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LEMS FLEXIBILITY – THE FUTURE OF LAND MAINTENANCE IN THE CAF

Major Jason Van Dyk

JCSP 45

Exercise *Solo Flight*

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"Thus an army without flexibility never wins a battle. A tree that is unbending is easily broken." – Lao Tzu, Tao Te Ching

INTRODUCTION

The Land Equipment Management System (LEMS) by definition is a "fully integrated and coordinated system that encompasses the entire range of equipment management and is designed to support land technical equipment from the factory through to the units in operations anywhere in the world."[1] This Canadian Armed Forces (CAF) doctrine has gone through a recent restructuring after years of ignorance, with the most recent version being published in early 2019.[2,3] The latest version emphasizes a doctrinal framework for delivering maintenance effects that have been proven over time, while highlighting the requirement for maintenance commanders to retain flexibility to both organize themselves and execute program delivery. The renewed emphasis on flexibility is essential, as the speed of evolution of doctrine simply cannot compete with the rapid evolution of technology. The Canadian Army's (CA) most recent operating concept for the Army of tomorrow, *Close Engagement: Land Power in an Age of Uncertainty* was produced as a follow-up to *Land Operations 2021* and attempts to provide a conceptual operational framework for the next 15-20 years.[4] The Corps of Royal Canadian Electrical and Mechanical Engineers (RCEME) must

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[1] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Land Equipment Management System.* Issued on authority of the Commander Canadian Army, Ottawa, 2019, 1

[2] *Ibid.*

[3] Bérubé, M. P., and Canadian Forces College. *Reconsidering Lines of Maintenance.* Canadian Forces College, Toronto, Ont., 2016.

[4] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Close Engagement: Land Power in an Age of Uncertainty*. Canadian Army Land Warfare Centre, Level 1 Circulation Draft, Ottawa, 2017, 2

remain in harmonious step with the evolution of the land operating environment to ensure relevancy and success on operations.

This paper will argue that in order to remain relevant, CAF maintenance organizations (specifically, RCEME), must remain flexible within the LEMS and quickly adapt to changes to both equipment technology and how the CA positions itself for the future fight. Most importantly, the concept of flexibility must be better defined and understood in order for success to be achieved. These adaptations should include but are not limited to: the embracing and understanding of emerging maintenance technologies, projected new equipment needs of the CA, digitisation, networking and maintenance personnel. The roadmap for this analysis will commence with a short background of the RCEME Corps and the evolution of current maintenance practices. It will then transition to an analysis of the Army of tomorrow, considering both future technology and provide a glimpse of what the maintainer of the future may look like in the context of a flexibility model. The argument will conclude with some recommendations for the Corps as well as the identification of further areas of study.

BACKGROUND

Maintenance organizations have a well-documented history of flexibility and adaptation. In fact, the birth of RCEME in 1944 was a direct result of the Royal Electrical and Mechanical Engineers (REME) birth in 1942, which was predicated on three main factors: The introduction of complicated electrical and mechanical equipment, the demand to maintain this equipment, and the start of

World War II (WWII).[5] An early example of the REME Corps ability to adapt to the evolving fight was the use of the forward repair group in the mid 1950's, introduced as a way to "beef up" the LADs and repair as far forward as possible, instead of the traditional move back to a 2nd line field workshop.[6] This field adaptation became such a success that "repair as far forward as possible" would become one of the tenets of LEMS, and one of the most widely preached and practiced tenets at that.

The current LEMS publications have been written in a manner that allows maintenance Commanders to exercise flexibility and adapt to the situation at hand. For example: "The chosen, and most effective, maintenance support system requires a carefully engineered combination of tasks, using Logistic Support Analysis techniques, to determine a maintenance plan that optimizes the equipment's availability."[7] This general concept could be applied in both the planning phases in the accepting of new equipment/technology, just as well as for the evolution of a tactical maintenance plan on the battlefield. A common argument against the LEMS is a perceived rigidity in its application[8]. This should not be confused with the ability of Commanders to Command, or our requirement to train and prepare for war. To illustrate: lines of maintenance have long been an area of contention, especially in our current data driven environment. The

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[5] Tatman, Jocelyn A., and Brian B. Kenneth. *Craftsmen of the Army: The Story of the Royal Electrical and Mechanical Engineers.* Leo Cooper [for the] Corps of Royal Electrical and Mechanical Engineers, London, 1970, 148

[6] *Ibid*, 342

[7] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Application of the Land Equipment Management System in Static and Deployed Operations.* Issued on the authority of the Commander Canadian Army, Ottawa, 2019, 2-1

