LEMS JOURNAL

LAND EQUIPMENT MANAGEMENT SYSTEM JOURNAL

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FOCUSING ON THE FUTURE

National Defence
Défense nationale

Canada

IN THE NEXT ISSUE

Extensive Trials Show MTVF Crane 'Good to Go' on Lifting LAV 6.0 Power Pack

There was good news and bad news in two-day trials conducted with the Mobile Tactical Vehicle Fitter (MTVF) crane at CFB Petawawa. Results indicated that the MTVF was quite capable of removing and installing the LAV 6.0 power pack – as it had been doing with both the LAV III power pack and turret. However, several glitches were uncovered in attempting to lift the LAV 6.0 turret and it was decided not to pursue this option. Maj Rob Cummings, former Tracked Light Armoured Vehicle (TLAV) Integrated Logistics Support Manager, has prepared a detailed report on the trials, pictured above, and his article will appear in the next issue of the *LEMS Journal*.

LEMS JOURNAL

LAND EQUIPMENT MANAGEMENT SYSTEM JOURNAL

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Members of *12e Régiment blindé du Canada* take note of the flood damage to provide a report to local authorities during Operation LENTUS 17 in Gatineau, Québec on May 9, 2017.

Photo credit: Cpl Gabrielle DesRochers, Canadian Forces Combat Camera.

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DIRECTOR GENERAL'S COMMENTS

LEMS Journal has a mandate to contribute significantly to informed discussions in ever-changing environments

By BGen A.T. Benson

As Director General of Land Equipment Program Management, it gives me great pride and pleasure to welcome readers to this first issue of the *LEMS Journal*. As we live in ever-changing economic, technological, and global environments, it is my hope that this journal will contribute in a significant way to informed discussions on land engineering equipment support related to security and defence issues in Canada and abroad. As such, the five programs within LEMS will be addressed in the Journal: Common, Ammunition, Land, Land Engineering and Test and Evaluation.

The first priority of the *LEMS Journal* is, of course, to serve as a platform for professional education and to foster further development of our highly skilled Canadian Armed Forces and public servants, while ensuring we remain relevant and responsive by consistently adapting and evolving ourselves – at a time where *Strong, Secure, Engaged* has become our vision for the next two decades.

It is my hope that articles provided in this journal will be valuable in bringing a better understanding of the accomplishments, roles, and level of expertise residing within our various professional communities that work collaboratively and diligently to effectively support the life cycle of our land equipment. I believe we have much to learn from each other, and that we can all benefit from the *LEMS Journal* by sharing innovative ideas, common interests, best practices, and lessons learned, to position our workforce and our leaders to face future challenges.

It is also my hope that articles provided in this journal will be valuable in bringing a better understanding of our underlying support to the Canadian Armed Forces, the Canadian population's fundamental interests, and of the Government's investments to enhance capability and capacity to support Canadian commitments to global peace and security.

May the *LEMS Journal* serve as a platform for the betterment of supporting the life cycles of our land equipment, by strengthening ourselves for our current and future roles – both as members and leaders of this great institution.

I wish great success and prosperity to the *LEMS Journal*, and I look forward to reading future issues.

SHARE YOUR THOUGHTS AND EXPERIENCES

The *LEMS Journal* is your forum for putting forward ideas, commenting on current or past articles, and sharing related experiences. If you wish to join the ongoing discussion, please send an article, your comments and/or feedback to: +LEMS Journal SGET@ADM(Mat) DLEPS@Ottawa-Hull.

Adapting to Dispersed Operations: **LEMS in the Future Operating Environment**

By Col Robert Dundon

EDITOR'S NOTE: *The following comments are solely the opinions of the author. This material is not doctrine and has not been approved by the LEMS senior leadership or the RCEME Corps senior leadership. It is intended to provoke thought and discussion on how to effect repair in an Adaptive Dispersed Environment.*

The Army is poised to eventually release Close Engagement: Land Power in an Age of Uncertainty – the capstone document for how the "Army of Tomorrow" will function. Essentially, we will be basing operations on something called Adaptive Dispersed Operations (ADO). The central idea is that advanced communications will give us an unprecedented advantage over adversaries because it will enable us to disperse, spreading ourselves widely over an area of operations, yet be able to come together (or aggregate) quickly to concentrate combat power and deliver fast, decisive blows.

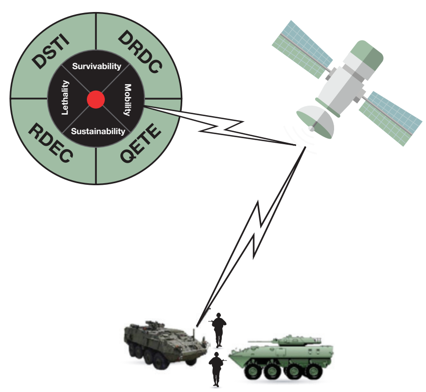
We will be expected to do this through the full spectrum of operations – including conventional offence and defence as well as enabling and stability operations (peace support and even humanitarian operations are included). Our experience in Afghanistan hints that ADO is possible, but how precisely we are going to achieve it is elusive. How to conduct repair and recovery in such an environment is even tougher to imagine, but many bright individuals are working on it right now, which makes this discussion timely. The Land Equipment Management System (LEMS) is vital ground for the Corps of RCEME. It is essential that we get support to ADO right. Perhaps a solution can be found at the intersection of how OnStar, Uber, and Amazon function.

The Army of Tomorrow is the Army we envision for up to 15 years in the future. Current technology trends hint that we will see: faster, more robust communications, with more bandwidth; less numerous fleets that are very advanced; and more technologically advanced sub-systems – so advanced in fact that they will be much like an aircraft's black box and only repairable by the original manufacturer. Where will this take us?

Modern Technology

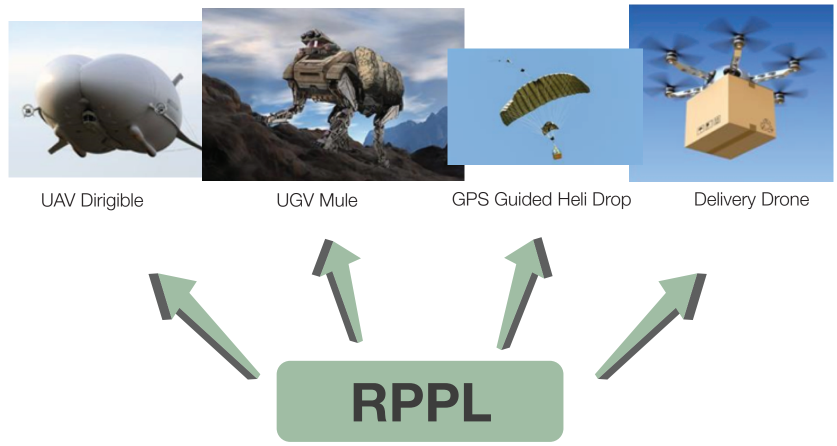
Imagine for a moment that our latest generation of weapons platforms are all equipped with an advanced health usage and monitoring systems (HUMS), a computer with sensors monitoring all the subsystems within the vehicle. As soon as a vehicle has a mechanical problem, breaks down, or is damaged, the HUMS performs a diagnostic and recommends repairs. If the vehicle cannot proceed any farther, the HUMS advises the commander and driver of the nature of the problem. Odds are that the environment will not be wholly secure, and consequently the crew dismounts to provide security for the disabled vehicle. Meanwhile the driver checks the readout from the HUMS.

