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TURNING THE BARREL ON A TIMBERWOLF

A lathe with a four-jaw chuck turns the barrel of a C14 Timberwolf Medium Range Sniper Weapon at the RCEME School Machining Workshop at CFB Borden. The action being performed is the indexing of the parting tool (a narrow-bladed device used in turning) in order to get an accurate measurement when the cut is started for the barrel.

Read more on page 3.

Photo credit: MCpl Sylvain Baril

Cover Photo: Cpl A.R. Walton, Veh Tech, 4 Rgt (GS), (at left) assists Sgt L.P. Dumont, EO Tech, 4 Regt (GS) in diagnoses and completing repairs on a liquid refrigerant cooling unit (LRCU) at CFB Suffield, HEBE Trial, RCAF experimentation supporting the Air Threat Evaluation Program (ATEP) target acquisition assessments. See page 11.

Photo credit: Sgt Tomy Gervais, MRR Det Commander, 128 Bty, 4 Regt, Gagetown

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DIRECTOR GENERAL'S COMMENTS

SUPPORT TO TRAINING AND OPERATIONS

PROJECT UPDATES

FORWARD THINKING

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DIRECTOR GENERAL'S COMMENTS

Lending vital support to Ukraine

By BGen Rob Dundon

Mariupol. Kherson. Melitopol. Just three of the recently fallen cities in Russia's invasion of Ukraine. At the outset, the Russians attempted manoeuvre warfare and failed. Miserably. The war seems to be moving into a new phase of attritional grind as each side positions for the long haul. Western warfighters of the world are reaping lessons learned from the conflict, but those of us in the Materiel Acquisition and Support and Land Equipment Management System are doing more than just watching – we are making a difference.

Manoeuvre warfare is a technique that can only be executed well with considerable trust and training, proving difficult for conscript armies. As a result, manoeuvre warfare had little opportunity to be executed well by Russian forces. Regardless, cities continue to fall because the Russians have resorted to their historical form of warfare that plays to their strengths – indirect fire. Cities are being pulverized with indirect fire before occupation. One Russian minister boasted the Russian forces are firing 60,000 rounds per day. I can only imagine how quickly they are burning through barrels, but they can afford to do so, resting upon deep supplies of ex-USSR equipment and ammunition. When you don't know what to do, do what you know.

The Ukrainians have not been idle. They have been innovating. They embraced the Western mission command philosophy to incredible effect and adopted an interesting form of asymmetric artillery warfare. SHORAD Stinger gunners and Javelin-equipped anti-tank teams have had a devastating impact. Their asymmetric application of the recently donated HIMARs systems targeting Russian ammunition depots and headquarters well behind the front lines is having an operational level effect. The burning from these attacks has been confirmed from space via NASA's Fire Information Management System (FIRM). Donations of Western weapons are making all the difference in Ukraine.

Early in the conflict, we assisted with Canada's donation of 390,000 individual meal packs, fragmentation vests, sniper rifles, M72s, grenades, 84mm systems, and M777 howitzers. On May 8, Canada committed to an additional $500M in donations, which demanded a more comprehensive response.

The strategic military aid donation program is now being overseen within ADM Policy by the ad hoc Materiel Assistance Coordination Cell (MACC). The team is led by RCEME's own Col Chris Moyle and Maj Randy Balkaran. They are currently in the throes of coordinating the donation of L3 Wescam targeting cameras for Bayraktar TB2 drones, replacement M777 barrels, Roshel armoured cars, and our new Armoured Combat Support Vehicles of the troop-carrying variant, all of which will showcase Canada's defence industry capability.

Beyond donations, we are readying our forward deployed forces in Latvia. Urgent acquisitions are underway for soldier-portable anti-tank systems, soldier-portable air defence systems, counter-uncrewed aerial systems (C-UAS) capabilities, and new CBRN suits for our personnel on Operation REASSURANCE.

Our equipment is designed and manufactured to achieve technological overmatch, which is precisely what we are seeing. However, we also see that maintaining our kit is difficult. Ukrainian soldiers are being taught to use the weapons systems in days. Learning how to fix them takes months. The use and damage of equipment are so intense that it is not being repaired in situ but instead is being back-loaded. We expect this problem to grow as Ukraine forces consume their Soviet-era equipment and transition to more complex Western systems. We may not have moved to wartime production, but the west has vast industrial resources that favour attritional warfare. Russia, under punishing sanctions cannot say the same. Western donations will likely peak in October, and it will prove interesting if Ukrainians seize the moment to take up the counter-offensive.

Kit plays a key role in the conflict, but whether a war of attrition favours the Russians or the Ukrainians depends largely on how we respond. It is time for those who acquire and support equipment to rise to the occasion. Nothing less than the future rules-based international order may depend upon it.

Supporting Elite Shooters: Maintenance of the sniper and target shooting rifles – a new Weapons Technician capability

By Maj Tony Nguyen

Supporting sniper and target shooting rifles can now be added as another tool in the Weapons Technician trade's toolbox.

The recent Precision Weapons Maintainer pilot course, completed at the end of March 2022 at the Royal Canadian Electrical and Mechanical Engineers (RCEME) School, was a great success – qualifying eight Precision Weapons Maintainer Technicians across the Canadian Armed Forces (CAF) over 45 training days. As qualified Precision Weapons Maintainers, these people repair, evaluate, perform machining, blueprint, and troubleshoot for the accuracy of precision weapons in a static or operational environment.

Shooting well is a fundamental requirement of being a soldier. With practice, soldiers improve – but among us there are those who surpass standard shooting. They are the elite of military shooters – the snipers. These highly skilled individuals provide detailed surveillance from a concealed position and, where necessary, reduce the enemy's combat ability by neutralizing high payoff targets.

Since snipers must pin down and demoralize the enemy, their weapons need to be maintained to a high degree of accuracy. As weapons, ammunition, and aids for ballistic calculations improve, so do the kill distances. In 2017, a Canadian Special Forces operator set a record 3,540-metre confirmed kill.

Cpl S.G. Seguin, a 1 RCR student on the Precision Weapons course, applies a bedding compound to a C3 sniper rifle based on the Parker Hale M82 rifle stock in order to have it properly bedded. Photo credit: MCpl J.Y.S. Baril

The importance of supporting operators and their precision weapons is the *raison d'être* of this Unique Specialty Qualification course taught at the RCEME School.

The Precision Weapons Maintainer services and finely tunes specialized equipment. This entails the necessity to identify accuracy faults, adjust bedding tolerances, re-barrelling, and the authority to correct manufacturing defects such as bolt intolerances. The Performance Objectives include action blueprinting, machining of weapon sub-components, ballistic theory, troubleshooting accuracy, maintaining stocks, evaluating targets, and collecting ballistic data.

Weapons technology is changing and so are the demands for support – and so it follows that a Weapons Technician's role and job requirements must evolve. Almost 40 years ago, the trade moved away from performing machining. The current requirement to ensure the accuracy of precision weapons has necessitated that Weapons Technicians bring back the practice of gunsmith machining. The Precision Weapons Maintainer course includes

MCpl H.M. Denis, an instructor at the RCEME School and also a student on the Precision Weapons course, tests the accuracy of machining work done on the precision of a C14 Timberwolf. Photo credit: MCpl J.Y.S. Baril

fabrications to meet specified low degrees of tolerance for the barrel and chamber. This is in line with the duties of Canadian Special Operations Forces Command (CANSOFCOM) RCEME technicians who work with tolerances on weapons used by Special Operations Forces (SOF) Operators.

Bringing back aspects of gunsmithing by way of the Precision Weapons Maintainer course builds the trade's skills and versatility. A gunsmith repairs, modifies, designs, and builds gun parts. This is a corollary to an armourer, who replaces worn parts in firearms. Gunsmithing entails the act of modifying and making changes to a firearm. It requires a very high level of craftsmanship and proficiency in machining. Undoubtedly, the Precision Weapons Maintainer's skills enhance the Corps' ability to support the CAF and is an example of RCEME continuing to grow world-class soldier-technicians that provide state-of-the-art, relevant maintenance.

The development, execution, and subsequent success of the Precision Weapons Maintainer course is in large part the result of the dedication of current and former Weapons Technicians from across the Department of National Defence, including Director General Land Equipment Program Management and CANSOFCOM. Weapons Technicians in the field force and those in the sniper systems project, as well as technicians at SOF units, infused their wisdom, experience, and knowledge into the course. There are so many who have contributed to this success.

Maj Nguyen is a RCEME Officer at CFB Borden, OC Art Coy, RCEME School, CTC, CADTC.

