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Vehicle Technician Cpl Sheon Rodman conducts a pre-use inspection on an ACE-804-H-CUP Air Conditioning Unit used on the C130J Hercules. Cpl Rodman is part of a team involved in aircraft ground servicing equipment tasks at Ali Al Salem Air Base, Kuwait.

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Cover Photo: The recovery team of the eFP Latvia BG Maintenance Troop Roto 11 (from left to right) Cpl Pierre-Luc Godin-Thomas, MCpl Vincent Bouchard-Grenier, Cpl Kevin Damico, and Cpl Mickael Hébert coordinate with the Estonian Armed Forces members during a recovery call on EX SPRING STORM 19 (EX KEVADTORM 19).

Photo credit: Cpl Patrick Martel, V-Tech 5e Bataillon des services.

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Director General
Land Equipment Program Management

Brigadier-General
Rob Dundon

Send articles and comments to:
LEMSJournalSGET@forces.gc.ca

Coordinating Editor
Tom Douglas
thomasmdouglas@gmail.com
Tel. (289) 837-3168

DIRECTOR GENERAL'S COMMENTS

INTERNATIONAL/INTEROPERABILITY

ENABLING ORGANIZATIONAL INITIATIVES

FUTURE CAPABILITIES

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DIRECTOR GENERAL'S COMMENTS

The future is now and... the future is ours!

By BGen Rob Dundon

It is with great pride and pleasure that I use this venue as the newly appointed DGLEPM as my first address to the LEMS Community, its technician, family, and supporters. This is not insignificant nor is the importance lost on me; as my predecessor, BGen A.T. Benson, stated previously the *LEMS Journal* is an essential forum for professional education, the development of skills, and our ability to adapt and evolve. I'd suggest it's all of those things and more. In fact, it should connect us to strengthen our bond, reinforce our brand, and further our collective intellect in making the right decisions for our structure and training in the future. I want these articles to trigger emotion, imagination, ideas, and – perhaps most importantly – critical thought and discussion.

There are key messages contained within this publication that point to technological advances and evolutions that are at our doorstep. You will note many references to the future, to our future, where keeping pace with technology can serve us greatly. Even a quick look at the summary should excite you... interoperability, additive manufacturing (AKA 3D Printing), artificial intelligence (AI). The future is now, and, with your help the future is ours!

Focusing specifically on the Corps of RCEME as it celebrates its 75th anniversary, RCEME personnel have maintained a reputation as innovators within the whole of the Canadian Armed Forces. That spirit characterizes us in our daily approaches and is reinforced by our dispersed network of specialists spanning the 'down and dirty' of the tactical business, to operational planning, to strategic management and acquisition of fleets. Our successful evolution in any or all of the above areas balances on this holistic view.

As you enjoy this journal be proud, be strong, be bold, and be critical. We need it. We need you.

BGen Rob Dundon signs to become the new Director General Land Equipment Program Management (DGLEPM). Seated to his far right is the outgoing DGLEPM, BGen A.T. Benson, who is moving on to a new position within ADM(DIA). Seated between the two is Patrick Finn, the ADM(Mat).

NATO Interoperability: RCEME in Latvia

By Capt Kevin Lee

The Spanish sapper crawls through the back door of his M113 armoured personnel carrier (APC) and reaches for his toolbox. Light, sideways rain; damp marshy roads; and faint echos of exploding artillery-simulators in the distance. It is a frosty February morning in the Adazi training area. The sapper hands the end-connector punch to the Slovakian mechanic who then, with a combination of broken English and body language, discusses with the Canadian Mobile Repair Team (MRT) commander where to unlatch the tracks of the vehicle casualty. As the pair start hammering the punch, two Slovakians attach the recovery cable to the pintle hook of the M113. "*Vas-y!*" the Canadian MRT Commander signals to his driver, and the engine of the Bison Mobile Recovery Vehicle (MRV) roars as it hauls the casualty towards the main road. The Slovakian driver jumps into his Pallet Loading System (PLS) vehicle and lowers the platform.

This was the second recovery call of a Spanish M113 in the past 24 hours, and by this time they knew what to do. The week-long Integrated Capstone Exercise (ICE) would mark the first major milestone for the Maintenance Troop of OP REASSURANCE Roto 11, where our RCEME technicians would truly learn the meaning of interoperability.

The Enhanced Forward Presence Latvia Battle Group (eFP LVA BG) stationed in Camp Adazi is composed of nine nations working together to deter aggressors, and defend Latvia if necessary. To this end, interoperability is our main focus throughout our exercises and mission as a whole, and serves as the foundation for our success. As the Maintenance Troop of the Framework Nation, our responsibilities go beyond the Canadian fleet. We also have a responsibility to support all Sending Nations (SN) and other NATO allies in all functions of maintenance that exceed their integral capabilities. This puts enormous pressure on the Canadian maintainers from a recovery and sustainment point of view, whether in garrison or in the field.

I recall the words from Commander Canadian Joint Operations Command (CJOC) Lieutenant-General Michael Rouleau during our first week. He warned that it would take a very long time to see our hard work bear fruit due to the numerous implications at the national, strategic, and multinational levels. However, he also suggested that if you take the foundation built by those who came before you, and you succeed in moving the "yardstick" a little further in the right direction, the mission can be considered a success. Being the fourth rotation in a peacetime mission such as this one, it is difficult to measure the magnitude of our success. Previous rotations had helped bridge the gap in compatibility between various SN platforms through numerous efforts, such as the NATO Recovery Matrix. This was our starting point. Over the next six months, our goal would be to take these theoretical calculations and practical recovery trials and apply them to real life scenarios to test the limits of our interoperability.

Since the Canadian Contingent's arrival in Latvia, Canadian maintenance elements have had limited exchanges with our Latvian counterparts. This set the stage for an unprecedented exchange opportunity between the Maintenance Troop of Roto 11 and the Maintenance Company of the Latvian Combat Service Support Battalion (CSS Bn). The idea was simple: exchange a couple of teams and their assets to have them work under the

command of the other organization, all the while living, sleeping, and working with their allied maintenance brethren. The first exchange occurred during ICE in February 2019. While the Canadian Maintenance Troop – accompanied by a Latvian Scania P112 wrecker and a MB2638 PLS dump truck – deployed with the A2 echelon, the Latvian Maintenance Company and their attached Canadian Armoured Heavy Support Vehicle System Heavy Mobile Repair Team (AHSVS HMRT) and Bison MRV deployed rearwards to the Brigade Support Area (BSA).

Forward support saw each Latvian asset paired with a Canadian-led MRT every time they responded to a Repair Recovery Request (RRR). To further test our interoperability, additional SN assets joined our maintenance "fastpacks" – namely the Spanish Leopard 2 Armoured Recovery Vehicle (ARV) and a Slovakian PLS. Throughout the week-long exercise, this multinational maintenance ensemble completed a total of 20 RRRs – half of them being vehicle casualties from other nations. Our rearward maintainers working under the Latvian Maintenance Company experienced Latvian Standard Operating Procedures (SOPs) first-hand. They took part in establishing the BSA, participated in the Latvian camp routine, practised recovery drills, and turned wrenches in the deployed garage. This gave them the opportunity to share their technical knowledge and experience with their host mechanics, creating bonds that would last throughout the entire mission.

Following the success of this exchange the winning formula was set, and ready to be applied and executed during our next major exercise. Ex SPRING STORM 2019 brought with it a plethora of preparation and sustainment challenges. During the preparation phase of this exercise, we integrated the sole Slovenian mechanic into our organization to work alongside our maintainers. This incorporation of multinational support ensured that the Slovenian High Mobility Multipurpose Wheeled Vehicle (HMMWV) fleet was ready to deploy on time. As the rest of the BG was getting ready to deploy, the Maintenance Troop was given the specific task to support the entire road move: a convoy of approximately 250 vehicles from Canada, Spain, the Czech Republic, Slovenia, and Latvia travelling from Adazi to a training area in Estonia. The recovery plan for this 400 km road move included only two Equipment Collection Points (ECP) before and after crossing the Estonian border.