But this is no ordinary driver. Much like our healthcare system has enabled the common soldier with the Tactical Casualty Care Course (TCCC) to



increase a casualty's chance of survival with prompt first-response attention, so too has the driver of the future been enabled – with an Equipment Casualty Care Course (ECCC). Armed with the information provided by the HUMS, a more advanced toolkit than any driver today would have, and a "blue-collar" artificial intelligence (AI) tablet, this driver is capable of doing preparatory work on the weapons system prior to the arrival of a Mobile Repair Team

(MRT). The HUMS will tell the driver where to find the problem. The advanced tool bag allows the driver to pull the Line Replaceable Units (LRU), or the "black box" that needs replacing. The AI tablet is where the real magic happens.



Equipped with something that resembles a ruggedized cellular telephone, but with a larger screen, the driver will have access to an interactive AI that mines repair schedules, technical orders, equipment diagrams, and, through the platform's communications system (if it is functioning), operates a reach-back capability. Think of this reach-back as OnStar on steroids. Through it the driver will be capable of reaching highly specialized technicians and an engineering team in the National Capital Region that are on standby 24/7 during Canadian Armed Forces operations. This team will consist of military personnel with extensive field experience. Thinking of how NASA deals with active space missions is an appropriate way to envision this interaction – orbiting astronauts do not talk directly to the scientists and engineers in Mission Control. Rather, they talk to a Capsule Communicator (CAPCOM), an astronaut peer who has been trained the same way they have, is intimately familiar with the equipment, and speaks the same language. A soldier is the one most able to understand the situation on the ground and pass information in the clearest possible way.

Our Own "Mission Control"

And much like NASA's Mission Control supports its CAPCOM, our Mission-Command-supported TECHCOM will have access to an unprecedented level of knowledge. Surrounding TECHCOM will be Land Equipment Program Management specialists in survivability, lethality, mobility, and sustainability, all with direct access to the Equipment Management Team (EMT) for that particular weapon system. These individuals will be capable of walking the driver through nearly any technical challenge. Stretching the OnStar metaphor even further, this team will be capable of engaging the driver through virtual reality. Much like today's cellular telephones with the right "app" can be used as a 3D virtual reality screen, our future driver could similarly use the AI tablet. As the driver looks through the viewer, the specialist technician could interact with the driver – virtually pointing to items rather than describing them, or potentially even providing haptic feedback to aid in demonstrating to the driver how to proceed. And all the while, much more is happening out of sight.

And that HUMS has not been idle. Simultaneously, as it has been telling the driver what is wrong with the equipment, it has been accessing the vehicle's communications to report its status. Teams working together tactically will be interconnected by eLAN – think of a mesh net, a small group of vehicles interconnected with their own local, personal Wi-Fi. For redundancy, a message can be passed through any of the nodes/vehicles to a "server" vehicle that has access to satellite communications (SATCOM) capability. Where Repair Recovery Requests took precious time to be relayed over multiple radio nets to access an MRT, the triple-R will be sent automatically and instantaneously. And the response will be just as fast.

The call will not be received in the traditional sense as we know it. Rather, it will be received, and responded to, by a digitized system. This supercomputer or artificial defence intelligence for equipment – let's call it SADIE – would be located in a relatively secure zone with robust communications. SADIE would have access to nearly total Blue-Force awareness. And with each element of the Blue Force acting as a sensor, she would have a comprehensive picture of the enemy situation as well. Accessing systems such as DRMIS and enterprise architecture software, she would have the ability to monitor consumption rates, holdings, usages, and untold other data – and be able to make sense of it all. SADIE would be the ultimate co-ordinator. But she would not operate alone. A human would always be "in the loop," monitoring and overseeing all actions, in the event of compromise.

In an adaptive dispersed environment, it makes no sense to centralize assets. Nor would it make any sense to centralize MRTs – which would be most effective if distributed across the area of operations making them much more responsive. Think of Uber. Arguably, what makes Uber so successful is not just being cheap, but rather being cheap and responsive. Everyone has suffered through waiting for traditional taxis, and everyone hates to be at their mercy. Uber is fast and on the scene within minutes. Where did the Uber driver come from? Who cares! All we know is that if an Uber driver is not available within minutes, the app gives you its arrival time. Imagine a comparable system in the theatre. Selection and dispatch of the MRT would be optimized by SADIE. She would select for proximity, time to arrival, workload of the MRT, and technical expertise required based on the skills of those in the MRT, and the parts and consumables they have on hand. SADIE would plot the best route of approach for the MRT, making certain to avoid known and potential hazards, and advise the casualty's driver of the ETA. But wait, you say – that MRT needs to stop at the equivalent of the Repair Parts Platoon to pick up the parts needed for the job. Not necessarily.

Responsive Delivery System

The third analogy made earlier additionally referred to Amazon. I am not thinking of their selection of books in this instance, but rather their responsive delivery system. SADIE has been busy in the background and the third aspect she has been dealing with is co-ordinating the parts. With accuracy, an AI could predict what parts will be required for repair calls. This demand would be sent directly to a supply agency that would find the parts and prepare them for delivery. Having the MRT pick them up or move them forward via conventional means is inefficient in the ADO environment. In the future, Supply will execute delivery via means we are only beginning to see with Amazon. At their disposal will be unmanned drones and GPS-enabled parachute drops from helicopters. But even more spectacular and efficient will be other means such as robotic mules.

> "In the future, Supply will execute delivery via means we are only beginning to see with Amazon."

Videos of walking, self-guided, six-legged robots abound on YouTube. There is even a video of a man attempting to kick one over, but it rights itself and carries on. Colloquially, these are known as mules. Autonomous, they would be the ideal delivery solution in adverse weather. Programmed by AI, they would have courses plotted based on terrain reference models. Not only would they avoid lakes and thick woods, but would additionally know where they would generate too much ground pressure to traverse an area effectively and consequently avoid it. And like the MRTs, they would be routed around recent enemy activity. Their capacity is enormous and the speed at which they can move is breathtaking.

Another option, recently imagined during the Methodology for Assessing Technology-Triggered Threats war-gaming sessions conducted by Dr. Gitanjali Adlakha-Hutcheon for the Canadian Armed Forces, is the GRASSHOPPER. This is a system that is efficient with significantly large loads that have more flexibility in their delivery time. Much like shipping container handling units (SHU) are attached to Seacans so they can be picked up by palletized loading systems, GRASSHOPPER is a comparable system that attaches to the top of a Seacan. It houses an inflatable dirigible and GPS-enabled propulsion. The balloon inflates, the Seacan lifts, and the GRASSHOPPER flies the load using nap-of-the-earth routes to where it is needed, landing the load with precision in near complete silence.

Further Option

These are but four of the potential options to get parts to an MRT. Another option is for the MRT to construct parts on its own. Manufacturing in the future will rely more on additive systems than ablative, and the economies of such a system make them ideal for MRTs.

In an ablative process, a part is carved out of a larger source material, which results in enormous waste. Effectively, much of the material is cut away and discarded as a milling machine would do. Additive processes are exactly the reverse: material is added to make the shape you want. This uses considerably less material, there is next to no waste, and storage of the bulk material takes up far less space. Additive manufacturing is ideal for "bespoke" manufacture, creating just one part rather than creating numerous parts. Ultimately, what we are seeking is a self-contained, multi-material, additive manufacture, trailer-able machine that a MRT tows behind it. Once the part required for the repair is known, the MRT calls up the machine code for the part from its collection of data files and presses "print." As they drive toward the casualty, the additive manufacturing machine makes the parts.

The ideal solution is that just as the driver is completing the extraction of the broken part, the MRT is arriving via one route, and the part from Supply is arriving via another. With all the pieces in place, the repair is effected. The MRT then proceeds to the local combat arms echelon to top up on muffler bearings and await the next job from SADIE.

