



An Operational Sustainability Model

A tool for examining operational sustainability from a human resources perspective.

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Defence R&D Canada
Centre for Operational Research & Analysis

Canadian Operational Support Command
Chief Military Personnel

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Abstract

In 2007, the Canadian Operational Support Command requested the development of a tool set to assist with management of joint operational support personnel. The Operational Sustainability Model (OSM), a discrete event simulation tool for examining personnel tempo, is one component of this tool set. The aim of the OSM is to help assess the ability of the Canadian Forces (CF) to meet the personnel demands of operations over a planning horizon of up to five years, by providing projections of personnel shortages in both operations and the establishment, and personnel tempo patterns. Additionally, the OSM can be used to examine potential future impacts of changes in the CF establishment structure on the CF's ability to sustain operations.

The purpose of this report is to describe the data requirements, assumptions and logic of the OSM. Examples of the types of results that can be produced are shown, but no actual analysis of the CF's ability to meet the personnel demands of current or future operations is presented.

Résumé

En 2007, le Commandement du soutien opérationnel du Canada (COMSOCAN) a demandé que soit mis au point un ensemble d'outils pour faciliter la gestion du personnel de soutien opérationnel interarmées. Le modèle de viabilité opérationnelle (MVO), un outil de simulation d'évènement discret pour examiner la fréquence de déploiement du personnel, est l'un des éléments de cet ensemble d'outils. L'objectif du MVO est d'aider à évaluer la capacité des Forces canadiennes (FC) à répondre aux demandes en personnel des opérations sur un horizon de planification allant jusqu'à cinq ans, et ce, en établissant des prévisions de pénuries de personnel dans les opérations et les postes de l'effectif ainsi que les tendances de la fréquence de déploiement du personnel. Le MVO peut également être utilisé pour examiner les effets potentiels futurs des changements dans la structure de l'effectif des FC sur la capacité de celles-ci à maintenir les opérations en puissance.

Le présent rapport vise à exposer les exigences en matière de données, les hypothèses et la logique du MVO. Il propose des exemples de types de résultats pouvant être obtenus, mais aucune analyse réelle de la capacité des FC à répondre aux demandes en personnel pour les opérations actuelles et futures.

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Executive summary

An Operational Sustainability Model: A tool for examining operational sustainability from a human resources perspective.

Patricia Moorhead; Mira Halbrohr; DRDC CORA TM 2010-104; Defence R&D Canada – CORA; June 2010.

Introduction: The Canada First Defence Strategy requires the Canadian Forces (CF) to be able to sustain two separate international operations simultaneously (one for an extended period of time, and one in a surge capacity) while continuing to meet domestic commitments. This level of demand poses a question for the joint operational support community: are there sufficient joint operational support personnel to meet the standard set forth in the defence strategy?

At the request of the Canadian Operational Support Command (CANOSCOM), a discrete event simulation tool named the Operational Sustainability Model (OSM) was developed to help answer this question. Development has been a collaborative effort between CANOSCOM Operational Research and the Workforce Modelling and Analysis Team within Director General Military Personnel Research and Analysis.

This report describes the data requirements, assumptions and logic of the OSM. The ability of the CF to meet personnel demands of current and future operations is not examined, however some examples of the types of analysis results that can be produced are shown.

Model Inputs: There are three main data inputs to the OSM. The first is the personnel demand anticipated over a planning horizon of up to five years, in the form of a list of all positions (for both operations and day to day tasks) that are to be filled by CF Regular Force personnel on a rotating basis. Second is the personnel supply, represented by a snapshot in time of CF Regular Force demographics. The last major input is a set of personnel tempo constraints, taken from the CF personnel tempo policy for international operations.

Model Results: Given a series of domestic and international task requirements over planning horizon of up to five years, the OSM determines where (e.g., operation, occupation, rank, Level 1 organization) and when (e.g., operation rotation, fiscal year) personnel shortages may occur. Additionally, the simulation results can be used to assess future personnel tempo patterns.

An underlying premise of the OSM is that Force Generation and Corporate function positions within the establishment should not be emptied in order to fill operational billets; that is, only those personnel in deployable (e.g., high readiness) establishment positions should be tasked for international operations. Running simulations with this premise “turned on” and then “turned off”, assists with the determination of whether or not potential future personnel shortages could be due to the establishment structure (not enough people in the right place) or a shortage of qualified personnel across the CF.

Another use of the OSM is to assess the structure of the establishment itself. By conducting what-if type analyses, potential impacts of changes in establishment structure on the CF’s ability to sustain operations, can be examined.

Significance: The development of the OSM has provided CANOSCOM and Chief Military Personnel with a tool for assessing the ability of the CF to sustain operations from a human resources perspective. Given known and anticipated personnel demands over a planning horizon of up to five years, the OSM can provide advance warning of where and when personnel tempo stresses may occur. By being made aware of potential problems before they occur, decision makers can be proactive in putting in place policies and/or practices to prevent the problems, or at least lessen their negative impacts.

Future plans: The first major enhancement planned for the OSM is to allow for both deterministic and stochastic generation of operation and task start and end dates. The current version of the OSM assumes known and fixed timelines for all operations and tasks to be conducted over the simulation period. This is not realistic for operations such as humanitarian assistance missions, the timing and duration of which may not be predictable.

Another area of focus will be replicating the OSM within the Managed Readiness Simulator (MARS) tool developed by the Land Force Operational Research Team. The general objective of MARS is to assess the ability of force units to sustain a managed readiness plan over time. It is a much larger and more complicated model than the OSM, however all of the capabilities required by and nested within the OSM should also be inherent in MARS.

Sommaire

An Operational Sustainability Model: A tool for examining operational sustainability from a human resources perspective.

Patricia Moorhead; Mira Halbrohr; DRDC CORA TM 2010-104; R & D pour la défense Canada – CORA; Juin 2010.

Introduction: La Stratégie de défense « Le Canada d’abord » demande aux Forces canadiennes (FC) d’être en mesure de maintenir en puissance deux opérations internationales distinctes en même temps (une pour une période prolongée et une dans une capacité augmentée) tout en continuant à respecter les engagements nationaux. Un tel niveau de demande suscite une question sur le plan de l’effectif de soutien opérationnel interarmées : le personnel de soutien opérationnel interarmées suffit-il à répondre à la norme formulée dans la stratégie de défense?

À la demande du Commandement du soutien opérationnel du Canada (COMSOCAN), un outil de simulation d’évènement discret dénommé modèle de viabilité opérationnelle (MVO) a été conçu pour aider à répondre à la question. La recherche opérationnelle du COMSOCAN et l’équipe de modélisation et d’analyse de la main-d’œuvre du Directeur général – Recherche et analyse (Personnel militaire) ont pris part à l’effort commun de conception.

Le présent rapport vise à exposer les exigences en matière de données, les hypothèses et la logique du MVO. La capacité des FC à répondre aux demandes en personnel pour les opérations actuelles et futures n’est pas examinée, mais quelques exemples des types de résultats d’analyse pouvant être obtenus sont présentés.

Entrées du modèle: Le MVO comprend trois entrées de données principales. La première est la demande en personnel prévue sur un horizon de planification allant jusqu’à cinq ans sous forme d’une liste de tous les postes (tant pour les opérations que pour les tâches quotidiennes) qui seront pourvus en rotation par le personnel de la Force régulière des FC. La deuxième est le bassin du personnel représenté par un coup d’œil ponctuel des données démographiques de la Force régulière des FC. La troisième entrée principale est constituée d’un ensemble de contraintes pour la fréquence de déploiement du personnel à partir de la politique sur la fréquence de déploiement du personnel des FC pour les opérations internationales.

Résultats du modèle : En fonction d’une série d’exigences des tâches nationales et internationales sur un horizon de planification allant jusqu’à cinq ans, le MVO détermine où (par exemple, opération, poste, grade, organisation de niveau un) et quand (par exemple, rotation d’opération, année financière) des pénuries de personnel pourraient survenir. Les résultats de la simulation peuvent en outre servir à évaluer les tendances futures de la fréquence de déploiement du personnel.

Un principe du MVO sous-tend que les postes de mise sur pied de la force et de fonctions intégrées au sein de l’effectif ne devraient pas être laissés vacants pour doter des postes opérationnels. Autrement dit, les opérations internationales devraient être confiées uniquement au personnel occupant des postes déployables (soit à disponibilité opérationnelle élevée). La tenue de simulations avec l’application de ce principe, puis avec son inapplication contribue à

déterminer si les futures pénuries potentielles de personnel seraient imputables à la structure de l'effectif (nombre insuffisant d'employés à un endroit donné) ou à une pénurie de personnel qualifié dans les FC.

L'évaluation de la structure de l'effectif en soi constitue une autre utilisation du MVO. En menant des analyses par simulation, il est possible d'examiner les effets possibles des changements dans la structure de l'effectif sur la capacité des FC à maintenir les opérations en puissance.

Signification: La mise au point du MVO a fourni au COMSOCAN et au Chef du personnel militaire un outil pour évaluer la capacité des FC à soutenir des opérations du point de vue des ressources humaines. À partir des demandes connues et prévues en personnel sur un horizon de planification allant jusqu'à cinq ans, le MVO permet d'indiquer à l'avance où et quand les contraintes pour la fréquence de déploiement du personnel peuvent se produire. En étant avisés des problèmes potentiels avant qu'ils ne surviennent, les décideurs peuvent mettre en place de façon anticipée des politiques ou des pratiques pour les prévenir ou, à tout le moins, réduire leurs effets négatifs.

Plans futurs: La première amélioration principale prévue pour le MVO consiste à permettre la production déterministe et stochastique de dates de début et de fin d'opérations et de tâches. La version actuelle du MVO est axée sur des échéanciers connus et fixes pour toutes les opérations et les tâches qui seront menées au cours de la période de simulation, ce qui n'est pas réaliste pour des opérations comme les missions d'aide humanitaire dont le moment et la durée sont ne peuvent être planifiés.

Un autre domaine d'intérêt particulier consistera à reproduire le MVO dans le programme de simulation de gestion de la disponibilité opérationnelle (MARS) mis au point par l'équipe de recherche opérationnelle de la Force terrestre. L'objectif général du MARS est d'évaluer la capacité des unités de la Force à maintenir en puissance un plan d'état de préparation géré au fil du temps. Bien que le modèle soit beaucoup plus important et complexe que le MVO, toutes les capacités requises par le MVO et qui s'y imbriquent vont également de pair avec le programme MARS.

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1 Introduction

The Canada First Defence Strategy (CFDS) [1] itemizes six core missions which the Canadian Forces (CF) must maintain the ability to conduct, at times simultaneously. Specifically, the CF will have the capacity to:

- conduct daily domestic and continental operations, including in the Arctic and through North American Aerospace Defence;
- support a major international event in Canada (such as the 2010 Winter Olympic Games);
- respond to a major terrorist attack;
- support civilian authorities during a crisis in Canada (such as a natural disaster);
- lead and/or conduct a major international operation for an extended period; and
- deploy forces in response to a crisis elsewhere in the world for shorter periods.

Support to international operations involves the stand-up, sustainment and eventual close-down of lines of communication. The CFDS requirement to be able to sustain two separate international lines of communication simultaneously (one for an extended period of time, and one in a surge capacity) while continuing to support domestic commitments, poses a challenge for the joint operational support community. Are there sufficient joint operational support personnel to meet the standard set forth in the CFDS?

1.1 Project Background

In the fall of 2006 the Canadian Operational Support Command (CANOSCOM) requested the development of tools to assist with the management of joint operational support personnel. Of particular interest was development of a modelling and analysis capability to project potential future personnel shortages arising from current and future operational demands.

At the time there was an immediate requirement to provide an analysis of the ability of CF joint operational support occupations to meet the personnel demands of Task Force Afghanistan (TFA) throughout 2007 and 2008. Given the tight deadline imposed for conducting an initial analysis, the decision was made to exploit existing relevant modelling and analysis tools if possible, rather than develop a new capability.

A search of literature and research programmes within Defence Research and Development Canada - Centre for Operational Research and Analysis (DRDC CORA), and amongst The Technical Co-operation Panel allies, identified two DRDC CORA tools for potential exploitation. First was the Managed Readiness Simulator (MARS) [2, 3] developed by the Land Forces Operational Research Team, followed by a spreadsheet based model [4] developed by the Personnel Operational Research Team (PORT).

The general objective of MARS is to assess the ability of forces to sustain a readiness plan over time. MARS simulates the ability of units within a force structure to meet personnel demands for generating high readiness units to satisfy operational requirements, while adhering to a plan to

train, deploy and reconstitute the units involved. While well suited to support the analysis requested by CANOSCOM, MARS was not sufficiently mature in the fall of 2006 to allow the analysis to be conducted within the time frame provided.

The spreadsheet model developed by PORT had been created to evaluate personnel capacity and rotational issues for sustained operations, by comparing personnel demands with measures of personnel supply. For each rank level within each military occupation considered, the spreadsheet model calculates the percentage of the personnel supply that would be needed per rotation to sustain a given operation, by dividing the total demand over time by the available supply. As this model was readily available it was utilized to conduct an initial analysis of the ability of the joint operational support community to sustain TFA from 2006 to the end of 2008.

There are two key shortcomings to the spreadsheet model. Firstly, the location of personnel within the CF establishment structure, which can affect availability for deployment, is not taken into account. Thus the spreadsheet model could not be used to assess impacts of establishment structure changes on the CF's ability to sustain operations. Secondly, as the approach averages out the personnel demand over time, fluctuations in demand levels within the timeline considered cannot be assessed. For example, if one of several rotations requires a surge in personnel that cannot be supported at that time, this detail can be lost when the total demand of all rotations of the mission is averaged.

After conducting an initial analysis with the spreadsheet model, the option of utilizing MARS for future analyses was investigated. In early 2007, a major revision of the MARS environment had begun. The timelines for this effort precluded the option of MARS being used to support CANOSCOM's analysis requirements for several months at a minimum. The decision was made to proceed with development of a new modelling and analysis tool to meet the needs of CANOSCOM, but with the future goal of incorporating the logic of this new tool into the revised MARS environment when mature.