With our own integral Canadian resources stretched thin, we looked to our allies for support. Perhaps the best example of this came when a LAV 6 broke down with a blown engine near the second ECP, and the decision was made to backload the vehicle to Camp Adazi. The Canadian AHSVS Flat Deck Recovery System (FDRS) was selected for the task. At the same time the call went out, a Polish lowbed responded almost immediately. Instead of the Canadians backloading the vehicle the entire way, they only went as far as the first ECP, where the vehicle was cross-loaded onto the Polish lowbed. This saved the Canadian crew almost 10 hours of driving, and allowed them to continue providing integral support to the rest of the convoy. The support provided by our allied crews, who were not initially part of the exercise, alleviated the workload from the Canadian recovery crew and ultimately strengthened our ties, while proving our abilities to operate interdependently.

As Canada's engagement as the Framework Nation of eFP Latvia continues into the foreseeable future, cooperation with allied nations will become increasingly important. Interoperability between allies has taken centre stage, thus making platform compatibility a focal point for mission success. As we enter a new era of defence procurement, we must ask ourselves: Should interoperability be regarded as a main criterion in the selection of future vehicle platforms? Until then, we will continue our role as a framework nation and a world military leader, which is solidified by our soldier technicians who demonstrate exceptional work throughout combined operations by moving the "yardstick" just that little bit further in the right direction.

Capt Kevin J. Lee, the 12e RBC Maintenance Officer, was deployed on OP REASSURANCE Roto 11 as the enhanced Forward Presence Latvia Battle Group Maintenance Officer (eFP LVA BG Maint O).

X Bty in **OPERATION REASSURANCE**

By MCpl Martin Collin-Boudreault

The Weapons Tech detachment assigned to X Battery, 5e Régiment d'artillerie légère du Canada (X Bty, 5 RALC deployed on OPERATION REASSURANCE (Latvia) in January 2019. During their deployment, they exhibited tremendous creativity and resourcefulness in supporting the gunners in achieving their training objectives. As soon as they arrived, they were up against major challenges such as the cold weather, lack of equipment and facilities, and limited resources to name just a few. The biggest challenge that the detachment encountered was the first exercise, scheduled a few days after their arrival. Hard work by everyone was required, combined with well-established coordination for using the maintenance facilities of the 12e Régiment blindé du Canada (12e RBC Battle Group [BG]). In addition, the cooperation of the dedicated X Bty crews, who provided excellent support for the maintenance of their new guns, was instrumental in the fleet's successful preparation.

Close Collaboration

Prior to deployment, 5 RALC had implemented a maintenance strategy that incorporated the M777 crews. Courses on the maintenance and optimal use of the M777s were introduced to prevent easily avoidable damage. The technicians were also involved in the delivery of conversion courses to the M777 and more advanced courses to the 2ICs of the gun crews. Functional tests were taught to the gunners to improve their skills in detecting faults and reporting flaws with ease and accuracy. These training sessions improved the gunners' technical knowledge and gave 5 RALC a high level of confidence in their weapons. The crews were very involved with the annual maintenance of the guns by washing and greasing the components and assisting the Weapons Techs in their duties, thereby significantly reducing the maintenance time required. Well-trained, involved, and conscientious crews coupled with skilled and committed technicians contributed to X Bty's success during OP REASSURANCE.

The unwavering support of the 12 RBC BG maintenance members, who allowed access to their facilities, equipment, and even personnel when the time came to handle the disassembled guns during the annual inspections, greatly facilitated the progress of the work and was much appreciated. It truly was a team of teams.

MCpl Collin-Boudreault is a Land Weapons Technician and was the section 2IC of the weapons maintenance shop in the 5ième Régiment d'artillerie légère du Canada (5 RALC). He was also IC of the X Bty weapons section on OP REASSURANCE (Latvia).

NEXT EDITION

LEMS Journal is your forum for putting forward ideas, commenting on current or past articles, and sharing related experiences. The next edition of the *LEMS Journal* is scheduled to be published early in the new year. If you want to be a part of the next edition, please send all articles to LEMSJournalSGET@forces.gc.ca **NLT November 1, 2019**.

OPERATION PROTEUS:
Canada's West Bank Contribution

By MWO Alex Auger

As a Maintenance (Maint) Subject Matter Expert (SME), I had the opportunity this past winter to deploy as part of Operation PROTEUS to conduct a Basic Logistics Course (BLC) for the Palestinian Authority Security Force (PASF). Operation PROTEUS is Canada's contribution to the international peace effort in the West Bank. Canadian Armed Forces (CAF) members serve with an international team as part of Canada's Task Force in Jerusalem (TFJ). Twenty-one CAF members and three police officers from various provinces are deployed in Jerusalem for a 12-month period supporting this effort. BLC 2019-01 was held from January 26 to February 20, 2019. It is currently delivered as a four-week training course at the Central Training Institute (CTI) in Jericho, covering basic concepts in supply, transport, maintenance, and food services.

A key Line of Effort (LOE) for Op PROTEUS is to develop the PASF in the effective provision of logistics support to its units. The PASF has established a Logistic Commission (LC) to centralize logistic support – which includes, supply and warehousing, transportation, distribution, food services, equipment maintenance, and infrastructure management and maintenance. In the future it may also include medical services.

The BLC was comprised of 24 Non-Commissioned Members and Officers from the PASF, coming from the 11 governorates that make up the West Bank – which has a population of approximately 2.8 million inhabitants in an area of 5671 km^2, roughly the size of Prince Edward Island. As with most courses, the candidates had few interactions during the first few days of training and, for the most part, kept to themselves. In order to break the ice, develop cohesion, and build confidence, we conducted a simple logistic exercise that involved the importation of Canadian-made maple syrup into the West Bank. This allowed student interaction in order to cover the 16 principles of logistics. The exercise was followed by a maple-syrup-tasting event, to the candidates' delight. Although the course had predetermined subjects and timelines, most classes evolved into professional discussions that complemented the teaching points. A few professional visits were completed as well in order to provide the candidates and SMEs with an understanding of PASF logistics and maintenance facilities.

Left to Right: CWO André Gouin, Capt Karmen Hill, SLt Esther Henry Lemieux, and MWO Alex Auger overlooking the Treasury (Al Khazna), Petra, Jordan.

Photo Credit: MWO Alex Auger

The BLC has been supported by Canada since 2012 and the PASF has reached a point where they have the knowledge and ability to conduct the course without Canada's involvement. Canada will continue to support the PASF LC through capacity building with the aim of improving professionalism.

MWO A.G. Auger is the company sergeant-major (CSM) of maintenance company, 5 Service Battalion (5 Svc Bn).

RCEME Day on **OPERATION UNIFIER** celebrated in the Ukraine

By Capt A.J.R. Bigonnesse

May 15 will always be an important date of the year for the members of the Royal Canadian Electrical and Mechanical Engineers (RCEME) Corps. This anniversary is even more special this year since it's the 75th. For eight Corps members the celebrations took place since they are currently deployed on Roto 7 of OPERATION UNIFIER in the Ukraine, illustrating once again that the Corps is a "regiment of small units everywhere." This mission underscores Canada's contribution in supporting the Ukrainian Armed Forces in developing their capabilities, in partnership with the United States and other countries providing similar training assistance. Corps members are called upon to provide real-time support as well as support to logistical and training operations of all kinds.

To commemorate this special day, the RCEME Corps members combined work and play by touring the Lviv Armor Vehicle Factory, located about 90 kilometres from the Polish border. Coincidentally, that facility was also celebrating its 75th anniversary on May 9, providing the two groups with a common heritage. At the beginning of its history, the Factory's primary task was to repair the damage done to Ukrainian and Russian armoured vehicles during the fighting against the Nazis in order to return them to the front lines as quickly as possible. The Factory is currently involved in modernizing T-72 assault tanks, as well as carrying out repairs on infantry vehicles such as the BTR-60, BTR-80, BMP-1 and T-64 for the Ukrainian army. It also produces DOZOR-Bs, which are light armoured personnel carriers. Since its creation, the Factory has carried out complex jobs and provided support in replacement parts and armoured vehicles for a number of countries around the world, which has earned it much praise for the work carried out and the quality of its technicians.

