Towards a Concept of Operations for Distributed Training Simulation in the Canadian Air Force

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ABSTRACT

Distributed simulation is a powerful tool for force generation that must be tailored to the force it intends to serve. To develop this complex capability a Concept of Operation (ConOp) is necessary to provide consistent direction, unity of effort, and alignment with existing policy. The document must address issues such as the goals for distributed training simulation, describe the governance structure, identify users, enumerate common services, and guide implementation. This paper describes factors shaping the treatment of these issues in a ConOp for a small multi-purpose, combat capable Air Force. The Canadian Air Force's Synthetic Environment Coordination Office is leading an effort involving Air Force operational communities, Army, Navy, and joint projects to develop a ConOp for Air Force distributed training simulation. Given the size, missions, and history of the Canadian Air Force, the approaches to interoperability with allied simulation networks and integration with Army and Navy emerge as pivotal issues to establishing an effective distributed simulation capability. Furthermore, leveraging the expertise of other organizations and isolation of the ConOp's technical specifications are strategies for keeping the ConOp current and coordinated with wider organizational developments. In highlighting how national circumstances influence the formulation of a distributed training simulation ConOp for Canada's Air Force, we seek to assist readers from other nations in considering similar decisions from their perspectives, which may lead to different solutions which address their own circumstances.

ABOUT THE AUTHORS

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ESTABLISHING A DISTRIBUTED SIMULATION CAPABILITY

Distributed simulation is a powerful tool for force generation. This capability can contribute to collective training while offering several benefits relative to live training, such as safety, cost, security, and environmental concerns. Nevertheless, distributed simulation should be tailored to the force it intends to serve. To develop this complex capability, a concept of operations (ConOp) is necessary to provide consistent direction, unity of effort, and alignment with existing policy. This paper considers the circumstances for employing distributed simulation for mission training in a small, multi-purpose air force. More specifically, this document describes the decisions facing the Canadian Air Force's Synthetic Environment Coordination Office in setting the functional capabilities for the distributed mission training capability being established for the Canadian Air Force. The issues are affected by national circumstances, such as the size, missions, and doctrine of the air force. Explanation of how these circumstances can influence the ConOp may be informative when considering functional capabilities of distributed mission training (DMT) for other air forces.

CURRENT CONTEXT

The Air Force currently conducts many live collective training events. These events provide valuable mission training to the Air Force, but cost, operational tempo, asset availability, safety, and security constraints limit the amount of such training that can be accomplished. Consequently, the Air Force has decided to use distributed simulation to conduct additional mission training. The objective of the DMT[1] capability is to enable collective training of Air Force units. DMT events will supplement, not replace, the various live collective training events conducted by the Air Force. Towards this end, the Air Force has been involved in several DMT activities for a number of years, such as the Coalition Mission Training Research series (e.g. Greschke, Mayo & Grant, 2002), First WAVE (NATO, 2007), War In a Box (Hazen, Jones, & Perreault, 2006), and distributed simulations between the CF-18 simulators at 3 and 4 Wing using the Advanced Distributed Combat Training System. As demonstrated by the preceding list of DMT events, the process of establishing DMT for the Air Force is underway. High level endorsement and research and development activities have enabled individual projects to begin delivering aspects of the capability and generating lessons for the use of the capability. For example, a Distributed Mission Operations Centre is established, persistent network enclaves are available, and simulation federates are operating. However, published processes, a full set of simulation sites, and centralized services are incomplete. A ConOp is now in development to incorporate those past lessons into current DMT operations, marshal existing projects, and streamline future DMT events.

The formation of the ConOp can consider the exercises Amalgam Warrior, Coalition Virtual Flag, Winged Warrior, and Trident Fury as indicative of the nature of exercises that must be hosted by the capability. It is crucial that the ConOp not take these exercises as a series of federations that need to be developed. Rather, they should constitute a single state of readiness. The DMT capability must enable the execution of all of these types of events. Whereas past DMT events within Canada's Department of National Defence have been transient, a key aspect of this new capability is availability. Once established, this capability must be available to Air Force units on a routine basis. Barring the idiosyncrasies of simulations at individual participating sites, engineering and development effort should not be required to conduct training events amongst arbitrary collections of sites utilizing a menu

[1] Distributed Mission Training and the acronym DMT are used in this paper to refer to the use of distributed simulation for mission training. It does not refer to the prior USAF DMT program. The authors prefer DMT as a more descriptive and simple alternative to other terms such as Mission Training via Distributed Simulation.

of terrain models within an established network enclave. At steady state, the effort should be primarily one of training planning, scenario development, loading available data, and scheduling.

