LEMS JOURNAL

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THE THRILL OF WEARING THE MAROON BERET

With the increasing amount of equipment that each individual paratrooper is carrying, there is a real need for technical support on airborne operations. It's important that LEMS maintains an active role in support of these operations to help ensure Canadian Armed Forces overall readiness. The Basic Para Course can be a challenging but very rewarding training opportunity for those looking to contribute in support of airborne operations. In this October 2020 photo (left to right, MCpl Dave Black, MCpl Patrick Thompson, MCpl Dave Campbell, and Sgt Alex Henri are about to perform their refresher jump. Photo by MCpl Dave Black.

Read more about the Basic Para Course on Page 9

Cover Photo: Pte(B) Hunter Lawrence Carr (Electronics Optronic Technician from 1 Service Battalion works on a tEODor robot at 1 Combat Engineer Regiment. To learn more about the evolution of Ground-based Telerobotics, see Page 22.

Photo by Cpl Roberto Granados

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DIRECTOR GENERAL'S COMMENTS

POLICY, PROCEDURE, AND TRAINING

SUPPORT TO OPERATIONS

FUTURE CAPABILITIES

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DIRECTOR GENERAL'S COMMENTS

Not just surviving, but thriving

By BGen Rob Dundon

No matter how I try to express it, anything I write would be an understatement of what we have experienced in the last year. We are still in the throes of what leaders call an exogenous event—something really bad, that leaves us with long-lasting, negative effects. We have just passed a one-year pandemic milestone. In one year, Canada has suffered half as many COVID-related deaths as we did in all of World War II. In twelve months, Canada may have spent over $240B combating COVID. We only spent $100B on all war production in World War II (corrected for inflation—we actually spent $10B in 1945 dollars). These figures point to the magnitude of what is transpiring. The nation has suffered, but many people rose to the occasion. You are going to see in this edition of the *LEMS Journal* that we are one of those groups. We are not just surviving, but thriving.

When international supply chains collapsed, 202 Workshop Depot rose to the occasion and launched an emergency, impromptu production line to fabricate non-medical masks for Canada's forces of last resort. The equipment management team for Deployable Camps led the national inter-agency effort to design, contract and deliver Mobile Respiratory Care Units, scalable 100-bed mobile health units capable of deploying to provide emergency health services to our most remote and isolated communities and hardest hit urban centres. When the national shortage of medical gowns was first realized, the medical system turned to the Quality Engineering Test Establishment as a trusted agency to test expired personal protective equipment from the National Emergency Strategic Stockpile, salvaging stock at the same time as potentially saving users from the risk of infection. These are but three highlights. Other examples abound.

All the while, we have continued to advance the effectiveness of the Land Equipment Management System in a very restrictive environment. Production has persisted. The capital program has not let up. Training has continued. And whoever thought we would see paratroopers jumping in non-medical masks? We are truly a resilient team.

I would be remiss if I did not mention those who continue to think about work and life beyond the pandemic. If anything, COVID-19 has pointed out to us the lack of resilience in our supply chains and the fallibility of globalization. In the coming decades, we will witness the "on-shoring" of North American industrial productive capacity. Additive Manufacturing (AM) will play a significant part in this. Cpl Casement, Cpl Atkinson, Cpl Couture and Lt Menezes recognize AM's importance and show us what progress is taking place in Gagetown, Trenton, and Latvia.

There is a perennial war going on, one we have been fighting for over 10,000 years—the war on bugs. It has shaped civilizations for millennia. This time around, the coronavirus is shaping us personally. The only thing of which I can assure you is that our tomorrows are not going to look like our yesterdays. Thankfully, our own team is showing us what that future can be.

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 summer of 2021. 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 **April 30, 2021**.

Trenton Recovery Training Course Focused on the **Use of RCAF Assets**

By Sgt C.K. Johnson

With the identification of the need for advanced and current recovery training at 8 Wing (Wg) Transport/Electrical and Mechanical Engineering (TEME), CFB Trenton, TEME delivered a course in November 2020 provided through the expertise of a local company called *Wreckmaster*. Training was focused on utilizing current Royal Canadian Air Force (RCAF) recovery assets to fulfill the role expected of all RCEME technicians in the unique environment the RCAF offers. This resulted in the successful training of 10 technicians.

Most equipment used on the area of operations of a Wing is completely foreign to the Army and offers an array of obstacles and logistical hurdles to overcome. This reality poses a serious challenge to any RCEME technician aiming to complete a recovery operation in a timely and safe manner. Since RCEME technicians are often full of very much deserved pride and will never admit defeat, this training offered them an opportunity to shake up some old mindsets while giving everybody valuable training experiences to draw upon when faced with an unknown piece of RCAF equipment that needs to be recovered.

Training consisted of three full days – starting in the classroom for a few hours building on the theory and dusting off the cobwebs on the knowledge we had all learned at the Centre of Excellence at the Royal Canadian Electrical and Mechanical Engineers School (RCEMES). Once the classroom work was completed, the next two days were jam-packed with practical exercises where the instructor ran the course through some well-thought-out and extreme cases of recovery with various equipment such as highway tractors, dump trucks, fork lifts, aircraft loaders, and aircraft mules – all at various stages of breakdown.

Cpl Tom Hollinger (left) and Cpl Dan Davies take part in a two-truck recovery lesson at CFB Trenton. Photo by MCpl S.H. Hughes

There were heavy dump trucks mired in mud that required the use of both recovery assets working in tandem to free the casualty. Using a broken-down, scrapped commercial truck as a casualty, all technicians got the chance to plan and conduct a complex rollover recovery using both recovery assets available to TEME – a flatbed wrecker and traditional five-ton wrecker.

The course ran through a lot of new technology and tooling available in the marketplace and demonstrated the best way to utilize these resources to maximize their pull effect. The knowledge and experience gained by all levels of technicians in attendance was so vast that students elected to present the instructor with a certificate of appreciation for the knowledge they gained and the overall level of passion the instructor had shown for the subject.

Wreckmaster Instructor Jeff Martin (in dark jacket) got top marks for demonstrating how to handle various vehicle recoveries. In this photo, he shows the ropes to (left to right) Cpl Rhys Minto, Cpl Andrew Snow, Cpl James Drever, Cpl Dan Davies, Cpl Soo Kil Kim, Cpl D.J. Gaynor, Cpl Tom Hollinger and Cpl Jon Fair. Photo by MCpl S.H. Hughes

An ongoing search for the best method of providing professional development for the personnel at 8 Wg Trenton, 8 Mission Support Squadron has earmarked this training as a yearly commitment to ensure all RCEME technicians have all the tools and training available for the continued success of recovery capabilities at the Wing. Recovery operations present an ever-changing landscape and, in order for RCEME to remain effective, we will always be looking for opportunities to learn and build on the experience gained throughout our career in this great Corps.

The RCEME Recovery Manual could not make the importance of recovery operations any clearer: "Quick and efficient recovery will deny any possible use by the enemy and assist in getting the equipment back into action with minimum delay"

Sgt Johnson is currently the IC of AMSE maintenance section within TEME, 8 MSS at 8 Wing Trenton.

Wreckmaster Instructor Jeff Martin (left) runs through the drill for a roll over recovery with (left to right) Cpl Jon Fair, Cpl Dan Davies, Cpl Tom Hollinger, Cpl D.J. Gaynor and Cpl Rhys Minto. Photo by MCpl S.H. Hughes

How to **Correctly Obtain Oil Samples** and the **Accurate Interpretation of Reports**

By WO (Ret'd) L. (Tex) Leugner

(From the Practical Handbook of Machinery Lubrication© – Excerpt lightly edited to reflect The Journal's style and format)

Taking Oil Samples

The troubleshooter must follow several fundamental rules when obtaining oil samples:

- To ensure a representative oil sample is obtained, the system must be allowed to reach its operating temperature with all contaminants suspended. So oil samples must be taken when the equipment is running or when it has been immediately shut down.
- Oil samples must be taken before the oil has passed through a filter, especially if the troubleshooter is concerned about particulate larger than 10 to 50 micrometres in size.
- Before taking the sample, flush the sampling valve or suction gun.
- Oil samples obtained carelessly will result in oil analysis reports that will be misleading and worthless.
- Oil samples should be taken at the **same** interval (hours or kilometres), at the **same** location, using the **same** method, and under the **same** operating conditions if proper trend data, repeatability, and reliability of results are to be expected.

