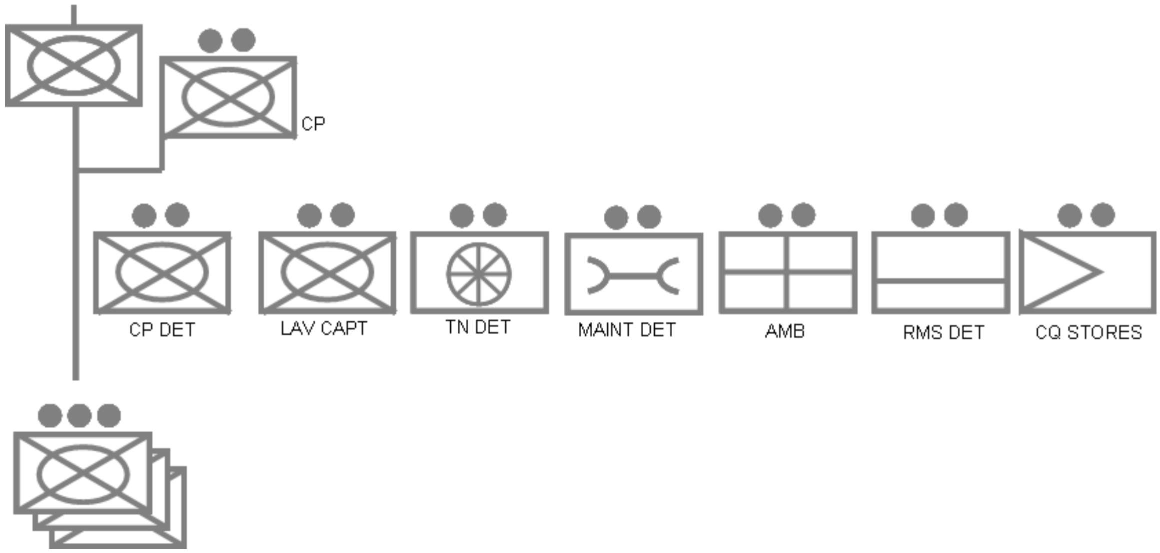

Figure 3: The AoT Company.

Figure 3 depicts the organizational diagram of an AoT Company. The integral elements of the AoT Company are the company HQ and three AoT rifle platoons. The headquarters is comprised of the company commander, executive officer, first sergeant, vehicle commanders and drivers. The company HQ also includes two fires and effects non-commissioned officers (NCOs), one command, control, communications, and computers (C4) NCO, one robotics NCO, one supply NCO, one trauma NCO, and one chemical NCO. The HQ is equipped with one infantry carrier vehicle (ICV), one command and control vehicle (C2V), one future tactical truck system – command and control (FTTS-C2), and one future tactical truck system – support (FTTS-SPT). Not included in the considerations of this seminar were the company's affiliated echelons.

For the seminar, the company's sensor suite consisted of three sets of the platoon assets, as described in Section 3.3.2, the vehicle sensor assets for the company HQ, and a number of company-level sensor assets. The company-level assets include three mini-UAVs with EO/IR cameras and an unattended ground sensor (UGS) system. The UGS system consists of a large number of semi-autonomous sensor nodes that can be placed on the battlefield and left to conduct their own surveillance, contacting operators when significant detections have been made.

3.3.4 Combat Team Orbat

For the purposes of this seminar, a combat team was defined as an AoT company accompanied by twenty Leopard 2 main battle tanks (MBTs). The sensor suite for the combat team consisted of the combination of the company sensor suite as described in Section 3.3.3 with the sensor components of the twenty Leopard 2 MBTs. The Leopard 2 tanks contributed twenty each of the optical sights, TI sights, and laser range finders (LRF). There were no other sensor assets that were unique to the combat team.