Building a ConOp from existing concepts and organizations leverages the expertise invested by others in previous and ongoing activities. Consequently the DMT capability is better able to maintain currency with the many evolving issues. Advances or evolutions within specific issues can in many cases be included by reviewing the referred documents and managing the roll-out of any changes necessitated in the DMT capability. This approach has two drawbacks, however. The first is that users need to obtain the current versions of the referenced documents. The second is that interpretation or filtering of the referenced documents may be required. The referenced documents may not address distributed simulation specifically, and may therefore require interpretation. The single source approach resolves these problems for the users.

PRICIE

In describing the issues an Air Force DMT ConOp will address, PRICIE is used as an organizing framework. PRICIE is an acronym describing the functional inputs to capability in Canada's approach to capability based planning. (DND, 2009a). It addresses:

- Personnel
- Research & development / operational research
- Infrastructure and organization
- Concepts, Doctrine, and Collective Training
- Information Management & Technology
- Equipment, Supplies, and Services

Personnel

Table 1 presents a list of roles for skilled personnel involved in implementing and maintaining a DMT capability (PWGSC, 2008; 2009). Their availability is particularly salient for an Air Force DMT ConOp. Personnel able to perform these roles are in high demand with the Department of National Defence and the Canadian Forces (CF). A core set of government employees perform many of these tasks but historically the demand for their services has outstripped the supply. To address this personnel shortfall, the DMT capability should include process maps and document templates to facilitate the collection and distribution of validated data.

Canada has sophisticated telecommunications and simulation industries that can provide personnel to also help address the shortfall in availability. For this reason, the DMT capability must include contracting vehicles that will allow ready access to these resources. Identifying and establishing access to flexible, responsive contracts is an important input to the DMT capability.

Table 1 Roles for Skilled Personnel

Project Manager
Federation Architect
Network Engineer
Network Technician
Simulation Test Director
Configuration Manager
Software Engineer
Computer Engineer
Computer Technician
Exercise Director
Role Players
Exercise Event Coordinator
Asset Administrator
Technical Writer
Terrain Database Modeller
3D Object Modeller
IT Security TRA and C&A Analyst
IT Security Methodology, Policy, and Procedures Analyst
Network Security Analyst
Physical Security Specialist

Research & Development and Operational Research

The DMT capability is being established using existing technology and concepts. Consequently, no research and development program is anticipated in fielding the capability. Nevertheless, the dynamic nature of the technology of distributed simulation is recognized. Monitoring, influencing, and exploiting the science and engineering of distributed simulation will enable a DMT ConOp to remain relevant and effective.

The primary avenue for Air Force DMT research and development activity will be the Canadian Forces Aerospace Warfare Centre (CFAWC). This exploits the fact that the CFAWC has a mandate for research and development in aerospace power and synthetic

environments as well as the responsibility to coordinate and operate synthetic environments for the Air Force (DND, 2005, 2007). Highly relevant research requirements and ready exploitation of research results can therefore be expected.

The CFAWC partners with government, university, and industry to meet its research, development, and operational analysis requirements. As part of the Department of National Defence, CFAWC is supported by DND's research agency, Defence Research and Development Canada (DRDC). In addition to the standard methods of accessing DRDC science and technology capability that are open to all of DND, the CFAWC has detailed agreements for direct and ongoing DRDC support that includes locating scientists within the CFAWC organization as well as research agendas within DRDC research centres. DRDC also facilitates access to science and technology in the defense science organizations of allied nations. Whereas DRDC provides access to a broad spectrum of science, technology, and analysis, the CFAWC uses agreements with universities to address specific issues or technologies. Contracts to industry are used to both implement technologies as well as access technologies of interest to the CFAWC.

Infrastructure and Organization

The DMT capability for the Air Force will be manifested, explicitly or implicitly, through the participation of multiple organizations. Coordination, development, and support of distributed training functions will be done by CFAWC, as per its mandate (DND 2007). Standards for simulation will be provided by the CF Synthetic Environment Coordination Office (SECO) and the Air Force SECO.

The building of distributed simulation infrastructure for the CF is the responsibility of the Canadian Advanced Synthetic Environment (CASE) project, which also addresses army and navy requirements. Management of the network is done by the Canadian Forces Experimentation Centre (CFEC) on behalf of CASE. The actual simulators and training devices, however, are the responsibility of the participating operational units. It is their responsibility, or other supporting offices, to attain local functionality and to configure their systems to operate in a collective simulation. The CFAWC will assist the units by providing common data, assistance with interoperability testing, and advice. Private sector contractors assist each of these organizations in delivering their aspect of the capability.