Interpreting Oil Analysis Reports

Wear metal rates begin higher than expected when a new or rebuilt machine component is put into service and gradually decreases after two or three oil samples. This is due to the break-in period. The wear rate trend will establish itself during this period and generally doesn't increase unless contamination such as dirt, dust, water, anti-freeze, or other contaminants enter the machine through leaking seals or air intake systems. The resulting wear metals are the result of wear, not the cause of it.

Any sudden increase in two or more wear elements is cause for concern. An increase in copper, lead, and/or iron suggests journal bearing wear in engines. An increase in silicon, iron, molybdenum (or chromium) suggests a contaminated air intake leak affecting piston rings. A combined increase of iron, chromium, and silicon in a hydraulic system indicates cylinder rod wear caused by dirt or dust contamination. When silicon and aluminum are increasing together, it suggests that contamination is an issue, (aluminum is not always a wear metal). Potassium, sodium – and "sometimes" boron of as little as 35 to 45 ppm – indicates a coolant leak. (A coolant leak may not always be detected through a glycol test alone). A sudden decrease in any particular wear metal is not always a good sign. It could mean that the wear particles have increased in size beyond the capability of the spectrometer. Remember that the spectrographic instrument cannot usually detect particles larger than about six to eight micrometres in size. Wear doesn't go away!

Whenever additive metal levels change significantly, either up or down, it suggests that the wrong lubricant has been added to the machine as a top-up or fill. The presence of additive elements does not mean that the additive remains active. It could be used up and no longer effective. ***This explains why the tests for the tan acid number (TAN) – to monitor the remaining lubricant life in natural gas engines and recirculating systems like hydraulics, turbines, and compressors – and the total base number (TBN) – to monitor the remaining lubricant life in diesel engines – are so important and should be part of every equipment reliability program.***

Four Important Points To Remember

1. Know the metallurgical makeup of the machine components in your care. (Common wear metals include iron, chromium, nickel, aluminum, copper, lead, tin, silver, and **sometimes** molybdenum).
2. Understand the purpose of the additives in the lubricants used on your site. (Additive metals include boron, magnesium, manganese, calcium, barium, phosphorus, zinc and **sometimes** copper, molybdenum, and sodium).

3. Understand the operating conditions that may affect your equipment. For example, contaminant metals include silicon (dust and dirt), sodium, potassium, and **sometimes** boron (coolant additives) and sodium and aluminum – **sometimes** as contaminants in dirt, dust, or road salt.

4. Statistically, contaminant particles of dirt, dust, water, excessive levels of wear metals, soot (in diesel engines) and varnish (in turbines, natural gas engines and compressors) that are larger than component-bearing clearances can cause more than 70 percent of lubrication-related failures.

L. (Tex) Leugner CD, Warrant Officer (Ret'd), is a certified Lubrication Specialist, Society of Tribologists and Lubrication Engineers.

Inadequacies Exist in the **Basic Oil Analysis Wear Package**

By WO (Ret'd) L. (Tex) Leugner

(From the Practical Handbook of Machinery Lubrication© – Excerpt lightly edited to reflect The Journal's style and format)

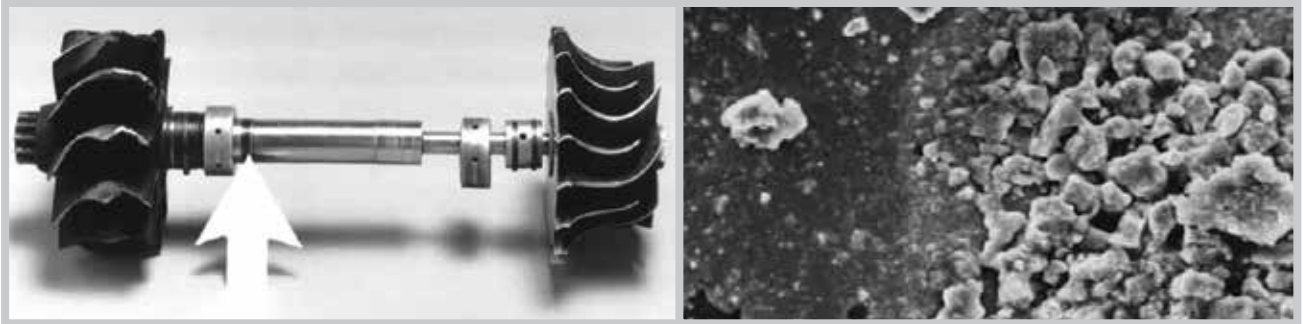
Industrial and military equipment users today rely on regularly scheduled lubricant analysis programs to monitor equipment component condition and determine oil change intervals. However, the "basic wear" oil analysis package that Canadian (and many US) oil companies and oil analysis laboratories provide to their lubricant-user customers is not a sufficient lubricant condition monitoring tool. These basic service packages only provide component wear rates, additive levels, viscosity levels, and basic physical oil condition and do not include information on the causes of oxidation, nitration, carboxylic acid levels or contamination.

What should be included are acid number analyses for natural gas engines and recirculating systems such as hydraulics, pumps, compressors and gear drives, and base number analyses for diesel engines. In addition, ISO standard 4406 or membrane filtration (patch tests) should be included for all recirculating systems in order to monitor contamination levels that spectrometric analyses are incapable of 'seeing' due to particle size. The inclusion of these additional analyses would provide "root cause failure detection", making these programs truly proactive.

These additional analyses should be provided to lubricant users as part of effective condition monitoring programs for the following reasons:

1. **Lubricants – both mineral base and synthetic – reach the end of life by oxidation, compression heating, thermal degradation conditions or a combination of these chemical reaction mechanisms.** The causes of high nitration and/or oxidation results are often combined with high levels of carboxylic acids and/or higher than normal viscosity levels. These lubricant users are not aware (in fact may not

Examples of sludge build-up in the left photo and varnish in the right photos could have been prevented had the operators made use of acid number analysis on a regular basis.



Excessive carbon soot buildup in this diesel engine caused a catastrophic turbocharger failure. The Scanning Electron Microscopic photo on the right clearly shows hard carbon soot that caused this failure. In addition to monitoring soot levels with Fourier-Transform Infrared Spectroscopy (FTIR), the addition of monitoring base number would have provided some indication of the remaining useful oil life.

even know) that in order to confirm the cause of these lubricant conditions, acid/base number analyses should have been applied to determine the remaining life of the lubricant. Highly recommended are the addition of acid number analysis to natural gas engine and recirculating systems oil analyses packages and the addition of base number analyses to diesel engine oil analyses packages. Without these additional tests, the generation of varnish, sludge, carbon, and other causes of potential equipment failure might not be known until it is too late.

2. **More than 70 percent of lubrication-related failures are caused by contaminated oil.** This is particularly true in gear drives and pumps whose shafts are supported by rolling element bearings with critical clearances, screw type compressors and high- pressure hydraulic systems using piston pumps and motors. This contamination is dirt, dust, water and other large particle contamination that cannot be 'seen' with just the application of spectrometric wear rate analyses. As a result it is recommended that the addition of ISO 4406 fluid cleanliness using optical particle counter analyses is included in these oil analysis packages. (The use of optical particle counters is recommended over pore blockage instruments because optical instruments will determine all contaminants including varnish). Karl Fischer water analysis is also recommended wherever water is a potential concern, such as in screw compressors.

A review of many hundreds of oil analysis report case histories has clearly shown that the absence of base or acid number and/or ISO contamination or membrane filtration (patch test) analysis contributed to such problems as over-extended oil drains, oil life degradation and unacceptable contamination levels that contributed to component failure or near failure.

The following photos illustrate several case histories where the full and complete use of the analyses tests described above would have prevented or at the very least, provided early warning of a potential catastrophic failure.

Oil analyses programs can only be truly effective if the right testing, applicable to specific equipment types is carried out – otherwise most oil analyses programs can be a waste of resources.

L. (Tex) Leugner CD, Warrant Officer (Ret'd), is a certified Lubrication Specialist, Society of Tribologists and Lubrication Engineers.

Excessive acid corrosion failure of a diesel engine bearing that could have been prevented had the operator made use of base number analysis on a regular basis.

