LEMS JOURNAL

LAND EQUIPMENT MANAGEMENT SYSTEM JOURNAL

ISSUE 2
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CONTINUED
FOCUSING ON THE FUTURE

National Defence | Défense nationale

Canada

FIELD OFFICER TRAINING EXERCISE:

The Royal Canadian Electrical and Mechanical Engineers School is mandated to provide the world-class soldier-technicians and officers of the Corps of RCEME with the necessary state-of-the-art training and skills to maintain the complex equipment in the Canadian Armed Forces. In the photo above, students on a training exercise are about to occupy a new harbour location.

See story on Page 16.

Cover photo: A member of a simulated opposing force fires a C-6 machine gun at a defensive position occupied by members of the Canadian Army Reserve, 4th Canadian Division, during Exercise STALWART GUARDIAN on August 26, 2015 at Garrison Petawawa, Ontario.

Photo credit: 32 Canadian Brigade Group Public Affairs | PA02-2015-0213-0181

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DIRECTOR GENERAL'S COMMENTS

Our focus on the future will bring even greater levels of capability

By BGen A.T. Benson

It is with pleasure, as Director General of Land Equipment Program Management (DGLEPM), that I introduce you to our second issue of the Land Equipment Management System Journal, where we continue with the theme of focusing on the future.

As I write, we are involved in the delivery of the *Strong, Secure, Engaged* equipment program. The Canadian Armed Forces is poised to advance to an unprecedented level with leading-edge technologies and capabilities to meet Canada's security mandate. There are high expectations from all of our stakeholders. I can assure you that we are up to the challenge to meet our mandate of a well-equipped Canadian Army – not just now, but well into the future.

Governing the life cycle of war-winning, Army-focused equipment is an activity with no finish line. Unlike tactical units, we cannot consolidate on the objective when we deliver on *Strong, Secure, Engaged* – or ever. Truly effective governance demands a continuous journey of improvement in our products, services, knowledge, and culture. The Land Equipment Management System Journal is one of our most important tools by which we hone all four.

To that end, in this issue we range from the battlefield to the strategic; from the venerable C6 machine gun to the forthcoming Headquarters Shelter System; from the mundane importance of using the correct fluids to the heady application of battlefield forensics. We do so while exploring the realms of science, education, engineering, equipment support, project management, investigation, and maintenance – each a discipline critical to the delivery of land equipment maintenance. The scope is broad, but as I stated earlier I am certain you too are up to the challenge.

SHARE YOUR THOUGHTS AND EXPERIENCES

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Thoughts on the **Future of LEMS** at the Tactical Level

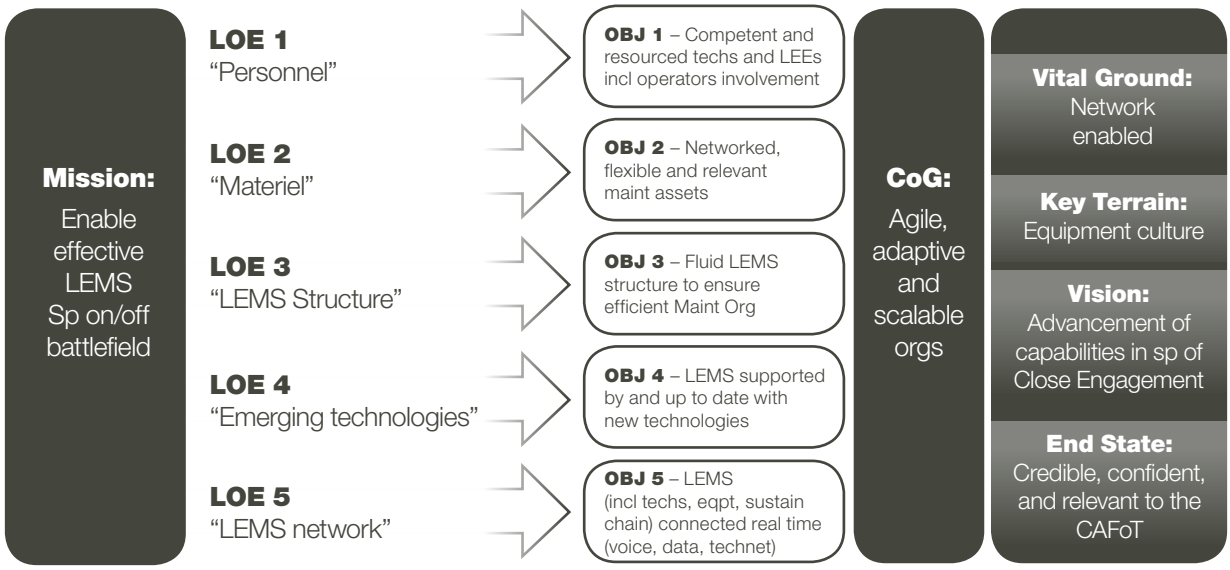
By LCol Jeff Spitzig

This article builds on the future vision of LEMS set out by Col Dundon in the previous issue of the Journal. It highlights the collective thoughts from numerous leaders within our Corps that were generated during two Working Groups (WGs) held to specifically address this topic in the past year and those from numerous follow-on conversations. It is intended to provide the reader with an introduction to the five areas of focus or Lines of Effort (LoE) on which future conversations surrounding this subject will be based.

Discussions on the future are often centred with great optimism on what can be achieved and how the future can be shaped. Artificial intelligence (AI) and 3D metal printing (Additive Manufacturing (AD)) are both emerging technologies being pursued by such enterprises as Amazon, Google, and General Electric (GE). Other companies such as Apple continue to be industry leaders in the pursuit of cutting-edge technology. Further, names such as entrepreneur Elon Musk regularly surface in announcing great accomplishments, or in predictions of impressive future achievements. Similarly, the Corps of RCEME is also looking forward at how best to leverage the advantages of future technology. Based on the Canadian Army's (CA) capstone document Close Engagement, leaders within the Corps have committed a great deal of time and effort to shape the structure of LEMS to best support the CA at the tactical level in the future. This article provides a glimpse into the focus areas of this work.

What does the future hold for the Corps of RCEME? How far away is LEMS from employing 3D printers and benefiting from AI? The Tactical Armoured Patrol Vehicle (TAPV), for example, uses Line Replaceable Units (LRUs) that are closer in nature to a commercial product than other current fleets. Could this then result in more

LEMS Effects



maintenance responsibility placed on the operator? Is it then unrealistic to think that, in the near future, an unattended system delivering an LRU to a vehicle casualty could negate the requirement to have a technician forward? For instance, could the vehicle operator receive the item, complete a one-for-one replacement, and then send the unattended system back with the damaged or faulty part?

Advances in 3D Printing

From a 3D printing perspective, how far away is the capability for an unattended system to print the part or LRU while en route to the forward location? By extension, could a similar unmanned system respond to the need to repair structural damages on a vehicle through the use of advanced procedures and composite material, again without human involvement? This touches on the tenet of: *Repair as far forward as possible*. Will technology make this: *Enable the repair as far forward as possible* more suitable in the future?

Migrating from the reactive response, how can technology be used to improve and/or augment predictive maintenance? Could Health Usage and Monitoring Systems (HUMS) be augmented by regular communications between vehicles and/or systems – which is then automatically compiled and sent as data to the command post? Sent in in the form of quick 'pings' on infrequent and irregular intervals, these pings could deliver simple codes that reflect the health of the platform – which in this case would not be exclusively vehicles but could include weapons, weapons systems, sites, and so on. The value of these 'pings' extends beyond the information they provide to include their small bandwidth needs and limited electronic signature that could be exploited by means of a cyber threat. This represents an evolution from the current standard of maintenance based on distance driven or on a set and structured schedule.

> **"Looking forward, technicians and junior leaders must be provided with more authority, responsibility and accountability."**

LEMS in the Future Battlespace

Scenarios such as these and many others have emerged during recent discussions focused on how to best effect LEMS support in the future battlespace. In his article in the previous journal, Col Dundon mentioned the concept of a futuristic supercomputer or means of AI he named SADIE that would serve in a secure area augmented by humans to coordinate the response to predictive maintenance calls and the employment of MRTs. He also proposed options on how repair parts could be delivered to vehicle casualties in the future. These recent discussions have simply responded to his call for further dialogue. As a consequence, five LoE's have emerged, all based on Close Engagement.

The credibility of the Corps has been achieved through the day-to-day efforts and continual success of soldier-technicians. Hence, identifying an LoE as *Personnel* was of utmost importance. Looking forward, technicians and junior leaders must be provided with more authority, responsibility, and accountability. The goal must be to increase the technical relevancy of technicians so they remain at the very least in stride with their peers in the civilian sector. From a tactical and technical perspective, technicians at all levels will be inculcated on a gradual scale to the six core tasks – plan, advise, develop, investigate, modify, and analyze – and to the four operational concepts of lethality, survivability, mobility and sustainability. Further, it is envisioned that training will empower the technician on promotion to warrant officer to advise on all four occupations. Change would also extend beyond the Corps to operators who would assume a greater level of responsibility and empowerment, supported of course by technicians or via communications with Field Service Representatives similar to the *OnStar on steroids* analogy used by Col Dundon.

A Significant Challenge

Materiel Resources is the second LoE. Building a supporting structure to accommodate the vehicles and materiel currently in-service – and those technologically advanced fleets of the future – presents a significant challenge. The CAF vehicle fleets have always been a mix of old and new; however, an unprecedented delta between the new and old fleets is anticipated owing to the rapid advancement of technology. The commonality of Integrated

Logistics Support (ILS) is one of a myriad of factors that can reduce the future support tail. And it's one that must be addressed now. It goes without saying that managing the relatively 'maintenance heavy' current fleets concurrent to future vehicles and systems with LRUs that can `ping` to highlight their predictive maintenance needs and then extending that to fully autonomous platforms will demand a rather fluid and adaptable structure.