The Operational Sustainability Model (OSM) project was initiated in the spring of 2007. Development of this modelling and analysis tool has been a joint effort between CANOSCOM Operational Research and Director Strategic Military Personnel Research and Analysis (DSMPRA) within Chief Military Personnel (CMP).

1.2 OSM Overview

The focus of the OSM is on personnel resources: are there sufficient personnel to meet operational demands? Given a series of domestic and international task requirements during a planning period of up to five years, the OSM provides projections of future personnel shortages that could be experienced. The OSM can also be used to assess the structure of the CF establishment: are there sufficient positions in the correct places to meet future operational demands?

Data inputs to the OSM include:

- the demand - A list of all positions (for both operations and the CF establishment) that are to be filled on a rotating basis over a period of up to five years;

- the supply - A snapshot in time of the CF Regular Force personnel demographics; and
- constraints – Personnel tempo policies for international operations.

Given the inputs, the model determines where (e.g., occupation, rank, Level 1 organization) and when (e.g., operation rotation, fiscal year) personnel shortages may occur. By conducting what-if style analyses, potential impacts of changes in establishment structure on the CF's ability to sustain operations, can be examined. Additionally, the simulation results can be used to assess future personnel tempo patterns. By providing projections up to five years into the future, the OSM assists with identification of potential problems before they occur. This can help decision makers to be more proactive in putting in place policies and/or practices to prevent such problems, or at least lessen their negative impacts.

A key philosophy behind the creation of the OSM is that only those CF members in deployable positions should be deployed to international operations; members should not be systematically extracted from infrastructure positions in order to fill operational billets. The default status of the OSM is to allow only those members in deployable (e.g., high readiness) establishment positions to be tasked for an international operational deployment. This constraint on the pool of personnel available for deployments can be “turned off”, in which case all personnel regardless of what function they are performing in the CF establishment could be tasked to deploy.

There are many assumptions underlying the OSM. Most important amongst these are the following:

- the CF personnel tempo policy for international operations [5] must not be violated;
- the population of CF members to choose from remains static throughout the simulation period; and
- international operational rotations are assumed to be six months in length, and regular establishment position postings are assumed to be three years in duration.

During implementation of the OSM, some additional assumptions must be made. These include a left out of battle distribution (the percentage of personnel who are not available for tasking on any given day due to temporary circumstances), and augmentation rates for the use of Reserve Force members in international operations. Values for these parameters must either be derived from studies of relevant data (e.g., historical patterns), or assumed based on subject matter expertise.

One key limitation to the current implementation of the OSM concerns occupational sub-specialty qualifications. The sub-speciality requirements of positions and the sub-speciality qualifications of individuals are not considered. This is due to data quality issues; position sub-speciality requirements for international operations are not being reliably recorded in the departmental system of record.

It must be stressed that the OSM is not a tool for career management. While the model does emulate the posting of personnel in and out of establishment positions and operational billets, the aim is to project aggregate patterns, not to trace the career paths of individuals. Within a simulation, postings are made based only on the rank and occupation requirements of the positions; the appropriateness of posting an individual into a position (in terms of individual career progression, succession planning, etc.) is not considered.

The OSM has been built within the Arena® simulation environment, an entity based discrete event simulation software package. The discrete event simulation paradigm was chosen as the movement of personnel from one position to another is highly dependant on time stamped events (e.g., operation start and end dates).

While the OSM is a discrete event simulation model, the full entity functionality of Arena is not used. Rather, all person and position information is stored in variables. This approach is taken as the sequencing of searches to find eligible personnel, and the nominations of personnel to positions, would be very difficult to properly control if each person was modelled as an individual entity. The use of variables greatly simplifies the model logic required to match personnel to positions.

1.3 Report Structure

Development of the OSM is a multi-phase process. The Phase I model was designed to examine sustainment of a single international operation [6]. Phase II expanded the model to consider multiple operations (international and domestic) as well as the manning of establishment positions. This paper documents the OSM as of the end of Phase II.

This report describes the data requirements, assumptions and logic of the OSM; it does not include any actual analyses of the CF's ability to meet personnel demands of current and future operations. The results of such studies will be published separately.

In Section 2 of the paper, the data inputs and key assumptions underlying the OSM are discussed. The model logic is described in Section 3. In Section 4, examples of the types of information that may be derived from the simulation results are shown. A summary and discussion of future model development plans are given in the final section.

2 Data Inputs and Model Assumptions

The aim of this section is to describe both the data requirements and underlying assumptions of the OSM. Most of the assumptions are reflected in the input data; however some are realized through the model logic.

The fundamental data inputs to the simulation model are as follows:

- a table of organization (list of positions), both for operations and the CF establishment, that are to be filled on a rotating basis over a planning horizon of up to five years;
- a snap-shot in time of the Regular Force population, including the timing and duration of each member's most recent posting to a deployed operation;
- the CF international operations personnel tempo (perstempo) policy [5];
- a left out of battle (LOB) distribution for Regular Force members; and
- Reserve Force augmentation rates for deployed operations.

2.1 Table of Organization

The table of organization used by the OSM is a list of all instantiations of establishment and operations positions that are to be filled during a chosen time period (typically multi-year). Each position has a unique identification number, and can appear more than once in the list. For example, if there is an Engineer position with the position ID number 123456 in Rotation 1 of an operation, and that operation is to be sustained for another three rotations, the position number 123456 will be found a total of four times (once for each rotation) in the table of organization. Similarly, the ID number of an establishment position can appear more than once in the listing, reflecting the CF annual posting process. The individual instantiations of the positions are differentiated from each other by their start and end dates; each new rotation starts immediately after the previous rotation finished.

In order to be able to match personnel to positions, and to allow for control of from where in the organizational structure personnel may be selected for tasks, the following information is collected for each position record.

- The deployment status of the position (deployable or non-deployable).
- The position task type:
 - ◆ Operations (Ops) for operations positions; or
 - ◆ Standby, Force Generation (FG) or Corporate (Corp) for establishment positions.
- The rotation in which the position occurs. For establishment positions, this field is not relevant.
- The position identification number.
- The date by which a nomination for the position must be made.

- The start and end dates of the reporting period, during which the person nominated to the position must report for duty. Reporting periods are used to create a “window of opportunity” around the start date of the position (for establishment positions) or the start date of pre-deployment training (for operations positions). This is done to minimize instances of a position being left unfilled because no-one was available on one specific date.
- The start and end dates of the position.
- The military occupation requirement of the position.
- The minimum and maximum rank requirements of the position; and
- If an actual nomination has already been completed for the position, the service number of the nominee.

For analysis purposes, it is necessary to be able to uniquely identify every record in the table of organization. While this could be done using a combination of position ID number and start / end dates, it is more convenient to assign each record in the table of organization a unique identification number.

The main source of data for establishment positions is the Human Resources Management System (HRMS). The position number, start and end dates, and occupation and rank requirements for establishment positions are obtained from HRMS. For operations positions, data extracts from the Canadian Forces Taskings Plans and Operations (CFTPO) database are used. For each operations position the position number, rotation number, relevant dates, occupation and rank requirements, and nominee service number (if the position has already been filled) are taken from CFTPO. The position deployment status and task type are created fields, and are discussed in the sub-sections below.

One note should be made with respect to data on the military occupation requirements of a position. Some positions in both the establishment and operations require the incumbent to possess a specific occupational sub-speciality qualification. While sub-speciality qualifications of individuals are reliably recorded in HRMS, sub-speciality requirements for operations positions are not yet reliably recorded in CFTPO. Due to this data imbalance, the current implementation of the OSM does not take into consideration occupation sub-specialities. As a result, the personnel tempos of sub-speciality groups within occupations are not examined during model simulations. For those positions that do have a sub-speciality requirement, the size of the pool of potential nominees to the position will be overestimated, possibly resulting in an underestimation of the personnel tempo for the parent occupation.

2.1.1 Position Deployment Status

A key philosophy behind the creation of the OSM is that only those CF members in deployable positions should be deployed to international operations; members should not be systematically extracted from infrastructure positions in order to fill operational billets. For this reason, each position in the table of organization is labelled as either deployable or non-deployable. The classification is based on the purpose and function of the position; it is assumed that the individual in the position is deployable.

By definition, all positions in international operations are deployable, thus all non-establishment operations positions are classified as deployable.

The labelling of establishment positions was conducted internally within CANOSCOM Chief of Operational Support Transformation (COST). Initially the classification was done at the unit level. For units deemed to be deployable which deploy as a whole, each position in the unit was categorized as deployable. For all other units, the individual positions were examined and classified based on purpose and function. Additionally, if it was determined that the position could be back-filled by a Reserve Force member or civilian, thus “freeing up” a Regular Force member, the position was classified as deployable.

The classifications of establishment positions have not yet been validated by any organizations or subject matter experts (SMEs) outside of CANOSOM COST.

As previously mentioned the default implementation of the OSM assumes only those members in deployable (establishment) positions can be posted to operations. This flag in the model can be turned off, thus allowing personnel from anywhere within the establishment structure to be tasked for international operations. Running the model in both modes helps analysts to determine if unfilled operational billets are due to the distribution of positions in the establishment structure or CF-wide shortages of personnel.

2.1.2 Position Task Type

Four position task type categories are assumed for the OSM: Ops, Standby, FG and Corp. All operations positions are assigned the task type “Ops”. All deployable establishment positions are categorized as “Standby”. The establishment positions deemed to have a corporate function are labelled as “Corp”. The remaining establishment positions are classified as “FG”.

The categorization of certain establishment positions as Corporate was done internally within CANOSCOM COST, and has not been validated by other Level 1 organizations.

2.1.3 Position Dates

A series of dates are attached to each record in the table of organization. These are:

- the Nominate-By date which is the date by which a nomination must be made;
- the start and end dates of the period during which the nominee must report for duty; and
- the start and end dates of the position.

The lengths of establishment position postings can vary from position to position. For example, a posting to major equipment procurement programme office may last for four years, while a posting to a field ambulance unit may be for only two years. Due to a lack of information on the typical lengths of postings to each establishment position, it is assumed that all establishment positions postings are for three years. As a result, the OSM will try to refill some positions too frequently and others not frequently enough, as compared to reality. However, assuming a uniform average position length of three years is a reasonable compromise for the purposes of simulation. Should information on the typical posting length for each establishment position become available, it can be utilized by the model.

The posting dates of the establishment position incumbents, as extracted from HRMS, are the starting point for determining the start and end dates for establishment position postings. As shown in Table 1, the “Posted-in” date is taken to be the position start date, and the position end date is assumed to be three years later. For establishment positions with no incumbent, the position start date is forced to be the simulation start date plus one day.

Table 1: Establishment Positions Start and End Dates.

Incumbent	Start Date	End Date
Yes	Posted-in Date	Start Date + 3 years
No	Simulation Start Date + 1 day	Start Date + 3 years
For incumbents who have been in the same position for many years (so that the Posted-in date plus three years results in a date prior to the simulation start date), the position end date is re-set to June 30 th in the first year of the simulation time period.		

Operations positions data are initially extracted from CFTPO. As shown in Table 2, for current and future rotations of operations that have been entered into the system, the position start and end dates are taken to be as is. When creating new rotations, the last rotation in the system of record is used as the position list template. This template is replicated repeatedly to create new rotations for the operation. In this replication process, it is assumed that all positions are six months in duration.

Table 2: Operations Positions Start and End Dates.

Recorded in CFTPO	Start Date	End Date
Yes	As recorded	As recorded
No	First Replicate: Template rotation Start Date + 6 mo x^{th} Replicate: $(x-1)^{\text{th}}$ replicate Start Date + 6 mo	Start Date + 6 mo

In reality some operations positions can span more than six months and be up to one year in duration. As a result, there may be some overlap in the manning of positions between the last rotation extracted from CFTPO and the first created rotation.

For each position, there is a date by which the nominee must report for duty; this would be the start date of pre-deployment training (operations positions) or the position start date (establishment positions). To avoid situations in which a position is left empty because no suitable candidate was available to report for duty on one specific date, the OSM allows for the creation of a reporting period.

For establishment positions, a two month time window is assumed. The reporting period begins on the position start date and ends two months later. Thus, nominees are not asked to report early, but can report up to two months “late”.

The reporting period for operations nominations is assumed to be zero days; nominees must report for pre-deployment training exactly on time. Pre-deployment training is assumed to be six months for all operational billets, so the Report-By date is taken to be six months prior to the position start date.

The lengths of the reporting periods used by the OSM have not been validated by SMEs.

Nominations to positions must occur prior to the start of the reporting period and the position start date. In reality, nominations should be made well in advance of a posting to allow the nominee time to prepare. For the purposes of simulation, the only constraint is that a nomination be made before the nominee must report for duty. Within the OSM, the Nominate-By date is taken to be four months before the position start date for establishment positions, and seven months before the position start date (i.e., one month before pre-deployment training starts) for operations positions.

The methodology for determining the start and end dates of the reporting period and the nominate-by date are summarized in Table 3.

Table 3: Position Reporting Period and Nomination Dates.

Position Type	Report Start Date	Report End Date	Nominate By Date
Establishment	Position Start Date	Report Start Date + 2 mo	Position Start Date – 4 mo
Operations	Position Start Date – 6 mo	Report Start Date	Position Start Date – 7 mo

2.2 CF Regular Force Population

While the CF consists of both Regular and Reserve Force members, only Regular Force demographics are utilized in the OSM. Many Reserve Force members are part-time employees, hence the baseline population can be difficult to capture; obtaining Reserve Force demographic data of sufficient quality to support the analyses being conducted is currently not feasible.

The OSM does not utilize the entire paid strength of the Regular Forces. Rather only the trained effective strength (TES) is used as these are the members who are deployable.

In order to be able to match personnel to positions, and to allow for control of when and from where in the organizational structure personnel may be selected for taskings, the following information is collected for each member of the Regular Force TES:

- service number;

- rank;
- Military Occupational Structure Identification (MOS ID);
- position number for the establishment position currently held;
- the deployment status of the establishment position currently held (deployable or non-deployable position)¹;
- the task type of the establishment position currently held (Standby, FG or Corp function)²; and
- the member's next Active Posting Season (APS) date.

