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Lost… but making good time: The Urgent Need for a Canadian Forces C^{4}ISR Framework.

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ABSTRACT

"People – men of frailty, judgment, and human decision – must control machines. Not vice versa."

- Loudon Wainwright, 1965

The information-based Revolution in Military Affairs (iRMA) that is gripping the attention of most of the world's modern militaries appears to be causing a ripple of uncertainty and indecision to flow through the Canadian Forces (CF). Despite the lack of an integrated plan to deal with the doctrinal, technological, and personnel implications of the iRMA, the CF is poised to commit to spending billions of scarce defence dollars in pursuit of a robust Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C^4ISR) capability.

This paper explores the overarching context of the RMA both from a generic theoretical basis and also from the unique Canadian perspective. Related issues of network centric warfare, complexity, chaos, and the Revolution in Military Affairs are highlighted before the Canadian context is overlaid on them. Resource scarcity, doctrinal deficiencies, and inchoate staff efforts frame the Canadian situation and underlie the challenge for Canadian C^4ISR capability development.

The paper concludes by describing current CF efforts to coordinate C^4ISR capability development and suggests that such efforts are likely to fall short given the CF's failure to address key systemic, organizational, and philosophical issues. To jumpstart the capability development process, a framework is proposed to provide an overarching structure to the unique C^4ISR capability development challenge.

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Masters of Defence Studies Research Project

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I – INTRODUCTION

"We cannot solve problems at the same level of awareness we were at when we created them."

- Albert Einstein

A recent Department of National Defence study[1] found that the Canadian Forces (CF) were poised to spend almost ten billion dollars over the next fifteen years investing in new C^{4}ISR capabilities[2] with no explicit framework to guide how these new capabilities will inter-relate or even a true understanding of how these capabilities will affect future force structures and capabilities.[3] Rationality, forethought, planning, and vision are desperately needed to ensure that critical future combat capabilities are not frittered away in an orgy of uncoordinated spending.

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[1] Canada. Department of National Defence. *Canadian Forces C4ISR Command Guidance & Campaign Plan - DRAFT*. Ottawa: DND, 07 November 2003, 38.

[2] C^{4}ISR stands for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance. The acronym refers to the broad aggregation of technology and processes that allow decision makers to observe the environment, communicate orders and intent, and receive feedback on the results of actions taken.

[3] Canada. Department of National Defence. *Canadian Forces C4ISR Command Guidance & Campaign Plan - DRAFT*. Ottawa: DND, 07 November 2003, 34

The current state of C^4ISR systems in the CF demonstrates the deleterious effects of years of discrete capability development, environmental parochialism, and functional stove-piping. As the information-based Revolution in Military Affairs (iRMA) takes hold, a more holistic and centrally planned system is necessary to ensure that the CF's core Command and Control (C^2) and decision support mechanisms are capable of effectively supporting the CF's operations.

The CF urgently needs an explicit strategic philosophy, vision, and framework to guide its joint C^4ISR investment. Despite a great deal of work on this matter, a number of underlying issues have not yet been fully addressed and current plans risk resulting in an inchoate mess. A failure to ensure that the foundation is properly laid – prior to further significant investment – risks being both wasteful and inefficient. This paper will examine the current problem, expose the underlying issues, and propose a conceptual framework to guide joint C^4ISR development while identifying several key areas for further study and discussion.

Recent departmental efforts to corral the C^4ISR issue and provide strategic level guidance, while well intentioned, still tend to develop along organizational lines and within existing organizational paradigms. While it is clear that this is a complex and challenging problem area and although a number of organizations have contributed various pieces of the C^4ISR strategic direction, the vast majority of these efforts exist and are developed primarily in isolation from the efforts of other directorates. For example, over the past two years, the Directorate of Joint Force Capabilities (DJFC) has spearheaded an effort to converge and focus these efforts into one set of documents designed to provide a coherent and unified strategic context to C^4ISR capability development. Unfortunately, these efforts have been undermined by

a lack of unified command direction on the desired focus,[4] leaving staff to propose compromise solutions in an effort to achieve consensus. Ultimately, without higher strategic guidance and vision, the staffs are left to toil within the constraints of existing organizational paradigms and are limited in their freedom of maneuver to put forth truly transformational solutions.

To be successful in leveraging the iRMA and to achieve an effective C^{4}ISR system, it is essential that the CF consider, understand, and anticipate the broad organizational, doctrinal, technological, and personnel issues raised by the iRMA. Unfortunately, the current system is carefully tuned to identifying and providing solutions to discrete problem sets, most usually in a service-based context. Indeed, the risk averse culture of the CF enterprise management system sometimes seems intent on reducing the Revolution in Military Affairs into what can best be thought of as an "Evolution in Bureaucratic Affairs."[5]

While this paper is critical of the current CF C^{4}ISR development path, it is not intended to be critical of the exceptional thought, effort, and dedication that has been expended by a number of hard working individuals in the CF. In many cases it would appear that the right things are being done and the right effort is being invested. Unfortunately, it is the underlying premise of this paper that such efforts are doomed to miss the mark – if not fail outright – because the underlying systemic issues have yet to be addressed. Until such issues are considered

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[4] This is bound to be a contentious assertion. Some will point to the CF C^{4}ISR Campaign Plan as indicative of recent strategic consensus and direction. However, it remains the author's contention that such direction remains nascent, incomplete, and insufficient.

[5] Credit is due to Lieutenant-Colonel R.E. Giffin for coining this phrase in discussion with the author. Originally the term "Evolution in Military Affairs" was used in this paper, but his description more accurately reflects the current bent of the transformational efforts within DND.

and their impact factored into the development of a truly integrated and effective C^4ISR plan, it is unlikely that the CF will truly reap the full potential of their significant investment.

This paper begins with a brief exploration of the current basic thought and theory that underpins the current military implementation of the iRMA whether it be Network Centric Warfare (NCW), Effects Based Operations (EBO), or any other related initiative. The effects of Chaos and Complexity theories will be discussed to provide measure to the limits of the promises of C^4ISR. And criticisms of the NCW theory will also be reviewed to provide critical perspective to the otherwise unchecked dream of a battlefield devoid of Clausewitzian fog and friction.

Armed with a clearer understanding of the iRMA environment, the contemporary Canadian context will be examined in an effort to understand the current state of affairs in the CF C^4ISR system and to better comprehend the very real constraints and restraints that will shape its development. The CF C^4ISR Campaign Plan (CP) will be reviewed and, where appropriate, form the basis of further discussion on the challenges inherent to the CF as it attempts to transform.

Finally, the key issues that need to be addressed will be exposed and an outline vision of their solutions will be proposed. The need for a robust philosophical and organizational structure will underpin the foundation of this solution. As well, appropriate tools to facilitate better planning and management of C^4ISR capability development will be suggested and notional examples given.

This paper concludes that current CF efforts to develop a coordinated and joint C^4ISR capability, while well-intentioned, are likely to fall well short of the desired end state due to the failure to address fundamental underlying issues.

II – UNDERSTANDING THE RMA

"The longstanding relationship between technology, complexity, and battlefield success has not been significantly altered by recent developments, and is unlikely to be changed by technologies now on the drawing board."

- Stephen Biddle

The current angst and change in military thought comes about as a result of an underlying transformation in the way war is fought. Such changes, occurring from time to time, result in fundamentally altered militaries that often bear little semblance to their predecessors. However, as Clausewitz famously avowed, the underlying principle in warfare has tended to remain largely immutable as the extension of policy by other means. What changes, then, are the ways and means.

This section will set the stage for the remainder of the paper by defining the nature of such changes in military affairs and will explore the underlying concepts at the heart of the current shift. It will begin by defining what is meant by a RMA and what forms the basis of the current iRMA. The focus will then shift to a brief overview of the popular implementations of this RMA, largely American, along with its attendant theories and criticisms. Finally, the philosophical underpinnings that shape and limit the bounds of certainty proposed by the iRMA will be surveyed and, from these foundations, reasonable inferences will be drawn that should be used to provide scope to Canadian C^4ISR ambitions.

It should be noted that the subjects discussed in this area have been discussed often and at great lengths in other papers. Therefore, this section is intended to be neither comprehensive nor exhaustive. Rather, it serves as a brief overview designed to expose the influences of certain key concepts that will shape the discussion later.

A RMA is generally defined to be a:

> "major change in the nature of warfare[6] brought about by the innovative application of new technologies which, combined with dramatic changes in military doctrine and operational and organizational concepts, fundamentally alters the character and conduct of military operations."[7]

From a historical perspective, different authors have identified a number of sometimes differing RMAs that range from such diverse discontinuities as the introduction of telegraphs to the development of nuclear weapons. These RMAs are often grouped into broader groups, called Military Revolutions (MR), that relate to the way that states prepare and make war. The Tofflers, for example, in postulating that the way we make war reflects the way we make wealth, recognize three MRs (that they refer to as: 'waves of change'): the agrarian wave, the industrial wave, and the information wave.[8]

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[6] This definition may cause semantic confusion over the assertion that an RMA represents a major change in the "nature of warfare" since Clausewitz argued that the fundamental nature of wafare – the clash of wills – is largely immutable. For the purposes of this paper it is understood that the term "nature of warfare" is intended to refer to the fundamental ways and means of conducting warfare and not the underlying character of military conflict.

[7] Department of National Defence. *Shaping the Future of the Canadian Forces: A Strategy for 2020*. Ottawa: DND, June 1999, 1

[8] Alvin and Heidi Toffler, *War and Anti-war: Survival at the dawn of the 21st Century,* 3, 30-31

The widely recognized current iRMA, part of the Tofflers' third wave, is characterized by the information technologies (IT) that enable it.[9] The application of IT to military applications brings with it the promise of greater situational awareness, faster information flows, ubiquitous connectivity, and unlimited access to information. Clearly, the military force endowed with such "information superiority" should be in a position to reap significant operational advantage, especially if the Clausewitzian fog and friction of war can be reduced.

Such seductive promises also foreshadow significant organizational, doctrinal, and equipment changes that are consistent with the definition of an RMA. Indeed, it is important to understand that the simple introduction of technology does not create an RMA itself; it is the organizational, doctrinal, and personnel changes that truly define the RMA.[10]

Such fundamental changes, as are called for by a RMA, are often very difficult for militaries to implement. The reasons for such difficulties are varied but most often relate to the mechanistic and hierarchical organization, and doctrinal philosophy common to most militaries. Such organizations are normally "marked by a fixed division of labor, hierarchical authority, standardization of operations, and reliance on precise regulations for achieving regularity, reliability, and efficiency."[11] These formalities can, and often do, engender a certain organizational inertia that is resistant to change. This inertia is often also compounded by the

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[9] Thierry Gongorra, *Everything You Always Wanted to Know About the RMA, But were Afraid to Ask.* Presentation to the DCDS Professional Development Seminar, 23 May 2002, 7.

[10] Department of National Defence, *The Revolution in Military Affairs (RMA) – A Primer,* Ottawa: DND, August 2002; available from http://vcds.dwan.dnd.ca/dgsp/dda/rma/primer_e.asp; DWAN; accessed 23 February 2004.

[11] Boas Shamir and Eyal Ben-Ari, "Challenges of Military Leadership in Changing Armies," *Journal of Political and Military Sociology*, Vol 28, No 1 (Summer 2000), 50-51.

very real fiscal restraints that limit the flexibility of military organizations to introduce new capabilities while maintaining current operational relevance.

Despite such difficulties, history has shown that it is essential to make the transformations required by the RMA – or risk being outclassed by an opponent who has done so. This lesson was clearly demonstrated during Operation Desert Storm when coalition forces were able to achieve an impressive victory over the Iraqi forces while minimizing their own casualties, thanks in large part to the use of sophisticated information-age weapon systems like J-STARS and precision guided munitions.

Cases such as Operation Desert Storm and, more recently, Operations Enduring Freedom and Iraqi Freedom clearly demonstrate that we are in the midst of a full-blown RMA and that this RMA is having a significant impact on the way we fight wars and organize our forces. Non-contiguous, non-linear, parallel operations are becoming a normal part of modern doctrinal parlance. It is essential that such structural and philosophical changes be considered in the development of the CF C^4ISR capability.

It is no surprise that the leaders in the current RMA implementation then are the Americans. Consistent with the Tofflers' assertion that the way that we make war follows the way that we make money, the American economy had already begun a shift to an information- and knowledge-based economy long before Iraqi forces crossed into Kuwait. It is, therefore, unsurprising that virtually all the major theories that stem from the iRMA are American. The dominant, and arguably seminal, theory is that of "Network Centric Warfare" (NCW) which

pledges orders of magnitude increases in combat power by networking decision makers, sensors, and shooters to achieve higher tempo of operations, greater lethality, improved survivability, shared situational awareness, and self-synchronization.[12] NCW is characterized by the ability of dispersed units to self-synchronize their activities through the use of shared situational awareness and intent.[13]

While there are many other iRMA based theories and concepts, such as Effects Based Operations, Rapid Decisive Operations, and ForceNet, we will restrict our review to NCW as it is largely indicative and representative of the overall work in this field.