> **"An opportunity exists now to shape the future of LEMS through the adoption of emerging technology."**

This eventuality ties into *LEMS Structure* LoE that focuses on the support backdrop to enable the technician and operator. In this future battlespace, a proactive support structure that minimizes the lines of communication will be invaluable. This focus area will address concepts such as human factors, data management and analysis, procurement channels, and redundancy. LEMS structure would provide the architecture of future support, and enable – among many other capacities – Col Dundon's *Uber* analogy of decentralized and responsive MRTs.

Moving from structure, identifying the needs of a *LEMS Communications* network was selected as another LoE. Communication has always been and will continue to be a crucial enabler in the battlespace. The goal is not to develop the communications architecture of the future but to define the requirements to enable LEMS in all possible roles and in all probable support structures. What will be most challenging is clearly articulating the need so that it is well understood and justified to ensure that future LEMS support is not unduly hampered by communications limitations resulting from a perception that it is less important and can therefore be a lower priority.

Emerging Technology

The fourth and most topical LoE is *Emerging Technology*. The decisions made in the prioritization and use of one aspect of technology over another will have ramifications on each of the other four LoEs. While not all inclusive, discussions have touched on robotics, additive engineering, artificial intelligence, and disruptive technology. There is such a wide range of opportunities to pursue that the challenge will be to limit the focus to what is reasonably achievable and to those actions that will be advantageous to the Corps in the future battlespace. These topics will likely serve as a springboard to others as some elements are implemented and additional concepts emerge.

> **"Communication has always been and will continue to be a crucial enabler in the battlespace."**

This is a pivotal time for the Corps of RCEME. An opportunity exists now to shape the future of LEMS through the adoption of emerging technology in a wide range of fields. While it will without doubt have the greatest impact, LEMS structure and communications network must be built to enable the innovative technological concepts pursued. In addition, the expected evolution of the vehicles and materiel supported cannot be ignored. All of these issues demand careful study and calculated risk. In doing this now, the Corps of RCEME will advance in tandem with the CA and set the conditions for success of future RCEME technicians and junior leaders. They have built the credibility of the Corps of RCEME and, through future dialogue and follow-on work, they will be empowered and enabled to continue to do exactly that.

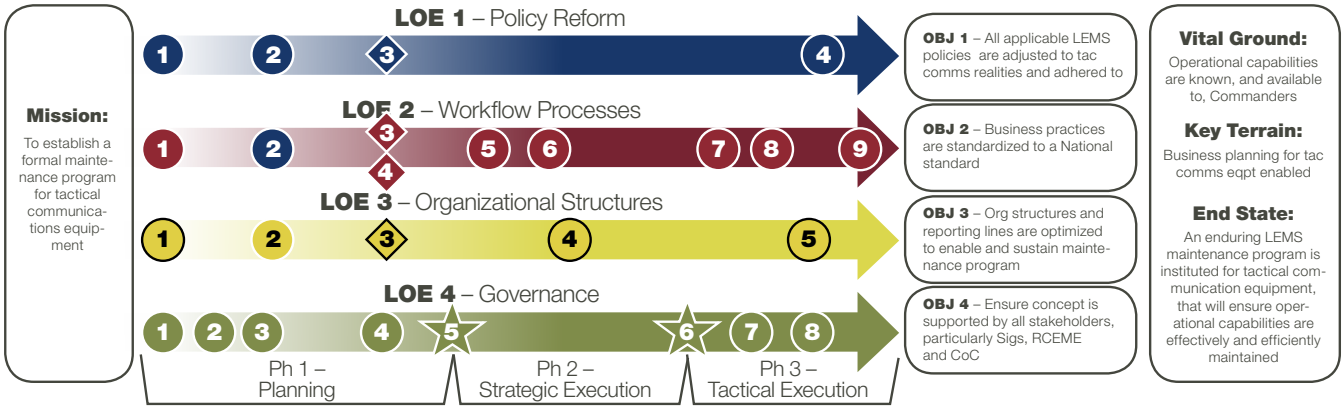
LCol Spitzig is Director Land Equipment Program Staff (DLEPS) 3, in DGLEPM and COS RCEME.

Progress Being Made on the **Reintegration of SIGS into LEMS**

By MWO Sean Hewitt

Key Signals and LEMS stakeholders met in early 2017 to discuss and establish a campaign plan to re-integrate and align Army Signals tactical communications maintenance within LEMS. With the approval and concurrence of the affected directors, including Director of Signals, Director Land Command Systems Program Management (DLCSPM), and Director Land Equipment Program Staff (DLEPS), work is underway on the journey toward the integration. Among the many efforts and tasks required for integration, DLCSPM has been working to integrate tactical communication systems, ancillary equipment supply, and maintenance management into LEMS. DLCSPM is a directorate within Director General Land Equipment Program Management (DGLPEM) whose role is to provide the Canadian Army and deployed task force commanders with effective Joint C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) program management.

In order to address the Army's Communication and Information System (CIS) maintenance deficiencies and capability gaps addressed by the fleet maintenance review, the initial planning working group defined four Lines of Effort (LOE) that needed to be addressed: *policy reform, workflow processes, organizational structures,*



Policy Reform	Workflow Processes	Organizational Structures	Governance
1. DLCI integrated into LPRC 2. DIRLAUTH established between Tech writers and DLCI Rep 3. DP - Applicable policies selected and prioritized for Sigs inclusion 4. Policies adjusted through LPRC	1. Maintenance workflow mapped 2. Capability gaps identified (DRMIS, trg, PYs, functions) 3. DP – Workflow approved 4. DP – TACIS functionality integration into DRMIS approved 5. DRMIS change requests completed through DLEPS 8 6. Funding for TACIS migration secured 7. Trade training courses adjusted 8. Local training packages established 9. TACIS integrated into DRMIS	1. Input from field force and targeted staff compiled 2. Options developed and compared, recommendation provided 3. DP – C2 Structure selected 4. ECP requirements identified 5. ECPs completed	1. Oversight Committee established 2. Comms plan developed 3. Link with strategic stakeholders and field force formalized 4. Opportunities to ensure enduring effect identified 5. MID signed and distributed 6. CAO signed and distributed 7. Comms between RCEME and Sigs Corps established 8. Oversight Committee integrated into LEMS Governance OC

◇ = Decision Point ☆ = CoC D&G

and *governance*. Due to the need to align the campaign plan's LOE with the Canadian Army Sustainment Review (CASR), the priority of effort as determined by the oversight committee was to focus on the integration of signals data into the Defence Resource Management Information System (DRMIS). As a result, DLCSPM has formed an internal working group to move forward on the integration of tactical signals equipment data into DRMIS. In order to achieve success, the internal working group will define the priority of work, coordinate activities, and track the work progress to achieve the end state of data integration into DRMIS.

> **"The priority of effort as determined by the oversight committee was to focus on the integration of signals data into DRMIS."**

From a DGLEPM perspective, Equipment Management Teams (EMTs), Life Cycle Materiel Managers (LCMMs), and project managers within DLCSPM will review and audit their internal management processes and procedures currently in use. Since DRMIS is the tool of record for equipment, project and maintenance management, it is necessary to ensure a full migration of relevant information into it. In addition to DRMIS, DLCSPM EMTs also use other tools for equipment management, such as COMSEC Accounting, Reporting and Distribution System (CARDS) – [for cryptographic related items] – and Tactical Asset Configuration Information System (TACIS). These tools will need to be analyzed in order to identify which processes and equipment can be migrated to DRMIS. Any data that can be reconciled between the different systems will be completed and Standard Operating Procedures (SOPs) addressing management procedures will be updated. The primary focus will be finding a means to reconcile and share data between DRMIS and TACIS, which will allow field technicians the ability to conduct tasks between the different systems in the interim.

Additional tasks required are both stand-alone and inter-related. First is the necessity to review current equipment breakdown structures within DRMIS to reflect necessary equipment and component repair requirements. For example, not only will communication suites need to be accurately reflected, so will the individual sub-components that make up the communication platform. Once equipment breakdown structures are properly compiled, then work can be completed on developing Preventive Maintenance (PM) and servicing schedules. Technical publications and permissive repair schedules will need to be reviewed, updated, and then translated by technical authorities (TAs) and LCMMs into usable formats within DRMIS to create viable PM schedules for communication platforms and equipment fleets that can be aligned with and managed alongside mechanical, weapons and electro-optical PM maintenance strategies for various fleet platforms.

The increasing complexity and integration of tactical communication systems means that a solid foundation of technical maintenance needs to be implemented to support effective fleet management. DLCSPM is working to create and sustain the necessary technical knowledge base required to support operational needs. Achieving the baseline functional state will enable the signals technical community to create "an enduring LEMS maintenance program instituted for tactical communication equipment that will ensure operational capabilities are effectively and efficiently maintained."

> **"...a solid foundation of technical maintenance needs to be implemented to support effective fleet management."**

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A. Briefing Note Canadian Army Communications Fleet Maintenance Review.

B. 3000-1 (DLEPS 4-5) Initial Planning Guidance – Campaign Planning for the Re-Integration of Tactical Communications into LEMS. 24 Mar 17.

C. Info Brief to DLEPS and DLCI – Campaign Plan, 9 Jun 17.

D. BN DLCSPM Preparations for the Reintegration of signals into LEMS.

MWO Hewitt is D6-4-2-2 ILS Maintenance Tasks/Procedures with the Directorate of Land Command System Project Management.

Ammunition Engineers Prepare for the Future by Attending a **Masters Program at RMC**

By Capt Jean-François Fournier

As military technology continues to advance, the trend has been towards the development of more socially and environmentally responsible design solutions to problems. Ammunition and Explosives (A&E) technologies have been no different and there has been a concerted effort within the industry and the CAF to make the use of A&E safer, more discriminatory, and more environmentally friendly. In order to manage the evolving technology developments in such new areas as insensitive munitions, laser ignited munitions, telescoping ammunition, energetic explosive binders, specialized propellant geometries, and guided small arms munitions – just to name a few – it is important for DND to maintain the engineering and scientific support required to adapt and capitalize on these and other innovations.

