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Human Factors Analyses of the Combined Aerospace Operations Centre (CAOC)

Preliminary Results

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Defence R&D Canada
Technical Memorandum
DRDC Toronto TM 2013-109
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Canada

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Abstract

To support the concept development of a Virtual-Combined Aerospace Operations Centre (V-CAOC), a series of Subject Matter Expert (SME) interviews was recently conducted to understand, from the Human Factors (HF) perspective, the current organizational setup and functioning of the National CAOC, the existing capability gaps, as well as possible solutions for V-CAOC. This technical memorandum is a summary of the preliminary analyses. Results presented in this document will be used as the basis to support future Human View (HV) modeling of V-CAOC.

Résumé

À l'appui de l'élaboration du concept d'un centre multinational d'opérations aérospatiales virtuel (CMOA-V), des entrevues avec des experts en la matière (EM) ont récemment été menées afin de comprendre, du point de vue des facteurs humains, la planification organisationnelle actuelle et le fonctionnement du CMOA national, des lacunes présentes au chapitre des capacités, de même que les solutions possibles pour un CMOA-V. Le présent document technique résume les résultats préliminaires qui servent de base au soutien de la modélisation future du système (Vision humaine) du CMOA-V.

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Executive summary

Human Factors Analyses of the Combined Aerospace Operations Centre (CAOC): Preliminary Results

Wenbi Wang; Curtis Coates; DRDC Toronto TM 2013-109; Defence R&D Canada – Toronto; July 2013.

Introduction or background: The Canadian Forces Aerospace Warfare Centre (CFAWC) is developing the concept of a Virtual Combined Aerospace Operations Centre (V-CAOC) to house a suite of capabilities (planning, executing, assessing, and air campaigns) which would render the physical location of the CAOC component elements irrelevant. According to its Concept Development Plan, human factors concerns have been identified as one of the three key elements (Human Factors, infrastructure, and processes) for achieving the desired effect of enhanced Command and Control (C2).

Leveraging an on-going Defence Research and Development Canada (DRDC) research project, a series of Subject Matter Expert (SME) interviews was recently conducted to understand the Human Factors considerations, and existing capability gaps in the current organizational setup and functioning of the National CAOC. As well, possible solutions to the issues identified were discussed in regard to the V-CAOC. This technical memorandum is a summary of the preliminary analyses.

Results: The following list highlights key observations obtained from the interviews.

- No SMEs objected to the concept of a V-CAOC. Some suggested this type of concept had already been applied in the support to deployed Ops and Exercises.
- Most SMEs commented that the co-location of an Air Component Commander (ACC), or an Air Component Coordination Element (ACCE), with the Joint Task Force Commander (JTFC) is preferred; trust development was raised as the main rationale for this preference.
- SMEs suggested that a V-CAOC may not be as well suited as a deployed CAOC (i.e., organized as a self-sufficient entity) to support complex operations such as OP MOBILE.
- The V-CAOC concept was seen as being able to enhance the agility of existing CAOC as it could be better prepared for future shifts in organizational or operational requirements.
- As the majority of Royal Canadian Air Force (RCAF)'s coalition CAOC activities will be led by the US, it was noted that the setup of a deployable V-CAOC team needs to consider the wider coalition requirements.
- SMEs noted that the size of the forward team depends on the scope of Ops (e.g., scale, location, type and number of air assets to be employed). However, they believed that, at a minimum, the forward deployed team will need 5 to 6 personnel, consisting such roles as ACC, deputy ACC, Intelligence (INT), Computer and Information Systems (CIS), Operations (Ops) officer, and Mission Support (MSN SPT).

Significance: The HF analyses reflect a user-centred approach in V-CAOC concept development. The SME feedback provided critical insights into user requirements. The effective use of such information in V-CAOC development ensures the design will be driven by functional needs rather than technical system solutions.

Future plans: Results from this study will be used as a use case to allow Human Views to be created for the V-CAOC. The information populated in the Human View, together with Operational View (OV) and System View (SV) models (developed in a parallel effort), will provide a comprehensive set of data to support the concept development of the V-CAOC. This combined effort, based on Department of National Defence/Canadian Forces Architecture Framework (DNDAF), will provide an integrated view of operational, human, and system requirements.

Sommaire

Human Factors Analyses of the Combined Aerospace Operations Centre (CAOC): Preliminary Results

Wenbi Wang; Curtis Coates; DRDC Toronto TM 2013-109; R & D pour la défense Canada – Toronto; Juillet 2013.

Introduction ou contexte: Le Centre de guerre aérospatiale des Forces canadiennes élabore le concept d'un centre multinational d'opérations aérospatiales virtuel (CMOA-V) muni de capacités (planification, exécution, évaluation et campagnes aériennes), ce qui rendrait l'emplacement des éléments constitutifs du CMOA sans pertinence. Selon le plan d'élaboration du concept, les préoccupations à l'égard des facteurs humains font partie des trois éléments essentiels (facteurs humains, infrastructure et processus) à l'atteinte de l'effet voulu du commandement et du contrôle (C2) améliorés.

En tirant parti d'un projet de recherche continu dirigé par Recherche et développement pour la défense Canada (RDDC), des entrevues avec des experts en la matière (EM) ont récemment été menées afin de comprendre la prise en compte des facteurs humains et les lacunes présentes au chapitre des capacités dans la planification organisationnelle actuelle et le fonctionnement du CMOA national. Les solutions possibles aux problèmes identifiés ont également fait l'objet de discussions en ce qui concerne le CMOA-V. Le présent document technique résume les analyses préliminaires.

Résultats: La liste ci-dessous énumère les principales observations découlant des entrevues.

- Aucun EM ne s'oppose au concept d'un CMOA-V. Certains ont dit que ce type de concept a déjà été appliqué pour soutenir les opérations et les exercices de déploiement.
- La plupart des EM croient que le regroupement d'un commandement de la composante aérienne (CCA) ou d'un élément de coordination de la composante aérienne (ECCA) avec le commandement de la Force opérationnelle interarmées (CFOI) est préférable. L'établissement de la confiance est la principale justification de cette préférence.
- Les EM ont laissé entendre qu'un CMOA-V pourrait ne pas convenir autant qu'un CMOA déployé (p. ex., organisé comme une entité autosuffisante) pour soutenir des opérations complexes telles que l'Op Mobile.
- Il a été estimé que le concept d'un CMOA-V serait en mesure d'améliorer l'agilité du centre actuel, car il permettrait une meilleure préparation pour les changements futurs dans les besoins organisationnels et opérationnels.
- La majorité des activités du CMOA de la coalition de l'Aviation royale canadienne (ARC) sera dirigée par les États-Unis. Ainsi, il a été noté que la mise sur pied d'une équipe déployable du CMOA-V doit tenir compte de l'ensemble des exigences de la coalition.
- Les EM ont souligné que la taille de l'équipe avancée dépend de la portée des opérations (p. ex., échelle, lieu, type et nombre de ressources aériennes à utiliser). Cependant, ils croient que l'équipe avancée déployée devrait compter au moins 5 ou 6 militaires

assumant, entre autres, les fonctions de CCA, de CCA adjoint, d'officier du renseignement, d'officier des systèmes informatiques, d'officier des opérations et d'officier de soutien de mission.