Using such a system, the time to conduct the repair can theoretically be cut in half. And this is important. We need to be conducting repairs faster... because there will be fewer MRTs. Remember what I said about fleets getting smaller? Expect to see fewer MRTs purchased, which ultimately results in fewer MRTs in the area of operations. But that will be OK. First, if we can do repairs faster, we will not need as many MRTs. Second, expect to see bigger crews on MRTs. Why? MRTs will be even more autonomous than we think of them today. They will have to be fully defensible

and the crew capable of fighting them. This will demand a minimum crew of three; fewer MRTs, but more techs on them. What should be the combination of techs? I don't think that is something to get into an argument over. They don't have to be mirror images of each other – in fact diversity amongst the crews would prove valuable as it would lend flexibility to the system. Remember, SADIE will dispatch the crew with the right set of skills aboard. What is more crucial to keep in mind is that by having fewer MRTs, and putting more specialized technicians aboard them they will become more highly valued targets by the enemy.

This is not THE answer to the ADO challenge, but rather AN answer. We within RCEME may not know what we know, but I have had great success over the last 30 years accessing that knowledge and tackling problems for which we do not know the answer by telling RCEME personnel the wrong answer. The inevitable response is that they correct me... with the right answer. So, I have presented what I know to be the wrong answer, but the intent is to make you think, to provoke thought, but more importantly to spark discussion. Rising to the call of ADO will require some seriously innovative thinking. My cohorts and I closely follow technology, but we are dinosaurs. It will be those of you who are Millennials, or younger, who are going to solve this intractable problem. I hope you will get involved and join the conversation.

Key Take-Aways

- ADO-enabled Mobile Repair Team.
- The fundamentals of MRTs have not changed, but future variants may necessitate new requirements:

– Autonomous
– 3-4 technicians
– Composite armoured
– Sat-comm equipped
– Equipped with a self-protect system (i.e. remote turret)
– Comparable mobility to equipment it supports
– Some limited special tools and test equipment (STTE)
– Trailer-able advanced manufacture system

Col Robert Dundon is currently a student at National Defense University in Washington, DC.

Update: Land Command Support System Life Extension (LCSS-LE)

By Mike Voisine, Kris Hatashita and Jan Francki

The Land Command Support System (LCSS) is a highly integrated tactical command and control system composed of many sub-systems that support the Canadian Army-wide command function.

The Land Command Support System Life Extension (LCSS LE) project will improve the exchange of information within and between specific Canadian Armed Forces' (CAF) vehicle fighting platforms.

DLCSPM is currently upgrading the Land Command Support System (LCSS) in the Canadian Army fleet of vehicles – Capability Pack (CP) JADE and CP TOPAZ. These LCSS capabilities include the introduction of an Ethernet Local Access Network (ELAN) that provides the central connection and network functions for all radio, intercom, applications, and user services.

The ELAN consists of a number of product configuration items (CIs) that have loose functionality analogues to the previous IRIS HIDS CIs. The ELAN subsystem has significantly fewer CIs due to being based on a modular architecture. Specifically, the CIs that are part of or directly used by the ELAN system and their IRIS HIDS equivalents are:

CSB (Communications Selector Box)

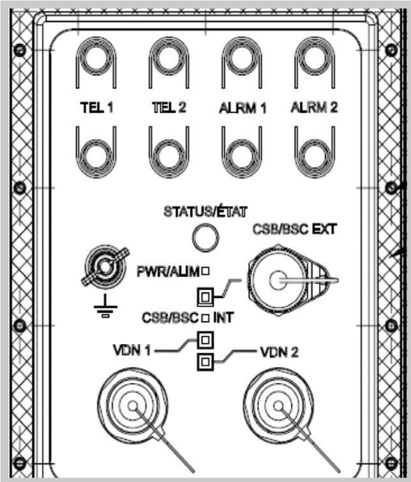
This is the Control Indicator for the ELAN subsystem that replaces the UCD and USB Control Indicators used in the HIDS system. It is the primary operational user interface to the ELAN. Unlike the UCD (and similar to the USB) the CSB is a single user device and is located in the platform at each crew station that needs radio or intercom access. Additionally, since the ELAN is a distributed system, the CSBs installed in a platform collectively replace the functionality of the HIDS Network Access Unit (NAU) and Radio Access Unit (RAU) in the ELAN system, resulting in significant space claim savings. As a result, in some vehicles the number of CSBs required is driven by the number of radios and other equipment present (as opposed to the number of crew positions, as is the situation in the large majority of ELAN platforms). This provides a great deal of logistical simplicity and flexibility in platform installation.

LESv2 (LAN Ethernet Switch – version 2)

The LESv2 acts as a network switch within the ELAN and provides additional connectivity to Ethernet attached equipment. The LESv2 is connected to the ELAN ring in the same way as the CSBs in a platform, and provides eight additional Ethernet ports.

PDU-SFF (Power Distribution Unit – Small Form Factor)

This is the power distribution capability for the ELAN subsystem that replaces the PDU-A, PDU-B and PDU-C used in the HIDS system. While IRIS vehicles typically had one PDU that came in three different sizes, ELAN has one size of PDU that is used modularly to provide the necessary number of ports, resulting in many platforms having two – and sometimes more – PDU-SFFs.

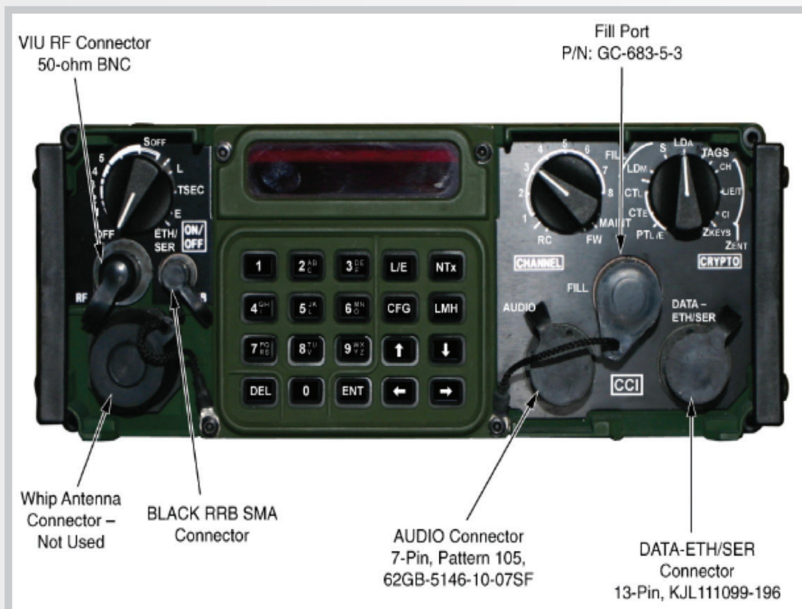


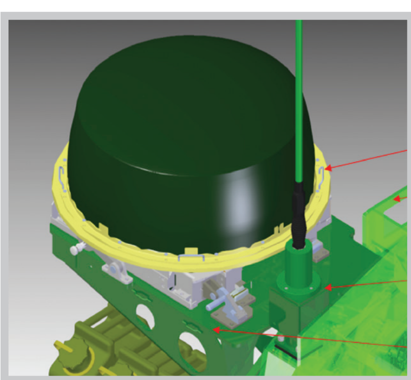
VIPs (Vehicle Interface Panels)

The ELAN system supports two VIP types. The VIP MK25 is a "full capability" VIP supporting EB-VDN line data and remote voice capabilities, field alarm connections, and external CSB/LESv2 connection to the platform. The VIP 25 is intended to be used in soft skin vehicles – with an adapter plate that provides a protective door – or in armoured vehicles when installed behind an armoured door as in the Bison, LAV 6 and Tactical Armoured Patrol Vehicle (TAPV).

Enhanced Combat Net Radios [CNR(E)] Radio

The conversion of CNR(P) Radios to CNR(E) will require the installation of the necessary cabling to Ethernet. CNR(E) radios – when Ethernet connected to an ELAN platform and operating using the enhanced waveforms – provide, in addition to voice capabilities, thin and thick data networks.