The service number, rank, occupation and position number information are taken from HRMS data extracts. The deployment status and task type of each person's current establishment position are obtained from the table of organization for the CF establishment (see Section 2.1). The APS date is a calculated field.

In addition to these data fields, a series of colour coded dates are created. These dates indicate when the member is eligible to deploy on international operations, based on CF international operations perstempo policy.

2.2.1 Population APS Dates

The APS date is the date on which the member is due to be posted to another establishment position. As noted in Section 2.1.3, all establishment postings are assumed to be three years in length. Thus the initial APS date for each member is taken to be the start date of their current posting (at the time of the population snapshot) plus three years. As the simulation progresses, individuals are posted in and out of occurrences of establishment positions.³ When a member is posted into a specific occurrence of an establishment position, his/her APS date is updated to be the position end date associated with that occurrence of the position.

It must be noted that while the OSM does attempt to emulate the annual posting process at a macro level, it is not a career management tool. The aim of the OSM is to project aggregate patterns, not to trace the career progression of individuals. Within a simulation, postings are made based on the rank and occupation requirements of the positions alone; reasons for posting an individual (e.g., promotion) and the appropriateness of posting an individual to a position (in terms of career development, personal compatibility, etc.) are not considered.

¹ When attempting to fill nominations to positions, it is necessary to know both the deployment status of the position to be filled and that of the position the potential nominee is coming from. Storing the deployment status of the establishment position currently held by the member, in the population table, reduces the number of table cross references required to match personnel to positions.

² Position task type is recorded in the population table for the same reason as position deployment status.

³ Recall that individual establishment positions can appear repeatedly in the Table of Organization, as they are to be refilled every three years.

2.2.2 Population Perstempo Colour Dates

The population data table that is read into the OSM contains fields for a series of colour coded dates indicating when a member is eligible to deploy on international operations. There are three such dates:

- Go Green date – the date by which a member can be deployed with no perstempo restrictions;
- Go Yellow date – the date by which a member can be deployed without an operational waiver being signed, however the recommended post-deployment exemption period has not been completed; and
- Go Orange date – the date by which a member can be deployed, however an operational waiver document must be signed.

Individuals are classified as “Red” once nominated to an international operations position. This is done to reflect the fact that the member is now committed and cannot be tasked for another position until this deployment is complete.

The initial set of Green / Yellow / Orange dates assigned to each member of the population listing are determined based upon the end date and length of the member’s last international operation (taken from CFTPO), and the perstempo policy.

If there is no international operation deployment recorded for the member in CFTPO, the person’s Green, Yellow and Orange dates are set to be their hire date plus two or six years for Non-commissioned Members (NCMs) and Officers, respectively⁴.

Detailed formulae for calculating and updating the Green / Yellow / Orange dates during the simulations can be found in Annex A.1.

2.2.3 Static Population Assumption

The OSM currently assumes that the Regular Force population demographics remain unchanged during the simulation time period. In other words personnel do not age, get promoted, change occupations or retire, and no new members are recruited. While the population demographics remain static, personnel are moved around from one position to another during simulation, emulating the annual posting process and the manning of deployed operations.

The static population assumption will have some level of impact on the simulation results. For example, preferred manning levels (the mandated number of personnel at each rank within each occupation) can change over time. Ignoring such changes can result in under- or overestimation of the personnel tempo for the affected occupations. Similarly attrition can have a considerable impact; the loss of one or two people, combined with a lengthy training period to become operationally qualified can drastically increase the personnel tempo of some small occupations.

⁴ It is assumed that occupation specific training averages two years in duration for all occupations. Officers are assumed to spend an additional four years pursuing government sponsored post-secondary education after enrollment and prior to their occupation specific training.

2.3 International Operations Perstempo Policy

The CF personnel tempo policy for international operations [5] provides the framework by which the OSM controls nominations to operations positions.

For deployments of 180 consecutive days or more, the policy states that a member is entitled to a 60 day respite period on return, and that an exemption period of 365 days (from the time of return) shall apply or else an operational waiver shall be required. During an exemption period members shall not normally be posted outside Canada or to an isolated post to which their families are not authorized to proceed at public expense. This does not preclude the possibility of a member beginning pre-deployment training within Canada, for another deployment, before the exemption period has ended.

If operational requirements dictate that a member must be deployed internationally before the 365 day exemption period has ended, or an exempted member volunteers for another such deployment, a waiver document must be signed

For deployments between 60 and 179 consecutive days, the perstempo policy recommends a two day exemption for each day deployed; operational waivers are not required for postings to international operations during this recommended exemption period.

For deployments of less than 60 days, the application of an exemption period on return is discretionary.

2.3.1 Implementation of the Perstempo Policy

The perstempo policy is implemented in the OSM through a colour coding system, as follows:

- Red - the member cannot be tasked, because s/he has already been nominated for deployment, is currently deployed or is in a 60 day post-deployment respite period;
- Orange - the member is in the 365 day exemption period following a 180 day or longer deployment, but can be tasked (a waiver is required);
- Yellow - the member is still in the recommended exemption period following deployments of 60 to 179 days, but can be tasked (no waiver required); and
- Green - the member can be tasked, with no perstempo related restrictions.

As stated above, the perstempo policy does not preclude the possibility of a member commencing pre-deployment training for a new deployment during the exemption period following a previous deployment. The only restriction is that the pre-deployment training for the new tasking must not overlap with any mandatory 60 day respite period to which the member was entitled. This reality is reflected in the OSM logic.

In addition to reflecting the literal meaning of the perstempo policy, the OSM attempts to “pay back” members for exemption period time that is not received. There are two situations in which this may happen.

1. If a member signs a waiver document, thus cutting short their 365 exemption period, the number of days remaining in the original exemption period are added on to the new exemption period entitlement after the new deployment (to a maximum total of 365 days).
2. If a member deploys while in a recommended exemption period following a deployment of 60 to 179 consecutive days, the number of days remaining in the first recommended rest period is added on to the new exemption period entitlement after the new deployment (to a maximum total of 365 days).

In this manner, the OSM attempts to apply a personnel tempo, for deployments of 60 consecutive days or more, that is more generous than the minimum standard set forth in the official policy. This adjustment is reflective of reality: in practice, when operational demands allow, commanding officers will usually try to give back unused exemption time to their personnel, in an effort to reduce the potential for burn-out and maintain morale.

For deployments of less than 60 consecutive days, the OSM does not attempt to grant exemption periods post deployment. The perstempo policy states that for such deployments the granting of exemption periods is discretionary. As no entitlement ratio (days deployed to days exemption) is provided in the policy, none is assumed within the model. Thus during a simulation it is possible for individuals to be tasked for short deployments repeatedly, with little or no rest between these taskings. The model logic could be adapted in future implementations to prevent such a scenario from occurring.

Detailed formulae for the perstempo calculations can be found in Annex A.1.

2.3.2 International versus Domestic Operations

The OSM does not currently distinguish between domestic and international operations. The assumption that only personnel in deployable establishment positions can be tasked for deployments applies to both domestic and international operations. The perstempo policy referenced is for international operations, but will be applied equally within the simulation to domestic operations.

For the purposes of this paper, references to “international operations” are understood to also include domestic operations. Should there be a future requirement to differentiate between domestic and international operations the appropriate logic can be added to the simulation model.

2.4 LOB Distribution for Regular Force Members

The term left out of battle refers to instances where a CF member cannot report for duty due to unforeseen temporary personal circumstances (e.g., short term illness). While no formal reference could be found, the army commonly uses a planning factor of 15%; that is, on any given day, 15% of a unit’s membership may not be able to report for duty due to unforeseen temporary circumstances.

Within the OSM, the LOB concept is assumed to apply to the availability of personnel to fill operational billets only. A temporary LOB designation is not considered to have an impact on a

member’s ability to be posted to an establishment position. For implementation during the simulations, the overall rate of 15% is translated into a distribution over time.

Firstly, the simulation period is divided into six month intervals, with the first interval starting on the simulation start date. It is assumed that individuals will be LOB for none, one, two consecutive, or all of these periods. Table 4 shows the distribution that is applied to each individual member to develop a LOB profile over time which states whether or not the member is considered to be LOB in each of the six month intervals. This distribution was decided upon by CANOSCOM COST staff, and has not been validated by SMEs.

Table 4: LOB Distribution.

LOB Status	# of 6 mo. Periods	Probability
Yes	All	0.01
Yes	2 consecutive	0.03
Yes	1	0.11
No	All	0.85

The possibility of a member being declared LOB for the entire simulation period, even though the LOB designation is temporary by definition, is included to reflect the reality that a temporary personal circumstance can become permanent in some cases, rendering a current member of the TES non-deployable in the near future.

The LOB profile is used to determine whether or not a member can report for the pre-deployment training associated with an operations position. This emulates pre-training losses only; it does not account for non-combat losses during training or any losses during the deployment itself.

2.5 Reserve Force Augmentation Rates

Typically up to 15% of positions in any given rotation of an international operation are filled by members of the Reserve Forces. When considering individual occupations, the percentage can be much higher. Given a table of Reserve Force augmentation rates, by occupation and rank, the OSM “rolls the dice” when attempting to fill each operations position to determine whether or not the nominee will be a member of the Reserve Forces.

The augmentation rates by occupation and rank used in the OSM should be based on historical data, where sufficient data for pattern analysis is available. Unfortunately, such a study has not yet been conducted. In the absence of such data, SMEs should be consulted to determine reasonable augmentation rate assumptions prior to conducting any formal analyses.

2.6 Position and Population Lists Ordering

The table of organization and the CF Regular Force population snapshot are ordered in such a way as to facilitate the running of simulations.

The position list is prioritized to ensure positions are filled chronologically, and that the higher priority and harder to fill positions are dealt with before positions having lower priority and/or less restrictive requirements. More specifically, the list of positions to be filled over the simulation time period is ordered in the following manner:

1. chronologically by the Nominate-By date;
2. by Vice Chief of Defence Staff (VCDS) Manning Priority, with the highest priority positions listed first;
3. by decreasing stringency of the rank and occupation requirements of the position (see Annex A.2 for details);
4. by MOS ID (by numeric code, from lowest to highest);
5. by the lowest rank requirement of the position, in ascending rank order; and lastly
6. by the highest rank requirement of the position, in ascending rank order.

The Regular Force population snap-shot is ordered by rank, with the highest rank first. Grouping members by their rank increases the efficiency of the search mechanisms used in the simulations.

3 Model Logic

The Operational Sustainability Model has been developed using Arena®, an entity based discrete event simulation software package developed by Rockwell Automation. While the OSM is a discrete event simulation model, the full entity functionality of Arena® is not used. Rather than modelling each individual as an entity, all person and position information is stored in variables. This approach is taken as the sequencing of searches and nominations would be very difficult to properly control within Arena® if each person was modelled as an entity.

The following subsections describe the logic of the various components and sub-models of the OSM.

3.1 Reading in the Model Data

The first stage of OSM implementation is to import the necessary data into the model. This includes the population information, a MOS ID decode table, start and end dates for the six month LOB periods into which the simulation period is divided, and the Reserve Force augmentation rates for international operations.

3.1.1 The Population Data

Each personnel record is read in one at a time. As each record is imported, a LOB profile for the length of the simulation period is assigned to the associated person.

Recall that the simulation period is divided into six month intervals, beginning on the simulation start date. Let P be the number of such intervals. Initially each personnel record is assigned a LOB profile of “No” for all P intervals, meaning the associated member is never left out of battle.

The simulation then “rolls the dice” according to the LOB distribution described in Section 2.4. If the member is designated to be LOB for one six month period, a discrete uniform $[1, P]$ distribution is used to randomly select a single interval, and the member’s LOB profile entry is changed to “Yes” for this interval.

If the member is designated to be LOB for two consecutive six month periods, a discrete uniform $[1, P-1]$ distribution is used to select the first of two consecutive intervals, and the member’s LOB profile entry for the selected and subsequent interval are changed to “Yes”.

In those few cases where the member is designated to be LOB for the entire simulation period, all of the member’s LOB profile entries are changed to “Yes”.

3.1.1.1 The Rank Lookup Table

As the population data are being read into the model, a sub-model is run to create a rank lookup table. Recall that the population data input file is ordered by rank, from highest to lowest. To streamline the process of searching for personnel within the correct rank group for a position, a

lookup table is created that guides the model to the appropriate section of the population table listing. The output of this sub-model is a lookup table that links each rank level to a record in the population data file where the listing of members with that rank begins.

3.1.2 The MOS ID Decode Table

Every individual occupation has a unique MOS ID. In addition to these codes, there are codes used by CFTPO to designate certain occupational groups. For example, the occupation group “Security and Intelligence” consists of two separate occupations: Military Police; and Intelligence Operators. A decode table was created to provide the mappings between occupational groups and individual occupations. This ensures, for example, that when a position with the occupational requirement of “Security and Intelligence” is to be filled, all Military Police and all Intelligence Operators of the appropriate rank will be considered as possible nominees.

3.1.3 LOB Period Start and End Dates

As described above, the simulation period is divided into six month intervals with the first interval starting on the simulation start date. The start and end dates of these intervals are imported into the model separately from the creation of the LOB profiles for the members of the population as the dates are not needed to create the LOB status profile for each person.

3.2 The Nomination Process

The nomination process is essentially deterministic. Personnel characteristics are matched to position requirements; either there is a match, or there is not. The positions in the table of organization are considered one at a time. Figure 1 shows the initial nomination process logic that is followed for each record in the position list.

After importing the position details, the next step is to check whether or not the nomination has already been filled. This will often be the case for positions in near future rotations of international operations, as nominations are entered into CFTPO several months in advance of a deployment. If a nomination has already been completed, this information is written to the simulation output file (step 9 in Figure 1) and the model returns to the beginning of the nomination process and proceeds to import the next record in the position list. If the nomination is still open, the model continues to the next stage of the nomination process.