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* will be published in the fall of 2022. If you want to be a part of the next edition, please send your articles – or your ideas for articles – to LEMSJournalSGET@Forces.gc.ca no later than **September 30, 2022**.

RCEME members provided mentorship on **Exercise MAPLE ARCH 21**

By Sgt Mitchell Godwin

In November of 2021, three RCEME members from 5th Canadian Division attended Exercise MAPLE ARCH 21 as mentors for Eastern European non-NATO logistics staff. This event was held at the NATO-Georgia Joint Training and Evaluation Centre in the Krtsanisi National Training Centre located outside Tbilisi, Georgia.

Exercise MAPLE ARCH 21 is an annual computer-assisted command post exercise carried out in non-NATO countries in Eastern Europe designed to train battalion headquarters personnel on the planning and execution of peace support operations in conjunction with other NATO countries.

The nations involved were Ukraine, Lithuania, Poland, Bulgaria, and the host nation of Georgia. There were also members of two multinational brigades attending: the Lithuanian-Polish-Ukrainian Brigade and the South-Eastern Europe Brigade.

The main role of the RCEME members during this exercise was to mentor their multinational counterparts on the application of logistics support to operational planning and the sustainment of troops deployed in peace support operations. We worked with the foreign nations' S4 cells that handle all logistic aspects of an operation – including the use of maintenance, supply, transport, and medical assets.

We discussed the ability of each country to support its nation's contingent through the scenarios injected by the exercise coordinators, and provided analysis and points for improvement on the organization's ability to overcome conflicting priorities due to equipment limitations. Additional injects to the scenario included: status updates of vehicle breakdowns, supply availability, and personal injuries and deaths.

(Left to right) Maj Michael Wood, Sgt Mitchell Godwin and Capt Robert Weatherill (promoted to Captain after photo taken) attended Exercise MAPLE ARCH in Tbilisi, Georgia and are pictured here at the JTEC Krtsanis National Training Centre. Photo credit: MCpl Matheson

An additional factor added to the simulations this year was the inclusion of a COVID-19 environment and its effects on operations.

Before the exercise commenced, the training audience, as well as the mentors, went through instruction on the utilization of the Military Decision Making Process – an American system utilized by NATO that is similar to the Operational Planning Process used more commonly in Canada. The command relationship between senior officers and senior non-commissioned officers was also stressed since working together during these operations can dictate the success or failure of completing the task assigned.

The first days of the exercise were spent gaining an understanding of our foreign counterpart. We would start each day discussing our military experiences and our personal lives.

Once the exercise began for the day, all discussions turned to ongoing operations in the simulation – determining the best way to provide the required logistics support. This quickly led to discussions regarding how each nation carried out tasks related to repair and sustainment as well as outlining the differences we have as nations, such as the placement of repair and recovery assets in a convoy. We learned a vast amount about each nation's planning processes and ways to adapt to efficiently work together in the future.

Sgt Godwin is a Planner at SMP Platoon, Maintenance Company, 5 Canadian Division Support Group Technical Services.

A Forward Support Group in Domestic Operations: Op LENTUS 21-06

By Capt Jeremy Tremblay and Lt David Hamilton

During the fall of 2021, British Columbia was struck by devastating atmospheric rivers. Enormous amounts of rainwater brought floods, landslides, and devastation to the homes of thousands of Canadians.

The Town of Hope, for example, received 252mm [1] of rainwater in just one weekend – equivalent to 10 billion litres of water or 516 million jerry cans. The BC Government declared a state of emergency and, in response, the Canadian Armed Forces (CAF) force generated and deployed a total of 748 personnel, nine aircraft and numerous support vehicles [2]. During the month-long deployment, 1 Service Battalion's (1 Svc Bn) Forward Support Group (FSG) provided second-line maintenance, supply, and transport assistance to the Joint Task Force Pacific (JTF(P)).

With the Lord Strathcona's Horse (Royal Canadians) (LdSH(RC)), the lead mounting unit, the FSG was positioned in Vernon with detached elements in Chilliwack and Richmond. As with any operational environment, enablers behind the scenes played a significant role in providing Real Life Support (RLS), delivering essential flood relief equipment, and sustaining the overall mission.

Local reservists vital in flood relief

As Hercules aircrafts packed with Land Task Force (LTF) troops arrived in Abbotsford, Primary Reserve (PRes) members from 39 Canadian Brigade Group (CBG) were relied upon to provide immediate logistical support to facilitate the deployment. PRes and Regular Support Staff RCEME technicians from 39 CBG were instrumental in executing the rapid and agile support concept for the mission. 39 Service Battalion (Svc Bn), headquartered in Richmond, was particularly well-situated to provide RLS to the sandbagging efforts in Aldergrove and throughout the lower mainland.

Highway closures in the BC interior (Highways 1, 3, 5, 7 and 8) impeded the passage of vehicles and supplies, which made sustaining the relief efforts that much more difficult. Road moves often lasted up to three times the normal duration due to landslides and washouts. The FSG employed one of the most important LEMS tenets – Self-Sufficiency – often implementing creative solutions to ensure Canadian Armed Forces efforts did not put pressure on the already strained local economy.

Is our recovery equipment at 1 Service Battalion up to the challenge?

As part of the FSG, 1 Svc Bn deployed recovery vehicles to support the entire LTF fleet. A total of three key assets were sent out the door to directly assist the front line for JTF(P): the Armoured Heavy Support Vehicle System (AHSVS) Wrecker, the Heavy Logistics Vehicle Wheeled (HLVW) Tractor, and a 35-ton (35T) low-bed

1. "These graphics show just how much record-breaking rain hit southern B.C. recently," 18 November 2021. [Online]. Available: www.cbc.ca.
2. "Minister's statement on assistance with flooding," 17 December 2021. [Online]. Available: https://news.gov.bc.ca/releases/2021EMBC0078-002409.

trailer. These three assets were selected based on the vehicle platforms to be supported: the Medium Support Vehicle System (MSVS) Standard Military Pattern (SMPs), LAV 6.0s and Bisons, Light Support Vehicle Wheeled (LSVWs) and Light Utility Vehicle Wheeled (LUVWs), and B-Fleet pickup trucks. The MSVS SMP [3] is an impressive platform that, based on the recovery assets of 1 Svc Bn, can only be highway suspend towed by an AHSVS Wrecker. The HLVW Tractor and 35T trailer were used to support all the other platforms, including the LAV 6.0.

The month-long domestic operation was no holiday for our maintainers since their support was crucial to the success of the mission. They provided 24/7 maintenance and recovery support to the LTF. The Maintenance Section Commander of the FSG, MCpl Frank Dufresne, provided the following testimony based on real-life accounts, which highlighted the strength of the RCEME Esprit de Corps:

"Our vehicles fared very well while driving through the Rockies. On the AHSVS Wrecker alone, we drove over 3600 km from Edmonton, AB, to Chilliwack, BC, and performed recoveries across BC. The most important recovery we conducted during that time was an MSVS trailer, transporting a sea container, which rolled over 40 km west of Valemount, BC. We were more than 400 km away from the casualty when the Repair Recovery Request reached the FSG Operation Cell. Since it was such a long drive to our casualty, I started to plan the recovery and concurrent activities on the move. Thanks to our equipment, experience, and training, the casualty was extricated with only slight superficial damage. This reflected positively on our unit, The Corps of RCEME, and the CAF."


MSVS SMP

In addition, throughout BC, the local volunteers added to the success of relief efforts. For example, on the Valemount rollover, volunteers assisted with the control of traffic, thereby granting our RCEME technician the freedom of movement to conduct the recovery quickly and safely.

The recovery equipment that 1 Svc Bn holds is currently capable of supporting all vehicle platforms within 1 Canadian Mechanized Brigade Group (1 CMBG). Our technicians work relentlessly to maintain our assets in order to ensure all-hours availability. Was 1 Svc Bn's equipment up to the challenge of supporting our ground force during Op LENTUS 21-06? Even though our equipment is growing old and in need of TLC, our recovery assets and highly trained technicians excelled at the task of providing assistance to fellow Canadians in their time of need.

The Corps of RCEME should be proud of the limitless ingenuity and professionalism of our technicians.

Lt Hamilton is the Platoon Commander of A Veh Repair Pl, Maint Coy, 1 Service Battalion, 1 CMBG, 3 Cdn Div.

Capt Tremblay is the Maintenance Officer of 3rd Battalion, Princess Patricia's Canadian Light Infantry, 1 CMBG, 3 Cdn Div.

3. Government of Canada, "Medium support vehicle system project," 09 August 2021. [Online]. Available: https://www.canada.ca/en/department-national-defence/services/procurement/medium-support-vehicle-system-project.html.