The photos above illustrate that excessive levels of water caused this bearing in a final drive to fail as a direct result of corrosion. The Scanning Electron Microscopic analysis directly above confirms corrosion rather than a spalling condition. The inclusion of Karl Fischer water analysis is necessary if water contamination is a concern.

Learn About **Land Equipment Engineering Technologists** Through Ten Q&As

By MWO Martin Leclerc

The Corps of RCEME is undergoing historical change in order to stay relevant to the evolving needs of the Canadian Armed Forces (CAF). Part of this transition is an evolution of the Military Employment Structure to a feeder-recepter model, where technicians from the four current RCEME Non-Commissioned Member (NCM) occupations will merge into Land Equipment Engineering Technologists (LEET) upon promotion to the rank of Warrant Officer (WO).

LEET will have improved roles and responsibilities, including advising on LEMS domains, recommending equipment modifications, and conducting technical investigations. The creation of the new LEET occupation will ensure the Corps of RCEME will be well-positioned to meet our tactical objectives now and into the future.

The following 10 questions and answers are provided for a better understanding of the change and its impact on the Corps and its members.

LEET in 10 Questions

1. What is the full occupation name and Military Occupational Structure Identification Code (MOSID)?

Land Equipment Engineering Technologist MOSID 00388

2. What is the French name?

Technologue en Génie de l'Équipement Terrestre

3. When will it be effective?

On the implementation date, currently scheduled for March 31, 2021, all changes will happen automatically and will be centrally actioned.

4. Who will be affected?

All current WO and MWO in the Corps of RCEME will be changing occupations to LEET at the time of implementation. Sergeants from the four feeder trades will compulsory occupation transfer to LEET upon promotion to WO.

5. Why is this structure replacing what we used to have?

The creation of the new LEET occupation will enable the Corps to better reflect the reality that the majority of WO and MWOs are doing the same types of jobs. As senior NCOs, responsibilities shift toward managing people and equipment, and will be less about individual trade skills.

6. How many people will be in the occupation?

At implementation LEET will consist of the following positions:

PRes: MWO: 1	Reg F: MWO: 171
WO 47	WO: 212

7. I'm an EO Tech. What will be the impact on my pay?

A pay evaluation effort is currently underway utilizing the Canadian Armed Forces Job Evaluation System (CAFJES). The results of this initiative will determine the Pay Trade Group of each occupation. Regardless of its outcomes, everyone's pay will be protected, meaning you will retain your existing rate until you move to a higher level on the pay scale.

8. I'm a Mat Tech sergeant. Will I be merited against all RCEME sergeants to be promoted to WO into LEET?

No. Each feeder occupation will rank its members, then the four merit lists will be placed in an algorithm that will determine the promotions to WO based on the size of the feeder occupations and the number of promotions available.

9. I'm an LCMM and my job is really specialized in my occupation. Does it mean that people without this knowledge will be filling my position in the future?

No. When all positions were revised, this was closely considered, and it was determined that 57 positions required a specific occupational background. This will be tracked by the CM and the list of positions with prerequisite qualifications can be modified as required.

10. Are there new tasks and skills required for this new occupation?

Yes. The tasks to be performed by LEET are in line with the guidance outlined in RCEME 2020 and are detailed in the new LEET Occupational Specifications. New training events will be developed to ensure members are ready for the tasks and challenges.

MWO J.M. Leclerc CD is a CA G4 Maint 2/Assistant Occupational Advisor LEET.

Paratroopers Are Making a Comeback as a Maintenance Attachment

By Sgt Alex Henri, with additional material from MCpl Patrick Thompson, MCpl Dave Campbell, MCpl Dave Black, MCpl Jim Tupper, and Cpl Ryan McLeod

The RCEME paratrooper

RCEME paratroopers are defined as a highly dependable attachment to a Para Company Group (PCG). They are qualified and well-disciplined both personally and professionally and understand that their primary role is to tend to mission objectives as a soldier and that their secondary role is to perform their specialized skill/trade as needed, when needed.

At one time, Canada had an entire Airborne regiment dedicated to parachute operations. Within that regiment almost every member was a qualified jumper and a paratrooper by job description, including the support trades. When the Airborne regiment was disbanded in 1995, the three companies, referred to as commandos, were dissolved to make up one "para" company of each of Canada's three light infantry battalions, the 3rd Battalion of the 22nd Regiment (Vandoos), the 3rd Battalion of the Royal Canadian Regiment, and the 3rd Battalion of Princess Patricia's Canadian Light Infantry.

Throughout the ensuing years, there were periods of time where maintainers held casual and hard paratrooper positions and joined in airborne exercises and operations within the three battalions, as related by MCpl Patrick Thompson's account further along in this article. There were also intervals where maintainers were not involved. In recent years, a lot depended on the relationship between the control office and the unit chain of command as well as the para company NCOs' individual impressions of maintainers. In another segment of this article, MCpl Dave Campbell relates how he never asked for his opportunity to serve in such a role. Rather, he "walked the walk" and was invited in. This first-person account speaks volumes about the amount of trust and camaraderie that must exist between maintainers and the members of the combat trades they support. Those who have had experiences overseas and on large-scale exercises know that this relationship is not specific to airborne tasks.

The Basic Para

As a RCEME soldier being selected for a Basic Parachutist course – and completing it – can be an extremely rewarding part of one's career. Success requires a high standard of physical fitness and exceptional mental resilience since the course can be very demanding. The regimen includes physical training twice a day, constant running from one place to another, pushups for mistakes made – not to mention the demanding practical stages of the course. Taking in all the pertinent information given during instruction and being expected to put it into practice perfectly can be

MCpl Patrick Thompson received his American "Jump Wings" after performing a jump with the 82nd Airborne under a T11 square canopy.

MCpl Jim Tupper. Photo by Sgt Alex Henri

daunting. For those who feel they are up to the challenge, the following is a rundown of what to expect.

The three-week course is divided into two distinct phases. The first two weeks are all in-class instruction with staff demonstrations. Immediately thereafter, a practical assessment will be made of skills learned. These classes are separated into the four main objectives of parachuting; Aircraft, Flight, Landing, and Equipment.

Aircraft involves learning all the drills necessary while inside the aircraft, including the sequence of events before exiting: hooking up the static line, checking equipment, proper movement to the door, and the exit itself. These drills and other specific emergency procedures are crucial in learning how to get out the door and under canopy.

Flight entails getting into the racks – specially made equipment that simulates being in the air – to conduct all drills associated with the descent. The racks are widely considered to be the most uncomfortable part of the course. On the agenda is the learning of the five points of flight procedure:

- Check canopy;
- Keep a sharp lookout during descent;
- Release waistband;
- Lower equipment; and
- Prepare to land.

Additional training features the correct drills for potential scenarios such as parachute malfunctions, averting mid-air collisions, avoiding obstacles on the ground, and preparations for unintentional landings.

Landing skills encompass the proper techniques for the four most likely directions to be encountered upon impact with the ground. The proper form required is quite simple and consists of hitting five points of contact in succession; balls of the feet, calf, thigh, buttocks, and diagonally across the back – crucial manoeuvres in the prevention of injury. The speed of descent is approximately 20 feet per second and hitting the ground at that rate using an improper technique could end badly.

Equipment training entails the learning of how to safely set up and rig equipment for all types of airborne operations. This can include a rucksack, weapon, snowshoes, and any other mission essentials. As a RCEME technician, this portion of the course is well-suited to the detail-oriented nature of the trades, making it seem relatively easy compared to other classes in the course.

At one point in Week Two, candidates encounter the Mock Tower – a 32-foot-tall structure used to simulate exiting the aircraft. All drills must be completed to rigorous standard before moving on. At the end of the second week, the trainees undergo a full day of testing, where the course staff gauges the individual's ability to react expediently to all words of command, as well as executing drills correctly and to a high standard. Successfully passing these assessments attests to the trainee's ability to jump out of an airplane, get off the drop zone and be ready for the next objective.

The third and final week is referred to as Jump Stage or J-Stage, involving a minimum five jumps, including one at night. Many candidates find this to be the most enjoyable part of the course, where all that hard work gets put into action – something not everyone will get the chance to do.