Air force operational units will be the users of the DMT capability, but, because of the collective nature of the training, the units are recognized as implicitly and mutually providing the capability. In addition, Air Force missions involve support to the army and navy. The participation of the army and navy will therefore be necessary to fully achieve a DMT capability. Furthermore, doctrine of the Air Force (DND 2004; 2006a) and CF (DND 2009c) as well as Government of Canada policy state that the CF will operate with allied nations. Simulator interoperation with NORAD, NATO, and the AUSCANUKUS nations will enable training with their forces and our shared missions to fully attain a distributed simulation capability for Canada's Air Force.

The Air Force DMT capability requires a governance structure designed to serve Air Force interests and obtain coordination to establish and maintain joint interoperability. Toward this end, the DMT capability should be responsive to the commander of 2 Canadian Air Division / Air Force Doctrine and Training Division which leads force generation efforts for the Air Force and is the parent organization of the CFAWC. A DMT steering group sets and manages the objectives for Air Force DMT. It is at this level that control is exerted to address both specific training requirements and joint interoperability. The Steering Group promotes interoperability by including representatives of the synthetic environment coordination offices of the Department of National Defence, the army, and navy along with Operations and Training team leads (see Figure 1). Interoperability and tool re-use is further facilitated by the advisory role of the Synthetic Environment Working Group (SEWG), a previously existing forum for leading modeling and simulation users within the Department of National Defence. The training audience is represented in the Steering Group by the Operations and Training Team leads.

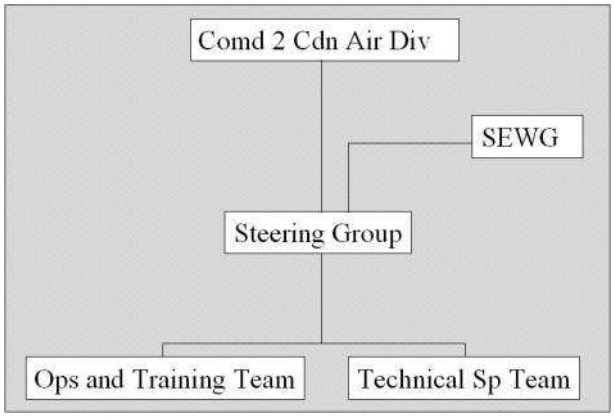

Figure 1. DMT Governance Structure

DMT requires secure, accredited networks. Efficiency in establishing and managing DMT networks is vital both to protect information and to deliver DMT in a timely fashion. A ConOp may identify the CF's lead organization for information technology security coordination, the Director Information Management Security (Dir IM Secur), in this regard, to establish and operate processes and services to obtain network engineering and configuration management. Not only does this approach abide by government and departmental security policies, it enables the DMT capability to leverage services and products delivered by Dir IM Secur, such as security guidelines, system documentation examples, configuration management databases, technical inspectors, and system engineering. Furthermore, because DMT involves multiple units, locations and functions, a ConOp will provide a responsibility matrix that will map the network security responsibilities associated with establishing and conducting DMT onto the participating organizations.

Concepts, Doctrine, and Collective Training

The DMT ConOp must necessarily conform to the goals and requirements of CF administrative orders and strategic vision that address simulation (DND 2004; 2006a; 2006b; 2006c), but it should also draw upon concepts and doctrine established internationally by practitioners of distributed simulation. This is clearly valuable, as it enables the Air Force to benefit from the collective work of experienced and talented people already working on these issues. Also valuable is the experience acquired from current and past Canadian Air Force use of DMT. The Air Force has participated in DMT events for several years and the knowledge acquired from conducting these events for Canadian goals and using Canadian organizations is an essential complement to international lessons.

The operational concept for the underlying data network is an example of the experience gained nationally. In previous DMT activities, including the Coalition Mission Training Research series (e.g. Greschke, Mayo & Grant, 2002), First WAVE (NATO, 2007), and War In a Box (Hazen, Jones, & Perreault, 2006), establishing an approved secure network was a protracted process because DMT network accreditation in Canada must compete for attention with other network projects. The CF's operational commitments, such as in Afghanistan, receive a higher priority in the accreditation process, which subsequently lead to reduced time available for testing and integration of DMT. As a result, the Air Force DMT ConOp should seek to establish persistent and flexible data networks.

To achieve persistence and flexibility, the network components of DMT may be treated as belonging to one of three parts. These parts are the local site, the network enclave, and the wide area network. These three parts working in concert enable DMT. This partitioning is intended to isolate the configuration management challenges that ensue from the inevitable changes to the hardware components.