Before starting the search for personnel eligible to fill the nomination, the list of occupations from which nominees must be taken is determined (step 3 in Figure 1). The position requirement can be for one specific occupation or an occupational group. In the latter case, the MOS ID decode table is used to obtain the list of acceptable occupations.

If the MOS ID code is unknown (e.g., an invalid code was entered into CFTPO), the position will remain unfilled. This information is written to the simulation output file, and the simulation then returns to the start of the nomination process wherein the next record in the position list is imported.

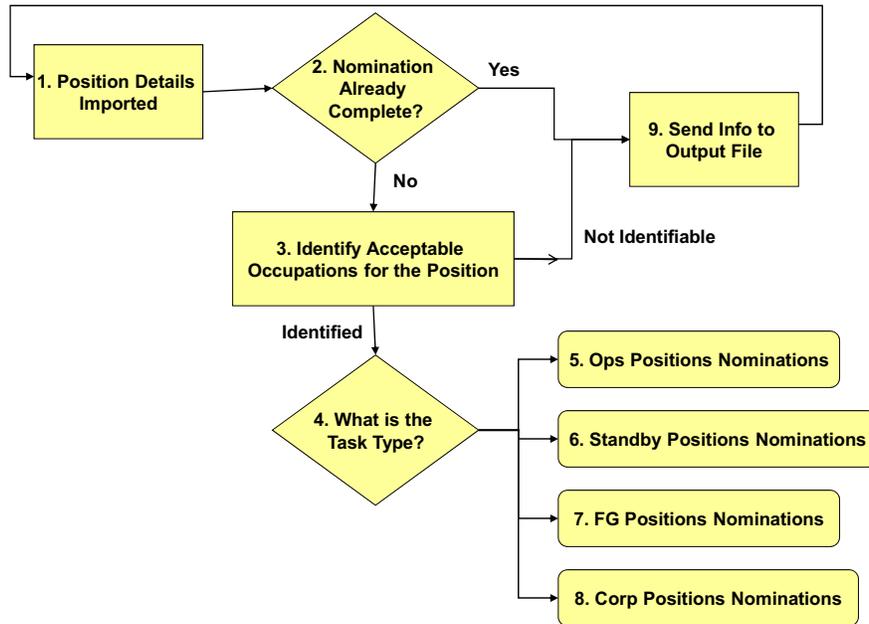


Figure 1: Model Logic Flow for Initial Stages of Nomination Process

If the MOS ID is valid, the next step is to assess the Task Type of the position (step 4 of Figure 1). This can be Ops, Standby, FG or Corp. The appropriate sub-model is then activated to complete the nomination of an individual to the position in question.

3.2.1 Nominations to Operations Positions

The first step in the nomination process for an Operations position is to “roll the dice” to determine if the position will be filled by a Reserve or Regular Force member. Based on the rank and occupation requirements of the position, the appropriate entry in the Reserve Force augmentation rates matrix is extracted. If the low and high ranks for the position are the same, there is a single entry in the matrix to be referenced. If the high rank differs from the low rank, the OSM currently takes the maximum of the two possible augmentation rates.

Let r ($0 \leq r \leq 1$) represent the augmentation rate to be used for the position. A discrete cumulative distribution, with probability r of Reserve Force nomination and probability $1-r$ of Regular Force nomination, is used to determine the force component of the potential nominee.

If the nominee is designated to be a Reserve Force member, it is assumed that the position is filled by a Reservist. This information is written to the output file, and the simulation returns to the beginning of the nomination process and imports the next record in the list of positions to be filled.

If the nominee is to be a Regular Force member, the model begins the process of searching the population listing for potential nominees.

Figure 2 shows the logical schema used to nominate a Regular Force member to an operational billet. The first set of filters for selecting potential nominees is based on rank and perstempo policy. Individuals must be of the correct rank for the position, and must have completed any mandatory 60 day respite periods prior to the position's Report-By date. (i.e., tasking the individual would not violate perstempo policy). In other words, the individual's perstempo colour status can be Green, Yellow or Orange, but not Red.

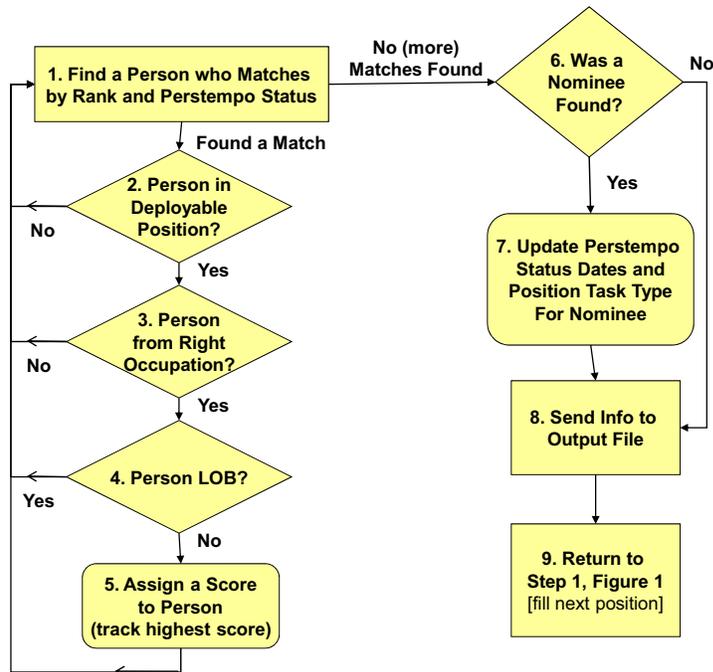


Figure 2: Model Logic Flow for Nominations to Operations Positions

If no individual is found satisfying these criteria, the position will remain unfilled. Information indicating this result is written to the output file, and the model returns to the beginning of the nomination process and starts to examine the next entry in the position list (step 1 in Figure 1).

After the first individual with the appropriate rank and perstempo status is found, the next question to ask is whether or not this person is currently in a deployable establishment position (step 2 in Figure 2). The OSM default is to exclude personnel from non-deployable establishment positions from being posted to international operational billets. If the currently selected member is not in a deployable establishment position, the model returns to the population list and searches for the next individual who meets the position's rank requirement and the perstempo status restriction (step 1 in Figure 2).

Given a potential nominee in a deployable establishment position, with the appropriate rank, and perstempo status, the next filter applied is the occupation requirement of the position (step 3 of Figure 2). If the position calls for someone in an occupational group, the MOS ID decode table is

referenced, and the potential nominee's occupation is compared to the list of occupations that comprise the desired occupational group. If the individual is not a member of an appropriate military occupation, the model returns to searching the population list for the next individual who meets the position's rank requirement and the perstempo status restriction (step 1 in Figure 2).

At this stage, the model has checked for matches between the position requirement and individuals based upon rank, military occupation, perstempo status, and deployment status of the establishment position currently held. The next step in the nomination process is to check the individual's LOB status profile: can this person report for pre-deployment training on time, or is s/he going to be LOB?

Personnel with an LOB status of "Yes" for the duration of the position's reporting period cannot be nominated to the position as they cannot report for pre-deployment training. The model does not check if the potential nominee will have an LOB status of "Yes" after the start of pre-deployment training. Such accounting for training and deployment losses could be incorporated in future versions of the model.

Potential nominees who can report for pre-deployment training on time, and have the appropriate rank and occupation specifications for the position to be filled, are next assigned a score (step 5 in Figure 2). The score is based on three things: the perstempo status of the person as of the position start date; how long the person has had that perstempo status as of the position start date; and the person's rank. In general, personnel who have been Green for the longest and are of the lowest required rank for the position, are given the highest scores.

Logic has been included in the OSM to allow for two possible adjustments to the score. If personnel from non-deployable FG and Corp establishment positions, rather than just deployable Standby positions, are permitted to be posted to operational billets, the score assigned to such individuals is reduced by a fixed amount. This adjustment will come into play only when the flag to exclude personnel from non-deployable positions from being nominated is turned off.

If the reporting period for pre-deployment training is more than one day in length, the potential nominee's score can be adjusted based on how many days after the reporting period start date s/he reports for pre-deployment training. If a person will not be able to report for duty until day two or later of training, his/her score is reduced by an amount proportional to the number of training days "missed". If a person can report for training on day one of the training period, the score is increased by a fixed amount.⁵

Details on the scoring formulae for operations positions nominations can be found in Annex A.3.1.

If the currently selected person has the best (highest) score observed so far, the individual becomes the preferred potential nominee. The model returns to searching the population for the next possible candidate for the position based on rank and perstempo status (step 1 in Figure 2). This search is process is repeated until all personnel eligible for nomination to the Operations position have been scored. The person with the highest score overall will receive the nomination.

⁵ This increase in score for individuals who can report for duty on time is not necessary, and is an artefact from earlier iterations of the simulation model. It will probably be removed in future versions of the tool.

Ties in scores are broken by selecting the person whose record comes first in the population listing.

There are two possible outcomes from the search for potential nominees: a nominee is found, or there were no matches for the position. If no match was found, the position will remain unfilled, and this information is written to the output file.

When a nominee has been indentified, the next step (step 7 of Figure 2) is to update that person's perstempo status change dates to reflect the new deployment. The new dates on which the individual turns Green, Yellow and Orange after the new deployment, are calculated and recorded. The formulae for these calculations can be found in Annex A.1.2. As well, the position task type associated with that person is updated to be "Ops", to reflect the fact that the person is now slated for deployment.

The final step in the nomination process is to write the nomination information to the output file. The model then returns to the position list and imports the record for the next position to be filled.

3.2.2 Annual Posting Process: Nominations to Standby Positions

Figure 3 shows the logical schema used to nominate a Regular Force member to a Standby (deployable) establishment position. The first level of screening used to identify potential nominees is based on rank, perstempo status and APS date. Individuals must be of the correct rank for the position, and must have completed any mandatory 60 day respite periods prior to the position's Report-By date. That is, the individual's perstempo colour status can be Green, Yellow or Orange, but not Red, so tasking the individual would not violate perstempo policy. Additionally, the individual must be eligible for a posting within the CF establishment: his/her current establishment posting must end before the reporting period for the new position has passed.

If no individual is found satisfying these criteria, the position will remain unfilled. Information indicating this result is written to the output file, and the model returns to the beginning of the nomination process and starts to examine the next entry in the position list (step 1 of Figure 1).

If an individual is found satisfying the above criteria, the next check is based on occupation: potential nominees must be from an appropriate military occupation (step 2 of Figure 3). If the position calls for someone in an occupational group, the MOS ID decode table is referenced, and the individual's occupation is compared to the list of occupations that comprise the desired occupational group. If the individual is not a member of an appropriate military occupation, the model returns to searching the population list for the next individual who meets the position's rank requirement, perstempo status and APS date restrictions (step 1 of Figure 3).

Unlike nominations to operations positions, there is no check of a potential nominee's LOB status during the nomination process for establishment positions. The LOB concept is applied to deployed operations only, to take into account instances in which a short term temporary circumstance renders a CF member unable to participate in pre-deployment training, and hence unable to deploy at the required time. Such temporary personal circumstances should not, and are assumed to not prevent members from starting a new multi-year posting to an establishment position.

Given a potential nominee who satisfies the rank, occupation, perstempo status and APS date requirements of the Standby position, the next step is to assign a baseline score to that person (step 3 of Figure 3). The score is based on: how far in advance of the end of the position’s reporting period the individual’s APS date occurs; how far in advance of the end of the position’s reporting period the individual ceases to be “Red”; and the individual’s rank. In general, individuals who have been waiting the longest for a new establishment posting, who have had the longest⁶ rest period since their last deployment, and who have the lowest rank required by the position, will receive the highest baseline scores.

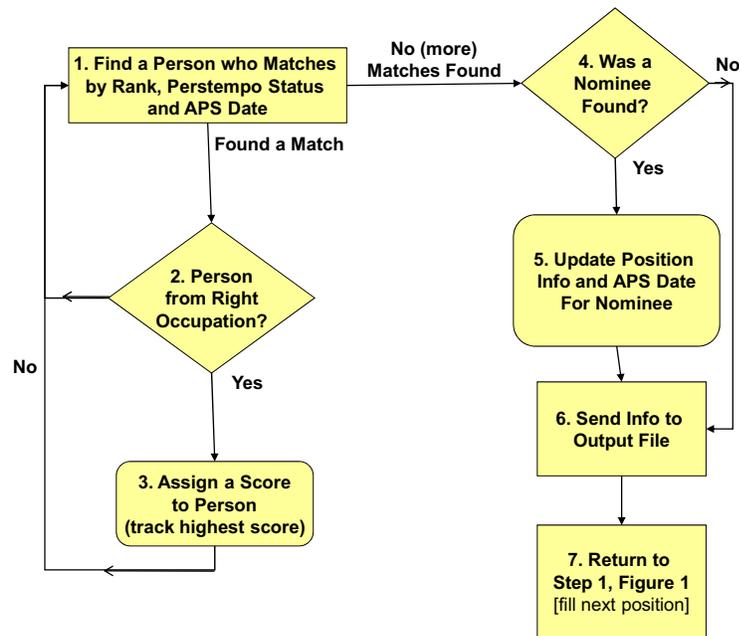


Figure 3: Model Logic Flow for Nominations to Standby Positions

The baseline score assigned to an individual may be adjusted, based on the task type of the establishment position the individual would be coming from, and how far into the reporting period the individual would be able to report for duty.

For postings to Standby establishment positions, preference is given to individuals coming from FG or Corp positions, as they are less likely to have deployed recently. If the potential nominee’s current position task type is FG or Corp, his/her score is increased by a fixed amount. If the individual is already in a Standby position, no adjustment is made to the baseline score.

Preference will be given to individuals who can report for duty on the first day of the reporting period. For individuals who fall in this category, the baseline score is increased by a fixed amount. Personnel who cannot report for duty until later into the reporting period will have their baseline score decreased by an amount proportional to the length of the delay.

⁶ When filling deployable positions (task type of Standby) preference is given to personnel who have not deployed recently.

