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THE CASE FOR ADAPTABILITY OF THE LAND EQUIPMENT MANAGEMENT SYSTEM: MOULDING THE SQUARE PEG

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ABSTRACT

In order to be responsive to an agile CA of the 21st century, LEMS must significantly become more adaptable. Increasing the adaptability of LEMS is a difficult challenge because of the dated management and control practices inherent to the system. These practices serve to continually increase the rigidity of structure and process of LEMS, along with the strengthening of a culture resistant to change. Application of today's information technology must not simply reinforce existing vertical hierarchical channels. Horizontal networks need to be formed to empower individuals in the system to collaborate. LEMS is too complex to reduce it to finite segments with centralized control. Networks can distribute decision making across LEMS and can provide system-wide performance measurement. Returning to first principles of maintenance and harnessing the innovation and creativity of soldiers are key ingredients to an adaptable LEMS.

TABLE OF CONTENTS

INTRODUCTION

In response to the uncertainty of the future operating environment,[1] exponential growth in technology, shifting political appetite on the use of the military[2] and the continual quest for increased value of public services for the Canadian society,[3] the Canadian Army (CA) must become more agile.[4] The resulting impacts on the Land Equipment Management System (LEMS)[5] are significant. Resource pressures will continue to escalate as will the need for performance metrics to demonstrate predictability of outputs. CA operations will necessitate a shift in maintenance service delivery. Cost efficiency and tighter discipline of LEMS activities will be expected.[6] These pressures suggest a growing complexity of LEMS and an analysis of its ability to remain responsive to the CA is warranted.

The Corps of Royal Canadian Electrical and Mechanical Engineers (RCEME) is the driver of strategic governance of the LEMS. RCEME, which does not own this system and acts as its custodian on behalf of the CA, may stand unintentionally ill-equipped to ensure LEMS can

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[1] Department of National Defence, *Land Operations 2021: Adaptive Dispersed Operations: A Force Employment Concept for Canada's Army of Tomorrow* (Ottawa: DND Canada, 2007), 4. The premise of this document is that the future security environment "will continue to exhibit high volatility and uncertainty."

[2] David Pugliese, "Trudeau Sends Message to Military and DND Staff", Ottawa Citizen, 13 November 13, 2015. Pugliese quotes Prime Minister Trudeau when he stated: "…making [Canada's military] stronger and leaner, more agile, and better equipped".

[3] Office of the Prime Minister, *Minister of National Defence Mandate Letter* (Ottawa: Office of the Prime Minister, 2015). Prime Minister Trudeau is clear in his message to the Minister of National Defence when he states: "We have committed to an open, honest government that is accountable to Canadians, lives up to the highest ethical standards, and applies the utmost care and prudence in the handling of public funds."

[4] "Agile" is not new since the CAF has always been asked to perform various functions at the will of the government. The Canada First Defence Strategy highlights the various mission sets that the CAF may be asked to perform, thus implying a degree of agility. Of late, however, agility seems to be at the forefront of institutional leaders. Both Commanders of the Army and Airforce has clearly stated the need to be more agile. Case in point is the Airforce's Airpower In Formation one-pager with an RCAF Vision that states as its first element "agile".

[5] Department of National Defence, B-GL-300-004/FP-001, *Sustainment of Land Operations* (Ottawa: DND Canada, 2010), 4-1. LEMS is "a fully integrated, coordinated and self-sufficient system that encompasses the entire spectrum of equipment management and is designed to support equipment from the factory through to the most forward fighting elements".

[6] Department of National Defence, B-GL-342-005/FP-000, *Strategic Management Plan: Horsepower for the 21st Century* (Ottawa: Director of Royal Canadian Electrical and Mechanical Engineering, 2014). The listed impacts on LEMS was extracted from the Strategic Management Plan of the Corps of RCEME as well as an unpublished draft presentation that attempts to review the vision of LEMS from this 2014 publication.

tackle challenges of a 21st century CA. Born out of necessity of keeping Canada's fighting equipment operational during World War I, LEMS has had to adapt and mould its structure, processes, strategy and people to the needs of its customer and of the strategic environment. Thought processes, control mechanisms and problem solving methods of LEMS were forged from the industrial era and have stood the test of time to serve the CA well in past operations. There is merit in questioning whether LEMS, a system developed in a period that pre-dates today's information technology, will continue to be in a position to support the CA. What will an agile CA demand of its maintenance system? How can LEMS navigate the diverging requirements of agility and strategic requirements of predictability inherent of public administration? If change is needed, does LEMS need a complete revamp or does it simply need additional capacity in certain areas? Surely these questions are being asked right now by LEMS stakeholders[7]. This paper suggests that these stakeholders are ill-equipped to answer the questions because the very system, to which they belong, is very rigid thus inhibiting creativity and innovation.

What This Paper Does

This paper posits that LEMS must become significantly more adaptive to support an agile CA of the 21st century.[8] To do so, it must recognize that it has stagnated in development of its control mechanisms and has had difficulty in applying modern concepts of the management of

[7] Department of National Defence, *Strategic Management Plan….* This document explicitly recognizes the need to evolve LEMS for the future CA.

[8] Agile is defined as "having a quick resourceful and adaptable character" while adaptable is defined as "able to change or be changed in order to fit or work better in some situations or for some purpose". Both definitions are from www.merriam-webster.com and were extracted on 17 April 2016. When considering these and multiple other available definitions, agile can be associated with the characteristic of being nimble, without explicit need of being modified to achieve the different states in the spectrum of nimbleness. Conversely, adaptive implies an element of change to achieve desired effect. Since LEMS is a sub-system of the CA – notwithstanding the non-CA stakeholders of LEMS such as Assistant Deputy Minister of Materials – it is assumed that LEMS would have an obligation to hold the ability to change or modify its output to the CA as the latter attempts to be responsive to its strategic masters.

complex systems. As a consequence, LEMS has grown increasingly rigid in structure and processes, and thus less responsive to a volatile future operating environment. Current attempts to modernize the system[9] are ill-suited for the task at hand. The application of new information technology is currently being used to strengthen the vertically aligned hierarchical structure that further cements the rigidity of the system. LEMS will become more adaptive by harnessing the power of horizontal networks that empower low level actors to contribute. LEMS must also return to first principles and re-examine its maintenance practices rather than riding on the coat tails of a culture resistant to change.

This paper has a goal of analysing whether LEMS in its current form will remain responsive for the support of an agile CA of the 21st century. As a framework, the analysis will principally revolve around theories of complex systems and their control to gain an understanding of why LEMS evolved to its current state. The impact of the growth of information technology on these theories, as it will be determined through an historical and academic analysis, is the crux of the arguments of this paper. Limitations in communications and information processing that had influenced the evolution of control of systems along with their structure and processes, are being lifted through developments in technology. The lifting of these limitations will be seen to enable the softening of the rigidity of structure and process of hierarchical control mechanisms, thus allowing a system to remain responsive to inputs and desired outputs. Therefore, a correlation between information technology and adaptability of LEMS will be made.

[9] K.J. Hamilton, *Director RCEME Initial Planning Guidance – LEMS Governance Working Group* (National Defence Headquarters: file 3000-4 (DLEPS 4-5), January 2016. This document, along with the 2014 Strategic Management Plan highlight some of the proactive work done by the Corps of RCEME in its attempt to modernize LEMS.

Simple adoption of more computers will not be suggested, for this would undermine the intent behind the use of technology in modern control mechanism: the development of networks. The use of networks, as it will be explained, enables an organization to gain, use and share information that would otherwise be limited in scope given its (and its peoples') inherent limitation to process information. The network will be seen as the backbone to an adaptive system, for it empowers stakeholders, creates social structure as it takes in consideration the human aspects of systems, augments the overall capacity of the system to perform its function, and can provide an ability to respond to emerging situations. So through networks, the disparity between the system control mechanisms that emerged from the industrial age, as adopted by LEMS, and those possible with today's information technology will shrink.

What This Paper Does Not Do

This paper is a thought piece and hence incomplete in detail. It is not a model to follow, but rather a framework to consider for continued development of strategic vision for LEMS. The reader, who is assumed to have working knowledge of LEMS, will not be subject to detailed action plans for specific solutions, nor will he/she bear witness to new doctrine. Rather, the expectation is that the reader will be subject to an alternate view of a typically hierarchical and vertically aligned structure, which tends to centralize control and to which there seems to be no other alternative. This paper presents a modern to view to the strategy of keeping LEMS responsive to the CA. It reconsiders the traditional methods that tend to centralize control and marginalize input from the lower levels of the hierarchy.

Simple adoption of private sector "best practices" will not be blindly suggested. Rather, the context of working in the public sector will be taken in consideration when examining

innovative ideas from the private sector. The intent behind worthy private sector practices is seen as more valuable than the method of adoption of such practices.

Additionally, the current constraints on LEMS that are seen as being solvable through the concepts provided in this paper will not be emphasized. For example, limitations that information security regulations impose on a wider use of information technology on the battlefield are assumed to be solvable through a mixture of wider acceptance of technology, risk, and uncertainty, and lower levels of control. Deeply ingrained traditions, linearity of thought, protectionism of trade divisions and other artificially imposed constraints could be diluted through a culture of change that an adaptable system could bring about. And lastly, the traditional vertically aligned hierarchies will be considered as being able to coexist with horizontally oriented networked organizations inherent of adaptive systems. This non-exhaustive list of constraints should not cloud the reader's perception of the framework of adaptability proposed in this text and thus an open mind is required.

Road Map

The basic breakdown of the paper is as follows: context leading to the current status of LEMS is provided Chapter 1, the impact of the growth of information technology on control mechanisms is contained in Chapter 2, and Chapter 3 provides recommendations to increase the ability of LEMS to adapt. More details are provided below for each chapter before embarking on the analysis.

Chapter 1 will consider how LEMS became the system that it is today from historical and academic standpoints. It will be shown that the very existence of the CA's maintenance system is rooted in the First and Second World Wars and its management practices from the industrial revolution. Of particular interest are the increasingly rigid structure of LEMS as it grew in

complexity, the marriage of replenishment and maintenance activities that remains prevalent to this day, and the culture that resists change. The short historical examination will be anchored on theoretical views of systems to understand why the evolution of LEMS occurred as it did. Importantly, LEMS development will be shown to have paralleled prominent control and systems theories that pre-dates the widespread use of the internet and social media.

Chapter 2 will examine modern control mechanisms of complex systems that emphasize concepts that may be foreign to traditionally hierarchical systems such as LEMS. It will also consider relevant academic work focussed on the use of networks to enable systems to grow and adapt, and the modernizing of public administration practices.

The last chapter will tie the text together. It will provide ideas for implementation with intent of creating an adaptive system of maintenance. It will provide general capacities that the system should emphasize and it will make bold suggestions to tackle the challenges inherited from dated control mechanisms. These recommendations will be mostly tactical in nature – though not without impact at the strategic level - and most will be within a realistic grasp for actual implementation.

CHAPTER 1 – LEMS: FROM THEN TO NOW

In this first chapter, LEMS is viewed from a few angles: looking back in time to determine its history, looking in from the outside to draw parallels with systems and control theories in order understand why it evolved as it did, and finally from within to expose its culture. This analytical exercise will serve to understand how LEMS got to its current state. Throughout, a critical view of areas in which LEMS has stagnated in development will be made to set the stage for the analysis in Chapter 2, which will focus on the impact of information technology on control mechanisms.

LEMS History

What follows is a ferociously abridged history of the evolution of LEMS in the CA. The historical review starts with tactical maintenance and works its way to the strategic level. In the First World War, one of semi-static warfare and with limited complexity and quantity of machines, the CA witnessed one of its first instances of dedicated and organized maintenance organizations.[10] These were focused on the maintenance of artillery pieces and the small number of vehicles. While quite decentralized in nature, the rudimentary maintenance system of the early 1900s consisted of recovery teams serving specific or a group of units (first line), divisional level workshops (second line) and other larger static workshops (third line).[11] The dramatic increase of manoeuvre and sheer volume and complexity of equipment of the Second World War brought an exponential increase in the number of technicians and the greater need to centralize control of maintenance activities.

[10] Murray C. Johnston, *Le 50^{e} des artisans du Canada* (Borden: Fond Des Officiers Du GEM, 1997), 22. Shortly before the First World War, artillery pieces with hydraulic recoil mechanisms sharply increased the need for knowledgeable technicians at the mercy of the equipment.

[11] *Ibid.,* 45.

The Army had learned, most famously through Rommel's success in North Africa from rapid and responsive maintenance assets far forward, that units required the necessary resources to maintain combat power, while being not so cumbersome as to hinder manoeuvre.[12] The invasion of France on D-Day and future battles solidified the hierarchy of maintenance organizations due to the necessarily long lines of communication and vulnerability of front line units, thus needing to hold static workshops rearwards and mobile repair and recovery teams forward. In concert with the refinement of the replenishment system, also featuring deliberate lines, or echelons, the maintenance system was subject to the availability of parts. A worthy sidestep is to discuss the evolution of lines of maintenance since they remain ingrained in maintenance doctrine to this day and geographically constrain the delivery of maintenance on the battlefield.