Importance: Les analyses des facteurs humains reflètent une approche axée sur les utilisateurs dans l'élaboration du concept d'un CMOA-V. Les commentaires des EM ont fourni des données essentielles sur les besoins des utilisateurs. L'utilisation efficace de cette information pour l'élaboration assure une conception basée sur les besoins fonctionnels plutôt que de solutions techniques relatives au système.

Perspectives: Les résultats de la présente étude serviront de cas d'utilisation pour permettre la création du système « Vision humaine » du CMOA-V. L'information générée dans le système, de concert avec les modèles « Vue opérationnelle » et « Vue des systèmes » (créés parallèlement), fournira un ensemble complet de données à l'appui de l'élaboration du concept d'un CMOA-V. Cet effort concerté, fondé sur le cadre d'architecture du ministère de la Défense nationale (DNDAF) offrira une vision intégrée des besoins relatifs aux opérations, aux ressources humaines et aux systèmes.

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Acknowledgements

The authors thank the RCAF SMEs for their support to this study and Maj Alistair Mackay and Dr. Murray Dixson for facilitating the data collection meetings.

1. Background

This report is a summary of the raw data and preliminary human factors analyses of the Combined Aerospace Operations Centre (CAOC) in support of the concept development of a Virtual-CAOC (V-CAOC).

The Canadian Forces Aerospace Warfare Centre (CFAWC) is developing the concept of V-CAOC, which refers to "a suite of capabilities designed to make the location of the CAOC component elements of planning, executing, assessing, and air campaign irrelevant" [1]. Particularly, V-CAOC is examining the feasibility of deploying a "small team forward with the Joint Task Force Commander linked via a 'black box' with reach-forward and reach-back to the CAOC in Canada". According to its Concept Development Plan, V-CAOC has identified the human factor as one of three key elements (together with infrastructure and processes) for achieving the desired effect of enhanced Command and Control (C2). Successful Human-Systems Integration (HSI) is a critical enabler for achieving overall project objectives.

Leveraging an on-going Defence Research and Development Canada (DRDC) Applied Research Program (ARP) project 14dd, an architecture framework approach was proposed to support HSI in V-CAOC.

In a nutshell, the use of architecture provides a solution to manage complexity in system designs. Architecture framework such as the Department of National Defence/Canadian Forces Architecture Framework (DNDAF) defines a common approach for development, presentation, and integration of architecture descriptions. The approach supports the development of complex systems, particularly those where system interoperability is critical. In systems where human operators are involved (e.g., V-CAOC), it is important that the human dimension is properly represented in the architecture descriptions. It is the objective of 14dd to develop the Human View (HV), an architecture viewpoint that captures the human dimension in architectural descriptions and provides guidelines on analyzing the human aspect of design concerns. V-CAOC provides a leveraging opportunity to apply the concept of HV, verify and validate it in a DND use case.

The purposes of this study were to firstly understand the current functioning of CAOC in terms of people, tasks and processes, and secondly consult Subject Matter Experts (SMEs) for inputs on the establishment of V-CAOC. Regarding the latter objective, the SME were interviewed to answer the following list of questions:

1) What is the capability gap in the current National CAOC to support deployed commanders?
2) When and why is a forward deployed CAOC team required?
3) What functions should/could be supported by the deployed team?
4) How can a V-CAOC be established, in terms of people, processes, and systems?

The report is a collation of notes and transcripts collected during the SME interviews and document reviews. The eventual outputs from this study will be presented in three sets of HVs: one set of as-is view describing the current organization of CAOC and two sets of to-be views illustrating the concept of a scalable V-CAOC solution that ranges from minimal to maximal

personnel footprint. This current report is an initial summary of the data. The actual HV models will be presented in a follow-up report.

2. Method

The data collection involved documentation review and SME interviews. Relevant reports from previous DRDC projects and CAOC documentations were studied. The first series of SME interviews took place at the 1 Canadian Air Division (1 CAD) Headquarters (HQ) at Winnipeg on 17-19 Sept 2012, followed by two additional interviews in Ottawa on 11 and 16 Oct 2012.

2.1 Document review

The following reports and documents were reviewed in this study.

1. Mackay, A.J. (2012). Virtual-Combined Air Operations Centre (V-CAOC) concept development plan.
2. Baker, K., Kelleher, D., Tryan, J., & Hales, D.(2007). Combined Forces Air Component Command. Technical note 1: Data Collection. Contract report for Defence R&D Canada Corporate.
3. Baker, K., Hales, D., Poursina, S., & Kelleher, D. (2007). Combined Forces Air Component Command. Technical note 2: Department of Defence Architecture Framework (DoDAF) analysis. Contract report for Defence R&D Canada Corporate.
4. Baker, K., Kelleher, D. Hales, D., Pronovost, S., & Armstrong, J. (2007). Combined Forces Air Component Command. Technical note 3: Hierarchical goal analysis and performance prediction. Contract report for Defence R&D Canada Corporate.
5. DND (2012). Air Force expeditionary capability: Concept of Operations (revision 1).
6. Baker, K., & Scipione, A. (under review). Dynamic decision support for the National Aerospace Planning Process (NAPP) enhancements. Contract report for Defence R&D Canada Valcartier.
7. Young, P.K. (September 2012). CAOC division functions. Slides presented at the ACC training course.
8. Marshall, S. (September 2012). CAOC briefing to ACC/ACCE training course. Slides presented at the ACC training course.
9. Foster, D. (September 2012). 1 CAD ACC Trg Cse: Aerospace planning. Slides presented at the ACC training course.
10. DND (2011). Combined aerospace operation centre operating instructions: Volume 2 Standards.
11. DND (2009). Combined aerospace operation centre operating instructions: Volume 3 Concept of operations.
12. CAOC (2012). Analysis Correlation and Fusion (ACF) structure brief (Unclas).

2.2 SME interview

Participant

A total of thirteen (13) SMEs were interviewed, who provided operational perspectives from the key CAOC divisions including Strategic Plans, Combat Plans, Air Mobility, Combat Operations, Intelligence, Surveillance and Reconnaissance (ISR), Mission Support, and CAOC training.

Procedure

The duration of each interview lasted approximately from 30 to 90 minutes. In each session, two researchers followed a semi-structured process to work with a SME, firstly to verify the information captured in existing CAOC documentation and reports, then to probe the current processes and tasks conducted in each functional division, and lastly to consult the SME regarding his/her perspective on V-CAOC.

3. Results

The results are an aggregation of information collected in both the document review and SME interview. Section 3.1 describes the existing organization and functioning of the National CAOC and supplies data for producing the CAOC 'as-is' HV. Section 3.2 reflects a collation of SME inputs on the concept of V-CAOC, based on which the two sets of 'to-be' HV for V-CAOC will be generated.

3.1 CAOC AS-IS

In the context of CF, CAOC is the principal centre from which air operations are directed, monitored, controlled and coordinated with the other CF components. It performs operational-level planning and coordination, and provides the means by which the Combined/Joint Force Air Component Commander (J/CFACC) commands and controls the Canadian aerospace power [11].