The tour started with a recovery request. In fact, the technicians had just arrived at the Factory when a recovery call came in for a Light Support Vehicle Wheeled (LSVW) ambulance in the training sectors of the International Peacekeeping and Security Centre (IPSC) training area. Like any good technician and dedicated member of the Corps, two of the members there for the tour were unable to enjoy that exchange and proceeded immediately to the IPSC to do the recovery. A visit to the Factory museum opened the event, offering a rich account of the facility's history. The members then moved on to the various assembly lines in the factory to follow the stages of work necessary to put vehicles back into service. The first step after the vehicles arrive by train is to completely strip them (engine, turret, electrical systems, etc.) of their auxiliary systems. The hull and turret then undergo grinding and straightening operations, finishing up with a fresh coat of paint. Lastly, the turret is installed on the vehicle, and the final preparations for a return to service are completed. This process seems simple, but according to the on-site technical expert, the technicians are able to produce a small number of vehicles per month.

The next part of the tour took the members to a warehouse with the look of a real Soviet-era museum. There was a vehicle used for putting out violent fires, consisting of a modified T-55 with a nozzle and a water tank. The second vehicle was the famous ARRV Lion, a towing and repair vehicle with the chassis of a T-72 assault tank. That

vehicle is primarily used to support T-64s and T-72s on the battlefield. Our technicians were able to compare that massive beast with the Canadian version, the ARV Taurus with a Leopard 2 chassis. The third vehicle was a T-72, and the last one was another towing vehicle, but this time mounted on a T-55 chassis. The unique aspect of this vehicle was a movable mast in horizontal position in transport mode that could be raised into a vertical position and be used as an observation point to call for help if the vehicle were to get bogged down. Our RCEME Corps members appreciated that vehicle so much that they decided to pose with it.

With the 75th anniversary of the RCEME Corps came the official change in beret colour, from green to dark blue. Lieutenant-Colonel J.R.F. Côté, Commander of the Ukraine Task Force, presided over the ceremony with the assistance of his Sergeant Major, Chief Warrant Officer P.P. Chartrand. As such, the beret change was able to be formalized on Ukrainian soil, inside an armoured vehicle factory in front of a heavy towing tank – what could be better! The tour ended with the issuing of a hand-made commemorative plaque by the members of the RCEME Corps on OP Unifier to Company Director Viktor Androshchuk (Above photo).

The tour of the Lviv Armor Vehicle Factory was a great success and has now become part of the RCEME Corps' history. Our technicians once again demonstrated innovation during a deployment by organizing an original event, in friendship and with respect for traditions. Two different cultures came together and were thus able to discuss a common subject, highlighting once again the strength of our profession.

Capt Bigonnesse is currently the Comd of the National Support Element (NSE) and J4 in OP UNIFIER – Canada's contribution in support of the Ukrainian forces to strengthen their capabilities, in partnership with the United States and other countries providing similar training assistance.

Entrance to the Lviv Armor Vehicle Factory.

RCEME in the Desert: **OPERATION IMPACT**

By Cpl N.J. Franklin

When people speak about what it means to be a Vehicle Technician, they tend to focus on the big and "exciting" kit (LAVs, Leopards, AHSVS and so on.). Rarely do we ever hear about the Aircraft Maintenance Support Equipment (AMSE) Tech. A lot of members within our Corps are unfamiliar with AMSE, or even know that it is part of the Vehicle Tech trade.

The AMSE course is a Vehicle Tech career course that enables members to work on aircraft ground servicing equipment. This equipment can vary greatly in size and complexity, as is the theme in our trade. Some examples range from Hydraulic Test Stands used for testing CC-177 Globemaster hydraulics, to Ground Power Units used for applying power to a CF-188, to simple bottle jacks used for changing tires on a CT-114 Tutor. We work closely with the Aviation Systems Technicians in order to ensure they have the tools necessary to make the airplanes serviceable. In short, without AMSE, the airplanes could not fly.

The presence of this skill set at Ali Al Salem Air Base (AASAB), Kuwait, consists of two AMSE-qualified personnel. Cpl Sheon Rodman and I are the team tasked with the repair and maintenance of all ground support equipment for the two CC-130J Hercules aircraft operating out of AASAB. The mission statement for this operation consists of three main points: In collaboration with coalition partners, **Joint Task Force – Impact** will build capacity in the Joint Operations Area, enhance regional stability, and demonstrate the Government of Canada's commitment to peace and security. As AMSE techs, our part in this mission is small but undeniably important.

In the photo above, Cpl Nicholas Franklin carries out a generator output load test on a Model L-390S Ground Power Unit (used on the C130J Hercules). In the photo at right, Cpl Franklin (left) and Cpl Rodman take a breather outside the RCEME Shop. Photos taken by MCpl Bryan Carter, Public Affairs Image Tech, Joint Task Force – Impact (JTF-I).

With a Weatherhaven portable shelter as a shop, we carry out inspections on all equipment and attend to all breakdowns that come up along the way, day or night. The most consistent battle throughout this deployment has naturally been heat and sand. We have diagnosed several electrical faults as being due to sand and grime resulting in poor connections and broken wires. Keeping equipment from overheating in +40°C temperatures has also proved challenging.

The Corps' 75th anniversary celebrates innumerable achievements over the years and in many lands. We AMSE Techs can be justifiably proud of playing a small but important role in the Corps' history – and future!

Cpl Nicholas Franklin was deployed as the senior Vehicle Technician for Joint Task Force – Impact, ROTO 0 from March 2019 – September 2019.

Hoarding is for Squirrels – The Materiel Systems and Supply Chain Role in LEMS

By Maj Santiago Duque

This time of year generally involves back-to-school shopping for families with school-aged children. These clothes end up augmenting those they were meant to replace for a myriad of reasons. Some of the older clothes are retained as hand-me-downs or are eventually placed in a bag designated for the Thrift Store. In the end, closets become packed with items of limited use and/or little value.

Inventory management and disposal may not be the most exciting aspects of LEMS – compared to operations and emerging technologies. Nevertheless, they are important and may have direct impacts on the conduct of operations.

It is very easy to keep materiel for a potential future use and, in most cases, easily justified. For instance, we may need a certain type of valve for current operations if there is a change in current conditions or we may need that piece of add-on armour for a future deployment. We can, at times, be excellent squirrels hoarding lots of materiel for very good reasons.

It turns out that most commonwealth militaries, including ours, struggle with the management of excess materiel. In our case, we have relied on the never-ending warehousing real estate that the Canadian Forces Supply Depots (CFSDs) offer. Unfortunately that never-ending real estate is getting full and increasing it would come at a significant cost.

As an example, 25 CFSD is at 98 percent capacity; it cannot accept bulk shipments of materiel unless it can be stored outside. This can be a significant challenge for the new acquisition projects involving the purchase of spare parts that require adequate storage.

> **"This is not just cleaning house; there is also a focus on long-term inventory management solutions..."**

The Office of the Auditor General (OAG) has conducted multiple audits of DND since 2006. They have identified several deficiencies in materiel management. DND must improve materiel stewardship, reduce storage costs, and optimize storage space. With a firm commitment to the Standing Committee on Public Accounts, DND established the Inventory Management Modernization and Rationalization Project (IMMRP) in 2013 in order to assist with the inventory management of excess materiel – and especially disposal.

Since its inception, IMMRP has collaborated with Life Cycle Materiel Managers and Technical Authorities within the Land Equipment Program Management Division to rationalize millions of dollars' worth of excess materiel. The project has successfully liberated prime real estate in the CFSDs and has also sold items to other militaries or to the general public. This is not just cleaning house; there is also a focus on long-term inventory management solutions including policy and training amendments and the development of an inventory management risk framework. With concrete results already achieved – and numerous improvements to come – being deliberate with what is held in our limited closets will benefit the conduct of operations both now and in the future.

Maj Duque is the Project Manager of the Inventory Management Modernization and Rationalization Project.

Implementing the Scaled Agile Framework for the **Land C4ISR Program**

By Maj Mathieu Couillard

The Director Land Command Systems Program Management (DLCSPM) and General Dynamics Mission Systems – Canada (GDMS-C) recently celebrated the first anniversary of a revolution in the way the Canadian Army's Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) systems are designed, developed, and fielded. The new process leverages the Scaled Agile Framework (SAFe)™, one of the fastest-growing software development methodologies. SAFe is a set of techniques designed to allow the scaling up of Agile software development teams. It has successfully been employed in defence programs in the United Kingdom and the United States, and in the commercial sector at some of the largest tech companies in the world.