3.3.5 Battle Group Orbat

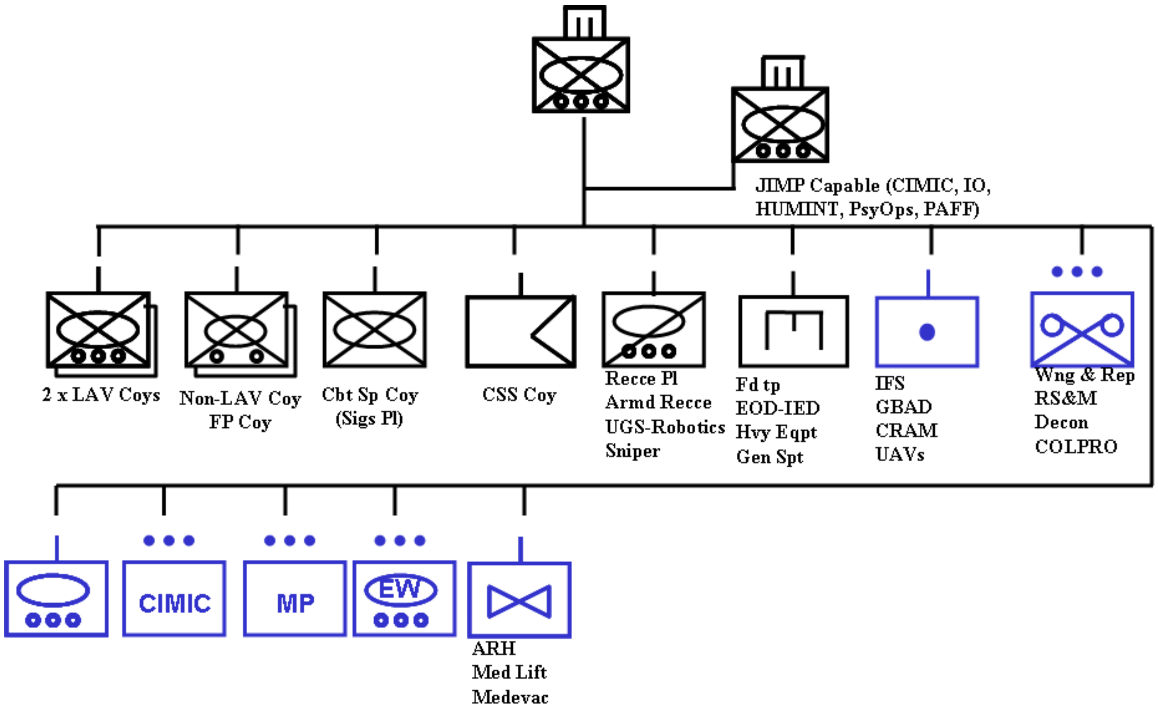

Figure 4: The AoT BG Orbat.

The AoT BG orbat, depicted in Figure 4, comes from the DLCD Optimized Battle Group (OBG) experiment. For the purposes of this seminar, the sponsor directed that the BG sensor suite was to be comprised of the sensors from three LAV companies, as defined in Section 3.3.3. It was unclear what additional, BG-level sensors would be available, so the participants were given more free reign for this part of the activity to come up with other potentially useful sensor systems.

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4 Results

4.1 Brainstorming Seminar Execution

The brainstorm seminar was held from 14 to 15 February 2008. As discussed earlier, officers representing a number of combat specialties were invited to attend an IPB-style wargame, but staffing constraints did not allow many of these SMEs to participate.

Fortunately, CFB Kingston is home to 2nd Electronic Warfare Squadron, and several NCMs were available to participate in the brainstorming seminar. Two Master Corporals and one Sergeant from 2 EW Sqn took part in the two day seminar, and provided their expertise as users of surveillance equipment. While the focus of these SMEs was on EW sensors, their previous experience in the CF allowed them to comment on the use of other sensor equipment.

The seminar began on 14 February with a briefing from the OR analyst and the study sponsor to familiarize the SMEs with the objectives of the study and the scenario and vignettes chosen as test cases. A general discussion of a number of issues in the EW domain followed, allowing the OR analysts and the sponsor to get a sense of the state of this profession.

After the general discussion, each of the vignettes in Section 3.2 was dealt with sequentially. Each vignette was first displayed as a JCATS screen, with a brief description of the context to set the scene. Through this method, it was determined that a number of the vignettes were lacking sufficient context for the SMEs to comment. In these cases, a further development of the context was made with the sponsor, with inputs from the SMEs based on their recent operational experiences in Afghanistan. Where further context was injected into the vignettes, this has been noted in the appropriate subsection in Section 4.2. Once the scene for the vignette was set, the SMEs provided their advice for the types of sensors that would be most useful.

On 15 February, after all of the vignettes were discussed, a review of the discussion points for each vignette was performed to ensure that the appropriate remarks had been captured, and that these still reflected the opinions of the SMEs. The seminar was then adjourned.

4.2 Judgements and Insights

The following subsections contain the opinions of the SMEs from the brainstorming seminar held from 14 to 15 February 2008. The first subsection deals with general issues in the EW domain while each of the subsequent subsections deals with the sensor requirements for the specific vignettes. The opinions expressed in this forum were taken as the SME opinion, not necessarily that of the Canadian Land Force.

4.2.1 General EW Comments

The session began with a discussion of the analysis software that is used in the Mobile Electronic Warfare Technology (MEWT). The SMEs felt that the software, developed by xwave, was too complicated to use, and thus is not employed in theatre. Rather, Microsoft Word is used to prepare reports and transfer intelligence. The SMEs indicated that new analysis software needs to be developed and that it must be rugged, yet simple to use. A modular toolset with standard data/document formats would be best, and the SMEs indicated that the analysis processes would be adapted to the software as required. Among the capabilities required of the software is the ability to do two lines of analysis (one to identify important signals, and one to determine the meaning of the intercepts). Also, MEWT operators are currently using Netmeeting and chat software to pass information quickly. These chat capabilities should also be a part of the new analysis software package.

In addition to suffering from an unwieldy analysis toolset, MEWT operators, in general, do not have a full understanding of electronic warfare until their deployment. The reason for this deficiency is a lack of training in EW techniques while within Canada. Due to privacy concerns, EW operators are not allowed to train on Canadian soil, and thus are required to learn on the job once deployed in theatre. Contributing to the training issue is the lack of a lessons-learned process due to the highly classified nature of EW work. The SMEs indicated that this often led to operators making the same mistakes as previous rotations. It was acknowledged that there is a need for some kind of lessons learned process to facilitate training.