Specifically, it is set up to support the following list of goals:

- Provide appropriate and timely aerospace effects to all Supported Commanders and missions.
- Possess a responsive and integrated C2 system.
- Develop cohesive air operation plans.
- Produce an effective National Air Tasking Order (ATO) that covers all flying, both Force Employment (FE) and Force Generation (FG).
- Deliver accurate and timely intelligence in support of operations.
- Provide centralized control / decentralized execution

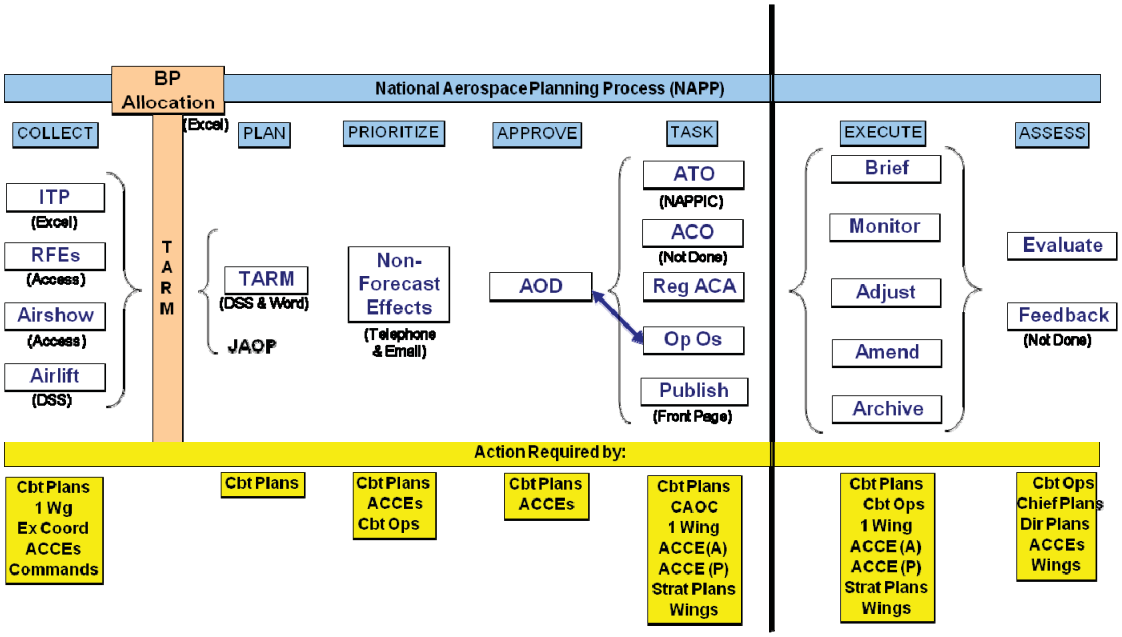

Figure 1. The National Aerospace Planning Process, adapted from [6].

As the J/CFACC's conduit for assigning air missions and tasks, CAOC is vertically connected with FE Command and Joint Task Force (JTF) Command at the JTF HQ, horizontally with land, maritime and special operations components, and downward with Wings, including Air Expeditionary Wings (AEW).

The Commander's intent is conveyed through various directives and orders generated and updated by CAOC such as Aerospace Operations Directive (AOD), Air Tasking Order (ATO) and Air Coordination Order (ACO). The production workflow follows the National Aerospace Planning Process (NAPP), as illustrated in Figure 1.

Overall Organizational Structure

The high level goals of CAOC are translated into four functional areas: maintain situational awareness, command and control of the Air Force, planning and coordination with external elements, and analysis of effectiveness. The organization of CAOC is set up to support these functions. Currently, CAOC consists of a command cell and eight divisions: Strategy (Strat Plans), Combat Plans, Air Mobility, Combat Ops, Intelligence, Surveillance, Reconnaissance (ISR), Mission Support, CAOC Training, and CAOC Standards. Figure 2 is a recent version of CAOC organizational chart, note however the SMEs revealed slight deviation from this chart in the interviews.

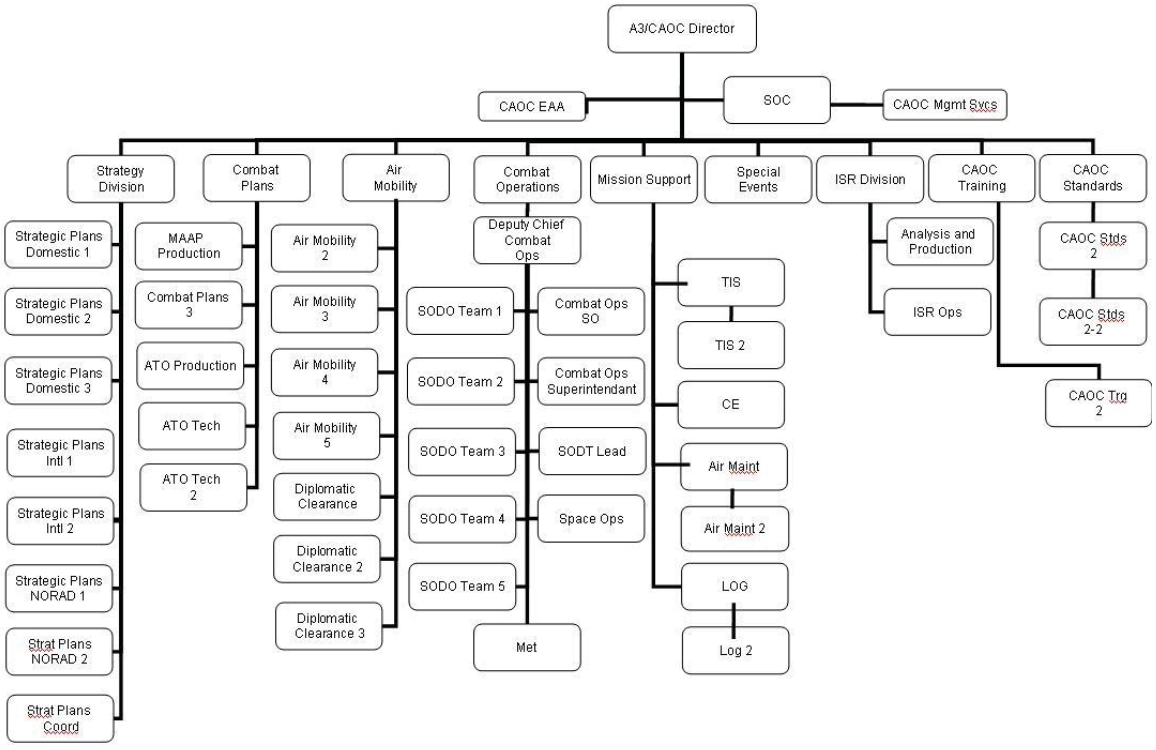

Figure 2. The current organizational chart for CAOC, adapted from [7]

Command Cell

The cell is comprised of a CAOC director, a deputy director, and a senior operations coordinator. The director reports to the deputy C/JFACC. Together the team provides oversight to the operation of the entire CAOC and ensures the CAOC functions as a unified organization.