On that note, the Director Ammunition and Explosives Management and Engineering (DAEME) welcomed two new RCEME officers into the organization this year. Both officers came right out of the Advanced Ammunition Engineering Masters at the Royal Military College of Canada (RMCC) in Kingston. This year-long post-graduate program includes eight post-grad courses delivered over two academic terms and a capstone project to be completed by the end of the year. This program provides the technical engineering knowledge required to perform project management and ammunition engineering tasks within DAEME, as well as providing some insight on new emerging technologies related to A&E.

The first academic term includes four courses designed to teach the theories associated with internal ballistics, external ballistics, the chemical principles of explosives, and the physical effects of explosives and explosions. For external ballistics, various trajectory solutions are explored that could be used to predict the trajectory of a projectile in flight, including the six degrees of freedom model trajectory – which takes into consideration the motion in the x, y, and z axis and the pitch, yaw, and roll of the projectile while in motion.

In internal ballistics, a number of design considerations are studied. These include propellant grain size and geometry considerations to tailor the burn rate for specific weapon systems. A visit to General Dynamics Ordnance and Tactical Systems (GD-OTS) and their propellant plant in Valleyfield, Québec included discussion of a recent design of a 19-perforation model with the outer surface shaped in rosettes to increase the surface area during the combustion, and, in turn, increase the burn rate and ultimately the muzzle velocity of the weapon system. The interest in manufacturing and using new propellant geometries was reinforced during a visit to Defence Research and Development Canada (DRDC) in Valcartier. DRDC scientists had just acquired a 3D printer with which they are examining the possibility of designing new and innovative propellant grain geometries using additive technology. This know-how could open up the possibility of 3D printing explosive charges. This eventuality could expand the use of explosives for new purposes as well as improving current explosive ordnance disposal (EOD) and breaching methods.

Program participants also learn about the generation of the shock wave during the detonation of an explosive and how to characterize blast and predict the effects of explosives on their environments. The chemical principles of explosives studies looks at the detonation reactions of explosives, the chemical reactions related to pyrotechnics, and the decomposition of explosives and propellants. It also provides a brief overview on metallurgy. Part of this course involves the exploration of new energetic materials, including research on the main energetic characteristics, synthesis reactions, stability and sensitivity, as well as environmental concerns. A novel explosive (LLM-105) and a new energetic binder (poly-GLYN) comprise part of the course of studies. LLM-105, for instance, is an explosive that has similar characteristics when compared to High Melting Explosive (HMX), which is a highly powerful explosive, and TATB, which is one of the most thermally stable explosives.

These characteristics are important in the development of insensitive munitions. As for poly-GLYN, it is an energetic polymer that could be used in propellants or plastic-bonded explosives. These explosives and propellants will typically have small amounts of polymers in their composition that act as a binder to stabilize the explosive. Energetic polymers, such as poly-GLYN, when used in place of current inert polymers, provide the potential to increase the explosive yield of currently used plastic-bonded explosives.

During the second term, emphasis is put on the design of the ammunition based on the terminal ballistics and the effect on the target and on whether the target is an aircraft, a ship, or a land vehicle. The introduction of a number of terminal ballistics models and the exploration of different types of weapon systems allows the analysis of the mechanisms found in small arms, in large-calibre guns and in missiles. An introduction to ammunition management is also given during this term.

In addition, the participants are required to conduct a capstone project as part of this Masters of Engineering program. One of this year's projects, titled the "Ballistic Trade-offs for Depleted Uranium Replacement in a Kinetic Energy Penetrator", looked at the density boundaries for a possible replacement material for a depleted uranium sub-calibre penetrator in a specific projectile used by the United States Air Force, as the CAF do not have any depleted uranium ammunition in its inventory. The intent was to achieve the same effect on target and define the trade-offs related to the material replacement, including the effect on barrel erosion and the gyroscopic stability of the projectile. Another project used modelling software to investigate the design considerations for impulse gauges for near-field blast studies – the purpose being to find a method to standardize impulse gauges, which are devices used in explosive experiments to characterize the impulse that is transferred by an explosive charge to a structure or person.

> **"One if this year's projects…looked at the density boundaries for a possible replacement material for a depleted uranium sub-calibre penetrator in a specific projectile."**

This program has well prepared these officers to take on new and interesting engineering challenges at DAEME as DND looks into the future of A&E. DAEME will continue to maintain the technical and engineering expertise required to capitalize on new A&E technologies.

Capt J.F. Fournier is a Qualified Ammunition Technical Authority (QATA) within DAEME responsible for conducting Safety and Suitability for Service (S3) assessments for various types of ammunition before they become in-service.

RCEME 75th Anniversary

2019 is fast approaching and thus, the RCEME 75th Anniversary. Stay tuned on the RCEME Corps' Facebook page as we will frequently post quick updates on RCEME 75th related events and product release information. There is also a separate RCEME 75th Anniversary Facebook page and web page where the majority of the detailed information on the 75th will be available for viewing. Recent additions to our sites include a Calendar of Events and a Product Release Timeline. Links available:

RCEME Corps Facebook page : https://www.facebook.com/groups/366428010229841
RCEME 75th Anniversary Facebook page : https://www.facebook.com/rceme75
RCEME 75th Anniversary page : http://rcemecorpsgemrc.ca/events/75th-anniversary/
Calendar of Events : http://rcemecorpsgemrc.ca/wp-content/uploads/2018/10/RCEME75_Calendar.pdf
Product release Timeline : http://rcemecorpsgemrc.ca/wp-content/uploads/2018/10/RCEME75_Timeline.pdf

RCEME plays a vital role within the Strategic Joint Staff

By Maj Charles Turcotte

The Strategic J4 (Strat J4) within the Strategic Joint Staff (SJS) has the responsibility not only of understanding element-specific needs but also possible efficiencies in integration that would synchronize joint sustainment processes. The goal is responsive and precise sustainment across the CAF.

In order to constantly maintain the strategic and cross-functional sustainment within DND, an implementation team, including members from the Royal Canadian Logistics Service and two officers from the Corps of RCEME, was created within Strat J4. The effort invested by this team better prepares Strat J4 with support perspective for sustainment and supportability in a joint environment.

Under the direction of Strat J4, the implementation team improved the problem definition and established a conceptual framework that was approved by the Chief of the Defence Staff (CDS) in April 2015. This approval included the authorization to continue restructuring existing organizations and sustainment functions to Strat J4. Therefore, being involved early in planning the support to operations at different levels, including military police, infrastructure, medical, maintenance or logistics, establishes the Strat J4 capability for addressing significant gaps in strategic sustainment.

The support of LEMS is vital to Strat J4's mission. LEMS identifies equipment management activities at the strategic level as being provided within the Director General Land Equipment Program Management (DGLEPM) through the various Equipment Management Teams (EMTs). The core responsibility of DGLEPM staff is to provide strategic support to army-owned equipment, as well as other CAF elements using the same gear, on all activities from acquisition to procurement and disposal.

For personnel employed in Strat J4, LEMS and sustainment principles and fundamentals practised in field units – whether deployed domestically or during operations – are still applicable at the strategic level. Foresight and simplicity within strategic sustainment means that the Strat J4 is involved from the beginning of planning cycles for all mandates or missions to which LEMS contributes, thus supporting Canada's Defence Strategy: ***Strong, Secure, Engaged***. Specifically, this involves long-term investments to enhance CAF's joint capability and capacity to support peace and security. In applying the range of CAF options available to support UN, North Atlantic Treaty Organization (NATO), or Canadian territory operations, a thorough and carefully considered CAF sustainment plan is required. The sustainment fundamentals of economy and cooperation bring together different elements and stakeholders with similar needs who work jointly to identify future equipment needs that avoid duplication of effort. Flexibility reminds us to be imaginative in order to allow the operational, tactical, and institutional level maneuverability to fit in with the overall plan.

The addition of RCEME personnel within the SJS helps Strat J4 optimize the integration, coordination, and strategic prioritization of all sustainment efforts within DND/CAF for operational efficiencies. This RCEME presence will continue to develop in the coming years to meet the needs of the CAF, and RCEME members will be ready to use their capabilities and experiences to contribute to its success.

Maj Turcotte served in the Capability Development section of the Strat J4.

Lessons from the past contribute to **CAF's future operational success**

By Maj Glen Butcher and Vince Horne

Captain Scott Beeston taking photographs of an Armoured Engineer Vehicle – Automatic Fire and Explosion Suppression System (AFESS) failure investigation, Wainwright, AB.

The authors of this article have both participated in new initiatives being piloted by the Quality Engineering Test Establishment (QETE) and the Land Engineering Support Centre (LESC) aimed at improving LEMS ability to respond more rapidly and effectively to equipment related issues whether these occur domestically or abroad during operations. The article describes initiatives and gives the authors perspective on the value of pursuing their further development with the aim of eventually implementing these formally within LEMS.

Domestic Failure and Accident investigations and Theatre Battlefield Vehicle Forensic investigations play an essential role in ensuring that the lessons learned from such events can be used to improve soldier safety and mission effectiveness. General equipment failures can occur at any time for a variety of reasons ranging from inadequate design or manufacturing to improper maintenance and/or operator training. During the Afghanistan mission, the CAF and their protection systems were introduced to new threats in the form of Improvised Explosive Devices (IED), Explosive Formed Projectiles (EFP), improvised rockets and Rocket Propelled Grenades (RPG). As RCEME officers and technicians, we are devoted to personnel safety and the fielding of protection systems that will help the soldiers to complete their mission by minimizing the possibility of becoming a casualty– and supporting technical investigations is an important means to that end.