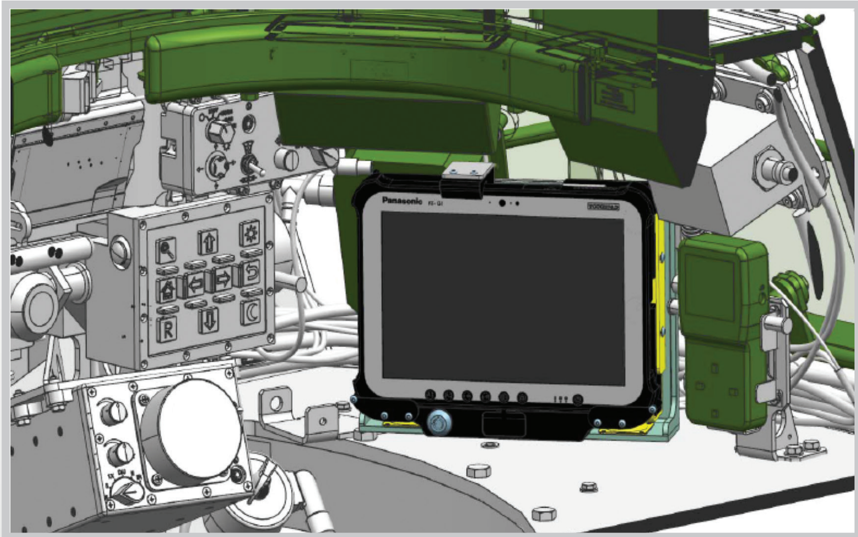


Satellite-on-the-Move (SOTM)

SOTM is an IP interface that, provided there is a connection into TACNET somewhere on the SOTM network, can be used to extend TACNET services out to Data Terminals in SOTM-equipped vehicles supporting Battle Command on the Move (BCOTM). SOTM capability includes a Vehicle Antenna Sub-System (VASS) and a Vehicle Equipment Sub-System (VESS).

LCSS Data Terminals

Army vehicles will be equipped with data terminals: TAPV being delivered with SAAB computers and display while LAV 6.0 and Tank Fleets will be fitted with Panasonic.



LCSS Compliance

All components of the LCSS upgrades and CPs are fully compliant with the latest military standards in place during the development of the system – with the exception of the LCSS Data Terminals qualified by their respective manufacturers. The qualification process ensures that each component is able to withstand the physical, electromagnetic, electrical, and information security environment into which it may be deployed. This facilitates the integration of the components into various configurations and helps to ensure that all systems comprising the ELAN components are mission-ready.

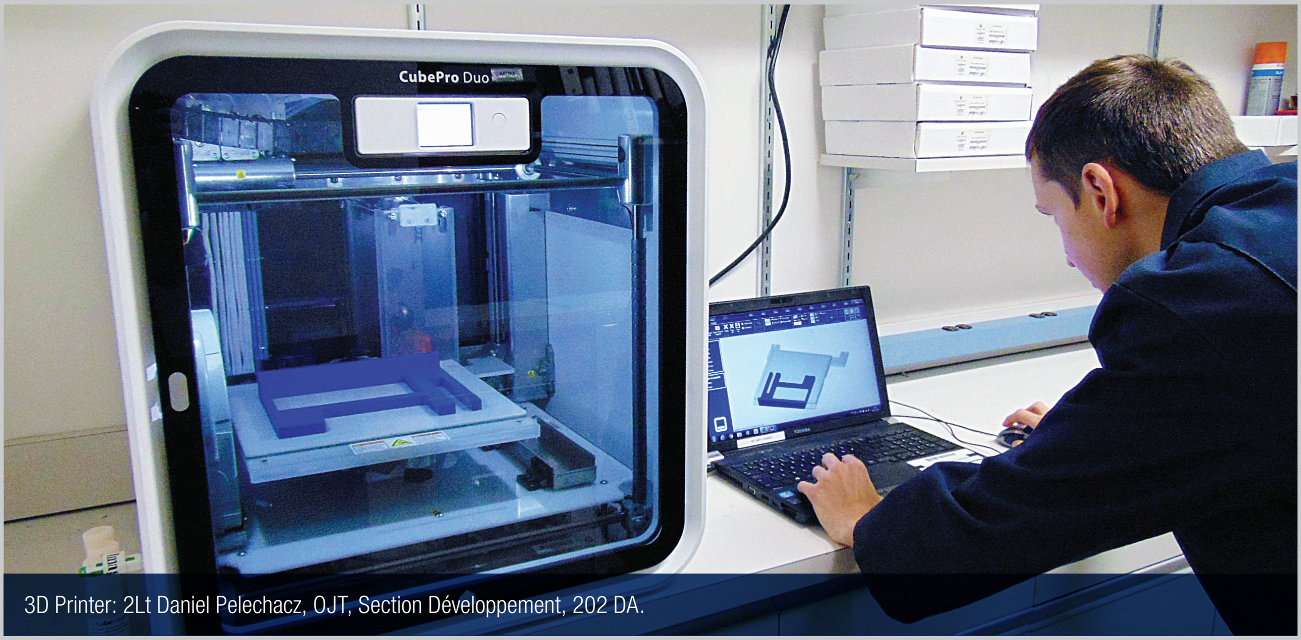
In addition to component qualification, once an ELAN configuration is installed on a vehicle that system is extensively tested in accordance with Safety Code 6 for radiofrequency (RF) safety requirements, CID/09/14 for emission security requirements and MIL-STD-464C for electromagnetic system requirements to ensure that the vehicle is safe, secure, and able to integrate into the communication network without compromising the LCSS in any way. Once the vehicle is deployed, DLCSPM undertakes a quality audit test program to ensure that compliance with all standards is maintained in the field. In this way the safety of the operators, the security of the information, and the electrical integrity and functionality of the LCSS are ensured throughout the operational life of the vehicle.

As the implementation of CP TOPAZ in the LAV 6.0 moves forward, the complex relationship and balance between command support space claims, cable criteria, power consumption, and E3 standards will have to be constantly weighed against vehicular, weapons, and human factor criteria. This requires a close relationship between DLCSPM, DAVPM and the Canadian Army. The result will be a highly protected, operationally mobile, and tactically agile combat vehicle that is targeted to remain the backbone of the Canadian Army's domestic and expeditionary task force until 2035. In addition to improved protection, mobility, and lethality, the LAV 6.0 will be fielded with a cohesive and integrated Command Support (CS) capability that will see the LCSS-LE integrated with all vehicle fighting management capabilities.

Mike Voisine is a contractor and Lead Director of Life Extension Platform Design with the Directorate of Land Command System Project Management. Kris Hatashita is a contractor consultant for Electrogmagnetic Compatibility with the Directorate of Land Command System Project Management. Jan Francki is a contractor, LAV Upgrade Coordinator with the Directorate of Land Command System Project Management.

Third-line innovation: 3D printing
202 Workshop Depot

By Lt Spenser Hui



3D Printer: 2Lt Daniel Pelechacz, OJT, Section Développement, 202 DA.