The **Reliability, Availability, Maintainability, and Durability** testing of the Armoured Combat Support Vehicle

By Maj Sebastien Massicotte

The three-and-a-half month Armoured Combat Support Vehicle (ACSV) Reliability, Availability, Maintainability, and Durability (RAMD) Preliminary Reliability Test (PRT) got underway February 28 of this year at CFB Shilo.

The first RAMD Phase (of at least three) is supported by 2 Princess Patricia's Canadian Light Infantry (2 PPCLI) with a crew of drivers, crew commanders, and other test participants. The three test vehicles are set to complete a 16,200 km test, or 36 Battlefield Days (BFD) worth of operations during the accelerated test, and two vehicles will undergo various maintenance procedures that require validation.

The test will provide sufficient data to validate the ACSV-unique systems on the Troop/Cargo Vehicle (TCV) and the Ambulance (AMB) variants prior to their fielding to the Canadian Army in 2022/2023.

The ACSV Project: An Overview

The project will deliver an armoured combat support capability to provide Command Support, Combat Support, and Combat Service Support to forward elements of a Brigade Group. The ACSV project was identified to replace the aging Light Armoured Vehicle II (LAV II) Bison and M113 Tracked Light Armoured Vehicle (TLAV) fleets. A non-competitive acquisition contract and an in-service support contract were awarded following direct engagement with General Dynamics Land Systems – Canada (GDLS-C), the Original Equipment Manufacturer of the Light Armoured Vehicle (LAV) 6.0.

The ACSV will be delivered in eight variants for a total of 360 vehicles:

- Troop/Cargo Vehicle (TCV);
- Ambulance (AMB);
- Command Post (CP);
- Engineer vehicle (ENGR);
- Electronic Warfare (EW);
- Mobile Repair Team (MRT);
- Maintenance and Recovery Vehicle (MRV); and
- Fitter/Cargo Vehicle (FCV).

RAMD Testing: What is it?

The RAMD test is conducted as a Department of National Defence (DND)-directed activity, typically in partnership with the prime contractor. RAMD testing is an important opportunity for stakeholders to collect reliability information on the ACSV under test usage and environmental conditions. This information will enable the Project Management Office (PMO) to validate the selected Chassis, Remote Weapon System (RWS), and variant-specific System Requirement Specifications (SRS) for the ACSV.

The test results will also lead to the early identification of issues that will require closer supervision by the Equipment Management Team (EMT) and provide data for future determination of maintenance requirements. Furthermore, this testing will be used to validate training, interchangeability of parts, Special Tools and Test Equipment (STTE), and some Technical Publications (TPs).

MWO Ménard (centre rear) showing the vehicle crews data acquired by QETE during a vehicle failure.

The RAMD tests are currently scheduled in three phases, following the production and delivery schedules of the prime contractor. The first phase had a February 28 to May 25, 2022 time frame. The second stage is scheduled to take place in 2023 and the final phase, which is split into two blocks, is planned for 2024/2025. To complete the RAMD testing, a minimum of 14 vehicles (across all variants) will undergo testing.

RAMD Test Methodology

The Tactical Mission Profile for the ACSV is used as the basis for the RAMD testing and consists of individualized Battlefield Days (BFD) – describing the activities that must take place in a 24-hour period. A typical RAMD BFD is comprised of driving and silent watch (SW) shifts. The test's focus is to accumulate mileage and test the appropriate systems during SW. As such, the main parameter of the ACSV RAMD is the BFD, specifically the kilometres driven that are used to calculate the reliability of the vehicles, and then used to calculate the operational time (OT) of the vehicle. During each shift, the ACSV crews will fill a shift log that records all pertinent information (kilometres driven, engine hours, consumables used during driving inspections and so on).

R **Reliability:** Probability that the vehicle can successfully complete a BFD.

A **Availability:** Probability that the vehicle is committable at the start of a mission or at some random point in time.

M **Maintainability:** Ease at which the vehicle can be maintained (Corrective and preventive maintenance).

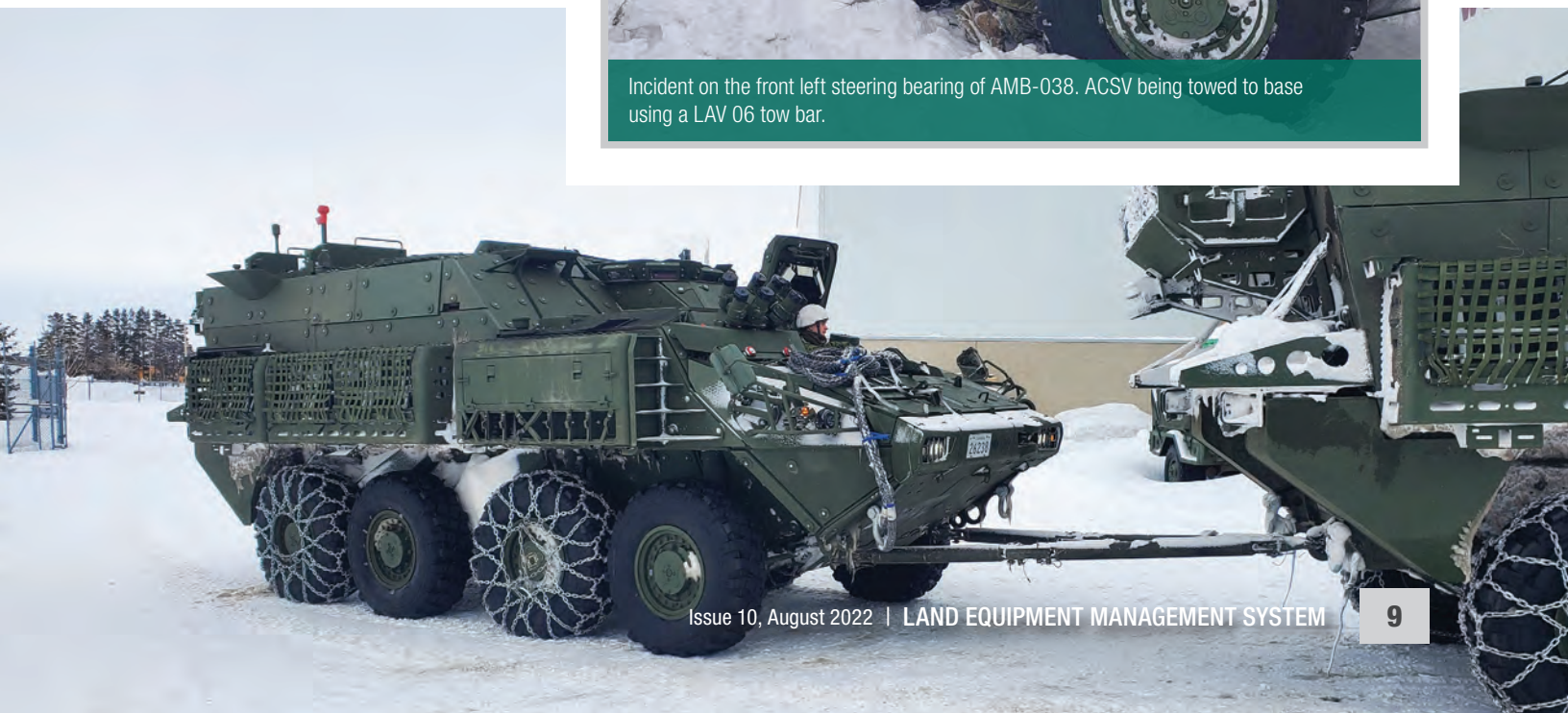
D **Durability:** Probability that the vehicle does not have a durability failure up to its overhaul point.

Addressing Failures

When an incident occurs – anything from a blown tire to an electrical fault – it is recorded on a Test Incident Report (TIR) that is then inputted into the RAMD Data Entry System (RDES).

An investigation follows to determine the root cause of the incident and the Quality Engineering Test Establishment (QETE) and GDLS-C Field Service Representatives (FSR) on-site teams can provide support during the

Incident on the front left steering bearing of AMB-038. ACSV being towed to base using a LAV 06 tow bar.



investigation process. The incident is then fixed in situ by the RAMD mechanics so the test can continue (e.g. repair blown tire). The repair time is carefully recorded on the TIR.

Each TIR is then scored in accordance with the Chargeability Categories (CC) found in the Failure Definition and Scoring Criteria (FDSC) of the contract. TIR scoring is a process completed during the RAMD Scoring Conference, and it is at this time that the PMO will review the investigation results and determine whether the incident is a failure, and then score it accordingly to the right CC. It is also during that time that the PMO may request the prime contractor to conduct a Failure Analysis on components.