Lines of maintenance were created within the Allied Forces during the First World War.[13] The basic principle was to ensure expediency and a light foot print of the forward units with the provision of recovery assets and resources for light repairs. "Working rearward, maintenance support [was] progressively provided by better equipped, and more sophisticated static [workshops]."[14] The segmenting of maintenance organizations and the type of repairs they conducted meant that the requirement for replacement parts was dependent upon the location of the workshop. Recipients of parts were at the mercy of the throughput of the lines of communications and unit integral carrying capacities. Thus the intricate dependency of maintenance organizations on the parts replenishment system was born during this period. Lines

[12] Murray C. Johnston, *Le 50^{e} des artisans du Canada*, 54.

[13] *Ibid*. Colonel Murray Johnston provides in his book a detailed account of the development of the British and Canadian maintenance organizations and procedures. No evidence is shown of attempts to organize maintenance resources in ways that differ considerably from having established lines, whereby there is an increasing deliberate nature of repairs as equipment is moved rearwards in the linear battlefields of both World Wars.

[14] Department of National Defence, B-GL-314-002/FP-001, *Maintenance in Battle: Volume 2* (Ottawa: DND Canada, 1989), paragraph 9.

of supply had been created following a concept of a "three-tier supply system" of the mid-19th century. The renowned historian Martin Van Creveld suggests the Allied Forces borrowed the tiered supply system from the Prussian Army. The Chief of Staff of the Prussian Army, Moltke the Elder, had sought to make more effective use of marching armies.[15] Moltke's system was focused on food, fodder for horses and other basic needs that preceded the necessity of spare parts, but the general concept of replenishment remains in use today in the CAF. Still vivid today are the strong links between lines of supply and lines of maintenance. The fundamental necessity of this marriage is challenged later in the text and will be viewed as a mere convenience with unintended consequences.

Another relevant factor stemming from the early 1900s revolves around the authorities vested in lower levels of LEMS. Being a new system during a period that the CA defined itself, LEMS was subject to centralized control stemming from the strategic level though with much more authority vested in the operational and tactical levels. This latitude fostered adaptability of the tactical maintenance structure and processes, and innovation. The composition of maintenance organizations varied dramatically to suit the needs of the Army. Flexible regrouping continually occurred to account for the mechanization of battlefield equipment and changes in tactics. The ingenuity of technicians and officers was harnessed. Witness the famous projects to transform Vickers guns into anti-aircraft weapons[16], the vehicle preparations for fording operations during D-Day[17] and the modification of self-propelled artillery vehicles into armoured personnel carriers known as Kangaroos.[18] These are a few of the multiple examples of innovation on the battlefield. Capability deficiencies were answered with the modification of

[15] Martin Van Creveld, *Supplying War: Logistics from Wallenstein to Patton* (Cambridge: Cambridge University Press, 1977), 116.
[16] Murray C. Johnston, *Le 50e des artisans du Canada*, 52.
[17] *Ibid.*, 80.
[18] *Ibid.*, 99.

existing equipment through the collaboration of RCEME technicians and industry, the coordination of the supply of parts and infrastructure, and operational level command direction. This level of latitude at the operational and tactical level is now far removed and has been placed at the strategic level.[19]

Post war years brought multiple changes to maintenance organizations, though little to the concept of segregated maintenance responsibilities on the battlefield. The establishment of Service Battalions in the late 1960s[20] further cemented the rigidity found in today's battlefield, whereby a brigade level workshop operates within set parameters (second line), as do unit maintenance platoons (first line). This modus operandi is diligently guarded, as witnessed in the recent publication on sustainment by the Army stating: "The echelon system must be maintained and reinforced as the CA prepares for future operational environments."[21]

LEMS has been shaped over the years by several strategic level factors. Colonel (Retired) Johnston asserts in his book *Canada's Craftsman at 50*, that LEMS has had to survive the Canadian Forces integration of the late 1960s, the drastic budget cuts of the post-Cold War period, the move from manual to computer assisted management, and of course advances in technology and associated procurement woes. In the early 1970s, efficiencies were needed to coordinate the responsibilities of engineering activities and thus the life cycle management program was created. This program was then further enabled as project management teams emerged in the early 1980s. It was in 1995 that engineering and maintenance functions were

[19] Today, the modification of equipment is subject to approval from the appropriate directorate within DGLEPM. Also, the adjustment of size and composition of maintenance organizations is a very restricted exercise with two major stakeholders: the Canadian Army Headquarters and DGLEPM. Latitude in reorganization of maintenance elements and the modification of equipment (and repair techniques) once possible are now controlled at the strategic level.

[20] Murray C. Johnston, *Le 50e des artisans du Canada*, 323.

[21] Department of National Defence, B-GL-340-000/FP-001, *Sustain: The Operational Function* (Ottawa: DND Canada, 2015), 24.

fused.[22] This created the Director General Land Equipment Program Management (DGLEPM) that still exists today. [23]

In sum, LEMS is a product of necessary development of maintenance organizations to meet the needs of the CA on the battlefield and of institutional growth shaped by political and strategic imperatives. Maintenance activity at the tactical level remains largely unchanged since the early 1900s though maintenance organizations have a diminished ability to adapt to the needs of the Army.[24] Lines of maintenance have stood the test of time and continue to be explicitly tied to lines of supply – perhaps unnecessarily. Lastly, the Corps of RCEME had proven its invaluable worth on the battlefields of yesterday, while today technicians and officers are restrained by strategic level control that inhibits innovation.[25]

To further understand the origins of control mechanisms that shape LEMS, the following sections will examine the growth of traditional system management practices and the evolution of control of large complex organizations. The last section will examine the culture that has formed in LEMS and the organizational inertia that has ensued.

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[22] Murray C. Johnston, *Le 50e des artisans du Canada*, Chapter 12. Before the creation of DGLEPM in 1995, equipment maintenance fell under the responsibility of the Director Electrical and Mechanical Engineering while equipment acquisition, design and standardization fell to a myriad of Army organizations such as the Army Development Establishment, the Army Engineering Design Branch, and several others.

[23] *Ibid.*, 309.

[24] Today, maintenance organizations are rigidly ingrained in unit strengths. Person-years are difficult to amend. In the case of operational deployments, standard maintenance organizations are first developed on paper as a reference, then adjusted commensurate with requirements and actual availability of technicians. This process is typically lengthy and difficult. In garrison, it is rare that maintenance organizations are modified, except for large scale exercises or in the event of significant equipment redistribution. Removing main battle tanks from an armoured regiment, for example, would be an instance where the maintenance organization would be reconfigured. Multiple instances of inadequate person-years in maintenance organizations do exist today and prove to be difficult to rectify due to personnel shortages and caps imposed on total unit strengths (thus inhibiting the growth of a maintenance platoon, for example).

[25] The basis of this comment will unfold throughout this chapter as the reader grasps the theories of control and resulting impact on culture.

Shaping the Institution

In order to contextualize LEMS within the strategic realm that shapes its structure, it is worth considering the implications of the management system that controls the DND: the Defence Planning and Management System (DPMS). This will serve to highlight some of the strategic imperatives that LEMS faces and temper ideas of vast remodeling of this system.

The administration and management of the DND is a cumbersome though necessary endeavour that transforms public funds into a useful and coercive force.[26] As a public good, the DND must judiciously follow the accountability requirements of the federal government. Stemming from this are the requirements to forecast and maintain some level of predictability of expenditures. The DND will be expected to cast long range forecasts on expenditures, find internal efficiencies, and respond to the needs of the government with a multi-role military - even with limitations imposed on the procurement of replacement equipment as recently announced in the 2016 federal budget. Thus, capital programming is essential, as is performance measurement. These requirements are not self-imposed by the DND for altruistic reasons, but rather to comply with evolving government direction on expenditure and standards of management and reporting.

The DPMS has evolved over time to accommodate higher level reforms and consequent internal reviews to satisfy the requirements of transparency and accountability to the Canadian public. Instances of the latter are wide ranging and include the Glassco Commission of the early 1960s (to provide more structure and long term forecasts to budgeting). The Glassco Commission gave birth to the Program Planning and Budgeting (PPB) System that attempted to associate departmental goals and funding[27]. Donald Savoie, a renowned Canadian expert in

[26] Douglas Bland, "The Public Administration of Defence Policy", in *The Public Management of Defence in Canada*, ed. Craig Stone (Toronto: Breakout, 2009), 11.

[27] Donald J. Savoie, *The Politics of Public Spending in Canada* (Toronto: University of Toronto Press, 1990), 53-55.

public administration, explains that the PPB System was a failure and it served to increase the already centralized control of resources in government.[28] Where the PPB lacked – in the control and management of the budgetary system in order to control the growth of expenditures - the Policy and Expenditure Management System (PEMS) was expected to fill the void. PEMS was "conceived as a collective top-down decision-making process"[29] for the setting of expenditure limits and priorities. Under PEMS, a link was made between the planned results and the allocation of resources. Savoie argues that along with PEMS was a series of regulatory and administrative restrictions put in place to provide the necessary control and feedback mechanism.[30] The budgetary process therefore became "overly bureaucratic"[31] and it was acknowledged that reforms were needed to curb the growth in expenditures.[32] In the late 1980s, there was a culture of tightening the strings on resource allocation and the well-known budget cuts of the 1990s are the result. This oversimplification of the politics of public spending serves to demonstrate that public policy casts long shadows in how the DND manages is programs. Case in point, the Treasury Board Secretariat, in response to government policies, introduced the Management Accountability Framework (MAF) and the Management Resources and Results Structure (MRRS) which, respectively, standardizes management and reporting practices for the public service to which the DND is subject to.[33]

The DND must have a disciplined management process to respond to the strategic conditions imposed on the department.[34] It must be transparent and predictable, follow regimented management practices and establish performance measurement methodologies to

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[28] Donald J. Savoie, *The Politics of Public Spending in Canada*, 59.
[29] *Ibid.*, 62.
[30] *Ibid.*, 68.
[31] *Ibid.*
[32] *Ibid.*, 326.
[33] Gregory Burt and Shawn McKnight, "Defence Strategy Management", in *The Public Management of Defence in Canada*, ed. Craig Stone (Toronto: Breakout, 2009), 20.
[34] *Ibid.*, 35.

remain accountable.[35] The problem lies in the need for predictability that runs at cross-purposes with the ever-increasing amount of uncertainty of future operating environments, technological developments and changes in political direction of the military. To reflect strategic imperatives that include public policy, the DND itself undergoes reforms, such as the Management and Command and Control Re-engineering (MCCR) process. The MCCR served to adjust the DPMS with aims of reducing costs, increasing efficiencies, and ensuring prioritization of activities. The MCCR mirrored business process re-engineering efforts that became popular in the private sector in the early 1990s. The inherent characteristic of the DPMS is that it serves to further centralize the control of resources and operational activities at the highest level. It also introduced control mechanisms aimed at ensuring compliance rather than system performance. As Major General Demspey states, the resulting issue "is one of exercising individual and collective leadership of the overall defence enterprise so as to produce relevance, responsiveness and reputation."[36] LEMS falls prey to this counter-productive effort of self-preservation and will be discussed in the last section of this chapter.

LEMS finds itself in an awkward position. At the strategic level, LEMS is at the mercy of government needs of predictability, forecasting and accountability. At the tactical level, it is required of LEMS to be flexible to volatile operational needs. It must also be responsive to changes of force employment concepts, redundant to account for operational risk, accepting of generational gaps of its personnel, and accepting of unpredictability and uncertainty stemming from various maintenance needs across the country and around the globe. The dissonance

[35] Ross Fetterly, "Budgeting for Defence", in *The Public Management of Defence in Canada* (Toronto: Breakout, 2009), 43. This statement is based on the key principles of the Expenditure Management System: establishment of a stable environment, early strategic planning, consultation with Canadians and parliamentarians in the budget, and evaluation of the process. Interestingly, the last key factor considers the process rather than the measurement of the result of the expenditure in comparison with the intended purpose.

[36] D.L. Dempster, "Generalship and Defence Program Management" in *Generalship and the Art of the Admiral: Perspectives on Canadian Senior Military Leadership, eds Bernt Horn and Stephen J Harris,* (St. Catharines, Ont: Vanwell Pub, 2001), 439.

stymies but does not break the system of maintenance. The coping mechanisms are centralized control and rigidity of process and structure, all too familiar to most public systems or organizations. But why?

Evolution of Control

This section seeks to explain why centralized control and rigidity exist in LEMS and shows no sign of letting go. Centralization of control is not a cause of technological advances, but rather a consequence. This is what James Beniger calls the "Control Revolution"[37] and it will serve to identify reasons why LEMS remains a highly centralized system. Beniger's book, *Control Revolution,* pre-dates widespread use of the internet but his theory of control remains valid. What differs nowadays are the exponential increases in information processing and efficacy of communication systems. These advances are non-trivial and require a short foray into control theory to understand their impact.

In his first chapter, Beniger explains in detail the societal, economic and cultural impacts of the industrial revolution. Advances in energy production, transportation, manufacturing and other sectors required heavy investment in capital – labour wages, energy, machinery – and had added an increasing amount of complexity to systems.[38] The complexity of systems was mitigated by reducing the system to compartmentalized and interdependent elements.[39] This meant that localized economies of goods and services made way to more global and segmented markets that responded to higher levels of organization. As a consequence, producers of goods were distanced from the consumers. This separation effectively cut the feedback loop required to manage supply and demand. As a result, the management of funds, transportation and

[37] James R. Beniger, *The Control Revolution: Technological and Economic Origins of the Information Society* (Harvard University Press, 1986), 6.

[38] Complexity relates to the interdependence of various elements of systems.