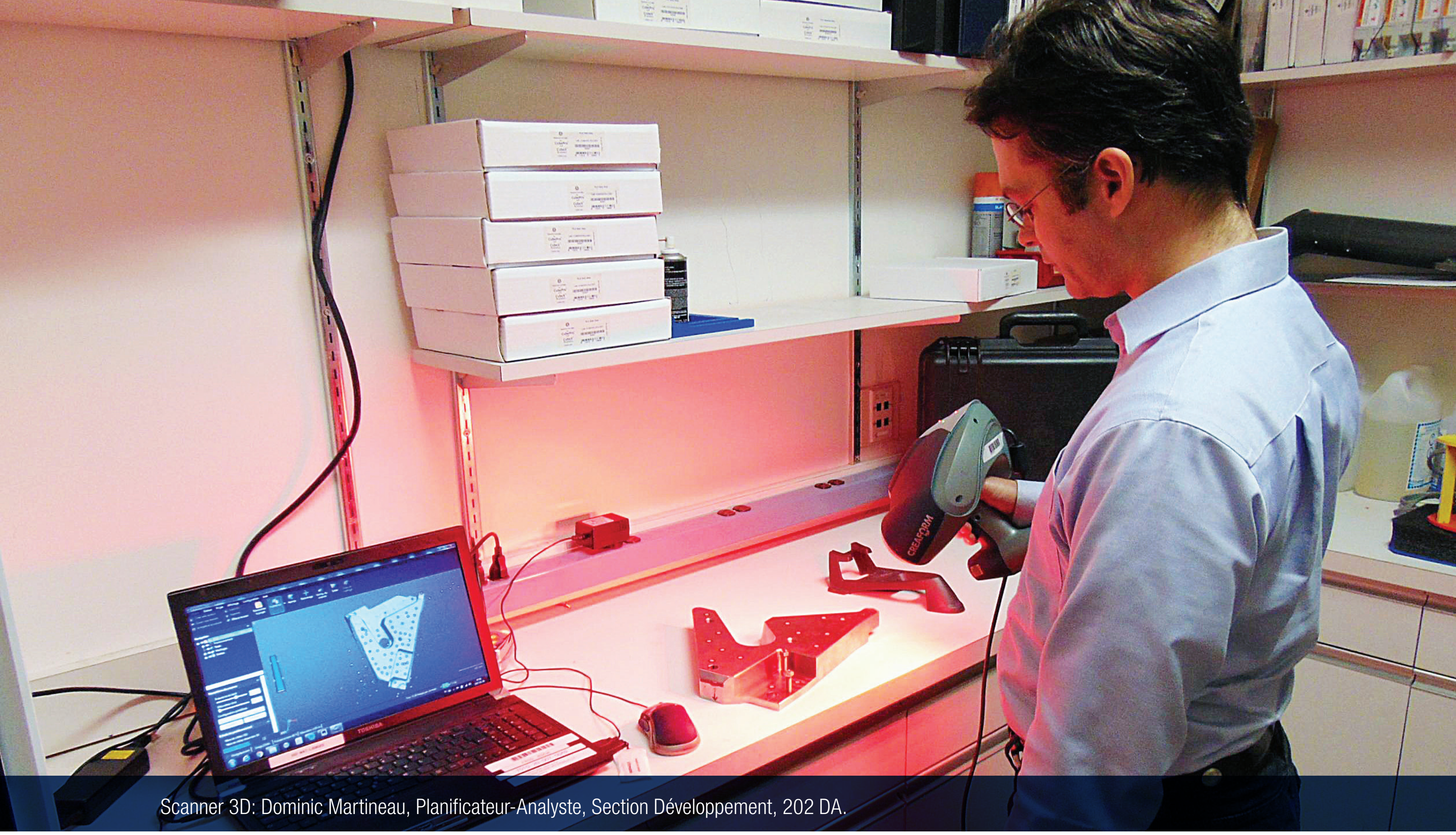
202 Workshop Depot always works hard to give the Canadian Armed Forces a battlefield advantage, whether by installing the best laser sensors available or by fabricating new parts from nothing. As the only third-line repair shop in Canada, 202 WD supports technological development and long-term investment to guarantee the Armed Forces a promising future. In order to increase its effectiveness, it is always on the lookout for the most innovative ideas on the market. Such ideas help create products of the highest quality that will enable our troops to achieve optimum performance in the field.

3D printing, also called additive manufacturing, is one such innovation. It is a cutting-edge concept that brings major improvements to the process of creating prototypes. Until 3D printing came along, prototyping was very expensive, but a necessary step in the manufacture of quality equipment. A 3D printer sharply reduces production costs, since no mould is required. In addition to being quick and user-friendly, it is economical, since it uses low-cost plastics. It also offers a much simpler way of improving parts, and quickly identifying shortcomings in designs and processes, than the traditional method.

In 2013, 202 WD acquired a laser scanner, which opened up a whole range of possibilities for development and reverse engineering. The scanner detects the labels attached to an object, and can create a 3D image of the object or generate a perfect electronic replica. It achieves amazing precision. A technician can use it to reproduce accurately the space available in a vehicle, so that new items of equipment can subsequently be incorporated. In many cases, CAF fleets include obsolete components that are no longer commercially available. Digitization makes it possible to fabricate such components with a very small margin of error.

In 2014, 202 WD connected the laser scanner to a 3D printer. It immediately became possible to create parts without having to wait, which is particularly useful in the case of components or equipment that can no longer be purchased. Production time is substantially reduced, moreover, because prototypes can be modified very quickly. One disadvantage of the printer, however, was its size: 250 mm by 250 mm by 200 mm. Larger parts had to be produced in sections, and then connected with adhesives.

Last year, 202 WD's Development Section acquired an industrial-size 3D printer, which can create objects



Scanner 3D: Dominic Martineau, Planificateur-Analyste, Section Développement, 202 DA.

measuring up to 0.5 m^3 in volume. Since it uses 0.6 mm plastic threads rather than 0.2 mm threads, production time is reduced to a third. This means that complete products can be produced in just a few hours, whereas in the past a number of sections had to be glued together to produce the desired object. The new capability represents significant savings in time and money. Ideas and solutions are now evolving at an exponential rate, because they can become reality within a very short time: sometimes only a few hours.

The Development Section has already used the 3D printer on many occasions, particularly when it became necessary to design and fabricate connectors for a tank and a mine-clearing plough, and the parts on order could not be delivered in less than two months. The 3D printer produced the needed parts overnight. The team was able not only to run a number of tests in the space of one week, but also to test some completely different concepts. In the latter case, it was very important for the components to fit together perfectly. An exact copy was therefore made of the rear of the plough, and the required connecting parts were then produced, making sure that they would all fit.

The 3D printer was also used to create a device to protect the driver's thermal camera on the Leopard 2A6. Located on the rear of the vehicle, the camera was unprotected and easily damaged. A number of configurations had to be considered. While the parts were relatively small and easy to make, each prototype would have taken one or two weeks to produce using traditional methods. The 3D printer cut processing time by a factor of 20.

The Development Section was also commissioned to reconfigure the mudguard on the Leopard 2A4, because rocks and other debris were getting jammed underneath it, and preventing efficient movement of the vehicle. In addition to suggesting a new design, the Section modified the materials used to make it. The mould alone would have cost $18,000 to make, and each prototype would have cost $1,000, not to mention the 10 to 12 weeks needed to fabricate them. With the 3D printer, each prototype took just two days to produce, at a cost of $150 to $200.

The 3D printer is a tool that can be used to develop prototypes efficiently and economically, at the location where ideas take shape. As we can see from the above examples, the new technology enables us to do better work. 202 WD has to be ready to act at any time, regardless of the weapons system involved, in order to provide appropriate support for the Canadian Armed Forces. To do so, it has to stay abreast of advanced technologies, and incorporate them into its business practices.

Lt Hui is the Production Engineer at 202 Workshop Depot.

Maintaining a Complicated Beast: LdSH(RC) and the Leopard 2 Main Battle Tank

By WO Steve Eddy

Replacing any vehicle in the CAF presents certain challenges that include training, equipment management, and maintenance. That was the situation between 2006 and 2010 when the Leopard C2 was replaced by the Leopard 2 Main Battle Tank (Leo2 MBT).