Cpl Ryan McLeod

Successful participants often find this course to be one of the more difficult but also among the most professionally run courses in the Canadian Armed Forces that a RCEME member will get to be a part of. While many other courses have changed over the years, the Basic Parachutist curriculum has stuck to its roots – a testament to a time long ago. Every day, the limits of endurance are pushed to the maximum in order to prove one's right to be there. Becoming a qualified paratrooper is a feeling like no other. There is sense of pride knowing the wings worn on your uniform are earned and not given.

Personal Experiences: MCpl Patrick Thompson

My journey within the world of the Airborne began with my posting to 3 RCR in September 2012. I had always had a desire to work with the infantry since joining as an EO technician, but my knowledge of the Airborne was severely limited. Within the first few weeks at the battalion, I noticed the maintenance personnel worked extremely hard both physically and mentally, all striving to be given the chance to attend the Basic Para course. Technicians were often the last to be considered and it took the most exceptional individuals, pushing their limits, to secure a spot. Their determination was remarkable, and they inspired me to make the push as well.

My opportunity came in November of 2015, not only resulting from my own hard work but most importantly from those who came before me. They had shown that maintainers could rise to the challenge when given the chance, and that we had a place among the Paras.

I was loaded on a course being run out of CFB Trenton at the Canadian Army Advanced Warfare Centre. We learned quickly to keep our heads up and always push forward. Day after day the instructors drilled into us the skills needed to parachute safely. The movements and actions were repeated over and over until they became second nature. They teach you not to think about it but just do it. If something goes wrong, it's only you under canopy so you need to act independently and do it right every time.

These lessons are not only for your own safety, but the safety of your fellow paratroopers. After a grueling three weeks, training 12 hours a day and pushing our bodies to the limit, it was finally over. I had completed my course with six jumps down, a few incredible stories, a bunch of bruises, and a set of wings on my chest. The pride I felt at that moment has yet to be matched by anything else in my career so far.

Airborne Maintainers

Once I was qualified, I started to engage with the Parachute Company (Para Coy) for more jumps. I received training in Drop Zone (DZ) drills and other follow-on activities related to airborne operations. I deployed with the unit on administrative jumps, joint drops with other units such as the Canadian Special Operations Regiment (CSOR), and I even got to conduct a wings exchange with United States Army Paratroopers.

Additional opportunities included Battalion Mass Tactical Week (BMTW), a large-scale exercise with the 82nd Airborne in Fort Bragg, North Carolina. We conducted classes, ground training, and progression jumps to learn the skills necessary to use the T-11 parachute safely. I jumped into the exercise as a technician attached to the Para Coy Company Quartermaster (CQ). It was around this time that I started to use a small toolkit I could jump with. I had to balance weight with versatility, having enough tools and parts to service the kit I worked on, but not so much that it would become a burden to carry. It also highlighted the need to focus on repair rather than replacement. When you have all of Maintenance there, you can bring everything you need, but when you're on the DZ and you're the only technician, it is best to figure it out in advance!

MCpl Patrick Thompson

MCpl Dave Campbell

I continued to forge a relationship between Maintenance and the Para Coy during Exercise Maple Resolve in 2017 and requested to be embedded into the company for the Field Training Exercise (FTX). They attached me to the CQ again and I deployed on both stages despite jump cancellations. In addition to my job as a technician, I conducted tactical manoeuvres, completed sentry

shifts, operated radios, and conducted CQ activities. My time in the field gave me a great opportunity to observe how the kit we service is utilized in operation. It also allowed for the identification of recurrent issues and for simple repairs to be conducted on-site. The entire exercise was proof that Maintenance in a close support role is a viable option and definitely something to continue developing.

Not long after, I was given the unique opportunity to deploy on an airborne exercise as a member of an infantry section. Exercise Talisman Sabre was a multi-national endeavour in which we conducted parachute training in Alaska, then flew across the Pacific and jumped into Australia to execute our mission. There was an amalgamation of personnel from 3 RCR that would make up a platoon and we were paired with two platoons from 3 PPCLI to form a company of paratroopers. The whole experience offered an exceptional chance to see soldiers from different parts of the country working together as a cohesive unit, and to see different nations working together in a complex operation to achieve their goals. It was most important for me to work on the skills necessary to be an effective soldier.

I have participated in many exercises over the years, expanding my skills and making Maintenance work in an airborne context. This however is only a small piece of a larger picture. I cannot alone accept credit for where we are today. It is instead the work of countless maintainers past and present that got us here. I have had the privilege of knowing great technicians and soldiers that gave me the inspiration to become a paratrooper. I currently serve alongside paratroopers that inspire me every day to be my best. I only hope that one day we can be the inspiration for future soldiers to make the push like we all did, so long ago.

The Pride of Wearing the Maroon Beret

Maintenance always strives for a close relationship with those they support, and the ties forged with the Para Coy, are especially close. To work alongside paratroopers in the field and be given the opportunity to wear the maroon beret is a great honour. Its meaning is enormous to those that wear it and not something to be squandered. It is a symbol of an individual who can be relied upon – one who is going to push as hard as possible to get the job done and who isn't afraid to share in that hardship. It shows others that this soldier will go all the way to succeed, and it is a symbol of accomplishment and pride that others will strive for. I have had the privilege to don that maroon beret and I can say that it holds great significance for me. Those who have worn it will understand what I mean when I tell others that maybe one day they could be one of those proud few wearing that highly respected headgear.

Personal Experiences: MCpl Dave Campbell

I am proud to relate how I acquired a paratrooper position as a vehicle technician in the 3rd Battalion of the Royal Canadian Regiment (RCR). Before my basic para I was embedded with Mike (Para) Company CQ staff for several exercises where I served as a maintainer and as a storesman. In 2018 I earned my way onto the coveted Basic Parachutist course held at CFB Petawawa. To date, this was one of the best experiences of my career. Immediately after completion of the course, I was brought into a paratrooper position in the Para Company Group (PGC).

The PCG encompasses all the paratroopers of Mike Company as well as essential support attachments such as the artillery, engineers, mortar detachment, sniper detachment and now, maintenance. I had the honour of putting up the prestigious maroon beret, which is bestowed upon all active paratroopers within the PCG. The saying to "put up" the beret is common around here because the beret is not a permanent fixture. It can be "taken down" whenever the airborne soldier is no longer a member of the PCG. In the moment when I put up the maroon beret, I took on the responsibility of maintaining and emulating a standard that is bound to timeless tradition and is second to none – one I will proudly maintain throughout the remainder of my career.

Requirements for Fitting in with the PCG

While attached to the PCG I was fortunate enough to work alongside and learn from many trades. As mentioned, there is an implied level of professionalism and dedication taken on in this position and therefore it provides an excellent environment to maximize one's skill sets. To aid in my effort to maintain such a high personal standard, I have been following these quotes passed down during my basic training – the RSM's 3:

- "You did then what you knew how to do, and when you knew better, you did better."
- "You cannot change what you fail to recognize and what you fail to recognize will only get worse until you do so."
- "Choose the behaviour, choose the consequence."

I believe that, no matter what rank you hold in the Canadian Armed Forces (CAF), you can always learn something

Photo by Sgt Alex Henri

from someone. It is important to take as many opportunities and experiences as possible, learn from them, and pass that wisdom to others along your path.

The LEMS Function

When preparing for Exercise Swift Response 2019 in Bulgaria, I and several storesmen received cross training from CSOR on the DAGOR ultra-light combat vehicle platform. This came about because the 82nd Airborne utilized this vehicle, as would our company when in Germany and after the jump into Bulgaria. While preparing in Germany, I was employed alongside the maintenance detachment of the Red Falcons, the US Army's 325th Infantry Regiment, to assist with repairing their equipment. There I witnessed how their maintenance shop operates in a deployed environment and I built a working relationship with them. And yes, I jumped tools with me. How else are you going to do your job if you do not have "all your stuff and things?"

I was expected to repair any assets on the drop zone (DZ) as required or help the other members of my company with any repairs when I arrived at the drop zone rendezvous (DZRV). We also conducted dry- and then live-fire air assault to occupy enemy trench systems. Four of us provided security for the sergeant major and we aided in the occupation after the first phase. 3RCR Oscar Company brought their A-game that day and we absolutely crushed the training scenario that was set up for us.

I was taken out of my position for unit logistical reasons but was told there was a plan hatching that would eventually see me under the coveted maroon beret once again. Sure enough, in October 2020, I and three other maintainers were presented with our maroon berets and given roles within the PCG where we still have four positions to date.