A design failure may lead to a re-design of a component by the prime contractor. The PMO may also decide to request an Engineering Change Proposal for non-failure items, such as Human Factor Engineering incidents.

Incident on the CTIS and brake lines on station R3 and L3 due to accumulation of ice and snow within the strut guard.

RAMD Metrics Calculations

Each action during RAMD testing is recorded in RDES, from the crew's Driver Inspection (DI) time to the time it takes to fix a failed component. These times are recorded on the respective SLs and TIRs and are used to calculate the RAMD metrics. Depending on the failure modes, the time it took to repair the failure will be used in the calculation of different metrics. For example, the Operational Availability, Ao, is calculated using:

$$Ao = (OT+ST)/(OT+ST+TPM+TCM+ALDT)$$

Where:

- OT is the Operational Time of the vehicle
- ST is the Stand-by Time of the vehicle, a function of OT
- TPM is the Total Preventive Maintenance time of all TIRs scored as such
- TCM is the Total Corrective Maintenance time of all TIRs scored as such
- ALDT is the Administrative and Logistic Delay Time, a factor of TPM and TCM
- RDES has the ability to calculate the RAMD metrics once the TIR are scored, and it is those RAMD metrics that need to be met in order to have the RAMD test successful.

Similar calculations of other relevant metrics can be made using the data gathered during the test.

Conclusion

The ACSV is a unique acquisition project that progressed from Options Analysis to vehicles under test in a three-year period. This fast-paced project is definitely a good challenge to those wishing to work in a challenging environment and learn more about reliability engineering. Given that the remaining ACSV variants are increasingly complex, the next RAMD phases will be even more interesting.

Maj Massicotte is the RAMD Test Director at the PMO ACSV, DGMPD(A&L), ADM(Mat).

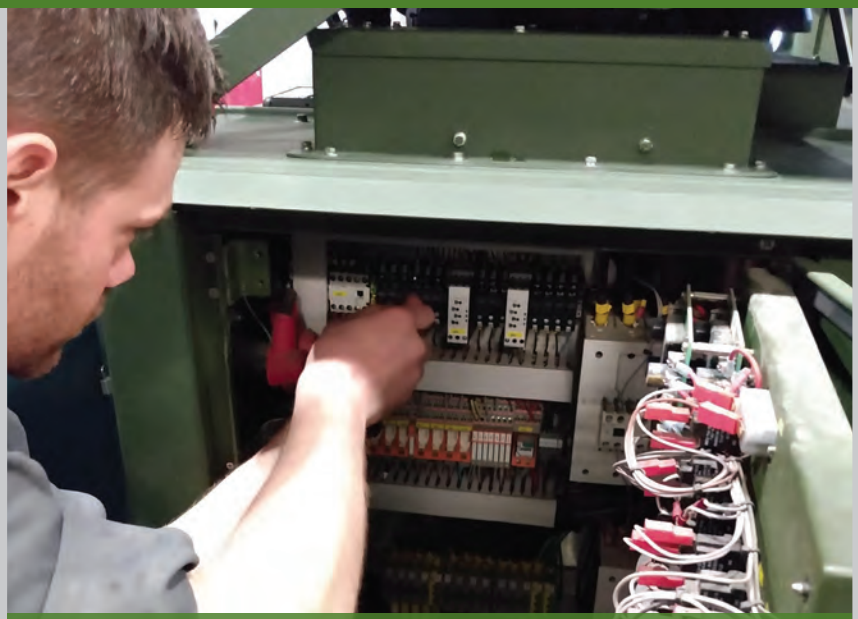
Medium Range Radar:
Only one Canadian unit has the air sensor capability this equipment provides

By Sgt Louis Dumont

4th Artillery Regiment, General Support, (4 Regt [GS]), Royal Canadian Artillery is the only unit in Canada to possess the Medium Range Radar (MRR) manufactured by Rheinmetall Inc.

The MRR is part of the Ground-Based Air Defence project and the objective is to provide ground forces with an air sensor capability. It can detect the sources of indirect fire, such as mortar, rocket, and artillery, and calculate the point of impact while providing air identification of hostile and friendly aircraft. The radar can be deployed in any condition ranging from -40 to +60 degrees Celsius, being heated and cooled automatically when the Liquid Refrigerant Cooling Unit detects an offset of five degrees Celsius.

Mounted on a trailer and towed, the surveillance system has been designed to be used in conjunction with the Medium Support Vehicle System (MSVS) Standard Military Pattern (SMP). The system has been engineered to increase its crew's ability to survive by enabling rapid deployment of under 20 minutes, thus avoiding being an easy target for the enemy. The radar is powered by a 65kW generator that is installed on the MSVS Load Handling System (LHS).



Cpl C.F. Douma, EO Tech, 4 Regt (GS) works on power controllers on MRR generator at 4 Regt (GS) Maintenance workshop on 14 Apr 2022.

Maintainer point of view

The contract process being used by the Canadian Army (CA) in the procurement of this equipment has a direct bearing on the effectiveness and sustainability of the maintenance capability. The technicians are aware of the shortcomings in the supply chain and work toward effective and sustainable solutions.

The MRR components are first-line only and the technicians have a direct line of communication with Rheinmetall Canada for any component repairs or spare parts. Constraints within the supply chain for parts can sometimes affect the maintenance of the capability, as many Rheinmetall suppliers are located in Europe and Israel.

However, the Maintenance Troop made some inquiries and were able to contact some suppliers across Canada and start a dialogue to increase the sustainability of the MRR. A good example is the procurement of a Central Processing Unit (CPU) battery produced in the United States (US) instead of

Cpl D.S.S. Sleeper, EO Tech, 4 Regt (GS), completes repairs on liquid refrigerated cooling unit (LRCU).

Cpl C.F. Douma, close the electrical access panel on the MRR generator while MCpl N. Courteau, Veh Tech, 4 Regt (GS) completes coolant system purge.

purchasing new CPU from Israel once the battery died. Also the technicians proposed to build a specific in-house battery charger to extend the life of the batteries, thus reducing the number of required spares as well as costs.

The MRR is also a platform that integrates multiple systems and requires the collaboration between all the Land Equipment Management System (LEMS) trades. Inspections must be carried out simultaneously by Vehicle Technicians, Electronic-Optronic (EO) Technicians, and Signals Technicians in order to keep the equipment serviceable at all times.

The MRR incorporates many different components that require a large variety of skills and knowledge on specialized subjects, including fibre optics, cooling units, refrigeration, hydraulic systems, high power distribution, computer software, and hardware.

Thus, technicians need to be more adaptive and ready to expand their fields of expertise. The high level of technology requires the technicians to step up their knowledge and ability by getting supplementary training on radar as well as unique specialty qualifications (USQ) and by doing "self-learning" on the system.

Recognition

The MRR has been deployed many times within the US in joint operations with the North American Aerospace Defense Command (NORAD) in the context of providing surveillance and testing the stealth capabilities of US fighter jets.

The radar earned a reputation as a very good observation system with surprising abilities. Recently, the Hungarian Army approached the Canadian Armed Forces (CAF) to have a closer look at our equipment and expressed great interest in the maintenance organization's innovative approach and comments.

During cooperative exercises, the Royal Canadian Navy (RCN) and the Royal Canadian Air Force (RCAF) asked 4 Regt (GS) to certify their equipment with the MRR, as only a higher certified radar can certify another of a lower level. The MRRs are currently Identification Friendly or Foe (IFF) MOD 5 certified and most of the equipment in the RCAF does not even have MOD 4 certification, making the radar a valuable tool within the CAF.

What is the challenge coming?

So far, the MRR has never been deployed in an operational theatre. The current focus of the RCEME and Sigs personnel is to enhance the MRR by implementing better operator maintenance, developing deep system knowledge, and building up a spare parts reserve.

Many modifications have been completed to the system to reduce breakage and to improve reliability, but more challenges are to yet to come. The technicians are ready for the challenges and innovations that are brought on by this equipment. When new technical problems arise, 4 Regt (GS) Maintenance and Signalers will answer the call.

Sgt Dumont is an EO Tech with 4 Regt (GS) 6 CCSB, 5 Cdn Div CFB Gagetown.

The Light Armoured Vehicle Reconnaissance Surveillance System provides cutting-edge technology

By Capt Caroline Ly

The Light Armoured Vehicle Reconnaissance Surveillance System (LRSS) – also known as LAV 6.0 RECCE – is a state-of-the-art LAV 6.0 variant which provides target acquisition, detection, recognition, and identification far beyond the Canadian Army's (CA) current reconnaissance capability.

