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FUSING ISLANDS OF INFORMATION:
THE CANADIAN FORCES' STRUGGLE TOWARDS COMMAND AND CONTROL SYSTEM INTEROPERABILITY

By / par

Colonel Michel W. Fortin

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ABSTRACT

As we begin the 21st century, technology is becoming indispensable to conduct military operations. The considerable reliance on technology to assist the commander and his staff and the increasing requirement to operate in joint and combined requirements, has heightened the need for greater information sharing capability to coordinate and synchronize command and control (C^2) between all elements across a theatre of operations. This paper examines the requirement for enhanced interoperability between the Canadian Forces' (CF) C^2 information systems in joint and combined environments. After a review of the importance of C^2 information systems and the need for greater interoperability between them, the paper proposes a scale to evaluate the level of C^2 system interoperability and uses it to assess the CF's existing C^2 information systems. Finally, it proposes requirements for future joint C^2 systems and maps out the current road towards interoperability and describes the challenges ahead. This paper concludes by highlighting that the CF must enhance the level of interoperability of its current C^2 information systems to enable a greater sharing of structured and unstructured C^2-related information to operate more effectively in joint and combined operations in the future.

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COMMAND AND CONTROL SYSTEM INTEROPERABILITY

> *"The key to success on the modern battlefield is not just the possession of technologically superior weapons and delivery systems, but the ability to effectively control and integrate these tools on the battlespace".*[1]
>
> *Norm C Davis (sharing one of the key lessons learned in the Gulf War)*

Introduction

Since the dawn of the Information Age, militaries have been trying to exploit the enormous advantages that information technology can provide to support command and control (C^2) of military operations. Considering the tremendous progress made over the past two decades, few would argue that technology has provided military commanders with a wide assortment of new capabilities that could only be dreamt of 20 years ago. New capabilities ranging from advances in telecommunications such as portable, wireless devices and video teleconferencing (VTC) to modern Web-base applications, including chat and e-mail, now permeate all facets of modern society and military operations. Developing systems that could assist military commanders to conduct command and control (C^2) functions of military operations have been at the center of development efforts over this period.

Providing technology that will give military commanders a clear, accurate and timely picture of the overall battlespace situation, accelerate the decision and execution cycle, and improve the synchronization of forces throughout the battlespace is the focus of C^2 systems. Considering today's fast-paced military operations and the necessity to coordinate significantly diverse, multinational forces, command and control ($C^{2)}$ is more challenging than ever. C^2 systems are certainly not new; they have been used for several years to assist in the planning, decision-making and execution of military operations at the tactical level.   What is relatively new is the requirement for C^2systems to share information between each other as military operations are increasingly being conducted in coalitions. Recent operations in Bosnia, Afghanistan and Iraq simply reinforce the reality that future military operations will be more frequently conducted using multinational forces. The synchronization of the planning and execution of these joint and combined forces across the entire theatre of operations will continue to be a tremendous challenge. The enormous amount of information that must be shared between participants at all levels, both horizontally and vertically, to effectively synchronize and conduct operations in this complex environment cannot be managed effectively without the use of C^2 systems[2].

Recognizing that the technologically-advanced US will likely lead most of the operations that they will participate in as part of a coalition, it is becoming critical that participating nations, including the CF, increase their level of C^2 interoperability if they wish to take part in future missions.   The reality, however, is that despite significant

[1] Davis Norman C., "The Marine Corps and Information Operations", *Marine Corps Gazette* (April 1997): 16.
[2] Mitchell, Paul T. "Small Navies and Network-Centric Warfare – Is There a Role?", *Naval War College Press*, Spring 2003, 2.

efforts made over the past decade to develop the CF's existing C^2 systems[3], they have a very limited capability to share information between each other.

Consequently, this paper contends that C^2 systems are so crucial in today's modern, fast-paced and complex military environment that the CF will not truly be effective in a joint and coalition environment until the existing systems reach an acceptable level of interoperability. In discussing its arguments, this paper has limited the scope to examining issues surrounding information technology related to C^2 systems.

First, the paper examines the CF's recent emphasis towards joint and coalition operations and the resulting importance of interoperability between its C^2 systems. It then considers the nature and challenges of C^2 and describes the critical importance C^2 systems have in supporting effective military operations in today's complex environment. Then, through an analysis of the required information exchange capabilities necessary to conduct C^2 effectively at the operational level, it presents a current assessment of the level of interoperability of the CF's current C^2 systems. Finally, it provides a view of the interoperability requirements of the future joint C^2 system and maps out the current road towards interoperability and the challenges ahead.

The Growing Trend towards 'Jointness'

Since the end of the Cold War, there has been dramatic increase in the number of military operations involving multinational coalition forces. From the first Gulf War to

[3] The CF's existing C^2 systems are: TITAN is the joint Canadian Force Command System, MCOIN is Maritime Command Operational Information Network, LF is Land Forces Command and Control Information System and AFCCIS is the Air Force Command and Control Information System.

recent operations in Afghanistan, the growing trend towards joint and combined operations is undeniable. In fact, the vast majority of the operations that the CF has participated in were as part of a coalition. The renewed importance of "jointness"[4] was formally recognized with CF's adoption of the Joint Operational Planning Process (JOPP) in 1995. In 1999, the CF's vision published in *Shaping the Future of Canadian Defence: A Strategy for 2020*, simply reconfirmed its importance by declaring that its overall objective is "to provide Canada with modern, task-tailored, and globally deployable combat-capable forces that can respond quickly to crises at home and abroad, in joint or combined operations".[5] More importantly, "jointness" and command and control are both clearly identified as critical attributes of this strategy[6]:

- **Jointness**. Identify and strengthen those specific capabilities that enable the CF to fulfill Canadian security priorities, deliver a joint capability to deal with weapons of mass destruction, information operations and other asymmetric threats, and form counter-threat partnerships with domestic and international partners.

- **Command and Control**. Foster jointness in command and control, as well as logistics and intelligence, including the development of deployable joint headquarters capable of exercising national command and logistics support of Main Contingency Forces.

Furthermore, the *Canadian Forces Strategic Operating Concept* (SOC), currently under development, clearly highlights the importance of 'jointness' and interoperability. It describes the future security environment as one that necessitates transforming the CF into "agile, knowledge-based forces capable of conducting effective joint, multinational

[4] *Jointness* involves elements from two or more services working together in pursuit of common objectives.

[5] Canada. Departmental of National Defence. *Shaping the Future of the Canadian Forces: A Strategy for 2020.* (Ottawa: National Defence Headquarters, June 1999): 6.

and interagency operations. "[7] Articulating the vision that the CF must "become interoperable with our closest allies and security partners, including local, provincial and federal authorities" [8], the document emphasizes that it is particularly important that the CF maintain interoperability with the US, as it is likely that the US will "act as the lead nation in most future operations in which Canada will participate".[9] As a small armed force, the CF must accept the reality that the priority of effort towards interoperability must continue to focus on interfacing with the US and its other key allies.