DLCSPM has long struggled with issues that plague most large and complex programs: lack of integration, interoperability, and coordination. Victor Khoo, Deputy Chief Engineer for the Land Engineering and Integration Services Contract (LEISC), first suggested that SAFe be implemented for the Land C4ISR program. The results have been tremendous. His perspective is that "SAFe has increased customer and employee engagement, alignment, and accountability across the organization. Everyone knows exactly what they are responsible for and how they contribute to delivering value to our customers".

For decades now, Silicon Valley has been leveraging the Agile methodology in software development and it has taken hold across the world. Agile is an approach to this initiative that prioritizes early development of product over lengthy process-driven periods. The Agile approach can break down as an organization scales up its development activities beyond a single team, especially if it evolves in a highly regulated environment. SAFe is a marriage of Agile and Lean principles specifically created to tackle these challenges. The general idea is that development teams are combined into an "Agile Release Train", which generates software builds in a synchronized cadence. This process of continuous integration allows the DLCSPM/GDMS-C team to identify defects every two weeks – where, historically, integration occurred at the end of every release (three months). The end result is a more tightly integrated and higher quality product.

DLCSPM and GDMS-C implemented the SAFe model from the bottom up, starting with the Mobile Domain, which includes vehicular communications suites, data terminals and ancillaries as well as the software. At the last Mobile Domain Program Increment (PI) planning session, held April 16 and 17, 2019, more than 100 engineers came together, as they had every 12 weeks for the past year, to plan the next increment of work – consisting of dozens of change requests and problem reports to deliver new features and improve system stability. Participants represented teams from DLCSPM and multiple Original Equipment Manufacturers. All participants left the event having formally voted to express their confidence in the plan and set it in motion.

The team continues to implement SAFe across the Land C4ISR program. The Agile approach is already expanding to other engineering disciplines and may be more broadly applicable in land equipment acquisition. PI planning embodies SAFe core values, centred on Lean-Agile leadership. Taking entire teams out of the office for three days to collectively plan the next increment of work may seem unreasonable for some; however, this event is key to generating a sense of urgency, accountability, and trust at all levels of the organization.

Maj Mathieu Couillard was DLCSPM 3-2, responsible for system engineering management of the Mobile Domain, which consists of the CA's fleet of tactical communications systems.

Data and Information Management in LEMS

By Roby Ayres

AUTHOR'S NOTE: In the first issue of the LEMS Journal, BGen Rob Dundon gave insights into the RCEME Corps activities to support Adaptive Dispersed Operations (ADO) through the use of advanced tools and applications at home and in theatres of war abroad. In the following issue, LCol Jeff Spitzig presented the building blocks to transform the structure of LEMS at the tactical level. Building on this concept, this article aims to clarify some of the principles of data management that LEMS needs at the strategic level to support LEMS equipment maintainers in the era of Close Engagement.

Data! The information age is upon us, and mathematicians and software engineers are increasingly driving business disruption. Software-driven data industries fulfil consumer needs through customized online experiences based on the customer's personal data. The success of the responsiveness of Uber or the product delivery of Amazon, for example, is based on these companies grooming user data to gain deep insights into user needs.

Many businesses and institutions are falling behind the technology curve. Within LEMS, the technology curve requires better data and information management. As an example, Health and Usage Monitoring System (HUMS) data is not being used to support optimized maintenance decision-making. The solution is two-fold: Data Culture and Data Ownership.

Data Culture

The LEMS community needs to get serious about the importance of technical data. The leap to predictive maintenance and optimized fleet availability is hindered by the lack of a strategic approach. Equipment management is a well-understood concept to LEMS maintainers, but without a data-driven culture, LEMS practitioners see the growing demand for data as an obstacle to productivity rather than the basis of improved decision support. "Feed the beast" is a term heard far too often in hallways and workshops.

LEMS culture currently devolves the responsibility for data integrity to the maintainer community who see this as an unwanted burden that hinders their primary task of fielding serviceable equipment. Those of us supporting LEMS at the strategic level also demand the maintainer community care for equipment as if they owned it. The *entire* LEMS community needs to take ownership and care for our equipment data as a "digital twin" of our physical equipment. All members of the LEMS community have a part to play at the individual, collective, and organizational levels to continuously monitor the quality of the data for which we are responsible. But who is accountable for this data?

Data Ownership

Figure 1 illustrates the concept of a "digital twin" as a representation of a physical asset. It is worth noting that inaccessible data – data which has not been acquired or maintained – reflects gaps in our overall equipment data. Currently, *everyone* owns a piece of the pie but no one is fully accountable for the full picture. Clear lines of accountability for data – a "data ownership" chain – is required to ensure that in an integrated environment like the Defence Resource Management Information System (DRMIS), all those responsible accurately represent their piece of the pie. The problem is not that LEMS doesn't care about data; it's just that we don't have the complete picture.

As the Canadian Army transforms towards a data-enabled future, the LEMS community must ensure top-down accountability and bottom-up responsibility for quality control of its data. From the bottom up, the data provided by much of the technology in today's equipment currently exceeds the department's capacity to consume it effectively.

Figure 1. LEMS Digital Data Twin.

Think of HUMS. Without an overall information management strategy, equipment managers and maintainers alike must balance the time, cost, and benefit of recording, accessing, and maintaining this enormous data pool along with the uncertainty of not having the tools or resources to manage the data effectively. No data strategy means no sense of importance is associated with HUMS or system sustainment data in general.

To summarize the problem faced by the LEMS community, data is seen as a burden not as an asset, and there is a lack of a top-down strategic approach to creating the digital twin for our systems. The solution starts with LEMS leadership.

Culture + Ownership = Empowerment!

The leadership of the LEMS community needs to develop and publish a data strategy, describing the framework of the digital twin of a weapons system. Changing LEMS to a data-driven culture starts with education. The Canadian Armed Forces (CAF) schools developing future LEMS leaders must incorporate the data strategy and emphasize the role played by each member of the community in maintaining the digital twin.

The culture shift must include the maintainer. The LEMS community cannot continue to download to maintainers the burden of data collection and verification. For LEMS to adopt data-enabled technology we must automate the capture of data from technicians in a (near) seamless fashion. The data strategy needs to explicitly recognize the need for automated data capture. Failure to automate data capture at the workshop leads to a data-entry-exhausted workforce and widespread distrust of the underlying data (Figure 2).

Figure 2. "Sometime even the tiniest of knots can be the most difficult to undo, courtesy assetinsights.net.

At the strategic level, if an equipment manager or decision-maker has to request data and wait for it until it is no longer relevant, then they are no closer to making better decisions. Latency between attaining timely and relevant data to support decision-making, incentivizes data hoarding. To combat these two obstacles to better data, the United States government's chief data scientist suggests that organizations must "democratize" data to the greatest extent possible to create a data-driven culture.

To democratize LEMS data, it is critical that we assess the information we need first. At the strategic level, an information management strategy is required as a governance framework for quantifying data requirements. The international community has already developed an information management strategy as specified in ISO 55000 – Asset Management Standard. ISO 55000 not only enables the development of business objectives but also provides a framework to identify gaps, risks and constraints with existing information systems.

Starting with the information management strategy of ISO 55000, what needs to be done to develop a LEMS Information Strategy? The answer is establishment of land system data models as part of the information strategy.

Creating Land System Data Standards

The requirements to support the equipment's digital twin should be built around a pre-established data model for an equipment class. A starting point would be to classify the equipment we already have so that we can categorize the associated data requirement against different information needs. One approach would be to look at the complexity and forward mobility of land equipment and its supporting elements to "right size" the data requirement.

Once classified, an information strategy can begin to take shape. For each category, data requirements can be defined to determine what equipment data needs to be prioritized, captured, aggregated, or ignored. More information means more data, and this approach can also be used to determine the size of the task for key assets, and limit the data needs for less critical assets.

This classification exercise is illustrated by Figure 3.