I was asked to write about my experiences so far in an attempt to inspire other members of the branch to perhaps one day seek out the same route. If you do, I will be honest. You will share in a lot of good times but also all the hardships that come with it. You will build friendships that are on a different level because you have gone through the same dangerous and intensive training together, no matter your trade. There is a camaraderie you feel and this extra bit of pride you put into your daily life. I certainly wouldn't trade it for anything.

Conclusion

As we wrap up this overview of the thrill of wearing the maroon beret, the reader might be wondering why the airborne concept is such a big deal. To be honest, it's not. It really is just another way to get to the battlefield. What's special is the personal drive one must have to want to do so voluntarily and with conviction. It's important that LEMS/RCEME maintain an active role in support of these operations to help ensure the CAF's overall readiness. We wouldn't want to be in a scramble to qualify techs for the real deal when we can start now and ensure a good base of training and forge solid relationships between RCEME personnel and the para companies.

In October of 2020, while the para company sergeant major presented maroon berets to members of 3 RCR maintenance platoon, he highlighted the fact that there is a real need for technical support on airborne operations. This is due to the increasing amount of equipment that each individual paratrooper is carrying (weapons and advanced optics). The fact that modern all-terrain vehicles such as the Polaris MRZR or the DAGOR can be easily rigged for air drops, and can be task-tailored for missions, makes these platforms a huge advantage for light infantry roles on the drop zone. Maintainers have to be ready and willing to perform the task in seriously austere conditions and the only way to meet that demand is to jump in with them, tools and all.

Currently at 3RCR we have six qualified parachutists, four casual para positions with the potential of becoming hard (earning monthly jump allowance), and two additional techs nominated for the next available course. We are keeping a mix of three trades vehicle techs, weapon techs, and electronics-optronics techs in the casual para positions in order to offer well-rounded support. As long as the career managers keep sending fit troops that want these jobs, the intent is to keep these positions filled and to have extra maintainers qualified and ready to step into said positions at a moment's notice. Having such an arrangement gives justification to allowing spots for maintainers on the recurring basic para courses.

Sgt Alex Henri is a vehicle technician at 3 RCR Maintenance platoon and a qualified basic parachutist.

MCpl Patrick Thompson is an electronics-optronics technician at 3RCR Maintenance platoon and a paratrooper with the PCG.

MCpl Dave Campbell and MCpl Dave Black are vehicle technicians at 3 RCR Maintenance platoon and paratroopers with the PCG.

MCpl Jim Tupper is a weapon technician at 3 RCR Maintenance platoon and a qualified basic parachutist.

Cpl Ryan McLeod is a weapon technician at 3 RCR Maintenance platoon and a paratrooper with the PCG.

Lean Six Sigma Principles Helped Expedite Non-Medical Mask Production

By Capt Spenser Hui & MCpl Richard Jr Hamel

Maintenance Platoon St-Hubert from the 2nd Canadian Support Group (2 CDSG) displayed innovation and resourcefulness by developing an efficient non-medical mask production chain by unknowingly applying the principles of Lean Six Sigma.

Lean Six Sigma is a methodology meant to improve performance by systematically removing waste in all its forms – including overproduction, motion, and waiting time.

This all-hands-on-deck team made up of various RCEME techs, reservists, and civilians was led by the core group of Materials Technicians.

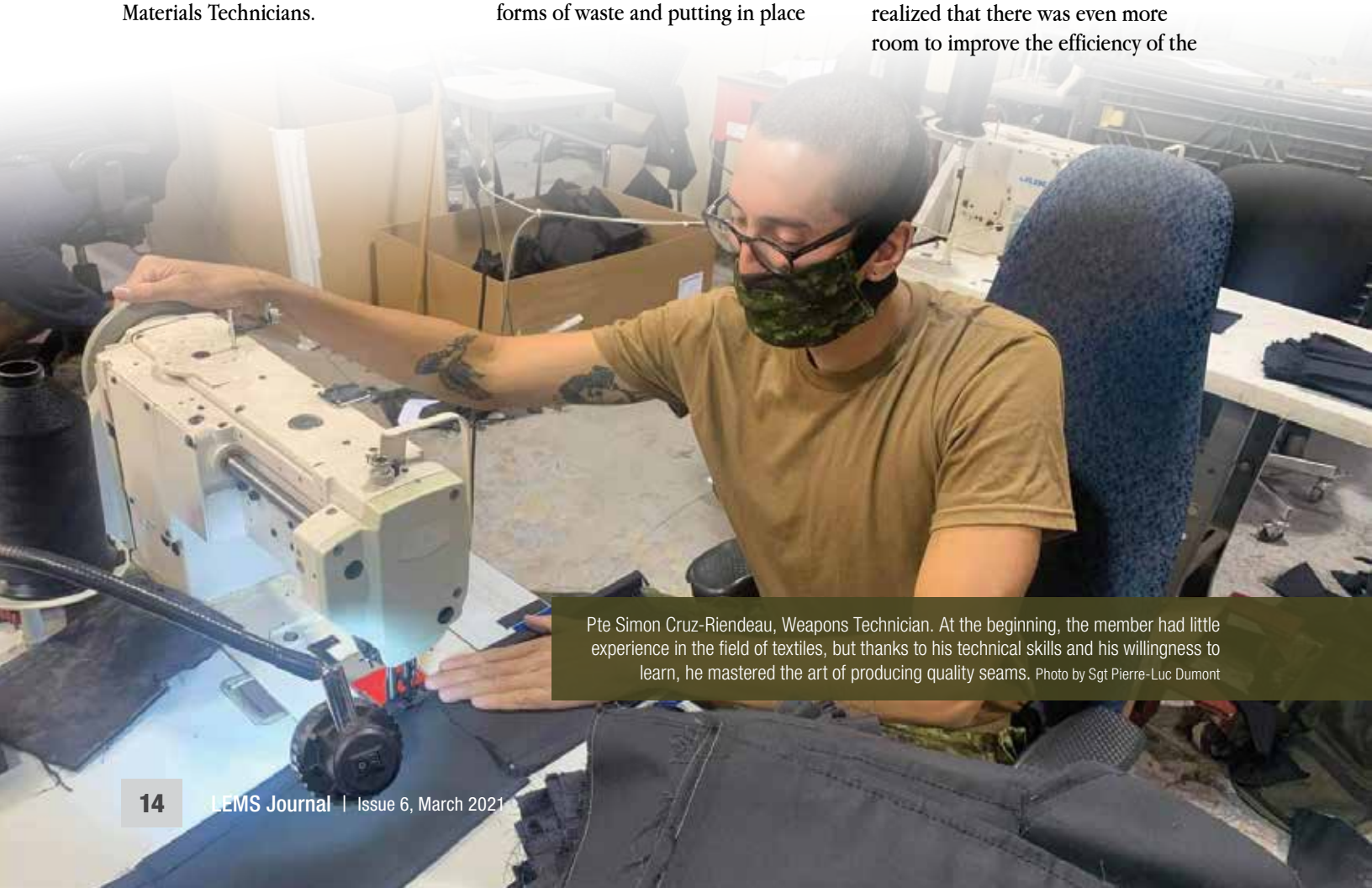
It is remarkable that even though none of the group had any industrial engineering experience, their approach mimicked the principles of Lean Six Sigma. Indeed, their incredible resourcefulness and keenness to continuously improve led them down a remarkably similar path.

Their first step was to develop a mask design that would provide the required protection and be comfortable, but that would also be easy to fabricate and minimized waste.

They then mapped out a stream of steps that would reach this end-state while working at removing the various forms of waste and putting in place various COVID preventive measures such as physical distancing. As such, they established an assembly chain that made optimal use of the skilled labour of their Mat Techs and civilian equivalent, that avoided unnecessary movement of materiel and personnel, and maximized materials.

The simple design and the efficacy of their assembly chain allowed them to initiate the distribution of masks to essential personnel in 2 Cdn Div, even before the first batch of commercial masks could be distributed to units.