No longer does the CF's requirement for greater interoperability limit itself exclusively to its military allies. The increased risk of terrorist threats in Canada, since September 2001, has heightened importance of greater cooperation between governmental departments and agencies, particularly in securing the country's maritime approaches.[10] As a result, the Federal government has launched a major initiative to enhance the sharing, collection and analysis of information between all departments and agencies that can contribute to producing a "more coherent and collective maritime security picture, which the Government of Canada can act upon to effectively coordinate policy, responses and resources"[11]. Once implemented, we can expect this level of cooperation to extend to other areas related to security. Just as interoperability and the exchange of financial information internationally is clearly indispensable in today's

[6] Ibid: 6.

[7] Departmental of National Defence. Canadian Forces Strategic Operating Concept (Draft 4.4), Ottawa: Deputy Chief of Defence Staff, 21 May 2004): 14.

[8] Ibid.

[9] Ibid.

[10] Montage/DMC, Maritime Information Management and Data Exchange Study for DND June 2003 (Draft): 1.

[11] Ibid: 1.

business world; it is inevitable that the same will be true for military forces that wish to operate in joint and coalition environments in the future.

Criticality of C^2 Systems

Over the past two decades, the information technology revolution has sparked a wide variety of innovative ideas about how to exploit technology to effectively support C^2 in military operations. Despite the significant progress made during this period, most of the C^2 systems implemented were focused on speeding up execution and enhancing situational awareness to *tactical* commanders rather than on improving C^2 and synchronization of forces across the theatre of operations. Technology related to the greater, and arguably more important, challenge of enhancing C^2 capabilities across joint and coalition environments has progressed at a much slower pace. This is not surprising since enabling the sharing of information across widely dispersed and diverse systems is a much more complex challenge. Making the challenge even greater is the fact that the CF's existing C^2 systems were mostly developed in isolation with few or no common standards incorporated into them, therefore making it very difficult for them to exchange information with other systems. Fortunately, the importance of making these systems interoperable has now been widely recognized and these challenges are being aggressively addressed.

Understanding the fundamentals of C^2 is essential to determine how the supporting C^2 systems need to be developed to maximize support to commanders in joint and combined operations. Essentially, command involves generating the conditions for success – including developing a vision, goals and objectives, setting priorities, allocating resources and producing the plan.[12] It entails dealing with all predictable, and particularly the unpredictable, components that contribute to uncertainty or the 'fog and friction' of war.

Reducing uncertainty in the battlespace is crucial for effective command and control. Ideally, commanders should use every means at their disposal to reduce uncertainty. Using C^2 systems that provide enhanced situational awareness is critical to assist in reducing uncertainty on the battlespace. More specifically, presenting timely information regarding enemy and friendly forces, physical environment (terrain, weather, etc), intelligence and logistical situation is vital to assist commanders in making enlightened decisions.[13]

Although, there have been numerous attempts to define models that describe the basic functions of C^2, only a few have been widely recognized. Over the last two decades, the most popular C^2 model is perhaps Boyd's OODA (Observe, Orient, Decide and Act) Loop. Originally developed in the mid-80s by former US fighter pilot, John Boyd, to analyze pilot decision-making at a tactical level[14], its simplicity and potential application in other areas has made it very attractive to examine the basic C^2 functions that a commander is required to perform (illustrated in Figure 1). The theory behind this cyclical process is that, in any conflict, the participant who can cycle through the OODA loop faster than the enemy can potentially control the operational tempo.

[12] Alberts, David S, Hayes, Richard E. "Power to the Edge – Command and Control in the Information Age". Washington, D.C.: DoD Command and Control Research Program: June 2003: 205.
[13] Hayes, Richard E. "C4ISR Framework of the Future", April 2000: 2.
[14] Alberts, et al., "Understanding Information Age Warfare", August 2001: 133.

C^2 Decision and Execution Cycle

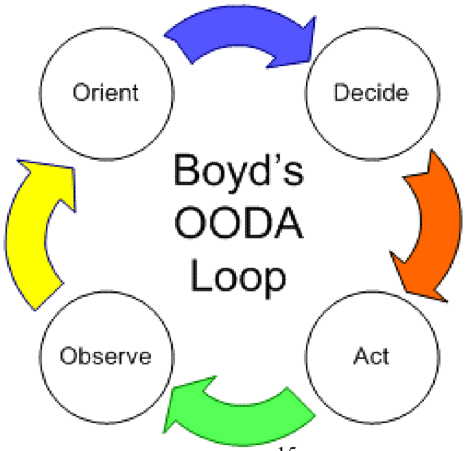


Figure 1[15]

The OODA loop model's simplicity, however, reveals several shortcomings when used to analyze more complex environments that have non-linear C^2 structures. This is apparent when comparing the simple C^2 structure assumed in the OODA loop with the more non-linear C^2 structure of an actual joint and combined operation that must also consider interaction between the strategic, operational and tactical levels. Regardless of the model selected to represent the C^2 process, the basic functions that need to be performed are similar to those presented in the OODA Loop model. In effect, commanders and staffs at each level will have their own C^2 cycles to manage, which in turn, have an impact on other related C^2 cycles. This is illustrated in the C^2 cycle interrelationships model (Figure 2), which shows that each C^2 decision and execution cycle will affect the C^2 cycles of superior and subordinate organizations. For example, the C2 cycle of the Coalition Joint Force Commander will affect or be affected several C2 cycles including those of all component commanders.

[15] Diagram adapted from Figure 3-1 of United States, Department of Defense. *Joint Command and Control Functional Concept v.1.0, draft.*, December 2003: 13.