Failure and accident investigation is critical to informing risk management and preventing losses. Material failures and accidents within DND impact operations, equipment availability, and safety. In the short term, risks associated with potential equipment failures must be carefully managed in accordance with Land Material Assurance (LMA), often requiring a compromise between assured safety and operational effectiveness. In the long term, efficient solutions are necessary. This requires obtaining detailed information and expert advice as soon as possible after an event; thereby, root-cause factors are identified and addressed in such a way as to restore the health of an affected platform both effectively and efficiently. Rigorous investigation enables

operators and technical authorities to make decisions with confidence, based in greater part on a more complete picture of the facts rather than speculation.

Whether in-theatre or on training exercises, failure and accident investigations should be initiated immediately following an event at the occurrence site once the safety and security of personnel is assured. The site needs to be secured (handling evidence before investigators arrive should be avoided unless it is absolutely necessary) and many photographs should be taken by first responders on-site for subsequent analysis. This is critical if the evidence has to be handled before investigators arrive. Photos should be taken near, close-up, and from a distance at all angles (including aerial for complex accident sites). Once photographs are taken and the technical authority (TA) for the equipment [domestically, the Equipment Management Team (EMT)], deployed, the senior maintainer must be provided with the information to support further investigation. Experts from the QETE Failure & Accident Investigation Group should be contacted for advice on the identification, preservation, and handling of important evidence. Following an initial investigation and coordination with the EMT, select evidence may be sent to laboratories such as QETE for detailed examination.

Each investigation is unique but several requirements are common: preserving evidence, retaining failed items, and documenting activities surrounding failures through witness statements. The collection of component maintenance history and fleet usage data is additionally useful, particularly for risk management.

Several agencies can do failure and accident investigation; however, the effective and efficient execution of a failure and accident investigation requires extensive experience and a suitable set of tools to collect information not available to most. Within DND, specialized engineering support organizations such as QETE, which has a RCEME captain failure investigator position, provide dedicated failure and accident investigation support domestically using facilities with specialized tools and experienced personnel to identify evidence that would be otherwise unobservable (such as fracture surfaces and material properties). Further, QETE pursues all aspects of failure investigation (design, production, operations, maintenance, environment, and others) to provide the best advice possible to address the needs of DND. One entity rarely has all the necessary information and the best results are usually obtained through involving multiple parties in the investigation, which is common practice at QETE.

In a theatre of operations, there is great value in employing a Battlefield Vehicle Forensic (BFV) qualified officer as a first responder to initiate the investigation and be involved in the reporting process and collection of evidence. Technical Liaison Officers (Tech LOs) trained by LESC carry this qualification and can reach back to DGLEPM to provide a quick analysis of the event. This capability in-theatre informs the possible solutions to increase the survivability.

One course available to RCEME Officers from the Tech LOs program is a five-day course on BVF provided by the National Ground Intelligence Center (NGIC) at the Sierra Army Depot in Herlong, California. The aim of this course is centred on approved forensics methodologies for collecting, gathering, preserving, and managing weapon-related data and material resulting from an attack against friendly armour.

The BVF course serves as the foundation that enables the follow-on triage to establish priorities and parameters for further analysis that can help develop new technologies and protective systems to increase survivability and neutralize threats. For example, from the early days in Iraq and Afghanistan, Allied forces, with Canada playing a leading role, gathered data from various explosive blasts and subsequently redesigned the seating in the back of their armoured vehicles. This led to a change from fixed mounted seats to suspended (use of ropes and pulleys) to the final blast attenuating seats. It was noted that the number of fatalities decreased even though the size of the blasts was increasing. These new engineering designs were the result of a thorough investigative process that included BVF, medical reports from the soldiers from previous incidents, and the analysis from their intelligence cell on the Tactics, Techniques, and Procedures (TTP) of the enemy.

Damaged TAPV during training near Sherbrooke, QC.

The BVF course provides an understanding of different weapons signatures including RPG, small arms, recoilless rifle, EFP, and IED, major vehicle platforms, major components, detailed

report writing, and evidence gathering techniques. The course also includes a practical portion whereby students perform BVF on the Mine-Resistant Ambush Protected (MRAP) fleet. This fleet includes the Cougar, RG-31, RG-33, MaxxPro, Caiman, Buffalo, and Husky. While working in teams of two or four, students are given timelines anywhere from 15 minutes to two hours to conduct forensic activities. Students were tested on their ability to obtain the necessary data for processing. This represents a capacity that could be employed at any level of support. In reality, the investigator may not have a lot of time to gather information before the vehicle is moved from the scene of the event in-theatre. It was important for teams to focus on the impact area of the attack and to gather as much information as possible in a logical order so that a detailed report could be written with a summary explanation of the findings.

As RCEME personnel working in workshops, in-theatre or even at an office in Ottawa on a project or EMT, it is important to evaluate what works, what does not, and what can be done to make things better – this is the goal of investigations. Being employable at any level of support, a team of two to four qualified RCEME officers or technicians could potentially use BVF skills to deploy anytime and anywhere to ensure the highest level of responsiveness to a threat. Contributing to even a minor change can save a soldier's life. The damages that are obvious after an attack may not always be a point of impact that kills or injures the soldier; it is potentially the secondary effects of a threat that cause more harm.

In summary, failure, accident, and battlefield forensic investigation is an essential part of equipment management; a thorough investigative process benefits the RCEME role in equipment management. This is a collaborative process that includes organizations such as QETE, LESC, Munitions Experimental Test Centre (METC), and Defence Research and Development Canada (DRDC). QETE has the expertise required to conduct detailed investigations of system components and support the EMT and LESC in developing solutions that maximize soldier safety and minimize the vulnerability of equipment. The METC and DRDC Valcartier also play a large role in survivability test and evaluation and future equipment development.

The technical training that was provided to Tech LOs on the BVF course adds to the Army's toolbox. BVF provides RCEME officers and technicians resources that can diligently gather evidence on battle-damaged vehicles in-theatre. Performing BVF on a vehicle is not to gather enemy intelligence or human effects results. However, it does allow the ability to provide essential technical advice to DGLEPM on future design requirements in conjunction with the intelligence and human effects to engineer an increase in survivability.

Further developing the capacity within the Tech LO program led by LESC in the future would ensure rigorous investigative practices are followed in-theatre and enable DND to effectively prevent recurrent failures and accidents. Tech LOs are in place with the ability to provide technical analysis and immediate feedback (hard forensic analysis) to inform the survivability decision cycle – the process by which survivability systems are generated and improved for our soldiers. Whether we consider investigation in-theatre or domestically on training, it is clear that the process must be necessarily thorough, informed, and collaborative.

Damaged MRAP veh with EFP charge, Red River Army Depot, Texarkana, TX. The rope designates the trajectory (potential flight path) of the projectile. From an analysts perspective they can possible determine what triggers the device and what the enemy is aiming to achieve.

Major Glen Butcher is a new member of the Strategic Joint Staff J4 Operational Support (OS) Capability Development Team. As an OS Capability Development Analyst he is responsible to identify requirements to support CAF operations (including LEMS functions) and to contribute to the development of future concept and capability initiatives.

Vince Horne is the Group Leader for Tri-Service Failure and Accident Investigation at QETE, with a dedicated team of ten engineers and technologists (including a RCEME captain) executing approximately 75 investigations each year.

Concealability as a **CJOC future requirement**

By Maj K.J.G. Zizian

The characteristics of conflict have changed significantly over the last 10 years. In its released Defence Policy – *Strong, Secure, Engaged (SSE)*, the federal government announced a new strategic vision for DND. This is a vision in which Canada is **strong** at home, **secure** in North America, and **engaged** in the world. The CAF will be prepared and equipped to advance our country's international security objectives – from conducting expeditionary operations to engaging in capacity building with partners – and to support our allies where our shared interests are at stake.

To accomplish its mission, the Canadian Joint Operations Command (CJOC) currently force employ CAF members on several small missions around the world. Recent operations have seen an increased requirement for Force Protection (FP) measures that include the wearing of civilian clothing and the use of specialized personal protective equipment (PPE). FP is a vital task in order to protect Canadian personnel in a variety of locations where the threat is asymmetric in nature and difficult to anticipate. The primary method of defence is to maintain a discreet posture thus limiting opportunistic attacks. Current operations in the Middle East are not conducive to the use of Standard Military Pattern vehicles but still require protection against threats such as; but not limited to, small arms fire and improvised explosive devices.

ASUV Toyota Land Cruiser 200.

Typically, LEMS focuses is on survivability, lethality, mobility, and sustainability. CJOC now views concealability as another critical factor requirement for mission success. This requirement can be met with commercially available Armoured Sport Utility Vehicles (ASUV) which provide the level of protection and mobility required to ensure the security of deployed troops.

CJOC has identified the requirement to conduct operations in areas where the threat levels justify the protection and mobility offered by ASUVs. Therefore, the CJOC ASUV fleet increased by 23 vehicles in 2017.

The vehicle is a full-size SUV modified to meet VR 7 ballistic armour that provides all-around protection and complete coverage for the crew. It has armoured windows and a protective inner shell with additional protection for the fuel tank.

ASUV Armoured window.

All accessories as per the Original Equipment Manufacturer (OEM) specifications were retained in the upgraded vehicle – such as air conditioning, radio, adjustable steering wheel, adjustable seats, electric mirrors, and so on. The rear door is a dual clamshell type and although there is extra weight due to

the armoured component, it can still be opened without too much effort. All doors are equipped with manually operated and spring-loaded dead bolts to prevent forced intrusions. Front windows can be pulled down with limited access.

This 4X4 with traction control will assist in multi-terrain situations and is powered by a V8 diesel engine that provides more than enough horsepower to handle the additional weight and ancillary equipment. The wheel assemblies are equipped with run-flat tire inserts that enable the vehicle to run for at least 50 km at a speed of 50 km/hour with all tires fully deflated and with the vehicle loaded to the Gross Vehicle Weight Rating. The brakes were modified to ensure durability and to keep the braking distance to a minimum. The suspension was also modified to ensure stability and durability in all situations.

ASUV Door dead bolt.

ASUV Antenna pass-through.

Concealed Body Armour.