The SMEs identified local cultural advisors (LCAs) as critical resources to mission success. These Afghan-Canadians worked with the EW operators to provide translation and context information for the intercepted signals. LCA burnout was a big issue in theatre, as there is not a large resource pool to draw from, and the varying competence levels of the advisors led to the more competent LCAs being used more often. The SMEs indicated that language training for the operators would be very useful, although they would still require LCAs to provide contextual information. In the end, the LCAs were identified as extremely valuable assets, and are actually a type of human intelligence (HUMINT) or cultural intelligence (CULTINT) sensor.

4.2.2 Vignette: Section Patrol Task – Urban

During the seminar, the SMEs were not satisfied with the limited context of the vignette, and thus wanted to make some further assumptions before discussing the sensors. The first issue was that the scenario would not have played out this way in Afghanistan, as the environment is so hostile that the section would not be so distant from its platoon. Thus, the SMEs considered this vignette to be taking place in a less hostile environment. Next, it was unclear what the purpose of the patrol was. Since sniper fire is only a threat to the dismounts, the SMEs assumed that the task was a dismounted presence patrol, with the LAV rolling along behind. The last assumption made by the SMEs is that the sniper fire did not injure any of the patrol. This allowed the patrol to fully and immediately prosecute the threat, as opposed to tending to the wounded.

Once the sniper attack has occurred, the commander may choose to begin gathering data with the MEWT. This could be a potentially useful action if the sniper was acting with a team of spotters and would have to coordinate his actions. The MEWT could thus provide lines of bearing towards the locations of the sniper and his observers.

Another useful sensor for this scenario would be an acoustic gunshot locator. Although this sensor could potentially have difficulty in an urban area (due to the multiple reflections of the sound waves on a complex urban canyon), it could also prove useful as a cueing sensor. If the locator could give a probable direction for the sniper, other assets, such as the MEWT could be cued to the same direction.

As the section began to focus on the threat, they would likely request UAV overwatch from a higher echelon. Current resources would not likely allow a special tasking of a UAV to monitor the section, but with the inclusion of micro-UAVs at the platoon level in these vignettes, the section could make use of this asset. In addition to the optical sensor, the SMEs thought that an IR imager and an EW collector would be useful. If the UAV was able to provide a second EW sensor, then the MEWT could potentially provide a fix (location point) on the sniper if he was transmitting, as opposed to just a line of bearing.

As the section approached the sniper's area, there would be concern that an ambush may be hidden along the route. In this case, the section commander may decide to employ the SUGV to scout ahead of the section, using its sensors to check for hidden adversaries or booby traps.

In addition to the systems discussed in the background for the activity, the SMEs were encouraged to come up with their own ideas for useful sensor systems. Among the possibilities discussed for this scenario was a potential "marker system" to help identify the sniper should he be able to slip into a crowd. In this discussion, the SMEs assumed that the sniper was hidden in a room in a building ahead of the patrol. After the sniper's firing location was found, a UAV or grenade launcher could be used to launch a paintball or paint-bomb into the room, which would paint anyone inside with florescent dye (the dye could fluoresce in the IR portion of the spectrum, making the sniper unaware that he had been marked). Special sensors on a UAV could then be used to track the marked individual as he attempts to escape. A similar idea of using a sensor to detect gun shot residue (GSR) was discarded, since the CF tends to operate in nations where firearms are ubiquitous (and thus anyone could have GSR on them) and where sanitary habits may not be sufficient to remove this residue from civilians' bodies, possibly leading to many false positive detections.

4.2.3 Vignette: Platoon Convoy Escort – Rural

For this vignette, the SMEs made several contextual assumptions before continuing with the discussion. First, it was assumed that the escort element was platoon sized (i.e. 4 LAVs). Second, the escort was assumed to be an organic asset of the CSS convoy. Finally, the SMEs assumed that the IED initiation resulted in a mobility kill of one of the convoy vehicles.

After the IED strikes the convoy, the vehicles would most likely stop since one of the convoy vehicles was immobilized. Assuming that the convoy is not taking fire, the troops would dismount and perform what is known as the "5 and 25 drill." Basically, the troops would ensure that the ground was clear of further IEDs within a radius of 5m from their vehicles, and then expand that safe bubble to 25m.

Once the convoy has stopped, the escort element's micro-UAV would be launched immediately. The UAV would be used to scour the immediate vicinity of the convoy for spotters and any enemy who are waiting in ambush. The commander might also call in a more sophisticated UAV from a higher formation, one that could potentially attack concealed enemies if they are detected.

If one of the convoy vehicles has been immobilized, the convoy would call in a quick reaction force (QRF) to provide additional security and recover the damaged vehicle. The QRF could potentially take hours to reach the convoy, so it would be necessary to set up a defensive perimeter. If the UGS was held at the platoon level, it could be deployed to form a sensor perimeter around the convoy's position, alerting the troops if any enemy approaches.

Another sensor discussed during the seminar was a dashboard camera. This sensor would not be used tactically, but would capture video of the IED strike as it happened. Arguably, this would not be useful to the convoy that has been struck, but it would provide forensic information for the investigation of the IED incident, and could possibly be used in training as a way to teach drivers what to watch out for on the road.