Joint C^2 Cycle Interrelationships Model

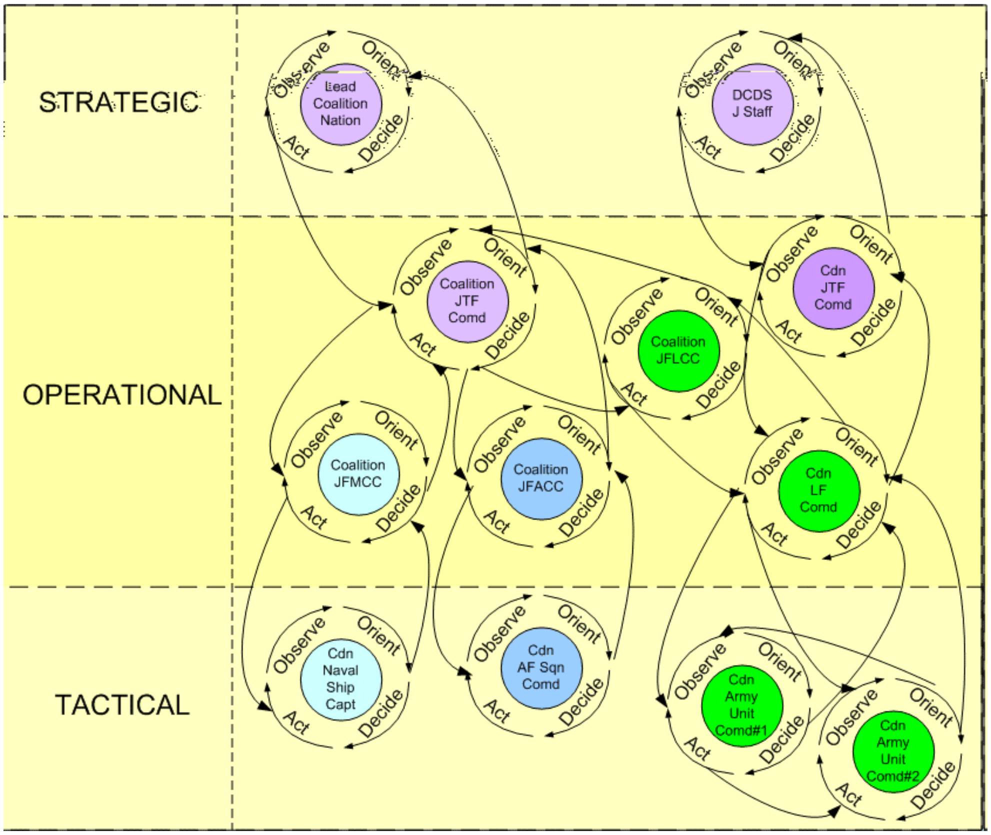


Figure 2

Supporting the myriad of decision and execution cycles up, down and across this complex, joint, and often combined, operating environment is a tremendous challenge. C^2 systems assist in the execution of this process by providing a selection of applications that assist in collecting, fusing and presenting battlespace information; developing and analyzing courses of action; and then producing, executing and monitoring the plan across the entire battlespace. Ultimately, mastering the C^2 cycle depends on fully exploiting the capabilities provided by highly dynamic and interoperable C^2 systems that will provide commanders at all levels with the shared situation awareness to synchronize operational tempo and decisions to ensure mission success.

The Nature and Importance of Interoperability

As we have seen, C^2 in joint and/or combined operations can only be carried out effectively at the operational level if there is a high level of interoperability between all systems supporting the command and control process. The tremendous amount of modern technology introduced into the operational environment over the past two decades has heightened the importance of interoperability. Exploiting technology to its fullest requires systems that are integrated and interoperable.

Clearly, the CF has recognized the need for greater interoperability. In fact, "enhanced interoperability" is one of the four key concepts highlighted in *Joint Operating Concept 2012*.[16] It highlights the criticality of improving interoperability, not only within DND, but also with its allies, other government departments, non-government organizations, international organizations and agencies. This depicts the "*Joint, Inter-Agency, and Multinational, Public (JIMP)*" conceptual framework that is likely to reflect the way operations will be conducted in the future.[17] Defining, accepting and implementing standards that enable information sharing across this broad spectrum of organizational boundaries will undoubtedly be a major challenge, not only technically but also culturally, as most organizations still have a reluctance to share information externally.

The growing number of multi-national and coalition interoperability and standardization committees, over the past few years, certainly points to a greater

[16] Joint Operating Concept 2012, DCDS Draft (24 July 2003): 1.

recognition that there is a pressing need for better information exchange capabilities when operating in common operating environments. Along with key allies, Canada has been very actively participating in such committees as NATO's Multinational Interoperability Council (MIC)[18], the Combined Communications Electronic Board (CCEB), the America, Britain, Canada and Australia Armies Standardization Program (ABCA) and the Air Standardization Coordinating Committee (ASCC). In particular, increased interoperability with NATO has also become a priority for Canada, and as a result, it has been actively participating in developing the NATO Standardization Agreements (STANAGS) related to data interoperability standards. The continued close coordination of these committees is essential to establish the standards required for greater interoperability between C^2 systems in the near future.

Achieving C^2system interoperability in a small force such as the CF is more complex than one might think. At first glance, one would tend to believe that reaching C^2 systems interoperability would be less challenging in a smaller force. In reality, one could argue that the opposite is true. If the objective was simply to achieve C^2 system interoperability between its environmental components (Air, Army, Navy), the way ahead would be relatively straightforward. However, since the CF will generally operate internationally as part of a coalition, it must also remain interoperable with its allies, particularly the US.

[17] Joint Operating Concept 2012, DCDS Draft (24 July 2003): 4.

[18] The Multinational Interoperability Council (MIC) is a forum for identifying interoperability issues to contribute to more effective coalition operations.

Typically, in US-led coalitions, the US adopts its own standards as the coalition's standards and relies on its partners to remain interoperable with them. Due to the limited number of interoperability standards and the necessity to operate together, the CF has been drawn towards adopting the standards of their key ally, the US, in order to maintain interoperability with their systems. This has been particularly true for the Navy and Air Force. Obviously, the dichotomy of needing to remain interoperable both "internally" (joint, within service components) and "externally" (joint and combined - each service component with its coalition counterparts) is a tremendous challenge that must be particularly addressed by small nations such as the CF.

CF C^2 Systems – A Collection of "Stovepipes"

Despite significant advances in implementing C^2 information systems in the CF, the level of interoperability between them remains a fundamental problem in enabling operational integration in a joint environment. Currently, the CF's C^2 system environment is comprised of four separate C^2 systems: the Canadian Forces Command System (CFCS - also known as "TITAN"), the Maritime Command Operational Information Network (MCOIN), the Land Forces Command and Control Information System (LFC2IS) and the Air Force Command and Control System (AFCCIS).

Clearly, the environmental commands have made enormous strides in implementing their own C^2 systems, however**,** the necessity to keep pace and compatibility with allies and US coupled with lack of central direction, common architecture and standards drove the environments to develop these systems in isolation. Unfortunately, the result is a collection of C^2 "stovepipes" systems that have an extremely limited capability to share information between each other. Left with few alternatives, the exchange of data between these systems was often attempted using individual point-to-point[19] interfaces or by manually bridging using “air-gaps”. By examining how each of them was developed independently, we can get a sense of how their divergent paths has resulted in the current integration problems and present a glimpse of the challenges ahead to make them interoperable.