[8] Bérubé, M. P., and Canadian Forces College. *Reconsidering Lines of Maintenance.* Canadian Forces College, Toronto, Ont., 2016.

perception that formation level maintenance organizations should be decreased in favour of larger unit level maintenance organizations is fundamentally flawed. According to close engagement, "The Army structure is based on deployable formations. The ability to operate at brigade group (Bde Gp) level is essential to ensure that the Army is interoperable with other CAF capabilities, allies and coalition partners."[9] Given that the CA wishes to continue its war preparation focus on the Bde Gp for the foreseeable future; nimble, agile, and maneuverable unit level maintenance organizations are essential. The challenge may be perception, even during post-WWII training exercises "formation commanders did not look favorably on the size and unwieldiness of field workshops and questioned whether those units pulled their weight – which on exercises of short duration, they could not do."[10] A simple solution for a formation level maintenance organization is to leverage the tenet of "repair as far forward as possible" and "mutual support" in both Garrison and Field environments, acknowledging that without a protracted war, the fruits of formation level maintenance organizations will not be fully recognized. This does not mean that they should be abandoned.

It is clear that LEMS is written in conjunction with the CA's Army of tomorrow concept. However, a rigid application of this doctrine may only yield success in a large conventional style war with today's technology. The reality is

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[9] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Close Engagement: Land Power in an Age of Uncertainty*. Canadian Army Land Warfare Centre, Level 1 Circulation Draft, Ottawa, 2017, 3

[10] Tatman, Jocelyn A., and Brian B. Kenneth. *Craftsmen of the Army: The Story of the Royal Electrical and Mechanical Engineers.* Leo Cooper [for the] Corps of Royal Electrical and Mechanical Engineers, London, 1970, 373

that maintenance Commanders must be flexible and deviate from established doctrine when/where necessary to successfully support our land forces. This must also apply institutionally; specifically in organization and training, in order to prepare for the commissioning of new and emerging technologies.

DISCUSSION

Future Warfare

The Army of tomorrow capstone document attempts to define what the future land operating environment (FLOE) will look like. "There is general consensus that the FLOE will be complex, dynamic, volatile and highly uncertain. It will be marked by multiple threats and challenges."[11] In addition, one must consider that the future adversary, both state and non-state sponsored, will be increasingly capable, possessing more advanced and potentially dangerous weapons and equipment systems. The challenge in trying to predict the future cannot be understated. Most nations with substantial defence forces are publishing their own versions of the FLOE. The UK's *Future Operating Environment 2035* (FOE35), offers a succinct and accurate description of the problem space: "The challenge of looking 20 years ahead is significant but this work does not seek to predict the future. Rather, it describes the characteristics of plausible operating environments, resulting from rigorous trend analysis."[12] In this vein, while it should be continually revised, the CA's analysis of the FLOE cannot be ignored

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[11] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Close Engagement: Land Power in an Age of Uncertainty*. Canadian Army Land Warfare Centre, Level 1 Circulation Draft, Ottawa, 2017, 4

[12] United Kingdom. Ministry of Defence. *Strategic Trends Programme: Future Operating Environment 2035*. Development, Concepts and Doctrine Centre, First Edition, London, 2014, VIII

and provides substance to the main argument of this paper. In short, "The most salient conclusion that can be drawn about the FLOE, and one we share with our major allies, is that flexibility, versatility and the ability to rapidly adapt may be the most important defence to the unpredictable nature of future conflict."[13]

To further depict the FLOE for the purpose of discussion, FOE35 uses a method called the "5C's", which stands for: congested, cluttered, contested, connected and constrained to define the characteristics of the future battlespace.[14] Although it cannot be assumed that the 5C's will apply to all future environments, it is a helpful method to help analyze LEMS considerations. A congested environment is likely to limit the friendly forces freedom of manoeuvre (FoM).[15] The deduction could be that the future mobile repair teams (MRTs) need to be more self-sufficient, able to operate without unlimited access to supply routes. Perhaps a shift to greater enable operators to diagnose/repair simple faults, would also limit the strain on technicians, allowing them to focus on more complex repair, away from the front lines. A cluttered environment affects the ability to distinguish items, people or events.[16] The key take-away from a cluttered future environment is the increasing reliance on new ISR and weapons technology to distinguish friend from foe. The RCEME Corps must remain in step with new technology and adapt their training to ensure they have technicians qualified and knowledgeable on this new equipment. It is likely that all future environments