The Leo2 MBT is a heavy-armoured main battle tank that derives its superior combat capabilities from a combination of firepower, protection, mobility, and controllability. While working with the Lord Strathcona's Horse (Royal Canadians) (LdSH[RC]), I have come to appreciate not only the Leo2 MBT's strengths as a fighting vehicle, but the tireless work put forth by the technicians who ensure its operability within the battlespace and during training. The Leo2 MBT presents our technicians with many challenges that they continue to address through creativity and ingenuity.

At LdSH(RC), despite the ~95% manning levels we currently have, the number of Leo2 MBT qualified technicians is fairly low, with only eight corporal and two master corporal vehicle technicians, two master corporal weapons technicians, and three electronic optic technicians. This is due to problems with the historical manning structure of an Armoured Regiment Maintenance Platoon being Leo1-based and not yet adjusted for a Leo2 fleet. These fifteen individuals are responsible for the inspection and repair of the 30 Leo2 MBTs and three Armoured Recovery Vehicles (ARVs) at LdSH(RC).

While unqualified technicians are able to do some work on the tanks, they are unable to operate independently or safely complete inspections. Once a technician has completed the Leopard course, he or she still must work closely with an experienced, qualified member until fully proficient, with an understanding of the intricacies of maintaining such a complex machine. In an attempt to alleviate the strain on these few qualified technicians, the possibility of running Leopard courses in Edmonton that would employ these qualified members as local instructors is being investigated.

While removing these experienced personnel from the shop floor for a short period to instruct others may temporarily amp up the stress on those remaining, the resulting exponential increase in qualified personnel would be greatly beneficial to the unit in the long term. The RCEME School is also increasing the number and maximum loading of courses in order to generate more qualified Leo2 Technicians. This is definitely needed to address attrition and promotions.

Infrastructure is another area for possible approval in order to facilitate inspections and repairs. At LdSH(RC), the tank maintenance facility has a limited-use overhead crane suitable only for pulling power packs and limited to only two bays – which means that the majority of the heavy lifting is performed by the ARVs. While this does give the technicians additional experience with the ARV, it also causes undue wear and tear on the fleet. A newer facility with a large capacity overhead crane, such as the facility in Wainwright, would be a great aid to the technicians. However, despite limitations, the LdSH(RC) technicians continue to adapt their practices and make the best use of the space and lift capabilities available.

Another area of frustration for the technicians is the availability of spare Leo2 MBT parts. There was an expectation that the magnitude of maintenance tasks associated with the Leopard 2 fleet in terms of frequency, labour hours required, and parts usage would be similar to that of the Leopard 1 family of vehicles with which the Canadian Army was very familiar. Initial provisioning for the Tank Replacement Project was conducted to procure a parts stock inventory based on a culmination of past experience with Leopard 1, recommended procurement lists from the original equipment manufacturer, and feedback from other user nations. The correlation has proven not to be the case – rather, the complexity, duration, frequency, and parts usage of maintenance tasks has proven to be significantly greater than anticipated. Accordingly, the supply stock initially generated by the project team was insufficient and quickly depleted.

With the establishment of the National Individual Standing Offers and Repair and Overhaul contracts, the proper tools were put in place to start filling the bins and sort out the Leopard 2 parts availability challenge.

The Force Mobility Enhancement project called for the modification of the Leopard 2 fleet with Tactical Mobility Implements to accept the mine roller system, track-width mine plough, and a dozer blade. These improvements help to ensure the safety of crews when deployed on operations and enable the CAF to respond effectively and successfully to the full spectrum of military operations.

The Leo2 MBT poses a great many challenges to those responsible for its maintenance. Ultimately, its unique requirements and quirks allow the RCEME technicians to truly live up to their motto "Arte et Marte" – By Skill and By Fighting – through innovative solutions and sheer determination.

WO Steve Eddy is the Maintenance Control Warrant Officer at Lord Strathcona's Horse (Royal Canadians) in Edmonton.

Qualifying Army Material Technicians to Conduct **Non-destructive Testing in the Field**

By Bruce Winsor

The Quality Engineering Test Establishment (QETE) has developed a Non-destructive Testing (NDT) program for the Canadian Army. It provides a mechanism for the training, certification, and recertification of the Army Materials Technician (Mat Tech 00134) in NDT. As the Land NDT Program Manager, QETE is also responsible for the development of the specific inspection procedures that will be used by the Mat Techs in the field. QETE has identified the equipment requirements and assembled a special tool kit containing all the necessary items for carrying out field inspections.

NDT consists of a group of processes that allows for the detection of critical material defects in Canadian Armed Forces (CAF) weapons systems. Defects such as cracks, which in many cases cannot be seen without the use of NDT, can lead to catastrophic failure – resulting in equipment unavailability and potential serious injury to personnel. NDT provides a mechanism for the detection of these anomalies before failures occur. Depending on the circumstances, these types of problems can be related to a single piece of equipment or may affect the entire fleet of a specific platform.

Historically, NDT in the Army has been carried out by personnel with limited training in this specific area. The provision of quality training and tools to the Mat Tech allows for greater day-to-day availability of this valuable skillset for maintenance of Army equipment. Basic NDT skills are now being taught on the Development Period 1 (DP1) and DP2 phases of Mat Tech development.

In order to provide the necessary skills to existing DP2 qualified Mat Techs, QETE has carried out "Roll-Out Training" at four Army bases (Edmonton, Petawawa, Valcartier, and Gagetown). The targeted group consists primarily of Mat Techs who are doing hands-on field inspections – typically carried out by personnel at the corporal and master corporal ranks. The training is an intensive one-week course that includes in-depth theory and practical training for both Liquid Penetrant Inspection (LPI) and Magnetic Particle Inspection (MPI). Army NDT Program certification examinations are completed by the Mat Techs during this week.

Feedback from the Mat Techs who have completed the roll-out training has been very positive. Participation and enthusiasm from individuals who have taken these courses has been very high. The level of interest and professionalism displayed is admirable.

As of this writing, seven roll-out training courses have been completed by a total of 75 qualified individuals. With the completion of the final course in Edmonton in March of 2018, the roll-out training will be complete. In the future, personnel will receive the certification upon completion of their DP2 development phase.

The specialized NDT tool kit – containing all of the necessary equipment and documentation to carry out basic LPI and MPI Inspections – is available for distribution under PSCN 5180-20-AOH-3164 through the Canadian Forces Supply System. By the fall of 2017, 41 of these kits had been issued to the field. The Life Cycle Materiel Manager (LCMM) for these kits is the Army NDT Program Coordinator (located at QETE).

The daily activities of managing the Army NDT program are performed by the warrant officer who occupies the NDT Mat Tech position at QETE (Army NDT Program Coordinator). A requirement of this position is to obtain CAN/CGSB 48.9712 Level II certification for both LPI and MPI either before or while occupying this position. Warrant Officer Peter Pipke, the Mat Tech who currently occupies this position, has received this certification. The Mat Tech community and QETE congratulate WO Pipke on this significant milestone for the occupation and the program as he is the first Mat Tech to achieve this distinction.

The first major fleet inspection carried out by Mat Techs under the Army NDT program was an examination on the LG1 Artillery Gun. MPI was used to detect anomalies in the Muzzle Brake area on the Cannon Tube. Mat Techs from Gagetown and Halifax were involved with this investigation. Based on the inspection results, this initiative was successful and provided confidence to the LG1 Technical Authority and the Operational Authority to move forward.

Current program initiatives include the development of a defect identification catalogue, which will be used for DP1 and DP2 training in Borden. The individual Mat Tech NDT recertification initiative, which consists of an annual written and practical examination, commenced in the fall of 2017.