The pioneer of C^2 systems within the CF, the Maritime Command Operational Information Network (MCOIN) was first developed and implemented in the early 1980’s. Already in its third generation, MCOIN III is extremely important to enable the Navy to interoperate with their US counterparts and to generate a shared, common Recognized Maritime Picture. Because it has direct access to the US Navy through CENTRIXS[20], it can conduct distributed collaborative planning and operations with the US Navy, utilizing e-mail, messaging and web-services. The high level of interoperability that the Navy shares with the US Navy’s C^2 systems is essentially due to the fact that both use the Global Command and Control System – Maritime (GCCS-M).

Similarly, the Air Force made an enormous leap forward in their C^2 capability by recently introducing the Air Force Command and Control Information System (AFCCIS). The primary effort of this first phase was to introduce the Theatre Battle Management

[19] Point-to-point interface refer to an interface that has been expressly developed to transfer data between two specific applications or databases. Frequently, the interface has been developed to transfer data between two systems that have no data interoperability standards, and therefore, this interface cannot be normally used to transfer data between two other sets of applications or databases.

[20] CENTRIXS is the Combined Enterprise Regional Information Exchange System. It is used in support of routine coalition peacetime deployments and exercises for naval and joint operations.

Core System (TBMCS); a system developed and incorporated across the US DOD, which provides the capability of generating and managing Air Battle Plans and Air Tasking Orders and providing a Recognized Air Picture across all air force units in the CF. Moreover, the initiative to install TBMCS on MCOIN III will provide the same capability to the Maritime-Air community, thereby, significantly increasing the Navy's ability to be exchange C^2 information with the Air Force at the operational level. Subsequent phases of this project will implement TBMCS on the other CF C^2 information systems.

Finally, the Army is currently in the process of attempting to integrate its existing tactical C^2 systems[21] into a single Land Forces C^2 system. Spearheading much of the CF's efforts towards data interoperability, it has successfully developed and demonstrated its Land Command and Control Information Exchange Data Model (LC^2IEDM), which is in the process of being accepted as the foundation for the CF's data interoperability architecture. This model is also being strongly considered as the basis for NATO's Joint C^3 Information Exchange Data Model (JC3IEDM). The LC^2IEDM also provides the architecture and standards used for Army's Online Data Store (ODS), which provides the capability of sharing information between applications used within the Army. Certainly, the Army's efforts to produce a common data model that can be shared by all environments will significantly accelerate the process of achieving greater C^2 system interoperability in the near future.

[21] The ACES (Army C2IS Evolution System) is mandated to integrate existing C^2 systems including components of the TCCCS (Tactical Command Control Communications System) and Land Forces Command System (Athena Tactical System).

Although the focus of this paper concerns interoperability between C^2 systems, it is important to emphasize that the requirement for information exchange definitely goes beyond these systems. Obviously, comprehensive situational awareness of the battlespace cannot be provided to the commander without information available from external sources such as logistics, personnel, maintenance and training systems.

We have seen that each of the environments has clearly indicated the intention to be fully interoperable in joint operations. What does "fully interoperable" mean? How do we measure levels of interoperability for C^2 systems? Considering that there is no accepted or recognized standard for measuring levels of C^2 interoperability, I propose a scale of five-levels of measurement based on increasing degrees of interoperability benefits and complexity to implement (illustrated in Figure 3):

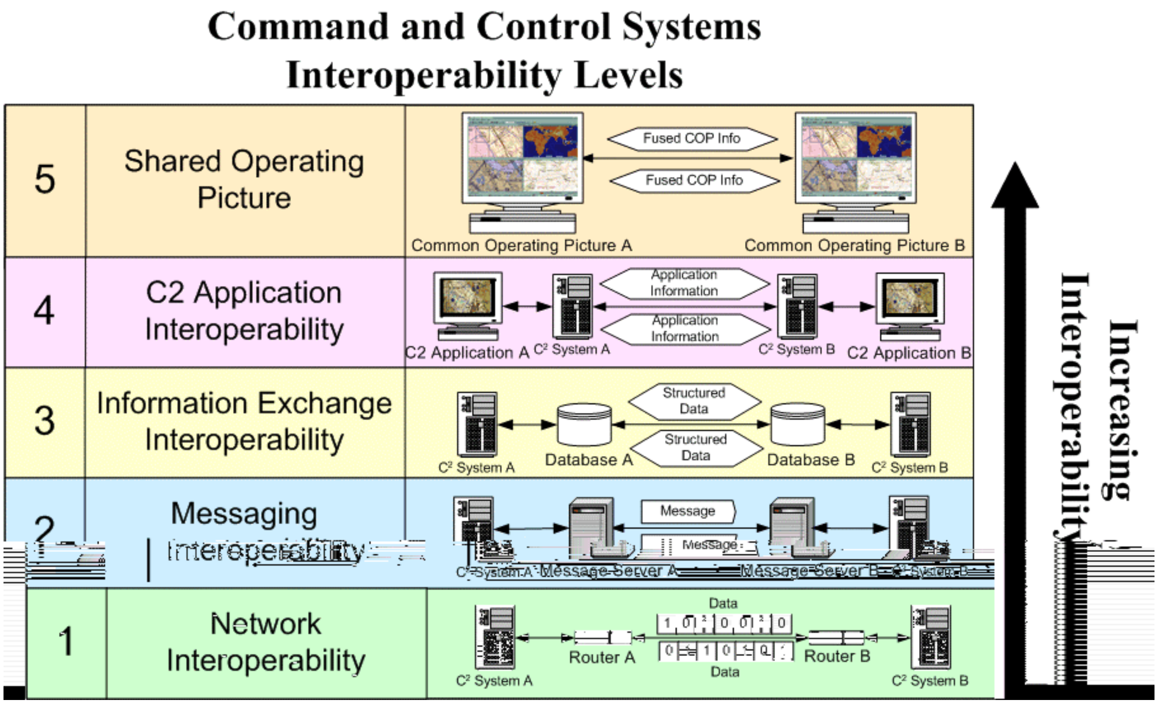


Figure 3 – C^2 Systems Interoperability Levels

- **Level 1 – Network Interoperability**. Achieving this basic level of interoperability enables C^2 systems to transmit data between each other at the network layer. This level of interoperability does not provide the capability to exchange information between C^2 systems (however, it is a prerequisite to it). Since the technology required to implement network interoperability is identical or similar to technology implemented for the Internet (TCP/IP), it is relatively simple to implement. An example of two systems meeting the Level 1 interoperability criteria would be two C^2 systems sharing the same network, such as MCOIN and AFCCIS which are both connected to the Classified Network (CNet).

- **Level 2 - Messaging Interoperability**. This level of interoperability indicates that the C^2 systems can exchange messages securely between each other. This requires the use of a standard messaging format such as ACP 128 or OTH-Gold to transmit secure messages between systems. Access to a common messaging directory (such as X.500) is necessary to facilitate addressing of messages. To attain this level, this capability does not need to be incorporated into the C^2application, but must be accessible from desktop of the C^2 system. For example, since the Navy's MCOIN can transmit military messages and e-mails to the US Navy (via GCCS-M) and vice-versa, they both meet Level 2 interoperability criteria between each other.