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[13] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Close Engagement: Land Power in an Age of Uncertainty*. Canadian Army Land Warfare Centre, Level 1 Circulation Draft, Ottawa, 2017, 6

[14] United Kingdom. Ministry of Defence. *Strategic Trends Programme: Future Operating Environment 2035*. Development, Concepts and Doctrine Centre, First Edition, London, 2014, 44

[15] *Ibid*, 44

[16] *Ibid*, 44

will be contested to varying degrees.[17] The deduction is that future maintenance equipment must be hardened and enabled sufficiently to resist/overcome the specific threat environment. An increasingly connected environment for both friendly and non-friendly forces presents opportunity as well as vulnerability.[18] RCEME tactical organizations must be equipped and trained to take advantage of the opportunity that connectivity provides. An increased amount of data availability will require increased analysis to ensure it is being leveraged to their advantage. Conversely, information protection will continue to be a challenge with adversaries seeking an advantage via cyber/informational warfare. Finally, a constrained environment results from both legal and strategic guidance that limits the ability to act in the future.[19] The requirement from the RCEME Corps will be similar to other elements: they must understand these limitations and exploit them to the maximum extent.

In order to understand how the RCEME Corps can position itself to meet the needs of this FLOE, a greater analysis of emerging technologies including how they can be leveraged to better advantage is required.

Emerging Technologies

One area of LEMS doctrine that is woefully lacking substance is the area of future maintenance concepts. This section outlines four specific areas of emerging technologies that have the potential to affect the LEMS: emerging maintenance technologies, information technologies, material handling systems

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[17] United Kingdom. Ministry of Defence. *Strategic Trends Programme: Future Operating Environment 2035*. Development, Concepts and Doctrine Centre, First Edition, London, 2014, 44

[18] *Ibid*, 44

[19] *Ibid*, 44

and support vehicle protection.[20] While these are all important aspects to consider for the maintenance organization of the future, their descriptions are not detailed enough, and there is no clear path to implementation. In short, LEMS doctrine fails to articulate any vision or strategy for emerging technologies.

One of the biggest challenges to implementing new technology/equipment is to first understand what effect is to be achieved? As articulated in the CA's *Close Engagement* "The FLOE presents a major challenge for capability development: which conflict do we prepare for?…It will be very difficult to judge the correct balance of investment against uncertain risks."[21] However, for the purpose of planning, the RCEME Corps should be focusing in on more generic concepts such as sensors and digitization, including the second and third order effects they will cause institutionally. Regardless of the platform, the biggest challenge will certainly be the management of the endless amounts of data that is increasingly available through items such as embedded sensors.[22] As one study concluded, "as the predictability of work improves through more knowledge of the health and performance of the asset, work becomes less reactive and there is more demand for preventative work."[23] There are several systems such as: Conditions Based Maintenance, Prognostic Health Management (PHM), Built-in Test (BIT) and Health and Usage Monitoring Systems (HUMS) that are being

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[20] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Application of the Land Equipment Management System in Static and Deployed Operations.* Issued on the authority of the Commander Canadian Army, Ottawa, 2019, 2-10

[21] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Close Engagement: Land Power in an Age of Uncertainty*. Canadian Army Land Warfare Centre, Level 1 Circulation Draft, Ottawa, 2017, 6

[22] Hodkiewicz, MR. "Maintainer of the Future." *Australian Journal of Multi-Disciplinary Engineering*, vol. 11, no. 2, 2015, 8

[23] *Ibid,* 8

employed in different equipment/applications and can provide the data required to make an organization more efficient.[24] As noted in the Australian *Future Land Warfare Report:* "Digitization and advances in technology will present significant opportunities for changing the way land forces are supported. The use of increased levels of automation may save manpower and enhance accuracy and speed of delivery."[25]

According to *Close Engagement*, the CA expects that CSS organizations will leverage new technology to generate a common logistics operating picture.[26] "Total asset visibility and access to real-time consumption data, will be pursued, with the goal of increasing the velocity of the resupply system."[27] *Close Engagement* expects that the AoT will be sustained by modular CSS elements leveraging new technology to increase awareness and enable items like predictive maintenance and just in time delivery of parts. MRTs will need to be network enabled, some even containing the ability to make parts in situ via additive manufacturing.[28] "Research and experimentation is needed to determine the extent to which additive manufacturing can reduce the need for stocks to be held in the supply system."[29]

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[24] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Application of the Land Equipment Management System in Static and Deployed Operations.* Issued on the authority of the Commander Canadian Army, Ottawa, 2019, 2-10