[39] James R. Beniger, *The Control Revolution…,* 11.

distribution became more complex. The growing difficulty for coordinating and communicating between the increasingly segmented and large components of the system - commerce in this case - was characterized by Beniger as a "problem of integration."[40]

Before delving further, a few parallels can be drawn to LEMS. The maintenance activities and procurement efforts became increasingly more complex and segmented as the world wars progressed. Witness the segregation of lines of maintenance, the creation of recovery teams and static workshops, the delineation of responsibilities for part replenishment and maintenance activity, and the creation of specific trades to respond to the growing complexity of repairs. More recently, the creation of project management organizations along with life cycle management processes, are examples of segmented and interdependent components of the system of maintenance. Considering for an instant how difficult life cycle management would be for billions of dollars of equipment spread across the globe without today's information management tools, the problem of integration that Beniger points out becomes obvious.

Another notable consequence of the industrial revolution that is germane to this study is the psychological effect on individuals. Anomie, "the breakdown of norms governing individual and group behaviour" is a problem arising from the breakdown of society into segmented components. [41] The problem lies not in the division of society into segments as there is merit to having common goals. Rather, the increasing isolation of the segments stymies communication between people in different groups and these individuals can "lose sight of the larger purpose of their separate efforts."[42] In the case of LEMS, segments can be conceptualized as being different trades, separate maintenance organizations, or the divide between tactical maintenance and project managers in Ottawa. In each case, there is an inherent set of blinders affixed to each

[40] James R. Beniger, *The Control Revolution…,* 11.
[41] *Ibid.*, 12.
[42] *Ibid*.

soldier and organization as they focus on their own realm with limited and difficult access to the decision makers at the highest level of control. The resulting psychological effect on soldiers will be considered in the last section of this chapter.

Returning to the problem of coordinating complex systems, it is fitting to consider how the problem of integration was mitigated. By definition, this problem stemmed from a lack of communication and information processing capacity to handle the increasingly complex organizations, the rapid growth of energy and transportation networks, the issue of anomie discussed above and the expanding geographical reach of markets.[43] As Beniger noted, a crisis of control was born. The solutions laid in a myriad of mechanisms aiming to ease the control of systems. The solutions included bureaucracy, rationalization, control of production, and control of distribution. The first two will be discussed in more detail.

Bureaucracy grows when control of activities toward specific goals is needed. The concept is not new as noted by Max Weber, a German sociologist and philosopher. Bureaucracy started to have appreciable impact during the industrial revolution in the early 1900s. Weber saw bureaucracy as a control mechanism that tended to minimize human influence in processes. Through clear division of labour, adherence to processes and strict hierarchy, control of systems would then become a rational and methodological process. An interesting note from Weber, as cited by Beniger, is that "the stability and permanence of bureaucracy are assured through regular promotion of career employees based on objective criteria like seniority."[44] A striking parallel can be drawn with LEMS though perhaps with a lesser emphasis of strict separation of control from human input as Weber suggests.

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[43] James R. Beniger, *The Control Revolution…,* 11.
[44] *Ibid.,* 15.

Rationalization, also identified by Weber, relates to the control the information. Specifically, he and his followers posited that "control can be increased not only by increasing the capability to process information but also by decreasing the amount of information to be processed."[45] The capability to process information has been taken care of by the exponential growth of development in technology. Whether the CAF has taken full advantage of implementing these technologies is a different matter to be considered later in Chapter 2. The latter portion of Weber's theory of control - reducing the amount of information to process - is referred to as rationalization. While straightforward as a concept, it has had deeply ingrained repercussions in society to which LEMS was not immune. Rationalization is a reductionist concept that aims to simplify, segment and even eliminate information to enable the controlling of complex systems that would otherwise be overloaded with data. This notion is supported by Canadian professor of public policy, Leslie A. Pal. He argues that the reduction of information served to benefit public administration and "has deep roots in an impulse to centralize, categorize and control."[46] Within LEMS, examples of rationalization are abundant and it is worth listing a few for illustration purposes.

The control of maintenance activity on the battlefield lent itself to the reduction of information by way of standardized reports and returns that were easily transmitted through overloaded radio bandwidth. Examples include the Status of Maintenance Resources (SMR), Repair/Recovery Request (RRR), request for the release of controlled stores and a plethora of others that are used by the CA writ large. Most reports and returns are ingrained in doctrine and have stood the test of time despite often being subject to complaint due to the difficulty of

[45] James R. Beniger, *The Control Revolution…,* 15.

[46] Leslie A. Pal, *Beyond Policy Analysis: Public Issue Management in Turbulent Times* (Toronto: Nelson, 2014), 21.

transmitting the levels of detail perceived as necessary.[47] It would seem that it is simpler to live with the shortcomings of standardized reports than to accept deviations.

Rationalization also reverberates in LEMS through the marginalization and regulation of individuals, trades and organizations. Individual administration has been simplified by way of blanket policies. Human resource management is less than optimized in favour of strict career paths and the geographical move of technicians based on the generic requirements of the organization. Trade divisions have been protected to manage the training of technicians and to neatly segregate maintenance responsibilities among the trades. Maintenance organization and divisions of responsibility were once tailored to meet the demands of their dependencies and have remained largely unchanged in recent history for sake of simplicity.[48] Many more examples could be made and the idea generated here is that control of LEMS has, in part, been enabled by rationalizing or reducing the amount of information to process. A suggestion is not made here to completely avoid the rationalization of information, for the control of LEMS would be imaginably difficult. The point, rather, is that rationalization has had inadvertent consequences such as the growth of rigidity of structure and processes in LEMS and resistance to change.

Evolution of Culture

The preceding sections of this chapter described the development of LEMS and this section will consider the resulting culture. The intent is to further expand on earlier discussions of rigidity by demonstrating that it permeates in the culture of LEMS. The idea that culture

[47] An example is the Status of Maintenance Resources (SMR). The SMR is meant to relay to a formation headquarters the availability of second line maintenance resources (i.e. maintenance assets belonging typically to the Service Battalion). The SMR is laid out in pre-determined paragraphs to enable the rapid transmission of information via radio whereby radio operators omit the stating of information that both see as being fixed by doctrine. The problem lies in the difficulty of changing the fixed information to meet the realities of the maintenance organization in question. Also, the limited information that is provided in the SMR typically needs to be amplified through human to human contact during meetings. So the rationalization of information introduces information sharing constraints.

[48] It is recognized that many more factors affect the structure of maintenance organizations. The idea here is that a generic maintenance platoon, for example, serves as a standardized unit of measure.

creates organizational inertia will first be exposed. Subsequent elements of this section will provide example evidence of the inertia caused by culture in LEMS that serves to keep this system rigid in structure and processes.

Culture is defined in *Cultural Intelligence and Leadership*, a CAF publication, as: "the link between an individual and the social group, organization or milieu in which he or she lives."[49] The definition implies that societal beliefs and behaviours of a group impact the individuals that make up this group. There is a reciprocal relationship whereby individuals can also influence the group, commensurate with their position in the group and own beliefs and behaviours. Without this mutual influence of group and individuals, the culture of a group would not evolve. Evolving or adapting a culture is a difficult task because of two important factors: individuals of the group that do not believe in (or even know of) the need for change exert inertia, and those individuals that do press for change have been shaped over time by the very beliefs and behaviours that they are attempting to modify. In order words, the culture of a group inherently resists change.

A culture that resists change does have merit, however. Culture enables organizations to survive despite a high turnover of individuals and provides stability in tumultuous times. The downfall, from the perspective of LEMS, is that culture contributes to a lag in development of the system since development (that is based on first principles) is replaced, in part, by prevailing views inherent to the culture at hand. So, the reasons upon which systems characteristics were founded become distant from the intended result as the influence of culture sets in. Rationally, if process W was developed for reasons X and Y, process W becomes ingrained in culture over time. Since culture creates resistance to change, process W may not be amended despite changes

[49] Bill Bentley, "Systems Theory, System Thinking and Culture", in *Cultural Intelligence and Leadership: An Introduction for Canadian Forces Leaders*, ed. Craig Stone (Kingston: Canadian Defence Academy Press, 2009), 10.

in the first principles that originally guided its development (X and Y). This phenomenon is not new and most people could attest being subject to ideas, processes or structures that exist for the simple reason for having been that way for a long period.

The tenets of LEMS[50] will serve well to anchor the discussion on inertia caused by culture and aptly sums up the upbringing of LEMS:

-repair as far forward as possible;

-preventive maintenance is essential;

-LEMS organizations must be mutually supportive and their task assignment flexible;

-there must be suitable equipment reserves;

-LEMS personnel must be trained and equipped to fight;

-maintenance support is most effective when maintenance commanders have direct technical control of all LEMS resources; and

-LEMS must have engineering and fabrication resources to respond quickly to technical problems and new situations.

Through two World Wars, multiple overseas missions and extensive experience of technicians and officers that contributed to the shaping LEMS, these tenets were developed. They were developed because of the necessities of the battlefields of yesterday and have contributed to the cultural fabric within LEMS. Interestingly, the resulting culture in turn influences the soldiers on today's battlefield – through training, prevailing mindsets and methods – though the first principles that led to the development of the tenets are not necessarily apparent. Using the first tenet as an example, seemingly distant first principles that led to its development

[50] Department of National Defence, B-GL-342-001/FP-000, *Land Equipment Management System* (Ottawa: DND Canada, 2001), 8-9.

will be shown to have been replaced by rather blind application of habitual practices ingrained in culture.

Repairing as far forward as possible is an expression widely used in LEMS, principally by the Corps of RCEME. The original intent was to reduce the amount of equipment downtime by bringing the repair capacity to the equipment rather than the reverse. Through mobile repair teams, repairs that were expedient in nature were executed as close to the equipment casualty as possible. These necessary elements were what dictated "the possible": expediency of repair, parts and tooling availability, knowledgeable individuals, and relative security. In the tenet, the inclusion of the words "as possible" implies the necessity to adapt the location of the repair to the prevailing conditions. This is difficult when in doctrine the arbitrary time restrictions on repairs for first and second line maintenance organizations[51] disregard the drastic tactical manoeuvre changes that occurred since the departure from strictly linear battlefields.

Today, many restrictive elements of LEMS dictate the location of repairs. Principally, repairs are geographically restrained because of the marriage of supply and maintenance lines. Maintenance organizations are segmented and are under the authority of specific units who tend to not share assets unless ordered. Cooperation at the local level between maintenance organizations is limited due to vertical communication channels. Also, an immeasurable number of decisions are based on the prevailing idea of permanently segmented maintenance activity. These include parts scaling, mobile repair team allocation, backloading procedures, command and control paradigms, technical administration mechanisms, and others. While it would seem that the tenet – repair as far forward as possible - remains valid, the location of repair is determined by common practice rather than first principles, and culture contributes to keeping it this way.

[51] Department of National Defence, *Land Equipment Management System*, 26-27.

Using the definition of culture and one of the tenets as an example, the idea that culture contributes to the rigidity of LEMS was demonstrated. A culture that inhibits change and thus seeks to maintain status quo will be referred to as a *culture of protectionism* for easy reference throughout the remainder of the text. Examining the environment in which a new technician or junior officer entering the Corps of RCEME is exposed will assist in quantifying the culture of protectionism in LEMS.

As members of the Corps of RCEME are also members of Canadian society, there needs to be some level of harmony between the cultures of both groups, for without, it would be difficult to imagine how both could co-exist. Civil-military relations are widely discussed in academia and allegiance to a particular point of view is not of grave concern here. Rather, the point to be made resides with the degree of divergence of the culture of individuals within LEMS from the prevailing societal culture. It could be suggested that this level of distinction, particularly relating to the use of information technology, is rising particularly high. For instance, a soldier can quite literally in one instance be globally connected as anonymously as one's desire through personal electronic devices and, in another, be set back in time in a hierarchical vertical communication military chain bound by strict protocols and lack of anonymity. Since information technology is growing at a much more rapid rate than DND's ability to adopt it, the cultural divide will likely continue to grow. Individuals that associate more with a culture of global connectivity may not be attracted to the increasingly distant culture in LEMS. If already within LEMS, these same types of individuals may have limited interest in furthering the interests of LEMS, thus breeding organizational inertia.

The democratization of ideas prevalent in society in comparison with the CAF is an interesting example of the cultural divide between LEMS and society. In a globally connected

society, individuals are free to contribute their ideas through a dizzying array of possible venues – social media sites are examples. Individuals can be empowered by collaborating to the development of ideas and participate in philanthropic activities around the globe. In contrast, soldiers operate in diligently guarded vertical communication channels with limited ability to contribute. In LEMS, innovative ideas from technicians must methodically track upward the chain of command. The communication channels that must be used are not designed for collaboration by like-minded individuals across the various maintenance organizations. There is no option to "crowd source" ideas or resources to fuel projects that stem from creative soldiers. The use of social media is largely guarded. Soldiers in LEMS face a large contrast in their ability to contribute and collaborate when compared to their civilian-clothed alter ego. Limiting the democratization of ideas from soldiers implies a level of unilateralism in decision making that results in the protection of the system's strategic governance – itself characterized by organizational inertia.[52]

Upon entering the training system within LEMS, technicians and officers are first and foremost trained to operate at the tactical level. They are taught to dissect problems in finite chunks for ease of solving. Linearity of thinking is inculcated through the systematic breakdown of procedures in pre-determined sequences – battle procedure, standard operating procedures, the operational planning process and the estimate process are prime examples. There is immense value in doing so and the point to be made rests not with this practice of linear thinking at the tactical level. Rather, the point rests with the challenge that the breeding of linear thinkers poses when these individuals need to operate outside the necessarily narrow parameters of the

[52] Chapter 3 will addresses recommendations for the empowerment of soldiers in LEMS and to harness their collaboration.

battlefield. When transitioning to the leading of an institution, or navigating complex challenges that involve various non-CAF stakeholders, linear thinking has severe limitations.