- **Level 3 – Information sharing/exchange interoperability**. To attain this level, a C^2 system must be able to share structured, C^2-related information or unstructured information (such as images, documents, Web pages) with other C^2 systems. It also provides the additional capability of pulling information rather the limited push-oriented environment provided by Level 2. This level is more difficult to achieve than level 2 because it requires "trusted" and directed access between systems, although gateways or firewalls may be used to exclude unauthorized users from a restricted portion of the C^2 system. At this level, the sharing of information between systems can be accomplished by transmitting information to and from a centralized data repository such as a data warehouse. For example, once information can be shared between the Army's LFCCIS and the Joint CFCS (Titan) using a centralized, classified database, which both C^2 systems can transmit to and receive information from, then they will have achieved Level 3 interoperability between each other.

- **Level 4 - Application Interoperability**. This level implies that applications can share information directly between applications residing on different C^2 systems. Normally, the simplest way to accomplish this is to use the same application. For example, if TBMCS application is used on both AFCCIS and MCOIN III(to track maritime air operations) and can exchange information from TBMCS application on AFCCIS to TBMCS application to MCOIN III, then they have met the criteria for Level 4 interoperability between each other. However, it is possible that two separate applications using similar information exchange standards can share information seamlessly by using common data/information standards such as XML[22] to exchange information.

- **<u>Level 5 – Shared situational awareness</u>**. Attaining this highest level of interoperability indicates that a C^2 system can exchange C^2, intelligence, sensor and reconnaissance information with one or more C^2 systems in order to produce a near-real time "customizable" common operational picture (COP) that can be shared among all contributing C^2 systems. For example, if any portion of the Recognized Maritime Picture (RMP) can be incorporated as part of a customized view that the Air Component Commander may be require, then it will have met Level 5 interoperability criteria.

Based on this scale of interoperability, Table 1 illustrates a comparative assessment of the <u>current</u> interoperability levels at the joint (between CF C^2 systems) and with US Coalition counterpart (ie. Cdn Army vs US Army). In some cases, the ratings are not clear-cut. For example, since AFCCIS can now share maritime air tracks with MCOIN through TBMCS, it does provide limited Level 4 interoperability between the Air Force and Navy's C^2 systems. However, this is the only information exchange capability that it provides with other CF C^2 systems beyond Level 2 interoperability, therefore. it was assigned a low rating.

[22] XML (eXtensible Markup Language) is a widely accepted standard for the interchange of structured information.

Levels of Joint/US Coalition Interoperability

	Joint					US Coalition				
	Interoperability Level (with other CF C^2 systems)					Interoperability Level (with related US C^2 system)				
C^2 System	1	2	3	4	5	1	2	3	4	5
TITAN/CFCS	Yes	Yes	No	No	No	Yes	Yes	No	No	No
MCOIN III	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
LFC2IS	Yes	Yes	No	No	No	Yes	Yes	No	No	No
AFCCIS	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No

Table 1

In reviewing the interoperability grid, it becomes apparent that none of the systems has high levels of interoperability across the scale. With the exception of MCOIN's and AFCCIS's interoperability with US Coalition, the current interoperability levels between Joint/Coalition C^2 Systems is limited to Level 2 (Messaging Interoperability). The CF's Joint C^2 system (called TITAN) does not provide capabilities beyond the ability to share files, e-mail and chat over a classified Web. The results of this brief analysis clearly indicate that the existing level of interoperability of these C^2 systems must be significantly enhanced if the CF is to work effectively in joint and/or coalition operations.

Interoperability Requirements of Future Joint C^2 Systems

Recognizing that the CF's current C^2 systems do not provide an adequate level of interoperability to effectively support command and control in joint and coalition environments, the obvious question is what are the minimum information exchange capabilities required for next generation of C^2 systems? The answer to this question needs to be centered around what the CF envisions as its future operating environment.

The *CF Strategic Operating Concept* indicates that "in future CF operations, unity of purpose and effort will continue to be achieved through the commander's intent, while success in execution will be best achieved by local, decentralized forces."[23] It describes network-enabled operations (NEO) as a key force-multiplier that will be accomplished by "networking all sensors, decision makers, and combatants to achieve shared battlespace awareness, increased speed of command[24], higher operational tempo, greater lethality, increased survivability and greater adaptability through rapid feedback loops." [25] It will be based on "a single command and control architecture that facilitates strategic, operational, tactical level joint, interagency, and multinational (specifically US) integration".[26]

Comprehensive and accurate situational awareness is key to mastering the decision cycle. It reduces uncertainty and significantly increases the capability for the commander to make the right decision. Although uncertainty can never be completely eliminated, the implementation of the right C4ISR infrastructure can help "reduce uncertainty to the point where the commander is confident that the decisions being made

[23] Departmental of National Defence. Canadian Forces Strategic Operating Concept (Draft 4.4), Ottawa: Deputy Chief of Defence Staff, 21 May 2004): 16.
[24] Speed of command is defined as "the process by which a superior information position is turned into competitive advantage… and is characterized by decisive altering of initial conditions, the development of high rates of change and locking in success, while locking out alternative strategies." Cebrowski, Vice Admiral Arthur K., *Network-Centric Warfare: Its Origin and Future (* US Naval Proceedings: January 1998): 8.
[25] Departmental of National Defence. Canadian Forces Strategic Operating Concept (Draft 4.4): 16.
[26] Ibid: 36.

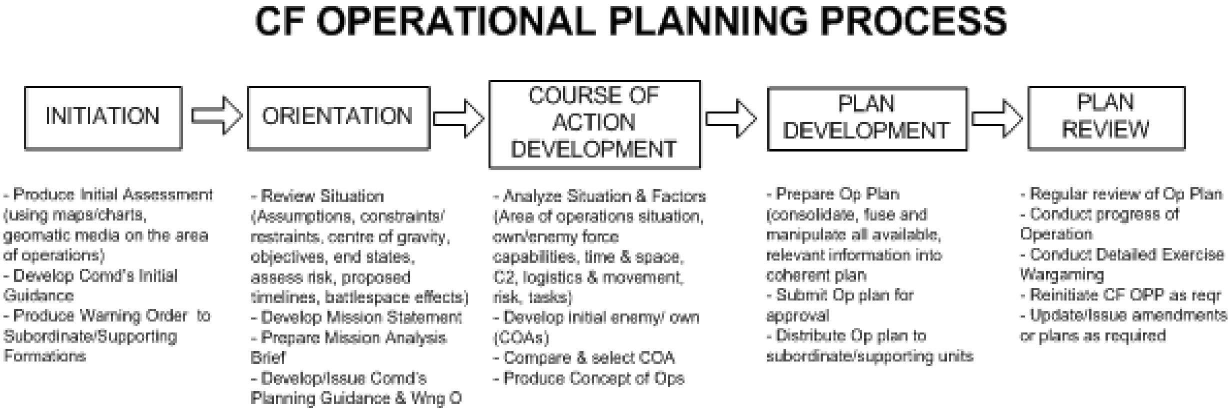
are the best obtainable in the operational circumstances."[27] To maximize the benefits and reduce the danger of information overload, it is vital to provide decision-support tools that can extract the most relevant information required for decision-making and present it in the most concise and accurate manner to enable the commander to fully exploit this information to make the best decision possible.