[25] Australia. Army Headquarters. *Future Land Warfare Report 2014*. Directorate of Future Land Warfare, Canberra, 2014, 12

[26] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Close Engagement: Land Power in an Age of Uncertainty*. Canadian Army Land Warfare Centre, Level 1 Circulation Draft, Ottawa, 2017, 9

[27] *Ibid,* 9

[28] *Ibid,* 26

[29] *Ibid,* 26

While digitization has the potential to drastically alter how the RCEME Corps executes its maintenance program, additive manufacturing, though further from mass implementation, has similar potential and is worthy of discussion. Additive manufacturing (otherwise known as 3D printing), could have significant benefits in a military application. Arguably, the most immediate and feasible usage would be the ability to manufacture and repair equipment components geographically close to the area where they are immediately needed.[30] This would have immediate impacts on the supply system (stockpiling), as well as the reduction of equipment down time. The biggest challenge currently with this technology is that complex metal processes are not projected to be available in the mainstream in the next few years.[31] The RCEME Corps has some momentum in the planning for this new technology, with a draft DGLEPM report on Additive Manufacturing Capability Development completed in 2017, followed by a DRDC report in 2018.

In summary, the RCEME Corps must embrace new technology that has the potential to streamline CSS activities, and remain adaptable to constant change. This was emphasized in *RCEME 2021* a strategic document produced in 2014, which stated: "In order to fully adapt to the strengths and weaknesses of technology…, the Army will have to adapt culturally to the new technological reality and the Corps of RCEME will have to reposition itself." [32] In addition to

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[30] Dundon, Robert, Quality Engineering Test Establishment. "Director General Land Equipment Program Management Report on Additive Manufacturing Capability Development" 202 Workshop Depot, May 2017.

[31] Veronneau, Simon, Geoffrey Torrington and Jakub P. Hlavka. 3D Printing: Downstream Production Transforming the Supply Chain. RAND Corporation, 2017.

[32] Canada. Dept. of National Defence. RCEME 2021 - *The RCEME in the Age of Adaptive Dispersed Operations*. Ottawa: Director of Royal Canadian Electrical and Mechanical Engineering, 2014, 1

emerging maintenance technologies, changes are likely required to the way maintenance tasks are going to be executed, requiring a holistic review of the entire maintenance process. Of particular importance will be what the future maintainer will look like, specifically, the roles and responsibilities and how they fit into a larger organizational change. However; given the plethora of correspondence and doctrine highlighting the need to be flexible, it is prudent to gain a better understanding of the term before carrying on.

Flexibility

Most references used in this paper emphasize the need for successful organizations (including the military) to remain flexible, without explaining in great detail, what flexibility actually means. Flexibility is about building redundancy (options) in an organization and takes significant effort to achieve. As shown above, we are on the cusp of a technological revolution that has the potential to drastically alter the way maintenance activities are executed. Simply put, the current method of training and delivering maintenance effects in the CAF does not lend itself well to maximize the benefits of this new technology. To better understand how flexibility could be achieved within the organization, we first need to better define the term.

Henk Volberda, a well-respected professor of strategic management at Rotterdam Erasmus University developed an organizational flexibility model, with an aim to allow managers to better understand the term and assist in the creation of flexible organizations.[33] The model, shown below, consists of five

[33] Volberda, Henk. "Organizational Flexibility Model". ProvenModels; Netherlands, 1992. Last Accessed, 26 Apr 2019. https://www.provenmodels.com/590/organisational-flexibility/henk-w.-volberda/

building blocks: three of which represent forces that lead to the resolution of the flexibility paradox, ultimately leading to organization change.[34] Although this is only one theoretical model of many on flexibility, this particular model is useful to apply to the Army of tomorrow, specifically in the pursuit of organizational flexibility for the RCEME Corps.

The first area; management challenge, concerns itself with the creation of sufficient and flexible enough procedures so that the organization is capable of

[34] Volberda, Henk. "Organizational Flexibility Model". ProvenModels; Netherlands, 1992. Last Accessed, 26 Apr 2019. https://www.provenmodels.com/590/organisational-flexibility/henk-w.-volberda/

reacting to issues in an effective and timely manner.[35] The three specific types of flexibility identified in the model are: organizational, structural and strategic flexibility. Arguably, the RCEME Corps performs well within the realm of organizational flexibility as standard operating procedures (SOPs) and doctrine such as the LEMS are both well-known, and allow for "frequent and small short term changes related to operational activities" as defined in the model.[36] Where the Corps currently falls short is in both structural and strategic flexibility. In fairness, most if not all CAF organizations would also struggle in this area. Simply put, our organizational structures are too rigid and not easily or quickly amendable to the rapidly evolving environment outlined in *close engagement.* The Force Mix and Structure Design (FMSD) currently in progress by the VCDS has a purpose to make changes to the CAF force structure to better realize the requirements of Strong, Secure, Engaged (SSE).[37] While these changes are essential, the outputs of FMSD are not likely to give the organization the long term flexibility that the Army of tomorrow requires.