Strategy Division (Strat Plans)

The main responsibilities of the Strategy Division are to develop, define, disseminate and assess CFACC air and space strategy. The division handles all Requests For Effect (RFEs) that have a planning window greater than 12 hours, although most plans are in the 96+ hour timeframe. It conducts a weekly plan synchronization meeting that involves 1 CAD staff, Air Component Coordination Element (ACCE), CFACC liaison officers (LO) and Force Element Lead Planners (FELP). Besides deliberate planning, the division also conducts a fair amount of contingency (or crisis action) planning.

Notably, the division's current setup differs from the description in the CAOC CONOPS in the following areas:
1) the division currently does not have a space role;
2) it does not conduct lessons learned (which is considered an A7 responsibility).
3) The geomatics function has been moved to the ISR Division.
4) The Total Air Resource Management (TARM, an annual planning document that records the Yearly Flying Rate (YFR) and the priorities applied to the use of air resources) is produced by a 1 CAD A5 staff.

Table 1 lists the 12 positions currently in the Strategy Division.

Table 1. Personnel composition of the Strategy Division

Position	**Rank**
Chief Strat Plans	LCol
Strat Plans Domestic 1	Major
Strat Plans Domestic 2	Major
Strat Plans Domestic 3	Capt
Strat Plans International 1	Major
Strat Plans International 2	Major
Strat Plans NORAD 1	Major
Strat Plans NORAD 2	Capt

Strat Plans Coordination 1	Capt
Strat Plans Coordination 2	Capt
Strat Plans Information Ops	Vacant
Strat Plans Assessment	Vacant

Key tasks and outputs produced by the Strategy Division include:

1. Joint Air Operations Plan (JAOP): Published on a quarterly basis, JAOP allows the CFACC/Commander Canadian North American Aerospace Command (NORAD) Region (CANR) to look beyond one month and updates guidance given to the FELPs. JAOP is comprised of Search and Rescue (SAR), NORAD, domestic and international operations, exercises, Very Important Persons (VIPs) and special events. The intent of the JAOP is to bridge the TARM to the monthly AOD. It is a word document.

2. Aerospace Operations Directive (AOD): AOD is an authorization document which contains all approved, non-approved and pending requests for all air assets for a specified period of time. It is a word document and is published on a monthly basis. It provides a link between the Strategy and the Combat Plans Division.

Combat Plans Division (Combat Plans)

The responsibility of Combat Plans is to optimize the deployment of RCAF's air assets by balancing and prioritizing supply and demand. Table 2 lists the current positions in the Combat Plans division.

Table 2. Personnel composition of the Combat Plans Division

Position	**Rank**
Chief Combat Plans	Major
MAAP Coord	Capt
Combat Plans 2 – MAAP generation	Capt
Combat Plans 3 – MAAP generation	Capt
ATO production	MWO
ATO Tech	Sgt
ATO Tech 2	MCpl

The main tasks for Combat Plans are the production of the Master Aerospace Action Plan (MAAP) and the Air Tasking Order (ATO).

The MAAP provides a snapshot in time to indicate the location and manoeuvres of all air assets in the Canadian Forces (CF). It enables the Commander to review, amend and approve missions proposed by the FELPs. The generation of MAAP requires inputs from FELPs, including those located at the Air Mobility Division, at 1 wing (for CH146) or in ACCE(Pacific) and ACCE(Atlantic) (for CP140 and CH124). The MAAP includes Special Events such as air shows and flybys. It is a classified document.

The MAAP is constructed two weeks in advance and updated on a weekly cycle. It is briefed to the Commander on each Thursday. The Commander's approval triggers the development and release of the weekly ATO.

The ATO records all approved aerospace missions derived from the MAAP and supplies the "authority to fly". ATO is classified. It is updated on a weekly cycle, which differs from the 72h battle rhythm used by our allies such as the United States Air Force (USAF). More specifically, the ATO is finalized on Friday at 1600Z and provides the authority to fly from 0001Z Monday to 2400Z Sunday. CAOC produces both a National ATO and a NORAD ATO.

The production and dissemination of the National ATO are completed using the National Aerospace Planning Process Integration Capability (NAPPIC). NAPPIC replaces Theatre Battle Management Core System (TBMCS), which is a USAF tool, for ATO production. It resides on the Consolidated Secret Network Infrastructure (CSNI) and has been adopted since July 2010. Compared with TBMCS, NAPPIC is a simpler, more intuitive system for users. Currently, access to NAPPIC is limited at the Wings due to CSNI connectivity limitations.

For the National ATO, each assigned/contributing unit (e.g., ACCE(Atlantic), ACCE(Pacific), and ACCE(Central)) builds their aerospace missions into separate Air Battle Plans (ABP) referred to as regional ABPs. Using the NAPPIC, the regional ABPs are then merged at the CAOC by Combat Plans to create the National ATO.

The NORAD ATO is also created in NAPPIC but is distributed through e-mail (on Releasable to Canada Enterprise Network (RELCAN)) to the appropriate stakeholders.

The ATO serves as a bridge between Combat Plans and Combat Ops. Currently however, changes made by Combat Ops to the ATO are not being fed back to Strategy Plans for any type of analysis on the effectiveness of the planning process or on the number of last minute changes.

Additionally, the planning of Maritime Patrol Aircraft (MPA) remains on the coast due to a perception that the Navy has special needs for the CP140 and CH124 therefore requiring the liaison that exists at the ACCE level.

The Tactical Helicopter (TacHel) community only interacts with CAOC for exercises and special supported needs such as the transfer of an airframe between regions. 1 Wing uses the Unit Level Tool (ULT) for planning and employment. Currently ULT is not linked with NAPPIC.

It was suggested that FELPs of these air assets (CH124, CP140, TacHel) preferably should be co-located in CAOC.

Within Combat Plans, there is also a cell that is responsible for managing special events. Currently, a Captain is the Office of Principal Interest (OPI) for CF18 display. A Major handles all tasking related to the Snowbirds and the planning uses a 2-year calendar.

Air Mobility Division (AMD)

The primary responsibilities of AMD involve the assignment of RCAF air mobility assets to meet the demands of the Government of Canada and management of diplomatic clearance requirements, including obtaining diplomatic clearance for RCAF aircraft that are planned to operate internationally and processing requests from all foreign militaries to operate in the Canadian airspace. The personnel composition of AMD is listed in Table 3.

Table 3. Personnel composition of the Air Mobility Division.

Position	Rank
AMD 1 (Chief of the Division)	Major
AMD 2 (FELP for the C17 fleet)	Capt
AMD 3 (FELP for the C150 fleet)	Capt
AMD 4 (FELP for the C130 fleet)	Capt
AMD 5 (FELP for the C144, Buffalo (C115), Twin Otter(C138) and Muff fleet)	Capt
Diplomatic clearance	
Diplomatic clearance 2	

Similar to the processes followed by Combat Plans, the air mobility RFEs are created by FELPs or the ACCEs and then fed into the MAAP. The main audience for the FELPs is Canada Command, CAOC, and 1 CAD SMEs, the regional ACCEs and occasionally outside agencies.

The Dynamic Scheduling System (DSS) is used by the air mobility FELPs for generating planning products, which are eventually integrated to the central ABP.