All of the preceding discussion in this section has dealt with the situation **after** the IED strike, but it would be preferable to detect the IED before the strike, and thus prevent a successful strike from happening. The most conventional method discussed of finding IEDs was to fly a UAV above the convoy route, well in advance of the convoy's departure. Using IR, EO, or a change detection sensor such as LIDAR, the UAV may be able to spot IEDs on the road, or IED emplacement teams at work. The problem with this technique is that flying a UAV results in periodic, non-continuous, coverage of the route, and IEDs may be too well concealed to detect. An alternative to this is to maintain a network of persistent surveillance systems, such as long range cameras on aerostats or towers, to detect IED emplacement teams as they dig in the devices. When using aerostats or towers, these static assets may not have full view of a road, and thus there may be shadow areas where an emplacement team could dig in an IED unobserved.

Another method proposed for detecting emplaced IEDs is to clear the roads on a regular basis. Once a road has been cleared, an IR fluorescent dye could be sprayed over the road and on the roadsides, which would only be visible using an IR sensor. If any dark spots are detected on subsequent trips, or by a convoy travelling the route, these may be clues to locations of emplaced IEDs. A number of issues surround this technique, as weather events such as sandstorms or rainstorms may wash away or obscure the dye. Also, the dye technique would not be useful in all areas, since agricultural activities and the build up of roadside debris could result in many false positives. Finally, the enemy could potentially turn the spraying of a harmless dye into a public relations nightmare through an information operations campaign by claiming that the dye is something more sinister (i.e. a chemical weapon).

The last technology discussed for this vignette centred on change detection. If the convoy vehicles are outfitted with sensors such as LIDAR or hyperspectral imagers, as they drive their routes they can collect information about the terrain and composition of the soil. This information can be stored in a computer, and on subsequent trips down the route, a comparison can be made against the established baseline. When a significant change is detected autonomously by a computer, the driver could receive an alarm about potential dangers in the road ahead and decide on his own to continue driving or stop and investigate. The issues with this technique include the massive data storage and processing that would be required, and the need for a computer to operate autonomously. Furthermore, the technique could be easily confounded in areas where terrain changes swiftly (as in the desert where sand can blow into different formations) or roadside debris regularly changes. Still, this technology could be useful in areas where terrain is relatively static.

4.2.4 Vignette: Section Observation Post – Rural

The SMEs indicated that Standard Operating Procedures (SOPs) dictate that at least three vehicles are required for an OP in current operations. Hence, this vignette was discarded from consideration.

4.2.5 Vignette: Platoon Observation Post – Rural

Since the vignette contained no contextual information on the type of OP, the SMEs discussed three types of OPs in sequence. The OP types were overwatch, reconnaissance/sniper, and Direct Action (DA) reconnaissance. DA reconnaissance OPs provide intelligence and overwatch for a DA mission which is to be performed by Canadian troops.

For an overwatch, the OP would be in one position for 24 – 36 hours, since remaining in one spot any longer would invite an attack. A minimum standoff distance of 300m would be required for a security perimeter, and sensors capable of night time operation (IR imagers, TIs, and IIs) would be an absolute necessity. If the UGS system is held at the platoon level, it would be extremely useful in covering holes in the coverage, as well as vital areas beyond the 300m perimeter. Immediately upon setting up the OP, the platoon's micro-UAV would be launched to provide basic overwatch, while a more sophisticated UAV could be requested from higher if a High-Value Target (HVT) arrived. While a MEWT would be useful to generate signals intelligence (SIGINT), its presence would require higher approval due to the risk of losing extremely sensitive equipment. The SMEs agreed that a tethered aerostat would provide a useful capability for this type of mission. The aerostat should be equipped with EO/IR sensors, as well as Electronic Signals Monitoring (ESM) equipment. The utility of an aerostat for this mission is based on the assumption that a small aerostat can be quickly winched up and down by the vehicle that will act as its transportation, making it a rapidly deployable, portable persistent surveillance asset.

In a DA recon OP, a MEWT would definitely be included to gather SIGINT and provide Voice Positive Identification (VPID) of HVTs. VPID is a requirement before any actions are undertaken. Prior to the DA, sensors would be required to establish the daily pattern of life. This may include UAVs and persistent surveillance assets such as the tethered aerostats. As the DA unfolds, all of the organic platoon assets (EO, IR, thermal, etc.) would be used. The platoon micro-UAV would be especially useful if it was capable of target tracking and passing targeting information to the platoon.

The recce/sniper OP is the most unique of the OP types discussed. Typically, these OPs involve dismounting and traversal over complex terrain. Since the dismounts already carry a large amount of weight in their packs, there is very little room available for additional kit. The snipers will typically carry compact EO and night vision surveillance gear. Other equipment, such as UAVs, would not be used as it would make the presence of an OP obvious. One of the ideas that came out of the discussions was the possible use of UGS to monitor approaches to the OP. This would allow the troops in the OP to focus more on the objectives of the mission while still feeling secure in their position. Another idea from the seminar was to use a MEWT, in a different location, to monitor the signals in the area. If the sniper observes a target using a communications device, he can alert the MEWT team, and they can focus their efforts in the right area. This would require the sniper to have the ability to communicate with the MEWT team, which would not always be possible.

4.2.6 Vignette: Company FOB Security – Rural

The defence of a FOB would require persistent surveillance using multiple sensor types. At least one of the company's UAVs would be in the air at all times. In addition to providing EO/IR surveillance of the area around the camp, the sound produced by a flying UAV has a deterrent effect on enemy activity.