The vehicle is equipped with an intercom for two way communication without exposing the operator to a potential threat. It is also equipped with a fire suppression system for the crew and for the engine compartment.

In order to allow the installation of an antenna on the roof of the vehicle without having to compromise the integrity of the armour, the contractor has designed a pass-through hatch located on the roof.

The ASUV showed great potential during road test trials. Although the armour adds a great deal of weight and makes the vehicle feel heavier than a standard SUV, it handles well in all situations due to many improvements made by the contractor. Both the diesel and gas engines, matched to a well-calibrated transmission, performed very well and provided plenty of power to overcome the weight of the vehicle. Braking distance and turning radius at moderate speeds were impressive. The armoured windows provide an excellent all-around visibility which is comparable with the baseline vehicle. The interior of the vehicle is spacious and provides ample capacity for the crew. The rear seats can be folded completely for additional cargo storage. Overall, the vehicle performance not only met but exceeded expectations.

CJOC currently manages a fleet of 27 ASUVs required to prevent loss of life and are critical to the operational success of our specific missions. They have proven to be a highly reliable asset and they will be employed in various operations all over the spectrum.

Concealed Body Armour

CJOC has also started to provide Concealed Body Armour (CBA) to CAF members deployed on operations where civilian clothing is essential in order to maintain a discreet FP posture required to minimize the threat of an opportunistic attack.

The CBA provides personal bullet protection to small-arms fire by meeting NIJ 0101.06 level IIIA (ballistic protection). It gives the user a system of protective gear options that is low-profile and offers an enhanced level of protection that is acceptable in certain venues where a broad range of civilian clothing is worn. This PPE is an invaluable asset providing an additional layer of safety while enabling the user to move freely with minimal restriction.

Technology and the uncertainty surrounding future operations are having a significant impact on equipment and doctrine. Notwithstanding the fact that survivability, lethality, mobility, and sustainability will remain the key pillars of LEMS, concealability is definitely a concept that will have to be kept in mind in order to support specific operational requirements in order to achieve mission success.

Major Zizian is the J4 Major Equipment & Transportation for the Canadian Joint Operations Command.

The RCEME School – **Leading the charge on the development of technicians and leaders of tomorrow**

Students get a hands-on look at equipment on the shop floor during a Veh Tech training session.

By Capt S.J. Kuzmich, RCEME School, HQ

The RCEME School has the obligation to ensure the world class soldier-technicians and Officers of the Corps of RCEME receive cutting edge training and have the skills required to maintain the complex equipment in the CAF. The RCEME School consistently evaluates how it conducts training and where technology and the CAF are moving in order to ensure that the Corps's soldier-technicians are prepared to meet the challenges in garrison, on exercise and on Operations. Through visits to other training institutions, local colleges, and liaising with the Army Learning Support Centre (ALSC), the RCEME School ensures that the training provided is modernized and up to date. This article outlines some of the many initiatives that the RCEME School is pursuing in the effort to ensure the soldier-technicians of tomorrow continue to remain at the cutting edge of innovation and have expert technical and soldiering skills.

Precision Weapons Maintainer Course: Two trades with one goal

By Sgt J.M. Smith (retired), RCEME School, Artisan Coy

In 2013, a capability deficiency was identified in sniper rifles and precision weapon maintenance. As a result, the requirement to modernize training for weapons technicians was recognized and put into motion. Precision weapons demand an equally skilled and experienced RCEME technician who can accommodate the needs of each individual user in meeting their task. In order to close the gap with regards to the skills and experience required by a weapons technician to maintain these precision weapons, the task of developing a course was established. The Precision Weapons Maintainer course is currently under development at the RCEME School to meet this requirement.

The course development began with the identification of the training and knowledge deficiency regarding maintenance and repair of precision weapons. With collaboration of experienced weapons technicians and snipers, research was conducted in order to determine the experience and knowledge required to enable technicians to correctly maintain and finely tune precision weapon systems. Deficiencies that were noted included necessity to identify accuracy faults, bedding and re-barrelling, and the authority to correct manufacturing defects such as bolt intolerances.

In May 2016, a Qualification Standard/ Training Plan writing board, which included Subject Matter Experts from across the CAF, was convened to find solutions and develop a plan to address these training deficiencies. Currently, six Performance Objectives are being developed that include action blueprinting, machining of weapon sub-components, ballistic theory, bedding, troubleshooting accuracy, maintaining stocks, evaluating targets and ballistic data collection. The training is planned to be conducted at the RCEME School for an expected 33 days on the pilot serial.

Over the last 35 years, changes in roles and job requirements have seen our weapons technicians transition away from conducting machining operations. As the capability to machine materials currently rests solely with the material technicians, development of the Precision Weapons Maintainer course has necessitated the requirement for both weapons technicians and material technicians to work together in order to share their expertise. Changes in training will now expose our weapons technicians to emerging technologies and allow a return to a more traditional gunsmith role in the support of precision weapons.

To aid the development of the Precision Weapons Maintainer course and provide vital experience and knowledge, the RCEME School has sought assistance from RCEME technicians employed with Joint Task Force 2 who have vast experience improving the tolerances on weapons used by Operators. These technicians provided advice on the skill-sets required to maintain precision weapon. The techniques they demonstrated have traditional roots in producing custom hand fitted components that are commonly found in the gunsmith profession and are skills that are currently being taught on the Materials Technician Advanced Machining course.

As part of the course development, material technicians of the RCEME School gave the weapons technicians training on machining techniques to provide them with the knowledge and skills required to continue the development of the Precision Weapons Maintainer course. Once the development is completed and the delivery of the course is underway it will provide the skills and versatility to weapons technicians in order to maintain these precision weapons and in turn, increase the trust and co-operation between our snipers and their maintainers. Enhancing our weapons technicians' skills will better assist their ability to support the Canadian Army (CA) and continue to expand the Corps of RCEME's world class soldier-technicians that provide state of the art maintenance.

Innovating Vehicle Technician Training

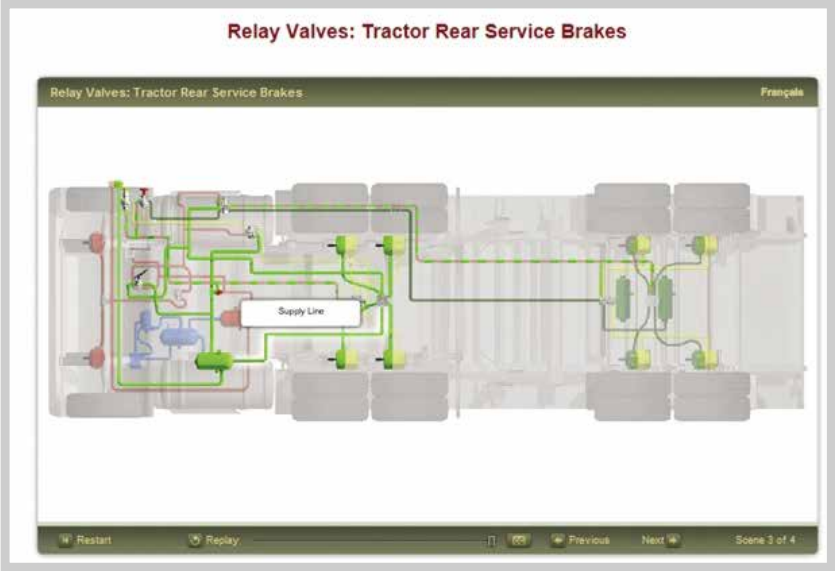
Through the Use of Modern Training Aids

By MWO R.C. Woolsey, RCEME School, Vehicle Coy

The Army Learning Support Centre (ALSC) in Gagetown has provided and continues to provide outstanding support to training at the RCEME School through the development of training aids. Two such examples developed in coordination between ALSC and Vehicle Company are the Air Brakes module and the Automatic Fire and Explosion Suppression System (AFESS) module. These training aids enhance the instructors' ability to teach these sub-components as well as provide the students with another means to understand the systems and how they operate, replacing some horrible PowerPoint slides that were previously used.

Currently DP1 Vehicle technician training uses the Air Brakes module to describe the operations of the air brakes system. The Air Brakes module is an interactive video with audio that describes the operation of the air brake system, including the antilock braking system. This tool affords the instructors the ability to walk and talk the students through the complete air brake system by showing the flow of air and easy identification of components.

Similar to the Air Brakes module, the AFESS module developed by ALSC offers a valuable training resource for instructors to use in the operation of the AFESS. This module is used in DP1 Vehicle technician training and features videos demonstrating how the AFESS works as well as additional videos that demonstrate the unique properties of the AFESS being employed in current



Air Brake Module

CAF vehicles such as the Leopard 2. This module is invaluable for instructors to teach students as it provides a method to demonstrate the overall operation of the systems and identify each component in one easy to view format that would be otherwise difficult to accomplish with just a physical vehicle by itself.

Vehicle Company is also working on two projects: a Recovery Simulator; and, a Vehicle Technician Text Book. The recovery simulator is going to be built in two phases in order to meet two different levels of training. The first phase is aimed at the DP1 Vehicle technician student so they can learn the equipment and controls. This will allow them to become familiar with the platforms being taught and will make the practical field training safer. Students will already be familiar with the controls and the impacts of accidents without having damage to equipment or injury to personnel. The second phase will be built with the DP2 Vehicle technician student in mind where the students are taught to command a recovery. This part of the simulator will target the selection of the correct equipment, completing the calculations, and development of the plan to execute the recovery. Following the inputs from the student, the simulator will execute the plan and if there are any errors it will identify the errors to help the student learn. Once developed this recovery simulator could provide units with a training aid that they could use for their own refresher training for their recovery crews. The goal is not to replace valuable field training, but rather to replace the outdated PowerPoint training methodology.

The difficulty with using industry automotive text books is that technology advances quickly, necessitating the requirement to procure new versions along with the limited ability for personnel to access these text books as refresher training and difficulties in finding bilingual texts. The Vehicle Technician Text Book strives to close this gap by using a format that is easily updated, and accessible to those that would like to brush up on their knowledge. This text book will also ensure that information is available in both official languages. The staff at Vehicle Company have developed the text and the future text book is intended to be in a format similar to Wikipedia. The text book will have the ability to be exported in PDF format and could be printed as required.