The limitations of linear thinking revolve around the effects of marginalizing the impact of human beings in systems, which is common practice in tactical level problem solving.[53] So, while linear thinking has its place, inculcating it in the training of technicians and officers blinds them to alternate methods of approaching problems. Again, this serves to create a culture of protectionism as leaders in LEMS typically resist ideas that do not necessarily fit well with their mental models forged by years of linear thinking practice. An example is the difficulty in accepting, at the tactical level, that a contractor will own the repair parts for the new tactical armoured patrol vehicle up until they are installed – the introduction of another layer of uncertainty brought by the handling of parts by a non-CAF organization is currently mystifying a large number of sceptical tacticians.[54]

Technicians and officers (and their ideas) are being marginalized at the tactical level. Earlier in this chapter the idea of rationalization served to explain one reason why this is so: to minimize the amount of information for ease of control. By de-humanizing processes, organizations become easier to control and their performance more manageable. In LEMS, technicians and officers learn from an early stage that their career path is laid before them with limited ability to deviate. They learn that decision making is a linear process that often can detract from using common sense. They learn that innovation is welcomed but very difficult to implement due to the rigidity of structure and process. Experience varies between every individual and these generic views are certainly biased by the author's opinion. But that is beside

[53] Linear thinking also effects on performance measurement and problem solving and these will be exposed in Chapter 2.

[54] Information gleaned from author during the past years of working at the tactical level as the tactical armoured patrol vehicle implementation plan was being developed and communicated to maintenance workshops.

the point. The point is that the marginalization of individuals in LEMS inherently marginalizes the use of their ideas. This contributes to creating a culture of learned helplessness. Learned helplessness is a sort of disabling ignorance or inaction when faced with opportunities that were previously inhibited by any sort of barrier – in this case the culture of protectionism and a vast array of rules, regulations and common practices of the CAF and LEMS. There are many occasions upon which individuals are offered the opportunity to provide input – conferences, commander's hours, group discussions, surveys - though it is common to witness but a few hands raise to offer insight. This suggests that pressing individuals to provide input on topics at a time dictated by the chain of command appears to be non-productive. Rather, an environment that lessens the marginalization of individuals and in which they could contribute on the topic and time that they choose – à la Wikipedia[55] - could serve to shrink the culture divide mentioned above and take advantage of potentially valuable input. The exact nature of the communication platform to use is irrelevant here. The general idea is the need to empower individuals to contribute more freely to the decision making bodies on any topic that concerns their life as a soldier. Be it their career, maintenance procedures, tooling, organizational structures, or any other topic, there must be a way to gather their input and encourage their contribution.

One last point on the culture of protectionism deals with the guarding of self-interests in the face of change. Consider the impacts on LEMS processes with the eventual integration of three dimensional printing, the self-diagnosing and self-healing properties of modern technology, or other emergent technology. If innovation means a loss of a function previously internal to an organization in LEMS, that organization will resist the innovation. If innovation means

[55] Wikipedia is an online encyclopaedia that is a self-correcting amalgamation of text from millions of individuals. Individuals provide input and can contribute at will, so long as the information is backed by credible references. The result is a rich source of information that is widely accessible and to which individuals *want* to contribute.

substantial modification of processes, the rigidity of LEMS will make the change difficult. The culture of protectionism in LEMS can serve as an impediment to innovation.

What is troublesome and invariably serves to foster resistance to innovation is the self-professed need of preserving relevance. The Corps of RCEME states in its centre of gravity: "the relevance of RCEME expertise to CAF operations."[56] There certainly are benefits to the Corps of RCEME given its need to fight for personnel, funds, infrastructure, training days and other resources that need to be shared with other CA entities. Though there is a philosophical argument that can be made here: relevance of RCEME expertise translates to preservation of RCEME expertise. This could run at cross purposes to innovation of the delivery of maintenance activity to the CA from a systems view (LEMS). For example, self-diagnosing vehicle and weapons systems with simple repairs consisting of assembly swapping – not unlike photocopier machines that do just that - could mean a decrease in the need for technicians in favour of increased operator maintenance. A self-preserving culture in the Corps of RCEME could stymie the implementation of such technology.

Summary

LEMS grew out of necessity to serve the equipment repair, life cycle management and acquisition activities required of the CA. Parallels were drawn between the development of LEMS and commonly accepted concepts used to describe the growth of any large scale system in the last century or so. The rise in complexity of maintenance activities of the early maintenance system marked a need for positive control of resources. Control was seen to be more effective by increasing the information processing power of the controlling mechanisms and by decreasing the amount of information to actually process. The former was constrained by available technology that caused the creation of vertical linkages to a central station. The latter cemented

[56] Department of National Defence, *Strategic Management Plan: Horsepower for the 21st Century*.

the centralization of control through bureaucracy, marginalization of people and processes, and a multitude of reductionist methods.

Along with the growth of rigidity in LEMS was the development of a culture that promoted resistance to change. It was seen that a system that breeds rigidity tends to breed a culture that complements, or even enforces this rigidity. LEMS is therefore characterized as having rigid structure and processes. It is controlled centrally at the highest level and has inculcated a culture that would make two things difficult: seeing that there is an issue with the present state of LEMS, and being capable of implementing change where needed.

The theories presented above served well to explain the general development of LEMS to this day. Since there is a strong link between information technology and control, it would suggest that further development of LEMS is related to its application of available technology. The next chapter will investigate this relationship of control and information technology within the context of the complex LEMS.

CHAPTER 2 – LEMS AND THE GROWTH OF INFORMATION TECHNOLOGY

It would be unfair to state that LEMS is unprepared to face the challenges of an agile CA of the 21st century simply because it lags behind in its adoption of information technology. The previous chapter outlined other reasons such as a culture of protectionism that resists innovation. These included ill-suited thinking skills tuned principally for tactical decision and strategic constraints such as funding, less than optimized acquisition and use of information technology and requirements for predictability. These elements are fundamentally shaped by traditional control mechanisms, which are influenced by information technology. It is thus the reason this why chapter will focus on the impact that the growth of information technology has had on systems and their control.

Chapter 1 explained that LEMS grew to become rigid in structure and process in large part due to the requirement to control increasingly complex maintenance activity and maintain accountability of resources. This control was itself limited by the available information processing and communications technologies. These limitations created vertical channels (hence centralization) and barriers that were overcame by the marginalization and reduction of information to process (hence rigidity). And to top it off, a culture of protectionism ensured that LEMS inherently resisted change. LEMS could benefit from harnessing the impacts of information technology to modernize its control mechanisms and reduce the rigidity of structure and processes. The resulting adaptability of LEMS would assist in remaining responsive to an agile CA.

This chapter will remove the barriers that inhibit the adoption of modern information technology in LEMS in order to consider the benefits. Importantly, it is the examination of what this information technology can provide, rather than the physical infrastructure that is of interest.

To do so, this chapter will first provide a basic understanding of the inter-connectedness of complex systems such as LEMS and modern problem-solving methods for such systems. This is where networks come into play: they are paramount for navigating challenges in complex systems and they provide a structure that enables the growth and dissemination of information. To explain and provide context to the notion of networks, three academic works will be examined: the advantages of networks from the point of view of growth of information (Hidalgo), the advent of use of networks in warfare (Bousquet), and application of networks in public administration (Bourgon).

How to Analyze a System

LEMS can be characterized as being complex and non-linear. This is generally derived from the fact that LEMS has a large number of elements that interact in a non-linear fashion (outputs are not necessarily proportional to the input) and their sum is not equal to the whole of the system.[57] That is, LEMS cannot be reduced to a finite series of smaller entities for purposes of problem solving for the basic reason that "the properties of the system as a whole are only meaningful when attributed to the whole, not to its parts."[58] An analogy may be useful to grasp the importance of this notion of complex system. Consider an automobile, itself a large number of parts assembled to form an object. There exists an assemblage that revolves around this automobile: that is, the many elements that are directly or indirectly impacted by any modification made to the automobile. For example, swapping the engine to one that is electric would impact parts manufacturers, factory production lines, factory worker skill requirements, petrol stations, the lubricant industry, boards administering various legislations such as emissions tests, advertisement messaging, and many others. LEMS is also an assemblage of sub-systems,

[57] Bill Bentley, "Systems Theory, System Thinking and Culture", 5.

[58] Peter Checkland, *System Thinking, System Practice* (Chichester: John Wiley and Sons Ltd, 1999), 314. This is the definition of emergent properties, a defining characteristic of complex systems.

organizations, economic and strategic ties, culture, infrastructure, and multiple stakeholders. The interconnectivity of each elements is what makes LEMS a complex system.

A characteristic of the wholeness of complex systems worthy of consideration relates to the measurement of performance. If a system cannot be reduced to finite segments for problem solving, it equally can be deduced that the measurement of performance of the system as a whole cannot be a sum of the performance of the segments. As Leslie Pal asserts, "a reasonable good decision is defined less by the process that produced it then by its appropriateness as a solution to the initial problem."[59] The segmenting of a system for ease of control is not in question. Rather, the idea is to consider the inter-connectedness of these segments when measuring performance. Measuring the performance of finite portions of a system may not take account the impact of actions taken to increase the output of portions of the system on others. This suggests that focus should be on measuring the effectiveness of a system in delivering products or services rather than the efficacy of finite portions of the system. This is the reality of operating in complex systems to which LEMS has been arguably slow to hoist aboard. As an example, a formation headquarters typically extracts data from its units in the form of equipment availability, time accounting of technicians, and stock on hand of low density parts that are controlled. The only integration of information is simply the averaging of percentage of equipment serviceability and a rather blind view of individual unit productivity level as it relates to amount of time technicians spend in various activities. The formation headquarters essentially attempts to add the sum of the parts of its maintenance organizations.

A more fulsome examination of the system of maintenance by the formation headquarters would serve to provide the commander with more reliable estimates of operational readiness. Additional system elements to measure could consist of spare capacity for units to assist others

[59] Leslie A. Pal, *Beyond Policy Analysis…,* 20.

(technicians, tooling, floor space, technical expertise), priority of repairs beyond the published lists, lag in the distribution system of parts affecting repairs, mean time between failure and mean time of repairs, actual effectiveness of preventive maintenance, etc. These types of assessments at formation levels could feed operational and strategic levels with knowledge rather than data and more aptly predict equipment availability for future operations. Currently, it is common practice for the strategic level of LEMS to directly extract time accounting data of individual technicians. It then sum the digits through spreadsheets and seeks from formation headquarters reasons that explain productivity levels. This type of analysis leads to frustration at the tactical level and unknown benefits at the strategic level. Further, the analysis ignores the influence of humans in the system.

All elements of LEMS have a human component that adds complexity. The human component of LEMS fundamentally influences the approach that should be taken to resolve problems or analyze system performance. Widespread literature on system thinking, the epistemology of the consideration of systems, revolves chiefly on the work on system theory by Peter Checkland. Checkland modernized work on the subject from the early 1900s. He coined the idea of soft system methodology for problem solving, which differentiates between "human activity systems" (soft) and "real world problems" (hard). Problem solving in hard systems will lead to a quantifiable and objective result. In soft systems, problem solving will lead to a result that is subjective to the observer rather than empirical or experimental evidence (also known as phenomenological stance).[60]

At the risk of oversimplifying Checkland's work, it can be stated that the human characteristics of systems render inadequate the traditional approach to management (of

[60] Peter Checkland, *System Thinking, System Practice*, 318.

optimizing).[61] Rather, Checkland argues that soft system methodology embodies a paradigm of learning (rather than optimizing). So rather than targeting solutions for perceived problems with only the use of pre-determined processes, the idea is to complement problem solving with inquisitive "investigations into the meanings which actors in a situation attribute to the reality they perceive."[62] Importantly, Checkland's methodology of soft systems favours the "usefulness [of actions] to the actors and not [their] validity to the analyst."[63]

What then can be extracted from Checkland's soft system methodology for the analysis of LEMS? Principally, it is the requirement to take into account the input of actors into problem solving rather than relying on pre-set processes and mental maps.[64] Also, linear thinking that is bred into tactical level leaders may not be the appropriate method to resolve complex problems in a human system such as LEMS. A Harvard Business Review article on frameworks for decision making amplifies this notion. The article emphasizes that in complex situations,[65] leaders tend to exert too much control over the organization and this tends to pre-empt patterns, innovation and creativity that may emerge.[66] This is not only applicable to problem solving, but also to policy making. One of many models to policy making includes the Walt and Gilson model with basic premise that classic policy making and analysis ignore the centrality of people.[67] This has two main implications: there needs to be a method to empower actors to provide input, and there must be a degree of acceptance of uncertainty and ability to deal with

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[61] Peter Checkland, *System Thinking, System Practice*, 278. This means that the "idea of manipulating models of the assumed reality in order to discover a solution which is either optimum or at least 'good enough' in a particular situation."

[62] *Ibid.*, 279.

[63] *Ibid.*, 283.