Details on the scoring formulae for potential nominees to Standby establishment positions can be found in Annex A.3.2.

If the currently selected person has the highest score observed so far, the individual becomes the preferred potential nominee. The model returns to searching the population for the next possible candidate for the position based on rank, perstempo status and APS date (step 1 in Figure 3). This search process is repeated until all personnel eligible for nomination to the Standby establishment position have been scored. The person with the highest score overall will receive the nomination. Ties in scores are broken by selecting the person whose record comes first in the population listing.

There are two possible outcomes from the search for potential nominees: someone is found, or no-one is found. If no nominee was found, the position will remain unfilled; this information is written to the output file.

If a nominee has been identified, the next step is to update that person's establishment position and APS date information to reflect the new tasking (step 5 in Figure 3). The individual's position number is updated to be that of the new position to which s/he has just been nominated. The associated task type and deployment status fields in the personnel record are set to Standby and Deployable, respectively. The APS date of the individual is reset to be three years after the start date of the new position.

The final step is to write the nomination information to the output file. The model then returns to the position list and imports the record for the next position to be filled (step 1 of Figure 1).

3.2.3 Annual Posting Process: Nominations to FG and Corp Positions

The same general process used for filling nominations for Standby establishment positions (as outlined in Figure 3) also holds for FG and Corp establishment positions. First, potential nominees are screened based on rank, perstempo status and APS date. Second, the occupational requirements of the position are considered.

The score assigned to each potential nominee to a FG or Corp position is based on: how far in advance of the end of the position's reporting period the individual's APS date occurs; how far in advance of the end of the position's reporting period the individual ceases to be "Red"; and the individual's rank. In general, individuals who have been waiting the longest for an establishment posting, who have had the shortest⁷ rest period since their last deployment, and who have the lowest rank required by the position, will receive the highest baseline scores.

The baseline score assigned to an individual may be adjusted, based on the task type of the establishment position the individual would be coming from, and how far into the reporting period the individual would be able to report for duty.

For postings to FG and Corp establishment positions, preference is given to individuals coming from Standby positions, as they are more likely to have deployed recently. If the potential

⁷ When filling non-deployable positions (task types of FG or Corp), preference is giving to personnel who have deployed recently, in order to even out their personnel tempo.

nominee's current position task type is Ops or Standby, his/her score is increased by a fixed amount. If the individual is already in a FG or Corp position, no adjustment is made to the baseline score.

Preference will be given to individuals who can report for duty on the first day of the reporting period. For individuals who fall in this category, the baseline score is increased by a fixed amount. Personnel who cannot report for duty until later into the reporting period will have their baseline score decreased by an amount proportional to the length of the delay.

Details on the scoring formulae for potential nominees to FG and Corp establishment positions can be found in Annex A.3.3.

If the currently selected person has the highest score observed so far, the individual becomes the preferred potential nominee. The model returns to searching the population for the next possible candidate for the position based on rank, perstempo status and APS date (step 1 in Figure 3). This search process is repeated until all personnel eligible for nomination to the FG / Corp establishment position have been scored. The person with the highest score overall will receive the nomination. Ties in scores are broken by selecting the person whose record comes first in the population listing.

There are two possible outcomes from the search for potential nominees: someone is found, or no-one is found. If no nominee was found, the position will remain unfilled; this information is written to the output file.

If a nominee has been identified, the next step is to update the position information and APS date for the nominee (step 5 in Figure 3). The individual's position number is updated to be that of the new position to which s/he has just been nominated. If the task type of the new position is FG (Corp), the task type field in the personnel record is updated to FG (Corp). The deployment status field in the individual's record is set to Deployable. Lastly, the APS date of the individual is reset to be three years after the start date of the new position.

The final step is to write the nomination information to the output file. The model then returns to the position list and imports the record for the next position to be filled (step 1 in Figure 1). The process of reading in positions, one at a time, and searching for a nominee is repeated until all positions have been dealt with.

3.2.4 Nomination Process Output

Multiple replications of the simulation may be run. In each replication, the stochastic components are the generation of the LOB status profiles for each individual, and the determination of whether or not each Operations position is to be filled with a Reserve or Regular Force member.

For each position record considered by the model, a results record is written to the output file. The information recorded is as follows: simulation replication number; the unique position ID; the nominee's service number; the nominee's previous and new establishment position numbers; the nominee's previous and new position task types; the nominee's previous and new perstempo status dates; and the nominee's previous and new APS date.

In those instances where a nomination was not made (i.e., the position was already filled, to be filled by a Reserve Force member, or no match for the position requirements could be found) coded values are inserted into the appropriate nominee information fields. These coded values enable identification of unfilled positions, by reason, during post-simulation data processing.

4 Example Simulation Results

The aim of the OSM is to help assess the ability of the CF to meet operational requirements for personnel, by using simulation to provide projections of what the future may look like. Simulation based projections are highly dependent upon the simulation design and the data inputs. Even small changes in some of the inputs (e.g., LOB rates, Reserve Force augmentation rates for international operations) can result in significant changes in the simulation outputs. Hence, the results produced by the OSM provide an indication of what *may* happen under a given set of assumptions, not a prediction of what will necessarily take place.

Given known and anticipated personnel demands over a planning horizon of up to five years, the OSM can provide advance warning of where and when personnel tempo stresses may occur. By being made aware of potential problems before they occur, decision makers can be proactive in putting in place policies and/or practices to prevent the problems, or at least lessen their negative impacts.

This section provides an overview of the types of information that can be derived from OSM simulation results, in particular: stoplight summary tables; patterns in unfilled positions; and patterns in operational waiver usage.

As the focus of this report is on how the OSM works rather than presenting an actual analysis using the tool, no effort has been made to ensure the data presented here are realistic in nature. In fact, the data used to create the example graphs and tables shown below are entirely artificial and are not indicative of the current state of affairs within the CF. Additionally, no effort has been made to ensure consistency between related graphs (i.e., numbers may not “add up”). As such, readers should focus on the overall theme and objective of each graph/table and not on the results themselves.

4.1 Stoplight Summaries

Stoplight style tables can be used to provide quick summaries of the simulation results. In general, the simulation results for operations and establishment positions are analysed separately, as the dimensions by which they should be examined are not necessarily the same.

For operations positions, a standard type of stoplight summary looks at the number of unfilled positions in a given operation by occupation and rotation. Figure 4 provides an example for a fictional Operation I. The cells are coloured either green, yellow or red. Green cells indicate that all positions in the associated rotation with the occupation referenced were filled without inducing personnel tempo stresses. Yellow coding indicates that at least one operational waiver was required to fill the positions for that rotation and occupation combination. If one or more positions for an occupation in a rotation remained unfilled, the associated cell is coloured red.

If required, the actual counts of waivers and unfilled billets can be included in the display. Stoplights can also be generated for individual occupations, as shown in Figure 5.

	Rotation							
Occupation	3	4	5	6	7	8		Legend
MOS 1	Green	Green	Green	Green	Green	Green		Filled
MOS 2	Green	Yellow	Red	Green	Red	Red		Waivers
MOS 3	Red	Yellow	Green	Green	Red	Green		Unfilled
MOS 4	Green	Red	Green	Yellow	Yellow	Red		
MOS 5	Red	Green	Green	Red	Red	Yellow		
MOS 6	Yellow	Red	Yellow	Yellow	Green	Green		

Figure 4: Stoplights for Operation I, by Occupation and Rotation

	Rotation							
MOS 1	3	4	5	6	7	8		Legend
Cpl/Pte	Yellow	Red	Yellow	Green	Green	Green		Filled
MCpl	Green	Yellow	Red	Green	Red	Red		Waivers
Sgt	Red	Yellow	Green	Green	Red	Green		Unfilled
WO	Green	Red	Green	Yellow	Yellow	Red		
MWO	Red	Green	Green	Yellow	Green	Green		
CWO	Green	Green	Green	Green	Green	Green		

Figure 5: Stoplights for MOS 1 in Operation I, by Rank and Rotation

In a situation where there are multiple concurrent operations underway, a stoplight table can be generated to show the overall operational tempo for several occupations. Figure 6 is an example of how such a table may look for three fictional Operations I, II and III. The colour coding used relates to the personnel / operational tempo. In this example, a colour coding of green implies personnel deploy, on average, at most once in every 10 rotations. The colour yellow indicates personnel deploy at most once in every five rotations, on average. If personnel tend to deploy more than once in every five rotations, the stoplight colour is red. This scale can be changed to reflect other desired perstempo cut-off levels.

	Rank							
Occupation	Cpl/Pte	MCpl	Sgt	WO	MWO	CWO		Legend
MOS 1	Green	Green	Red	Green	Red	Yellow		Op Tempo 9:1
MOS 2	Yellow	Yellow	Yellow	Red	Green	Green		Op Tempo 4:1
MOS 3	Green	Red	Green	Green	Green	Yellow		Op Tempo > 4:1
MOS 4	Red	Green	Red	Yellow	Yellow	Green		
MOS 5	Green	Red	Yellow	Yellow	Red	Green		
MOS 6	Yellow	Red	Green	Red	Yellow	Green		

Figure 6: Stoplights for Operations I, II and III by Occupation and Rank

Stoplight summaries may also be generated for CF establishment positions. In this situation the relevant time line is fiscal year, and the colour coding scale is based on the percentage of positions filled. An example is shown in Figure 7.

	Fiscal Year						
Occupation	1	2	3	4	5		
MOS 1	Green	Green	Green	Green	Green		
MOS 2	Yellow	Red	Green	Red	Red		Legend
MOS 3	Yellow	Green	Green	Red	Green		100% Filled
MOS 4	Red	Green	Yellow	Yellow	Red		80-99% Filled
MOS 5	Green	Green	Red	Red	Yellow		< 80% Filled
MOS 6	Red	Yellow	Yellow	Green	Green		

Figure 7: Stoplight for Establishment Positions by Occupation and Fiscal Year

4.2 Unfilled Positions

The stoplight summaries highlight where / when unfilled positions may occur. It is possible to examine these patterns in greater detail.

For operations positions, patterns in unfilled billets can be examined by any viable combination of operation name, operation rotation, fiscal year, occupation and rank. Unfilled establishment positions patterns can be examined by fiscal year, Level 1 organization, position task type (Standby, FG or Corp), occupation and rank.

Consider the situation in which the CF is involved in three major operations (Operations I, II and III) at the same time. The figures that follow show some of the ways in which unfilled billet patterns can be presented.

Firstly, the unfilled positions in a single operation can be broken down by rotation and military occupation. In Figure 8, the data are grouped by occupation; they could just as easily be grouped by rotation if desired. For a single operation and a single occupation, the number of empty billets can be viewed for each rank. An example of this is shown in Figure 9.

It is also possible to examine patterns across multiple operations. There are many ways to do this, as the rotation schedules of operations are usually not the same, and may not coincide with standard calendar or fiscal year phase markers. Additionally, there will often be more than one instantiation of a position (e.g., for six month rotations) in any given twelve month period.

One approach could be to determine the calendar / fiscal year of an operations position by where the position start date falls. Each instantiation of a position could be considered as a unique data point. The number of unfilled position occurrences by year and operation could then be calculated. In this approach, if a position remains unfilled for two consecutive rotations, the number of occurrences would be counted as two, even though only one position was empty during the year. Figure 10 shows how such a graph could look for three operations running over several years.

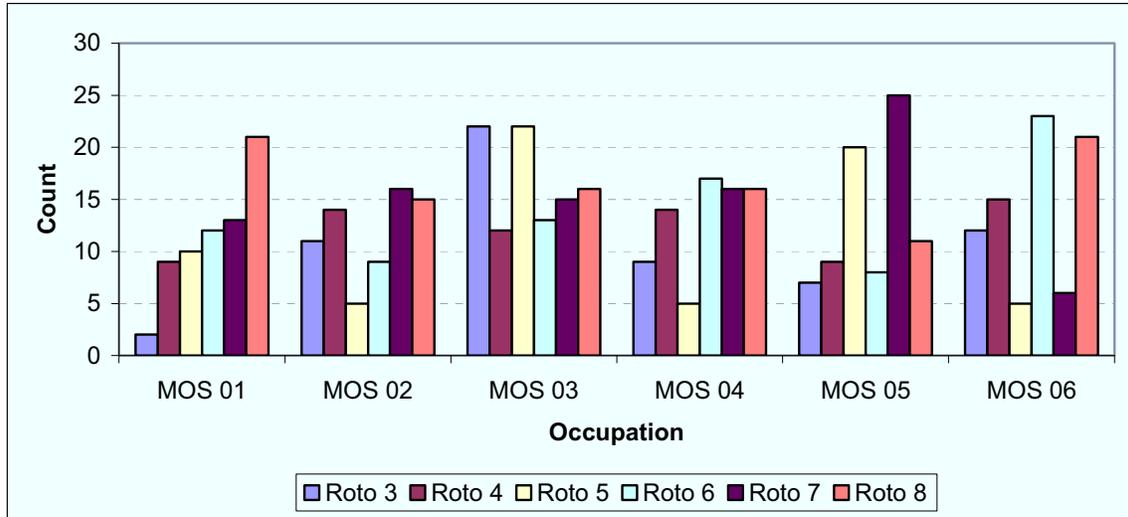


Figure 8: Number of Unfilled Positions in Operation I by Occupation and Rotation

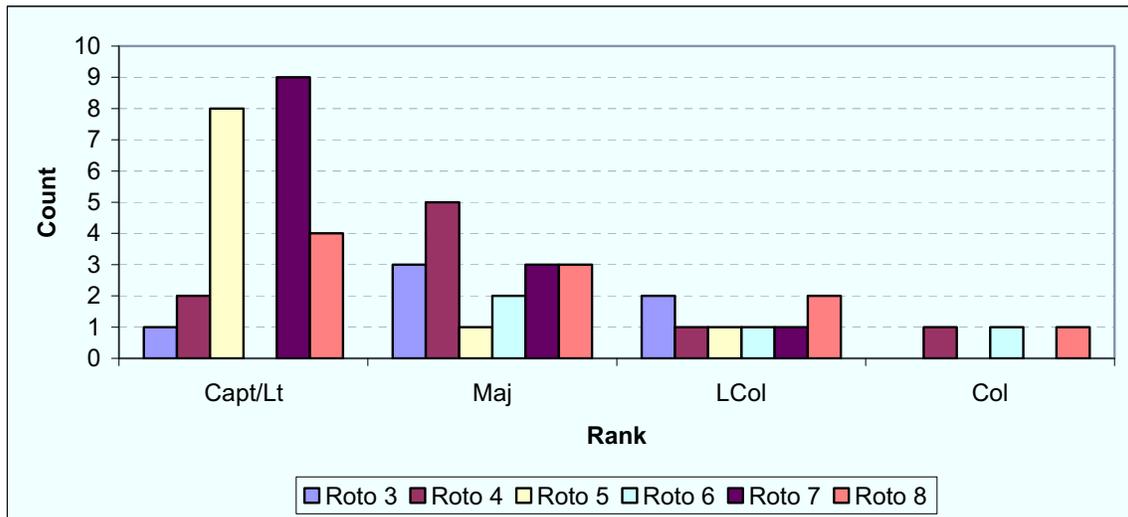


Figure 9: Number of Unfilled Positions in Operation II for Occupation X by Rank and Rotation