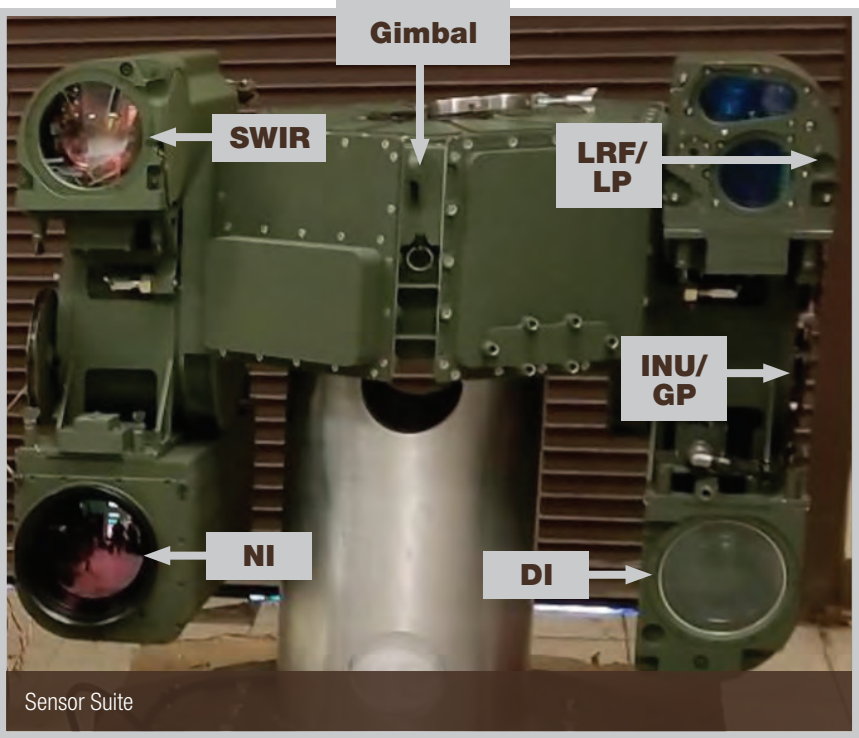
Two main subsystems distinguish the LRSS from the regular LAV 6.0: The Surveillance System (SS) and the Silent Watch Battery Pack (SWBP). The SS comprises the surveillance suite, which in turn is composed of the Sensor Suite and the radar, the Operator Control System (OCS) and other peripheral components.

Sensor Suite

The sensor suite, the heart of the reconnaissance capability, is mounted on a mast that can extend to 10 metres for static employment and three to five metres for on-the-move operations.

The surveillance data is acquired via the sensor suite consisting of five cutting-edge electro-optical components mounted on a 360-degree gimbal. The main functions of the sensor components are:

- **Day Imager Pod (DI-Day camera):** Provides colour video output. It has automatic and manual gain and focus control and has continuous and discrete optical zoom;
- **Night Imager Pod (NI-Thermal camera):** Provides black and white video output. It operates in the mid-wave infrared region and is capable of recovery after saturation in less than 67 milliseconds (ms) and of non-uniformity correction in less than five seconds;
- **Shortwave Infrared (SWIR) camera:** Operates in the near- and short-wave infrared region and can see through smoke, glass, and rain with high clarity by employing imager video blending. It provides high quality video imagery of the scene;



Sensor Suite

- **Laser Range Finder (LRF) combined with Laser Pointer (LP) pod:** Operates at 830 nanometre (nm) wavelength, class 1/1M eye-safe laser, capable of firing one hour continuously. The LP can point to selected targets with a range of six-kilometre minimum and the LRF/LP provides the operator with an accurate aiming point to lase a Target Silhouette 5; and
- **Inertial Navigation Unit (INU) with GPS integration:** Supports acquisition of distant target locations and produces self-location within one metre.

Radar

Integrated above the sensor suite is the MSTAR V6E radar that is capable of simultaneously detecting and tracking multiple targets. It has a 90 percent probability of detection for personnel at 12 km and small vehicles at 24 km. The Surveillance Suite can be tripod-mounted and operated remotely with 200 metres of fibre optic cable.

The SS is maneuvered through the OCS, which consists of a Primary Mission Management Unit (PMMU) with two high-definition (HD) displays and a Primary Hand Controller enhancing the maneuverability. The Secondary Mission Management Unit (SMMU), a ruggedized notebook, supports remote operation and is equipped with a Secondary Hand Controller.

MSTAR V6E

Silent Watch Battery Pack

The SWBP provides silent watch capability for up to eight hours and serves as a secondary function to start the LAV engine. This lithium-ion battery has 1600 amp-hours of capacity and 8000 recharge cycles. Operating the SS without starting the LAV's engine enables the crew to minimize their thermal and noise signature. The SWBP is designed to fit in the pre-existing LAV 6.0 winch pocket.

Additional information about the platform

The groundbreaking LAV 6.0 platform provides mobility, protection, firepower, and carrying capacity to enable the crew to fight and survive while conducting reconnaissance and surveillance operations.

Replacing the Elite II LRF (low resolution file), the TDS-LRF has the improved capability of Detection, Recognition and Identification (DRI). This innovative LRF has an upgrade day camera digital zoom and an eyepiece heater that will automatically shut off at above 20°C. It allows gunners to discriminate against targets that are causing interference with ranging through the Range Gate function – meaning it "ignores" the interference to be able to distinguish a target from obstacles in front of it. It also provides the capability for the LAV 6.0 Fire Control System to automatically update the ballistic solution just by changing the laser return selection switch, with no need to clear the solution and re-lay.

The LRSS is also enhanced with the Land Command Support System (LCSS), which consists of a Control and Communication system and a Beyond Line of Sight Digital System. This enables the crew to plan and manage the tactical battle. The integration of CP TOPAZ computer hardware and tactical

TDS-LRF

battlefield software improves operational and combat effectiveness by digitizing the lower tactical echelons, specifically the LCSS mobile domain.

The Add-On Armour for the vehicle platform protects the crew, vehicle, and equipment. It is enhanced by the ballistic blanket and the Exposed Crew Protection Kit (ECPK) around the turret and in the rear sentry hatch.

With the first LRSS being delivered gradually starting in the fall of 2022, the fleet of a total of 66 vehicles will be fielded to Armoured Corps units with Initial Operational Capability in March 2023 and Full Operational Capability in March 2024. The LRSS will also be issued to Royal Canadian Electrical and Mechanical Engineers (RCEME) and Royal Canadian Armoured Corps (RCAC) schools for training and to the Army Equipment Fielding Centre for operational stock.

Conclusion

The LRSS will provide the CAF with unique cutting-edge technology to conduct reconnaissance operations, upgrading the current identification and surveillance capabilities and capitalizing on advanced technologies to ensure interoperability with other LAV platforms.

Capt Ly, RCEME Officer, is currently working on the LRSS Project as Deputy Integrated Logistics Support Manager (ILSM) at Director Armoured Vehicles Program Management (DAVPM), Assistant Deputy Minister (Materiel).

The 202 WD: **Always prepared to go above and beyond**

By MCpl Yan St-Pierre and Lt Kiho Lee

The 202 Workshop Depot (202 WD) in Montreal provides agility to the Canadian Army (CA) and the Director General Land Equipment Program Management (DGLEPM) with an experienced and dynamic workforce – quickly reassigning technicians to high-priority tasks to meet clients' needs.

Recently, 202 WD lent support to the Army Equipment Fielding Centre (AEFC) during a critical Army task. Because the AEFC had to complete a large number of assignments in a short time frame, some of them were taken over by 202 WD.

The Depot's experience and expertise in multi-task planning and management enabled the successful completion of several projects simultaneously, including adding armour and installing armoured cabs within the allotted time. This could not have been achieved without the logistical support of the AEFC's operations and the personnel from the 25th Canadian Forces Supply Depot (CFSD).

The first task involved adding armour panels to four Tactical Armoured Patrol Vehicles (TAPV) within a month. Despite the many discrepancies vis-a-vis the manufacturer's installation procedures, the seasoned technicians came up with innovative fixes that were then submitted to the manufacturer for future use.

While the first task was still underway, 202 WD was asked to add armour to five Light Armoured Vehicles (LAV) 6.0s. Although the team of civilian and military personnel ran into obstacles – including modifying the armour plates and repositioning the hold-down nuts on the vehicles – they displayed extraordinary cooperation and fellowship through it all.

During the project, an extra four TAPVs and a LAV 6.0 were added. 202 WD was able to quickly schedule and prioritize this second task to complete it within the expected time frame. Thanks to excellent personnel management and the technicians' hard work, the depot met the deadline and outperformed the Defence Resource Management Information System (DRMIS) planning system's projections.