[64] *Ibid.*, A10. Checkland sums this up well: "In every situation there is a human situation in which people are attempting to make purposeful action."

[65] David J. Snowden and Mary E. Rose, "A Leader's Framework for Decision Making", *Harvard Business Review* (November 2007), 74. Complex situations are those in which problems cannot be broken into finite portions, there is a level of unpredictability, and many possible outcomes exist.

[66] *Ibid.*

[67] Gill Walt and Lucy Gilson, "Reforming the Health Sector in Developing Countries: The Central Role of Policy Analysis", in *Health Policy and Planning* (Oxford University Press, 1994), 353-370.

emerging, or alternate solutions to problems. Networks offer the linkage to actors while acceptance of uncertainty is reliant on a culture shift. These elements will be investigated in this chapter.

In sum, LEMS is too complex of a system to apply linear thinking for problem solving. Consideration must be made to focus on the performance of the system as a whole rather than the efficiency of its parts. Also, bureaucratic processes inherent of large systems cannot eliminate human intervention. Therefore, discreet and objective results when problem solving must give way to acceptance of uncertainty and emergence of alternate solutions. In other words, exercising strict and centralized control renders a system rigid and stymies innovation and creativity. An adaptive system, on the other hand, is one that favours information sharing among all actors. The value of information (and its growth) along with methods of sharing it are the topics of the next sections.

The Growth of Information

To complement the notion of the complexity of systems, the works of César Hidalgo will serve as a scientific look into the value of information and networks needed to share it. Hidalgo, a statistical physicist and Associate Professor at MIT, examined in great detail the relationships between the growth of information, how it is translated to knowledge and knowhow, and how the latter two are shared and stored. His research was directed at understanding the complexity of economies, and the material adequately informs the analysis on LEMS. The intent is to grasp the notion that harnessing the growth of information directly relates to the performance of a complex system.

Here, the reader will be spared of the interesting though lengthy discussion by Hidalgo on the inherent properties of information in nature. Rather, this analysis will outline the links that he made between the science of nature and the science of complex economies.

According to Hidalgo's research, three rules guide the growth of information in a complex economy. For the purposes of this analysis, information relates to the physical order of objects.[68] For instance, an engine is the orderly arrangement of parts, who themselves are orderly arrangements of atoms. In the case of LEMS, the growth of information translates to the growth of the system's ability to provide product and services to the CA. The three rules that govern the growth of information are: energy must be spent to create information (or physical order), there must be a way to store that information, and there is a need to be able to compute (or handle) the information.

Life is generally about generating order, which consumes energy.[69] Consider the effort needed to control any type of system: energy must be expended to exert control. Similarly, energy must be spent to impart knowledge and knowhow into a technician or officer through training and experience .[70] In Hidalgo's terms, an individual or an organization that is imparted with knowledge and knowhow is said to have gained physical order, or information.

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[68] César Hidalgo, *Why Information Grows: the Evolution of Order, from Atoms to Economies* (New York: Basic Books, 2015), 30. "The universe is made of energy, matter, and information". Hidalgo cites work from Ludwig Boltzmann, a scientist who devoted his study to the understanding of physical order. He was perplexed by the fact that in nature, order disappears – consider a gas that dissipates, and heat that flows from hot to cold. Conversely, nature was able to grow order through plants that blossomed, and social structures organized themselves. Hidalgo argues that "the idea of information took science by storm" in the 1950s and 1960s. The notion of information transcended science fields. Hidalgo's point is that information is physical, though not a solid or a fluid. It is "as physical as movement and temperature" and it is physical order rather than matter. The arrangement of a deck of card is information, and so is the way atoms are arranged to make a mechanic's wrench.

[69] The basic premise revolves around the second law of thermodynamics. The universe, which is expanding, tends to lead toward an increase of entropy, or disorder. Therefore in order to create order, there must be energy expended.

[70] César Hidalgo, *Why Information Grows…,* 38. Knowldege "involves relationships or linkages between entities […] that are often used to predict the outcomes of events with having to act". For example, knowing that gravity acts on all objects in proximity to Earth, one can anticipate that releasing a ball from a rooftop will cause it to fall to the ground. Knowhow, on the other hand, "involves the capacity to perform actions".

The second rule indicates that information must be stored in order to use it and act upon it to make it grow even more. In nature, information is stored in solids - the seed of a tree contains information that dictates what type of tree will grow. In LEMS, storing information is done in various forms. Information is stored by way of imparting knowledge and knowhow in multiple individuals, it is written down in doctrine, it is inculcated in culture, and it is ingrained in organizational structures and processes. It is the practical application of this information that forms the purpose of LEMS through the provision of maintenance activity and technical expertise. Hidalgo uses the example of toothpaste in a recorded dialogue about his research.[71] He asked the audience who had used toothpaste in the past day and received the expected result: everyone. He then asked who could synthesise sodium fluoride that makes the paste, and of course the crowd went silent. The point he made was that humans can "crystallize imagination", meaning that humans can store information through the ordering of physical order. This human ability enables the average person to use the knowledge and knowhow in their daily morning routine of some scientists at a faraway toothpaste factory for their purposes. In LEMS, the storing of information enables the practical application of maintenance activity in order to be responsive to the needs of the CA anywhere on the globe.

The last rule that guides the growth of information relates to the notion of networks. The rule states that computational capacity is required in order to use stored information and enable its growth in structures that are more complex. Returning to the seed of a tree, it can be said that it was able to compute the information that it had stored. This produced a tree with even more computational ability, for it can photosynthesise light and can orchestrate the shedding of its leaves. These are practical uses of information that the seed could not compute on its own.

[71] "Why Information Grows," YouTube video. Posted by "Talks at Google", 6 August 2015, https://www.youtube.com/watch?v=r38kK26SieE

In LEMS, the ability of one technician to compute (e.g. to apply his/her knowledge and knowhow) is lesser than the ability of a large maintenance organization. Similarly, the entirety of the system of maintenance can compute drastically more since it orchestrates the entire life cycle of equipment. LEMS is a human system, and Hidalgo asserts that embodying computational ability in a network of people is difficult. This is because individuals are limited in their ability to gain and store information. Hidalgo refers to this limit as a "personbyte."[72] Similarly, organizations, which are groupings of individuals each representing a personbyte, have their own limit to the knowledge and knowhow they can gain and store. This is referred to as a "firmbyte."[73] One key characteristic of organizations is that their firmbyte is lower than the simple addition of their personbytes. This is due to the cost of transactions. These include skill fade of technicians when in administrative positions, friction of human interaction, the non-seamless integration of various chains of command, and a whole host of others. In a maintenance workshop, one could consider the myriad of administrative procedures, rank related limits of responsibility, secondary duties, leave of absence and other factors that limit how the organization can maximize each personbyte.

The finite computing ability of individuals and organizations imposes the creation of more complex structures that transcend these limitations. Networking is the active creation of links between organizations. In a complex system such as LEMS, the network can extend between various maintenance organizations, the myriad of directorates within DGLEPM, industries, government and any stakeholder. So networking is not new, though the following elements of networking served as a guide for this study.

[72] César Hidalgo, *Why Information Grows…,* 157.
[73] *Ibid.*, 169.

When transaction costs within an organization are lowered, personbytes are maximized and thus that organization contributes more ably to the growth of information of the network. Therefore, procedural and structural changes that favour individuals to achieve one personbyte (i.e. attain their limit of knowledge and knowhow) and that enable the organization to make full use of the individuals will directly impact the overall delivery of the practical use of knowledge and knowhow. This suggests that for LEMS to maximize its output, a balance must be struck between rationalizing information for ease of control[74], and empowering individuals to gain and subsequently apply their knowledge in knowhow.

From Hidalgo's work, several other notable notions can be drawn and applied to LEMS. Being responsive to the CA's needs translates to being able to gain, store and use knowledge and knowhow. To do so, complex forms of information need to be distributed with as low as transaction cost as possible through a network of actors. The collective computing capacity of all actors, including the lowest tactical level, can serve to overcome the finite ability of individuals and organizations to gain, store and use knowledge and knowhow. Hidalgo sums up well how one should understand LEMS processes:

> […] through a perspective centered on [its] ability to pack and unpack knowhow and information, to embody knowhow in networks of people with a finite capacity to carry knowhow, and to create items [and services] that embody the practical uses of that knowhow and augment people's abilities.[75]

So, LEMS should endeavour to maximize personbytes by directing energy to select and train individuals[76] and conduct individualized talent management. LEMS should also maximize

[74] Chapter 1 described rationalization of information as a means of control. It is a reductionist activity that limits the amount of information to process. While argument was made that reducing and marginalizing information can be detrimental, there is a benefit: reducing and streamlining information can lead to a reduction of transaction costs, thus enabling a greater use of individuals' abilities within an organization.

[75] César Hidalgo, *Why Information Grows…,* 301. Hidalgo makes reference to a complex economy when making this statement, though it is applicable to a complex system such as LEMS.

[76] Peter F. Drucker, *Managing One Self* (Harvard Business School Publishing Corporation, 2008), 16. Since not every individual learns in similar ways, as famed Havard business author Peter F. Drucker suggests, the training

its firmbyte by building horizontal networks that maximizes the inclusion of actor input, lessening the transactional costs of applying knowledge and knowhow, and harnessing the human's ability to "crystallize imagination."[77]

The Public Service in Need of Modernization

The characteristics of complex systems also suit the description of the relationship between the government and society, as former Clerk of the Privy Council Jocelyn Bourgon explained in *A New Synthesis of Public Administration*.[78] Bourgon tabulated in her book two years of research from experiments that reached six countries with a simple quest of understanding whether current practices in the public administration are well adapted to the challenges of tomorrow. Much like this paper posits for LEMS, Bourgon categorically asserts that *no*, the dated practices are not up to the task.[79] The principle reason is that the dated practices are rooted in developments having occurred before the widespread use of the internet, which has had immeasurable consequences on the complexity of systems and their control, and societal changes. The result is a system of Band-Aids and processes designed to resolve the problem of the day: they are neither comprehensive nor adaptive.

From the study, Bourgon and her team do not suggest a total revamp of the public administration system, but rather the addition of certain capacities and functions. These added capacities and functions are needed to deal with the impact of the increased density of

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system should account for these differences in order to maximize each individual's personbyte. Hidalgo assets that knowledge and knowhow are difficult to transmit: an individual cannot learn how to diagnose and fix an engine within a semi-permissive environment in extreme weather conditions simply by reading a manual. So the investment in training and experience is of great value. This relates to the first rule of the growth of information from Hidalgo, that of needing to use energy to create information.

[77] César Hidalgo, *Why Information Grows…,* 127. Complex products or the delivery of a service are not random arrangements of atoms or random acts by individuals, rather "they are ordered arrangements of atoms that originated as imagination." Here Hidalgo emphasizes that individuals, unlike any other mammal, can be very innovative if permitted to be.

[78] Jocelyne Bourgon, *A New Synthesis of Public Administration: Serving the 21st Century* (Kingston: McGill-Queen's University Press, 2011).

[79] *Ibid.*, Chapter 1.

communications and growth of information processing, along with the growing disconnect between the complexity of issues, expectations of society, and capacities of the government. Bourgon suggests adding anticipative, inventive and adaptive capacities. She also advocates the addition of emergence, compliance, performance and resilience functions.[80] A fulsome review of the implications for government is outside the scope of this paper, though some of the notions from Bourgon are worth considering in the context of LEMS. Actual implementation of capacities and functions in LEMS would be admittedly difficult without their wider acceptance within the Canadian government.

The goal of the compliance function is to reduce the risk of mismanagement of public funds by the control of processes in accordance with rules and regulations.[81] Bourgon suggests that compliance systems should minimize the cost of controls, which tend to creep up if left unchecked. The aforementioned tendency of bureaucracy to centralize control has a direct effect on the rise of costs of controls. So in LEMS, consideration should be put toward reducing the cost of controls while still ensuring compliance to rules and regulations. In practical terms, this relates to the reduction of administrative burdens that are meant to ensure compliance but cloud simple tasks – time accounting, submission of claims, paper-based leave passes, ordering of parts, etc. A link to Hidalgo's notion of transactional costs can be made here: reducing the cost of controls is akin to reducing the transactional costs that inhibit the growth of information and practical application of knowledge and knowhow.

Also within the compliance function is the departure from focussing on sub-system results in favour of system wide results. Since complex systems are characterized by overlapping connections inhibiting the ability to isolate issues, system wide results are more telling. The

[80] Jocelyne Bourgon, *A New Synthesis of Public Administration…,* 122.
[81] *Ibid.,* 100.

earlier section in this chapter on *How to Analyze a System* discussed the difficulty in LEMS in assessing system performance given the focus on examining data from finite elements of the system.

A side note on compliance is made here. What remains unknown is the alleged implementation of delivery units by the Trudeau government.[82] Delivery units stem from a reform on performance measurement pioneered by the British government. Deliverology, the term that explains the effect that delivery units are designed to achieve, is an innovative method that acknowledges the complexity of the machinery of government. It recognizes the idea of measuring the performance of a system as a whole.[83] The issue, however, is that it relies on goals, metrics, data inputs/outputs, analysis and feedback that all stem from the top tiers of government. The result on LEMS could mean a more stringent demand of data from its stakeholders and commensurate increase in costs of controls needed to accumulate, analyze and process the added performance measurement requirements. Traditional control mechanisms in LEMS are likely to transfer the burden of data collection at the lowest levels though centrally retain the analytical function to respond to the compliance requirements. A more modern LEMS would find ways to reduce the resulting costs of transactions, harness the possibility of measuring system performance, and seek innovative input from all actors before cementing its processes.