To provide a comprehensive picture of the situation, all potential sources of relevant information need to be interconnected together in a ubiquitous network of nodes similar to the Internet. Ideally, all information residing on this system should be accessible using common formats that will enable the seamless exchange of information between systems and applications. Sophisticated search engines to allow decision makers at all levels to quickly access the information they need as well as the capability to fuse relevant information from multiple sources and present it in a manner tailored for each decision-maker are also essential components of the future C4ISR infrastructure. This comprehensive picture should include not only positional information of friendly and enemy forces, but also any information that the commander might wish to consider throughout the decision and execution cycle.

Campaign planning and monitoring applications that enable optimal execution of all five stages of the Canadian Forces Operational Planning Process (CFOPP) must be part of future C^2 systems. They need to be specifically designed to promote and simplify the use the CFOPP by incorporating the process into these applications. Figure 4

[27] Department of National Defence. *CF C4ISR Command Guidance & Campaign Plan* (Ottawa: National Defence Headquarters: 02 December 2003): 6.

illustrates the five stages, initiation, orientation, courses of action development, plan development and plan review and the key activities that must be optimized by future C^2 systems. These applications must provide situational awareness and decision assisting capabilities that go well beyond the series of PowerPoint briefings imparted to the Commander. They must provide interactive presentation, analytical and monitoring tools that will increase the overall efficiency of all key activities performed throughout the entire joint planning and execution process.



CF OPERATIONAL PLANNING PROCESS

INITIATION
- Produce Initial Assessment (using maps/charts, geomatic media on the area of operations)
- Develop Comd's Initial Guidance
- Produce Warning Order to Subordinate/Supporting Formations

ORIENTATION
- Review Situation (Assumptions, constraints/ restraints, centre of gravity, objectives, end states, assess risk, proposed timelines, battlespace effects)
- Develop Mission Statement
- Prepare Mission Analysis Brief
- Develop/Issue Comd's Planning Guidance & Wng O

COURSE OF ACTION DEVELOPMENT
- Analyze Situation & Factors (Area of operations situation, own/enemy force capabilities, time & space, C2, logistics & movement, risk, tasks)
- Develop initial enemy/ own (COAs)
- Compare & select COA
- Produce Concept of Ops

PLAN DEVELOPMENT
- Prepare Op Plan (consolidate, fuse and manipulate all available, relevant information into coherent plan
- Submit Op plan for approval
- Distribute Op plan to subordinate/supporting units

PLAN REVIEW
- Regular review of Op Plan
- Conduct progress of Operation
- Conduct Detailed Exercise Wargaming
- Reinitiate CF OPP as reqr
- Update/Issue amendments or plans as required

Figure 4[28]

Establishing a collaborative information environment that is able to deliver timely intelligence is critical to the commander's ability to react to changing situations throughout the assigned battlespace. Collaborative tools, such as chat and video teleconferencing, are key to enabling commanders at all levels to actively participate and provide input, as required, during the decision-making process. Not only will this increase the understanding across the entire spectrum of the operational environment, but it will also improve the speed and quality of decisions.[29]

[28] Department of National Defence. *Canadian Forces Operational Planning Process*, B-GJ-005-500/FP-000, (Ottawa: National Defence Headquarters: 6 November 2002), Chapter 4.

[29] Department of National Defence. *CF C4ISR Command Guidance & Campaign Plan* (Ottawa: National Defence Headquarters: 02 December 2003): vii.

Finally, it is important to highlight that architecture, rules and processes that govern and regulate information flow between these systems will have to be established to ensure that accurate information is directed rapidly towards the right decision-makers. Otherwise, there will be a significant risk of network congestion, particularly to deployed units, as well as an increased danger of information overload to decision-makers requiring them to sift through less relevant information. To successfully manage the enormous flow of information, these rules will have to be customizable and programmable into future C^2 systems.

Having reviewed the C^2 capabilities necessary to successfully support future joint and coalition operations, it is possible to determine the acceptable level of interoperability for future joint C^2 systems based on the interoperability scale. Since most of these capabilities need access to information residing across tactical and operational level C^2 systems, Level 3 (Information Exchange Interoperability) is the minimum level of interoperability required, as it is the first level enabling the sharing of structured information between C^2 databases.

The Road towards C^2 System Interoperability

Recognizing the tremendous benefits to be achieved from greater integration, the CF has taken concrete steps to enhance its C^2 capabilities and interoperability across the entire spectrum of operations by developing a clear C4ISR [30] vision and comprehensive plan. In addition to C^2 systems, C4ISR incorporates all of the connectivity, sensors and information technology that support C^2 Having formally acknowledged its importance in Strategy 2020, the CF followed with a vision, a plan and governance structure that would oversee the joint implementation of C4ISR capabilities. Led by the C4ISR Oversight Committee, the CF published, in September 2003, the Command Decision Support Capability Principles & Goals (CoDSC), which described the overarching vision to provide "an effective CF-wide C^2 capability that achieves operational advantage across the entire spectrum of military operations through the time attainment of trusted and relevant information"[31].