In summary, the Army NDT Program provides a mechanism to meet the evolving NDT inspection requirements of the Canadian Army. It emphasizes the need for qualified personnel in conjunction with the use of approved equipment and procedures to carry out NDT inspections. It is a multi-faceted approach with Mat Techs providing an immediate response for day-to-day routine inspections through LPI and MPI examinations. The combination of trained and qualified personnel, proper equipment, and validated inspection procedures is the key element that helps ensure reliability of the process by providing a clear mechanism for repeatability. Inspection procedure development and advanced inspection capability such as Ultrasonic and X-ray testing can then be undertaken by QETE personnel who are NDT certified in accordance with the National CAN/CGSB 48.9712 standard in all these techniques.

NDT is a valuable resource that can be used to help maintain the safe and efficient operation of DND/CAF assets. This capability is now available from the Mat Tech trade at the Brigade level and through QETE to all Canadian Army equipment and fleets. Equipment and asset managers are encouraged to contact WO Pipke at QETE to engage the Army NDT inspectors to support their needs.

Bruce Winsor is Subject Matter Expert, Non-Destructive Testing, Quality Engineering Test Establishment (QETE 2-5).

Tactical Armoured Patrol Vehicle (TAPV) Project is **Right on Target**

By Maj Rick Cormier

The Tactical Armoured Patrol Vehicle (TAPV) Project is in the process of delivering 500 TAPVs and associated Integrated Logistics Support. The TAPV is being fielded in order to replace the Coyote and RG-31 Nyala fleets, as well as complement the Light Utility Vehicle Wheeled fleet. Textron Systems Canada Incorporated (Textron), a subsidiary of Textron Marine and Land Systems based out of Slidell, Louisiana, was awarded the contract, which includes both acquisition and support components. Rheinmetall Canada is a major subcontractor of Textron for in-service support to the TAPV.

Two variants of the TAPV are being fielded: 193 Reconnaissance and 307 General Utility vehicles. There will be 364 TAPVs equipped with a Kongsberg PROTECTOR Dual Remote Weapon System (RWS), armed with the C16 Automatic Grenade Launcher and C6 General Purpose Machine Gun. The remainder of the fleet is fitted for but not with the RWS.

The TAPV Project is well into the implementation phase, with more than 375 vehicles fielded across the Canadian Army (CA), as of December 2017, and the majority of support in place. Delivery started in August 2016 and it is forecasted that fielding of the 500th TAPV will occur by mid-2018. Coinciding with the handing over of the final TAPV, technical authority will transition from the TAPV Project to the TAPV Equipment Management Team within the Directorate Armoured Vehicle Program Management.

Unique from other CA fleets, the TAPV fleet is being delivered with a long-term (25-year), performance-based support contract that will see Textron provide the initial support solution and continue to furnish in-service support throughout the life of the TAPV.

The foundation of the support contract is the Performance Based Accountability (PBA) framework, which defines clear and measurable metrics that will measure the level of performance of Textron's fleet and support services. There are agreed levels of performance that must be achieved by Textron, with incentives for achieving increased levels that will encourage continuous improvement to both the vehicle and support solution. By way of summary, the following are the performance metrics included within PBA:

- *Reliability*: Measured as the number of kilometres between failures for the vehicle and number of hours of operation between failures for the RWS.
- *Maintenance Burden*: Calculated on the number of maintenance hours per kilometre on the vehicle and number of maintenance hours per hour of operation of the RWS.
- *Technical Problem Solving*: Determined by the average time Textron resolves technical problems.
- *Supply Responsiveness*: Gauged by turnaround time for spares delivered to the handover point (Depot).

The basis of payment for the support contract differs from traditional time- and materials-based contracts. Under the TAPV support contract, Textron is paid a firm fixed price to provide predefined in-service support for the life cycle of the fleet. Within this price, DND makes annual payments to Textron based on actual usage (kilometric and RWS hours). Included within the usage payment is the cost associated with the replenishment of spares consumed via maintenance work orders. The support contract also includes a mechanism to call up additional work ranging from accident or battle damage repairs to engineering changes on the fleet.

Incentives Cut Costs

Looking at both the PBA framework and the Basis of Payment within the support contract, it becomes clear that Textron is highly incentivized to improve reliability and reduce the overall life cycle costs in-service. From the PBA metrics, reliability as a distinct performance metric will directly impact incentives. Indirectly, reliability also affects the PBA metrics for maintenance burden, technical problem solving and supply responsivity. The more reliable the TAPV, the less corrective maintenance required, resulting in fewer technical problems to resolve and reduced supply demand – all of which has the potential to positively impact Textron's performance. Similarly, the fixed cost per usage is the largest payment within the support contract, so the more reliable the TAPV, the less spares consumption, which will translate into increased profit. This leads to a mutually beneficial arrangement. Textron is financially incentivized to continuously improve the TAPV reliability and DND will reap the benefits of increased vehicle availability across the TAPV fleet.

Although the overall concept of maintenance support for the TAPV fleet differs from other fleets currently within the CA, this will not translate into significant changes at the unit level. RCEME technicians will conduct first and second line repairs. Third line repairs will be conducted by Textron with 202 Workshop Depot remaining as the technical reserve

The maintenance task list for all corrective maintenance is built into the Defence Resource Management Information System (DRMIS) and the TAPV preventive maintenance program is configured as a DRMIS Maintenance Plan. The preventive maintenance program differs from other armoured vehicle fleets within the Canadian Army, with the major divergence being that an 1,136 inspection is completed annually (or at 6,000 km), as opposed to semi-annually.

The majority of the raw data used to calculate performance is drawn from DRMIS. Therefore, to support the performance management framework, it is imperative for every maintenance workshop to remain disciplined in its use of DRMIS. This includes closing work orders as soon as practicable after completing each job and ensuring maintenance tasks are properly captured using the correct maintenance activity from the task list. It is equally important that operator and preventive maintenance schedules are followed, and that all pertinent activities are completed in accordance with the technical manuals. Failures that can be traced back to non-adherence to the maintenance program will lead to additional costs to DND. The technical publications are in the form of fully integrated Interactive Electronic Technical Manuals that will eventually be available through DWAN and are currently provided via stand-alone laptops.

The TAPV Information System contains a Health Usage Monitoring System (HUMS) that will monitor the usage, environmental conditions, configuration, and sub-system technical operating data. The HUMS will facilitate data collection and provide evidence for failure analysis to the Equipment Management Team. The DRMIS and the Fleet Management System are the primary data entry points and sources used to measure performance and usage, while HUMS will be used to validate the data as required. As a result, HUMS downloads are part of the preventive maintenance program.

TAPV Recovery Trial

The TAPV project recently completed a recovery trial in Valcartier, Québec where the TAPV was successfully direct-towed by the LAV 6.0, TAPV, MTVR and AHSVS using the recently fielded Articulated Tow Bar and the modified Leopard Tow Bar. Also, the AHSVS proved more than capable of suspend-towing the TAPV but due to safety concerns with AHSVS adaptors this procedure is unfortunately not authorized at this time. Interim recovery direction for the TAPV fleet will be promulgated through an Address

MCpl Sylvain Dionne suspend-tows the TAPV using the AHSVS during recovery trials in Valcartier.

PHOTO CREDIT: Maj Jerome Duguay, PMO TAPV Integrated Logistics Support Systems.

Indicating Group (AIG) early in 2018. The long-term recovery requirements of the TAPV will be included in the Enhanced Recovery Capability Project.

From a supply perspective, the provision of spare parts for the TAPV is different from other Canadian Army fleets. Most notable is that replenishment of spare parts is a Textron responsibility and TAPV unique parts are owned by the contractor until they are physically consumed against a work order and installed on a TAPV. Therefore, supply support to the TAPV uses a joint DND/contractor supply chain, with transfer of control from Textron to DND occurring at the Canadian Forces Supply Depots (CFSD). Care, control and custody of Textron-owned material from receipt at Depot until installed onto a TAPV is a DND responsibility and will mirror current departmental supply discipline and policy. Textron will be financially compensated for any loss or damage of contractor-owned resources while within DND control.