The next input; organizational design, concerns the flexibility potential of an organization by defining the flexibility mix. Too small of a mix will require the loosening of conditions, too large of a mix will require rationalization.[38] The three components that influence the potential are: technology, structure and culture. It could be argued that the RCEME Corps is currently struggling with both

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[35] Volberda, Henk. "Organizational Flexibility Model". ProvenModels; Netherlands, 1992. Last Accessed, 26 Apr 2019. https://www.provenmodels.com/590/organisational-flexibility/henk-w.-volberda/

[36] *Ibid*.

[37] Canada. Dept. of National Defence, Chief of Defence Staff. *Defence Plan 2018-2023*. Issued on the authority of the Chief of the Defence Staff, Dept. of National Defence, Ottawa, 2018, 9

[38] Volberda, Henk. "Organizational Flexibility Model". ProvenModels; Netherlands, 1992. Last Accessed, 26 Apr 2019. https://www.provenmodels.com/590/organisational-flexibility/henk-w.-volberda/

technology and structure, which results in an adverse effect on its flexibility potential. One such example is the limitation of our current system of record, Defence Resource Management Information System (DRMIS) to be utilized effectively in a deployed environment due to lack of connectivity and/or bandwidth limitations. As technological innovation in the CAF equipment, including RCEME MRTs will require consistent connectivity; this area of weakness must be turned into an area of strength. Also, we limit ourselves structurally by our control measures on spare parts such as release authorities and scaling at the first and second line level. Both of these issues create unnecessary delays in the returning of equipment to service. These examples, amongst others, reflect an organization which perhaps requires a greater flexibility mix now, a certainly in the future.

The third input, changing competitive forces, evaluates the turbulence in the operating environment, to determine whether the flexibility mix of an organization is sufficient.[39] The environment is evaluated based on four separate levels: micro, task, aggregation and macro. The turbulence is evaluated based on three dimensions: complexity, dynamism and unpredictability. In terms of the CA's operating environment, it can be affected greatly dependent upon the mission and current geopolitical climate. As identified earlier, *close engagement* describes the FLOE as highly uncertain, this makes predictability for the future

[39] Volberda, Henk. "Organizational Flexibility Model". ProvenModels; Netherlands, 1992. Last Accessed, 26 Apr 2019. https://www.provenmodels.com/590/organisational-flexibility/henk-w.-volberda/

very difficult for the RCEME Corps.[40] Also, the evolution of non-state actors in modern conflict and accessibility of advanced weaponry has led to a more complex operating environment. Essentially, the RCEME Corps will be expected to perform the same level of service to deployed CA elements, in a more complex and unpredictable environment. The deduction here is that the current flexibility mix within the organization is likely insufficient to meet the needs of the army of tomorrow.

There are signs that the RCEME Corps has been taking their evolving role in the Army of tomorrow seriously. One example can be found in Director RCEME (DRCEME)'s initial planning guidance (IPG) for training realignment. This document places emphasis on adapting the organization to remain relevant, referencing the previously crafted RCEME centre of gravity (CoG), developed in the strategic management plan *Horsepower for the 21st Century*.[41] However, these documents are now years old and change is slow in coming. Professor Volberda describes the importance of listening to the conditions within an organization and overcoming the challenges associated with a change adverse culture: "They strive to order so that current routines get exploited to the fullest, but on the other hand need to dynamically develop new skills through exploration by treating *disturbance as information about internal conditions* instead as noise"[42] The

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[40] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Close Engagement: Land Power in an Age of Uncertainty*. Canadian Army Land Warfare Centre, Level 1 Circulation Draft, Ottawa, 2017, 4

[41] Canada. Dept. of National Defence. *RCEME Training Realignment Working Groups*. Ottawa: Director of Royal Canadian Electrical and Mechanical Engineering, 2016.

[42] Volberda, Henk. "Organizational Flexibility Model". ProvenModels; Netherlands, 1992. Last Accessed, 26 Apr 2019. https://www.provenmodels.com/590/organisational-flexibility/henk-w.-volberda/

RCEME Corps must embrace the technological disturbance in the context of the Army of tomorrow and strive for a more flexible organization.