Fundamentally, NCW theory is underpinned by Metcalfe's Law, which states that the value of a network increases exponentially in proportion to the square of the number of nodes in the network.[14] Therefore, according to Metcalfe's Law, the value of the network rises very quickly as the number of participants in a network increase. NCW theorists extend – and, arguably, mischaracterize[15] – Metcalfe's law by postulating that combat power in a network-enabled force also increases in a manner driven by Metcalfe's Law. While such a simplistic relationship almost certainly overstates the case, it is intuitively obvious that the sharing of information and situational awareness can confer significant advantage.

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[12] David S.Alberts et al, *Network Centric Warfare – Developing and Leveraging Information Superiority*, Washington, DC: CCRP Publication Series, 1999, 86.

[13] Ibid, 88

[14] Ibid, 29-30

[15] See, for example: Ralph E. Giffin, and Darryn J. Reid. *A Woven Web of Guesses.* unpublished discussion paper, 2003, 12-15.

NCW is also driven by Moore's Law, which ensures that the technological "horsepower" required to process the ever-increasing information flows will be available. In essence, Moore's Law says that computing power will double every eighteen months.[16] The impact of Moore's Law on IT is obvious to anyone who has purchased a PC only to watch it quickly sink into virtual obsolescence, seemingly overnight, as newer and faster chips are released on a relentless schedule.

In practice, NCW theory is being implemented in the American forces through a variety of projects designed to provide ubiquitous connectivity and shared awareness. Capabilities like Global Command and Control System (GCCS), Blue Force Tracker (BFT), Secure Internet Protocol Router Network (SIPRNET) – among many others – represent efforts to build the family of systems that will enable the NCW aspirations.

There is little doubt that such connectivity is important to future western coalition operations. Vice-Admiral Cebrowski's[17] oft quoted statement that "if you are not on the net, you are not benefiting from the Information Age, and you're not on the team"[18] clearly suggests that those who are not interoperable with the US NCW doctrine will either be marginalized or be left out of future operations. However, such interoperability comes at great cost: estimates for

[16] More correctly, Gordon Moore predicted that the number of transistors on computer processors would double every eighteen months. While it has proven remarkably durable over the past two decades, there are very real physical limits that will eventually serve to limit Moore's Law as the size of transistors shrink to the atomic level.

[17] Vice-Admiral Cebrowski, United States Navy, is widely considered to be one of t.34 Tm(r)Tj10.02 0 02 43y10.02 0 0 10.02

building the Global Information Grid (GiG) – designed to provide ubiquitous connectivity – run as high as $10 Billion USD.[19] Such tremendous costs are typical of what to expect if ubiquitous connectivity is one's ambition. It is also worth noting that the relentless pace of technological change, driven by Moore's Law, also promises to require recurring re-capitalization of these capabilities.

However, despite its promises, NCW is not without its critics. The most potent criticism of NCW attacks its underlying philosophy: that more information yields better knowledge and understanding. Constructs showing the hierarchy of information, such as that shown in figure 1, are common in NCW literature and suggest that the aggregation of data yields information, knowledge, and, ultimately, wisdom.[20] While such constructs are seductively simple and appear intuitively obvious, there exist significant criticisms of such expectations. As an example, Giffin offers a compelling contrarian's view that builds off of both Hume's "Problem of Induction" and Karl Popper's criticisms of inductive reasoning to offer an opposing epistemological basis for military information management.[21] Even if one dismisses critics like Giffin, Complexity and Chaos theory also raise their own questions about the predictive nature of observation in

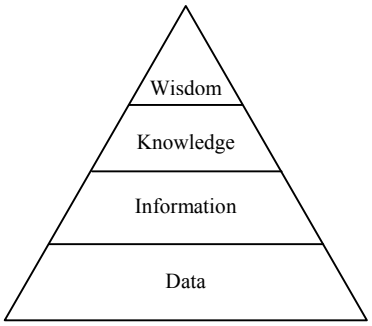

Figure 1 – Hierarchy of Information

[19] David W. Roberts and Joseph A. Smith, *Realizing the Promise of Network-Centric Warfare,* Joint Forces Staff College, 10 March 2003, 5.

[20] For an example of just such a reference in a Canadian context, see: Department of National Defence. *Defence Information Management Strategy*. Ottawa: DND, 23 March 2000, 4.

[21] Ralph Giffin, *Superstitious Rituals*, Ottawa: National Defence Headquarters. (unpublished discussion paper), 2002

complex adaptive systems. The point of such criticism is not to suggest that data and information are not valuable, but rather to debunk the notion that more is always better.

Even without the philosophical challenges, there is also the very real problem of simple information overload. While IT may scale with Moore's Law, the reality is that the humans who must interface with such systems are shackled with a relatively fixed 'cognitive bandwidth'[22] that limits their ability to absorb and understand information. It is of critical importance that decision makers understand the principles behind such limitations if they are to minimize their weaknesses and build on their strengths.[23] Huge volumes of data are of little use if decision makers cannot find the information they require or they are so overwhelmed by irrelevant network messages that they fail to see the critical message. A common example of the latter situation is painfully familiar to those who have e-mail boxes that are jammed with spam messages. Examples such as these suggest that Metcalfe's Law is, in practice, bounded at large values of 'n' – therefore, simply adding nodes to the network does not imply an increased value proposition for all participants.[24]

> *"Where chaos begins, classical science stops. For as long as the world has had physicists inquiring into the laws of nature, it has suffered a special ignorance about disorder in the atmosphere, in the fluctuations of the wildlife populations, in the oscillations of the heart and the brain. The irregular side of nature, the discontinuous and erratic side -- these have been puzzles to science, or worse, monstrosities."* - Jaime Gleick in Chaos: Making A New Science

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[22] Cognitive bandwidth is a phrase that refers to an individual's ability to absorb, process, and understand information. While highly individualistic, cognitive bandwidth is also affected by the form and manner in which information is presented to the user. Thus, reams of data presented in tabular format may be more difficult to grasp than if such data is presented graphically in the form of a chart.

[23] Christian Rousseau, "Commanders, Complexity and the limits of Modern Battlespace Visualization." Toronto: Canadian Forces College National Securities Studies Course Paper, 2003, 14.

[24] Ralph E. Giffin, and Darryn J. Reid. *A Woven Web of Guesses.* unpublished discussion paper, 2003, 9-11.

Although it is debatable whether philosophical questions – in and of themselves – mortally wound NCW, Complexity and Chaos Theories also pose significant questions that appear to further limit the promise of NCW. It is within the nature of many to assume that relationships in the real world are largely deterministic, or at the very least, stochastic and this implies an element of predictability to events. Chaos and Complexity suggest otherwise.

Chaos Theory deals with the fact that even simple, non-linear, deterministic systems can exhibit behaviours that appear random and unrelated. But, more correctly, chaotic systems are sensitive to initial conditions and it is our inability to accurately measure and account for all of these conditions that causes the results to be unpredictable.[25] Meteorology is often cited as an example of chaos in action – small changes in initial conditions can give rise to catastrophic storms. The inference to be drawn from Chaos Theory is that even deterministic systems may produce unexpected and seemingly divergent behaviours that defy predictability.[26] Because of their deterministic behaviour, chaotic systems are often predictable in the short term but can become widely divergent with the passage of time.

Despite the limits on predictability imposed by Chaos, there continues to be a number of efforts to model such chaotic behaviours. These efforts are spurred on by the recent dramatic increases in computing power that promise to alleviate the bounds of processing power on modeling chaotic systems. The most common examples of these systems are often used to model

[25] Ibid, 3.

[26] A more complete, yet understandable, explanation of chaos can be found on the Internet here: http://www.santafe.edu/~gmk/MFGB/MFGB.html; accessed on 24 February 2004.

and predict meteorological conditions. Contemporary advances both in measuring initial conditions and in modeling their relationships have indeed improved the accuracy of such models but they still remain distant from providing any certainty in their predictions. Such limitations apply equally to the battlespace and serve as a caution against the reckless, and costly, over application of technology against chaos in the search for predictability or certainty. Ideally, we should not aspire to achieving comprehensive predictive success but rather we should accept the inevitable and unavoidable need to simplify, approximate, and react to changes observed in execution. It is the observations of discrepancies that are more valuable to the decision maker as they allow him to adjust and adapt to the actual events in the battlespace rather than act simply on predicted results.

We can derive similar lessons from Complexity Theory, but Complexity is not the same as Chaos. Instead, Complexity deals with the emergent behaviours of complex adaptive systems. Complex adaptive systems are those comprised of a variety of self-organizing components that act individually but are both affected by their environment and whose actions can also affect the environment around them.[27] It is in these interactions that complex adaptive systems demonstrate emergent behaviours. Emergent behaviours arise from the interactions of simple rules that guide system participants but within which each participant has some latitude of maneuver. What is important here is the understanding that the interactions of simple rules among system participants result in emergent behaviours that are neither fully predictable nor necessarily repeatable, even given the same starting conditions.

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[27] John F. Schmidt, "Command and (out of) Control: The Military Implications of Complexity Theory," *Complexity, Global Politics, and National Security.* David S. Alberts and Thomas J. Czerwinski, eds, Washington: National Defence University, 1997), 233-235.

To be considered complex, a system must be deterministic, non-linear, and exhibit pattern-forming self-organization.[28] This description can be applied, without license, to describe most military organizations. In this sense, a series of army units on the battlefield can not only be considered complex adaptive systems operating in an environment bound by chaotic interactions, but they can also be considered to be comprised of complex adaptive systems themselves.

Even if we knew with absolute certainty the initial state of every participant in a system, we could not reliably predict the outcome of their interactions in a complex or chaotic system. To try to do so would not only be the height of folly but would also be wasteful of time, energy, and bandwidth (mental and physical). Instead, decision makers must make reasonable assumptions and simplifications about the outcome based on their understanding of the situation, their experience, their understanding of the overall emergent patterns, and their judgment and then measure deviations from the expected situation to determine if these deviations are of consequence to the operation. Indeed, the very execution of any detailed joint or combined plan involves the actions of complex adaptive systems that are able to self-correct to the desired state if the commander's desired end-state is well understood. Understanding and directing these interactions speak to the very essence of command and control.

[28] Christian Rousseau, "Commanders, Complexity and the limits of Modern Battlespace Visualization." To

As mentioned at the beginning of this section, it is well beyond the scope of this paper to discuss in great detail or at length the many criticisms of NCW theory.[29] Rather, it is intended only to sensitize the reader to the fact that NCW does not offer a panacea, nor does it pretend to promise it. However, ardent supporters of NCW have sometimes distorted the value of the concept while marginalizing criticisms. It is therefore essential to expedient and effective C^4ISR capability development that the limitations of NCW theory be properly considered before embarking on a complex and expensive capability generation program.

This section has outlined the ramifications of the RMA, its implications, and its consequences in simple terms. There is little debate left over whether or not we are in the midst of an information based RMA. Clearly, recent conflicts have shown the vast divide that exists in effectiveness between second-wave industrial militaries and post-industrial, third-wave military organizations.

The current RMA can be expected to result in significant changes in military doctrine and operational and organizational concepts. Indeed, it has been postulated that the RMA does not occur as a result of the application of new technology, largely IT in this case, but only truly comes about as the result of the transformative organizational, doctrinal, and philosophical changes that are enabled by the introduction of the technology.

[29] For more detailed and complete criticisms of NCW theory see, for example: , John A. Gentry, "Doomed to Fail: America's Blind Faith in Military Technology," *Parameters*, Winter 2002-03, 88-103. or Ralph E.Giffin and Darryn J. Reid, *A Woven Web of Guesses,* unpublished discussion paper, 2003.

The pursuit of the iRMA is in full swing among many of our allies, most notably the U.S. military. In fact, the vast majority of iRMA theories and implementations have come as a result of the significant investment made in this area by the U.S. Of these theories, NCW is still largely the dominant and most widely recognized of these theories. NCW brings with it the promise of increases in combat power made possible by networking decision makers, sensors, and shooters to achieve higher tempo of operations, greater lethality, improved survivability, shared situational awareness, and self-synchronization.

Tempering the promises of iRMA based theories such as NCW are a number of limits on the generation of knowledge and our ability to predict the outcomes of chaotic and complex systems. Even if such limits could be stepped around, the human mind is bounded by very real cognitive limitations that result in a finite ability to absorb and process information. These limitations have very real and very significant implications on the use of IT to achieve the promise of the iRMA. In the following sections, we will discuss the implications of such limitations in conjunction with the limitations imposed by the Canadian context to clarify several key planning issues that must be considered in the development of the CF C^4ISR capability.

III – INTRODUCING THE CANADIAN CONTEXT

"A Revolution in Military Affairs (RMA) is clearly underway, and it will have significant implications for Canadian Forces operations and activities, and on the military capabilities needed for the future"

- General J. M. G. Baril, Chief of the Defence Staff

Having briefly explored the underlying basis for the C^4ISR discussion, it is now appropriate to understand the Canadian perspective and context in which the CF C^4ISR capability must be developed. It is crucially important that the CF's C^4ISR implementation reflect the realities, constraints, and restraints extant in its environment. Equally important is the requirement that C^4ISR – as a critical enabler of command – be consistent with, and support, the emerging CF command philosophy.