The anticipative capacity that Bourgon suggests requires the ability to detect emerging issues along with the creation of a culture that favours innovation and an acceptance of unpredictability. The idea is to reverse the trend of governments to be in consistent reactionary mode. Despite best intentions to anticipate events, resiliency must be bred into the machinery of

[82] Doug Saunders, "How the Liberal Dream Machine Will Work," *Globe and Mail*, 23 October 2015.
[83] Michael Barber, Paul Kihn and Andy Moffit, *Deliverology 101: A Field Guide for Educational Leaders* (California: Corwin, 2011), Chapter 1.

government to deal with unanticipated events. This can be done, in part, by the active role of actors (anyone, including ordinary citizens) who thereby would share the responsibility for the development and implementation of solutions.[84] This cooperation between government and society is characterized by Bourgon by three aspects: co-existence of networks and hierarchy (inclusiveness of society within boundaries), co-creativity of solutions (shared responsibility), and co-production (individuals become value creators).

The collaborative government structure proposed by Bourgon is directly applicable to LEMS. The inclusion of soldiers and officers as co-creators and co-producers (rather than strict top-down direction) is certainly within grasp given the relative small size of the DND and the availability of technology to enable the necessary networks. The difficulty, however, stems from the rigidity of structures and processes that currently characterize LEMS. As discussed previously, the predominance of vertical communication channels and rigid protocol is not conducive to collaboration by all actors of the system.

In sum, Bourgon and her team suggest that changes are needed in how societies should be governed to meet the challenges of the 21st century.[85] They suggest that the power of the network must be harnessed to enable cooperation between government and society. This would serve to empower individuals and provide innovative solutions to complex problems. Effort should also be focused on measuring the effectiveness of the whole system of government rather than on the efficacy of finite elements. All of these elements are directly applicable to LEMS and will be featured in the last chapter. The next section takes a scientific view of warfare to further demonstrate the benefits of networks.

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[84] Jocelyne Bourgon, *A New Synthesis of Public Administration…,* 24.
[85] Bourgon's study is currently limited to liberal democracies.

Networks in the Context of Warfare

In *The Scientific Way of Warfare,* Senior Lecturer in International Relations Antoine Bousquet used metaphors to explain the scientific development of warfare: the clock, the engine, the computer and the network. What will be discovered is where the theories of control in the first chapter stopped, the network can be seen as the next logical step – one that the LEMS has not embraced yet.

Battlefield sequencing as Frederick the Great sought to accomplish was once used to "reduce individual initiative."[86] Much like the deterministic properties of a clock, battlefield sequencing "scrutinized individual parts [of a system] or sequences of events that could be reliably distinguished, measured, and compared […]."[87] Some of this predictability remains a sought after quality on the battlefield to reduce how much information to process. The reductionist action relates to the notion of rationalization of Chapter 1 where marginalization of people and processes aided in control.

The advent of the engine and related thermodynamic studies was used by Bousquet to explain the increased fluidity of military action. The engine, representing the automation of processes, mobility of soldiers, complex weapon systems and others "[reversed] the relationship of the labourer to his tools".[88] The mathematics of probability inherent to the science of thermodynamics displaced some of the linear thinking of early battlefields.[89] As mechanization increased lethality, firepower and mobility on the battlefield, logistical complexity rose dramatically. Moltke's three-tier supply system alluded to in the beginning of Chapter 1 was used extensively to mitigate the complexity by compartmentalizing and segmenting

[86] Antoine Bousquet, *The Scientific Way of Warfare:Order and Chaos on the Battlefields of Modernity* (London: Hurst and Company, 2009), 56.
[87] *Ibid.*, 42.
[88] *Ibid.*, 67.
[89] *Ibid.*, 70.

replenishment activity. The birth of LEMS in the CA can therefore be said to have been developed during the period of the engine, as Bousquet describes it.

As Beniger's theory of control explains, the computer was invented to establish control of systems. On the battlefield, systems no longer followed clockwork actions of soldiers and were subject to the uncertainty inherent to thermodynamic science and exponential growth of information to be processed. Command and control systems thus needed to depend on technology for the dissemination and processing of information. The use of computers ensured a transition of mechanistic warfare to cybernetic warfare. Through information technology, one could control the battlefield, or certainly attempt to do so: "the inherent limitations of [cybernetic warfare is its] attempt to make war into an entirely controllable and predictable activity."[90] Perhaps this desire to make war predictable contributed to centralizing control (to minimize divergence of action) and increase rigidity (to predict outputs).

It is the last metaphor used by Bousquet – the network - that is the crux of further development of LEMS. Exponential growth of information technology has led to the creation of networks through which systems can flourish amid chaos using decentralized command.[91] Chaos and decentralized command are likely far removed from the vocabulary of most in uniform, but worth considering.

The Power of the Network

The network holds the potential to bring about the benefits of empowering lower echelons of the system of LEMS that were previously marginalized due to limitations of information technology that imposed constraints on control mechanisms. It will be shown that

[90] Antoine Bousquet, *The Scientific Way of Warfare*, 161.
[91] *Ibid*.

networks provide open loop feedback necessary for complex systems by empowering stakeholders (particularly at lower levels) to co-create and co-produce results.

"Chaos breeds life, when order breeds habit."[92] Through the effects of rigidity it was demonstrated in Chapter 1 that a culture of protectionism of status quo was formed. Ergo, habit has been bred by order, as Bousquet suggested in his quote. But chaos is not synonymous with lack of order. Rather, chaos has the appearance of disorder, but in fact chaotic models obey deterministic laws that are typically hidden without close inspection. A fulsome explanation of chaos theory is outside the scope of this paper, though some context is worthy of detail. What may appear as chaotic may very well be the congregation of simple patterns present in individual components of a system. An alphabet soup is a prime example: individual letter-shaped noodles follow simple patterns, but when they float in the soup, chaos appears to ensue despite having followed a strict recipe and method for making said soup.

The congregation of inter-related components gives rise to complexity. Attempts to bring order to the system from the top down has been the prevailing modus operandi in LEMS. Consider here a parallel with the popular axiom in RCEME speak; "we are a regiment of many small units".[93] Each unit has operating procedures and set establishment of resources to fulfill its tasks that are continuously being controlled by the top of the hierarchy. But what if these units could have more leeway to develop their own patterns? Would disorder ensue in the system as a whole? Breakthroughs in the science of nature and in the private sector in using networks tell us that actually, "disorder finds its own order".[94] This suggests that tight control imposed from the top down onto the many small units may well be hindering the attainment of a larger scale order.

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[92] Antoine Bousquet, *The Scientific Way of Warfare*, 163. Henry Brooks Adam quoted by Bousquet.
[93] Department of National Defence, *Strategic Management Plan ….*
[94] Antoine Bousquet, *The Scientific Way of Warfare*, 169.

Some control is of course needed. Boundaries need to be established to regulate behaviour. So the key lies in finding an appropriate balance of control.

Such a balance has not been found in LEMS. As a consequence, it is a complex system artificially bound by pre-determined parameters, administrative and bureaucratic impositions and is all round rigid in structure and process. Complex systems need to be adaptive to survive and binding them to set parameters or desired fixed states stymies their development. To be adaptive, complex systems rely on "positive feedback"[95] rather than strictly being bound from hierarchy above. This feedback can originate from the components of the system and the operating environment. So rather than harnessing a vertically aligned structure through which predictable results are wanted and crafted by the aid of rigidity, the basic premise of modern complex systems theory is almost the very opposite: decentralized and semi-autonomous systems "can operate more effectively and with great degree of adaptability."[96]

To illustrate the power of decentralized organizations that harness the input and self-corrected activity of individual/small elements, a metaphor used by Brafman and Beckstrom in *The Starfish and the Spider* will be used here. These authors consider the advantages of the starfish's lack of centralized control mechanism. Severed limbs continue to function and restore the functions of a starfish, or restore order. A spider, in comparison, dies if its head or any important function is no longer functioning. There are advantages of not leaning on a centralized control centre.[97] An obvious concession needs to be made for necessary centralized control of the military, though a healthy balance of decentralized action within centrally imposed boundaries

[95] Antoine Bousquet, *The Scientific Way of Warfare*, 165. Positive feedback "is present when disturbances are amplified and thus move the system further away from its point of origin", a behaviour that is certainly alien to anyone wanting predictability. Negative feedback, on the other hand, is what is typically considered as the input of a system in which the latter stabilizes itself to a desired equilibrium.

[96] *Ibid*, 182.

[97] Ori Brafman and Rod A. Beckstrom, *The Starfish and the Spider: The Unstoppable Power of Leaderless Organizations* (New York, Portfolio, 2006), Chapter 1-2.

could be beneficial to increasing the efficacy of the force and harness the initiative of individuals at lower levels.

The private sector is ripe with examples of successful business growth through the use of information technology in a significantly different way than traditional methods. Rather than harnessing the growth of information technology to enhance the ability to centrally control maintenance activities, as LEMS appears to be doing, businesses are harnessing the value of horizontal networks. These networks encourage and enable input from the lower components of a system. Two examples of the power of the network are provided for illustration purposes.

Consider the large network of taxis in Toronto, whereby there is centralized control of fees, standards, licences and areas of operation. Taxi drivers are restricted to being waved down by customers or to incoming notifications from their respective central dispatcher. Uber, which took the taxi industry by storm, decentralized much of the control down to individual drivers. Further, the company expanded the information processing capability by using every interested person's smart phones to create an informed network of drivers and clients. Laws and insurance woes aside, Uber took advantage of the taxi industry's stagnated progress in delivering customer service. While the taxi service may have been able to adapt, the point is that it did not and now suffers the consequences. Uber took advantage of the power of the network and demonstrated that centralization is not the only method of control.

The empowerment of ordinary people and the democratization of ideas and activities, both enabled by the power of networks, are now very commonly found in society. Consider the transformation of encyclopaedias from massive book collections to a few clicks of a computer mouse, whereby millions of people can contribute. Other examples include the transformation of consumerism through online procurement and the digitization of the music industry. These

industries have harnessed the knowledge of millions of people, dramatically increased accessibility to the information, and constructed a self-correcting system that has (effectively) no central controlling station. As it was seen in the latter part of the first chapter, these examples of empowerment of individuals is in stark contrast with the reality within LEMS.

The CAF is certainly not anti-network as it has embraced basic elements of information sharing on the internet and the benefits of enterprise resource planning software. However, the increase in networking ability has been applied to enforcing the existing vertical channels rather than expanding the horizontal chains. Returning to Bousquet is useful to emphasize this point. Bousquet claims that the recent apparition of network centric warfare (NCW) falls short of desirable outcomes and misses the point of complexity theory. He explains that the growing popularity among military theorists on NCW has value in that it promotes the establishment of networks – a necessary condition for decentralized control. The problem lies in that NCW has enhanced the ability to exercise centralized control by linking sensors, shooters and decision makers, thus giving commanders a sense of knowledge and *control* of the battlespace. Information superiority seems to be the aim and infrastructure has been built to maximize higher command tiers their exercise of command and control rather than to leverage horizontal collaboration.[98] A simple though relevant case in point in LEMS is the increasing emphasis on quasi-real time pull of data from the lower levels – via the system of record of the day -, which falls short once a formation deploys in the field. Connectivity loss instantly stymies the best laid plans and forces a return to ad hoc and decentralized actions from technicians who want nothing but serviceable equipment in the hands of operators. Interestingly, the default setting when disorder, or chaos, arises is exactly what Bousquet is suggesting; the lower levels contribute to finding solutions, which in turn establishes a level of order to the greater system. So information

[98] Antoine Bousquet, *The Scientific Way of Warfare*, 219-222.

technology must not only be focused on the vertical communication channels, but also the horizontal ones.

Lastly is the idea that "evolution thrives in systems with a bottom-up organization, which gives rise to flexibility".[99] This does not discount the need for top down direction and control measures, though opens the dialogue to the idea that decentralized and semi-autonomous systems "can operate more effectively and with great degree of adaptability".[100] A horizontal network is required to exercise decentralized control and the system must permit lower levels of the hierarchy to explore, adjust and develop suitable structures and processes.[101] This is far from reality within the LEMS framework; centralized control is fiercely sought and lower level autonomy is extremely limited. Consider the relative simplicity of a brigade level exercise in which rather intuitive solutions to resource and structural issues are stymied by centralized control (often stemming from the strategic level). Measures such as administrative rights to systems of records, cumbersome task order control spreadsheets, scales of parts issue dictated by higher command, and a myriad of other facets are imposed. This leaves maintenance organizations but a grouping of technicians at the mercy of antiquated processes.

The creation of networks by innovative uses of information technology is not new to the CAF or LEMS, but it appears as gains were made to reinforce existing vertical channels rather than creating horizontal ones.

Summary

This chapter made a link between the complexity of LEMS and advantages of developing networks to complement traditional means of controlling such a system. Traditional centralized

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[99] Antoine Bousquet, *The Scientific Way of Warfare*, 180. Prirogine and Stengers quoted by Bousquet.

[100] *Ibid.*, 182.