AFESS Module

Taking Tactical Exercise Without Troops (TEWT) to the Next Level

By Capt S.J. Kuzmich, RCEME School, HQ

Both RCEME technicians and officers learn to fight and survive on the battlefield from the onset of their training but once they commence their DP3 – RCEME Common, DP4 – RCEME Common or RCEME Officer DP1 they are required to develop the knowledge and skills required to site a maintenance organization and prepare a defence. This can prove to be a challenging skill to learn and ALSC is working with Regimental Company to develop a Siting Simulator that will provide instructors with an additional tool to teach siting. This tool will provide the students a resource to practise and hone their skills. Quite often students struggle when transitioning from the whiteboard in the classroom to the practice in the field. The goal is to use this simulation to ease this transition.

The Siting Simulator will include the ability to site a Maintenance Platoon and Maintenance Company in both a wooded and urban environment. The students will be provided a description of the enemy threat such as dismounted or motorized which will allow students to conduct their estimate and site their vehicles, trenches, weapons systems and defensive tasks such as observation posts and trip flares. Once the siting is completed the simulator will complete a simulated attack on the defence based on the threat and identify areas of improvement for the student. This simulator will provide students with a resource to practise their siting abilities before transitioning to the wood-line to conduct sitings. It will also provide the instructors with an additional asset to provide feedback to students.

> **"The goal is to use this simulation to ease this transition."**

The RCEME School consistently strives to ensure that RCEME technicians and officers receive world-class training and are prepared to meet the ever changing and advancing world. Through the development of new training and the implementation of new training aids, the RCEME School will continue to produce excellent technicians that are on the leading edge of technology. Technology is a tool we are using to augment and improve classroom preparatory training to maximize the training experience for the students once they start their hands on and practical assessments.

RCEME students make use of training boards to further enhance their skills.

Mobile Tactical Vehicle Fitter – LAV 6.0 Power Pack and Turret Lift Update

By Maj Rob Cummings

The Mobile Tactical Vehicle Fitter (MTVF) with the Palfinger crane has been employed in the support role at 1st and 2nd line maintenance units since it came into service and is capable of removing and installing the Light Armoured Vehicle (LAV) III power pack and turret. In 2015, the Tracked Light Armoured Vehicle (TLAV) Equipment Management Team (EMT) of Directorate Armament Sustainment Program Management 2 (DASPM 2) asked if the MTVF could support the new LAV 6.0 fleet in the same way. They enlisted support from the Land Engineering Support Centre (LESC) at Uplands, a sub-unit of 202 Workshop Depot, where the LESC engineers investigated and analyzed the MTVF geometry and specifications to ensure that these tasks were theoretically possible.

The engineers confirmed that it was possible based on numerous factors including the weight of the power pack and the weight of the turret with Add-on-Armour as well as the location of the Center of Gravity (CoG) and crane specification.

Next, in June 2016, Nivard Audet, TLAV EMT Coordinator, and MWO Pierre Carrier, Trial Officer of the TLAV EMT, along with Heather McDonald of LESC, teamed up with Vehicle Technicians MCpl George Eldridge and Cpl Dean Condon and with Weapons Technicians Cpl Jonathan Roberts and Cpl Yvan Trudel, all of 1 Royal Canadian Regiment (RCR) – augmented with support from MCpl Jean Claude Glandon and Cpl Scott Simmonds of the 2 Royal Canadian Horse Artillery (RCHA) for a two-day trial at Canadian Forces Base Petawawa in 1 RCR's Maintenance lines.

The original intent was to conduct two tests during this trial – the first was the "Removal/ Installation" of the power pack and the second was the "Removal/ Installation" of the turret. However, it was decided not to conduct the latter due to safety concerns. The test for the power pack included its removal from the LAV 6.0, moving the power pack over to verify that it could be placed on the MTVF deck, then moving it to the power pack stand and finally reinstalling the power pack in the LAV 6.0. This was intended to prove the MTVF's needed capabilities during operations or exercises.

Prior to commencing the trial and before lifting higher, the load was raised one inch and held for 30 seconds to ensure it was secure and to confirm that the load would not exceed the MTVF's capabilities found on its load chart. Attention was paid to the mandatory two-foot rule, whereby the crew confirmed that there existed two full feet of space between the recovery vehicle and the vehicle causality. Following calculations using the load

chart, the test was performed using a maximum horizontal crane extension of 145.7 inches (370 centimetres). Despite sufficient calculated clearances between the lifted power pack and the LAV 6.0 deck, the LAV 6.0 was lowered under power, from the driving height to the transport mode height, just to be sure, while the engine was still connected and capable of powering the adjustment.

The trial proved that the crane was capable of lifting the LAV 6.0 power pack out, but there were problems. The boom experienced significant creep and droop issues while leaking hydraulic fluid, and, after expansion, it was seen to slowly retract up to four inches over 30 seconds. These issues led to the crane operator making several needed corrections and significantly elevated the risk to the technicians working with the power pack, test vehicles, and test equipment. The results of this first trial were disappointing, but they indicated that there may have been an unknown cause of the failure.

At the conclusion of the trial, Mike Rondeau, the Chassis Technical Authority for the TLAV EMT, requested that a sample of the MTVF crane's hydraulic fluid be sent for Spectrometric Oil Analysis Program (SOAP) testing. The results that came back a week later showed that the crane had contained the wrong fluid. With this new information in hand, he requested that 202 Workshop Depot prepare a second MTVF in accordance with the associated Canadian Forces Technical Orders (CFTOs). This MTVF successfully lifted the LAV 6.0 power pack with the boom extended to 3.7 and 1.8 metres without any evidence of overload, droop or hesitation. Even though the power pack lift was declared a success after the second trial at 202 WD, LESC still recommended that the MTVF crane not be used to lift the LAV 6.0 turret even if creep can be removed from the system, due to the coarse movements of the crane, the tight clearances between the turret and the LAV 6.0, and the need to operate the crane at its load limit for this procedure. Consequently, the TLAV EMT will not pursue the turret lift for the LAV 6.0.

SOAP is conducted by performing an elemental analysis of structural metal and other material particles entrained in machinery oil samples and determine the chemical composition. By comparing results to the known profile of the system being examined abnormal wear of various parts may be identified and corrective and/or preventive maintenance performed before expensive repairs are required or catastrophic failures occur.

Recognizing the requirement for the lift of LAV 6.0 power packs, the Palfinger CFTO has been amended to include instructions on how to set up for the removal and installation of the LAV 6.0 Power Pack using the MTVF. Technical tip: During your next MTVF 1136 inspection, send your crane's hydraulic fluid for SOAP testing.

Maj Cummings is the TLAV Integrated Logistics Support Manager (ILSM).

The Future of the C6 Machine Gun in the Canadian Armed Forces

By Maj Geoff M. Wall and Bobby Cruise

The C6 Machine Gun has provided a baseline, quite literally, for military planning for over 30 years. It is a trusted, reliable, and proven weapon system that is an integral part of the CAF. If we could keep this capability, maintained in the same state for the foreseeable future, we would. However, the original C6 fleet is increasingly showing its age – and although an extensive refurbishment program has been ongoing for some years, it is time to carry out a refresh. As could be expected, the update of an entire fleet of weapons, which is still in-service and continues to be heavily used, requires careful planning if the CAF is to maintain this critical capability. This article will outline some of the issues resulting in the C6 fleet update and highlight what has been done so far to maintain the fleet. It will then describe the extensive planning, manufacture, and procurement of the C6A1 by various stakeholders for subsequent delivery into service. The goal for the C6 weapon platform is to rebuild the strategic medium machine gun weapon fleet by the end of 2024 – with the first C6A1 currently forecast to enter service in Fall 2019. The article is written for a wide audience and to ensure that the current in-service support and future of the C6 can be clearly understood by all.

Background

The Belgian 7.62 mm General Purpose Machine Gun (GPMG) was designed in the early 1950s at Fabrique Nationale (FN) by Ernest Vervier. It has been used by more than 80 countries, and continues to be made under licence in several jurisdictions – including Argentina, Egypt, India, the United Kingdom, and Canada (as the C6 GPMG) – that purchased the intellectual property rights in the 1980s to support and produce C6 weapons.

Initially purchased by Canada from FN in 1975 and subsequently delivered into service approximately 10 years later, the C6 machine gun, now over 30 years old, took over some of the roles that had been covered by both the FNC2 and the C5A1 Machine Gun. On the vehicle side, the C6 was originally used for the Leopard tank but additionally used for the increasingly wheeled Canadian fleets such as COYOTE, LAV and BISON.

The C6 machine gun is available in three primary variants: Infantry (Flex) used at Section/Platoon level, Coaxial for Armored Fighting Vehicles/Tanks and Aircraft (Helicopter) variant. The main differences are: the shoulder butt, gas regulator in a different configuration and sights on the Coax. Within Coax there are a variety of versions for the different vehicle fleets such as a right-hand ammunition feed. For reasons of maintenance support, simplicity, and fleet reliability the intention is to standardize the fleet with as many common components as possible.

The C6 is used by all main elements of the CAF – namely Army, Navy and Air Force – with the fleet size of 4964 prior to the C6A1 program.

New capital projects, TAPV (Tactical Armoured Patrol Vehicle) and MHLH (Medium to Heavy Lift Helicopters) have added to the overall fleet size with their recent and ongoing acquisitions. The initial production weapons will fulfill these needs, although the Royal Canadian Air Force (RCAF) weapons were assembled and delivered from the new-old stock weapons on hand in 2015. DSSPM (Director Soldier Systems Program Management) has signed service level agreements with the TAPV and MHLH projects that require DSSPM to deliver complete Flex and Coax versions of the C6 to support the vehicle production schedules. TAPV requires 364 weapons plus 36 spares for the vehicles being delivered across Canada. The effect of the additional requirements and attrition of aging weapons equates to the gap between allocations and actual fleet size widening as time goes forward; this necessitates the acquisition of C6 weapons immediately.