This section will explore the current thought and understanding prevalent in the CF on the subject of C^4ISR. To do so, it will begin with a brief survey of current C^2 doctrine to identify its common threads divergences. As well, the current architecture of CF C^4ISR will be reviewed to provide an understanding of the current state of the art against which the desired end state may be later compared.

Once a baseline is established, this survey will turn to the capability development process currently in existence to promote a better understanding of how the CF identifies deficiencies, considers options, and acquires capability. To do so, it will be necessary to outline the CF capability based planning process and the Defence Management System (DMS) as well as to explain the impact of service based acquisition on joint capabilities. To emphasize the challenge of this issue, a brief review of the current fiscal realities facing the CF will also be presented.

Finally, this section will dissect the current C^4ISR planning documents to show where they excel and better understand where they are limited. In doing so, the analysis will focus largely on the work of the Directorate of Joint Force Capabilities (DJFC) as they have emerged as the leading C^4ISR concept developers within the National Defence Headquarters with the development of the CF C^4ISR Campaign Plan (C^4ISR CP).

As is the case with such short surveys, this section risks being criticized as superficial. However, it will cover a broad swath of inter-related issues and will preserve its brevity by focusing only on those areas that impact the development of C^4ISR capability.

This survey of the CF C^4ISR will conclude that the current lack of a complete theoretical C^4ISR foundation will have a significant impact on the CF's ability to develop appropriate solutions and to field appropriate capabilities to meet prescribed C^4ISR objectives. In addition, it will postulate that this shortcoming is in no small part due to existing organizational frictions that unduly affect joint capability development.

C^4ISR exists primarily to support command and effective decision-making. This is not to suggest or imply that C^4ISR be developed solely to drive information up to high level commanders and centralize decision-making. To the contrary, as we will see later, command can be exercised by decision makers at all levels, including those not in formal command positions. As with any joint capability, it is important that there exists a shared understanding of what is meant by key terms.

The CF joint definition of command is that "authority vested in an individual of the armed forces for the direction, coordination, and control of military forces."[30] This is precisely consistent with the NATO definition of command and is also used as the basis for the Land Force's[31] and the Air Force's[32] definitions. However, the army further defines command to include the concept of control as a subset or an aspect of command.[33] The Maritime Forces also include the concept of control as a subset of command in their command definition that states that command "is the authority vested in the CO for the direction, co-ordination and control of the ship and her company."[34] We see some consistency here as the CF has largely just adopted NATO's definition of command.

Control, on the other hand is defined in CF joint doctrine as "[t]hat authority exercised by a commander over part of the activities of subordinate organizations."[35] This is also the definition used by the Air Force.[36] But this is where the conceptual unity begins to show diminishing coherence. NATO defines control as the "process through which a commander…

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[30] Department of National Defence. *Canadian Operations*. Ottawa: DND, 18 December 2000, 2-1.

[31] Department of National Defence. *Command*. Ottawa: DND, 21 July 1996, 3-4.

[32] Department of National Defence. *Out of the Sun. Aerospace Doctrine for the Canadian Forces*. Ottawa: DND, 1997, 34.

[33] Department of National Defence. *Command*. Ottawa: DND, 21 July 1996, 7.

[34] Department of National Defence, MARCORD 4-15 *Command, Control and Charge in HMC Ships,* Available from http://navy.dwan.dnd.ca/english/marcords/v1/04-15.asp; DWAN; accessed 26 April 2004, 1.

[35] Department of National Defence. *Canadian Operations*. Ottawa: DND, 18 December 2000, 2-2.

[36] Department of National Defence. *Out of the Sun. Aerospace Doctrine for the Canadian Forces*. Ottawa: DND, 1997, 35.

organizes, directs and co-ordinates the activities of the forces allocated to him."[37] As already mentioned, the land force doctrine subordinates control as an aspect of command while also recognizing it as not only a unidirectional process but also as a dynamic process of feedback. The maritime definition of control is very specific: "the responsibility vested in the CO to give direction and orders…."[38]

The DJFC generated C^4ISR CP skirts the issue of promoting unity in the C^2 definition by not explicitly defining it anywhere in the main document but rather simply referring to C^2 as if to suggest that it is a commonly understood and agreed upon concept. Pigeau and McCann's definitions[39] are buried in a later annex but it is unclear – and unlikely – that these definitions were used throughout the document given the number of authors and the lack of explicit agreement earlier in the document. To further add to the imprecision, the Strategic Capability Investment Plan (SCIP), defines C^2 as "the ability to collect, analyze and communicate information, plan and coordinate operations, and provide the capabilities necessary to direct forces to achieve assigned missions."[40] Finally, as though to ensure the confusion is complete, the Command Decision Support Capability Document (CoDSC) – a document designed to provide part of the vision for C^4ISR development – defines C^2 somewhat obliquely as "the establishment of common intent to achieve coordinated action" a definition that it borrows from

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[37] NATO Control definition references AAP6

[38] Department of National Defence, MARCORD 4-15 *Command, Control and Charge in HMC Ships,* Available from http://navy.dwan.dnd.ca/english/marcords/v1/04-15.asp; DWAN; accessed 26 April 2004, 1.

[39] Ross Pigeau and Carol McCann, "Re-conceptualizing Command and Control," *Canadian Military Journal*, Vol 3, No 1 (Spring 2002): 56.

[40] Department of National Defence. *Strategic Capability Investment Plan*. Ottawa: DND, November 2003, 1.

Pigeau and McCann's re-conceptualization of command and control.[41] But to equivocate, it then points the reader to the glossary at the back of the paper where it promises the current official CF definition of C^2.

Even within these definitions, there is no unified doctrine on how they are to be applied. The army subscribes to a form of command, referred to as mission command, loosely based in *Auftragstaktik*[42], that promotes decentralized decision-making, freedom and speed of action, and initiative.[43] Conversely, the air force preaches the tenet of centralized control, de-centralized execution that espouses that command and control should be retained at the highest level possible.[44] Without much digging, it is apparent that there are fundamental differences in not only the definitions but also the applications of command and control.

Given such a diverging state of understanding on such a fundamental principle, it is apparent that this might portend difficulty in generating consensus on joint C^4ISR architecture. More troubling is the likelihood that, in a service-dominated capability development framework, the needs of individual services may result in C^4ISR services that are not interoperable with other services or with key allies. These differences arise because individual services are able to create their own operational and tactical level C^2 systems that place primacy on meeting their specific C^2 needs, often at the expense of interoperability.

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[41] Department of National Defence. *Command Decision Support Capability*. Ottawa: DND, 03 September 2003, 5.

[42] *Auftragstaktik* is a German term that refers to mission-oriented tactics or mission orders.

[43] Department of National Defence. *Command*. Ottawa: DND, 21 July 1996, 30-36.

[44] Department of National Defence. *Out of the Sun. Aerospace Doctrine for the Canadian Forces*. Ottawa: DND, 1997, 36.

It is clear that, to create a fully functional and interoperable joint C^4ISR system, it is necessary to have conceptual coherence in the underlying principles. And, in an information-enabled environment, it is essential that information exchanges be unencumbered by technical and doctrinal difficulties. Interoperability is typically defined as the ability of different entities to exchange and accept services from each other. Such a definition implies that interoperability has components beyond the obvious technological requirements for simple connectivity. To be fully interoperable implies additional requirements including doctrinal alignment, process coherence, and common language. Since each organization (and sub-organization) often has its own discrete doctrine, processes, and vernacular, it is obviously quite important to choose relationships carefully as the cost of interoperability can be quite high. It is also clear that pursuing certain interoperability relationships must necessarily come at the expense of others.

In the Canadian context, there is some tension over which interoperability relationship should enjoy primacy: should the CF focus on joint operations and ensure alignment between the services or should the CF recognize the "reality" that CF units normally fall under coalition control and align our interoperability efforts with key allies – if so, which ones? Canada's Defence Policy – while not addressing the issue explicitly – indicates that the CF's relationship with US forces is of paramount importance and directs the CF to "maintain the ability to operate effectively at sea, on land, and in the air with the military forces of the United States…."[45] Strategy 2020 also places emphasis on the need to "strengthen our military relationship with the US military to ensure Canadian and US forces are inter-operable and capable of combined

[45] Department of National Defence. *1994 White Paper on Defence*. Ottawa: DND, Available from http://www.forces.gc.ca/admpol/eng/doc/white_e.htm; accessed on 26 February 2004, 1994, 7.

operations…."[46] However, Strategy 2020 also requires the CF to "foster jointness in command and control…."[47] To meet these primary interoperability requirements, while also considering the need to maintain the ability to effectively operate within NATO, will require careful delineation of lines of interoperability and explicit direction on where key interfaces must be maintained.

To illustrate the complexity of such relationships, it is useful to look at the classified C^2 domain. As figure 2 illustrates,[48] to even maintain core C^2 connectivity within our core alliances and within the CF itself requires a complex system of systems that could less politely be described as a "kludge." That this connectivity is necessary is not a point of debate but these relationships serve to highlight the complexity and the implicit costs required to maintain modern C^2 connectivity. These costs are referred to as the "entry fee"[49] and it should be noted that entry into these relationships implies a commitment of dependency in that we must ensure that we maintain our end of the connection to a standard often prescribed by another nation or alliance. It is, therefore, necessary that the CF choose its partnerships carefully and manage its C^2 infrastructure costs wisely to maintain a degree of control over the cost of maintaining these links.

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[46] Department of National Defence. *Shaping the Future of the Canadian Forces: A Strategy for 2020*. Ottawa: DND, June 1999, 6.

[47] Ibid, 6.

[48] Figure 2 is based on the CF C2IS Convergence diagram found at: Canada. Department of National Defence. *Canadian Forces C4ISR Campaign Plan – Interim Report*. Ottawa: DND, 27 June 2003, K-1.

[49] Department of National Defence. *Canadian Forces C4ISR Campaign Plan – Interim Report*. Ottawa: DND, 27 June 2003, 18.

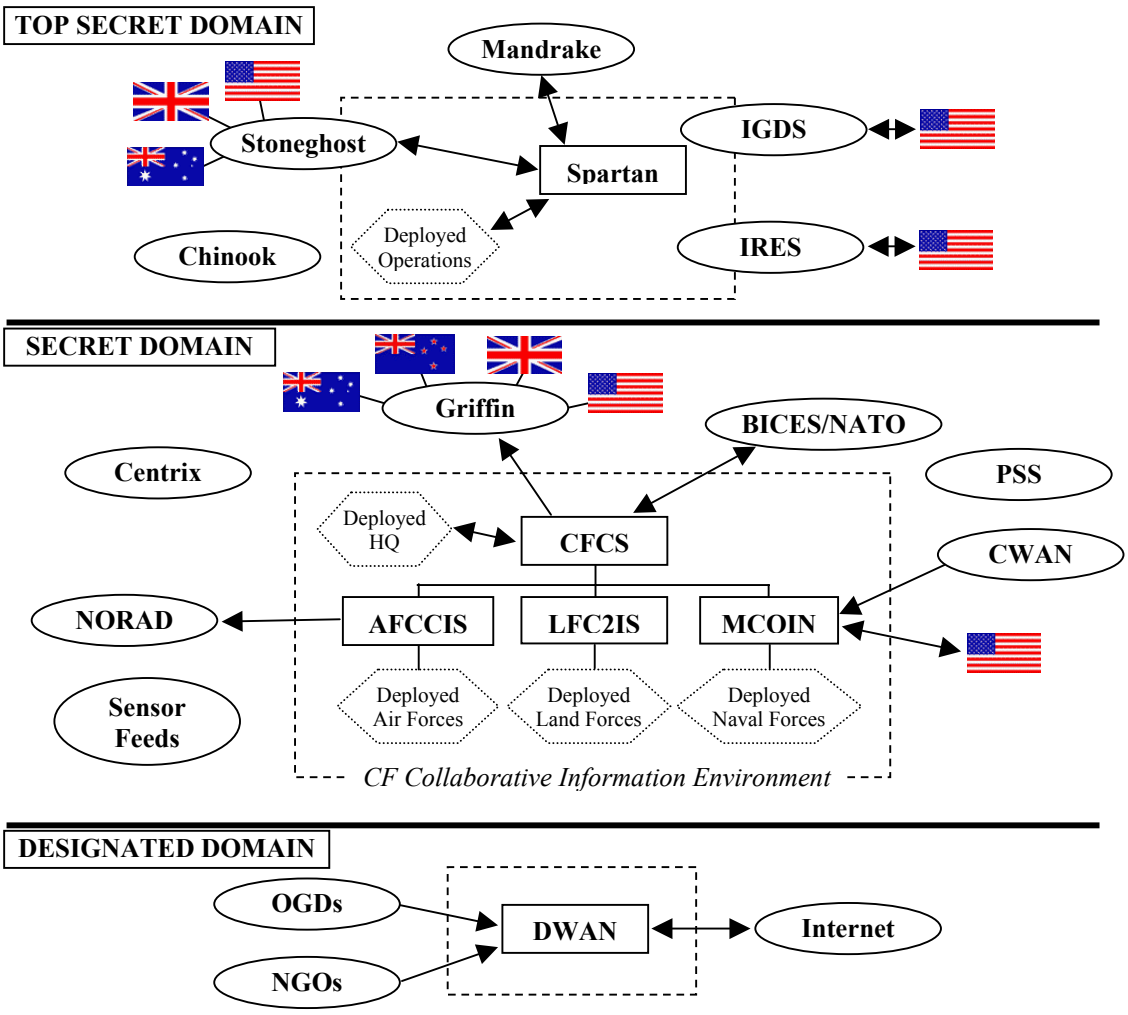

Figure 2 – CF C^{2}IS Architecture

When looking at the CF C^{2}IS architecture at the secret level, it becomes even more apparent that service based C^{2}IS development has led to there being divergent C^{2}IS architectures – one for the joint level and three service based architectures. Such divergent architecture paths, while being effective from a single service perspective, create significant additional cost and complexity for the CF. A 1994 Auditor General report found that:

> "The Canadian Forces is fielding several systems that are based on different computer software families and cannot interoperate. There was no central manager of technology to co-ordinate system development and ensure that systems could work together. As a

> consequence, the systems cannot pass information among themselves, even though their users will be required to work together in joint headquarters."[50]

It is particularly unfortunate that such development paths also tend to result in significant overlap in both effort and capability – inefficiencies that the CF can ill afford.[51] It is not too much of an intellectual stretch to infer that the current state of the C^2IS infrastructure can be construed as an indictment of the current capability development structure. It is equally easy to conclude that the current C^2IS governance structure is ineffectual and does not provide a compelling value proposition to encourage service participation in a common architecture.