[101] *Ibid.*, 210. Here Bousquet refers to the concept of swarming and uses the analogy of an ant colony. While individual ants are unaware of the entirety of information surrounding its activity, the collective input for multiple ants results in an efficient system.

and rigid control mechanisms can benefit from the lifting of previous barriers imposed by information technology constraints. Work from Hidalgo demonstrated the value of networks in surpassing the finite abilities of individuals and organizations to gain, store and use information. Bourgon shed light on the necessity of government to harness networks to enable innovation, co-creation and co-production of public administration and individual actors. Finally, Bousquet's scientific view of the evolution of warfare pointed to the next logical advancement for LEMS. This includes accepting some level of uncertainty, enabling some form of decentralized control, and building horizontal information sharing networks to empower low level actors. The final chapter will provide general recommendations that heed to this advice.

CHAPTER 3 – PRACTICAL RECOMMENDATIONS

> *An equipment management system requires not only highly efficient management practices, but also the capability and flexibility to survive and operate under battlefield conditions*.[102]
>
> - Department of National Defence, *Sustainment: The Operational Function*

> *Paving over a zigzagging cow path gives a zigzagging paved road*.
>
> - Paul Bracken, *The Military After Next*

These two quotes aptly sum up the premise of this paper. The 2015 publication on sustainment identifies the need for adaptability and Bracken's analogy speaks to the consequence of modernizing efforts that consist of simple application of technology onto old business practices.

The recommended changes presented in this final chapter must to be considered within the framework of adaptability of a complex system. An open mind is needed rather than one nested in a culture of linear thinking. The intent is not to totally reshape LEMS. Rather the intent is to modernize its control mechanisms and add (or emphasize) capacities to the system that enable it to remain responsive to an agile CA of the 21st century. LEMS should be more anticipative of issues, foster institutional learning, favour horizontal collaboration, seek system wide performance measurement and build resiliency. The enhanced capacities will first be explored. Subsequently, a few recommendations will be provided that certainly do not form on their own stead a perfect solution. Rather these ideas will serve to contextualize the enhanced capacities to address some of the current shortfalls of LEMS.

Enhanced Capacities of LEMS

Building a capacity to anticipate (events, issues, obstacles, constraints) relates to diminishing the reactionary mode of LEMS toward being able to foresee events. It accepts that

[102] Department of National Defence, *Sustainment: The Operational Function*, Section 3.

adapting a complex system to meet the demands of the CA takes time and effort, and therefore any early warning is advantageous.[103] This sensing capacity is needed at all levels to fuel decision making. At the strategic level, there is a requirement to foresee developments in procurement strategies, operating concepts of the CA, technological growth of weapon systems, impacts of generational gaps of new recruits, and so on. At the tactical level, there is a requirement for a sensing function of the wider sustainment framework (in-transit visibility, asset visibility, replenishment capacity, equipment diagnostic and prognostic capabilities – all with intent of forecasting operational capability). The ability to sense is tied to the ability to build networks in order to synthetize information that stems from all available sources. What should not occur, however, is a substantial growth of central control mechanisms aimed at managing and regulating the increase in data sharing (as would ensue in the current state of LEMS). What goes hand in hand with the ability to sense, and therefore to anticipate, is the capacity of the system to learn.

To learn, there must be recognition of failure, willingness to rectify the issues that caused the failure, and acceptance of change within the system. "Surfacing the invisible work"[104] of maintenance activity is a step in the right direction to foster these three elements of learning. The 'invisible' includes all of the facets of maintenance activity: from procedures to tooling, parts, knowledge, control mechanisms and all linkages that feed into ensuring equipment remains

[103] Jeremy Black, *War and Technology* (Bloomingdale: Indiana University Press, 2013), Chapters 6 and 7. Black argues quite eloquently that states often underestimate the complexities related to transitioning to the use of new technology and methods of warfare.

[104] Stephen Graham and Nigel Thrift, "Out of Order: Understanding Repair and Maintenance," *Theory, Culture and Society* 24, no. 3 (May 2007): 17. Graham and Thrift's article takes a philosophical look at the realm of maintenance activity of society in general. They argue that it is through the repair of equipment that society innovates and learns. By" surfacing the invisible" as a matter of normal course, rather than being reserved to situations of catastrophic failure, a society can engage in evolutionary development. And it is through inquisitive processes of repair that the wider "politics of repair" shapes the entire assemblage, or infrastructure that surrounds maintenance activity. In short, the more visible and engaging the process of repairing equipment is, the more likely society (or organizations) can learn and innovate.

serviceable. Surfacing the invisible is the opposite of any attempts made to render maintenance activity as a black box from which broken equipment enters and serviceable equipment emerges.[105] It is recognition that "failure is key" [106] to learning because it engages a process of inquisitive questioning of the root causes of the break down that go beyond mechanical reasons (to include procedural and operational causes). Or rather, failure *can* be the catalyst for such a process through which innovation and creativity can emerge. The system must allow failure to be such a catalyst.

Failure can fuel human ingenuity because "repair and maintenance do not have to mean exact restoration."[107] While the exact restoration of an engine may ensue from its repair, an outcome of the inquisitive process that surrounded the maintenance activity could lead to breakthroughs with immeasurable benefits. These could include changing the operating conditions of the engine, the preventive maintenance cycle, the tooling requirements, the repair procedures, and so on. Importantly, the inquisitive process must be inclusive of the operators and the commanders that seek to have functional equipment, for their innovation can contribute to operational readiness. Surfacing the invisible goes further than "equipment culture".[108] The intent of the latter is to inculcate in operators an element of identity with their equipment to foster good care. The former adds elements of transparency of all facets of maintenance and inclusiveness of all stakeholders to enable the co-creation and co-production of maintenance activity. To do so, there is a requirement to connect all actors through a network.

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[105] Expanding on this topic would certainly include discussions on the impact of sealing components that limit repairs by manufacturers, and self-diagnostic and self-healing properties of equipment that are emerging with new technology. There is a paradox around the idea of reducing maintenance to a black box for ease of repair on the battlefield and the resulting consequence of inhibiting innovation by those who would otherwise be more engaged with repairs.

[106] Stephen Graham and Nigel Thrift, "Out of Order…, 7.

[107] *Ibid.*, 6.

[108] Department of National Defence, *Strategic Management Plan….* The term equipment culture is featured prominently in the RCEME Strategic Plan though without a detailed definition of what it entails. The intended benefits are obvious: increasing the operational readiness of the CA.

To fuel the communication requirements of co-creation and co-production is a broad network that breaks through the current vertical silos. Networks enable the packing and unpacking of knowledge and knowhow nested in individuals and organizations into a greater array of possibilities. The network is the backbone of the anticipative capacity discussed earlier. Current stovepiped links between unit maintenance organizations and the strategic level severely stymie innovation. While the unofficial technical network does provide some horizontal collaboration, it is a far reach from having fully open lines of communication with an accompanying culture of assisting other units to achieve system performance. Information technology, in its limited quantity, is typically focused on connecting the top tiers to the bottom tiers of an organization. Rarely does it focus on connecting organizational elements horizontally. Currently, bridging these communication gaps requires energy and it produces substantial transactional costs, thus limiting the network and sharing of information. Until resolved, this unfortunate reality will restrain innovation. It will also stymie efforts to measure whole system performance.

Measuring performance of a system is not only a mandated requirement to remain transparent to the public, but also a necessary exercise in a resource constrained environment. The complex system of maintenance cannot be reduced to finite elements to which performance metrics are individually assigned. The current reporting mechanisms, as stated in earlier text, are by design specifically orchestrated to measure discrete portions of LEMS. There must, therefore, be focus put on measuring the effectiveness of the system as a whole. This will require creating or freeing up communication channels for the provision of inputs from a wider array of actors in

the system. It will also require moving away from a culture of protectionism and delinking the control mechanisms aimed at compliance and those aimed at system performance.[109]

Resiliency is needed in a complex system so it can adapt to change. Resiliency is a broad capacity that cannot be neatly packaged and given to a staff officer to manage. It is rather the building of a system and associated culture that accepts a level of uncertainty and can thrive in absence of perfect information. The present rigidity ingrained in the system by way of strict processes, linearity of thinking, culture of protectionism, and hierarchical control mechanisms serve to characterize LEMS as brittle; it does not weather unpredictable events particularly well.[110]

In sum, LEMS can become an adaptive organization by enhancing several capabilities. The backbone is the network for it enables communication and it must reach all actors rather than being limited to vertical channels. LEMS needs a sensing function to anticipate future challenges and synthesize information for better decision making. To grow, LEMS must form learning organizations that are not inhibited by a culture or protectionism. All actors must be empowered through horizontal networks to favour collaboration and innovation. System-wide performance measurement that is distinct from compliancy efforts is needed to account for the complexity of the system. Lastly, acceptance of uncertainty is needed if LEMS is to operate in an adaptable, collaborative and learning organization.

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[109] Jocelyne Bourgon, *A New Synthesis of Public Administration…,* 99-100. As Bourgon argues, a culture of compliance has been created to answer to the growing number control mechanisms imposed from higher layers of command. This has adverse impact on innovation and ties up communication channels. In a maintenance workshop, almost all technical communication that is provided to higher levels stems from mandated requirements (time accounting and basic productivity statistics are prime examples). In a formation, maintenance data is sent to the formation headquarters as per doctrinal requirements. Very little can be done in the current construct of a formation level headquarters to measure the effectiveness of maintenance activity because it focuses on past performance of a number of finite elements and excludes several influences on the system (assumptions need to be made due to lack of asset visibility, lack of in-transit visibility, spare maintenance capacity that could be shared, …).

[110] This broad statement may not represent well all facets of LEMS, as there are many examples of it having weathered significant funding reductions, drastic demands of equipment acquisition such as the period of war in Afghanistan. The comment is derived from general tendency of systems that are rigid in process and structure to resist change and therefore require tremendous amount of energy and turmoil to overcome unpredictable inputs.

Repair as Far Forward As Possible

For LEMS to become more adaptive and to remain true to the first tenet of LEMS - repair as far forward as possible – new ideas need to be generated that question current doctrine. It is recommended that lines and levels of maintenance be eliminated and lines of supply divorced from maintenance activity. An increase in the decentralization of tactical maintenance is also recommended.

'Forward' is an antiquated term referring to the front lines of a linear battlefield where the fighting troops normally operated. The term arguably remains valid in a non-linear and non-contiguous battlefield as it is quite evident that it refers to the location of the equipment casualty. So it is the term 'as possible' that is of import. It was discussed in the first chapter that 'as possible' has lost its raison d'être and repairs are primarily executed as dictated by the segregated lines of maintenance, rather than first principles.

The first major recommendation is to eliminate lines and levels of maintenance. Consequently, this also means the divorce of maintenance activity from the lines of supply. Here is why. The repair of equipment is a service. It requires knowledgeable technicians (or a self-diagnosing systems and operator maintenance accessible to most), tooling, parts, and an accounting mechanism to ensure effectiveness of resource use. Moreover, it requires a certain level of local security. What equipment repair does not inherently need is to be tied to a geographical area and pre-determined rigid dependency matrices, as is the case now. The historical relevance of the unity of lines of supply and lines of maintenance was drawn in Chapter 1. Do the maintenance activities in today's Army depend on being tied to lines of supply? Absolutely not.

Tactical maintenance activity is currently cemented in the bond between lines of supply and lines of maintenance. The historical (and remains the predominant) view of sustainment is anchored on reducing the logistical footprint of forward units by limiting supplies to what is estimated to be needed. The unit of measurement is typically one day of supply of specific commodities. Predictable consumption rates, finite carrying capacity, and historical precedence have afforded the supply framework to be slow in implementing technology that could aid in its discipline. Asset visibility, tracking and prediction methods all too familiar to corporations for decades are severely lacking in the CAF. This has had monumental impact on tactical maintenance as it anchors repairs to where the parts are located and has cemented a breakdown of maintenance organizations.

Rather than being seen as a truly mobile service needing only parts, tooling, knowledge and some level of security, maintenance activity is currently seen as a segmented array of finite organizations belonging to specific elements on the battlefield. Each organization is capable of finite repairs and operates in a communication silo toward the very top of the hierarchy. There are benefits to pigeonholing maintenance tasks as it anchors doctrine, facilitates control, and regulates the distribution of resources to specific organizations. These undeniable benefits are, however, outweighed by the current rigidity of structure and process that stymie innovation and adaptation. Reorganization to accommodate battlefield requirements is difficult at best.[111] Also, the current segregation of maintenance activity on the battlefield (between first and second lines

[111] Technicians in a unit maintenance organization conducting 'first line' maintenance are no less capable of conducting 'second line' repairs. What stymies flexibility on the battlefield is the deliberate equipping of maintenance organizations (in tooling, special testing equipment and parts scales) and prohibitive administrative burdens for any activity outside prescribed norms. Modest investments in tooling and test equipment, horizontal networking for the sharing of infrastructure and knowledge and reduced 'costs of transactions' are changes within reach. It is common, though occasionally frowned up, that in garrison a tank regiment will conduct its own second line maintenance. Additional protocols are required to do so but it provides the tank regiment with more control over its maintenance program.

of maintenance) dilutes accountability of repair activities by forcing the repair responsibilities to straddle chains of command and multiple parts replenishment chains.