To provide coordination and control during DMT events, the CFAWC Ottawa detachment was identified as the Air Force simulation centre. The simulation centre is designated the Distributed Mission Operations Centre (DMOC). Although bearing a name similar to the USAF Distributed Mission Operations Center at Kirtland AFB, the Canadian facility differs from it and from the UK's Air Battlespace Training Centre. The scale is much smaller, reflecting not simply the fewer personnel available to operate the facility, but also the narrower range of missions to be trained. The assets held are also different. The CFAWC DMOC simulators are intended for training support only. The simulators are not designed to provide training to their operators, but rather for the training audience that interacts with them over the network. The rationale is that simulators for trainees will be located only with the operational units, and that the DMOC assets be as economical and flexible as possible. Another difference is the rationale for location of the DMOC simulation centre. The Ottawa location is not co-located with an operational air unit. Instead it is located near telecommunications, security, and research facilities. The CF's network operations centre, Dir IM Secur, and university and defence researchers are co-located or close by.

Currently the Federation Development and Execution Process (FEDEP) (IEEE, 2003) is used as the simulation engineering process model, in accordance with Canada's ratification of the associated NATO STANAG 4603. The DMT capability must support DIS and HLA approaches to simulation interoperability (discussed below); hence the ConOp must identify a simulation engineering process model that addresses both. Currently the Distributed Simulation Engineering and Execution Process (DSEEP) appears as a likely successor to FEDEP.

Information Management & Technology

Specific information technology infrastructure and standards are desirable. By identifying preferred standards in a ConOp, training of technical staff can be focused, the number of simulation tools to be acquired and maintained can be limited, and reuse is facilitated.

The ConOp should also be guided by the Defence Technical Standards List (DND, 2009a) (DTSL) to promote interoperability with the wider defence enterprise.

Of the simulation interoperability standards identified by NATO (2009), two are preferred for their prevalence within the CF, interoperability with allies, and Department of National Defence policy. Canada has a legacy of expertise and equipment with the Distributed Interactive Simulation (DIS) standard that reaches back at least as far as 1993 (e.g. Magee, 1995). As well, the US Air Force and the UK's Royal Air Force, key training partners for the Canadian Air Force, use DIS. A DMT ConOp should therefore mandate DIS support. Canada also has a legacy of equipment and experience with the High Level Architecture (HLA) (IEEE, 2000). Canada ratified the adoption of HLA in the STANAG 4603 and identifies HLA and DIS in the DTSL. Support for it, too, should be identified in a ConOp

Although HLA and DIS support the transmission of voice data, typically as simulated radio traffic, a ConOp may adopt an additional voice communications method for a number of reasons. First, simulated radios require functioning simulation interoperability, yet establishing that interoperability is greatly facilitated by voice communications and the use of conventional telephones for this purpose are often precluded for security reasons. Furthermore, radio simulations can be expensive, incurring additional license fees or significant hardware costs. Also, some training scenarios call for the use of telephones. Finally, Canada has a small military and consequently most of the civilians contributing to the development and execution of the simulations are unfamiliar with radio procedures. As a result, the voice over internet protocol (VOIP) standard H.323 should be identified as part of the DMT capability to provide another means for voice communications.

Fundamental to distributed simulation is a wide area network. The ConOp should identify the Canadian Forces Experimentation Network (CFXNet) as the wide area network for Air Force distributed simulation capability. Beyond selecting the extant system, choice of the CFXNet is again driven by cost and interoperability factors. The CFXNet, managed by the CFEC for the Department of National Defence, is available to all of the CF, thus facilitating joint distributed exercises. Finally, the CFXNet is the Canadian segment of the Combined Federated Battle Lab network (CFBLNet). This facilitates establishing simulation events with the Air Force's training partners in other nations on the CFBLNet.

Equipment, Supplies, and Services

The majority of the equipment employed in Air Force distributed training simulation resides within the local sites and is associated with that site's simulators. Canada does not have an office that acquires simulators for all of the CF. Instead, they are typically acquired as part of a platform or weapon system project and consequently their specification is not within the domain of a DMT ConOp. In addition, the complexity of addressing the individual simulator components is beyond the capacity available to the Air Force's Synthetic Environment Coordination Office. A ConOp should rather address equipment that is primarily associated with distributed simulation in general and Air Force SECO advice be directed at the general themes that apply across the specific platforms being simulated.