The third challenge was to replace the stock cabs on seven Medium Support Vehicle System (MSVS) Standard Military Pattern (SMP) transport vehicles with armoured cabs. Our experienced technicians were able to advise the three teams created specifically for this major undertaking. The installation and verification of the communication systems added to the workload.

Paul-Siano Bernard, Jonathan Berteau, Cpl Simon Boucher, MCpl Gabriel Frenette, Costa Kapoglis, preparing to add the armour panels. Photos: Jean-François Houle

Through sustained efforts during overtime, in addition to normal working days, the teams of civilian and military technicians were able to finish the vehicles within the time frame requested by the Army. The quality of 202 WD's work met the Army's high standards through close cooperation between their analysts and Life Cycle Material Managers (LCMMs).

The last task requested was to install extra armour on a Bison ambulance and prepare it for shipping to the operations theatre. 202 WD had to add the armour and additional components to ensure that they were complete and functional. To meet weight constraints for vehicle handling aboard the ship, the armour was removed and repacked, except for the inside of the fenders and the belly plate mounting to expedite re-installation in the operational theatre.

In sum, we can state that, despite the heavy workload, the 202 WD personnel were able to rise to the challenge with great success. By working closely together, 202 WD, AEFC, and 25 CFSD were able to meet the Army's needs in the preparation of the many vehicles our Canadian soldiers rely on to meet whatever challenges arise.

Lt Lee is an Assisting Officer for WS Program, CFB Longue-Pointe, 202-WD, ADM (Mat).

Mcpl St-Pierre is a vehicle technician at CFB Longue-Pointe, 202-WD, ADM (Mat).

Cpl Simon Boucher stripping the interior of a LAV 6.0 to add ballistic blankets.

Mélanie Winiarski and Martin Barré performing the final checks before the fenders are added on.

202 Workshop: The Wolf Project highlighted welding complications and how to overcome them

By Lt Kiho Lee, Cpl Justin Beauvais, and Dominic Martineau

What do the technicians do at 202 Workshop Depot (202 WD) when they encounter an unforeseen problem? What if the solution is not as straightforward as anticipated?

202 WD is capable of supporting all land vehicles and weapons systems within the Canadian Army and, as such, is no stranger to complex tasks. With experienced technicians and a multitude of experts from different fields working together, 202 WD provides innovative solutions to many open-ended technical problems in a cost-effective way. As well, 202 WD has the capacity to utilize advanced technologies to test technical strategies and provide solutions to complex tasks.

202 WD was tasked with performing a complete hull inspection of the Wolf multipurpose armoured vehicle fleet and to repair defects in support of Director Support Vehicles Program Management (DSVPM).

The inspection and repair process had been initially established and supported by the Quality Engineering Test Establishment (QETE). However, during the inspection, the technicians found each vehicle was affected by various degrees of cracking in several different locations. This significantly increased the complexity of the repair process and presented a difficult welding problem. The welding section had to consider the degree and orientation of cracking and adapt to each individual vehicle, implementing a specific repair solution for each problem area.

The cause of the cracking was deemed to be due to many factors such as insufficient stress relief, high humidity, high ambient temperatures, and the composition of the base material. Furthermore, if the cracks were not

Completed Wolf with New Generation Technology.

repaired in time, they could spread – thus weakening the structural integrity of the armour.

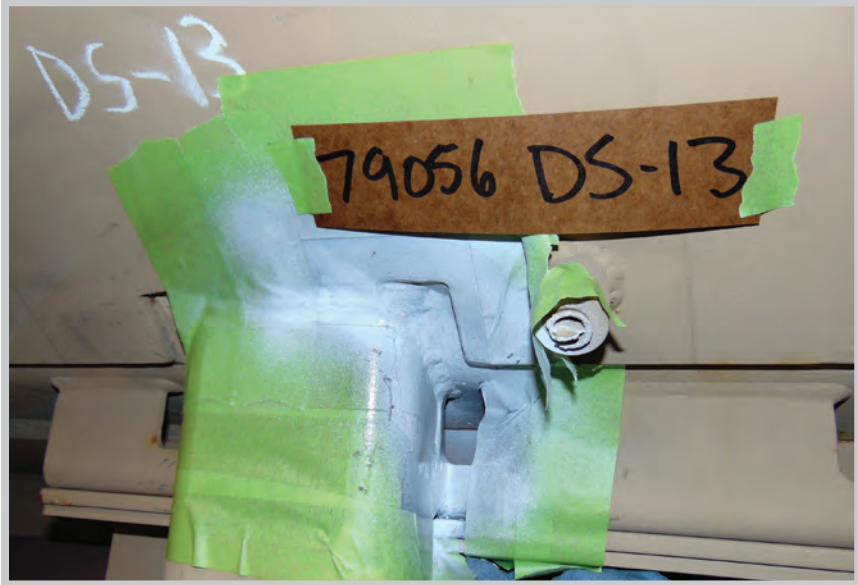
In the heat of the Montreal summer, the welders worked to test several potential solutions:

- Reducing the welds completely;
- Experimenting with different welding materials; and
- Examining the possibility of using different welding methods.

Problem spots were rewelded several times to ensure both durability and functionality. As one technician who was involved heavily in this process stated:

"Getting it to work is one thing but doing it right and documenting the process thoroughly is important to us as well. This will save countless hours for our technicians both in the shop and in the field, so it was worth it."

Add on Armor Panel, Replacement and Inspection.



Despite the time-sensitivity of completing the task, the personnel involved conducted frequent inspections and logged any further issues, trials, and results so that they could be referenced at a later date. The repair process as well as the data generated was closely monitored by the fleet Life Cycle Material Manager (LCMM).

In the past, technicians working on the Leo 2 were able to successfully resolve similar issues by changing the welding material to stainless steel. However, at the end of this long and rigorous process, the decision was made to either replace the armouring as a whole or weld anchor points at the end of the cracks to stop their progression. This ensured the highest possible quality for the end product.

Through collaboration with QETE and DSVPM, 202 WD members proved their ability to tackle a complex welding task and succeeded in finding creative solutions to technical problems. Technical excellence and collaboration between partners is one way The Corps of RCEME excels to keep equipment operationally ready for the Canadian Army.

Lt Lee is an Assisting Officer for WS Program, CFB Longue-Pointe, 202 WD, ADM (Mat).

Cpl Beauvais is a material technician at CFB Longue-Pointe, 202 WD, ADM (Mat).

Dominic Martineau is an analyst at CFB Longue-Pointe, 202 WD, ADM (Mat).

Tactical Armoured Patrol Vehicle Update: Many lessons learned since last LEMS profile

By Capt Nicholas Bourgon

The following is an update to the Tactical Armoured Patrol Vehicle (TAPV) report from LEMS Journal Issue 1 of April 2018. Readers might wish to refer to that piece for anything generic about the TAPV, as this account will focus on lessons learned since 2018 as well as general fleet updates. This article will cover the following topics:

- Deployment of TAPV on Operation REASSURANCE;
- Field Retrofit Updates;
- Aberdeen Test Center Stability Testing; and
- Lessons Learned on TAPV Performance Metrics.

Deployment for Op REASSURANCE

The TAPV fleet was selected to replace the Coyotes on Operation REASSURANCE as part of the NATO enhanced Forward Presence (eFP) Battle Group in Latvia. As of May 2022, 10 TAPVs were being deployed to Latvia to support this operation along with one Ready Pack (RP). The topic of a deployed supply chain capability could potentially be revisited in a future LEMS Journal once the Equipment Management Team (EMT) has some data on how the supply system is working to support these deployed vehicles.

Field Retrofits

The TAPV fleet has undergone two major modifications since 2018, which are classified as Field Retrofit 001 and Field Retrofit 002. Field Retrofit 001 began in March 2019 and was concluded in December 2019. The following engineering change proposals (ECPs) were integrated into the fleet through this retrofit:

- HD software/firmware;
- EKEEL software;
- ABS module;
- Hatch bolt replacement;
- Tie-down addition W/Washer;
- Side door bracket inspection/modification; and
- Quick release pin replacement.

Field Retrofit 002 began in January 2022 and is scheduled to finish in August 2023. The following ECPs are being integrated into the fleet through this retrofit:

- Replace steering arm bolts;
- Drill a drain hole in the arctic heater exhaust pipe;
- Oversize hull mounting holes and inspect/grind welds on the vehicles that will not have a Vehicle Interface Panel (VIP) installed by DND;

- Oversize cover mounting holes and add washers;
- Replace front hatch's handle mounting bolts for AoA install;
- Replace bolt on steering coupling from a one inch to a ¾ inch length;
- Update TIS Software as per SUP-014; and
- Make a modification to install Vanner enclosure on the remaining 300 vehicles.