In order to visualize what the maintenance organization of the future may look like, it is beneficial to analyze academic research already completed on the subject and draw some parallels for the sake of comparison and constructive thinking. There may not need to be a need to reinvent the wheel, rather look at organizations already having success with the same problem set.

Maintenance Organization/Maintainer of the Future

The University of Western Australia completed a study on the future of the maintainer, specifically, how the evolution of technology and asset management will change the training and role of the modern maintainer.[43] Professor Melinda Hodkiewicz and Mr. William Jacobs co-authored this white paper. In terms of their credentials; Professor Hodkiewicz has a PhD in performance and condition-monitoring and has received numerous awards for her work in industry and the academic world. Mr. Jacobs holds a master's degree in Engineering and his honours thesis on Electric LHDs in underground mining was published.[44] While their paper was written with a focus on the mining industry, the analysis is well delivered and many concepts should be considered for use in the CAF maintenance organization of the future.

Before we can discuss the model proposed by Hodkiewicz and Jacobs in further detail, a review of the organizational drivers of change that they developed in consultation with industry managers is essential, as they can be considered

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[43] Hodkiewicz, MR. "Maintainer of the Future." *Australian Journal of Multi-Disciplinary Engineering*, vol. 11, no. 2, 2015, 1

[44] *Ibid*, 29

strikingly similar to what we are facing in the CAF. They are: Asset Design, Organizational Strategy and Technical Support Equipment.[45]

Asset design considers changes to technology that have the potential of changing how maintenance activities are executed. Embedded sensors can be added to equipment at low cost, with the added challenge of managing and interpreting large amounts of data.[46] In his paper *Training Technicians to Meet the Army's Future Equipment Support Requirements,* LCol Chenard states: "The proliferation of technology on the battlefield of tomorrow will require a technician that is more adaptable and flexible than ever. This implies a balance between cognitive abilities, practical skills and technical experience."[47] Autonomous equipment presents an area of great potential for military application. Unmanned equipment, such as the UAV has offered the military significant advantages in the areas of stealth and force protection for several years now. Autonomous vehicles could provide similar advantages on the battlefield in areas of force protection and even less wear and tear on equipment due to the removal of the human element.[48] Implications for the RCEME Corps, could be a reduction of the requirement to position technicians forward, and rely on autonomous equipment to recover equipment casualties to safe areas for further diagnosis and repair. The final element to asset design is modular components. A switch to modular equipment designs would have implications from the supply

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[45] Hodkiewicz, MR. "Maintainer of the Future." *Australian Journal of Multi-Disciplinary Engineering*, vol. 11, no. 2, 2015, 7

[46] *Ibid*, 8

[47] Chenard, R. R., and Canadian Forces College. *Training Technicians to Meet the Army's Future Equipment Requirements.* Canadian Forces College, Toronto, Ont., 2016, 7

[48] Hodkiewicz, MR. "Maintainer of the Future." *Australian Journal of Multi-Disciplinary Engineering*, vol. 11, no. 2, 2015, 9

chain to the maintainer on the ground. For the supply system, an increase in the amount of stocked parts would be necessary to facilitate repair in a reasonable time. For maintainers, a lower skill set may be required as the activity becomes replacement, rather than the potentially lengthy activity of advanced diagnostics and repair of the part in situ.[49]

Technical support equipment refers to the plethora of different methods such as predictive analytics and reasoning algorithms to achieve real-time diagnostics and remaining useful life of equipment.[50] The challenges to implementation are similar to the challenge of embedded sensors, namely, the ability to harness the data in a useful manner. There are examples of successfully harnessing the data in private industry, such as Qantas. Qantas leverages diagnostic software and a digital maintenance platform to provide a real time maintenance picture at the point of execution.[51] Building a capability to interpret and distribute this data within the RCEME Corps would increase organizational flexibility and directly support the Corps CoG within the Army of tomorrow.

Hodkiewicz and Jacobs quantify organizational strategy by looking at three areas: the reduction of maintainers on site, leveraging OEM maintenance packages at procurement, and safety. The benefits of reducing the personnel footprint in austere (or dangerous) locations are obvious: Improved health and safety (force protection) and reduced costs being the main considerations.[52] Leveraging OEM maintenance packages is something the CAF has begun to do

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[49] Hodkiewicz, MR. "Maintainer of the Future." *Australian Journal of Multi-Disciplinary Engineering*, vol. 11, no. 2, 2015, 10

[50] *Ibid*, 10

[51] *Ibid*, 11

[52] *Ibid*, 11

more frequently in recent years. So called "Person Years (PY) neutral" fleets such as the Tactical Armoured Patrol Vehicle (TAPV) have leveraged these contracts out of necessity, as additional uniformed maintainers were not considered.[53] A safe assumption for the RCEME Corps is that our PYs will not grow in the AoT, and could even be reduced as a result of the growth of other capability requirements in the CAF and re-organization efforts currently underway. The deduction is that the CAF must continue to leverage contracted maintenance solutions for routine (garrison) maintenance, while leveraging uniformed technicians for field operations.