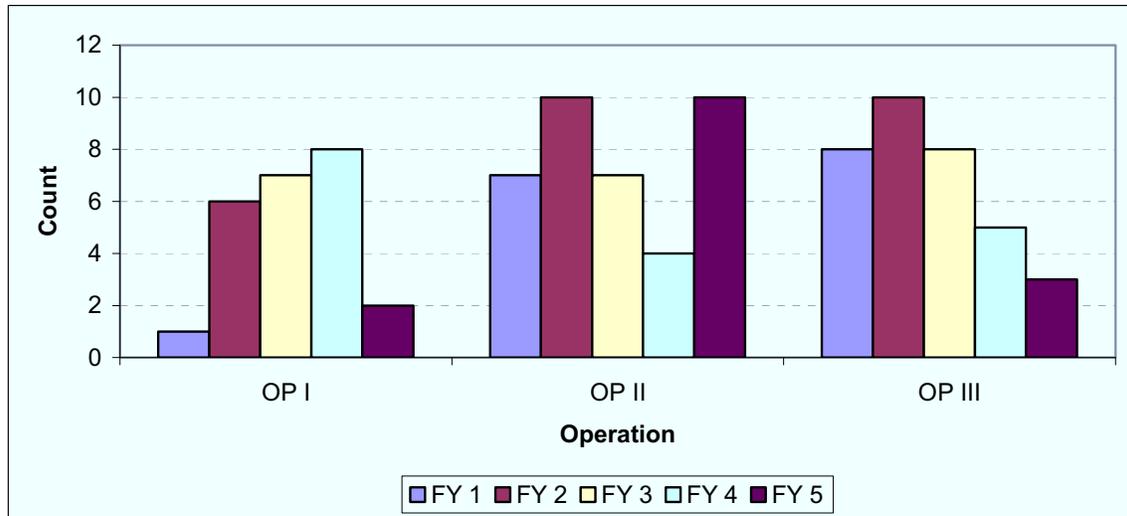


Figure 10: Number of Unfilled Position Occurrences for Operations I, II and III by Fiscal Year

Patterns in unfilled establishment positions can be examined based on such dimensions as task type (Standby, FG or Corp), Level 1 organization, occupation and rank. As with operations positions, determining how best to view establishment position patterns over time can take some thought.

One option is to determine the calendar / fiscal year of an establishment position from the position start date. For each year, the number of positions left unfilled out of those with start dates in that year, can be calculated. This is the number of “new” empty position occurrences observed. Adding to this the number of positions that were left unfilled in previous posting seasons and are still empty⁸, yields the total number of empty position occurrences observed in each year. Figures 11 through 13 provide some examples of graphs that can be generated from the simulation results.

⁸ Instances of establishment positions not filled will remain empty for the duration of that instantiation of the position, which is a period of three years.

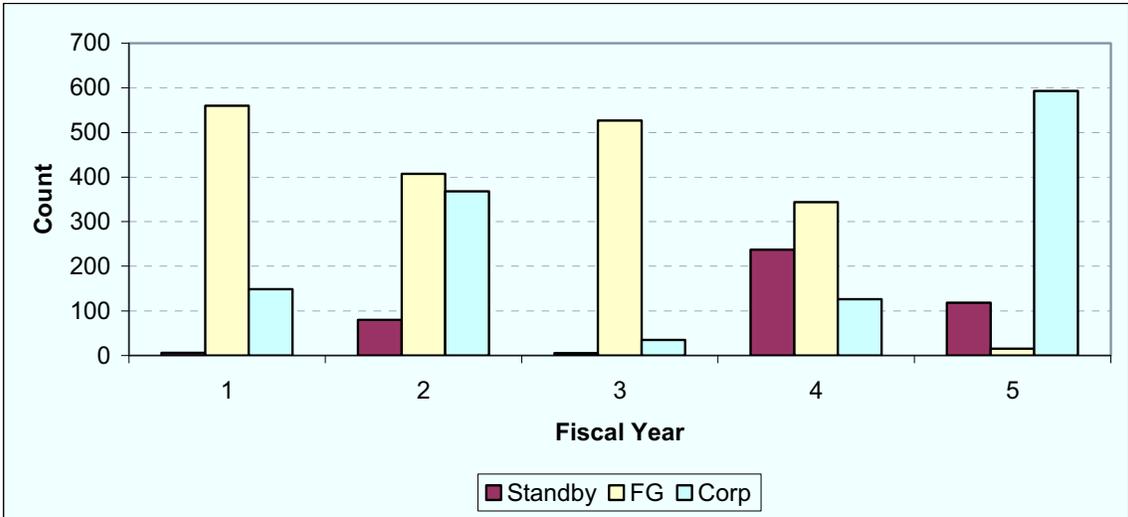


Figure 11: Number of Unfilled Establishment Position Occurrences by Fiscal Year and Task Type

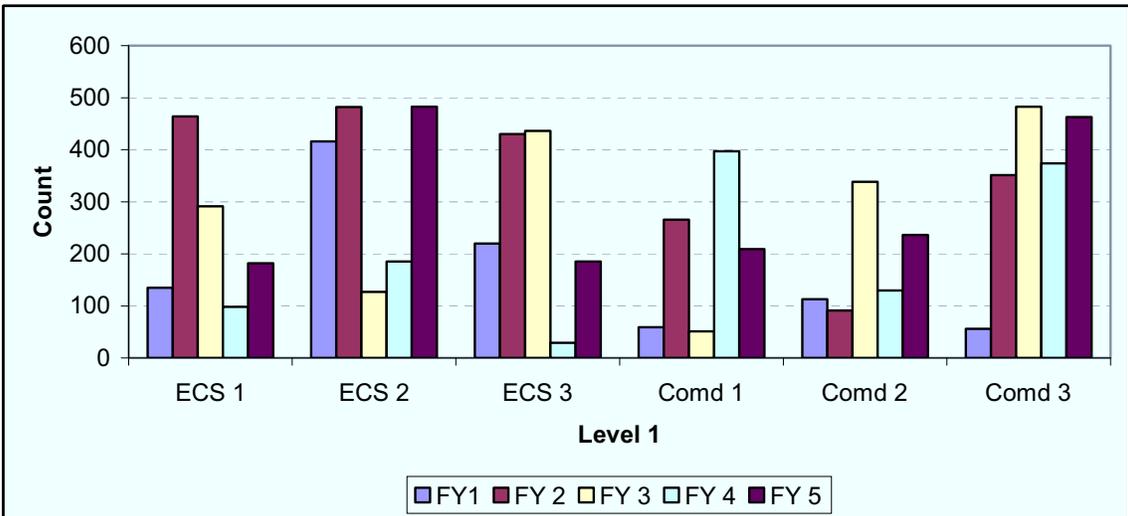


Figure 12: Number of Unfilled Establishment Position Occurrences by Level 1 and Fiscal Year

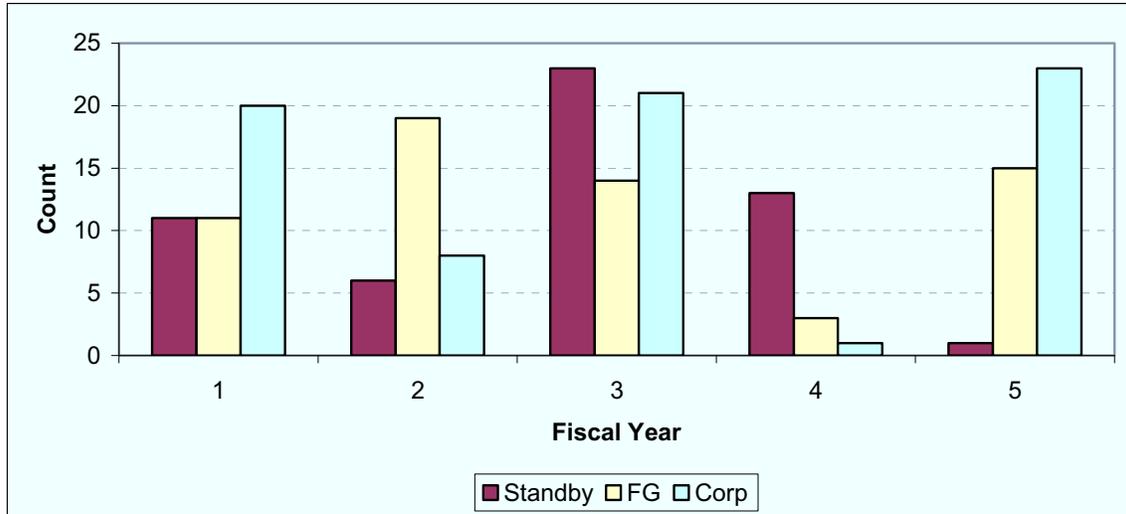


Figure 13: Number of Unfilled Establishment Position Occurrences for Occupation X by Fiscal Year and Task Type

4.3 Operational Waiver Usage

Recall that operational waivers must be signed in order for personnel to deploy again before the exemption period following a previous deployment of 180 days or more is complete. The OSM resorts to the use of waivers only when necessary. As with unfilled operations positions, waiver requirements can be examined by dimensions such as operation rotation, occupation and rank (Figures 14 and 15).

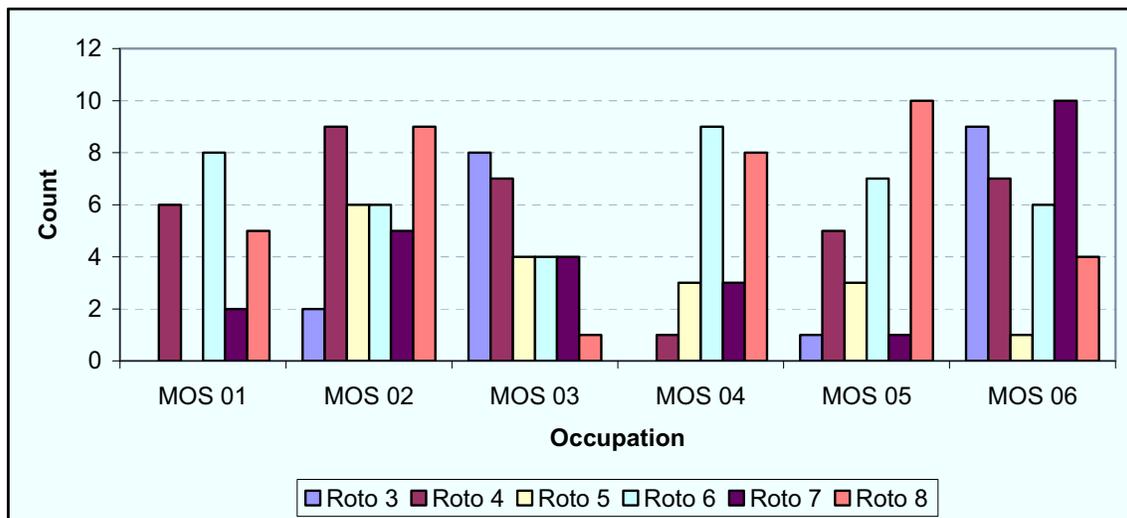


Figure 14: Number of Waivers Used in Operation I by Occupation and Rotation

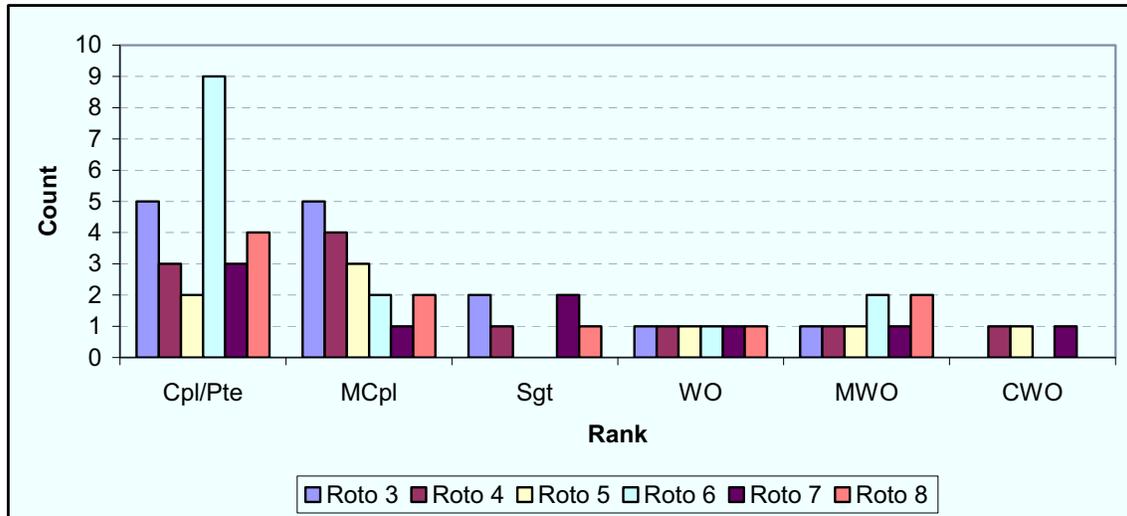


Figure 15: Number of Waivers Used by Occupation X in Operation II by Rank and Rotation

When there are multiple operations being conducted over the simulation time frame, the total waiver usage pattern can be investigated. Figure 16 shows one type of graph that can be produced to show the combined waiver demand.