LCMM Support

The C6 Machine Gun is supported by one Life Cycle Materiel Manager (LCMM) in the Small Arms Equipment Management Team (EMT) – part of DSSPM within the Director

Employment	Users	#
	TAPV	400
	TLAV	126
	RCN	10
	Main Battle Tank (MBT)	82
	LAV 6	630
	Others Vehicles	730
	Infantry units	512
	Others units	638
	Training centre & Schools	318
CANSOFCOM		170
Ops/Log Stock		322
TOTAL		**3938**

USERS	#
MBT LEO +ARV	112
LAV 6	572
Others	35
Ops/Log Stock	72
TOTAL	**791**

USERS	#
HLMH	45
Tac Hel	190
TOTAL	**235**

Total = 4964

General Land Equipment Program Management team. The C6 GPMG LCMM provides an overall soldier systems approach while supporting this capability by taking the holistic requirements of the various weapons systems across the CAF into consideration. This is achieved in close collaboration with the Directorate of Land Requirements and elements of the Canadian Army Staff. This cooperative effort ensures that the correct weapons scaling can be aligned with the current and future organizational laydown stipulated by the Directorate Land Force Development (DLFD) in line with the direction received from the Commander of the Canadian Army. Ultimately, the LCMM is required to have intimate oversight of the C6 and their location in order to be able to provide the appropriate support.

Current Support Issues

As expected with a fleet of this age and use, the maintenance and ongoing support is increasingly demanding with a number of failures of the C6 weapons system. Specifically, the rivets and surrounding components (side plate, bottom plate) of the C6 show signs of wear most frequently. Local inspection at 1st and 2nd Line is often subjective and relies on the experience of the

weapons technicians and their experience of the C6 platform. Similarly, despite formal CFTO (Canadian Forces Technical Orders) instructions, successful repairs are largely based on the technician's experience. Given the age of the weapons and combined with a varied maintenance repair approach, this results in a tired fleet that requires a more considered, holistic maintenance approach.

Repair and Overhaul

To ensure that the C6 remained at full readiness and at planned mid-life, one recognized course of action that was explored was to consider a complete Repair and Overhaul (R&O) of the fleet. With the intent of breathing new life into the C6 fleet, and essentially putting new (refurbished) weapons back into service, a contract with Colt Canada was envisioned to replace all required parts over a number of years by cycling the fleet. However, despite the best efforts to ensure as much efficiency as possible through this process, R&O for C6 Machine Guns resulted in an expensive, time-consuming, and logistically heavy approach. The cost of the overhaul program looked likely to exceed the economical repair cost value. Also, taking into account the period of the R&O program, it would likely turn out that the whole process would be required all over again. Members that completed the engineering activities during 2013/14 engaged Colt Canada / FN Herstal / Quality and Engineering Test Establishment to determine the technical viability of the C6 fleet overhaul. The definitive conclusion from that activity was that there was ***no means of measuring how much remaining life was left in a C6 receiver.*** Therefore any machine gun that had a complete R&O activity without being able to determine accurately the integral metallurgical state of the various components of the weapon might in fact fail in short order due to the receiver being near end of life.

IRAN

A short-term contracting method of returning equipment back into service that was engaged by the LCMM during this period was the use of focused repair. The IRAN (Inspect and Repair As Necessary) program was subsequently created in conjunction with our small arms partner, Colt Canada, to ensure that only those C6 deemed Beyond Local Repair (BLR) by 2nd line weapons technicians were inspected more closely and only those that required it were repaired, 'as necessary'. One of the outcomes from this program is that the number of C6 Machine Guns that are identified as Beyond Economical Repair (BER) is approximately 30 percent and, due to the age of the weapons, rising. That is to say that DND loses up to one-third of the C6s that are sent through the IRAN line at Colt Canada.

Reduced Condemnation Criteria

DND would like to replace only those weapons that are worn (BER) and keep weapons that will remain serviceable for the expected lifespan. Various methods of returning C6 back into service as quickly as possible have been tried including reducing the condemnation criteria – such is the supply criticality of C6. Reducing the condemnation criteria focused on areas of the weapon that were not integrally important to the firing operation. Repair operations would then take place only on those components considered critical to the firing of the gun. Other parts of the weapon system would not be considered. However, this was not a popular approach and was rejected due to an understandable perception in reduction of safety for the user. It was clear that R&O was expensive and only returned refurbished older weapons back into service while IRAN induced a loss in numbers of weapons – which was felt across the whole fleet. Various other methods of maintaining the fleet have been considered but still do not bring the required levels of equipment support that retain C6 Machine Guns in service. The subsequent outcome from a very tired, old fleet of weapons with restrictive support or maintenance options has resulted in a significant shortfall in C6 availability across the CAF. To alleviate immediate concerns, a number of CFTOs have been produced – specifically Tech Update #109 that refers to the inspection of loose rivets and the procedure for back-loading suspected BER C6 Machine Guns. However, this is a short-term measure and not a long-term solution.

Update Required

Based on quotations from Colt Canada, the cost of the R&O on the remaining legacy C6 weapons starts to approach the production costs of a new C6 weapon. Subsequently, DND directed that there would be a new machine gun to replace the entire fleet. As testament to the C6 timeless design and long-term, proven reliability, it was decided that the Medium Machine Gun fleet would be replaced by a new version of the C6 made under licence from FN Herstal, Belgium by Colt Canada. A number of factors were considered before making this decision – such as the performance of the weapon, extensive spares remaining in depot, modification requirements to existing infrastructure (vehicle and aircraft mounts), leveraging of the manufacturing licence owned by Canada, and Canadian industrial benefits for an initiative that would likely be greater than $100-million.

The new C6A1 will be a Canadian-manufactured C6 Machine Gun and the first ever such weapon in Canada. The long-term supportability of new weapons is more cost effective than continuing to extend the life of the legacy weapons to 50 years. All new C6A1 weapons will be required to be delivered with their EIS (Equipment Issue Scale), cleaning kits, and barrel bags.

TDP Update and Receiver Manufacture

Small arms procurement by DND has the opportunity to make use of contracting under the Munitions Supply Program. The Government of Canada's industry partner for small arms is Colt Canada in Kitchener, Ontario. For the C6 weapon, Canada can acquire new weapons based on the original Fabrique Nationale design with Colt Canada manufacturing them to meet DND's needs. Due to the nature of the manufacturing rights, Colt Canada will only be able to sell C6 weapons or subcomponents to Canada. The Canadian Technical Data Package (TDP) – which has recently been updated to bring it in line with current drawing standards and to ensure that it reflects accurately – defines the new production configuration. There is also a critical link between the completion of the TDP tasking and production start. Colt Canada and DND have worked tirelessly to regenerate the original hand-drawn FN TDP to bring it in line with current requirements and modern drawing standards. Colt Canada is also developing the design and manufacture production tooling – leading to Canadian ownership of this process.

To accelerate the production line setup, a task was given to Colt Canada to develop the main component of the C6 – the receiver. The production of the C6 receiver required significant investment by Colt Canada in terms of resources and cost and machinery along with considerable engineering experience to ensure that a high-quality product lasting for another 30 years and beyond was the result. Despite having access to the FN TDP, some of the engineering challenges remained and it is a credit to the coordinated effort between the small arms EMT and the engineers at Colt Canada that the resulting receiver, when assembled into a machine gun shortly afterwards, was fired successfully by the Small Arms Senior Technical Authority (SASTA) at first trigger pull.

The resulting C6 receiver was completed in November 2016 and can be seen on the attached image.

Estimates from Colt Canada indicate that production deliveries at peak will be around 75 weapons per month or 900 per year. If Colt Canada can produce 550 in 2019, and 900 for the remaining five years it will take until the end of 2024 before the last legacy C6 systems are removed from the fleet. In early 2021, the fleet size will match the requirements based on existing natural attrition. After the 'catch-up' point, the remaining C6s will be divested at the same rate as production can back-fill them.

C6A1 Replacement Program

Configurations were boiled down to the three in-service configurations, of which the air variant was built and delivered out of the existing equipment. The remaining two variants, FLEX in the A1 condition and the COAX, have been designated for complete fleet replacement. The procurement strategy for replacement was then planned in a two-phase approach. The first proceeds immediately with a contract for the funded requirement to replace 703 FLEX weapons already lost to attrition, as well as 445 FLEX for new incoming fleets such as the TAPV and MHLH. The second phase, to be approved shortly will replace the remaining 3,626 FLEX and COAX weapons through a formal capital project. Early on in the procurement process it was identified that this procurement was to be completed within the Munitions Supply Program (MSP) at Colt Canada in accordance with the approved strategy from the Director General level Defence Procurement Strategy Governance Committee (DPSGC).

This procurement strategy then necessitated the investment in setting up the production line at Colt Canada, as they had not yet produced a complete C6 machine gun. The first contract, let in March 2017 for $32.1-million, gives the Canadianized production line engineering validation and the manufacture of the first 1148 C6A1 FLEX machine guns. During the second phase, a number of ancillary items will also be procured, such as ammo carrying bags, hot barrel bags,

and optical sighting systems – which will improve the existing machine gun capability and ease of employment.

Delivery and Lifespan

Production of new, Canadian-made C6A1 machine guns has begun and delivery is currently scheduled to start in mid-2019 continuing through the two contracts until 2024, at which time the fleet of 4,964 C6 machine guns will be in service.

Based on DND's experience with the existing fleet of C6 machine guns, we can expect the renewed fleet to last between 25 and 30 years of service. Having a Canadian source of supply for the complete machine gun on a standing offer will greatly improve LCMM's ability to ensure that this weapon remains effective and available into the foreseeable future. Using our knowledge of existing C6 issues, it is also planned that some of the original C6 will be repurposed into dry training weapons to alleviate the degradation on the new C6A1 and therefore further increase the lifespan of the new weapons.