Given the drivers of change above, the white paper proposes what the maintainer of the future *could* look like, using an analogy from the medical profession. This model could be adaptable to the RCEME Corps and could provide it with the ability to support the Army of tomorrow, to include the leveraging of new technology, while remaining flexible to future organizational change. A depiction of the model is shown below.[54]

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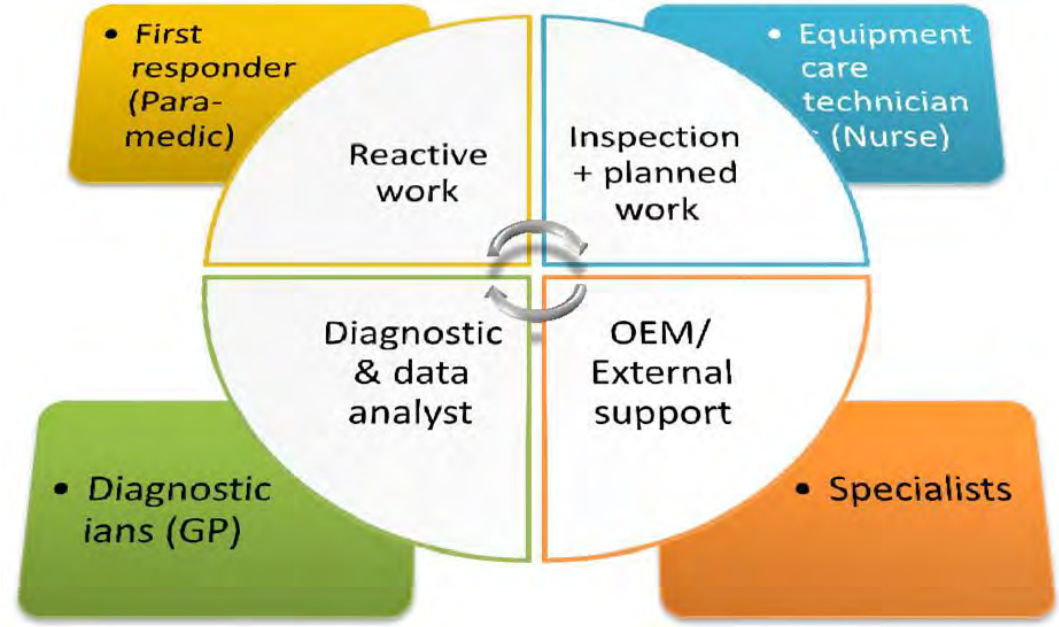
[53] Canada. Dept. of National Defence. *Tactical armoured patrol vehicle*. Ottawa, Ont., 2018. https://www.canada.ca/en/department-national- defence/services/procurement/tactical-armoured-patrol-vehicle.html

[54] Hodkiewicz, MR. "Maintainer of the Future." *Australian Journal of Multi-Disciplinary Engineering*, vol. 11, no. 2, 2015, 24



We will further describe each of the four different roles for maintainers that are proposed in this model and; where applicable, discuss potential benefits to the CAF/RCEME Corps in utilizing this model.

The first responder in this model is equated to that of a paramedic in the medical community. This would entail front line, corrective maintenance and would be comparable to the duties of a 1st line MRT in a tactical maintenance organization in the CAF today. This role would be the most unchanged of the four proposed roles, but with the evolution of technology, the maintainers in this role would likely require upgraded skills to deal with an increase in digitization.[55] Essentially, they would need to be trained and familiar with all the digital tools and equipment on the fleets they are servicing.

The equipment care technician in this model is equated to a nurse in the medical community. This role would largely focus on inspections and

[55] Hodkiewicz, MR. "Maintainer of the Future." *Australian Journal of Multi-Disciplinary Engineering*, vol. 11, no. 2, 2015, 25

preventative maintenance. Militarily, the biggest difference between this role and the previous role is the location in which the work is being completed. In the current CAF maintenance construct, inspections are considered a 1st line task and are completed at the unit level, but rarely in an unsafe environment. Flexibility could be achieved by removing the task of inspection from the 1st line level and/or utilizing a contracted maintenance solution to conduct inspections during peacetime garrison operations.