The reason that deviations from common standards have occurred is primarily because of a lack of any such central standards. In the absence of any central direction, the services have pursued a rational doctrine of enlightened self-interest in the pursuit of their individual C^2 systems. Probably the best example of this approach is that of the maritime forces. Due to the particularly strong relationship that the Canadian maritime forces have had with the US Navy (USN) – often serving as integral units of US Carrier Battle Groups (CVBG) – the maritime forces have developed a system of C2 systems and tactical data links that integrate virtually seamlessly with the USN.

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[50] Despite the passage of almost a decade since this report was filed, little of material consequence has changed, see: Office of the Auditor General. *1994 Report of the Auditor General of Canada*. Ottawa:Government of Canada, 1994. Available from http://www.oag-bvg.gc.ca/domino/reports.nsf/html/9425ce.html; Internet; accessed 28 January 2004, 5.

[51] This too was noted in the 1994 Auditor General report and yet parallel capabilities are still being developed in C^2 systems. The recently developed SCIP, for example, shows continued development on CFCS (a joint C^2 system), AFCCIS (an air force C^2 system), and LFC2IS (now called ACE, a land force C^2 system).

However, in creating such a tight relationship, joint connectivity has been relegated to a lower priority. Recent experience on Operation Apollo suggests that the maritime forces have made a wise choice and, in the absence of any other strategic direction than that espoused in Defence White Paper 94 and Strategy 2020, one could only agree with them. The outstanding issue that has not been discussed, however, is at what cost? As defence-scholar Dr. Paul Mitchell notes, the main issues raised by NCW are not likely to be technological in nature but rather policy based.[52] Again, this lends credence to the premise that the necessary thought must be invested up front. In the absence of such consideration, individual services will tend to act in their own best interest. Such actions may or may not be congruent with the needs or wishes of the organization but the onus is truly on the parent organization to create the conditions or framework to guide its subordinates to act in the best interests of the organization.

Currently, the CF employs a process known as Capability Based Planning (CBP) to guide its defence investment. The CBP method is a sound process, linking required capabilities to policy objectives. The policy objectives are in turned established through direction contained in the White Paper[53] and guided by a vision of a "future force" outlined in Strategy 2020. To further guide staff planners, the CF has also introduced a set of Defence Scenarios that provides examples of typical missions and roles the CF might be expected to fulfill in a variety of circumstances spanning the entire spectrum of conflict. As well, a Canadian Joint Task List has

[52] Paul T. Mitchell, *Small Navies and Network-Centric Warfare – Is there a role?*, 1.

[53] Capability based planning policy direction also comes from other government policy that is received from time to time. Arguably, the current White Paper offers little value as policy direction given its age and the significant changes that have transformed the security environment in the past decade.

been produced to give a structured set of tasks, spanning the full gamut of defence requirements, that can be used to construct representative force capabilities to meet the needs of the scenarios.

Required capabilities identified through the CBP process must be acquired from outside the CF or developed from existing capabilities. The process to acquire new capabilities is managed through the DMS, a system that is congruent with Treasury Board direction guiding the legitimate expenditure of public monies. The DMS process is highly structured, largely inflexible, and lengthy to the point of attracting the attention of the Auditor General. The Auditor General noted that "information technology projects take, on average, over 14 years to complete."[54] Because C^2 systems are largely technology driven, Moore's Law intimates an accelerating pace of advance and "if projects take too long to complete, plans become outdated and specified equipment obsolete, or even unavailable."[55]

More recent reports have also been unapologetically critical of the glacial pace of projects navigating the DMS. The recent departmental report on *Achieving Administrative Efficiency* concluded that the capability acquisition process was "slow and cumbersome" resulting in average acquisition times exceeding 15 years, a period considered to be "too long."[56] Despite this conclusion, the Minister's report only recommends implementing the recommendations of Department's *2e*

seeking to reduce the time required to 10-12 years.[57] Given that Moore's Law promises to double the performance of IT systems every 18 months, can a reduction in acquisition time from fifteen years to ten years really stave off the certainty of obsolescence through inefficient acquisition?

Notwithstanding the inefficiencies in the underlying system, there is still a requirement to ensure that projects are developed in a coherent fashion to meet the identified capability needs of the CF. The basic process employed by the CF is shown at figure 3.[58]

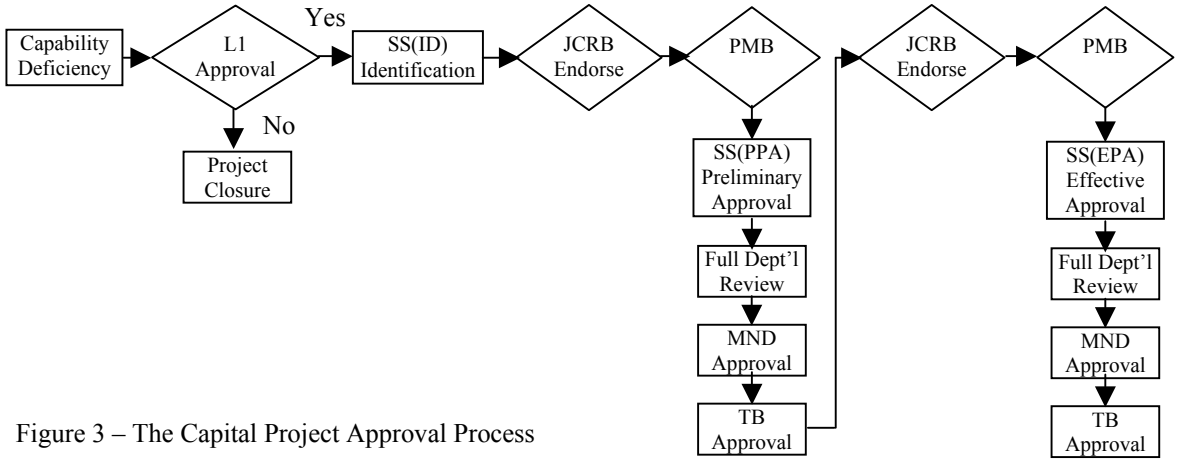

Figure 3 – The Capital Project Approval Process

Under this process it is possible for any Environmental Chief of Staff (ECS), as a Departmental Level 1 manager, to initiate a capital project by approving an internally generated capability deficiency. While the rest of the process is designed to ensure that projects meet the needs of the CF and are phased to reflect the realities of the funding envelope, there are two basic failings of the current system. First, the project can expend significant time and energies following a flawed approach before a departmental review finally ends it. This inefficiency and

[57] Ibid, 122-23.

[58] Figure 3 is derived directly from: Department of National Defence. *Achieving Administrative Efficiency*. Ottawa: DND, 21 August 2003, 119.

waste could be mitigated, particularly in the C4ISR capability context, if the project had a framework within which to synchronize itself and ensure its acceptability prior to departmental review. Secondly, the current governance structure lacks adequate context in which to assess and compare proposed C4ISR capabilities. This latter flaw means that projects can be approved on the basis of little more than "professional judgment" from within the aegis of any of the stove-piped services.

The lack of context within which to consider different projects is particularly troubling in the C4ISR field because C4ISR is all about context. To be relevant and useful, C4ISR systems must relate to each other in an interoperable and synergistic way. This implies the need for a balanced system providing a mix of mutually supporting and enhancing capabilities. However, without the necessary context in which to judge candidate projects, it is difficult for the governance structure to judge whether the CF is over investing in one area at the expense of another.

As an example of this problem, the C4ISR CP divides the overall C4ISR capability area into five discrete functional areas: direction, collection, processing, dissemination, and decision support. By categorizing the expenditures of 138 C4ISR projects against these functional areas, it was discovered that 43% of the capital investment was placed against dissemination, 39% against collection but only 8% was being invested in processing capability. On the surface, this imbalance in funding allocation would seem instructive and might even suggest over investment in collection and dissemination at the expense of processing. Lamentably, such analysis would be specious without a better understanding of the relative dollar cost to capability ratio for each

category; it is entirely possible and likely that collection systems, for example, are more expensive per unit of capability than processing systems.

Lacking such context and the tools to effectively compare disparate parts of the C^4ISR development program, the critical roles of the Joint Capabilities Review Board (JCRB) and the Project Management Board (PMB) are greatly complicated. Members of each committee must instead rely heavily on professional judgment and staff recommendations to make decisions on very expensive and mutually dependent commitments. Given the extremely constrained capital budget situation currently facing the CF, the importance of such decisions becomes even greater and the need for good decisions becomes critical. C^4ISR systems, being heavily dependent on IT, are path dependent[59] and are also often prohibitively expensive to re-capitalize if they prove to be inadequate.

The impacts of constrained capital resources are manifest in today's CF. Obviously such constraints severely limit the solution space available by narrowing the options of affordable capabilities and reducing the margin of error by making it cost prohibitive to re-capitalize failed investments. A detailed understanding of the causes and effects of capital budget constraints is not necessary to understand the limitations they impose on a military force in the midst of transformation. But a basic understanding of the magnitude of the problem is useful in understanding the need for the efficient investment of funds in new capabilities.

[59] For a detailed discussion of path dependency causes and the dangers of "lock-in," see: Ralph E. Giffin, and Darryn J. Reid. *A Woven Web of Guesses.* unpublished discussion paper, 2003, 9-11.

Strategy 2020, in setting out the transformation strategy for the CF, established a capability investment goal of a minimum of 23% of the Defence Services Program (DSP) to be invested in capital.[60] This level of investment was considered indispensable not only to re-capitalizing existing essential capabilities but for investing in new, transformative capabilities – such as C^4ISR – that would enable the CF to:

> "field a viable and affordable force structure trained and equipped to generate advanced combat capabilities that target leading edge doctrine and technologies relevant to the battlespace of the 21st century."[61]

This commitment to transformation and to enabling the RMA was also re-affirmed in the annual Departmental Report on Plans and Priorities from that same year; it committed the CF to meet the challenge of:

> "responding effectively to the so-called *Revolution in Military Affairs* – that is, managing the impact of rapid technological change on military operations, communications, equipment, doctrine and force structure."[62]

Sadly, the reality of the past four years is that capital expenditures have never met this goal and the goal itself appears to have disappeared from consideration as it no longer appears attainable. Indeed, in the very year the goal was first set, the CF managed to commit only 19.7% of the DSP to capital expenditures and that amount has dropped since.[63] By fiscal year 2000-2001 (FY00-01), the investment level was down to 18.6%,[64] remaining stable in FY01-02 at

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[60] Department of National Defence. *Shaping the Future of the Canadian Forces: A Strategy for 2020*. Ottawa: DND, June 1999., 9.

[61] Ibid, 9.

[62] Department of National Defence. *1999-2000 Report on Plans and Priorities*. Ottawa: DND, 1999, 10.

[63] Ibid, 19.

[64] Department of Nat

18.8%,[65] before dropping again in FY02-03 to 17.9%.[66] This erosion is most likely to continue as the demands of current operations eat into the funds available for the investment in the future.

Looking specifically at the C^4ISR capital situation, the Strategic Capability Investment Plan (SCIP) forecasts spending approximately $4 billion over the next 15 years in the field of "knowledge-based command and sense," a field that can be considered an analogue to C^4ISR. This spending represents almost 15% of the capital funds available for equipment investment.[67] At first glance, this seems to be a substantial investment but when compared to the magnitude of investment originally identified in the CF C^4ISR CP review – $10 billion over the next 15 years – it can be reasonably deduced that significant decisions have already been made on the spending priorities and that not everything envisioned originally will be affordable under the current capital realities. Even if it is assumed that the SCIP and the C^4ISR CP do not correlate exactly in their definition of what constitutes a C^4ISR project – and it is probable that they don't exactly correlate – the sheer size of the difference in planned expenditures cannot be ignored.