After multiple iterations, the team realized that there was even more room to improve the efficiency of the



Pte Simon Cruz-Riendeau, Weapons Technician. At the beginning, the member had little experience in the field of textiles, but thanks to his technical skills and his willingness to learn, he mastered the art of producing quality seams. Photo by Sgt Pierre-Luc Dumont

The first day of the production line for non-medical masks. MCpl Richard Jr. Hamel, Cpl Nicolas Gagné and Cpl Joel Lussier at the sewing machines; MCpl Yan St-Pierre cutting; and Pte Philip Jahchan and Pte Marie-Soleil Lefebvre assisting with diverse tasks. Photo by Sgt Pierre-Luc Dumont

production process by drawing on the principles of batch processing. As an example, they would sew a string of masks from a single thread reel without cutting in between. Once the reel was finished, they would cut the string of masks into single units. After making this change, for many days their daily production totals could be zero, yet their weekly production increased by more than 50 percent.

Supply chain was also a challenge due to high demand of similar materials and reduced staffing in local businesses. Indeed, multiple factors had to be monitored so that production continued. As such, careful analysis was done to choose alternative materials that met the mandated standards. The team continued to refine the design to further reduce material waste, and material orders were put in well in advance to allow for the abnormally long delivery time.

The team also coordinated with their counterparts in St-Jean and Valcartier to ensure materials were well distributed between these sections so that the overall divisional production continued at maximum capacity.

In total, the effort produced more than 18,000 masks between March and July 2020. Their success accelerated the resumption of activities in the reserve units of 2 Cdn Div and the training of recruits at Canadian Forces Leadership and Recruit School (CFLRS). It also allowed for the creation of a divisional operational stockpile and contributed to the national supply. This search for perfection through continuous improvement of the processes involved provides an excellent example of how Lean Six Sigma can be applied in manufacturing.

Capt Hui is the Maintenance and Transport Officer at 2 CDSG Tech Services.

MCpl Hamel is the IC of the Materials section at Maintenance St-Hubert within 2 CDSG Tech Services.

As an innovator, Cpl Nicolas Gagné optimized cutting methods that allowed the team to spend less time on preparation and focus efforts on assembly. Photo by Sgt Pierre-Luc Dumont

The Many Benefits of **3D Printing in a Military Environment**

By Cpl Sean Casement and Cpl Drew Atkinson

Over the last several years, Canada has seen a vast number of technological marvels and innovations that have brought new ways of thinking and the ability to accomplish feats no one thought possible. In an effort to modernize and adapt with a constantly advancing global environment, the Corps of RCEME has encouraged its members to find new ways to improve their capabilities and bring fresh ideas to the table.

As the next generation of materials technicians are immersed in a technological environment from an early age, they are combining their passion and dedication to their trade to introduce these new innovations, specifically 3D printing, to the forefront of the maintenance world. Though not typically used in mass production, 3D printing has the capability to enhance any material section by providing a steady supply of custom parts made on demand. In a few hours, the shop can produce parts that would otherwise take months to acquire. An added benefit is the reduction of potential errors and waste, such as ordering incorrectly sized parts or ordering in surplus.

The earliest talk of 3D printing started in the early 1960s and has significantly evolved since. It has, however, taken more than 40 years to reach the consumer market of today. Most modern 3D printers are made of inexpensive and readily available components, the majority of which are open source, which gives the consumer the freedom to experiment with a wide variety of modifications to include changing or altering the program code.

Although there are many forms of 3D printing, the most common is Fused Deposition Modeling (FDM). This is a simple process where a plastic filament is fed into a heated chamber by an electric motor. It is then melted and extruded through a nozzle with an opening typically ranging from 0.3 to 0.8 mm in diameter. The melted plastic is then deposited onto a build surface that is heated to assist in the adhesion of the plastic.

After the base layer is plotted by the printer, the nozzle is lifted to plot the second layer. The machine will repeat this process forming a three-dimensional shape. For example, a Cartesian-style printer will move its nozzle in the X axis and the build surface will move in the Y axis. The Z axis is controlled with a threaded rod called a lead screw. The nozzle is then pulled in each axis via belts or lead screws. It is fairly similar to the mechanism inside an Etch A Sketch or claw machine found at arcades.

The other main form of 3D printing is stereolithography (SLA), more commonly referred to as resin printing. This method dips a build surface in a vat of resin and cures it using a UV light travelling layer by layer. This creates an extremely high-definition model that can also be incredibly tough

Handle designed and printed in ABS by Cpl Atkinson.

and strong. Resin printing is still in its infancy when compared to FDM printing, yet it has come a remarkably long way in the last couple of years. So far, 3D printers have advanced, and the selection of resins has become more varied.

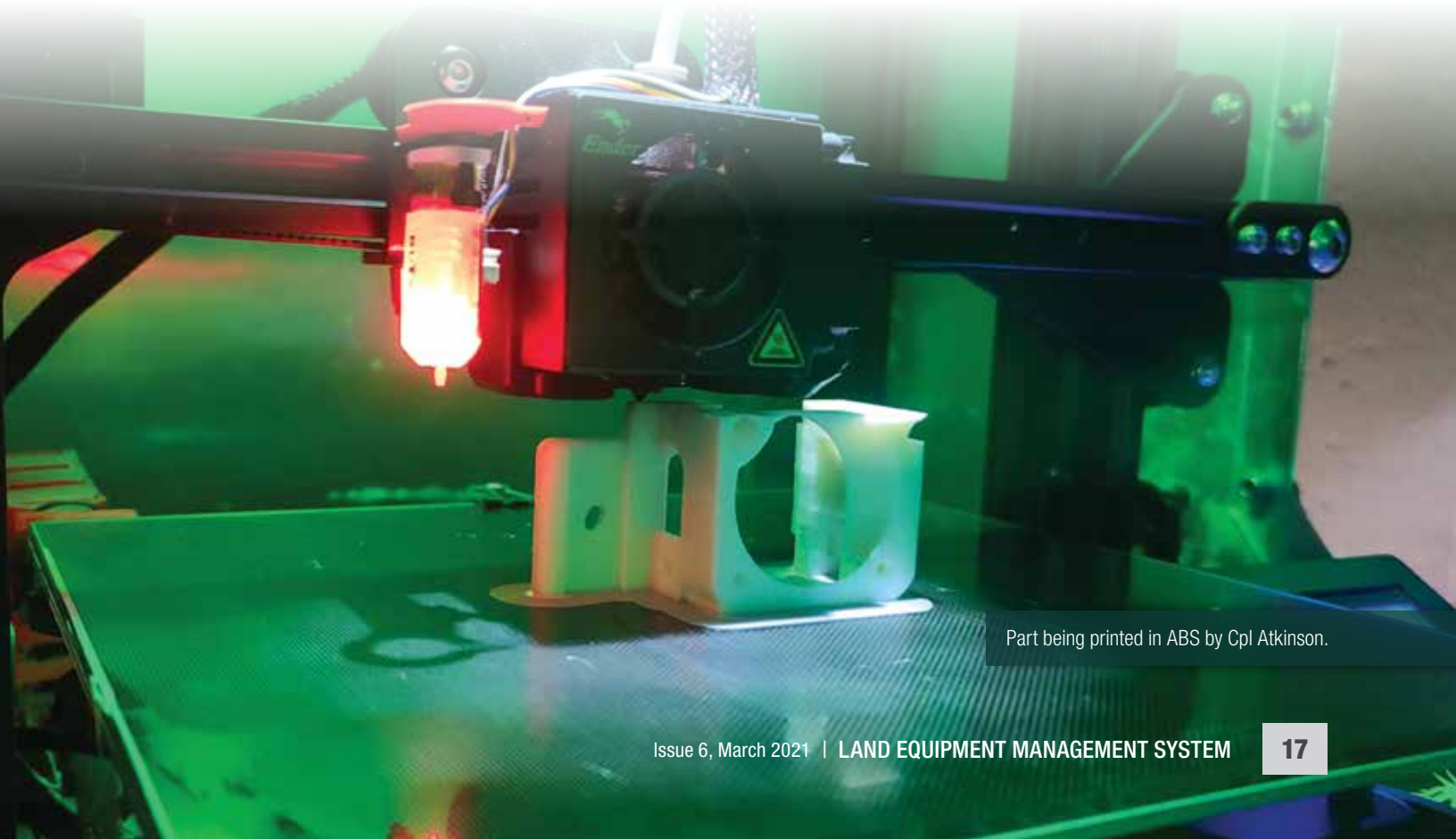
Most 3D printers use plastic filament, typically sold in one-kilogram spools of nearly any color, and commonly named after the abbreviation of their molecular structure to simplify their terminology. There are many different types of filament, the most common being Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA), which are used primarily by hobbyists for making models and small light-duty parts. Some of the others include Thermoplastic Polyurethane (TPU), Polyethylene Terephthalate Glycol (PETG), Polyether Ether Ketone (PEEK), Polycarbonate (PC), ULTEM, and nylon. Most filaments can be combined with materials such as carbon fibre, glass fibre and even Kevlar – all of which have unique properties and can be used in different applications. Thus, this method of manufacturing is incredibly versatile and can be applied to virtually any industry, including the military.