The diagnostic and data analyst would be considered a general practitioner in the medical community. This position would be largely office focused and would become the primary diagnostic expert and maintenance planner.[56] While this exact role doesn't currently exist in CAF maintenance organizations, the current role of the control office could be re-rolled to perform this function. "Maintainers trained in diagnostics could make full use of the emerging technologies and embedded sensors. They would be involved in providing the information necessary to support the role of maintainers."[57] Of note, as this would be a data/analytical driven position, the RCEME Corps could consider this to be an Officer position, or potentially an Officer/NCO combination working for the Unit Maintenance Officer (Maint O). This area has the greatest potential to be a real game changer.

Finally, specialists (same role as medical community) would be required as maintainers with an elevated level of training/experience on a specific role or piece of equipment. Currently the RCEME Corps offers specialty qualification

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[56] Hodkiewicz, MR. "Maintainer of the Future." *Australian Journal of Multi-Disciplinary Engineering*, vol. 11, no. 2, 2015, 25

[57] *Ibid*, 25

courses to selected maintainers in areas such as the Leopard 2 Main Battle Tank. For the foreseeable future it is anticipated that these specialty qualifications will continue to be required, along with the usage of Field Service Representatives (FSRs) from industry to assist with the diagnosis and repair of new equipment fleets, especially during Initial Operating Capability (IOC).

In summary, the major shift from current CAF maintenance organizations to the proposed structure above is the creation of a dedicated diagnostic and data analytic cell within each maintenance organization and an increased usage of contracted maintenance for routine tasks. What has not been discussed in great detail, but is also worthy of consideration for the maintenance organization of the future, is the role of the operator in this process. With increased usage of onboard diagnostics systems, it is conceivable that minor repairs could be carried out by operators with minimal requirement for specialist tools.

Of course, this structure only provides one option of how the RCEME Corps can improve its flexibility. The argument can be made that there is no one model than would offer the level of flexibility required to support the Army of tomorrow. The sheer uncertainty of the future operating environment casts a shadow on any rigid organizational structure that could be conceived. However; the conclusion cannot be to sit back and do nothing. Conceptual framework documents are written to allow planners and decision makers to consider the possibilities and do their best to plan for eventualities. The RCEME Corps would be well-served to make organizational changes, that although may appear rigid in structure, offer flexibility to take advantage of a data-driven environment.

Conclusion

Close Engagement attempts to provide a framework for what the CA should be positioned for in the 15-20 year horizon. "Land power will continue to be essential to the maintenance of national defence and the exercise of sovereignty. It assists in maintaining a cohesive international system that supports Canadian interests. "[58] The short term requirements of the CAF are articulated in greater detail in Strong, Secure and Engaged.[59] These documents, along with other strategic visionary papers (both CAN and foreign) contain common overlapping themes of a future that is unpredictable, volatile and requires great amounts of flexibility in our defence organizations.

In order for the CA to remain flexible to meet the needs of *close engagement*, the corresponding support organizations need to remain in step with the strategic vision from the top. This will ensure that support organizations modernize/adapt when required in order to stay relevant and most importantly, useful. Within LEMS, the RCEME Corps is no exception.

It is recommended that the RCEME Corps immediately invests in advanced diagnostics and data analytics, incorporating these practices down to the unit level. Consideration should also be given to leveraging contracted maintenance to alleviate workload pressures on our technicians and free up PYs for additional analytic staff. These initial steps would immediately lead to an increase in organizational effectiveness and provide future flexibility to meet the

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[58] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Close Engagement: Land Power in an Age of Uncertainty*. Canadian Army Land Warfare Centre, Level 1 Circulation Draft, Ottawa, 2017, 3

[59] Canada. Dept. of National Defence, and Canada. Ministère de la défense nationale. *Strong, Secure, Engaged: Canada's Defence Policy.* National Defence = Défense nationale, Ottawa, Ont., 2017.

needs of the Army of tomorrow. Future maintenance organizations will be data-driven, this is something that must remain in the thoughts of the decision makers within the LEMS and the RCEME Corps.

Further areas of research could include a holistic look at the supply systems' ability to stock sufficient parts in the right place at the right time to allow more efficient methods of maintenance to succeed. Another area of great potential would be to work with and analyze large corporations, such as Qantas, to leverage their data analytic processes to our advantage. There is no need to build capability from scratch.

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