A telling insight into the shortfalls of the SCIP funding levels is evident in the Chief of the Land Staff's (CLS) impact assessment letter of June 2003. In this scathing indictment of both the SCIP investment plan and the overall level of funding available for capital investment, the CLS makes the point that the CF currently has a "four-service program [funding requirements]

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[65] Department of National Defence. *2001-2002 Report on Plans and Priorities*. Ottawa: DND, 2001, 56.

[66] Department of National Defence. *2002-2003 Report on Plans and Priorities*. Ottawa: DND, 2002, 39.

[67] Department of National Defence. *Strategic Capability Investment Plan*. Ottawa: DND, November 2003, 10.

and a two-service budget."[68] The CLS goes on to deem the SCIP to be reflective of an "unfocused approach that distributes reductions without a clear connection to transformation objectives."[69] Such an uncharacteristically blunt expression of frustration from an L1 manager is clearly indicative of the frictions that arise from a tightly constrained capital program, especially when such constraints come at a time of fundamental transformation for the land forces.

From this brief look at the capital funding situation, it is evident that the funding levels envisioned in the SCIP represent a compromise between what is desired and what is affordable. It is equally clear that the capital investment level prescribed in Strategy 2020 is not attainable and is unlikely to be articulated as a target again. Given these realities, it is manifestly obvious that the right C^4ISR investment choices are required up front. The CF simply cannot afford to err and start over again. As well, recognizing that the C^4ISR capability is both holistic and synergistic, effective and efficient investment must consider the capability from the context of a systems perspective and smart investment must be made in those areas that promote the greatest marginal gains in system effectiveness.

In recognition of these realities, the CF has made numerous attempts to corral the C4ISR issue into a manageable framework. The most significant work in this area has been the efforts of DJFC. DJFC staff have created a family of documents designed to create a coherent vision – articulated in the Command Decision Support Capability (CoDSC) Vision document – and link the present to that vision through the C^4ISR CP. The CoDSC describes the overall C^4ISR vision

[68] LGen R.J. Hillier, *Strategic Capability Investment Plan-Land Effect.* (NDHQ: file 3136-5 (CLS), 26 June 2003), 1.

[69] Ibid, 1.

and expected capability by providing a set of underlying principles and characteristics. The critical document is the C4ISR CP as it provides some context and recommendations to guide CF C4ISR development. Without a doubt, these documents, and others in the same family of documents, form an impressive body of work and express an implicit acknowledgement of the fact that the C4ISR capability development system up to the present has been badly dysfunctional. However, it remains the contention of this paper that the C4ISR CP, in its current form and existing in its current environment, is insufficient to provide a reasonable assurance of success.

The C4ISR CP is based on the operational concept of the campaign plan process as a tool to focus staff efforts on solving a complex problem. This metaphor is interesting and largely sound in this application but the limitations of this approach should also be fully understood. First and foremost, a campaign plan is intended to be used to focus efforts to arrive at a clearly defined and well-understood end-state. In the case of the C4ISR CP, it is clear that no definitive end-state can be articulated, as C4ISR capability development is more a voyage than a destination. In recognition of this, the C4ISR CP instead proposes a vague and ill-defined future that is tied to the guidance contained in Strategy 2020, and as further articulated in the CoDSC. To provide clearer goals, the C4ISR CP proposes a system of "waypoints" or convergence points in the form of "Target Integration Models" (TIM).[70] While this construct is useful and ultimately more realistic than setting explicit long-term goals in the face of an uncertain future security and technology environments, the TIM concept lacks sufficient specificity to provide a useful tool for governance structures to measure compliance or for capability development staffs to derive

[70] Department of National Defence. *Canadian Forces C4ISR Command Guidance & Campaign Plan - DRAFT*. Ottawa: DND, 07 November 2003, Annex G.

sufficient direction to allow them to self-synchronize to an agreed-upon architecture. To be effective, the TIM concept needs to be supported by fully developed operational, technical, and security architectures.

Another area of weakness in the C^{4}ISR CP is its reliance on the campaign planning concept of the estimate process to develop its initial assessment of the C^{4}ISR state of affairs. Inherently, this is a descriptive process that was used not only to develop an understanding of the C^{4}ISR capability state of the union, but also to develop a number of inferences and deductions that form the basis of the C^{4}ISR CP. Such a descriptive process cannot help but internalize the inherent flaws in the existing environment. Essentially this means that the C^{4}ISR CP has attempted to develop a description of "what should be" based largely on an analysis of "what is." This need not be a fatal flaw so long as future capability development is guided by a more top-down normative approach to determine the desired capability.

However, the true fatal flaw of the current C^{4}ISR CP is that that it is constrained to operate within the extant organizational and governance structure. Such an approach, especially when married with the descriptive approach used to develop many of its goals, is unlikely to solve any of the failures of the current organization nor is it likely to drive the level of organizational, doctrinal, and personnel changes implicitly required by the iRMA. Operating within the bounds of a service-dominated capability development structure, with no clear C^{4}ISR champion at the L1 manager level, it is inconceivable that a joint document like the C^{4}ISR CP will be able to exert any significant influence over the ECSs should its direction clash with what is perceived to be in the individual service's best interests. Working within such an

organizational structure fails to provide the C4ISR CP any mechanism to unhinge individual service control of C4ISR capability development.

These criticisms are not meant to be a repudiation of the C4ISR CP concept. Indeed, the C4ISR CP provides a necessary and useful reference on the current status of C4ISR capability development in the CF. But the impacts of the constraints under which it operates and the shortcomings in its developmental model cannot be ignored if it is to achieve its potential as the key capstone document outlining C4ISR capability development in the CF. In the next section, key enablers and activities will be proposed to unchain the C4ISR CP from these restrictions and allow it to fulfill its promise.

This section has provided the essential Canadian context required to understand the challenges that shape and limit C4ISR development in the CF. A very broad overview of this context was necessary to set the stage for the next section where the necessary framework will be introduced.

In conducting this review, several key inferences and deductions were made. First, it was clear that the CF lacks a clear guiding definition of Command, Control, and C2. This shortcoming speaks to a larger shortfall in the area of a guiding philosophy of how C2 will be exercised in the post-iRMA CF. In fact, there currently exist fundamental differences in the C2 philosophies of the three services and such differences portend potentially significant differences in the preferred approach of each service in developing the C4ISR capabilities that will enable it to operate effectively in the operational environment of the 21st century. It is manifestly clear that

an investment in military thought should come prior to any significant investment in new military capability.[71]

These philosophical dissonances are amplified in an organization whose force and capability generation processes are designed to support service-based requirements before those of the organization in general. When considered in context with the widely disparate operational environments of each service, it is obvious that there will be localized requirements for C^4ISR capabilities. These divergent requirements can be seen manifested in the convoluted C^2IS architecture examined. While many of these differences in the C^2IS structure can be attributed to the requirements of connectivity with key allies, many are also within the CF's span of control to influence and control.

Next, the exploration of the capital investment governance structure and capital investment funding level realities gave us insight into the challenges ahead and the constraints on future C^4ISR capability development. Given both the tight fiscal environment and the need to develop C^4ISR holistically as a system, it is clear that the existing governance structures lacks the necessary tools needed to help guide their decision-making to ensure that the optimal capability mix is acquired.

Finally the review of the C^4ISR CP noted a number of underlying issues that threaten the effectiveness of the entire DJFC C^4ISR guidance document family. Overall, the C^4ISR CP is a critically needed guidance document that is impressive in both its breadth and scope. However,

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[71] R.E. Giffin, *Superstitious Rituals*, Ottawa: National Defence Headquarters. (unpublished discussion paper), 2002

its descriptive approach coupled with the implicit constraint of having to work within the current organizational realities severely threatens to undermine the utility of the document as a capstone C^4ISR development document.

C^4ISR capability is derived from the synergistic convergence of organization, technology, and personnel guided by enlightened doctrine. The current system is woefully inadequately prepared to guide a joint capability development undertaking of this magnitude. The organizational and governance structures are inappropriate to support this requirement. And the philosophical basis for the joint doctrine has not yet been articulated in coherent fashion and therefore has not been accepted pan-CF. The following section will develop and articulate a framework to guide the development of CF C^4ISR capability and identify those areas requiring further study and thought prior to any significant investments in C^4ISR.

So far this paper has surveyed the broad RMA environment in which the CF finds itself and has provided a Canadian context in which to situate the current challenges. While this overview has been brief, it is brief because there is little new to discuss here – the challenges of the RMA and the CF's situation have been heavily debated. It was therefore only necessary to provide the essential context in which to position the proposed solution framework.

IV – DEVELOPING THE C^{4}ISR FRAMEWORK

"We are drowning in information but starved for knowledge. This level of information is clearly impossible to be handled by present means. Uncontrolled and unorganized information is no longer a resource in an information society, instead it becomes the enemy."

-John Naisbitt, Megatrends 1982

This section will provide the framework for a solution to guide CF C^{4}ISR development. Some of what will be proposed is not completely new but is simply the amalgamation of current work into a more coherent structure. Much of what is new is bound to be contentious. However, consensus on the solution space is no longer important - what is important is the creation of a cogent and realistic framework within which to develop the C^{4}ISR capabilities so critical for the future of the CF. A failure to create such a guiding framework carries with it the significant risk of failing to develop an effective CF C^{4}ISR capability, and such a failure would be expensive indeed. More troubling is that such failure is not only reasonably foreseeable, it is entirely preventable.

In this section, it will be argued that the necessary framework for developing the required C^{4}ISR capability is comprised of three steps:

1. Get the philosophy right;
2. Get the organization right; and
3. Provide the necessary tools to guide the development.

Each step will be discussed in turn and its constituent parts exposed to provide sufficient detail to enable further discussion and development. Some of the parts of this framework already exist in documents like the C4ISR Campaign Plan – indeed the C4ISR Campaign Plan covers many of the steps mentioned above – but the missing piece has been the overarching framework that binds the existing parts with conceptual unity. And, unfortunately, some of the existing work in this area is simply wrong – sent astray by organizational, cultural, or philosophical compromises. In such circumstances, alternatives will be offered.

Although this section will conclude that that the necessary work to fully implement the critical C4ISR capability has not yet been done, a seminal framework will have been laid out here for discussion and guidance of further efforts to develop the key enabling C4ISR structures of the 21st Century.

Step 1 – Getting the Philosophy right

It would be a truism to point out that an investment in thought should precede a significant investment in resources. And it would be patently unfair to suggest that a great deal of thought has not already been applied to the issue of C4ISR capability development. However, a brief survey of CF doctrine and key CF C4ISR literature shows that there is little coherence in either the current C2 doctrine or the pan-CF C4ISR architecture. While the C4ISR CP defines C4ISR as consisting of:

> "the concepts, the connectivity, the information systems, the sensors, and the tools in support of and required to achieve effective Command & Control across the entire spectrum of CF operations…"[72]

[72] Department of National Defence. *Canadian Forces C4ISR Command Guidance & Campaign Plan - DRAFT*. Ottawa: DND, 07 November 2003, 14

there is evidence of a lack of coherence within the document as to just what is meant by "Command & Control." These shortcomings in basic doctrinal concepts and fundamental philosophical foundations are recognized in the following quote from Capability Outlook 2002-2012:

> "The lack of a solid theoretical foundation will have a significant impact on the CF's ability to offer appropriate solutions and to field appropriate forces in capability areas such as Command and Information & Intelligence to meet prescribed objectives."[73]

What is clear is that there is only one infosphere from which we derive all of our observations. Regardless of what perspective we take or what means we employ, we develop our observations from only one reality. This implies that the nature of the infosphere is inherently joint and that maximum benefit can only be realized through the synergistic sharing of information gleaned from multiple perspectives. It can also be inferred that such information exchange should not be focused on achieving commonality but rather on recognizing the differences in our perceptions and understanding the reasons for them. This implies the need for a common understanding and philosophy of what exactly the C^2 process is that we are trying to support.

In their influential work, *Re-conceptualizing Command and Control*, Pigeau and McCann also lament the inchoate state of the understanding of command and control. Starting with a blank page, they have re-defined Command and Control in a manner that is more general in its

[73] Department of National Defence. *Capability Outlook 2002-2012*. Ottawa:DND, July 2002., 7

meaning than the typical doctrinal definitions and more useful from the perspective of C^4ISR capability development. Pigeau and McCann define Command and Control as follows:[74]

> **Command**: the creative expression of human will necessary to accomplish the mission.
>
> **Control**: those structures and processes devised by command to enable it and to manage risk.