Toolbox Coat Hook printed in PETG by Cpl Casement.

It is important to start integrating this technology into LEMS now in order to create base level knowledge, networks, and experience. The technology is advancing at such a rapid pace that within the next few years metal 3D printing will be as easy to do as it is to print plastic.

The Canadian military and its members need to master a solid base knowledge in order to keep up with the leading edge of this emerging technology. Implementing this skill will allow technicians to gain hands-on experience, allow training programs to grow, and improve the self-sufficiency of the Canadian Armed Forces (CAF) as a whole. Units can build a network to share designs, troubleshoot, and problem-solve across the country – procedures similar to civilian hobbyists with websites such as Thingiverse. Hopefully, this article has shed some light on what this tool can do, and how it can be adopted by the CAF to maximize its effectiveness in the areas of logistics, maintenance, and innovation.

Cpl Casement and Cpl Atkinson are employed as Material Technicians with Maintenance company of Tech Services Branch CFB Gagetown.



Part being printed in ABS by Cpl Atkinson.

Enthusiasm Grows Over **The Capabilities of Additive Manufacturing** at CANSOFCOM Trenton

By Cpl Dan Couture

Additive Manufacturing (AM) at the Canadian Special Operations Forces Command (CANSOFCOM) Trenton has rapidly become an important part of the support capability. The creative solutions that are possible, as a result of AM, have empowered various RCEME trades to imagine, create, manufacture, and implement new solutions to arising problems. Through AM, the unit's needs are quickly sourced – removing dependence on manufacturers and thereby enabling members to solve problems ingeniously.

Although conventionally a Materials Technician function, AM was initiated at the unit by the Electrical-Optronic (EO) technicians. The entry into the AM world started with a Makerbot 3D printer in 2018. Since this was a new capability, training was required to implement the technology. Members took courses through civilian agencies and returned to the unit to adapt the material for military and CANSOFCOM implementation.

The practical experience has been the greatest success of the AM initiative, as it enabled the creativity to flow and evolve through various tactical challenges. Preliminary experiments and lessons learned with polylactic acid (PLA), the most commonly available plastic for 3D printing, created an excellent start to the fine-tuning of AM skills. Quickly realizing the potential of this capability, the unit pushed forward with its development.

Figure 1. The Makerbot Plastic Printer was the first printer introduced to the Unit.

One of the first challenges came with software. After trialling different programs – such as Fusion 360 – Solidworks eventually stood out from the rest. A computer-aided design (CAD) software, Solidworks allows the user to create complete parts and combine parts to build assemblies, testing for fit and tolerance. To print the designed item, a slicer software is equally required. We use Cura, created and maintained by the company Ultimaker.

With continued advancement came the need to use plastics other than PLA, and with these new materials came new tools for creation. A larger and enclosed Ultimaker 3D printer was acquired that featured a bigger surface area for build plates, capable of supporting increased intricacy of builds from stronger and

more practical materials. Currently, a variety of materials such as ABS plastic, polycarbonate, composites, flexible composites, and metals are used. Compounding the AM capability is the use of complementary technologies, such as Arduino, to further manipulate efforts to create practical solutions to everyday problems.

Through a combination of civilian courses, industry connections, and research (Thanks YouTube!), intricate and complicated designs have been successfully explored and created, in conjunction with fulfilling primary unit duties. The onset of the COVID-19 pandemic provided the additional downtime required to significantly advance the team's abilities. And like many other users of AM, there was a quick adaptation of skills to support the fight against the pandemic, resulting in the creation of face shields, ear savers, and prototype ventilators.

A simple example of how the unit's AM program came together was the fabrication of a cover for a detector that was often damaged due to the glass screen breaking easily. With the AM experience came the capability to design a custom mount for the detector with a printed Lexan disc over the glass, thus eliminating the problem entirely. Not only did this save the detector from damage, it also reduced the amount of service required. This improved efficiency for the unit was easily gained from a specialized print that takes under one hour to create.

Figure 2. The protective cover (right) that was made for the glass on the TBM detector (left).

The growth of the program has necessitated the need for further training, better printers, and a broader professionalization. The team is comfortable with the basics and is actively seeking to create advanced parts – constantly redesigning and optimizing as part of the rapid prototyping design process. Small production run parts, or experimental ideas that were nearly impossible to produce before are now fabricated quickly with immediate user input. AM has removed barriers, providing all trades the opportunity to become *Tool Makers* as opposed to solely *Tool Users*.

AM has been an important driving force at the unit, which is looking forward to seeing its continued development in the Canadian Armed Forces as a whole. The many possibilities that AM offers can play an important part in the future of the Corps of RCEME, particularly as the possible applications continue to grow.

Cpl Couture is an electronic optronics technician at Maintenance Troop of CANSOFCOM Trenton.

Figure 3. The ventilator prototype that was made by Technicians at the height of the first wave of the COVID-19 pandemic.

Decentralized Additive Manufacturing: An Update on Operation REASSURANCE

By Lt Sean Menezes

Two 3D polymer printers were deployed on Op REASSURANCE in September 2020 to prove and develop the Canadian Armed Forces' (CAF) Decentralized Additive Manufacturing (DAM) capability. An article in the Fall 2020 edition of the LEMS *Journal*: "Fabricating the Future – Additive Manufacturing on Op REASSURANCE" highlighted the initial deployment and challenges with the DAM on that operation.

Some of these challenges included the complexity of governance required to support DAM, data management, quality control, risk of these activities, as well as the fundamental soldier-technician skills needed to meet DAM operational requirements. Following the success of this preliminary trial, the future goals of the DAM on Op REASSURANCE are being reinforced though a Technical Assistance Visit (TAV) led by 202 Workshop Depot personnel between Op REASSURANCE 20-02 and 21-01 to maintain the momentum built to date, and ensure this nascent capability is handed over deliberately between rotations without being permitted to languish.

S5 Ultimaker 3D Printers KVN and HAL.

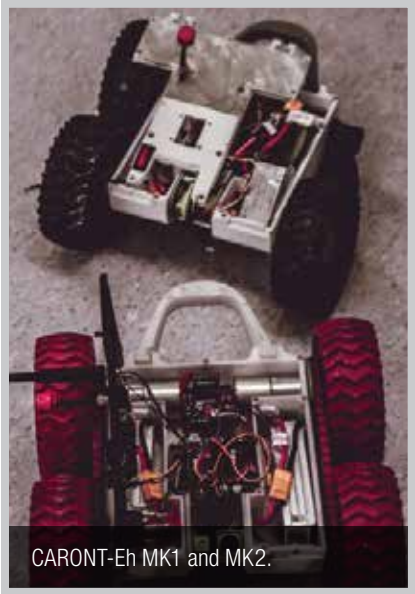
DAM'S Relevance to LEMS

With the ability to reduce strain on supply systems, rapidly prototype to create on-demand solutions from at home or abroad and increase operational effectiveness with forward deployed assets and sustainment, what was once imagined can now be printed and proven with Additive Manufacturing (AM).

Since the arrival of two Ultimaker S5 3D printers to the Task Force Latvia (TFL) National Support Element (NSE), AM has been a continuous source of sustainment, support, and innovation to Canada and our allies. The two printers are capable of printing single, batch, or complex components in a variety of materials and have been working overtime to support Op REASSURANCE Latvia in a variety of tasks from replacement components to fielding new forward deployed assets.