C4ISR Support to Command Cycle

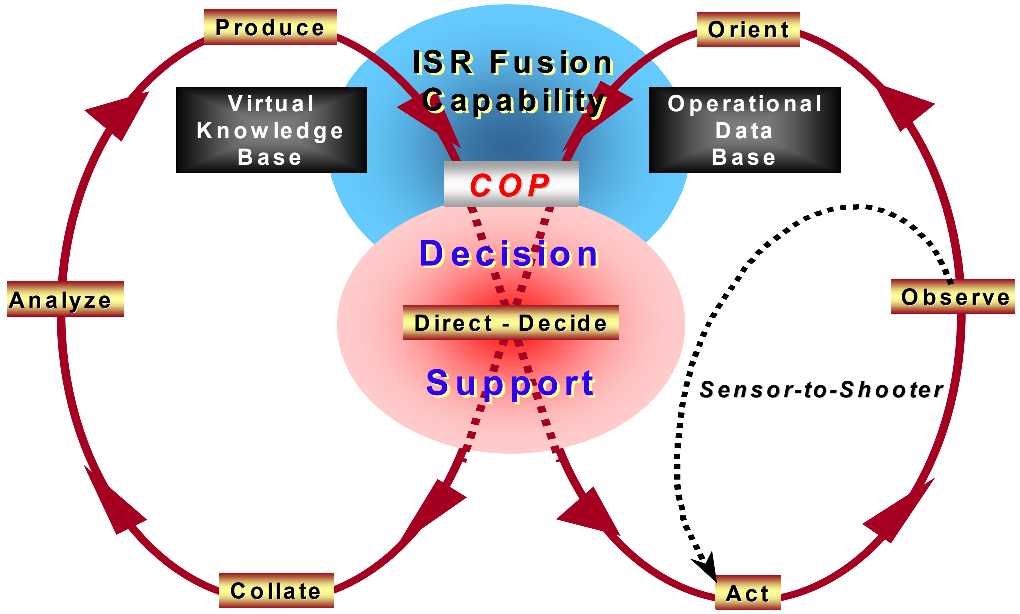


Figure 5[32]

[30] C4ISR stands for Command and Control. Computing Intelligence, Surveillance and Reconnaisance

[31] Department of National Defence. "CF C4ISR Command Guidance & Campaign Plan": 4

[32] Ibid.

The approach of how the vision will be achieved was produced shortly thereafter, in December 2003, with the publication of the C4ISR Command Guidance and Campaign Plan. This plan emphasizes how technology can assist commanders and decision-makers through the "Command cycle" illustrated in Figure 5. In this model, the decision-maker is at the center of two activities the C^2 decision cycle and information and intelligence processing cycles. Essentially, the smooth integration of these two cycles into an integrated system, which is referred to as the C4ISR Support-to-Command Cycle, is perceived to be the key to effective decision-making.[33]

Joint C4ISR "Target Integration Model"

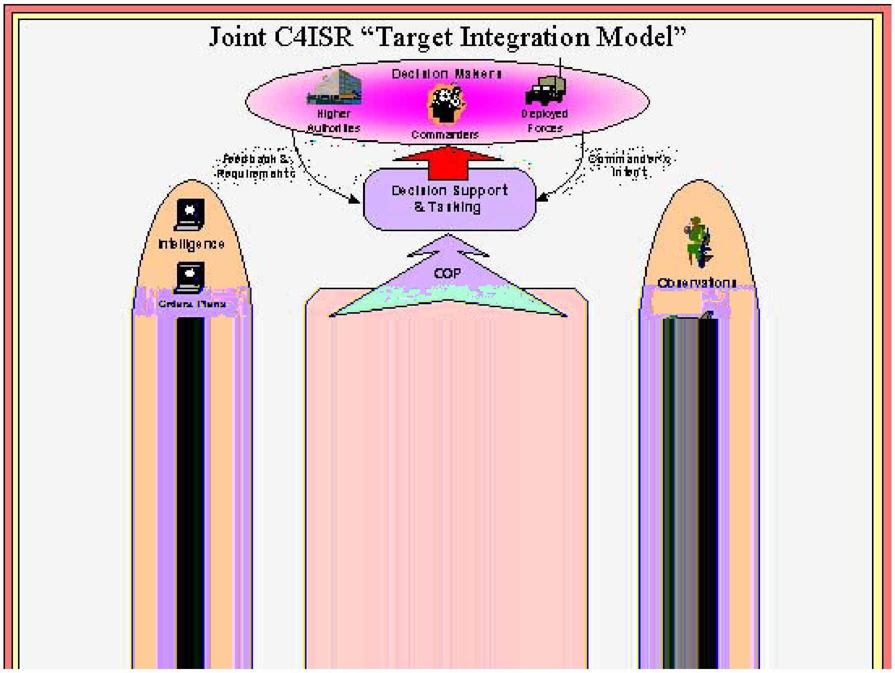


Figure 6[34]

By 2008, the aim is for "the CF to have a robust, interconnected, and integrated C4ISR capability in support of decision-making."[35] Transformation towards this end

[33] Ibid: 9.
[34] Department of National Defence. "CF C4ISR Command Guidance & Campaign Plan": 13.

state is contingent upon the development and implementation of a Joint C4ISR Target Integration Model (TIM). The concept behind the Joint C4ISR TIM is based on fusing of background (static) information and current (dynamic) information from all available sources (sensors, human intelligence, situational reports) together into a near-real time common operating picture (COP) to support military commanders and decision-makers [36] (illustrated in Figure 6). Ultimately, it is the key to achieving greater interoperability between CF C^2 systems.

From a joint perspective, three projects are critical to achieving this vision in the near term. First, the Canadian Forces Command System (CFCS) II project will unify the CF's operational networks (TITAN, MCOIN III, LFC2IS and AFCCIS) and provide the means for sharing situational awareness and collaboration amongst CF decision-makers. Next, the Joint Interoperability and Information Fusion Centre (JIIFC) projects will focus on providing the capability to manage and display the operational information provided by the integration and fusion of all relevant information need to directly support the decision-making process (ie. Generate the "Common Operating Picture"). Finally, the Defence Information Services Broker (DISB) project will provide the tools that will enable all DND/CF to share information across all military and corporate systems and repositories across the DND/CF. Once these projects have been successfully implemented, the CF will have achieved a major step towards joint interoperability.

[35] Department of National Defence. "CF C4ISR Command Guidance & Campaign Plan": 13.
[36] Ibid.

These interoperability challenges are not exclusive to the CF. In fact; no nation has been able to claim that its C^2 systems are fully interoperable in both the joint and coalition environments. Even the US, which has long recognized these issues and has been pouring an enormous amount of funding into this area, has not been able to claim complete success – yet.

Indeed, as far back as the early 1990's, the US DOD recognized that it would require an evolutionary approach to progress the issue of joint C^2 interoperability. As a result, it created an annual event (known today as) the Joint Warrior Interoperability Demonstration (JWID) that would be used to spearhead and coordinate joint interoperability efforts.[37] It spawned immediate success, as within six months of the first JWID (1994), it was able to field baseline segments of what later became the Global Command and Control System (GCCS).[38] In 1997, JWID expanded to include US coalition partners including Canada.[39]

As of 2005, JWID will be renamed Coalition Warrior Interoperability Demonstration (CWID) recognizing that the emphasis has shifted towards multinational interoperability demonstrations now that more than 20 countries participate in this annual exercise. Sponsored by the DCDS and led by the Canadian Forces Experimentation Centre (CFEC), CF's participation in CWID is aimed at enhancing its interoperability within coalition and domestic environments by testing emerging C^4I technologies and

[37] United States, Department of Defense. *Joint Warrior Interoperability Demonstration 2004 Guidebook*.- Manual History. (Hampton, VA: Joint Chiefs of Staff, June 2004): 7.
[38] Ibid.

solutions. [40] In 2004, the CF successfully tested several C^2-related capabilities including enhanced situational awareness and CFCS interoperability testing with various components of GCCS.