These definitions provide a more useful basis for defining C^4ISR because they are not bound to existing concepts of command, which view command as simply being exercised by a commander who is in a position of legitimate authority. The proposed definition recognizes that while only humans can command, any person can exercise a degree of command. This concept is of prime importance in C^4ISR system design because C^4ISR is meant to support command and control. If a legacy definition of command is employed – one that explicitly states that command is exercised only by appointed commanders – this has significant implications for the design of information flows and systems. It is essential that C^4ISR systems not simply be designed to drive information upwards and orders downwards. To fully realize the potential of C^4ISR, it is essential that information flows be unbound from the hierarchy and that all participants in the system be able to derive appropriate benefit from their participation. Therefore, the Pigeau-McCann command and control definition should be implemented as the standard definitions for the CF.

Determining the precise information requirements of individual users requires the systematic analysis of their functions and outputs. However, from a systemic point of view it is

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[74] Ross Pigeau and Carol McCann, "Re-conceptualizing Command and Control," *Canadian Military Journal*, Vol 3, No 1 (Spring 2002), 56.

useful to have a model that describes in general terms the types and granularity of users information requirements. Again, Pigeau and McCann's analysis provides a useful model. Since C[4]ISR is designed to support commanders,[75] the information flows that they receive should correlate to their expected responsibilities. Pigeau and McCann propose a "Balanced Command Envelope" to describe how competency, authority, and responsibility evolve to higher levels in a largely linear progression as a commander rises in the military hierarchy. In the same manner, information requirements can be mapped to the Balanced Command Envelope to create a "Balanced Information Envelope." Simply explained, a commander at the lower tactical levels requires information that is more time sensitive, of greater granularity, and of narrower scope than a senior strategic commander who must deal with information aggregates that are less time sensitive but of a broader scope to be able to understand the broader strategic context for which they are responsible. The value of a Balanced Information Envelope is that it helps define not only information requirements for the various levels of command, but it also forms the basis of the underlying philosophy by implying the need for higher level commanders to deal with the general rather than the specific.

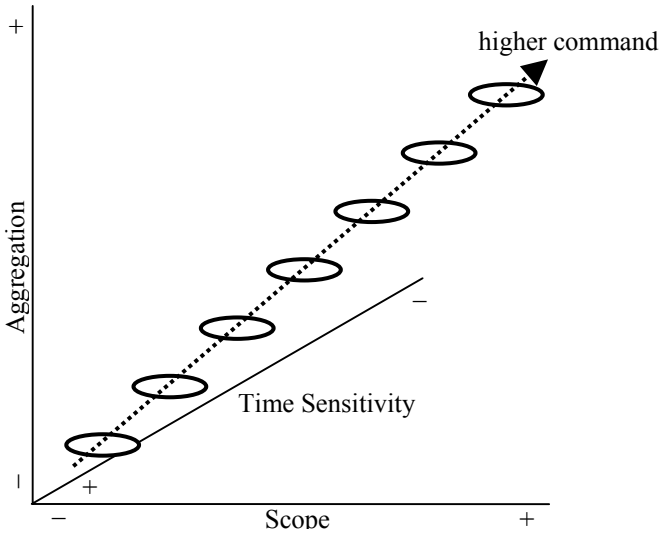

Figure 4 - Balanced Information Environment

[75] Commanders in this context (and from this point on in the paper) is meant to adhere to the Pigeau-McCann construct of "one who commands," not simply one who is a commander by virtue of their position.

In an increasingly litigious world where talk of "accountability" permeates even the military vernacular, this last point is bound to be controversial. But it is imperative that the information delivered be in the appropriate level of detail to meet the commander's needs at whatever level they operate. This does not imply directly that high-level commanders should not be able to drill down into the data but rather that this should be the exception, not the rule. United States Air Force Lieutenant-Colonel Roman outlines the dangers of falling into the tempting trap of allowing IT to enable excessively centralized and rigid control in his thoughtful comments on the matter:

> "The seductiveness of information technology stimulates military organizational orientation towards greater centralized control and more rigid hierarchical organizations instead of the desired orientation of decentralized control and more flexible organizations. Unless the US military recognizes the danger of succumbing to technological temptation, control functions may take priority over command functions resulting in both a less efficient and less effective military."[76]

The last point that needs to be examined from the perspective of an information philosophy is the issue raised by Giffin in *Superstitious Rituals*. Giffin's position is controversial in military circles, but he is correct in asserting that we need to invest the effort to determine how best to use our newfound information sources to best enable military operations.

In an information-based environment where access to information becomes ubiquitous, we risk decision paralysis if we marry the unlimited availability of information with an insatiable appetite for information, all within a culture that believes more information results in better knowledge, and better knowledge results in better decisions. The foundations of this latter

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[76] Gregory A. Roman, *The Command or Control Dilemma – When Technology and Organizational Orientation Collide,* Maxwell: Air War College, 1997, 3.

philosophy are manifest in CF information and knowledge management publications,[77] where the information hierarchy is used to suggest that data from empirical observation aggregated into information can ultimately lead to knowledge.

Indeed, the OODA loop[78] is a popular manifestation of this philosophy, suggesting as it does that a linear and deterministic cycle of observation and decision can lead to superiority. This construct works well in the context originally intended by Boyd – air-to-air combat – where information availability is tightly bounded. In recent applications, many organizations have overlaid more complex functional cycles over the OODA loop in an effort to preserve the structure of the OODA loop while mitigating its limitations.[79] However, in an environment where information is, for all practical purposes, unlimited, it is conceivable that one might never get beyond the observe step if one doesn't bound the information requirements before beginning to "observe" or collect information.[80]

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[77] For example, see: Department of National Defence. *Defence Information Management Strategy*. Ottawa: DND, 23 March 2000. 4.

[78] The OODA loop – Observe, Orient, Decide, and Act – was first proposed by Colonel John Boyd of the USAF in the 1950s to describe the decision making process employed in air-to-air combat. It later became popular in organizational decision-making and C^2 contexts. For more information on Boyd's development of the OODA loop, see: Robert Coram. *Boyd: the fighter pilot who changed the art of war.* Boston: Little, Brown, 2002.

[79] For an example of this type of "overlay" see the CF C^4ISR CP's "Generic C^2 Loop" in: Department of National Defence. *Canadian Forces C4ISR Campaign Plan – Interim Report*. Ottawa: DND, 27 June 2003, G-5.

[80] More detailed criticisms of the OODA loop are beyond the scope of this paper, for a more sophisticated analysis of the limitations of the OODA loop see: David J. Bryant, *Critique, Explore, Compare, and Adapt (CECA): A new model for command decision making,* Toronto: Defence R&D Canada, July 2003.

The TOEDA loop (figure 5) offers an alternative to the OODA loop, presenting a more organic, non-linear decision cycle with multiple recursive feedback paths.[81] It differs fundamentally from the OODA loop in that it adds the action of 'Thought' (T) before 'Observation' (O). This more closely reflects the normal sequence of rational thought, where the decision maker naturally develops mental models or hypotheses to guide and bound the information requirements, prior to the observational stage. Once the observations are made, they are 'Evaluated' (E) against the mental model developed in the first step. If the observations refute the model, we must return to the first step and re-think our problem. If the observations support the model, we accept it as valid and move to 'Decide' (D) on a course of action. This is followed by 'Action' (A). Once the action is complete, we return to the observe step, evaluate the results, and continue to iterate the decision-action loop as long as our results support the model. If at any point the observed situation appears to refute our model, we again return to the thought step to re-conceptualize as required, as shown in figure 5.

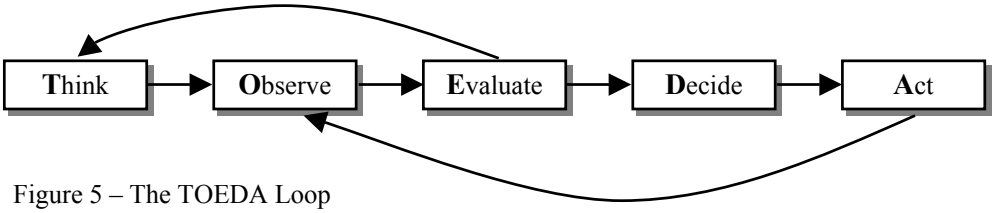

Figure 5 – The TOEDA Loop

Secondly, the concept of a Balanced Information Envelope that is bound to the Pigeau-McCann concept of the Balanced Command Envelope should be adopted. Without such a model

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[81] The TOEDA loop represents the synthesis of the OODA loop with the concept of critical rationalism (see: Giffin, *Superstitious Rituals*) and Dörner's "Steps in the organization of complex action," see: Dietrich Dörner,. *The Logic of Failure: Recognizing and Avoiding Error in Complex Situations.* New York: Metropolitan Books, 1996, 43-47. Bryan also offers an alternative construct to the OODA loop that he terms the "CECA" loop, see: David J. Bryant, *Critique, Explore, Compare, and Adapt (CECA): A new model for command decision making,* Toronto: Defence R&D Canada, July 2003.

to guide the development of information requirements, the CF runs the risk of inundating decision makers with too much information, at the wrong level of granularity, and in the wrong temporal context to support their balanced command requirements (as implied by the Balanced Command Envelope).[82]

Finally, the CF needs to develop a more sophisticated understanding of how information should be used to support effective decision making and must re-examine its reliance on suspect intellectual constructs that suggest more information results in better decisions. The impact of such unquestioned conjecture is the risk that a culture steeped in risk aversion will become mired in indecision when offered an environment with unlimited information. Boyd's OODA loop is one such anachronistic construct that pervades the iRMA discussion. In its current form, it is an overly simplistic and linear approach that is inappropriate for environments steeped in uncertainty and awash in information and data.[83] Implicit to the OODA loop are the assumptions that more information supports better decision making and that the correct interpretation can be derived by objective observation of facts.[84]

To solve the philosophical issues raised in this section, three adjustments need to be made to the current CF information philosophy. First, the Pigeau-McCann definitions of command, control, and C^2 should be adopted as the CF standard definitions. These definitions allow a broader, and more correct, understanding of the fundamental nature of these functions. In

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[82] It is recognized that such implications for information structure may well require a philosophical shift in the current mentality of many decision makers – particularly those at senior levels. The increasing availability of timely and precise information provides a seductive environment for supervisors to indulge the micro-management of functions best handled by their subordinates.

[84] R.E. Giffin, *Superstitious Rituals.* Ottawa: National Defence Headquarters. (unpublished discussion paper), 2002, 7.

accepting these definitions, the challenge of C^4ISR capability development is better defined to provide the context for a truly transformational capability. Second, a concept to match information granularity, time sensitivity, and scope to the commander's information needs, as implied by the Balanced Command Environment, must be adopted. Finally, the underlying philosophy that greater objective observation results in a better understanding of reality must be challenged and models such as Boyd's OODA loop be replaced with models that better explain rational decision-making under conditions of uncertainty.

All of the philosophical adjustments suggested here need to be reflected in both CF doctrine and in C^4ISR documentation. Reliance on outdated and impractical constructs risks undermining the interdependent and synergistic wherewithal required by the C^4ISR capability. For this reason, it is vital that these changes be adopted pan-CF and their implications be clearly understood by those creating C^4ISR policy.

Step 2 – Getting the Organization right

> *"The CF must also be capable of undertaking rapid organizational and conceptual transformation. The current CF structure, with its bureaucratic and hierarchical levels of command, leads to slow, sometimes ineffective change. Historically, it has taken decades to develop new concepts and to field new systems."*
>
> Capability Outlook 2002-2012[85]

Ever since the Management, Command and Control Re-engineering Team (MCCRT) completed the post-Cold War reorganization of the CF, there has been growing recognition that the resulting organization, while superior to its predecessor, is not yet optimized. Indeed, there is a growing understanding that organizational structures, in so far as they relate to C^2, must be

[85] Department of National Defence. *Capability Outlook 2002-2012*. Ottawa: DND, July 2002. 9

fluid, organic, and responsive to the ever-changing security environment.[86] Strategic and operational level structures exist to provide several key functions: enterprise governance and policy, force generation, and force employment – both domestically and internationally.

Since C^2 systems and the broader C^4ISR capability are intrinsically linked to the extant C^2 organizational structure, it is important that any significant change in the fundamental organization of the CF take place before the architecture of the future C^4ISR capability is developed and certainly before any further significant investment is made. The current CF C^2 organization is large and unwieldy, especially at the operational level where headquarters (HQs) are situated along both environmental and geographic lines. With nine operational level HQs, of which only one is a joint HQ aligned to support deployed operations, the current structure reflects much of the independent service-based culture. Such a large C^2 organization will result in an equally large and costly C^4ISR infrastructure that is certain to prove financially unsustainable given both the pace of technological change and the rate of change among key allies.[87] Essentially, efficient acquisition of C^4ISR capability is heavily dependent on the efficient organization of the CF's basic C^2 structure and organization.

Rationalizing the operational level HQ structure is a significant task that has been studied at least twice since MCCRT but has not yet resulted in any real change. As Little explains, the pace and complexity of operations have continued to increase since the end of the Cold War[88]

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[86] Allan D English and BGen (Ret'd) Joe Sharpe. *Principles for Change in the Post-Cold War Command and Control of the Canadian Forces.* 28 June 2001, 10-14.