Stability Testing at the Aberdeen Test Center

It was decided in 2018 following several TAPV rollovers that further stability testing should be conducted to better understand the vehicle dynamics in order to try to find a solution to reduce rollovers. Three TAPVs were sent to the ATC in Maryland in the fall of 2019 to begin testing. The first round of testing was completed in December 2021 and another round of testing is scheduled to occur in the spring/summer of 2023, after which the TAPVs will return to Canada.

Performance-Based Accountability (PBA) Metrics and Lessons Learned

DND has learned some hard lessons about performance metrics during our experience with the TAPV fleet. These include:

- Basing performance metrics off of fleet usage is fraught with risk that is heavily balanced against the contractor;
- Reconciling performance metrics must be based on thorough and transparent work orders and failure data that is shared early in the life of a work order; and
- The quality of the data that feeds the performance metrics is of paramount importance.

These lessons come from the following observations:

- DND has only put a fraction of the usage on the TAPV fleet that was anticipated at the time of contract award. Usage is a key factor in four of our nine performance metrics and, in some cases, it has shown to be mathematically impossible to meet the metrics based on our low usage. Although 2020 and the pandemic are the most obvious example of low usage of the fleet, the reality is that the Canadian Army has never put the usage in that was anticipated at contract award.
- Our performance framework is only intended to hold the contractor responsible for predictable, usage-driven component failures that occur when the TAPV is operated within the parameters that we specified in the contract. We call these inherent failures. However, the reality is that a large portion of our failures have come from usage beyond those parameters, from operation not in accordance with the Operator Instruction Manual, and from maintenance not in strict accordance with the accepted maintenance plan. We refer to these as non-inherent failures (DND-caused failures).
- Our work order data, which the contractor uses to challenge the cause of failures, has not been shared with the contractor until after the work orders were closed in the Defence Resource Management Information System (DRMIS). Understandably, there are many cases where a work order might not be closed for months. And when it finally is, the event that caused the failure was so far in the past that it is challenging to confirm the cause. The reconciliation effort would be much more efficient if failure modes were identified up front when work orders are opened and diagnoses are performed. However, that is not generally the way of things. We have not developed a culture and an obligation to provide complete and transparent failure mode data in our work orders.
- In a large number of cases, technicians are not associating corrective maintenance work orders with the preventive maintenance inspections that identified the failures. This makes performance reconciliation more burdensome. And similarly, a large number of technicians are not associating corrective maintenance work with the approved TAPV Maintenance Task List items that cover the repair. This deprives DND of measures of the maintenance burden of the TAPV fleet.

Capt Bourgon is a RCEME Officer and the TAPV EMT Coordinator at DAVPM, within DGLEPM.

Fuel Cell Technology: Working toward a solution to the climate change crisis

By Maj Scott Ormsby

Whether it is the 'Greening Defence' initiative under Canada's defence policy *Strong, Secure, Engaged,* or other governmental policies aimed at addressing the climate crisis, there are many factors that are nudging the Department of National Defence (DND) toward more environmentally sustainable operations. Organizations such as ADM(Mat) and The Corps of RCEME are striving to innovate and adapt evolving technology – and one area that should be considered is fuel cell technology.

Fuel cell electric powertrains are an advantageous green solution for armoured vehicles for a number of reasons:

First, as compared to battery-only powered vehicles, they perform better at higher weights and payloads, comparable to the performance of a combustion engine in terms of fuel efficiency. While both fuel cell stacks and batteries create electric energy to feed into the vehicle powertrain, the key difference is that fuel cell stacks use hydrogen as fuel, passing the hydrogen through a proton exchange membrane (PEM) that results in a chemical reaction creating electric energy as output with water as a by-product. Batteries rely on their initial state of charge (SOC) to provide energy, in addition to whatever may be regained through regenerative braking. Where PEM fuel cells can use more fuel as needed during increased energy demand – similar to that of a combustion engine – batteries have to expend more capacity to meet increased energy demand. Not only do batteries have to work harder to match a fuel cell stack in energy conversion at more intense performance, but increased charging and discharging of energy for the battery outside of its designed depth of discharge and target SOC reduce its overall lifespan, making battery-only vehicles more expensive to maintain as a fleet as the battery packs get replaced more frequently.

Second, off-roading across dynamic terrain provides a benefit to the fuel cell vehicle in the form of energy recovery through regenerative braking down slopes and during stop-and-go driving – which helps extend the vehicle's operational range in a way that a conventional combustion engine doesn't. When using a parallel powertrain architecture with the fuel converter (fuel cell stacks) and energy storage system (ultracapacitors, potentially combined with a battery system in a hybrid energy storage setting) both can be used to simultaneously provide power to the vehicle when needed, improving vehicle performance when situations require a large power draw on short notice.

Third, as mentioned previously, fuel cell electric powertrains only produce water as a by-product of their usage and, as such, result in zero greenhouse gas emissions from pump-to-wheel. In addition to the environmental benefit, they operate at reduced noise and thermal profiles when compared to a combustion engine, providing some passive tactical benefits for the vehicle platform.

Fourth, fuel cell powertrains work well with ultracapacitors (UCs) as energy storage systems, which would provide many advantages. For instance, ultracapacitors allow for rapid energy storage and discharge when needed such as for acceleration, and also operate at wider temperature ranges than batteries. UCs function at temperatures ranging from -40 to +65 whereas batteries require thermal management systems to prevent capacity loss. UCs thereby more readily enable vehicles to perform missions in a variety of environments ranging from arctic to desert, and everything in between. When used with a standard mission profile for a vehicle fleet, vehicle controller logic can be used to efficiently govern powertrain energy management to extend vehicle operational range and help reduce the wear and tear from powertrain degradation. Combustion engine battery hybrids were not considered as a comparative solution in this article, as they still rely on gasoline/diesel, and still produce greenhouse gas emissions from pump-to-wheel.

Fuel cell electric vehicles are not a thing of the future – they are already being used in the civilian sector with platforms such as heavy duty mining trucks. Such fuel cell electric mining trucks weigh comparably to or even more than some of the Canadian Armed Forces' (CAF) armoured vehicle fleets and are used successfully in driving conditions that can be similar to the activities of military armoured vehicles – namely being driven off-road

on undulating terrain and using dynamic load profiles. Thus, it is not out of reach to consider the possibility of designing and implementing the use of a fuel cell electric military armoured vehicle fleet.

Like any new technology, there are many obstacles to overcome and many opportunities for finding feasible solutions. For instance, while combustion engine vehicles using gasoline and diesel fuel are susceptible to combustion and explosion, fuel cell vehicles have a similar risk. Designing a future fuel cell electric vehicle would require powertrain protection to be taken into account for its survivability.

Logistics and supply chain management would also need to change, moving from 'the way things have always been' with gasoline, diesel, and jerry cans to something newer in the way of resupply mechanisms. This being said, if humans are capable of innovations such as space flight and nuclear power, then they are also capable of providing logistics and survivability solutions to an already existing technology that has been proven to work. It is better to proactively explore and lean into the future than it is to be dragged into it, only to be behind everybody else on the technology curve.

For those interested in the topic of fuel cell electric military armoured vehicles and their feasibility, the author has written his MASc thesis on the subject matter and may be reached at scott.ormsby@forces.gc.ca should the reader want a PDF copy to read beyond this article.

Maj Ormsby is the Deputy Project Manager at LAV SVE, DAVPM, DGLEPM, ADM(Mat).

FORWARD THINKING

A new challenge on the horizon: **Quantum Machine Learning**

By Capt Boniface Yogendran

The Department of National Defence (DND) and the Canadian Armed Forces (CAF) are heavily investing in digital transformation. It has been proven that this initiative can greatly help the organization improve its productivity. However, the transformation is complex and comes with tons of challenges.

Some industries have managed to successfully transform and are preparing themselves for the next challenge. In December 2021, Zapata Computing commissioned a survey of 300 leaders at large global enterprises. One of the key findings of the survey is that 69 percent of the enterprises across the globe are preparing for quantum transformation. Unlike digital transformation, quantum transformation is not a "lift and shift". We need to be prepared to handle this challenge in future.

We can still use a 20-year-old computer to do some of our work. The output will not be efficient, but it can get done with some struggle. The main problem is that the underlying physics behind the computation haven't changed for nearly four decades. However, a person in the year 1990 would find it impossible to work with a 1970s system where the computers in that era were electromechanical and used punch cards. The underlying physics behind punch cards and digital system are completely different.