Combat Operations Division (Combat Ops)

Combat Ops is responsible for monitoring the safe and effective execution of the ATO. It supports Strategic Plans and Combat Plans by maintaining and updating the NAPPIC database and participating in the assessment process. It is also the initial point of contact for external agencies to reach both the CAOC and the CFACC. For contingency operations such as aircraft accident, Combat Ops is the initial action team.

Figure 3 shows the organizational chart for the Combat Ops division. Notably, the meteorologist position that appears on earlier versions of the organizational chart has been taken away. Different from the CAOC CONOPS, the Operations Support Cell, (i.e., the Deputy Chief, the Combat Ops Staff Officer and the Superintendent) is comprised of day staff. The Combat Ops Staff Officer (Capt) ensures documentation is current and coordinates Information Technology

(IT) issues with NORAD and within 1 CAD HQ. Space Ops is currently manned by a USAF Major and is double hated supporting the Canada Command as well.

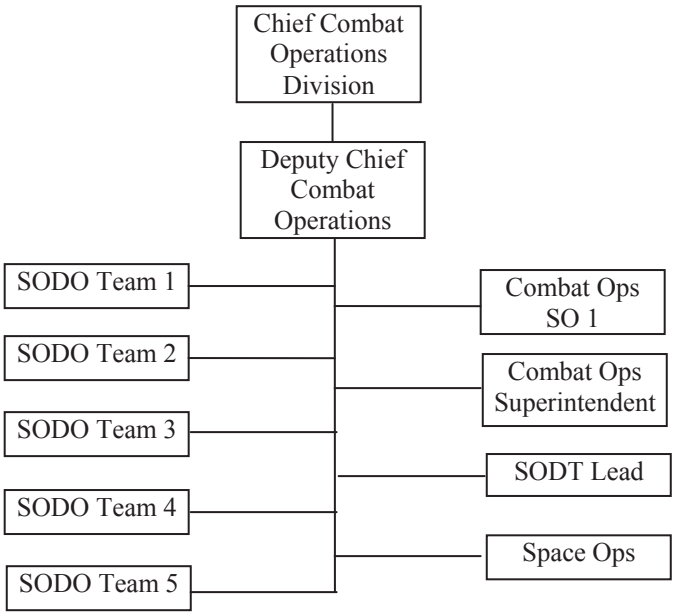

Figure 3. The organizational chart for the Combat Ops Division.

The Senior Operations Duty Officer (SODO) Watch team maintains a 24/7 capability, develops and preserves complete situational awareness of all aerospace operations, including those operations in support of Canadian Expeditionary Force Command (CEFCOM) and other Supported Commanders to the extent possible. It is the continuous link between all Air Force units and Wings and the Commander of 1 CAD.

As shown in Figure 4, the SODO Team consists of a SODO, a Defensive Duty Officer (DDO), a SODO Technician (SODT), two Defensive Duty Technicians (DDT) and two ISR Technicians (Senior Intelligence Duty Officer (SIDO) and IDA). Other support personnel can be added to augment this team as necessary, such as Meteorologist (MET), Mission Support (MSN SPT), Provost Marshall and Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE). SODO reports to the Chief of Combat Operation (CCO) (LCol rank) who works on a week-long duty.

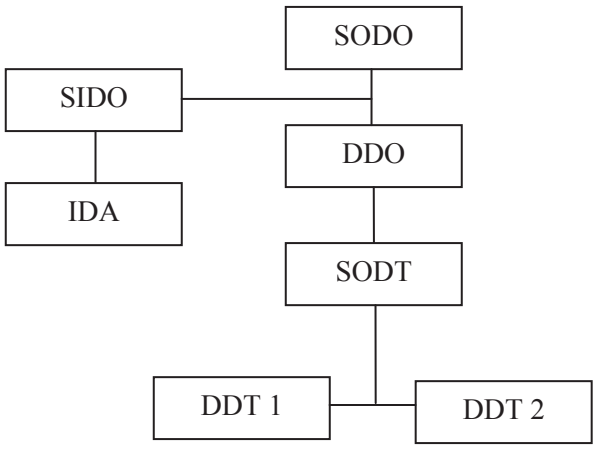

Figure 4. The personnel composition of a SODO team.

The DDT and SODT can make technical changes to the ATO. The authority to change the ATO is with the SODO for minor changes (e.g., minor flight delays), and with the CCO for major changes.

The SODO team stands 12 hour watches (e.g., 0600-1800). The team must be trained to Combat Mission Readiness level which is a 2-3 month process. Currently, 7 of the 32 staff are under training since they were recently posted into the division.

Once the ATC is published, it is then "owned" by Combat Ops and its execution is overseen by the SODO teams. If an RFE requires action within the current week window (i.e., Non-Forecasted Effects (NFEs)), Ops personnel are responsible for addressing the request.

The Ops floor has a daily brief at 0745 for all domestic, expeditionary, and NORAD Ops.

Intelligence, Surveillance and Reconnaissance (ISR) Division

The ISR Division supports CAOC and its subordinate units by providing a common threat picture that is critical to the planning and execution of air operations.

Currently, the division has approximately 35 people, including 28 in Analysis Correlation and Fusion (ACF) / Processing Exploitation Dissemination (PED), 5 in the A2 Plans, and 2 in Intelligence Support. There is a plan to grow Intelligence Support into 4 or 5 people. Of the 28 in ACF/PED, half are day workers and the other half are shift workers who support Combat Ops.

The division's support to the processing of tasking order is to be developed. SME suggested it is useful to develop a CAOC campaign plan (e.g., AOD) that can be plugged into the Joint Campaign Plan (JCP).

Some of the future plans for ISRD include the development of a robust targeting capability and extension of the intelligence collator in the PED squadron.

Mission Support Division

The division provides mission support (Maint, Log, CE, TIS) to the planning, execution and monitoring of RCAF operations in the domestic and expeditionary operations, including NORAD Ops. It is the CAOC focal point for ground operations and activities involving aircraft and airfields.

Figure 5 is the organizational chart for the Mission Support Division.

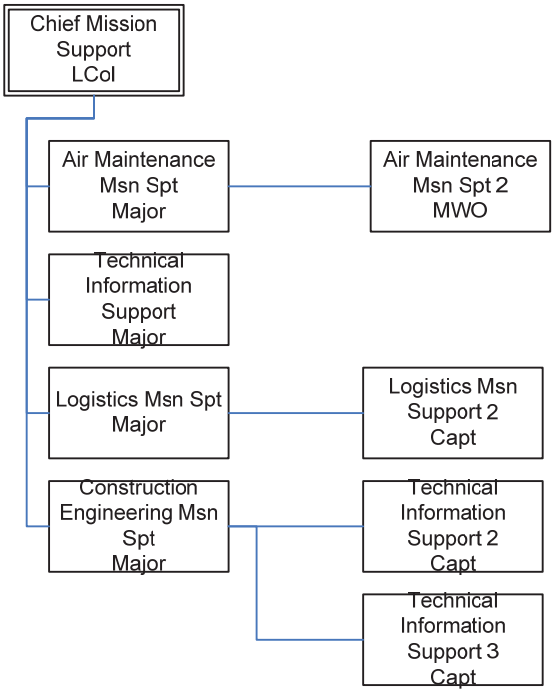

Figure 5. The organizational chart for the Mission Support Division

The mission support personnel interact with other divisions in CAOC, including Strat Plans, Combat Plans, Air Mobility, and Combat Ops. Representatives from mission support are involved in all CAOC briefings. Good information flow between the A Staff at 1 CAD and the CAOC mission support personnel is critical for work effectiveness.