In addition to UAV surveillance, the FOB would have a MEWT in constant operation, monitoring the FOB area for signals which may indicate enemy activity. If only more than one MEWT is available in the FOB, multiple MEWTs may be employed to enhance the capability of locating enemies near the base.

There was some discussion of the utility of using tethered aerostats to provide persistent surveillance of the FOB area. The SME consensus was that this would be an excellent platform to provide EO/IR imagery. It was suggested that the aerostat could also carry a second EW collector, which could be used in conjunction with the MEWT to calculate cuts to suspect signals. It was believed that the presence of an aerostat would also act as a deterrent to enemy activity, although less than the UAVs.

Another idea proposed the use of the UGS system to monitor areas up to 2.5 km from the FOB perimeter. It is possible that complex terrain (such as that experienced in Afghanistan) could obscure lines of sight relatively close to the FOB. The UGS system could be used to fill these holes in the surveillance plan, and thus prevent the enemy from using them for attacking the base.

It was noted that there would need to be self-destruction mechanisms built into the sensors that could be left behind (such as the UGS nodes). The self-destruction would need to completely disable and wipe the memory of the sensors, as well as deny the use of their components to the enemy. This might mean melting the sensor innards, since a civilian could be injured by a more violent self-destruction method.

4.2.7 Vignette: Company Cordon and Search – Complex Rural

The SMEs commented that this vignette would only be valid if the context is a lower level cordon and search, such as searching for a weapons cache, ammunition cache, or to clear an area. The discussion of the vignette proceeded along the lines of a search for a weapons cache within a compound of buildings.

The first part of the discussion of this vignette centred on the need for aerial surveillance of the area of operations. The company's mini-UAVs would be launched quickly to monitor the area. The SMEs indicated that if it is possible to transport an aerostat deflated on the back of on of the company vehicles, this would also be an excellent aerial surveillance tool. The aerial assets will provide all of the EO/IR types of surveillance for the operation.

Another useful tool for this type of operation is the MEWT. The MEWT is able to provide SIGINT, which may be rich if an enemy spotter is observing the cordon and search. The use of the MEWT on cordon and search operations in Afghanistan resulted in the company being able to locate sensitive areas, as well as hidden enemy observation teams from radio chatter.

After discussing the cordon and search of the compound, the SMEs turned to an area of concern from the theatre of operations in Afghanistan, although it is applicable to other areas of the world as well. The concern for the Kandahar region is the presence of a network of underground tunnels, known as karezes or qanats. These tunnels function as an underground irrigation system, bringing water from the high altitude mountains to the plains. The karezes have been constructed from both natural underground riverbeds and man-made tunnels. Karezes are often large enough for people to walk through, and villagers frequently use them to stay out of the sun when walking between villages. Obviously, the kareze system also provides an excellent transportation system for the enemy, and surveillance of these tunnels would be necessary for a successful cordon and search mission. Potential sensors that could be put to use in monitoring the karezes include ground penetrating radar and UGS systems.

4.2.8 Vignette: Combat Team Attack – Complex Rural

About 72 hours prior to the attack, reconnaissance, sniper, and MEWT teams would deploy to the area to establish the pattern of life in the target area. Not wanting to tip off enemies at the objective, surveillance would be covert, and aerial surveillance by UAVs would only be possible by flying the UAVs obliquely past the target.

In the beginning of the attack, a number of possibilities would be considered. The combat team may consider beginning with an indirect fire attack to stimulate the enemy communications. This would allow the EW team to generate SIGINT, and help to locate enemy teams. The combat team may also approach the objective with their Electronic Counter Measures (ECM) package powered up, effectively jamming enemy spotter teams that may be located up to 10km from the objective.

Once the attack is underway, the mini and micro-UAVs would be launched. Constant coverage by UAV would be maintained as the operation progressed. It was felt that UGS and aerostats would not be useful in this vignette, as the operation would be very dynamic and these assets work best from a static position. The use of IR fluorescent markers, shot from UAVs, was proposed as a way to track escapees or mark enemy hiding spots for ground troops.

It was felt that the organic combat team assets would be sufficient to the task. However, there were several sensor technologies proposed that could add to the team’s capability. The first sensor proposed was a TWSAR. This device, which is still in development, would allow the troops to see enemies and weapons through walls, allowing LAVs to target enemies hidden within the compound buildings. Another useful sensor would be a metal detector. Weapons caches are frequently plastered into the walls of mud huts in Afghanistan, and the search for caches would be greatly assisted by a device to find metal hidden behind a mud wall.

The use of the combat team’s UGVs for searching the buildings within the compound could be very useful, but the SMEs raised a concern about the radio frequencies (RF) from the remote control possibly setting off remote controlled IED booby traps. The SMEs also indicated that the use of armed UGVs was especially interesting as they could be used both as sensors and weapons systems.

4.2.9 Vignette: Battle Group Defensive Operation – Mixed

For the defensive operation, the SMEs indicated the BG organic sensors were likely sufficient for the job. Three MEWTs would be present at different locations within the defended area to provide cuts and fixes on the enemy. While the sensor coverage would be as complete as possible, there would be a number of holes in the coverage due to the terrain. The UGS would likely be used to fill many of these holes. Each of the recce detachments would be equipped with mini-UAVs in order to get Beyond-Line-Of-Sight (BLOS) coverage.