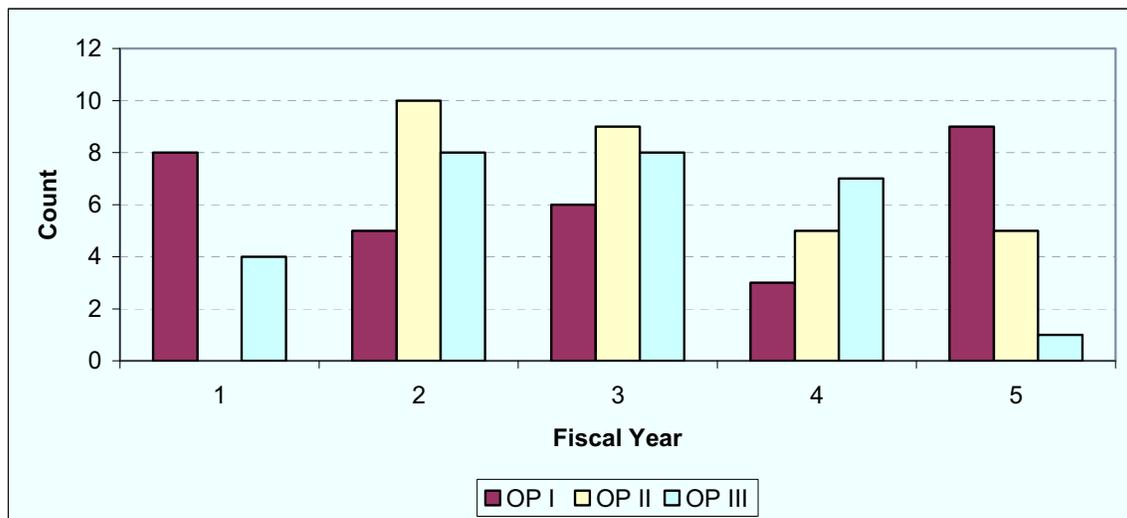


Figure 16: Number of Waivers Used by Occupation X in Operations I, II and III by Fiscal Year

4.4 Not Enough People versus Not Enough People in the “Right Place”

As described in Section 2.2.1, one of the underlying philosophies of the OSM is that deployed operations billets should be filled by personnel from deployable establishment positions; establishment positions with FG or Corp functions should not be emptied to staff international

operations billets. Within the simulations, a flag is used to filter out personnel currently in non-deployable establishment positions from the list of possible nominees to operations positions.

When the pool of potential nominees to operations positions is restricted to those in Standby establishment positions only, two possible causes of personnel shortages are: there are insufficient personnel in deployable units / positions to sustain the operation; or, there are insufficient personnel across the CF. Which is the case?

To help answer this question the filtering flag can be turned off. This allows all personnel in the establishment, regardless of the type of position they currently hold, to be considered for deployment to international operations. If any operations' positions cannot be filled, the reason could be that insufficient personnel with the requisite rank and occupation specifications exist within the CF to sustain the operation(s).

Consider the following example, for a fictitious Operation I. Firstly, the OSM is run with the "personnel from deployable positions only" flag turned on. This means that only those personnel in Standby establishment positions can be nominated for deployment on this operation. Unfilled operational billets are identified as shown in Figure 17. A simulation is then run with the flag turned off; all personnel in the establishment, regardless of the nature of the position currently held, are potential nominees to billets in Operation I. Figure 18 shows the resulting unfilled position pattern for the same set of occupations.

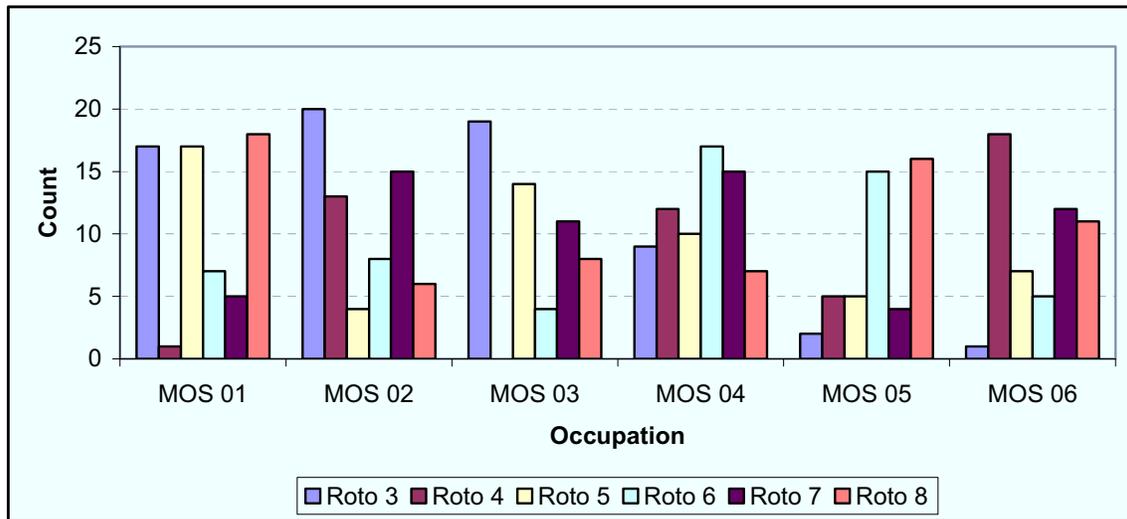


Figure 17: Unfilled Positions in Operation I when Nominations are Restricted to Personnel in Standby Establishment Positions

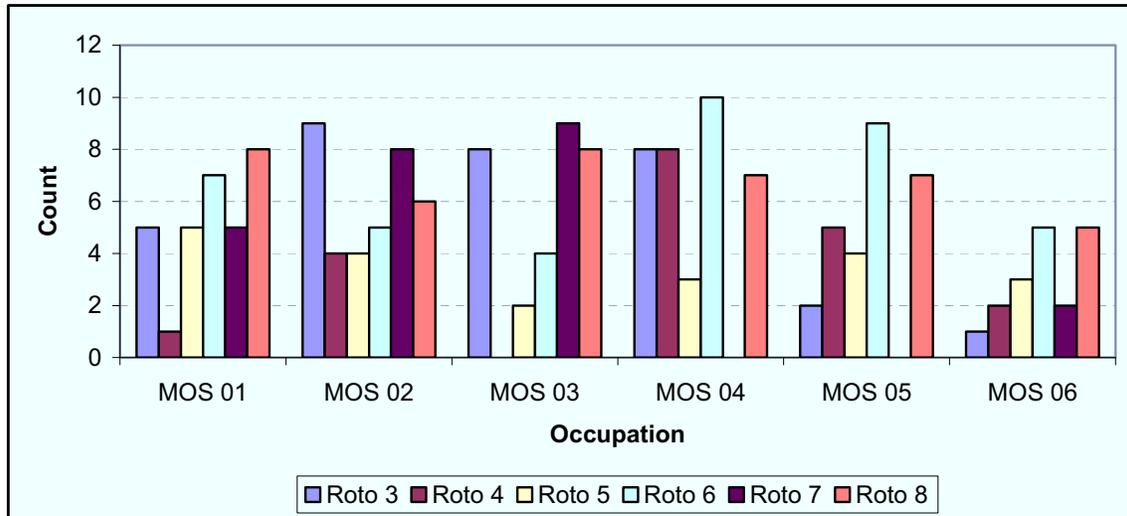


Figure 18: Unfilled Positions in Operation I when Nominations are Opened to Personnel from all Establishment Positions

Consider the simulation results for occupation MOS 04 in Rotation 7. If nominations are restricted to personnel from Standby establishment positions only, it is anticipated that 15 positions in Rotation 7 will remain unfilled. If nominations are opened up to all members of the establishment, the picture changes: no empty billets are expected.

This type of result suggests there are sufficient personnel in occupation MOS 04 to meet the requirements of Operation I in Rotation 7⁹, but not enough of them are in Standby establishment positions. In order to fill these 15 billets with Regular Force personnel, other MOS 04 members will need to be extracted from their current FG or Corp function postings. This will leave empty positions in the establishment that will need to be back filled in some manner.

A somewhat different outcome is shown for occupation MOS 06 in Rotation 6. Five positions are expected to remain unfilled, regardless of whether or not nominations are restricted to personnel in Standby establishment positions only. In this case, it would appear that there are insufficient personnel in MOS 06 to meet the requirements of Operation I in Rotation 6. Unless new personnel can be found to fill these positions (e.g., Reserve Force members or contractors), they are likely to remain empty.

Comparison of simulation results with the “deployable only” flag (restricting deployed operations positions nominees to personnel from deployable establishment positions) turned on and off, helps users to assess whether shortages are due to not enough personnel or not enough personnel in the “right place”. This information can assist in assessing impacts of planned or anticipated changes in the structure of the CF establishment on the Forces’ ability to sustain operations.

⁹ Recall that the OSM does not take occupation sub-specialty requirements into consideration. Thus, the results imply that if there is no demand for sub-specialty qualifications, then there are sufficient personnel in the occupation to meet operational demands.

5 Conclusion

The Operational Sustainability Model has been built to assist CANOSCOM and CMP efforts to ensure effective and efficient management of joint operational support personnel. The objective of the OSM is to provide projections of where and when personnel shortages may occur, as a result of operational demands, over a planning horizon of up to five years.

The inputs to the model fall into three general categories:

- the demand - A list of all positions (for both operations and the establishment) that are to be filled on a rotating basis over a period of up to five years;
- the supply - A snapshot in time of Regular Force personnel demographics; and
- constraints, such as personnel tempo policies for international operations.

Given these inputs, the model determines where (e.g. occupation, rank, Level 1 organization) and when (e.g. operation rotation, fiscal year) personnel shortages may occur during the time period examined. More specifically, the main results obtainable from the OSM are projections of:

- operations and establishment positions that may not be filled;
- operational waiver usage patterns; and
- personnel / operational tempo statistics.

The results can be broken down by timeline (fiscal / calendar year, operation rotation), task type (Ops, Standby, FG or Corp function), Level 1 organization, occupation and rank. Example graphics were provided in the paper to show how the simulation results can be easily presented for interpretation.

In default mode, the OSM follows the philosophy that only personnel in deployable establishment positions should be posted into deployed operations billets. Running the OSM in this mode helps to assess whether or not there are sufficient personnel in high readiness units and other deployable positions to sustain operational demands.

Turning off the default mode opens up staffing of operational billets to all members of the CF establishment, regardless of the function of the position the person currently holds. Running the OSM in this second mode assists with the assessment of whether or not sufficient personnel exist within the CF as a whole to sustain operational demands. By conducting what-if style analyses, potential impacts of changes in establishment structure on the CF's ability to sustain operations, can be examined.

The development of the OSM has provided CANOSCOM and CMP with a tool for assessing the ability of the CF to sustain operations from a human resources perspective. Given known and anticipated personnel demands over a planning horizon of up to five years, the OSM can provide advance warning of where and when personnel tempo stresses may occur. By being made aware of potential problems before they occur, decision makers can be proactive in putting in place policies and/or practices to prevent the problems, or at least lessen their negative impacts.

5.1 Key Model Caveats

Simulation results from the OSM must be interpreted subject to the caveats imposed by the simulation design, the input data, and the underlying assumptions that have been made.

The classification of all CF establishment positions by deployment status (deployable or non-deployable) and task type (Standby, FG and Corp) has not been validated by any organizations or SMEs outside of CANOSCOM COST. As these classifications play a fundamental role in the filling of operations and establishment positions, any significant changes could have a noticeable impact on the simulation results.

A second key input to the model is the perstempo policy for international operations. For deployments of less than 60 consecutive days, the policy states that the granting of post-deployment exemption periods is discretionary. The OSM does not attempt to grant personnel an exemption period after such short deployments. Thus, during a simulation it is possible for individuals to be tasked for short deployments repeatedly, with little or no rest between these taskings.

It must be remembered that the OSM assumes a static supply of personnel; demographic changes over time due to factors such as attrition, promotion, recruitment and occupational transfers are not taken into account. Thus the impacts of changes in the number of personnel at a given rank level within an occupation are ignored.

The current implementation of the OSM ignores occupational sub-speciality qualifications and requirements. This is due to data quality issues, specifically for sub-speciality requirements of international operation positions. As a result, the personnel tempo status of sub-speciality groups within occupations is not examined. For those positions that do have a sub-speciality requirement, the size of the pool of potential nominees to the position will be overestimated, possibly resulting in an underestimation of the personnel tempo for the parent occupation.

The application of the LOB principle reduces the size of the pool of personnel available to fill operational billets. This principle is applied during the nomination process, but not thereafter. Thus, the OSM is not taking into account non-combat losses during pre-deployment training or any losses during the deployment itself. Additionally, the overall LOB rate of 15% and its distribution over time have not been validated by SMEs. Changes to the overall rate and/or distribution would certainly have an impact on the simulation results.

The simulation results are also sensitive to the rates used to determine the level of Reserve Force augmentation for deployed operations. These rates, which are declared for each rank and occupation combination, should be based on relevant historical patterns. In the absence of such data, assumptions on the allowable level of augmentation will need to be made; different assumptions can lead to differing simulation results.

Finally, it must be stressed that while the OSM does emulate the annual posting process at a macro level, it is not a career management tool. The aim of the OSM is to project aggregate patterns, not to trace the career progression of individuals. Within a simulation, postings are made based only on the rank and occupation requirements of the positions; the appropriateness of a

posting for an individual (in terms of individual career progression, succession planning, etc.) is not considered.