Training Division

The division is responsible for oversight of the CAOC training program and ensures all CAOC divisions members obtain and maintain the certification and proficiency needed to effectively perform the unit's mission.

A Managed Readiness Plan (MRP) has been developed to provide trained ACCEs for supporting CAOC. Currently, there are concerns about the lack of a sufficient understanding of the CAOC functions by A4 Log, CSE and Maintenance personnel.

There are plans to develop a collective training standard for the RCAF, much like the Army's readiness program which defines training plans from individual to brigade levels. Such a program exists in the Rotary Wings community due to its close operational alignment with the Army.

Figure 6 shows one sample training progression plan to achieve a high readiness posture.

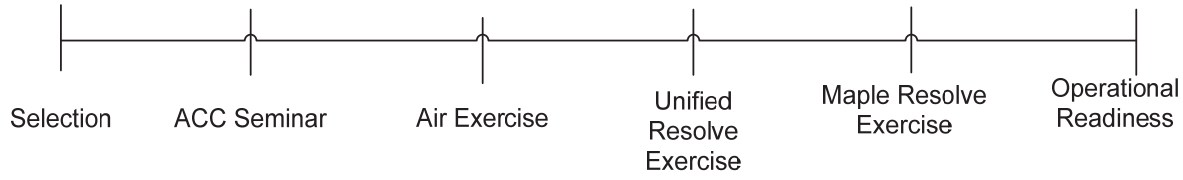

Figure 6. Illustration of a training progression plan.

Standards Division

The standards division is to ensure the standardization of all CAOC procedures and provide the CAOC Director and Division Chiefs with a tool to validate mission readiness.

Detailed analyses of the Standards Division were not conducted in the current study.

3.2 V-CAOC

One of the main impetuses behind the concept of V-CAOC is to extend the 'global reach' of the existing National CAOC and support a Joint Task Force Commander (JTFC), or more specifically, to support an Air Component Commander (ACC) who is responsible for making recommendations to the JTFC for the proper employment of aerospace forces. SMEs suggested it is preferable that the ACC and his staff are co-located with JTFC, since for planning and tasking, the ACC requires support from a CAOC. The question then arises of what CAOC functions shall/can be forward deployed and what functions shall/can be supported by reaching back to the National CAOC in Winnipeg. Currently this is the central issue for V-CAOC concept development. In this analysis, we focused our attention on two extreme states of V-CAOC options, expressed in terms of personnel footprint of the forward deployed CAOC team, that is, a maximal manning (V-CAOC max) and a minimal manning option (V-CAOC min). It is understood that in practice the size of the forward deployed team is scalable and any intermediate options (between V-CAOC max and V-CAOC min) is possible depending on specific operational needs.

In the interviews, we directly probed SMEs regarding their opinion about the V-CAOC concept and the feasibility, as well as desirability, of supporting each CAOC function from the National CAOC.

In this subsection, we first briefly describe two organizational concepts that support distributed and deployed air operation: the Air Component Coordination Element (ACCE) and the Air

Expeditionary Wing (AEW). Key SME inputs on V-CAOC are then summarized. Lastly, we present a collation of SME feedback on the recent OP MOBILE and OP NANOOK 12 in which the CAOC support shed light on possible V-CAOC implementation options.

Air Component Coordination Element (ACCE)

Different from an ACC, who has the Operational Control (OPCON) of assigned, attached and "made available" forces, an ACCE is accountable to the delegating JFACC / ACC. It is a liaison team to facilitate the integration of aerospace power and effects in a joint environment and represents the JFACC / ACC at the JTFC HQ. It is important to note ACCE only has a planning function (e.g., FELP), and does not have tasking authority.

Currently, six ACCEs have been established across the country including ACCE(Pacific) and ACCE(Atlantic). All personnel in the ACCEs report to the Director of the CAOC.

Air Expeditionary Wing (AEW)

The Air force Expeditionary Capability CONOPS describes the concept of an AEW in detail. In a nutshell, the AEW as a complete unit exists only when it is required to deploy. In the simplest configuration, an AEW is comprised of a command element (tactical level), an Operational Support Element (OSE), a mission support element (MSE), and one or more air detachments, as illustrated in Figure 7. The entire AEW would be tasked by an ACC.

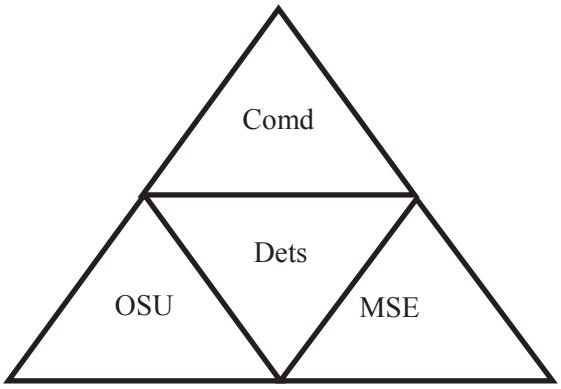

Figure 7. The concept illustration of an Air Expeditionary Wing.

The Air Force Expeditionary Concept (AFEC) cell's task is to help generate the command element, the OSU and the MSE. The current plan is to prepare 3 Wing in Bagotville to be the standby AEW by 2015.

In relation to V-CAOC, it was suggested that a deployed ACC needs at least A3 and A5 capability to deploy with them. Based on previous experience including the ACCE for OP MOBILE, a 21-staff construct for a deployed ACCE was proposed with representation from A1, A2, A3, A4 (3 reps), A5, A6, and A8. Among them, the requirement for A3 and A5 staffs are considered robust. The FELPs for the AEW must liaise with CAOC staff for both strategic and mission planning.

The key systems identified by SMEs to support AEW include Air Force Command and Control Information System (AFCCIS), CSNI, Land Command Support System (LCSS), Defence Wide Area Network (DWAN), Air Force planning tools such as NAPPIC, DSS, ULT.

Figure 8 shows a tentative progressive training plan for AEW development. It was suggested that Exercises such as Maple Flag and Maple Resolve are needed to train at the last two levels.

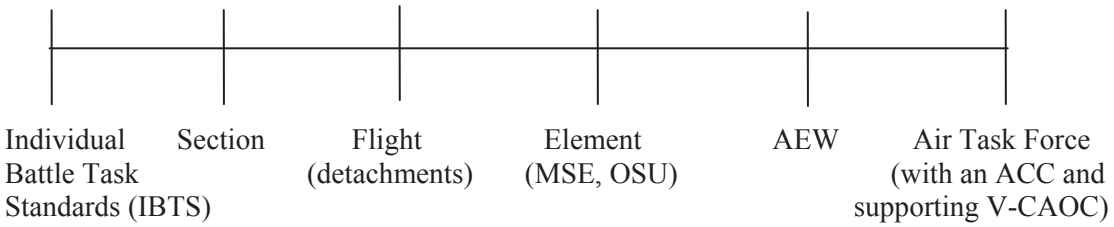

Figure 8. A tentative progressive training plan for AEW development.