Continuing active participation in multinational interoperability standardization committees such as the NATO's MIC and ABCA is essential to achieving the overall goal of increasing the interoperability not only for coalition operations, but also for joint operations since ultimately, all information that can enhance military operations at all levels should flow fluidly across the entire spectrum.

Unquestionably, the road towards C^2 system interoperability has many serious challenges ahead. From a technical aspect, acquiring increased bandwidth for deployed units; establishing common, shared data repositories that enable the sharing and integration of all relevant C^2 information across the joint and coalition environment, and developing the technology to display the 'common operating picture' are the probably the three biggest technical challenges to achieving a fully interoperable C^2 system.

In reality, the greatest challenge to full C^2 interoperability is perhaps not a technical one, but one that revolves around information releasability rules.[41] Most nations, governmental departments and agencies are reluctant to release sensitive or classified information externally, regardless of its purpose. The US military, for

[39] Ibid.

[40] United States, Department of Defense. *Joint Warrior Interoperability Demonstration 2004 Guidebook*. 7.

example, uses the SIPRNET[42] to plan and conduct operations[43]. Unfortunately, the SIPRNET is not directly accessible to its allies, and therefore, cannot be used to effectively share C^2 information for coalition operations. The proposed workaround, the "Coalition Wide Area Network", will provide access to a limited amount of information thru a series of gateways and firewalls. [44] Obviously, since the CF will normally be operating in a joint environment as part of a US-led Coalition, not having access to the C^2 information on the SIPRNET may severely hamper the CF's capability to conduct effective operations in a Coalition environment. Similar issues exist with other allies. Regardless of the technology implemented, if this issue isn't resolved, working effectively with the US will be increasingly difficult in the future. As a "trusted" partner, the CF needs to continue to work with the US and its other allies to break down these information-sharing barriers.

Inevitably, as future C^2 systems provide greater capabilities, this will result in greater reliance on them and in turn, create new challenges. Guaranteeing the accuracy and reliability of the C^2 information is certainly one of them. As decision makers increasingly depend on these systems to provide common situational awareness across all levels of the battlespace, ensuring the timeliness and high quality of the information

[41] Mitchell, Paul T. "Small Navies and Network-Centric Warfare – Is There a Role?", *Naval War College Press*, Spring 2003: 5.
[42] The SIPRNET refers to Secret Internet Protocol Router Network, which is the US network backbone for classified information. It is used as the network for most classified systems including the Global Command and Control System. It is separated both physically and logically from other networks.
[43] Ibid: 3.
[44] Ibid: 6.

provided will become even more important.[45] Commanders and their staffs will be expecting that the information provided is consistent and that they can develop and execute their plans based on timely and accurate information to ensure synchronization across all elements. Obviously, any time lag or inconsistency of friendly or enemy positions provided to combat forces could be disastrous. Problems ranging from synchronization problems, execution delays or even friendly fire incidents could be a direct result of delayed or incorrect information.

Furthermore, the enormous dependency on C^2 systems may lead to an environment where any disruption of information flow will result in a paralysis of the C^2 decision and execution process. This is particularly true at the operational level, where the complexity of the battlespace requires the use of C^2 systems to coordinate and synchronize the planning and execution of multiple elements across the entire theatre of operations. Inevitably, the indispensability of C^2 systems will increase the probability that they will be targeted directly through either kinetic means or indirectly using denial of service attacks on networks using methods such as viruses. As well, if adversaries are able to capture or corrupt information on these systems so vital to C^2, then this will likely cause significant disruptions in the commander's decision-making process.[46] Consequently, the requirement to protect C^2 systems against all threats that will affect their availability and reliability will be increasingly vital in the future.

[45] Alberts, David S., et al. *Understanding Information Age Warfare* (US Department of Defense, CCRP Publication, August 2001): 159.

[46] Ibid.

Conclusion

Undoubtedly, the CF will continue to actively participate in joint and coalition operations in the future. Key to the success of the CF's contribution to these missions is its ability to operate seamlessly with its allies in a joint operational environment. Extensive networks of intelligence, surveillance, reconnaissance and targeting assets, combined with horizontal and vertical connectivity to all elements of the contributing forces, are required to provide commanders at all levels with increased situational awareness and reduced uncertainty to allow them to make the best decision possible. Considering the wider span of control and the rapid pace in which situations can develop in the modern operational environment, highly connected and interoperable national C^2 systems reaching across all participating components, regardless of their location, will be vital to conducting effective joint and coalition operations in the future.

Clearly, the lack of C^2 system interoperability remains a fundamental problem within the CF. Despite significant progress made by each environment in developing their own C^2 systems, their limited levels of interoperability remain a significant obstacle to enabling the CF to operate coherently in a joint and coalition environment. As a minimum, the CF must aim to achieve Level 3 interoperability (based on the proposed scale); that is, the capability for C^2 systems to share structured and unstructured C^2-related information across all components.

Ultimately, improved interoperability can only be achieved with the CF's continued participation of in domestic and multinational standardization committees such as NATO's MIC and ABCA.   Within the CF, tremendous efforts are being expended to establish comprehensive information architecture for C^2 systems. The publication of the C4ISR Campaign Plan and the CF's aggressive push to implement it in a coordinated and evolutionary manner that takes full advantage of emerging technologies and interoperability standards is definitely an enormous step towards realizing the ultimate goal of a shared COP that will increase situational awareness and reduce uncertainty for the commander in the battlespace. Without a doubt, projects such as CFCS II, JIIFC and DISB, and the CF's continued participation in events such as CWID will progress the existing C^2 systems towards an increased level of interoperability.

Recognizing that the technical challenges are significant, perhaps the greatest barrier towards eventually realizing the goal of seamless information exchange across C^2 systems is the continued reluctance by nations and organizations to share information externally.   Realistically, it is unlikely that nations such as the US will provide open access and allow even trusted nations to have access to all of their C^2 information. However, the CF needs to take steps now to clarify with the US and other allies what information will be shared so that the C^2 systems can be developed to maximize and leverage this information to the fullest extent to support commanders in future joint and coalition operations.

While technology will never be able to completely eliminate the "fog and friction of war" on the battlefield, it is definitely an essential enabler that will be increasingly vital to support the commander throughout the decision-making and execution process in the future. Clearly, the CF's current C^2 systems are not up to the task of operating seamlessly in joint and coalition environments. Fortunately, the CF recognizes the issue and has a clear plan of how to achieve the vision of high C^2 system interoperability with its allies. Will it succeed in achieving its objectives? Only time will tell.

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