Acquisition of DMT equipment is subject to multiple controls and constraints and therefore a key issue in establishing Air Force DMT. The equipment used for the DMT capability is being acquired by leveraging technical and procurement expertise outside the Air Force. A single organization, Public Works and Government Services Canada (PWGSC), has the responsibility for procurement of all federal government departments. In this role, PWGSC has established standing offers for some of the key equipment, such as networking equipment (routers, switches, computer servers, IP phones, video teleconferencing equipment, and storage devices). Making use of these standing offers conveys multiple benefits. First, the Air Force is able to comply with the demands of Canada's procurement regulations and multiple trade agreements with a minimum of effort and delay. Second, in establishing these standing offers, the equipment is evaluated and frequently benchmarked, thus alleviating some of the technical challenge in equipment selection. Finally, these standing offers serve to establish commonality of equipment, thus facilitating interoperability.

A ConOp will call for a core set of central services available to users of the distributed simulation training capability. These services are intended to be commonly and persistently available to users.

Central to the concept is exercise management and control. The Air Force's DMOC will assume that role. First, it can assist local sites with establishing themselves with the ability to participate in DMT

simulations. Second, it can coordinate the planning of training events. This will include obtaining suitable network bandwidth, organizing planning conferences, test and integration planning, and assisting with data distribution. Third, it can provide support exercise execution. Role players, computer generated forces, test directors, and exercise directors are available from the DMOC.

To facilitate the exchange of data, commonly available storage area should be identified in the ConOp. This enables formal structures, such as a repository, but also dynamic, short term storage places for exercise specific data. This includes materials such as exercise mission related documents, integration test plan results, and after action review materials.

A source of terrain databases should be identified in the ConOp. Access to stable terrain databases for the participating simulators has been a recurring difficulty in Air Force simulation events. To forestall this, the ConOp must call for a set of terrain databases, representing a limited number of operational areas, to be built and integrated within all Air Force simulators participating in DMT. The set of terrain databases are selected to provide a common menu of operational areas that will support joint and combined training. When an exercise is planned, the terrain database should be available for loading. Building a database should not be required.

In the same manner as with terrain, 3D object models are a common service that should be identified in the ConOp. The Air Force may take responsibility for obtaining visual models of platforms relevant to its training missions and make them available to the rest of the CF and international training partners when possible. The model assets of the army, navy, and joint organizations can be leveraged as needed.

VOIP service, VOIP dial plans, and IP address plans are identified in a ConOp as services to be managed centrally for all participants. These plans need to be done in coordination with the CFEC, which has the responsibility for the wide area network. Through this coordination, stable and repeatable interoperability with army, navy, and international partners is expected.

COMPARISON WITH OTHER APPROACHES

Delivering the operational concept in a timely manner was a key goal of the effort. Interoperability with other organizations was another key goal. To achieve these goals, the effort adopted the strategy of addressing specific issues through reference to existing policies, standards, organizations, and processes. This strategy can be contrasted with the approach taken with Australia's SIMMAN (Australian DSO, 2007). The SIMMAN is a treatment of simulation within the Australian Department of Defence that provides customized information in a single source.

This ConOp can also be compared with NATO's Pathfinder Integration Environment (PIE) (NATO, 2008). Both seek to facilitate the flexible and timely development and execution of simulation scenarios using distributed simulation. Re-use is a central idea to each effort, but the scope and approach differ. The PIE is intended to provide knowledge and simulation resources (including software code) to facilitate simulation based solution to a broad spectrum of military problems. Through reuse of modeling and simulation resources, the PIE will assist the establishment of national and multinational simulations. This Air Force DMT ConOp also seeks to reuse information and modeling resources. However this ConOp differs in two important ways. First, it is focused on the instantiation of a particular national effort (Air Force DMT) that is within its mandate. Therefore, the ConOp is more proscriptive in its treatment of resources, reducing specificity only when required to retain flexibility. Second, reuse in the ConOp is heavily weighted toward the reuse of networks. The continual reuse of networks (i.e. persistent accredited networks) is an overriding concern for the ConOp.

FUTURE DEVELOPMENT

The capability being established is both complex and far-reaching. Consequently, the operational concept is intended to evolve. For these reasons, the operational concept is embodied in a living document with the most dynamic information contained in annexes that are readily updated by subject matter experts as experience accumulates and developments in technology and organizations occur. Furthermore, to manage complexity, promote interoperability, and facilitate communication, the capability will be expressed within an architectural framework. Just as the DAF, MODAF, and DoDAF, have been adopted in Australia, the UK and US (as well as analogous frameworks in other nations), the Air Force will seek to use the Canada's Department of National Defence Architectural Framework (DNDAF) (DND, 2009b) to produce a set of views that will serve the stakeholders.

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