SME Inputs on V-CAOC

In the interview, No SMEs raised objection to the concept of V-CAOC. Many suggested such a concept (deployed CAOC function with reach-back and reach-forward capabilities), to a certain degree, had already been applied in practice to support deployed Operations and Exercises. Some pointed out the implementation of a fully virtualized CAOC however will face many challenges. For example, it was suggested a virtual CAOC will likely work for limited or domestic operations. In complex operational scenarios like OP MOBILE, a deployed CAOC that is organized as a self-sufficient entity, is needed.

The following list is a summary of key SME inputs regarding concerns relevant to the V-CAOC concept development.

1. Operational reality. The majority of coalition CAOC (in which RCAF participates) will be led by the US. As a result, the setup of a deployable V-CAOC team needs to consider the wider coalition requirements. For example, US tools such as TBMCS will likely be adopted as oppose to our own NAPPIC. However, SMEs generally think it is not a big barrier to provide adequate training on these tools to RCAF operators.

2. Manning requirements. The current CAOC is comprised of 90 people, which is under-staffed in light of its initial manning plan of 172 people. As a result, some doctrinal CAOC functions such as ‘assessment’ are not fully supported right now.

3. Operator workload. Currently Strat Plans and Air Mobility are the two busiest teams within CAOC. Future enhancement to these two divisions may be necessary to support V-CAOC.

4. Deployable CAOC functions. With respect to functions that can be forward deployed (i.e., “pushed out of the door”), the SMEs suggested:

1) Strategy Division can be forward deployed, particularly the planning cell for Current Ops.

2) Combat Plans can be forward deployed. Specifically, it is feasible that ACC or ACCE (co-located with JTFC) generates its own ATO and copy/inform the National CAOC.

3) Combat Ops and Mission Support does not necessarily need to be forward deployed unless the duration and complexity of the operation demand it. When needed, the A4 support can either be located with the ACC or the detachments.

4) For ISR Division, the deployable portion of the CAOC could be targeting with reach back for analysis and correlation functions.

5. Scalability of the forward deployed team. The size of the forward team depends on the type and number of air assets to be deployed. Generally speaking, at a minimum, the forward deployed team will need 5 to 6 personnel, consisting of such roles as ACC, deputy ACC, INT, CIS, Ops officer, and MSN SPT.

6. Lessons learned from past OP and EX. Recent experiences in OP MOBILE and OP NANOOK 12 provide many insights on how CAOC functions can be distributed in different geographical locations.

OP MOBILE

OP MOBILE was the Canadian contribution to the NATO-led coalition operation to protect the civilian population of Libya. A NATO-led CAOC was established to conduct the air campaign and a Canadian Air Coordination Element (ACE) was stood up to manage RCAF assets, review the MAAP and ATO generated by the NATO CAOC. Since the ACE directly interacted with the NATO CAOC, an examination of its setup provides some insights for V-CAOC. The following list is a summary of key Human Factors issues obtained from a brief interview with the Commander of ACE.

1) The C2 structure of ACE was an area of concern. In Op MOBILE, the structure was modified several times and eventually consisted of 21 positions, aligning with the AEW concept discussed previously. Figure 9 shows the functional groupings of involved positions. The End of Tour report calls for the establishment of “a CF C2 structure for an operation involving air assets be developed and take into consideration of AF doctrine and AF Expeditionary concept.”

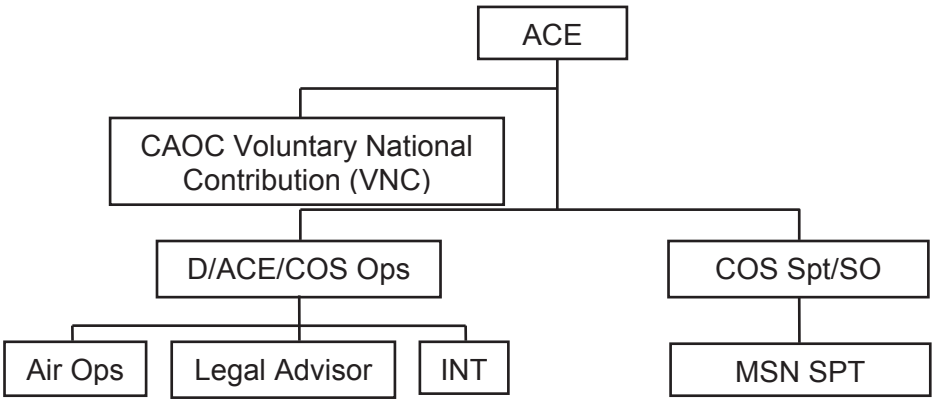

Figure 9. C2 structure of ACE in OP MOBILE

2) Functionally the Ops, INT, MSN SPT, and Legal Advisor (LEGAD) were considered critical. Personnel (A1) and Finance (A8) might be managed remotely, however given the amount of demand for financial reporting, it was preferable to keep these roles in theatre.

3) Insufficient manning was identified in areas like MSN SPT and INT particularly during the initial phase of the operation.

4) Frequent personnel rotation and staff training were areas of concern for providing continuity to the operation.

5) Deployable communications were limited at the involved sites due to both the amount of equipment systems and communication bandwidth.

OP NANOOK 12

The recent OP NANOOK 12 was centred on two scenario-driven events in two separate locations in Canada's high North. The first involved the deployment of land and air forces to the Western Arctic to assist the Royal Canadian Mounted Police in a security event in Tsiigehtchic, Northwest Territories. The second involved the deployment of Canadian Armed Forces land, sea, air and special operations forces to the East to the Hudson Bay/Hudson Strait and Churchill, Manitoba, to intercept a vessel of interest.

The ACCE team that supported OP NANOOK 12 consisted of 15 staff, including 5 members (i.e., A5, A6, A2 collator) in Ottawa (at Star Top) supporting the ACCE director, 6 members forward deployed in Inuvik, Churchill, Yellowknife and Tsiigehtchic respectively, and the remainder (e.g., A1, A4, A8) in Winnipeg.

OP NANOOK typically had 6 or 7 lines of air tasking each day. The ATO was entered into the national system in Winnipeg where OP NANOOK representatives were embedded in the CAOC for supporting the exercise. The forward deployed team had limited access to NAPPIC during the operation. The ACCE planners submitted air tasking requirements (in excel spreadsheets) to

Combat Ops at 48 hour battle rhythm. ATO amendments were handled by the SODT or DDT1. During the operation, the ACCE Director had a daily telecom with all staff.

It was generally agreed that to best support an operation and interact with the CAOC, the battle rhythm, planning cycle, briefing cycle, and volume of work all need to be considered. The SMEs felt the 15-staff ACCE created for OP NANOOK 12 was sufficient. A slightly augmented CAOC team with some forward deployed staff was a workable solution.

Additionally, the SMEs pointed out the following issues that should also be considered.

1) Some pointed out the ACC director in OP NANOOK was a "glorified Liaison Officer", different from the ACC in OP PODIUM who had full Operational Command (OPCOM) of the air assets.

2) Connectivity was one of the most serious issues. Specifically, the forward deployed team had limited access to NAPPIC during the operation.