[87] Interview: LGen M.K. Jeffery, 18 February 2003

[88] Colonel Chris L.Little, "Mason Crabbe – Worth Another Look?" Toronto: Canadian Forces College Advanced Military Studies Course Paper, 2002, 31.

and the emphasis on joint and combined operations means that the CF will need to continue to find ways to be more effective. The path to greater effectiveness begins with a review of the unwieldy operational level C2 structure. Re-conceptualizing the operational level C2 structures is a task beyond the scope of this review but certain key principles must guide any such re-organization:

1. For force employment – whether domestic or international – the emphasis must be on joint operations.
2. Force generation should remain an environmental responsibility but the number of headquarters devoted to this task must be substantially reduced not only to improve efficiency, but also to foster greater consistency.
3. At the operational level, force generation and force employment should be separated.

From a strategic point of view, C^4ISR capability development is a force generation task similar to any other. However, as an inherently joint capability that is a synergistic blend of various sub-capabilities, C^4ISR is especially sensitive to environmental stove-piping and incoherent development. Currently, the majority of capability generation is orchestrated by the ECSs as the strategic force generators. Unfortunately, the need for a joint capability generator was only recognized in the past few years. Under the current construct, the Assistant Deputy Chief of the Defence Staff (A/DCDS) has the responsibility to coordinate all joint force development. Unfortunately, as an L2 manager, the A/DCDS lacks the influence and authority of the ECSs who operate as L1 managers. In a tightly constrained capital environment, this means that joint force capabilities may not get the priority they require. More importantly, in the case of

C^4ISR, the lack of authority of the A/DCDS prevents him from compelling the ECS to follow any joint standards and architecture (were they to exist). Therefore, the lack of an appropriate level of authority for the joint force generator means that environmental agendas can trump joint force capability development.

There are two solutions to this problem, either of which could remedy the current power imbalance. The first solution would work within the current strategic organization by utilizing the authority of the CDS and influence of the VCDS to guide joint C^4ISR development. Within this concept, the CDS would provide unambiguous direction that endows the A/DCDS with the legitimacy and authority to develop C^4ISR vision and guide its development. The VCDS would use such C^4ISR guidance to shape the SCIP to ensure compliance with the directed vision. This solution requires the CDS and VCDS to provide strong direction that would, when and where necessary, run counter to the advice of individual ECS. This subordination of environmental priorities to joint priorities is essential to the coherent development of the joint C^4ISR capability.

An alternative to the first solution is to create a new joint force capability developer and place him in a position of dominance over the individual ECS. This would require a significant re-organization of NDHQ to create a "Joint Force Capability Chief" who would be the dominant L1 manager and who would subordinate the ECS as L2 managers responsible only for capabilities that fall solely within their environmental boundaries. Such a solution would be difficult to implement since it would run afoul of significant pressures from the existing environmental empires. However, this would be the more lasting and effective of the two

solutions and would ensure that the emphasis is placed on developing capabilities that are interoperable and effective.

Notwithstanding the final solution, it is clear that the current operational and strategic level C^2 structures are unnecessarily large and unwieldy. This inefficient structure complicates C^4ISR capability development in that no clear authority currently exists to ensure that joint capabilities – such as C^4ISR – take precedence over environmental priorities. Also, the underlying structure largely drives the size of the C^4ISR support infrastructure and risks making it both unaffordable and unsustainable.

To mitigate these risks, the operational level HQs must be reduced and streamlined to allow for – among other things – a sustainable C^4ISR footprint. As well, the strategic force generation structure must be reviewed to provide the necessary visibility and authority to properly guide joint capability development.

Step 3 – Provide the necessary tools to guide the development

Once the underlying latent issues – philosophy and organization – are suitably addressed, it is essential that the required tools be provided to direct and guide the complex development of the C^4ISR capability. There are two sets of tools that are required to guide the development of the C^4ISR capability: an integrated architecture and a governance structure.

An integrated architecture provides a number of important outputs to guide the development of the C^4ISR system but essentially it fulfills four critical functions: it provides an overall view of how the system is intended to operate and what functions it fulfills; it provides a baseline of standards against which cooperating systems can ensure their interfaces cooperate; it provides a security context to which the systems must adhere; and finally it provides a baseline against which overall compliance can be measured. Obviously, such guidelines must be dynamic to be able to cope with an evolving environment but also must be centrally controlled to ensure sufficient stability and coherence of the system.

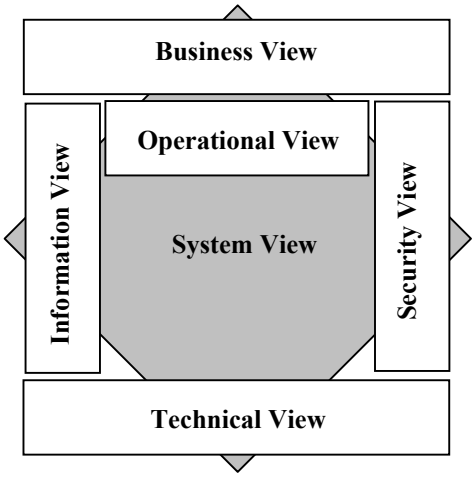

Figure 6 – BOSTIS Model

The Director of Enterprise Architecture (DEA) has produced a sophisticated architecture model referred to as BOSTIS[89] as part of an overall Integrated Defence Enterprise Architecture (IDEA). The BOSTIS model (see figure 6)[90] provides a comprehensive set of descriptions that explain the overall system and its relationships to other processes. As a relatively mature and comprehensive model, BOSTIS should form the basis of the C^4ISR architecture.

[89] The BOSTIS acronym is comprised of the six different views that the DEA architecture describes: Business, Operational, System, Technical, Information, and Security. For more details see: http://img.mil.ca/dgimsd/dea/IDEA/framework_E.htm on the DWAN.

[90] The BOSTIS diagram in figure 6 is reproduced from the DEA DIN site available at: http://img.mil.ca/dgimsd/dea/IDEA/framework_E.htm on the DWAN.

In the BOSTIS model, it is the systems architecture view that provides a broad description of how the system operates and the functions it must carry out. The C^{4}ISR CP provides a very good initial systems architecture view in the form of the Target Integration Model (TIM).[91] Recognizing the need for managed evolution, the C^{4}ISR CP provides for a moving, 5-year target in the form of subsequent TIMs, which provide the high-level context for the system. This approach is both highly appropriate and effective. Therefore, the C^{4}ISR CP development cycle should form the central process for C^{4}ISR architecture development.

However, the C^{4}ISR CP TIM is incomplete as it only provides one section of the entire model described by BOSTIS. To provide sufficient detail to guide further development, it is essential that the remaining elements be developed in detail. It is particularly critical that the security and technical architectures be completed as soon as practicable as they provide critical information on how systems must relate and interface. The full BOSTIS architecture, when completed should be centrally controlled and immediately available to all C^{4}ISR related projects.

Obviously, certain elements in this model are heavily dependant on the organizational structure and, as recommended earlier, the structural questions must be answered before the architectural development can be completed. Failure to do so risks significant wasted investment as well as a sub-optimal C^{4}ISR capability.

The completed architecture provides an important piece of context for the governance structure. A governance structure is necessary to provide control over the development of the

[91] Department of National Defence. *Canadian Forces C4ISR Campaign Plan – Interim Report*. Ottawa: DND, 27 June 2003, G-1.

system and the development of its follow-on iterations to create the desired future capability. There are, therefore, two essential components to the C^{4}ISR governance structure: a strategic capital investment management function and a strategic architecture management function.

As described in Section 3, the capital investment management function is currently provided through the existing DMS mandated capital project approval process. This process is designed to provide careful governance and to be aligned with the Treasury Board requirements and approval process. The current process has two shortcomings that were already mentioned: it takes too long, and it lacks the necessary context to effectively manage C^{4}ISR capability development.

The MND's report on achieving administrative efficiency suggests streamlining and differentiating the approval process to achieve better efficiency and shorter approval times. While this appears to be a positive development, the reality is that the proposed "efficiencies" only result in a reduction of average acquisition time from the current fifteen years down to ten to twelve years.[92] As discussed, this is simply not satisfactory for C^{4}ISR development. The unfortunate reality is that, because the DMS process is tied to TB requirements, it is unlikely that the CF can effect significant change to this process unilaterally.

However, there are innovative development approaches that work within the DMS's constraints. The Canadian Forces Command System (CFCS) project uses a cyclical approach that iterates a new cycle approximately every twenty-four months. Therefore, while the entire

[92] Department of National Defence. *Achieving Administrative Efficiency*. Ottawa: DND, 21 August 2003, 120-124.

project stretches over a more typical length of time within the DMS framework, individual, overlapping cycles within the project itself define requirements and deliver capabilities more quickly. While one cycle is in the implementation phase, the next cycle has already entered the definition phase thereby ensuring that the follow-on cycle both builds off the success of the previous cycle and arrives soon after. This highly successful approach should be used as the standard model to deliver most core C^4ISR capability.

The strategic management function is provided by the C^4ISR Oversight Committee (C^4ISR OC), which in is a sub-committee of the Joint Capabilities Review Board. The C^4ISR OC also employs a C^2 Joint Capabilities Action Team (JCAT) to focus specifically on the C^2 and I^2 (Intelligence and Information) capabilities. The purpose of this organization is to provide strategic guidance on the goals and desired outcomes of the C^4ISR development process. As the inter-relations of this governance structure are described in detail in both the C^4ISR Command Guidance[93] and the C^4ISR CP,[94] a detailed explanation will not be reproduced here. Rather, it is sufficient to note that the fundamental structure is sound and the proposed governance structure is well designed to provide a collaborative environment in which appropriate guidance can be developed. However, as noted previously, because of the limitations in the authority structure for joint force capability development, the current direction risks irrelevance because an errant ECS could choose to ignore a joint standard in favour of producing an environmentally preferred

[93] Department of National Defence. *Canadian Forces C4ISR Command Guidance and Campaign Plan – Draft*. Ottawa: DND, 07 November 2003, 9.

[94] Department of National Defence. *Canadian Forces C4ISR Campaign Plan – Interim Report*. Ottawa: DND, 27 June 2003, 10.

solution. Therefore, the current governance structure – despite its fundamental soundness – remains open to being undermined by the underlying organizational issues.

In addition to the organizational reforms needed to fully enable the C^4ISR governance structure, the C^4ISR strategic management function provided by the C^4ISR OC, and its subordinate organizations, needs to provide a comprehensive set of analysis tools to be used by the capital acquisition governance structure and also to be used by staff personnel involved in the development of C^4ISR capability. While the C^4ISR CP already provides a rudimentary set of tools to enable this function, they lack the depth and the scope to be an effective decision-making and synchronization tool. A fully developed set of tools will satisfy three important functions: a well-developed vision that articulates the capability levels being sought, an architecture against which to guide and measure compliance, and a performance measurement framework against which to consider options and evaluate performance.

The capability level vision should be derived from existing strategic guidance articulated in Strategy 2020 and should be expressed in a manner similar to that used by Capability Outlook 2002-2012. Simply described, the different C^4ISR capability areas need to be identified[95] as functional components, and capability goals need to be developed and expressed for each functional component at each level of operations. Once this is done, the current level of capability is mapped against the envisioned capability goals to identify gaps and deficiencies.

[95] The C4ISR CP has done so already and its definitions are used in this paper, for more information see: Department of National Defence. *Canadian Forces C4ISR Campaign Plan – Interim Report*. Ottawa: DND, 27 June 2003, 35-36.

This capability level vision matrix then provides an indication of which areas need urgent attention. A notional example of this construct is shown in figure 7.[96]

	Direction	Collection	Processing	Dissemination	Decision Support
Military Strategic	H	L	H	H	H
Operational (Domestic)	H	M	M	H	M
Operational (International)	H	L	M	H	M
Tactical	H	H	H	H	M

Figure 7 – Notional C[4]ISR Capability Matrix

As shown in figure 7, capability goals are expressed simply in terms of High (H), Medium (M), and Low (L). These levels refer to desired levels of capability as described in the C[4]ISR CP.[97] Each area is then coloured to indicate the current level of capability as it relates to the desired level. This approach, so successfully developed in the Capability Outlook 2002-2012, is deceptive in its apparent simplicity. To develop a meaningful table, exemplified in figure 7, requires detailed analysis of each square; this analysis breaks each square down into the capability components described by the PRICIE model[98] and provides the depth that is useful for the guidance of C[4]ISR capability development.

From this matrix, a performance measurement framework (PMF) is developed using indicators for each box to measure the level of capability in each area. These indicators are used

[96] The capability levels expressed here are merely notional and are for example only. A full set of required levels will need to be produced through a consultative process.

[97] Department of National Defence. *Canadian Forces C4ISR Campaign Plan – Interim Report*. Ottawa: DND, 27 June 2003, 36.

[98] The PRICIE model is a construct of the CBP process that sub-divides a capability into its constituent components of: Personnel; Research and development; Infrastructure and organization; Concepts, doctrine, and collective training; Information management; and Equipment, supplies, and services.