In addition to the sensors which have been discussed earlier, the SMEs indicated that other assets would be present. These included Counter Battery Radar (CBR) which would be located somewhere near the BG HQ, and air defence assets. It was noted during the seminar that SMEs for these systems would be required for subsequent seminars.

The SMEs again indicated that aerostats would be useful for this task, providing persistent BLOS surveillance. It was indicated that a number of "dummy" aerostats would be required to complicate an enemy's objective to destroy the sensors on these platforms. Another suggestion involved giving the UGS nodes a capability to trigger smoke or flash bombs in order to deceive an enemy.

The final comment for this vignette was that it is vital that the sensors be connected to each other in a network. This would allow all of the sensors to work in concert, cueing each other to gather more information on initial detections. If it is possible to create this network, the amount of information that could be fed to the commander is immense. It would be essential to have processes and staff in place to filter and provide information to the commander.

5 Conclusion

5.1 Seminar Main Themes

The sensor mix brainstorming seminar provided an excellent opportunity to gather information on sensor requirements from subject matter experts. The vignettes were set in the near-future time frame to allow the SMEs the freedom to be creative in their conversations, and yet keep them grounded in contemporary technologies. The main themes from the brainstorming seminar are presented below.

It was obvious from the suggestions of the SMEs that the bulk of their experience and expertise laid in the EW domain. The SMEs suggested the use of a mobile electronic warfare technology system in a number of the vignettes. The benefit of the MEWT is that it is able to provide a bearing to a radio source, and thus would be of use in finding enemy positions. In the vignettes where several MEWT units are present, each MEWT is able to produce a line of bearing, and thus an enemy's location can be more exactly determined. An issue with providing MEWTs to lower level units is the security requirement. Since the MEWT is a highly sensitive technology, great care must be taken to keep it out of enemy hands. As such, it is unlikely for MEWTs to be held below platoon level, and they would require self-destruct mechanisms for their deployment.

One of the major themes that came from the seminar was that the addition of micro and mini UAVs will be most welcome in the lower level formations. Currently, requests to higher for UAV coverage are frequently turned down due to the lack of sufficient resources. It was obvious from the vignettes that the lower level commanders would be able to put the UAVs to good use, resulting in much greater Situational Awareness (SA) for the troops. It is highly desirable for the UAVs to be simple to use, requiring little to no piloting skill of their operators. It is likely that in the near future, micro and mini UAVs will be capable of flying themselves along flight paths set out by the operators. This will decrease the workload associated with operating a UAV.

An idea which played a major part in several of the vignettes was the possibility of using tethered aerostats for persistent surveillance. In the vignettes where the unit was fairly static, the aerostats were thought to be very useful for both surveillance and deterrence. In addition to a standard sensor suite of EO and IR imagers, the SMEs proposed mounting a small MEWT device to the aerostat which would mitigate the effects of terrain on RF propagation, and potentially provide a second line of bearing, allowing EW operators to generate fixes on enemy sources. It was proposed that the aerostat could be tethered to the back of a vehicle and winched down and deflated for transport. In this manner, the aerostats could be used on certain operations that would allow the transport vehicle to remain stationary, yet outside of a FOB or strongpoint.

From the main themes, it was obvious that the SMEs who participated in the seminar had an extensive background in electronic warfare. In most of the vignettes, the SMEs indicated that a MEWT system would be very useful. While the study sponsor was aware of the SME bias towards EW sensors, it was anticipated that subsequent brainstorming seminars will capture the opinions of the other combat arms trades, thus negating the bias of any single community of experts.

5.2 Activity Assessment

While staffing constraints affected the scope of the activity, the study sponsor was pleased with the results obtained. The expertise of the SMEs in the EW domain provided a unique perspective on the vignettes that were considered and the participants were able to give full consideration to EW specific issues. The unfortunate consequence to the staffing constraints was that other ISR domains (e.g. EO/IR, radar, etc.) were not as fully explored, and they suffered as a result of the bias toward EW sensors. To remedy this, subsequent brainstorming activities should be held with other ISR communities of practice.

From an OR perspective, this activity was a scenario-based brainstorming methodology, similar to an interview-type methodology. The result of the activity was a collection of SME judgements and insights on the utility of various sensor types for the various vignettes. Obviously, this type of activity will not provide detailed assessments of sensor performance in the selected environments. Rather, the brainstorming activity provided baseline information on sensor use that will inform subsequent modeling and simulation work, which can provide a more objective and quantifiable measure of effectiveness for sensor assessment.

The use of JCATS for this activity allowed the participants to visualize the vignettes using real terrain and maps provided by DLSE. Icons representing the various vehicles were manipulated during the discussions under the direction of the SMEs. In general, the JCATS terminal provided focus for the discussions of the vignettes. While JCATS functioned perfectly as a mapping tool, it did not provide all of the functionality that was desired for the activity. Specifically, JCATS had no capability to simulate and display sensor “fields-of-view” or “range fans” that would have provided visual representations of the sensors’ operational capabilities. For future iterations of this type of activity the use of mapping software should be included, but the capability to place and orient vehicles and orient and display sensor fields-of-view would be very useful. Some of these capabilities may be resident in GIS tools, but even these may require the development of algorithms to calculate the “fields-of-view” of sensors that do not operate in the electromagnetic spectrum (e.g. acoustic sensors, seismic sensors, etc.).