5.2 Future Work

The current version of the OSM assumes a known and fixed timeline for all operations and tasks to be conducted over the simulation period. That is, the start and end dates of all positions to be filled on a rotating basis over the simulation period, must be known in advance, and recorded in the appropriate input data table. This is somewhat unrealistic as the timing and duration of some operations, such as humanitarian assistance missions, cannot be predicted in advance. In Phase III of model development, functionality will be added to allow the timings and lengths of some missions to be randomly generated during the simulation, based on assumptions as to how often such missions could be expected to occur.

Recall that the perstempo policy does not preclude individuals from being tasked for short deployments (less than 60 days) repeatedly, with little or no rest between such deployments. Given that most short deployments of joint operational support personnel are at the start and end of rotations, and last for only a few weeks, this shortcoming in the current OSM implementation should not be of concern for analyses of joint operational support occupations. Should the OSM be used to analyse other occupations, problems could arise. For example, aircrews are often deployed on 56 day tours. The OSM could deploy members of an aircrew on consecutive tours indefinitely. Efforts will be made in Phase III to develop additional model logic that would prevent such patterns from occurring.

Phase IV will involve replicating the OSM within the Managed Readiness Simulator (MARS) tool developed by the Land Force Operational Research Team. The general objective of MARS is to assess the ability of forces to sustain a managed readiness plan over time. It is a much larger and more complicated model than the OSM. In some respects the OSM is a “mini MARS”.

MARS development was well underway when the OSM project was initiated, and MARS was considered as a potential solution to address CANOSCOM’s analysis needs. However, MARS was not yet mature enough to provide the required analysis results. Additionally, MARS’ ongoing development timelines were not appropriate for the needs of the OSM project. It was thus decided to go ahead with OSM development to support CANOSCOM, but to do so with the eventual goal of combining the OSM and MARS.

It is anticipated that all of the capabilities required by and nested within the OSM will also be inherent in MARS. This will be investigated during Phase III of OSM development, to prepare for Phase IV. Should it not be possible to replicate the OSM within MARS, the two models will remain independent of each other.

References

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Annex A Formulae and Calculation Details

A.1 Perstempo Status Change Date Formulae

The perstempo status change dates are calculated based on the timing and length of international operation deployments, and the personnel tempo policy.

A.1.1 Perstempo Calculations for the Initial Population Snapshot

For the initial population snapshot, each person's most recent international operation deployment is referenced. This could be a deployment in the past, or in the future if upcoming rotations of operations have been entered into CFTPO and nominees for the positions identified.

Let E represent the end date of an individual's most recent international operation deployment, and L represent the length of the deployment in days. The person's "Go Green", "Go Yellow" and "Go Orange" dates are calculated as shown in Equation A.1.

$$\begin{aligned} GoGreen &= \begin{cases} E & L < 60 \\ E + 2 * L & 60 \leq L < 180 \\ E + 365 & L \geq 180 \end{cases} \\ GoYellow &= \begin{cases} E & L < 180 \\ E + 365 & L \geq 180 \end{cases} \\ GoOrange &= \begin{cases} E & L < 180 \\ E + 60 & L \geq 180 \end{cases} \end{aligned} \tag{A.1}$$

As mentioned in Section 2.2.2, for individuals without an international operation deployment record in CFTPO, the "Go Green", "Go Yellow" and "Go Orange" dates are set to the person's hire date plus two or six years, for NCMs and Officers respectively.

A.1.2 Perstempo Calculations During the Model Simulations

During the Operational Sustainability Model simulations, updating of individuals' perstempo status change dates is based on three components: the end date and length of the deployment to which the person has just been nominated; the person's perstempo status prior to the new deployment; and the perstempo policy.

Let E represent the end date of the international operations position to which the individual has just been nominated and as before, let L represent the length of the deployment in days. The individual's perstempo status as of the position start date will either be Green, Yellow or Orange. If the status is Yellow or Orange, then the individual's recommended exemption period is being

cut short, and the OSM attempts to return this unused exemption time to the individual after the new deployment.

Let T_Y and T_O represent the time remaining in the individual's Yellow and Orange status, respectively, as of the position start date. Table A.1 shows how these values are used to update the perstempo status change dates for each nominee to an international operations position.

Table A.1: Formulae for Updating Perstempo Status Change Dates

Colour Status		Deployment Length		
Pre-Deployment	Post-Deployment	< 60 days	60 to 170 days	180+ days
Green	Green	E	$E + 2*L$	$E + 365$
Yellow	Green	$E + T_Y$	$E + \min[2*L + T_Y, 365]$	$E + 365$
Orange	Green	$E + T_O$	$E + \min[2*L + T_O, 365]$	$E + 365$
Green, Yellow, Orange	Yellow	E	E	$E + 365$
Green, Yellow, Orange	Orange	E	E	$E + 60$

A.2 Position List Ordering by Stringency of the Position Requirements

As discussed in Section 2.6, the list of positions to be filled over time is ordered in the following manner:

1. chronologically by the Nominate-By date;
2. by Vice Chief of Defence Staff (VCDS) Manning Priority, with the highest priority positions listed first;
3. by the *stringency of the rank and occupation requirements* of the position;
4. by MOS ID;
5. by the lowest rank requirement of the position; and lastly
6. by the highest rank requirement of the position.

Criterion number three refers to the level of detail in the position's rank and occupation specifications. Some positions require a nominee from one specific occupation and of one

specific rank; others require a nominee from any one of a group of occupations and a range of possible ranks. The first example is more stringent in its requirements than the second.

Positions with the same Nominate-By date and VCDS priority will be sorted to appear in the following order:

- First: positions with a single occupation and single rank specification;
- Second: positions with a single occupation and multiple acceptable ranks specification;
- Third: positions with multiple acceptable occupations but a single rank specification; and
- Fourth: positions with multiple acceptable occupations and multiple acceptable ranks specification.

A.3 Potential Nominee Scoring Formulae

Each possible nominee to a position (Operations, Standby, FG and Corp) is assigned a score. The individual with the highest score is nominated to the position in question. There is a set of scoring formulae to choose from; which one is used depends on the task type of the position to be filled.

A.3.1 Scoring Formulae for Operations Positions

The score assigned to each potential nominee to an international operations position is based on five factors:

- the perstempo status of the individual as of the position start date;
- how long the individual has had that status, as of the position start date;
- the individual's rank;
- the task type of the individual's current (pre-nomination) position; and
- how far into the reporting period the individual can report for duty.

The most important factor is the perstempo status; the CF personnel tempo policy must not be violated. Next in importance are the length of time an individual has had their perstempo status, and the task type of the position the person is currently occupying. The OSM aims to distribute the operational burden as equitably as possible by trying to deploy those who have been away from operations the longest first, and by posting personnel recently returned from operations to non-operational positions.

Let C represent the perstempo status (Green, Yellow or Orange) of the individual as of the position start date. The number of days the person has been Green, Yellow or Orange, as of the position start date, are denoted by D_G , D_Y , and D_O respectively. Let R be the numeric value associated with the individual's rank (ranging from 1 for General, to 18 for Private). The baseline score assigned to an individual is calculated as follows:

$$BaselineScore(C) = \begin{cases} 1,000,000,000 + 100 * D_G + R & C = Green \\ 1,000,000 + 100 * D_Y + R & C = Yellow \\ 1,000 + 100 * D_O + R & C = Orange \end{cases} \quad (A.2)$$

The baseline score can be increased or decreased based on the last two factors listed above. Let K be the task type of the individual's current (pre-nomination) position. The new score assigned to the person is given by:

$$NewScore(K) = \begin{cases} BaselineScore(C) + 10,000 & K = FG \text{ or } Corp \\ BaselineScore(C) & K = Standby \text{ or } Ops \end{cases} \quad (A.3)$$

For operations positions the reporting period is assumed to be one day; either nominees can begin pre-deployment training on that day, or they cannot. However, the model logic exists to accommodate the situation wherein there is a range of consecutive days during which the nominee can commence pre-deployment training. As long as the nominee's perstempo status becomes a minimum of Orange before the end of the reporting period, s/he can report for duty in time.

Let D_L (days "late") represent the number of days after the start of the reporting period that a potential nominee would be able to start pre-deployment training. D_L cannot be more than the number of days in the reporting period itself. The final score assigned to a potential nominee for an international operations position is calculated as:

$$FinalScore = \begin{cases} NewScore(K) + 1,000 & D_L = 0 \\ NewScore(K) - 10 * D_L & D_L > 0 \end{cases} \quad (A.4)$$

A.3.2 Scoring Formulae for Standby Positions

The score assigned to each potential nominee to a Standby establishment position is based on five factors:

- how long the individual has been eligible for a posting, as of the end of the reporting period;
- how long the individual has had a perstempo status of Orange, as of the end of the reporting period (i.e. how long since the last international operations deployment);
- the individual's rank;
- the task type of the individual's current (pre-nomination) position; and
- how far into the reporting period the individual can report for duty.

Let D_{APS} represent the number of days between the individual's APS date (the date on which s/he is eligible for a new posting) and the end of the reporting period for the new position. The number of days the person has been Orange as of the reporting period end date, is denoted by D_O . As before, R is the numeric value associated with the individual's rank. The baseline score assigned to a potential nominee to a Standby establishment position is calculated as follows:

$$BaselineScore = 1,000 * D_{APS} + 100 * D_O + R \quad . \quad (A.5)$$

The baseline score can be increased or decreased based on the task type of the individual's current (pre-posting) position and how far into the reporting period s/he can report for duty. Taking into account the task type variable (denoted by K), the new adjusted score is given by:

$$NewScore(K) = \begin{cases} BaselineScore + 1,000,000 & K = FG \text{ or } Corp \\ BaselineScore & K = Standby \text{ or } Ops \end{cases} \quad . \quad (A.6)$$

For Standby establishment positions the reporting period is assumed to be two months in length; nominees can report for duty on any day in this time window. As long as the nominee's APS and "Go Orange" dates occur before the end of the reporting period, s/he can report for duty in time.

Let D_L (days "late") represent the number of days after the start of the reporting period that a potential nominee would be able to start work in the new position. As before, D_L cannot be more than the number of days in the reporting period itself. The final score assigned to a potential nominee for a Standby establishment position is calculated as:

$$FinalScore = \begin{cases} NewScore(K) + 1,000 & D_L = 0 \\ NewScore(K) - 10 * D_L & D_L > 0 \end{cases} \quad . \quad (A.7)$$

A.3.3 Scoring Formulae for FG and Corp Positions

The score assigned to each potential nominee to a FG or Corp establishment position is based on five factors:

- how long the individual has been eligible for a posting, as of the end of the reporting period;
- how long the individual has had a perstempo status of Orange, as of the end of the reporting period (i.e. how long since the last international operations deployment);
- the individual's rank;
- the task type of the individual's current (pre-nomination) position; and
- how far into the reporting period the individual can report for duty.

Retaining the previous definitions of D_{APS} , D_O and R , the baseline score assigned to potential nominees to a FG or Corp establishment position is calculated as follows:

$$BaselineScore = 1,000 * D_{APS} + 100 * D_O + R \quad . \quad (A.8)$$

The baseline score can be increased or decreased based on the task type of the individual's current (pre-posting) position and how far into the reporting period s/he can report for duty. Taking into account the task type variable (denoted by K), the new adjusted score is given by:

$$NewScore(K) = \begin{cases} BaselineScore + 1,000,000 & K = Standby \text{ or } Ops \\ BaselineScore & K = FG \text{ or } Corp \end{cases} \quad . \quad (A.9)$$

For FG and Corp establishment positions the reporting period is assumed to be two months in length; nominees can report for duty on any day in this time window. As long as the nominee's APS and "Go Orange" dates occur before the end of the reporting period, s/he can report for duty in time.

Recall that D_L (days "late") represents the number of days after the start of the reporting period that a potential nominee would be able to start work in the new position. The final score assigned to a potential nominee for a FG or Corp establishment position is calculated as:

$$FinalScore = \begin{cases} NewScore(K) + 1,000 & D_L = 0 \\ NewScore(K) - 10 * D_L & D_L > 0 \end{cases} \quad . \quad (A.10)$$

List of abbreviations/acronyms

APS	Active Posting Season
CANOSCOM	Canadian Operational Support Command
CF	Canadian Forces
CFDS	Canada First Defence Strategy
CFTPO	Canadian Forces Taskings Plans and Operations
CMP	Chief Military Personnel
CORA	Centre for Operational Research and Analysis
Corp	Corporate
COST	Chief of Operational Support Transformation
DGMPRA	Director General Military Personnel Research and Analysis
DND	Department of National Defence
DRDC	Defence Research & Development Canada
DRDKIM	Director Research and Development Knowledge and Information Management
DSMPRA	Directorate of Strategic Military Personnel Research and Analysis
FG	Force Generation
HRMS	Human Resources Management System
LOB	Left Out of Battle
MARS	Managed Readiness Simulator
MOS ID	Military Occupational Structure Identification
NCM	Non-Commissioned Member
OSM	Operational Sustainability Model
Perstempo	Personnel Tempo
PORT	Personnel Operational Research Team
R&D	Research & Development
SME	Subject Matter Expert
TES	Trained Effective Strength
TFA	Task Force Afghanistan
VCDS	Vice Chief of the Defence Staff

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In 2007, the Canadian Operational Support Command requested the development of a tool set to assist with management of joint operational support personnel. The Operational Sustainability Model (OSM), a discrete event simulation tool for examining personnel tempo, is one component of this tool set. The aim of the OSM is to help assess the ability of the Canadian Forces (CF) to meet the personnel demands of operations over a planning horizon of up to five years, by providing projections of personnel shortages in both operations and the establishment, and personnel tempo patterns. Additionally, the OSM can be used to examine potential future impacts of changes in the CF establishment structure on the CF's ability to sustain operations. The purpose of this report is to describe the data requirements, assumptions and logic of the OSM. Examples of the types of results that can be produced are shown, but no actual analysis of the CF's ability to meet the personnel demands of current or future operations is presented.

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