Departmental Initiatives and What's Missing

The departmental focus on Defence Analytics and the transformation efforts

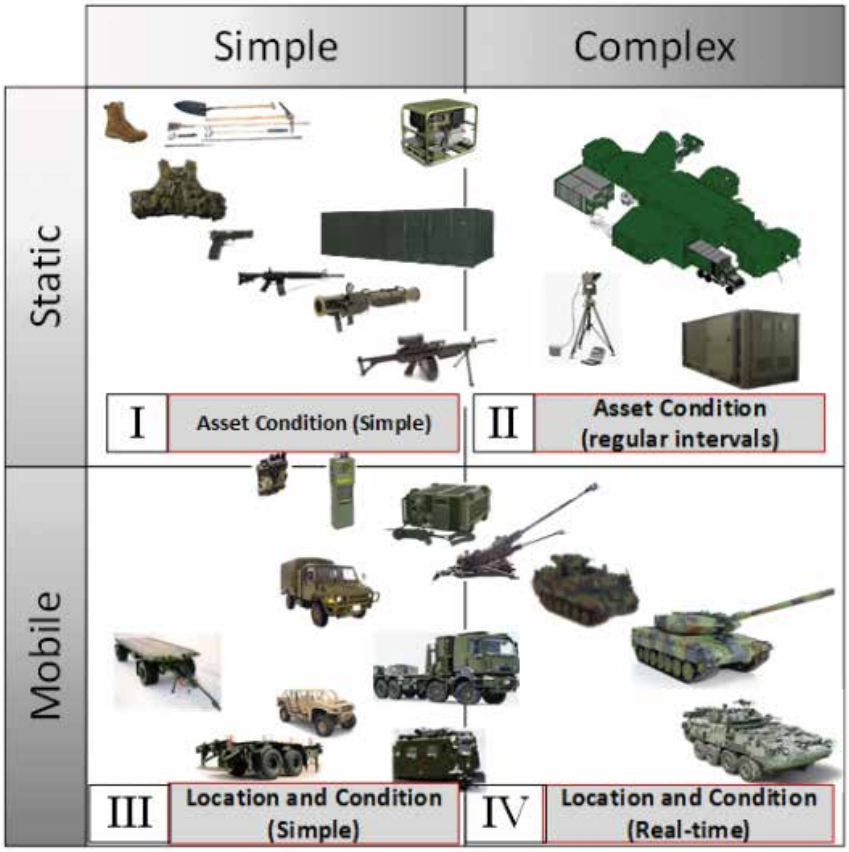

Figure 3. Equipment asset classification based on mobility and complexity.

within the Materiel Acquisition and Support Campaign Plan, are addressing data ownership and data standards at an institutional level. Many of these initiatives are expected to improve the end-to-end digital landscape within the Materiel Group:

- The Materiel Identification (MI) project will provide a significant opportunity to centrally identify and verify our existing equipment data. Furthermore, the project will provide a set of information management tools to help LEMS practitioners maintain clean data.
- The Modernization/Implementation of Sustainment and Logistics (MISL) project aims to review the end-to-end defence supply chain by simplifying and automating supply, warehousing, transportation, and ammunition management functions.

Other anticipated improvements include:

- The Data Remediation and Marking (DRM) project which will support the marking of equipment and end items with 2D barcodes to simplify supply transactions.
- The Automatic Identification Technology (AIT) project aims to deliver barcode readers, enabling logistics professionals to automate data capture.

Significantly, what is missing from the above list of institutional initiatives is the creation of a data culture. While all of these initiatives have the potential to improve the way we do business, the requirement for a data-driven culture needs to be addressed – an opportunity for the LEMS community to lead change.

Conclusion – And a Challenge to LEMS Leadership

If we do nothing, we risk the digital age passing us by altogether. What part do we play in shaping the digital future for LEMS? The data democracy starts with you. Each of us has a responsibility to nurture LEMS data, and continue to build trust in the information it provides to the community. For the LEMS leadership, the urgency to evolve towards a data-driven culture is critical as technology continues to leap across greater bounds with each passing year. A common vision and information strategy must be created to align the community to face the problems of tomorrow, or else the community will forever be consumed chasing solutions to the problems of yesterday.

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Roby Ayres is Director Land Equipment Program Staff (DLEPS 6-3) responsible for the Land Records Control Office, Repair Parts Scaling, and LEMS Central Data Management

QETE's Failure and Accident Investigation Capability Supports Exercise Maple Resolve 19

By Capt Gary Lacoursiere (AERE), Scott Beeston and Capt Kosta Grygoryev (RCEME).

Exercise Maple Resolve (MR) 19 was the premier Canadian Army training event of the year and was a proving ground for approximately 5500 Canadian and Allied soldiers (including army troops from the United States, Britain and France), eight Canadian operational and support units including the Royal Canadian Air Force (RCAF), and hundreds of vehicles in a contemporary operating environment. Occurring annually in May, operations were conducted 24/7 over the vast training area of CFB Wainwright, AB.

The Director General Land Equipment Program Management/Director Land Equipment Program Staff (DGLEPM/DLEPS) Ops tasked the Quality Engineering Test Establishment (QETE) to provide continuous on-site technical engineering and investigative support to Ex MR 19. Lessons learned from multiple vehicle fires and accidents during the same exercise one year earlier called for investigative support from QETE. Challenges in acquiring and communicating timely and detailed technical information related to field events to the fleet technical authorities within Equipment Management Teams strained equipment support networks. The DLEPS Ops proactive integration of QETE staff a few weeks before and during the exercise addressed these challenges, enabling timely technical decision-making when problems arose.

QETE plays an essential role in managing materiel within ADM(Mat) and the Canadian Armed Forces, providing engineering support including failure and accident investigation services. QETE has multiple specialty areas (such as chemistry, mechanical, climatic, metrology, among others) under one roof, all versed in failure investigation, including pursuing all other related aspects (design, production, operations, maintenance, environment – and so on) to provide the best advice possible to address the needs of the Department of National Defence (DND).

Initial support was provided during commissioning of deployed fuel farms for the exercise. QETE was responsible for testing initial fuel samples from the farm to ensure the fuel was suitable for service in RCAF aircraft. Capt Gary Lacoursiere from QETE's Petroleum, Oils and Lubricants Group was on-site to ensure exercise personnel had the required resources to obtain initial samples and support operations for the duration of the exercise.

Commissioning of deployed Aviation Fuel Farm to support operations.

Commissioning of deployed Aviation Fuel Farm to support operations

QETE investigators were situated within the confines of the 1 Service Battalion camp, providing ready access to vehicles recovered from operations following an incident. They also provided maintenance personnel with the expertise to support investigation efforts and return the vehicles to service. Investigators established a network of contacts with key stakeholders including local G4 operations staff, field maintenance units, DGLEPM/DLEPS Ops, deployed Field Service Reps, local Base Fire Marshal staff, Mobile Support

(Left) Engineering Variant LAV 6.0 following recovery from rollover site.
(Right) Remote Weapon System was torn from mount and jammed into hatch.

Equipment (MSE) safety personnel and General Safety personnel. An efficient communications strategy was developed within the network to allow any required technical investigations to commence as quickly as possible following an incident.

Within a week, a Light Armoured Vehicle (LAV 6.0) and a Tactical Armoured Patrol Vehicle (TAPV) experienced rollovers (without injuries to personnel). Captain Grygoryev went to work to document vehicle damage, and to interview crews to identify the circumstances surrounding the incident. Information collected was then passed through the network to EMT authorities for decisions regarding equipment disposition.

If there is a delay in collecting evidence following an incident, items may get moved, tracks can be erased, fracture surfaces may corrode, and witnesses may not recall as many details. Most importantly, event sites and equipment must be secured and photographs taken, which give technical staff a lot to work with later on.

A following investigation on a Leopard II Main Battle Tank (MBT) power pack fire involved the systematic removal of the pack and detailed assessment of soot patterns, burn marks, and other anomalies. The hull was found partially filled with combustible fluids. When fuel collects unnoticed within the engine compartment it can be ignited by multiple sources and, in this case, evidence suggested it was most likely that fuel had splashed onto, and was ignited by, hot exhaust surfaces such as the engine turbos.

Scott Beeston also deployed to support the exercise, investigating additional incidents. Another fire involved a Leopard II MBT power pack in which an engine fan control solenoid came out of position, allowing oil to leak and ignite on nearby hot engine components. A second event involved a United States Army High Mobility Multipurpose Wheeled Vehicle (HMMWV) that had been completely consumed in a fire. Using witness testimony from the exercise front line, combined with physical evidence from the burned vehicle, a probable cause was identified where an engine-driven fan drive had failed catastrophically, releasing oil and igniting a fire.