A Multinational C4ISR Demonstration

An illustrative example of how DAM can be employed in support of operations is the CARONTE-Eh Unmanned Ground Vehicle (UGV). While deployed, the Canadian NSE was briefed on a project currently underway within the Spanish Army Sapper Battalion to address recurring C4ISR complications noticed within built-up and dispersed operations. The manufacture of an UGV was proposed to leverage modern technology to help soldiers overcome reconnaissance challenges through using AM and available electronics, which led to the creation and deployment of CARONT-Eh, a First Person View (FPV) Reconnaissance UGV.



CARONT-Eh MK1 and MK2.

The Canadian-led AM Team used the deployed printers to sustain the Spanish AM initiative that was being field tested on a deployed operation for the first time. Through this relationship, the AM team also produced its own models, and implemented enhanced components through rapid prototyping in theatre. This gave the first two CARONT-eh UGVs to the Enhanced Forward Presence Battle Group (eFP BG) and the Canadian Army. With a fully 3D-printable frame, and minimal electronic cost – under $500 and 96 hours from pushing start print to being ready for deployment – CARONT-Eh was welcomed into the battlefield by infantry battalions to collect information in these ever-increasing and complex urban environments.

The printers at first were used for design and rapid prototyping. Print and design iterations were conducted concurrently by technicians of both countries, offering support to one another until the final product was achieved, and CARONT-Eh MK1 was born. This concept of decentralized support enabled designed components to be shared, redesigned, or printed by AM operators from across the globe.

Putting CARONT-Eh to Work

Following the successful build, CARONT-Eh was deployed on Ex BEAST CROSSBOW, a Level Three live-fire that saw multiple buildings with a variety of open and closed doorways, as well as others rigged with Improvised Explosive Devices (IED). Operators were able to use the UGV to identify IEDs and traps in primary entrances.

With the increased intelligence and situational awareness provided by CARONT-eh, the commander was capable of selecting an alternate entry point from a safe location, directing sappers appropriately. The infantry then gained access – clearing, and ensuring survivability from, traps emplaced within the compound. The command decision to deploy CARONT-Eh to select the secondary entrance point took less than five minutes.

DAM Support as Far Forward as Possible

The ability to rapidly create a supply of replacement parts with DAM led to the trials to support CARONT-Eh forward in the field. A Light Support Vehicle Wheeled AM Special Equipment Vehicle (LSVW AM SEV) was equipped and deployed to the field for mobile printing for expedient field repairs. AM operators were able to immediately diagnose and replace broken components from print to reassembly in under 90 minutes for redeployment to the field.

CARONT-Eh introduced a new capability to soldiers in the field, and demonstrates the ability not only to manufacture forward, but also to conduct expedient repairs forward using DAM. CARONT-Eh is a great example of what the AM TAV seeks to preserve as a capacity – the skills, training, and tools to create and innovate on the battlefield.

What was once imagined, can now be printed!

Lt Menezes is a RCEME Officer and Additive Manufacturing TAV Lead from 202 Workshop Depot, Montreal integrating deployed additive manufacturing as far forward as possible for the Enhanced Forward Presence Battle Group on OP REASSURANCE, Latvia.

The **Evolution of Ground-based Telerobotics** To Meet the Needs of Today and the Future

By Cpl R. E Granados

If one were to imagine what an army of the future might look like, it is probable that robots would be front and centre in this vision. Telerobotics is the field of semi-autonomous robotics controlled at a distance by an operator.[1]

Getting ahead of the curve with telerobotics will allow the Canadian Army to stay on a par with its adversaries by increasing ground-based situational awareness, increasing the capabilities of our troops, reducing the risk to soldiers, and being able to better oppose contemporary threats. Its development is also necessary to counter emerging threats where current technologies are at an impasse.

Advances in telerobotics have been made in the Counter-Improvised Explosive Device (C-IED) realm since the conception of the first Explosive Ordnance Disposal (EOD) robot developed in 1972 by the British Army.[2] Many models of such robots have emerged and have increased capabilities for niche applications. These capabilities include increased mobility, tactile manipulation, control interfaces, and cameras.

Recent advances in telerobotics have been deployed in modern EOD robots through applications of solid-state devices and improved user interfaces (UI). The Digital Vanguard Remote Operated Vehicle from Allen-Vanguard Corporation is an example of a modern

As mentioned in the photo on the front cover, Pte(B) Hunter Lawrence Carr is one of those working on developing state-of-the-art robots that will save lives in combat.

Photo by Cpl Roberto Granados

telerobotic system. Its advantages over older models of EOD robots include its use of a second-generation (2G) command system and digital controls, allowing for increased range and increased programmable functions.

The vehicle's compact design can be attributed to solid-state devices allowing fewer conductors, as signals can be passed by 1s and 0s rather than analog signals that require a wire for each function. It also utilizes a PlayStation® remote as a method of control. The potential familiarity for operators may seem trivial, but it is not. Improved UI makes it easier to train users, which will be critical if we expect to see telerobotics become commonplace.

We can see an example of this improved UI in the upgraded version of the tEODor – the tEODor EVO by Telerob, a similarly tasked EOD robot. It is much bigger and capable of lifting more than its Vanguard counterpart. The tEODor EVO can be controlled using touch screen interfaces, allowing for better situational awareness by showing a complete overview of information and functions.

Along with miniaturization and versatility, advances in semiconductor technology allow for better cameras to be placed on smaller devices, with newer telerobotic electronic-optronics having higher and higher resolutions or even optional infrared cameras as in the case of Vanguard. C-IED is an inherently risky task and the development and implementation of advanced robotics have no doubt saved many lives. However, there is no room for stagnation in finding new ways to apply telerobotics.

Tactical Drones

The United States Marine Corps has been experimenting with integrating drones at the squad level.[3] Utilizing tactical drones in an infantry section is a force multiplier in Military Operations in Urban Terrain (MOUT). Improved UI, such as hand-held multi-touch displays, can be used to expand a section commander's situational awareness, which is integral in such a dynamic and

Digital-Vanguard ROV, an EOD robot at 1 Combat Engineer Regiment.
Photo by Cpl Roberto Granados

dangerous environment.[4] The realm of possible applications of telerobotics in a battlespace is limited only by our imagination. We must ask ourselves: What is next and where will we see it?

New research shows that artificial intelligence (AI) can be trained to recognize road signs or facial expressions,[5] so why not a T-72 from a Leopard 2? Limitations in human reaction time and data processing are currently being exploited through telerobotics and that will soon be the case through AI as well.

Recent conflicts show that drones are being used en masse to overwhelm air defence systems.[6] AI integration assists in data processing and decision-making, opening a new realm of tasks we can assign to semi-autonomous robots. These tasks could include transportation of materials, casualty extraction, electronic warfare (EW), route clearance, air defence, and potentially direct action.

By using AI's increasingly reliable ability to recognize objects, we may eventually be able train it to find IEDs by recognizing and flagging disturbed ground or other suspicious characteristics faster and more reliably than a human on the ground – or identify hostile assets in a reconnaissance role. Several robots could be working together to patrol an area under an integrated network, allowing fast and reliable passage of information between each other or even to a higher command. AI could be used to passively survey the Arctic and notify a central command of anomalies. AI is Pandora's Box – once it is implemented and its advantages become apparent, we should expect it to become a staple in future technologies.

Maintenance Challenge

One reality we must be prepared to face is the detailed maintenance required on such advanced machines. Technicians must be expected to understand a system's software and mechanical complexities, and as robotics become more integrated with a future Land Equipment Management network, they could have self-diagnosis software flagging the system for repair with GPS data, allowing quicker and more reliable repairs.

As mentioned previously, digital technologies are starting to replace easily repairable analog robotics, so improvised fixes are becoming more challenging and more reliant on part-swapping. Therefore, an increase in spare parts would be expected in future repairs. Technicians themselves could be going out for a recovery accompanied by a robot carrying their spare parts and tools in more austere environments than a conventional vehicle could manage.

Telerobotics are in our future, even if no system is free of challenges. Limitations of robotics include being disabled through electromagnetic disruption and other EW means such as hacking. Enemies could exploit our integrated networks, mine for data, or pass misinformation through our means.[7] Recognizing these issues will hone our ability to utilize futuristic telerobotics and, limitations aside, semi-autonomous telerobotics will undoubtedly remain a tool in a commander's arsenal. Even with trained AI, a machine's ability to improvise is hampered by its own nature. Human soldiers will remain the supreme asset on the battlefield and will be the ones to push past the final wall.

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