By the 1990s, electromechanical systems became obsolete and almost all businesses started using digital computers. What was the driving force behind this change? Digital computers proved that they are inexpensive and computationally efficient compared to an electromechanical computer. Since the business world wanted a better return on investment, digital computers became the norm. Now, quantum computers (QC) are displaying so many advantages over digital computers that

Capt Yogendran at MIT's quantum computer lab.

most industries are leaning that way. It is highly unlikely that QC will completely replace modern computers, but they will work alongside them.

One of the primary functions of modern computers is the collection and analysis of data to make better business decisions. A subset of Artificial Intelligence, known as Machine Learning (ML), is one of the well-known methods used by industries to understand the patterns of their processes, suppling recommendations to optimize them. Therefore, ML is considered one of the crucial technologies for today's business. That said, growth in data volume introduced certain levels of complexity in ML algorithms and data mining techniques. Since even the fastest supercomputers cannot tackle some of these complex problems, a field of research has come into play to revolutionize information processing.

The complexity in information processing comes from the way the systems store and access the information. Modern computers use classical mechanics to handle information and they are known as classical computers. The properties of classical mechanics constrain the system to store information in a bit that holds a value of 1 or 0, while quantum mechanics allows the system to store information in a qubit that holds a value of 1,0 or any value in between. The latter property is known as superposition that allows a qubit to store more information in comparison to a bit. For example, a classical system would require 1024 bits to store 10 qubits worth of information.

Computers built using quantum mechanics are known as quantum computers (QC) and they are now available on the market. These systems can solve complex problems with a significant speed when compared to a classical system. A quantum supremacy experiment by Google in 2019 showed that a QC can solve a problem that was considered impossible with a classical system. However, this experiment was not tied to any business problem. Recently, a Toronto-based company, Xanadu Quantum Technologies, proved that its QC was able to solve a problem in under 36 microseconds – a task that would take the fastest super computer about 9,000 years.

The QCs available today deliver no business value but hold the promise of a competitive advantage in the future – a trend similar to almost all technical revolutions. For example, even though the internet was introduced in the 1960s, it did not go mainstream until graphics integrated internet browsers were introduced in the 1990s.

Usage of data to make decisions is an integral part of LEMS business, with DND/CAF investments being made toward digital transformation. Within the LEMS community, we have started working to modernize digital tools like the Defence Resource Management Information System (DRMIS) to store and access data – and such investments will increase the volume of data. The primary goal of digital transformation is to use data to make evidence-based business decisions. Handling large volumes of data is labor intensive, and so ML techniques will be needed. As mentioned earlier, some problems or algorithms are complex or impossible given the current system.

The ML system used by QC, known as Quantum Machine Learning (QML), is expected to handle these challenges more effectively. QML is a subset of QC, just as ML is a subset of computer science. It is anticipated that QML will have a similar impact on business just as ML changed things 10 years ago. Therefore, it is safe to assume that QML will have the highest impact on the LEMS community.

The overall investment for QC and quantum-related technologies has significantly increased over the years (Figure 2). This resulted in an increased amount of research output

Zapata's Race Analytics Command Center providing data analytics service to Andretti Autosport racing team.

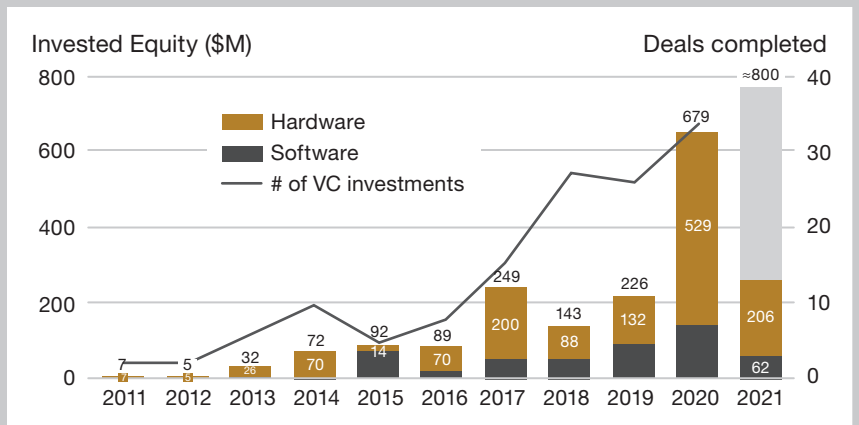


Figure 2. Venture Capital investments and deals in QC over the years. Businesses are seeing value in QC the way they saw value in AI and ML 10 years ago.

Source: Boston Consulting Group analysis of Pitchbook

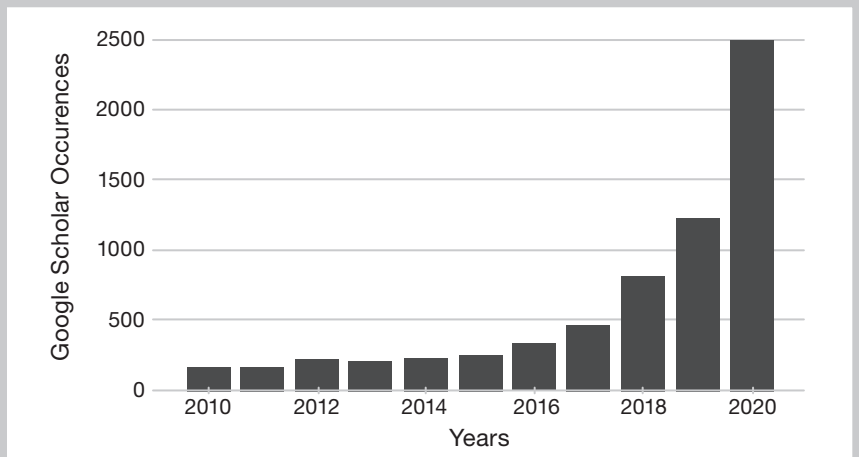


Figure 3. Quantum Machine Learning research trend gathered from Google Scholar. The number of research output is growing significantly. Source: Google Scholar

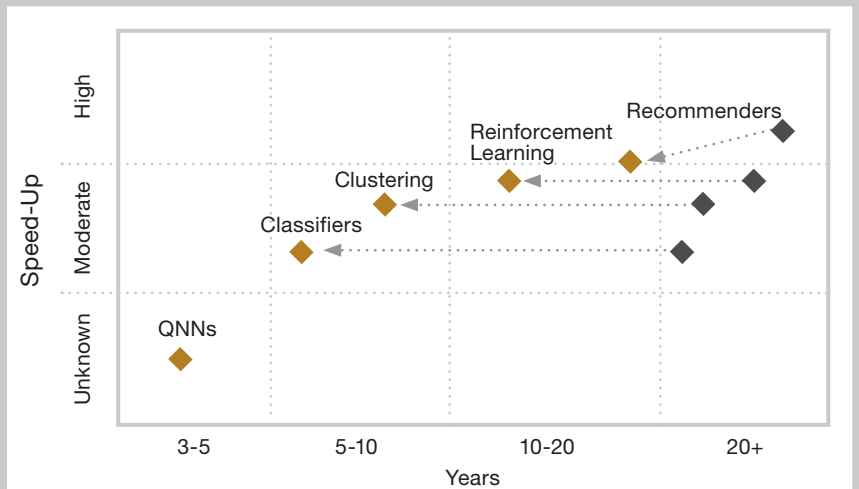


Figure 4. Quantum machine learning progress and expectation. Some algorithms that were expected to be ready in 20+ years are now within the realm of 5-10 years.

Source: Forge Webinar Q4 2020: Prospects and Challenges of Quantum Finance

related to QML (Figure 3), shortening the timeline of possibility of running certain ML algorithms on QC (Figure 4). As shown in Figure 4, some algorithms that were considered possible in the next 20+ years are now possible in the next five to 10 years.

Due to the nature of this rapid growth, most industries such as finance, information technology and the automotive sector started to position themselves to innovate and adapt this technology. Among automotive industries, companies like Porsche, BMW, Volkswagen, and Ford have begun to work on some of the QML-related challenges such as job scheduling and supply chain optimization. BMW launched a Quantum Challenge program in the year 2021 to encourage research relevant to their business requirements for the future. Just recently, Zapata Computing signed a partnership agreement with Andretti Autosport to leverage quantum algorithms to provide race analytics.

Our business challenges are similar to those of the automotive industry. The Enterprise Resource Planning (ERP) system such as Systems Applications and Products in data processing (SAP) was first used in the automotive industry and is being utilized by the LEMS community. Therefore, we can assume that we would see a similar impact with QML.

The future is always unpredictable, but there are some obvious signs that would let us approximate the change. We cannot wait to react until problems arise. We need to be strategic about building capabilities to understand and adapt to changes. Otherwise, our capabilities gap will turn into our weakness. The QC revolution is inevitable. Our only choice is to prepare to take advantage of it.

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