3) There were issues with the battle rhythm. For example, the team in Ottawa operated Monday to Friday, from 0800 to 1900, whereas the air operations were conducted outside this time window.

4) Embedding staff training into their existing daily operation was difficult. Complicated by the fact that some operators were introduced into OP NANOOK shortly before the final planning conference, as a result, the roles and responsibilities of the OP NANOOK CAOC personnel were not well known prior to the start of the operation. For example some suggested their understanding of the ATO process or NAPPIC prior to the operation were limited. Also in some cases, the expectations for reporting were not clear at the start of the operation, resulting for instance in the real time take-off and landings information not being reported.

4. Summary

To sum up, the concept of V-CAOC was well appreciated by the interviewed SMEs. As many suggested, the principle has already been successfully applied in the past to support deployed operations and exercises, even though a formalized concept has not been completed yet.

Most agreed the deployed V-CAOC team should be scalable. Factors affecting the size of the deployed team include the authority of ACC, the number and types of deployed air assets, the connectivity (e.g., secure network access) to the National CAOC, as well as operator workload (as determined by battle rhythm etc.)

OP MOBILE provided an example to establish an ACCE working with a coalition CAOC which managed ATO production and execution independent of the Canadian National CAOC in Winnipeg.

In OP NANOOK 12, the bulk of task planning and ATO production were completed by reaching back to the National CAOC. It provided a base model to design V-CAOC min. Since the supporting staff were distributed at five different locations, a close examination of the lessons learned from OP NANOOK 12 will greatly assist concept development for V-CAOC.

SMEs suggested the co-location of ACC/ACCE with JTFC is preferred. This requirement reflects the current limitation in cultivating trust when team interactions are primarily facilitated by technological means. Since the end goal of V-CAOC is a suite of capabilities designed to make the location of CAOC component elements irrelevant, it is suggested that the V-CAOC project will review existing researches on collaborative teaming and tele-presence which shed light on both collaboration requirements from the human's perspective and technological solutions generated by Virtual or Augmented Reality research.

As listed in the Section 1, Background, the SMEs were asked "what functions should/could be supported by the deployed team?" It was determined that the functions to be supported by a V-CAOC are directly related to the duration and complexity of the exercise or operation the ACC is responsible for. In the case of OP MOBILE, where the MAAP and ATO generation was performed by the NATO CAOC, the plans function was of less importance for the ACE team. In contrast, the intelligence and legal functions needed to support targeting and reinforce the Rules of Engagement were of much greater importance than the case in OP NANOOK.

Lastly, the concept of V-CAOC enhances the agility of the CAOC and better prepares it for future shifts of organizational or operational requirements, for example, the needs for the ISR Division to work in a larger network of Intelligence Community (which will be delivered by the INSIGHT TDP to generate the Future Intelligence Analysis Capability (FIAC)). SME also mentioned potential plans to centralize MET support by creating a Joint MET center.

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List of symbols/abbreviations/acronyms/initialisms

1 CAD	1 Canadian Air Division
ABP	Air Battle Plans
ACC	Air Component Commander
ACCE	Air Component Coordination Element
ACE	Air Coordination Element
ACF	Analysis Correlation and Fusion
ACO	Air Coordination Order
AEW	Air Expeditionary Wings
AFCCIS	Air Force Command and Control Information System
AFEC	Air Force Expeditionary Concept
AMD	Air Mobility Division
AOD	Aerospace Operations Directive
ARP	Applied Research Program
ATO	National Air Tasking Order
C2	Command and Control
CANR	Canadian NORAD Region
CAOC	Canadian Aerospace Operations Centre
Capt	Captain
CBRNE	Chemical, Biological, Radiological, Nuclear, and Explosive
CCO	Chief of Combat Operation
CE	Construction Engineer
CEFCOM	Canadian Expeditionary Force Command
CF	Canadian Forces
CFAWC	Canadian Forces Aerospace Warfare Centre
CIS	Computer and Information System
CONOPS	Concept of Operations
CSNI	Consolidated Secret Network Infrastructure
DDO	Defensive Duty Officer
DDT	Defensive Duty Technicians
DNDAF	National Defence/Canadian Forces Architecture Framework
DRDC	Defence Research and Development Canada
DSS	Dynamic Scheduling System
DWAN	Defence Wide Area Network
FELP	Force Element Lead Planner
FG	Force Employment (FE) and Force Generation
HQ	Headquarter
HSI	Human-Systems Integration
HV	Human View
IBTS	Individual Battle Task Standards
INT	Intelligence
ISR	Intelligence, Surveillance and Reconnaissance
IT	Information Technology
J/CFACC	Joint / Combined Force Air Component Command
JCP	Joint Campaign Plan

JAOP	Joint Air Operations Plan
JTF	Joint Task Force
JTFC	Joint Task Force Commander
LCSS	Land Command Support System
LO	Liaison Officer
Log	Logistics
MAAP	Master Aerospace Action Plan or Master Aerospace Attack Plan
Maint	Maintenance
MCpl	Master Corporal
MET	Meteorologist
MPA	Maritime Patrol Aircraft
MRP	Managed Readiness Plan
MSE	Mission Support Element
MSN SPT	Mission Support
MWO	Master Warrant Officer
NAPP	National Aerospace Planning Process
NAPPIC	National Aerospace Planning Process Integration Capability
NFE	Non-Forecasted Effect
NORAD	North American Aerospace Defense Command
OPCON	Operational Control
OPI	Office of Principal Interest
OSE	Operational Support Element
PED	Processing Exploitation Dissemination
RCAF	Royal Canadian Air Forces
RELCAN	Releasable to Canada Enterprise Network
RFE	Request For Effect
SAR	Search And Rescue
SIDO	Senior Intelligence Duty Officer
Sgt	Sergeant
SME	Subject Matter Expert
SODO	Operations Duty Officer
SODT	SODO Technician
TacHel	Tactical Helicopter
TARM	Total Air Resource Management
TBMCS	Theatre Battle Management Core System
TIS	Technical Information Support
ULT	Unit Level Tool
USAF	the United States Air Force
V-CAOC	Virtual-CAOC
VIP	Very Important Person
YFR	Yearly Flying Rate

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To support the concept development of a Virtual-Combined Aerospace Operations Centre (V-CAOC), a series of Subject Matter Expert (SME) interviews was recently conducted to understand, from the Human Factors (HF) perspective, the current organizational setup and functioning of the National CAOC, the existing capability gaps, as well as possible solutions for V-CAOC. This technical memorandum is a summary of the preliminary analyses. Results presented in this document will be used as the basis to support future Human View (HV) modeling of V-CAOC.

À l'appui de l'élaboration du concept d'un centre multinational d'opérations aérospatiales virtuel (CMOA-V), des entrevues avec des experts en la matière (EM) ont récemment été menées afin de comprendre, du point de vue des facteurs humains, la planification organisationnelle actuelle et le fonctionnement du CMOA national, des lacunes présentes au chapitre des capacités, de même que les solutions possibles pour un CMOA-V. Le présent document technique résume les résultats préliminaires qui servent de base au soutien de la modélisation future du système (Vision humaine) du CMOA-V.

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CAOD, Virtual-CAOC, Human Factors Analysis

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