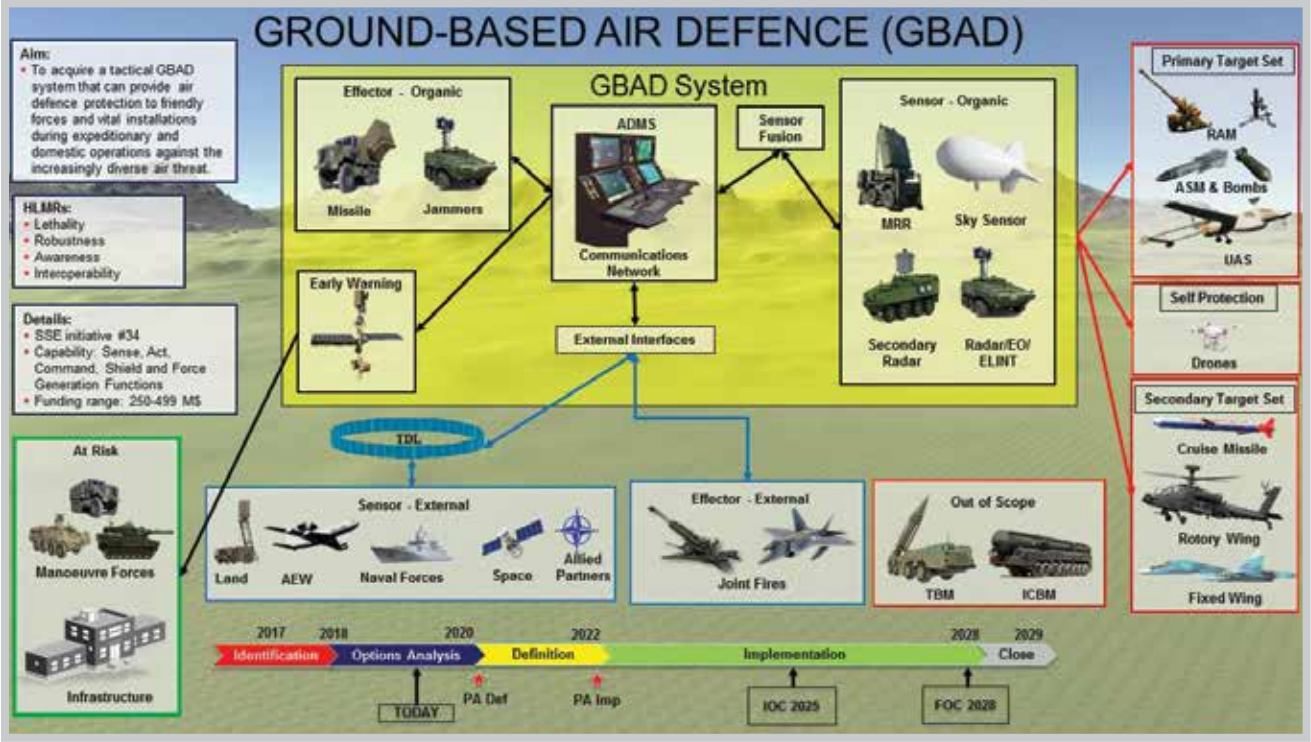
Exercise Maple Resolve 19 provided high fidelity combat training for Canada and its Allies. With that training came all-too-real examples of equipment failures and accidents that can impact operations. Conducting investigations to determine the mechanism(s) and the cause(s) of failure, and to develop recommendations to mitigate the effects and avoid reoccurrence is QETE's primary mandate. QETE's direct, on-site support to the exercise facilitated the timely investigation of incidents and enabled the Canadian Army to effectively risk manage its equipment in support of operational training.

Capt Gary Lacourstere is an RCAF AERE officer working at QETE with duties in the Petroleum, Oils and Lubricants Group and the Failure & Accident Investigation Group. Capt Kosta Grygoryev is a RCEME officer and works as an accident investigator within QETE's Failure & Accident Investigation Group. Scott Beeston is a recently retired RCAF AERE officer and the newest public servant accident investigator within QETE's Failure & Accident Investigation Group.

Maintenance personnel remove a Leo II power pack during a fire investigation. Note fuel staining on the side of the pack and fuel accumulation in the bottom of the engine compartment.

Scott Beeston holds a failed fan drive, believed to be causal to a U.S. Army HMMWV vehicle fire.

Ground-Based Air Defence:
The Importance of Network Integration



"It's complicated." Major Bruno Di Ilio, CD – DLR 2 Project Director

By Eric Adams, CD, PEng

The Ground-Based Air Defence (GBAD) project is a Defence Policy initiative to bring back an air defence capability to the Canadian Armed Forces (CAF). In the modern battlespace secure digital communications, both in voice and data, are required and are increasingly difficult to achieve due to the limited bandwidth of current in-service radios. Identified as a significant problem with the "fusion" of multiple sensors, legacy with new radios, effectors (guns, missiles or directed energy weapons), and command software, the GBAD project team has taken steps to mitigate the integration risk.

The Canadian Army (CA) requires a GBAD system (See diagram above) capable of protecting all land-based force elements from enemy airborne weapons. The primary engagement targets for the tactical GBAD system includes Rocket, Artillery and Mortar (RAM) munitions, Air-to-Surface missles (ASM) and bombs and Unattended Aerial Systems (UAS). Secondary targets such as rotary-wing aircraft, fixed-wing aircraft and cruise missiles will be a residual GBAD capability. The GBAD project will address the current capability deficiency by delivering an air defence system that will include the effector platform(s), munitions, a sensor suite, and an Air Defence Management System (ADMS) software that will provide command and fire-control abilities. It will be linked into the CAF Airspace Coordination Centre (ASCC), allowing

it to access the common air picture in a greater coalition theatre-wide air defence system. The GBAD solution will be based on common and open technology architecture, integrated and networked CAF Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) capable, while providing for interoperability with the Royal Canadian Air Force, Royal Canadian Navy and allied partners.

In order to respond to incoming air threats, commanders and subordinates at every level need to be situationally aware and be proactive as there is very limited time to react. Neutralizing these threats involves the process of sensor surveillance and identification followed by target engagement or non-engagement if the threat will not cause casualties or damage. Identification of a threat is important for two reasons: to ensure that there is no fratricide, and to select an appropriate weapon effector to engage the airborne threat. A single sensor is not effective for detection and identification of all airborne threats, and therefore fused information from multiple sensors to prevent duplication or misidentification is essential. It is similarly imperative that the acquisition and sharing of information happen as quickly as possible due to the very limited time between detection and the enemy airborne weapon reaching its intended target. Once the threat has been communicated, an appropriate effector platform is designated. This could be anything from fixed-wing fighters, missiles, guns, or directed energy platforms to defeat the air threat. The key to this concept is to have overlapping areas of coverage (see Figure 2) and to be able to effectively identify and quickly defeat the threat

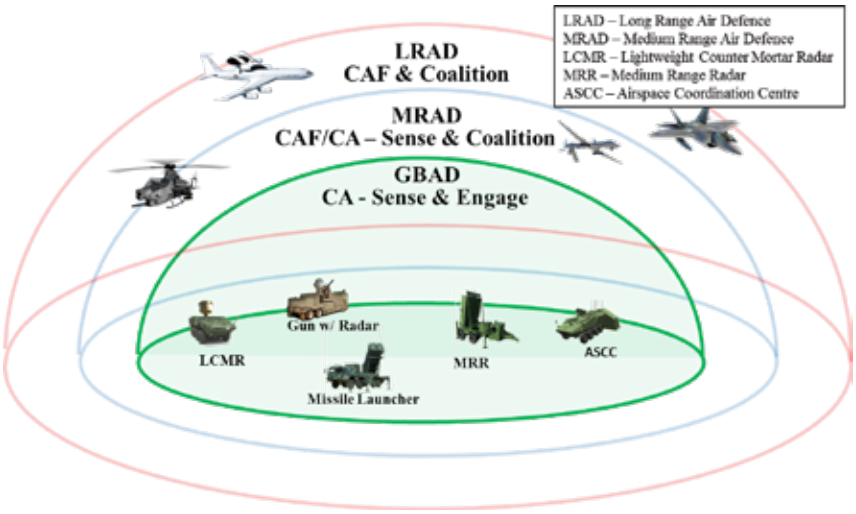


Figure 2.

through assignment of the appropriate weapon resources based upon the enemy air threats.