Textron replenishes spares to the Depot each time one is consumed against a TAPV work order. Response time for delivery to Depot is seven days for critical parts (those parts required for the vehicle to move, shoot, observe, or communicate) and 30 days for non-critical parts. DND is responsible to return repairable spares to Rheinmetall Canada within 90 days to support their Repair and Overhaul program. Additionally, Textron is responsible for disposal. Therefore most material subject to disposal (e.g. controlled goods) will be returned to the contractor for action.

The inventory of spares held within the Canadian Forces Supply System will consist of 60 days of supply (DOS) broken down between Depot (16 DOS), Base (30 DOS) and Unit (14 DOS). These holdings are based on analytical failure rates and the scaling will be continuously adjusted by Textron to account for actual consumption rates to maintain a true inventory of 60 DOS.

Members of *12e Régiment blindé du Canada* take note of the flood damage to provide a report to local authorities during Operation LENTUS 17 in Gatineau, Québec on May 9, 2017.

The TAPV has already deployed on domestic operations as part of Operation LENTUS 17-03, the Canadian Armed Forces assistance to flood relief efforts in the Province of Québec from May 6 to June 5, 2017. The TAPV performed well and there is no doubt that this is the first of many operational deployments that will rely in part on the TAPV fleet.

The Performance Based Support Contract has great potential to deliver good value for money. Continuing to work within the intent and spirit of the support contract will allow for improvements to the support concept with the end goal of providing the best possible service to the Canadian Army.

Key Take-Aways

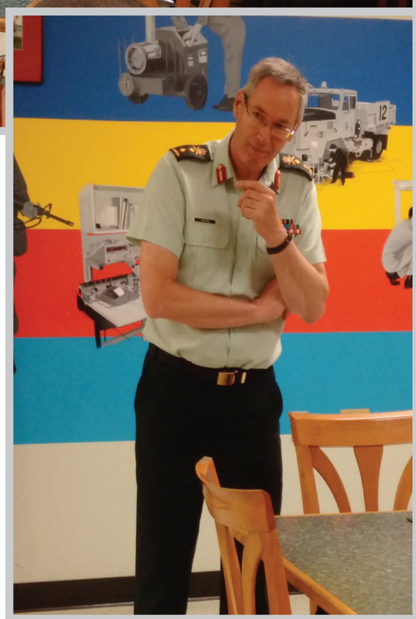
- Performance data is drawn from DRMIS so disciplined use and accurate data entry is imperative.
- Close work orders as soon as practicable after each job.
- Use the correct maintenance activity from the maintenance task list.
- Follow the operator and preventive maintenance schedules.
- Complete all maintenance activities in accordance with the technical manuals.
- HUMS downloads are a necessary part of the preventive maintenance program.
- Repairable spares must be received back at Rheinmetall Canada within 90 days to maintain the responsiveness of the parts supply chain.
- Deviations from our obligations will result in additional costs for Canada and/or the inability to hold Textron to their commitments.

Maj Rick Cormier is TAPV Equipment Management Team Coordinator.

PHOTO CREDIT: Cpl Gabrielle DesRochers, Canadian Forces Combat Camera.

RCEME Senior Serving Visits Cold Lake Maintenance Workshop

By Cpl Sean Jenkins



Tucked away in Northern Alberta, against the border with neighbouring Saskatchewan, lies the busiest RCAF fighter base in Canada. Providing state-of-the-art tactical training and support and deploying fighter aircraft at a moment's notice, 4 Wing Cold Lake is not only home to world-class fighter pilots, but to a small and dedicated crew of world-class RCEME technicians as well.

On May 25, 2017, with Exercise Maple Flag 50 – the 50th iteration of the Air Force's largest international training event just around the corner – the crew of Building 400 welcomed a visit from MGen Alexander Patch, OMM, CD, the Deputy Chief of Staff to the Assistant Deputy Minister (Materiel) and Officer Commanding the Command of the Materiel Group. As an RCEME officer, MGen Patch has a bachelor's degree in Mechanical Engineering and is a graduate of the Advanced Military Studies Course and the Canadian Forces Command and Staff College. MGen Patch outlined some of his service history – which included learning the ropes as a junior officer with 2 Service Battalion and the Royal Canadian Dragoons to eventually commanding the entire Area Support Group. In 2009, he assumed the role of Director General Land Equipment Program Management (DGLEPM) until his promotion and appointment to his current position in Ottawa.

The mandate of the Materiel Group team is to manage the full life cycle of defence materiel, from acquisition through maintenance and support to disposal. Given the extensive scale of these responsibilities, our team greatly appreciated that MGen Patch took the time to visit our workshop and discuss the well-being of the shop and the important role we play in materiel assurance, especially from a location as isolated as Cold Lake.

He brought with him messages on behalf of the senior staff of the Corps and also shared the exciting news that the RCEME council has endorsed the change of our beret colour.

Since the visit, the RCEME Corps Sergeant Major, CWO Marty Walhin has revealed that a decision on the matter has now been made: "Having reviewed Army historical documents, and compared several samples of fabrics and a few berets, we unanimously chose the blue beret that is the current British Army issued version. It is dark, but distinctly blue, and provides a compatible colour with both Army DEU and Combats."

Once funding is approved we could expect to see an 18 to 24 month delivery time, potentially lining up with the 75th anniversary of the Corps in 2019.

MGen Patch stressed the importance, as he referred to it, of "building your case." Equipment and/or workforce requirements that are perhaps falling behind around the workshop need a well-documented case, and one tool that can help in building that case is the Defence Resource Management Information System (DRMIS). In 2012, the DGLEPM managed approximately 30 major fleets, representing 22,685 platforms and 280,531 centrally managed line items, including all ammunition and roughly 100 in-service support contracts. Given the size and complexity of this enormous vehicle and equipment portfolio, the readiness levels of fleets must be maximized in order to meet operational demands in a security environment that continues to be unpredictable and volatile. Although it is one of RCEME's great strengths to be able to do more with less, the better we can document in detail the needs of our working environments and the issues with the fleets, the more we can get access to new equipment and personnel strategies.

MGen Patch gained a good appreciation for our challenges with manning, procurement, and diversity of equipment, and we provided a good understanding of how the workshop applies ingenuity and initiative to look after the Wing.

"Having reviewed Army historical documents, and compared several samples of fabrics and a few berets, we unanimously chose the blue beret that is the current British Army issued version. It is dark, but distinctly blue, and provides a compatible colour with both Army DEU and Combats."

The following day marked the belated 73rd anniversary of the Corps. Traditionally, it is held on May 15 every year, but, due to operational logistics and an effort to encourage the inclusion of all available past and present RCEME members, we chose to celebrate on May 26 instead. The day started off with an excellent and hearty breakfast hosted by the 4 Wing kitchen team and ably served by Sgt Danny Cairns, Sgt Ben Browne, Sgt Donald Bryer and Sgt Chris Diotte. Sufficiently fueled up, we took on one another in a high-spirited game of softball. It came complete with outrageous catches, outlandish calls, and one hit so close to being knocked out of the park that it hit the railing of the outfield fence! In true RCEME fashion, there was a healthy and respectful amount of name-calling combined with good sportsmanship – which made for an excellent game.

Members then made their way over to the 4 Wing campground for a BBQ lunch, raffle ticket draws, and the ceremonial cutting of the cake. Although the festivities don't reach the scale of some of the larger bases like nearby Edmonton or the RCEME School in Borden, it is an equally momentous occasion. It gives everyone the opportunity to foster the comradeship and unity that is integral to the RCEME Corps here at 4 Wing Cold Lake.

Editor's Note: *MGen Patch retired from the CAF in July, 2017, shortly after his visit to 4 Wing Cold Lake.*

Cpl Sean Jenkins is a Vehicle Technician with RCEME Flight, 4 Mission Support Squadron.