5.3 Future Work

As discussed previously, the sensor mix study will proceed in a phased approach. Subsequent brainstorming seminars will incorporate SMEs from other specialties in order to gather information from a broad spectrum of communities. In this way, the biases of each trade will be heard, and a more holistic sensor mix can be found.

Additional work for the subsequent brainstorming seminars will include a review of the vignettes used in the initial activity. While the vignettes represented a variety of situations that were of interest to the sponsor, they do not represent the breadth of the force planning scenarios being used by the Chief of Force Development (CFD). For future brainstorming seminars and modeling/simulation experiments, it would be advisable to consult with CFD and the writers of the FSE documents during the scenario development phase. This would result in more realistic vignettes that more fully cover the planning scenarios of priority to the Army.

Following the brainstorming stage, a more rigorous analysis of the sensor mixes will be required. For this assessment, the sensor suites will be deployed in an IPB wargame (computer assisted or otherwise) and the coverages will be evaluated. Another possibility for future work includes using a synthetic environment to test the sensor suites with simulated entities.

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Annex A DLR In-Service Sensors, 28 Sep 2007

The following table was extracted from the DLR In-Service Sensors Spreadsheet, dated 28 September 2007. This table was used in the creation of the baseline sensor mixes for the various formations in the seminar brainstorming session.

NAME / TYPE	NOMENCLATURE	# Systems	Date
STANDALONE / MANPORTABLE SYSTEMS			
Optical			
M22 Binos		1500	94/95
Light Weight Binos		400	1994
C7/C9 Optical Sight	C79 Indiv Wpn Sight	62000	
Thermal			
Eryx TI Sight	Mirabel	435	1999
NODLR	AN/TAS-502	219	1991
Lasers			
Laser Range Finder (LRF)	AN/GVS-5A	510	1979
Melios LRF	AN/PVS-6	350	1998
Vector LRF Binos			
Lightweight Laser Target Designator (LLTD)	LTM-91	11	
Small Arm Laser Pointer	AN/PAQ-4B	200	
Radar			
MSTAR	AN/PPS-501	162	1997
Image Intensification (I^2)			
SIMRAD Sniper Scope	KN 252 F	160	93/95
Night Vision Set (Kite Sight)	AN/PVS-505	240	1992
Night Vision Set Crew Served (Maxi-Kite)	AN/TVS-505	163	1999
Night Vision Goggles (NVG)	AN/PVS-504	2700	1988
Night Vision Goggles (NVG)	AN/PVS-504A	1341	1997
NVG 5x adapter			
Unattended Ground Sensors (UGS)			

	CLASSIC UGS		
Seismic			
Acoustic			
Magnetic			
Infra-Red			
PLATFORM INTEGRATED SYSTEMS			
Coyote			
MSTAR	AN/PPS-501	162	1997
MicroFLIR		32	95/96
NODLR	AN/TAS-502	219	1991
Day Camera		152	95/96
MELIOS LRF	see above		
Periscope/Drivers Viewing Aid (DVA)		203	1997
PLATFORM DEPENDANT SYSTEMS			
Miscellaneous			
501 Drivers Viewer	AN/VVS-501	997	78/94
ADATS			
Radar			
TI/FLIR			
I2 TV			
Precision LRF			
Cougar			
Radnis Periscope Sight			
TOW II			
TI	AN/TAS-4A	152	1994
Optical			
Leopard C2			
Optical Sight (12 x)	EMES 18 FCS		
TI	EMES 18 FCS		
LRF	EMES 18 FCS		
Coyote			
Comd's II Sight		203	1997
Comd's Day Sight		203	1997
Drivers Viewing Aid (DVA) (WFOV)		203	1997

Drivers Viewing Aid (DVA) (NFOV)		203	1997
Gunner's TI Sight (Wide FOV)		203	1997
Gunner's TI Sight (Narrow FOV)		203	1997
Gunner's Day Sight		203	1997
Turret Mtd LRF			
LAV III			
Comd's II Sight			
Comd's Day Sight			
Drivers Viewing Aid (DVA) (WFOV)			
Drivers Viewing Aid (DVA) (NFOV)			
Gunner's TI Sight (Wide FOV)			
Gunner's TI Sight (Narrow FOV)			
Gunner's Day Sight			
Turret Mtd LRF			
Skyguard			
Radar			
Radar			
LLTV			
NBC Sensors			
Chemical Agent Monitor	CAM		
Chemical Agent Detector	GID-3		
Radiation Meter	AN/VDR-2		
ELECTRONIC WARFARE			
ICE	Comms DF		
AERIES	Comms DF		
TRILS	Non-Comms DF		
TCAS	Comm Intercept		

Table 1 : In-Service CF sensor systems used in creation of baseline sensor suites.