Automation of the decision action cycle is required to respond to threats quickly – therefore the ADMS will be the major sub-component of the GBAD system. The autonomous nature of the system will allow sensors to detect, acquire, and identify potential threats at greater distances, providing command staff the flexibility to better assess the situation. The ADMS will recommend the optimum weapon effect platform(s) to intercept and defeat or neutralize hostile air threats in near real time, enabling the operator to make the decision to intercept the threat in time.

To get all the pieces to work seamlessly together is the challenge. If anything interrupts the rapid flow of information, it may result in the system not effectively identifying or engaging a threat, thus endangering lives. Therefore, the importance of an integrated network of sensors and effectors with an ADMS – and the communication network to tie it together – cannot be understated. The Project Director, Project Manager and their teams are working to ensure that the CAF receives the best GBAD system that accomplishes the mission and protects CAF soldiers and assets from enemy airborne weapons.

Eric Adams is part of the PMO team within Director of Armament Sustainment Program Management (DASPM 7) providing ILS Engineer/ Analyst support for the Ground-Based Air Defence Project.

Additive Manufacturing in LEMS – Repairing as far forward as possible

By Maj Jessica Ross and MWO Timothy Goldfinch

EDITOR'S NOTE: Maintenance organizations have leaned forward and are experimenting with the use of AM in the course of repair work. As there is no policy yet that governs the use of AM in the conduct of repairs, the technicians responsible for the repair and their leadership must ensure that the fabricated part is safe, fit for purpose and compliant with all applicable regulations. The Land Materiel Assurance/Land Engineering Support Centre team is currently developing a framework that will encourage innovation with AM without any undue risk. Further, and equally important, any AM initiative cannot compromise the safety of personnel, jeopardize materiel, nor pose a threat to the environment.

Those who have been keeping up to date with the LEMS Journal already know that there is a great deal of discussion about the potential for Additive Manufacturing (AM) – often called 3D printing – as a tool to increase flexibility and readiness by potentially shortening supply chains, enabling rapid prototyping, or reducing the logistics footprint. As a simple web search of "military 3D printing" will show, many of our closest allies are already using this tool extensively in a wide range of environments and purposes, so the question remains: How does AM fit into LEMS today?

An incorrect fuel pump part was sent as a replacement for one supporting a heater being used for exercise. Due to a shortage of heaters, it was decided to attempt an in house print in order to create the part needed, and return the heater to service the same day.

There are several initiatives underway to answer this question – to forge the path ahead and enable experimentation into how this disruptive technology could be leveraged by the Canadian Armed Forces (CAF). These include establishing a CAF-wide Centre of Collaboration to capture and coordinate efforts across all elements (see companion article) developing the Department of National Defence's AM policy to facilitate Intellectual Property and safety discussions, as well as expanding the training of Materials Technicians (Mat Techs).

While these overarching efforts are taking place, in our role as the Occupation Advisors for the Mat Techs we hear many questions about what this may look like on the ground. How can our technicians inform the employment concept as it is taking shape? How should we best take AM from the lab or third- line organizations to the field force, following the RCEME tenet of "repair as far forward as possible?" What skills will our Mat Techs need? Fortunately, not only can we look to our counterparts in other militaries, but several units across the CAF have taken it upon themselves to trial this capability at a local level.

For instance, Base Maintenance in Wainwright, Alberta recently procured a Fusion3 F410 3D printer (recommended for use with Simplify3D design software). The team in Wainwright has designed parts needed to complete repairs to a composite structure, enabling them to refurbish a part that

would otherwise need to be completely replaced. While acknowledging that some of the policy requirements are still being worked through, there is a great deal of enthusiasm to hone the skills that will be needed, and explore the possibilities of where and how this equipment could potentially be used.

Another Maintenance Platoon was faced with the wrong part sent to conduct a repair to a fuel pump for a heater used on an exercise. Instead of waiting for a new part to be shipped, the technician was able to design, print, and install a new one within two hours. This is a simple but tangible example illustrating the power of this technology, and how it could immediately be used in workshops across the CAF.

Finally, the yardsticks are moving forward thanks to efforts within 202 Workshop which has been tasked to assemble a deployable AM capability, with the goal of being deployed in 2020 in support of a Brigade level exercise. To this end, an Ultimaker S5 printer is being purchased, and discussions are underway to determine how it should be staffed, operated, and used in a field context. Questions to tackle include: *How will the system be staffed? Where will it fit? What parts should be targeted as early test cases? What kind of reach-back will be needed... or will it be possible to be self-sufficient?*

Print time for both parts was 32 minutes to completion. No post processing was required for these parts, meaning that they were available for immediate installation and use.

Designing the part took one hour with emphasis placed on measurements (fuel pump spindle and fan motor flutes). From these measurements, two Solidworks designs were created – one similar to the OEM part, and one redesign* that added durability.

*Note: Actual part installed was redesigned in order to avoid IP conflict.

Introducing a new technology can present a chicken-and-egg situation in terms of defining exactly *what* is needed and available, and *how* it should or could be employed, as it takes time to fully appreciate the strengths or limitations of new skills and new equipment. By enabling relatively low-risk, low-cost, local initiatives, harnessing the creativity and expertise of our technicians and engineers, and sharing lessons learned across LEMS and the CAF, we are taking the next bold steps toward exploiting the full potential of this capability.

Special thanks for the inspiration and contributions made by:

- Maj Fernando Echavarria-Hidalgo
- LCdr John Faurbo
- Maj Nick Tranquilla
- Capt Chad Mooney
- Sgt Neil Lange
- MCpl Benjamin Arbuckle
- MCpl David Davis
- René Provencher

Maj Ross served as the Occupation Advisor for the Material Technicians between 2017 and 2019. She was recently posted to 2 Service Battalion as OC Maint. MWO T.W. Goldfinch is the Life Cycle Material Manager of MECC shelters within DCSEM, and the Material Technician Assistant Occupation Advisor.

Final images show the printed part reassembled, and the fuel pump ready for installation. Overall processing / assembly time was two hours to return equipment s serviceability.

Collaboration is the key to enabling 3D Printing

By LCdr John Faurbo

Additive Manufacturing (AM) – also referred to as 3D Printing – is set to transform the supply and maintenance system within the Canadian Armed Forces (CAF), and there are already teams of people working to embrace the use of this technology. The challenge, and opportunity, is that they are each approaching it from different perspectives and with different goals.

On November 8, 2018, the Quality Engineering Test Establishment (QETE) and 202 Workshop hosted a forum to explore the use of 3D printing within the Forces. The forum included representation from the Army, the Royal Canadian Navy, the Royal Canadian Air Force, the Canadian Special Operations Forces Command (CANSOFCOM), the Assistant Deputy Minister (Materiel) ADM(Mat) **HQ**, Defence Research **and Development Canada**, and Strategic Joint Staff. The forum highlighted many great ideas and initiatives. However, at this stage, there were more questions than answers. This community quickly identified and recommended that the CAF needs an organization to help answer questions and to align our efforts.

Concurrently, the Blueprint 2020 Defence Team Innovation Challenge brought together a diverse group of CAF members who also identified a missing link with respect to 3D Printing. The Department of National Defence (DND) team consisted of:

- LCdr John Faurbo;
- Lt(N) Christopher Chang;
- Sgt Philippe Haggart;
- MCpl David Davis; and
- Dr. Shannon P. Farrell.

They proposed a Centre of Collaboration to help institutionalize AM into the CAF. The proposal received significant praise from the judges and took second place in the competition out of a field of more than 170 competing teams.

This Centre of Collaboration would seek to develop and implement a strategic plan that brings together the various internal and external stakeholders in order to enable the use of AM throughout the Canadian Armed Forces. This will be supported by six lines of effort:

- Raise awareness about the many benefits and uses of this technology;
- Foster networking and collaboration between current DND and Allied practitioners;
- Work with the Director Material Policy and Procedures (DMPP) to produce a policy that will enable the safe implementation of 3D printing;
- Provide solutions and advice to align future procurement with AM;

- Proactively engage with industry to promote the adoption of technology highlighting the mutual benefits for the CAF and industry; and
- Be responsible to monitor the evolving state of 3D Printing technology.