The consolidation of maintenance activity should be accompanied by an increase in versatility of maintenance organizations in terms of the types of repairs they can perform. Rather than allocating levels of repairs to specific organizations (or lines), maintenance organizations should be provided with the resources to fulfill all maintenance activity that can be performed on the battlefield. Two schools of thought exist: centralizing maintenance in formations or decentralize by augmenting each units' maintenance organization. The former is akin to the Australian Army's recent Force Modernization Review in which their formation Combat Service Support Battalions inherited significant maintenance resources that were previously in combat units.[112] The Australian Army has not divorced the lines of maintenance and lines of supply, though has made steps to centralize maintenance activity in formations. This paper posits, rather, the decentralization of maintenance within formations. The basic idea would be to augment unit maintenance organizations so they can perform all maintenance tasks on the battlefield. As historian Martin Van Creveld stated: "The aim of the military organization is not to do with the smallest number of supporting troops, but to produce the greatest possible fighting power."[113] Augmenting a combat unit's maintenance organization should not be seen as a means to encumber its maneouverability, but rather as a means to give it the resources needed to remain operationally ready. It means increasing the accountability of unit commanding officers for the

[112] Australian Army, *Australian Army: Our Future – Army Modernization Update* (Australia: Directorate of Plans, 2014). This public document does not state explicitly the details surrounding the increase of the Combat Service Support Battalions' maintenance organizations at the cost of combat unit maintenance organizations. The information was received through an undisclosed source. The exact numbers of personnel is not of importance here, but rather it is the fact that the Australian Army has not divorced the lines of maintenance and lines of supply, though has made steps to centralize maintenance at the formation level.

[113] Martin Van Creveld, *Supplying War…*, 235.

readiness of their equipment, which currently straddles their and the service battalions' chains of command.

Together, the elimination of lines and levels of maintenance and the increase in independence of unit maintenance organizations hold tremendous potential to increase the adaptability of LEMS and to truly repair as far forward as possible.

Empowering Soldiers

Considered by many as the bread and butter of the Corps of RCEME, the Mobile Repair Team (MRT) is the basic component of a maintenance organization. In fact, the MRT is the face of RCEME at the tactical level because equipment failures force the technicians to work closely with operators. It is the individuals that make up the MRT that are responsible on a daily basis to pack and unpack knowledge and knowhow to provide the service of repair on the battlefield. This section examines ways to maximize the personbyte of soldiers and LEMS' practical application of knowledge and knowhow.[114]

Soldiers[115] should be regarded as value creators, contributors, innovators, and inventors rather than workers subject to rigid processes and top driven control. Today's soldiers could be significantly more adaptive and network-based that the soldiers of our World Wars. Also, their intellectual agility is capable of much more than rigidity of thought. Soldiers should be involved in the co-creation and co-production of ideas that form an evolving system of maintenance. Bourgon argues that collaboration from actors increases their buy-in, can reduce costs of transactions (by increasing trust and reducing resistance to change) and provides a sense of self-

[114] The reader is reminded that the personbyte is the upper limit of knowledge and knowhow that an individual can have. The firmbyte is the same limit but that of an organization. The firmbyte is lower than the sum of the personbytes within the organization due to the cost of transactions. Networks are used to share information and maximize the overall system's practical applicability of knowledge and knowhow to produce a service. The lower the transaction costs, the wider a network can be cast.

[115] This term can encompass, for the sake of this section, to include officers. Specifically, soldiers refers to all individuals that work within the realm of LEMS.

worth.[116] All of the benefits contribute to empowering soldiers. Literature on positive psychology provides ample proof of the value of giving a sense of purpose to individuals.[117]

Empowering soldiers also means giving them a degree of autonomy to perform their functions. The CAF preaches mission command though it is difficult to apply when considering the constraints imposed on the daily work of soldiers. The rigidity of process and structure abundantly exposed in this paper is testament to the difficulty for soldiers to be part of solutions to problems. Autonomy does not mean independence of action without regard for boundaries. It means being given the latitude to develop solutions. It means fostering a culture that accepts input, which will serve to remove the disabling ignorance discussed in Chapter 1. Much like prior discussions on horizontal networking and co-creation, there must be focus on harnessing the input of soldiers versus stifling them with archaic regulations. Specificity of such solutions is outside the scope of this paper, though consideration should be given to enabling the capture of knowledge and knowhow through, for example, Wikipedia-like web pages. One can envision the gathering of input from soldiers on repair processes, best practices, educational links, trade-specific issues and so on.

Another facet to consider in the empowerment of soldiers is the management of talent. Maximizing the potential of individuals is not only beneficial to the organization but also can serve to provide more interesting challenges and job satisfaction. The current practice of succession planning is a form of career plotting with obvious benefits to the organization by putting the right people in the right positions. Talent management, on the other hand, deals with the development of such people. There must be recognition that not all soldiers will maximize

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[116] Jocelyne Bourgon, *A New Synthesis of Public Administration…,* 52.

[117] Shawn Achor, *The Happiness Advantage: Seven Principles that Fuel Success and Performance at Work* (New York: Crown Business, 2010), Part 1. Achor, a Harvard professor, argues that the long standing belief that success brings happiness is false. Rather, happiness fuels success. Being empowered is a major source of happiness in the work place.

their potential by streaming up the chain of command. Not all soldiers are fit for higher levels of responsibility, nor do they all aspire for such progression. There needs to be the disentanglement of organizational needs for talented people in certain positions, and personal desires and limitations. Talent management requires an investment in developing an adaptive military human resources system. Notwithstanding that LEMS does not own responsibility for the development of human resource policies, its stakeholder organizations have instituted their own forms of control and culture that contribute to the current rigidity of career paths.

More localized control of the career of soldiers could lead to an increase in the ability of harnessing the strengths of individuals through talent management. So if there is a desire to further centralize career management functions, thought should first be put toward the benefits of the exact opposite. Moreover, talent management must be more fulsome than the movement of personnel on a spreadsheet that follows pre-set types of jobs with set time periods. With a more flexible, and likely more subjective human resource process, must come a greater degree of adaptability of the myriad of factors that affect career progression. For instance, pre-set job types and experience 'needed' for progression should not be so fixed as to discount the rise of select individuals that demonstrate potential to excel despite not having said pre-requisites. After all, not all individuals learn the same way[118] and thus will not reach their potential when subject to a one-size fits all career solution. Pre-set career paths once created to ease the control of human resources – rationalization at play – should be discarded for more individualized talent management.

Lastly, LEMS stakeholders must decide what kind of soldier they need: parts changers or capable technicians? Generalists with innate abilities to learn and adapt, or sculpted specialist with finite task ability? The prior discussions on adaptability, acceptance of uncertainty and

[118] Peter F. Drucker, *Managing One Self*, 16.

learning suggest that generalists are more apt to be the best soldiers for LEMS.[119] Specialization is brought about through precise learning in a finite field. Counter-intuitively, it seems that as technology progressively makes its way into the CA arsenal of equipment, maintenance activity becomes less of a matter of specialty of technicians to tackle the complex on-board systems. The sealing of components (for opening by the manufacturer only), the advent of self-diagnostic capabilities, and the modularity of assemblies may not necessitate that all technicians be imparted with specialty knowledge. Rather, it is the navigating of circumstances leading to the repair that requires thought, innovative ideas and versatility of solutions.

It is typically not the repair that causes a trained technician to stumble on courses of action. It is rather the process of synchronizing multiple activities such as assembling a team with proper tooling and preparation. It is also the often difficult tasks of finding the equipment casualty, executing link up drills with operators and navigating the archaic parts replenishment system. More challenges include adjusting battle rhythms, communicating horizontally for assistance and vertically for command and control, and dealing with security threats. The unpredictability of the future battlefield means that these conditions will fluctuate, while the actual repair of a tank, for instance, will not vary with any significance. Therefore, a maintenance organization will be best suited with technicians that are adept at adapting, that can learn independently, and that excel in situation with less than perfect information.

Summary

Not all is doom and gloom in LEMS – it can become more adaptive. This chapter highlighted areas in which strategic governance of the system should be focussed in order to set the conditions for change.

[119] It would be interesting to draw conclusions on this topic with a review of the transition of the Corps of RCEME (for some trades) to system-based training rather than platform-based training. The Vehicle Technician trade is a prime example that could be studied.

LEMS should be more anticipative of issues by forming a sense function. Rather than relying on past data on productivity of finite maintenance organizations, there must be a way to collect system-wide data to better predict equipment availability and enable decision making. Moreover, institutional learning must be enabled if LEMS is to evolve. Failure of equipment and procedures should be embraced as an opportunity to innovate and reduce future instances of failure. By involving all actors, including operators and commanders in an inquisitive process of diagnosis and repair, the institution can learn.

The complexity of LEMS should not be underestimated and thus its reduction to finite segments for performance measurement should be curbed. There needs to be better synthesis of input from interconnected sub-systems and disentanglement of compliance and performance measurement activities. Moreover, resiliency must be bred into the culture of LEMS to accept uncertainty and to accept innovative contributions of lower level actors that challenge the status quo.

To fuel and to create the backbone of these added capacities in LEMS is an investment in horizontal networks. Rather than incrementally reinforce vertical hierarchical chains, there must be open channels to foster collaboration from all actors. Co-creation and co-production among multiple layers of actors in LEMS will serve to empower individuals to be value creators and innovators.

Empowering soldiers can bring immeasurable benefits. Today, soldiers are significantly more capable to be connected through a network to contribute to the greater good of their organizations. By reducing the level of marginalization of soldiers and their ideas, LEMS can evolve and become more adaptive. After all, LEMS is a human system and should therefore not be reduced to rigid processes that serve to preserve the status quo for ease of control.

This chapter also provided a bold suggestion to challenge LEMS practices that may no longer be following first principles of maintenance. Specifically, it was suggested that tactical maintenance activities should be consolidated and disentangled from lines of supply. Moreover, it was argued that unit maintenance organizations become responsible for their entire tactical maintenance needs through the decentralization of maintenance activities at the formation level.

Lastly, a question was launched to LEMS stakeholders: what kind of soldier-technician is needed? Is there a one-size fits all solution? The position of this paper is that a soldier with more generalized technical training and that can adapt and learn is of more value than a soldier with highly specialized technical skills. Importantly, the human resource system must conduct talent management to find the right career path for the person, not the right person for the rigid career path.

CONCLUSION

This paper posited that LEMS must become much more adaptable in order to remain responsive to the CA. In analysing modern works on control and management, four key findings surfaced.

Current attempts to modernize LEMS are ill-suited for the task. Efforts are not wasted though they serve to strengthen vertically aligned hierarchical and centralized control mechanisms that originated from the post-industrial era. Investments in information technology are directed at reinforcing vertical communication channels through which significant energy is being spent in ensuring compliancy of top driven rules. The result is the compounding of the rigidity of the system. Moreover, centralized control marginalizes the innovative and intellectual capacity of soldiers with tremendous opportunity costs to the system. Sadly, institutional stakeholders of LEMS do not seem to understand how to reverse this worrisome downward trend of responsiveness to the CA. But alas, not all is lost.

Information technology has enabled the empowerment of individuals within systems. With today's information technology, the past practices of marginalization of information for ease control of systems are largely unnecessary. Through bureaucracy and rationalization, information stemming from people and processes had been reduced and marginalized and subsequently communicated to the top of the hierarchy for centralized decision making. Information technology has now enabled the creation of networks and has exponentially increased the available information processing power. Therefore, the system can afford much greater amounts of input, processing power can be distributed amongst various levels of the system, and the synthesis of information for decision making need not rest solely at the very top of the hierarchy. So the empowering of all actors in LEMS is possible. It can provide innovative

ideas and foster buy-in from individuals. Also, decentralized control of certain functions can be exercised. This will give greater system adaptability and resiliency because of the distribution of responsibility for decision making.

Individuals and organizations have a finite ability to pack and unpack information. The practical application of knowledge and knowhow of a system is how products or services are delivered. The ability of a system to do so is dependent upon two main factors: transaction costs in the system must be minimized and networks are needed to transcend the finite ability of persons and organizations to pack and unpack information. The sources of transaction costs are enormous and include culture, administrative burdens, trade restrictions and many more. The reduction of rigidity of structure and process within LEMS can directly contribute to reducing the costs of transactions, thus increasing its output. The second method to increase the output is to harness networks that transcend the organizational boundaries to enable the gaining, sharing and computing of information. Consider the potential of an array of unit maintenance organizations that are purposefully interconnected and through which administrative and procedural transactional costs (friction) are minimized. The network thus increases the collective ability of LEMS to apply knowledge and knowhow.

LEMS is too complex of a system to reduce it to finite segments. LEMS is necessarily organized into different entities across the spectrum of its stakeholders for ease of control. The problem lies in the application of performance measurement and problem solving skills to LEMS that are designed for simpler system that are less interconnected, that do not have a major human influence, and that have predictable outputs. Linear thinking is bred into soldiers and performance measurement is typically done by evaluating finite portions of the system. These practices tend to favour predictable and quantifiable outputs and measure efficiency of sub-

systems rather than the efficacy of system responsiveness to the CA. Acceptance of uncertainty of results, system-wide performance measurement and the development of analytical thinking skills in individuals are measures to increase the adaptability of LEMS as they acknowledge its complexity.

These key findings and associated recommendations within this paper should guide the strategic governance of LEMS. There must be recognition that past practices are not necessarily best practices just because they are ingrained in culture. It is quite clear that the future operating environments will challenge the CA and LEMS will need to adapt to meet emergent issues. Challenging the status quo and recognizing our soldiers as valuable contributors are reasonable first steps in the path to evolve in being more adaptive.

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