The Future

The C6 Machine Gun in its many configurations has proven to be an effective weapon system with a unique capability. The production and manufacture of the C6A1 in Canada provides us with a weapons system capable of meeting the needs of the CAF for at least another 30 years. The new machine gun will feature a durable polymer butt stock instead of the current wooden style. Soldiers will be able to attach pointing devices and optical sighting systems to the new weapon to help increase their operational effectiveness. To meet the operator's needs, a multiple position gas regulator will replace the current type, allowing the user to fully adjust their rates manually or fire without the necessity of removing the regulator or the barrel. This ease of adjustment does come with a cost as weapons technicians will have to initially set up each gas regulator on individual machine guns, slightly increasing equipment down-time prior to use. Although the adjustable gas regulator is not new to the configuration of the Canadian C6 Machine Gun as a similar system was used in the past, training will be necessary to bring some personnel up to date – both the technician and the soldier.

As ever, the C6 Machine Gun, similar to any equipment used within the CAF, is only as good as the operators and maintainers who are intimately involved with its use and safe operation. The human dimension is as important in using the C6 as the finely tuned engineering dedication shown by the team at Colt Canada or the relentless coordination of this large fleet by the sole LCMM responsible for its daily in-service management and technical support.

The experienced Small Arms Capital Program (SACP) team has a clear focus on the requirements to bring into service a new C6 Machine Gun. The team members' interaction and coordination with both the user and industry will provide a weapons system that is as reliable and long-lived as the original. The lessons learned and the further knowledge gained through the development of the C6 receiver by Colt Canada and the EMT will pay dividends as we embark on a further period of in-service management of this weapons system. This program will see the replacement of the complete C6 GPMG fleet, ensuring in part that the CAF have the tools they need for the foreseeable future. And – which is more – it is all manufactured in Canada.

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Contract Gives the Green Light for a **New and Improved Headquarters Shelter System (HQSS)**

By Elefteria Gagaous, with contribution by HQSS Team

After a competitive process, the Government of Canada announced in February 2017 that Weatherhaven Global Resources Ltd. of Coquitlam, B.C.– one of the world's leading providers of redeployable shelter systems – was awarded two contracts valued at approximately $168-million (taxes included) to procure shelters and related equipment, plus an initial five years of in-service support.

The first award, the Headquarters Shelter System (HQSS) Acquisition Contract, is for the procurement of shelters and related equipment. The second agreement is the HQSS In-Service Support (ISS) Contract, which will provide maintenance and support services for the first five years with four five-year option periods. Should the government exercise all options on both contracts, the value could be up to $350 million (taxes excluded).

The Project

The enterprise is a joint, strategic project that will deliver capability to the CAF with the Army taking the lead. The other joint stakeholders are the Royal Canadian Air Force (RCAF), Canadian Special Operations Forces Command (CANSOFCOM), Canadian Joint Operations Command (CJOC), and the Health Services Group (HSG). The HQSS project will acquire a new tent-based shelter system and related equipment such as flooring, lighting, heating, ventilation and air conditioning equipment, and cargo containers for the CAF. The newly designed system will provide the CAF with a modular, tactical, mobile soft-walled shelter capable of housing tactical command posts that can be set up and torn down quickly without the aid of specialized equipment. The new shelters will be used both domestically and abroad, and will be able to operate in all environmental conditions envisioned for CAF operations and training.

The Need For HQSS

The CAF requires a Headquarters Shelter System to partially replace the current Tent Expandable Modular System (TEMS), commonly known as Mod Tents, that has been in service since 1970. Since its acquisition, requirements for Command, Control, Communication, Computers, Intelligence, Surveillance, and Reconnaissance electronic equipment, work space usage, and supply of electricity have evolved significantly. Specifically, headquarters organizations and medical

groups require significantly better tactical facilities than are available using Mod Tents.

The new headquarters shelter system will provide better protection against harsh weather, greater layout flexibility to adapt to different operational needs, and improved electrical and lighting systems with heating and air conditioning.

The CAF plays a significant role in defending Canada in the North, supporting United Nations peace operations, providing international humanitarian assistance, and maintaining strong commitments to North American Aerospace Defense Command (NAADC) and the North Atlantic Treaty Organization (NATO). The shelters will be deployable both at home and around the world and will function in a wide range of environments and climates. The new shelter system will also be lighter in weight, more robust, and more energy efficient. It will also provide significantly more collaborative working space than its predecessor.

HQSS At A Glance

The HQSS consists of sub-systems and ancillaries. The sub-systems include operations shelters, planning shelters, and office shelters, each equipped with a solar shade, shelter connector hubs, vehicle boots, and blackout vestibules complete with a hard door. The ancillaries include environmental control units, oil-fired diesel heaters, semi-rigid flooring, LED tactical lighting kits and cargo containers.

The HQSS has been developed with six equally important high-level operational requirements in mind.

1. **Flexible Foot Print and Modularity:** The individual shelters that make up the HQSS complex are of various sizes, modular, and flexible in their interconnectivity to enable a unit to be configured to meet the requirements of different missions. Multi-directional configuration is possible, both directly between shelters and utilizing the connector hubs. In addition, the shelters are made of modular and common frame and fabric components with removable insulation and liners. All aspects of the HQSS are focused to provide a collaborative workplace. The three main components are the Operations Shelter, the Planning Shelter and the Office Shelter, all providing an environmentally controlled setting. The Office Shelter is the smallest of the three main units and can accommodate five people and their workspaces. The Planning Shelter is sized to accommodate up to 20 individuals and their workspaces. The Operations Shelter is the largest of the three main shelters and it can accommodate 30 occupants and their workspaces.

> **"Six to eight soldiers…are able to achieve basic shelter set-up within 20 minutes."**

2. **Set-up/Tear Down Simplicity:** The fast set-up/tear down and storage procedures are simple and robust enough to be effective in all weather and restricted light conditions. From the commencement of a shelter's set-up, six to eight soldiers – depending on the size of the shelter – with only one being familiar with the system, are able to achieve basic shelter set-up within 20 minutes. Any removable parts or fabrics are easily identifiable for their use in low light level conditions and simply stored for transport.
3. **Tactical Mobility:** The design of the HQSS enables it to be manually set up/torn down and moved multiple times within a given mission scenario and varied climatic conditions. It also packs into sufficiently small containers to be moved easily within an operational setting by all current CAF transport vehicles.
4. **Repair Simplicity:** It is anticipated that portions of a shelter system will be damaged while deployed. The parts of the system that are most likely to fail will have available spares. The shelters are designed for easy and rapid replacement of fabric and frame components. First-level repairs will be accomplished within one hour and second-level repairs within three hours using tools and techniques commonly available to our Material Technicians in all operational units. Furthermore, the conduct of first- and second-level refurbishment in the field will be achievable while a shelter remains erect and operational.
5. **Climatic Protection:** The system is waterproof and provides snow load capability to safely operate in Canada's widely varying climate. It will protect the occupants and their electronic equipment from high winds, driving rains, and dust. The environmental control unit/heating system, when combined with the insulating properties of the shelter, will provide comfortable internal temperatures while operating in extreme ambient temperatures from -51 degrees Celsius to +49 degrees Celsius. The system's semi-rigid flooring will allow a stand-off capability from the ground and be capable of accommodating uneven

terrain. The flooring will also integrate a cable management system for electrical and data cables.

6. **Collaborative Working Environment:** The modern headquarters environment involves multiple groups that collectively view the same situational awareness screens to plan and execute their tasks. The layout of the HQSS's internal space is designed to foster collaborative work areas, space for briefings, and room for the multitude of Command Post digital display screens. The variety of potential configurations of equipment and spaces is virtually infinite. The layout of the HQSS internal space will be determined by the units in the field and the requirements of their mission.

Usage Of The HQSS

The HQSS will dramatically enhance the CAF's ability to plan, coordinate, and command its personnel during training and deployed operations by providing a modern shelter system for all unit and brigade headquarters.

The shelters can serve as command posts in an area of operations for larger headquarters, a planning area, and office and utility areas. Other functions, including accommodation and medical facilities, will also be supported with this equipment.

The shelters will have vehicle boots capable of connecting to in-service vehicles and vehicle-mounted hard shelters, thus expanding the versatility of the system. The HQSS will also be capable of being packed and stowed into a cargo container or on an aircraft pallet for transportation by air, sea, and land.

Procurement Under The Contract

The acquisition contract will procure 1,435 shelters, and it also includes options to acquire an additional 338 shelters. The contract includes provisions for related equipment including shelter connector hubs, hard doors, black-out vestibules, vehicle boots, tactical lighting kits, semi-rigid flooring, environmental control units, heaters, and cargo containers.

In-Service Support (ISS) Contract

A unique aspect of this system is that the winning company was also awarded the ISS contract for a period of five years – with four five-year options. It will provide support activities such as maintaining technical publications, repair and overhaul, spare parts supply, configuration management, system engineering and technical investigations, and field technical services. The ISS contract will allow for timely support over the life of the HQSS while minimizing life-cycle costs and helping to ensure the CAF is ready for missions.

Next Steps

The preliminary designs have been completed for the HQSS along with soldier trials confirming the design conducted at CFB Edmonton last spring. First deliveries of the HQSS to operational units are expected by early 2019 with final deliveries expected by 2021. A significant portion of the current TEMS shelters will be removed from service after complete delivery of the HQSS equipment. The remaining Mod Tents will remain in-service for years to come for less demanding applications and to augment HQSS for more basic shelter needs. The need to provide a common, safe, supportable, and effective system is of prime importance. The HQSS will be used to support CAF activities in Canada and abroad for at least the next 25 years, and is anticipated to last much longer.

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Elefteria Gagaous is the Project Control Officer for the Headquarters Shelter System project where she has worked since joining Directorate Combat Support Equipment Management (DCSEM) team in 2012.