The Centre of Collaboration would also be the focal point to try to overcome many of the pan-CAF barriers facing the adoption of 3D Printing. These issues include: certification, Intellectual Property (IP) management, security of digital files, and integration into the supply and maintenance systems. These are not trivial tasks, but the key to the solution is collaboration. Every organization that is looking at AM is working to solve these problems. If we can maintain open lines of communication and share lessons learned, we can overcome these obstacles.

The 3D Printing revolution has already been used successfully to deal with the issue of orphaned legacy parts that are not economical to produce. The Royal Canadian Navy is moving forward with operationalizing a printing capability for both polymer and metal materials. This will enable the ingenuity of maintainers and facilitate both minor parts replication and emergency repairs. The Army is doing the same thing. Currently they are investigating technologies for forward-deployed polymer and metal printers. And these are but a few of the current initiatives in the Forces.

While the Defence Additive Manufacturing Collaboration Centre works toward its official start within QETE, the collaboration has begun. We are already working with all the services to move this technology forward and to overcome the barriers. It is an exciting time for us.

If you are interested in using Additive Manufacturing within your organization please contact the author for support and information: john.faurbo@forces.gc.ca.

LCdr John Faurbo is the Additive Manufacturing Engineer for Director General Maritime Equipment Program Management (DGMEPM), and the lead for the Defence Additive Manufacturing Centre of Collaboration.

How to make **Artificial Intelligence** in LEMS successful

By Capt Boniface Yogendran

AUTHOR'S NOTE: The Government of Canada (GoC) is moving forward to support Artificial Intelligence (AI) implementation within its organizations. This article introduces some basic AI terminology and begins to answer the question: How can LEMS keep up?

During the Treasury Board Secretariat AI Day on March 4, 2019, (Figure 1) the Chief Information Officer of the GoC highlighted the importance of all employees being involved in the implementation of AI to achieve the best results possible. Acknowledging the speed of innovation, the Treasury Board Secretariat has established a list of qualified AI suppliers to expedite new procurement.

Successful implementation of AI in any setting, including LEMS, relies on understanding organizational culture to make the best choices among the various fields of AI, the use of algorithms, quantity and quality of available data, and adequate software platforms.

AI fields

So what is AI? It's the theory and development of computer systems to perform human intelligence-based tasks. There are multiple fields of AI, but the most commonly used fields are:

Symbolic AI: The machine follows mathematical rules created by humans.

Machine Learning (ML): The machine creates rules from training data and performs tasks that are simple to describe (e.g. spam classification).

Figure 1. Capt Boniface Yogendran, Capt Steven Gamache and Maj Dohyun Shin give the thumbs up sign at the AI Day forum.

Deep Learning (DL): The machine uses artificial neural networks (electronic simulations of our biological brain structures) to perform tasks that are difficult to describe to machines but intuitive for humans. (e.g. image classification.) DL is a sub-field of ML. It requires large amounts of data and high computing power.

Figure 2 illustrates the progression of AI development to today's focus on Deep Learning. All the recent AI breakthroughs – from self-driving cars to facial recognition and speech recognition are built on Deep Learning algorithms developed by Canadians.

Algorithms

An algorithm is a set of rules given to the machine to perform a task. In the LEMS Journal 2018, BGen Rob Dundon discussed his vision of having an Amazon-like supply chain and Uber-like Mobile repair team in the CAF. This piqued the author's interest to research their AI algorithms.

The research revealed that Uber's platform, MICHELANGELO, uses an ML algorithm called Gradient Boosted

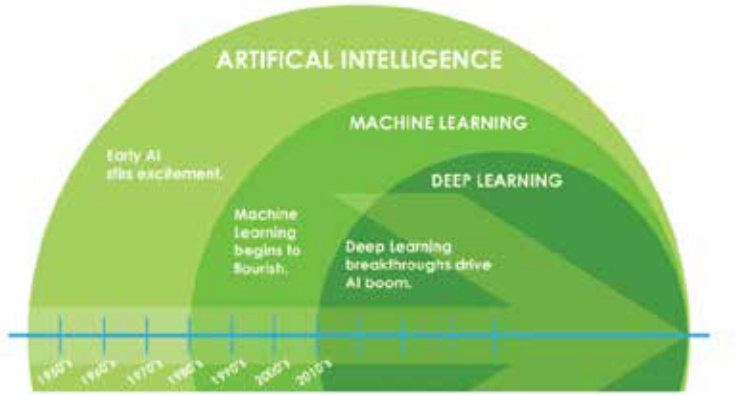


Figure 2. Timeline of Artificial Intelligence evolution.

Decision Tree Regression models (GBDT) to predict driver demand based on local events, which is a probabilistic challenge. Amazon's platform, FORECAST, uses a DL algorithm called Multi-Quantile Recurrent Neural Network (MQRNN) to predict product demand, based on shopping habits that are always changing and not logical.

The strength of both algorithms is their ability to make surprisingly accurate predictions in staggeringly complex environments. Their weakness, common to all modern AI, is reliance on a stable set of rules - not something that warfighting is known for. So, no matter how many computing resources an AI has, human guidance is still necessary to confirm cause-and-effect relationships. In other words, human intuition reacts faster and more reliably when the game changes. This weakness can be overcome through selective application of AI and realistic expectations of its outcome.

For example, consider LEMS applications like predictive sustainment or fully autonomous parts supply. Understanding and defining the task set is the first step in identifying an effective algorithm. Garrison challenges differ from those that arise in deployments. An AI system built for a garrison environment will actually fail during deployment due to the different rules and parameters. (Failure meaning inaccurate predictions; the program will happily continue to spit out numbers.) Similarly, models for deployments with different operative environments would not be interchangeable.

Data Quality is the Key

Data is an electronic record of events and far more impactful than the actual algorithm. An algorithm learns the relationship between input and output variables, then translates this relationship into a set of rules. When a new set of input variables is supplied, the algorithm predicts the output based on the rules it built. The effectiveness of the algorithm's predictions depends solely on the quality of the data. Our technological superiority in LEMS depends on the quality of data and the strength of our data culture.

Google's search algorithm is open to the public, but their data is not revealed to anyone.

Software Platforms

The software platform is a service provided by a vendor to manipulate data with an algorithm. Four main options for software platforms are:

- On-Premise Deployment
- Infrastructure as a Service (IaaS)
- Platform as a Service (PaaS)
- Software as a Service (SaaS)

The main difference between those four options is the data ownership, going from total control by the clients with an On-Premise Deployment to full vendor responsibility with a SaaS. Other criteria to consider when choosing the software platform are flexibility and cost. The most common approach to developing a custom AI application is to create the prototype internally using different tools and then outsourcing the final product development to a commercial vendor. An example of a software platform is SAP HANA Cloud, which is offered as SaaS. Amazon Web Services and Microsoft Azure are examples of software platforms offered as IaaS and PaaS.

Potential applications in LEMS

Predictive maintenance and supply chain automation are long-standing LEMS goals. AI might be the tool we've been waiting for, but the results will only ever be as good as the quality of our data. To realize these goals, the upcoming DRMIS transformation needs to go hand-in-hand with an institutional transformation of our data culture.

AI applications in smart phones and wearable technology offer another range of opportunities. BGen Dundon's vision of an AI tool targets the needs of our technicians in the form of a blue collar AI tablet. (Dubbed the DIGGER, or Data and Information Gathering for Global Equipment Repair). The DIGGER tool would initially perform repetitive tasks that would evolve into a more complex companion device for support tasks. An easy comparison is Google Ads, but pushing tech bulletins, common platform faults, and tips for your current operating environment. The envisioned DIGGER has the potential to be a loyal companion to every technician, providing vital information to help make each mission a success.

The successful application of AI in LEMS requires AI expertise in the LEMS community. The Farrierworks initiative was formed by a few officers in the Ottawa region to discuss topics like the ones included above, and to build computer-related competencies. This group is informal and is open to all members across Canada. If this topic interests you, contact Boniface.Yogendran@forces.gc.ca to be part of this evolution.

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Capt Yogendran is employed at DLEPS 6 (DRMIS) and is pursuing a Master of Science degree in Data Science at the University of Edinburgh.