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List of Abbreviations/Acronyms/Initialisms

2IC	Second in Command
AoT	Army of Tomorrow
ARV-A	Armed Robotic Vehicle – Assault
BG	Battle Group
BLOS	Beyond Line of Sight
C2V	Command and Control Vehicle
CBR	Counter Battery Radar
CCD	Charge Coupled Device
CCTV	Closed-Circuit Television
CF	Canadian Forces
CFD	Chief of Force Development
COE	Contemporary Operating Environment
COIN	Counter Insurgency
CORA	Centre for Operational Research and Analysis
CSS	Combat Service Support
CULTINT	Cultural Intelligence
DA	Direct Action
DLCD	Director of Land Concepts and Designs
DLR	Director of Land Requirements
DLSE	Director of Land Synthetic Environments
DND	Department of National Defence
DRDC	Defence Research & Development Canada
ECM	Electronic Counter Measures
EO	Electro-Optical
EW	Electronic Warfare
FOB	Forward Operating Base
FTTS-C2	Future Tactical Truck System – Command and Control
FTTS-SPT	Future Tactical Truck System – Support
GIS	Geographical Information System
GSR	Gun Shot Residue

HQ	Headquarters
HUMINT	Human Intelligence
HVT	High Value Target
ICEWARS	Integrated Communication Electronic Warfare Analysis Radio Frequency Sensor
ICV	Infantry Carrier Vehicle
IED	Improvised Explosive Device
II	Image Intensifier
INT	Intelligence
IPB	Intelligence Preparation of the Battlefield
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
ISTAR	Intelligence, Surveillance, Target Acquisition, and Reconnaissance
JCATS	Joint Conflict and Tactical Simulation
LAV	Light Armoured Vehicle
LCA	Local Cultural Advisor
LCDORT	Land Capability Operational Research Team
LiDAR	Light Detection and Ranging
LRF	Laser Range Finder
MBT	Main Battle Tank
MEWT	Mobile Electronic Warfare Technology
NCM	Non-Commissioned Member
NCO	Non-Commissioned Officer
NEOps	Network Enabled Operations
NVG	Night Vision Goggles
OBG	Optimized Battle Group
OP	Observation Post
OPFOR	Opposing Force
ORBAT	Order of Battle
PIR	Passive Infrared
QRF	Quick Reaction Force
RF	Radio Frequency
RFID	Radio Frequency Identification

SA	Situational Awareness
SASNet	Self-healing Autonomous Senor Network
SIGINT	Signals Intelligence
SIREQ	Soldier Information Requirements
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SUGV	Small Unmanned Ground Vehicle
TAG	Thrust Advisory Group
TDP	Technical Demonstration Project
TI	Thermal Imager
TTP	Tactics, Techniques, and Procedures
TWSAR	Through-Wall Synthetic Aperture Radar
UAV	Unmanned Aerial Vehicle
UGS	Unmanned Ground Sensor
UGV	Unmanned Ground Vehicle
VPID	Voice Positive Identification

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Chapman, I. M.

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This Technical Memorandum describes the first phase of the DLCD Sensor Mix Study which was conducted in February 2008. The objective of this study was to evaluate how sensor mixes contribute to mission success in a number of vignettes across a range of formation levels (from Section to Battle Group).

In February 2008, a brainstorming seminar was held at DLCD in Kingston with members from the 2nd Electronic Warfare Squadron. During the seminar, the subject matter experts discussed the utility of various sensor types for each vignette, and brainstormed a number of sensors that would be useful in each situation. The main themes that emerged from the seminar included the desire for extensive use of UAVs with electro-optical and infrared imagers as well as the potential to use aerostats as sensor platforms on more static missions (e.g. Forward Operating Base defence). Perhaps owing to their expertise in the field, the SMEs discussed the potential use of electronic warfare sensors for each vignette.

It was decided that a second brainstorming phase was required with subject matter experts from other intelligence, surveillance, and reconnaissance communities to get a holistic view of the sensors. Following this, a more in-depth study involving sensor suites and virtual wargaming will provide more information to military decision makers.

Ce Mémorandum Technique décrit la première phase de l'étude sur les combinaisons de senseurs menée par la DCSFT en février 2008. L'objectif de l'étude était d'évaluer comment différentes combinaisons de senseurs contribuent au succès d'une mission, et ce pour des niveaux de formation allant de la section au groupement tactique.

Une séance de brain-storming a été tenue par la DCSFT en février 2008, à Kingston, avec les membres du 2ième Escadron de guerre électronique. Au cours de ce séminaire, des experts en la matière (EM) ont discuté de l'utilité de divers types de senseurs pour chacune des vignettes, et lancé des idées au sujet des senseurs qui seraient utiles dans chaque situation. Les principaux thèmes qui ont émergé de ce séminaire ont été le souhait d'une utilisation soutenue d'UAVs dotés de senseurs électro-optiques et d'imageurs infra-rouges ainsi que la possibilité d'utiliser des aérostats comme plates-formes de senseurs dans le cas de missions plus immobiles (ex. défense des bases d'opération avancées). Probablement à cause de leur expérience dans le domaine, les experts participant ont discuté de l'utilisation potentielle de senseurs de guerre électronique pour chacune des vignettes.

Il a été décidé qu'une seconde séance de brain-storming serait nécessaire avec des experts provenant d'autres communautés reliées au renseignement, la surveillance et la reconnaissance afin d'obtenir une perspective holistique des senseurs. À la suite de cette seconde séance, une étude plus en profondeur incluant différentes combinaisons de senseurs et l'utilisation de jeux de guerre virtuels pourra fournir davantage d'information aux décideurs militaires.

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