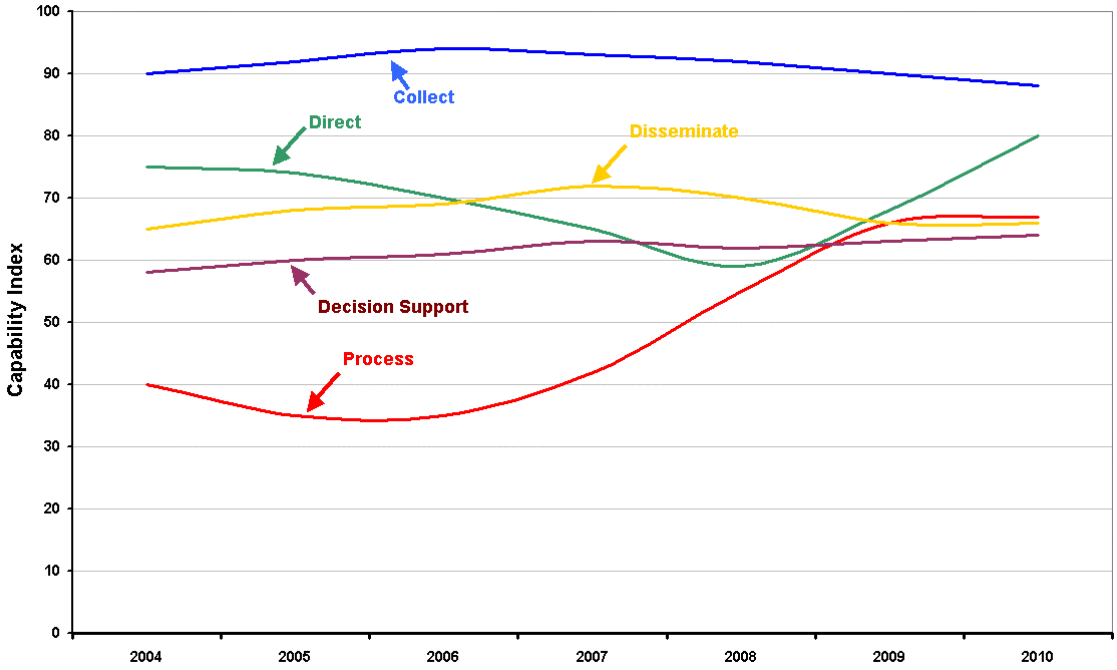

Figure 8 – Notional C⁴ISR Capability Chart

to provide an indexed capability level for each given capability area. The results of this PMF allow the development of predictive tools to judge the efficacy of C^{4}ISR capability development and to track the projected capability trends over time. As well, such a model is extremely useful for guiding investment decisions as different scenarios can be modeled to deduce the consequences of different courses of action. Each capability area can also be depicted over time so the effect of different investments can be gauged within the overall context of the C^{4}ISR capability as is notionally shown in figure 8.

To provide the broader context, a C^{4}ISR capability index can be derived from the individual capability indices to provide meaningful year-over-year projections of capability trends. The index is created by amalgamating the individual C^{4}ISR capability indices in a weighted utility matrix that provides a combined index. By weighting the index, it is recognized that various constituent capabilities provide varying degrees of utility and it also allows the

emphasis to be placed on areas of concern. Figure 9 shows a notional weighted capability matrix built from the same data as figure 8.

		2004		2005		2006		2007		2008		2009		2010	
	Weight	Raw	Final	Raw	Final	Raw	Final	Raw	Final	Raw	Final	Raw	Final	Raw	Final
Direction	0.3	75	23	74	22	70	21	65	20	59	18	68	20	80	24
Collection	0.2	90	18	92	18	94	19	93	19	92	18	90	18	88	18
Processing	0.2	40	8	35	7	35	7	42	8	55	11	66	13	67	13
Dissemination	0.2	65	13	68	14	69	14	72	14	70	14	66	13	66	13
Decision Support	0.1	58	6	60	6	61	6	63	6	62	6	63	6	64	6
C4ISR Index		**68**		**67**		**67**		**67**		**67**		**70**		**74**	

Figure 9 – Notional Weighted Capability Matrix

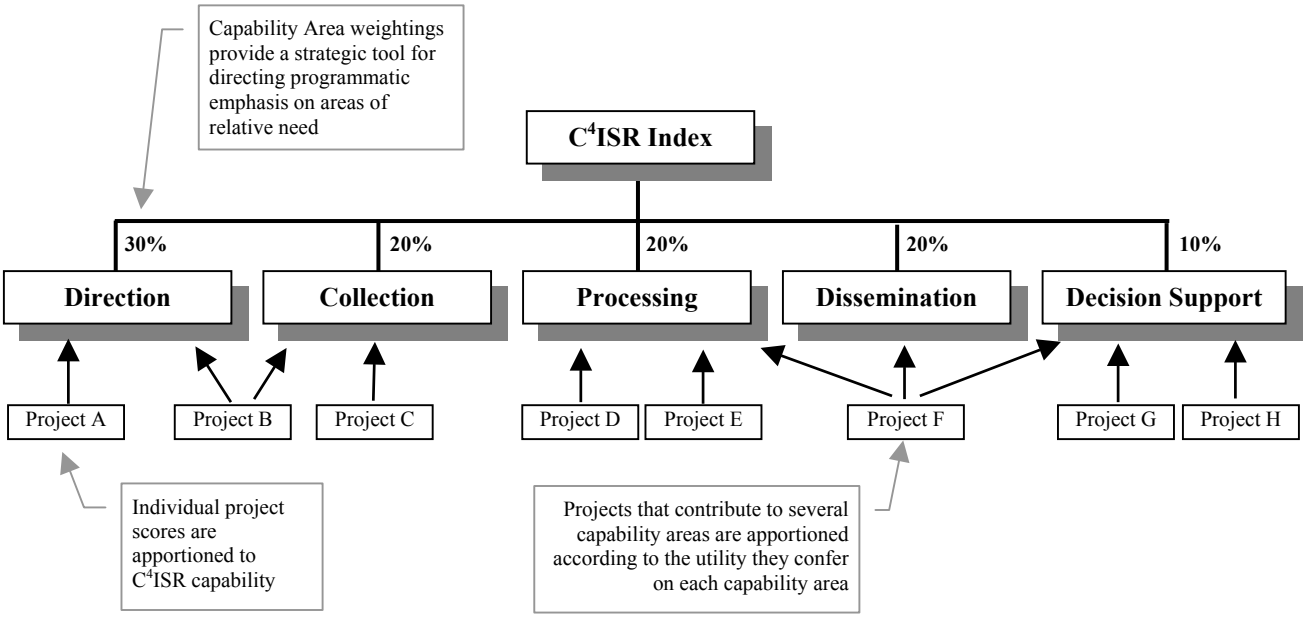

Figure 10 – C^{4}ISR Capability Index Framework

In practice, this methodology would be very simply employed. The architecture provides a basic filter against which proposed capabilities are considered. Those that are not consistent with and compliant with the standards of the C^{4}ISR architecture are rejected prior to reaching PMB. This filtering process provides a significant incentive to project staffs to ensure that their project is compliant with the standard. Second, the C^{4}ISR capability matrix provides PMB the

context against which they can determine the degree of need for each proposed capability. Areas of relatively high need would receive priority thereby ensuring the system is self-balancing. And finally, the PMF provides a tool for both "what-if" analysis and for measuring the relative effectiveness of C^4ISR investment.

Objectively quantifying the impact of each project on the overall C^4ISR Index would undoubtedly be the most significant challenge to this overall framework. However, the process is inherently manageable when viewed from a project-level perspective. Each C^4ISR project contributes to the overall C^4ISR index by providing capability in one or more C^4ISR capability area as shown in figure 10. The relative amount or utility that each project contributes to the overall C^4ISR index is a matter of professional judgment and sound analysis. To develop this assessment, each project would be assessed according to a variety of factors in each of the PRICIE categories through the use of a centrally developed project scoring matrix – an indicative example of which is provided in figure 11. In the example, the PRICIE construct is used as an illustrative example of the type of categorization that could be employed to define the areas that contribute to the development of C^4ISR capability. However, it is entirely probable that a different categorization would result from the comprehensive analysis that would be required to produce this scoring matrix.

Completion of the project scoring matrix would be the responsibility of each project's staff and validation of the score would be conducted by the review of a central C^4ISR capability development staff. It is this centrally controlled validation and comparison of products that would provide the fidelity of the model and ensure that the relative balance of scoring between

projects would be sound and useful. It would also ensure that the project scoring matrices would provide decision quality information to the PMB thereby giving them clear insight into the consequences of programmatic decisions – an insight that is lacking today.

This section has laid out the three basic steps required to build the framework necessary to guide the development of C^{4}ISR in the CF: get the philosophy right, get the organization right, and provide the necessary tools to guide the development. All three steps are inter-related and mutually supportive. A failure to ensure that the appropriate foundation is laid has the potential for dire consequences or, at the very least, an expensive and sub-optimal experiment in C^{4}ISR capability development.

PROJECT SCORING MATRIX

	Factor	Rationale	Raw Score	Weighting Factor	Totals
P	Factor A1				
	Factor A2				
	Factor A3				
				Adjusted Section Score:	
R	Factor B1				
	Factor B2				
	Factor B3				
				Adjusted Section Score:	
I	Factor C1				
	Factor C2				
	Factor C3				
				Adjusted Section Score:	
C	Factor D1				
	Factor D2				
	Factor D3				
				Adjusted Section Score:	
I	Factor E1				
	Factor E2				
	Factor E3				
				Adjusted Section Score:	
E	Factor F1				
	Factor F2				
	Factor F3				
				Adjusted Section Score:	
				PROJECT TOTAAdAAdA	

It is clear that much of this framework exists in various documents and that many of the concepts proposed in this section build off others already in use in other parts of the CF. What is essential to realize is that the C^4ISR development framework, like C^4ISR itself, is an inter-dependant process that requires coherence and synergy to be effective. It is equally clear that the framework proposed here is not complete – it represents a strawman to guide more work in this area and to provide a central construct around which to build coherence.

V – SUMMARY AND CONCLUSIONS

Through the course of this paper the overall C^4ISR issue has been explored, first from the generic perspective of the iRMA, then from the Canadian perspective, before finally delving into the very reason for this paper: the recommendation of a central framework to guide C^4ISR capability development.

What is clear from this discussion is that the status quo is neither sustainable nor is it likely to result in a balanced and effective C^4ISR capability. Given the state of environmentally stove-piped capability development and the severely constrained solution space as defined by the capital budget, it is obvious that a centrally controlled process is needed to ensure the balanced investment of funds.

What is equally clear is that the iRMA is in full swing and our allies are moving forward quickly. Without a parallel development effort in the CF, we risk failing to fully make the shift to the Toffler's third-wave information-based military. Of even greater consequence for a military

that depends on its partnerships, alliances, and coalitions for collective defence, we may not be able to effectively participate in future coalition activities if our core C^4ISR systems are not interoperable with those of our allies.

Within the context of the RMA, key theories such as Chaos and Complexity provide boundaries upon what we can reasonably expect to achieve with our C^4ISR capability. Such boundaries also have significant implications for our culture and our philosophy. We simply cannot proceed with the flawed belief that perfect observation will lead to a complete understanding of any given situation or the mistaken conviction that we can adequately predict it. We can infer from these limitations that a risk-averse culture that values information as a source of knowledge and wisdom will find itself mired in an endless spiral of spending attempting to achieve the unachievable.

And, from an exploration of the Canadian context to the iRMA, it is evident that we simply do not have the financial means to embark on such an expensive experiment. Instead, we need to invest the thought up front and ensure that we address the fundamental philosophical and organizational issues first before committing to significant, and largely unfocused, investment in C^4ISR.

The key steps that form the core of a coherent C^4ISR policy for the CF are deceptively simple and unmistakably critical. First, we absolutely must reconsider our underlying concept of what constitutes Command, Control, and C^2. These are the key functions that define C^4ISR and, without unity of understanding, we risk driving towards different ends. As well, the need to

develop a more sophisticated understanding of how we use information to generate understanding is key to being able to develop systems that respond to decision-makers' needs rather than simply provide more information to a system already flooded in undigested information.

Armed with an understanding of what we are trying to achieve with our information, we must organize our C^2 structure to be enabled by the C^4ISR capability and to be an efficient system upon which to overlay new investments. Not only must the organizational change lead the investment, we must also re-consider the structure of our strategic capability development process to ensure that joint capability development rises to the pre-eminence that it requires. It will be of scant benefit if the operational level issues are addressed but the required enabling C^4ISR architecture doesn't emerge to support it because it became lost in a parochial and stove-piped capability development system.

The final key to a useful C^4ISR framework is the provision of the necessary governance structure and its supporting tools. The combination of these two enablers provides the guidance necessary to ensure that a coherent and useful system is conceptualized, defined, and implemented.

The future is ours to create. As Toffler said: "The best way to predict the future is to create it." The development of a powerful and efficient C^4ISR system depends on the careful integration of many disparate capabilities. Such a complex development cannot be left to chance.

It must be managed and directed. As it stands now, the CF lacks the framework to manage and direct this development. The time is now to correct this deficiency.

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