Defence Research and Development Canada
Recherche et développement pour la défense Canada

Decision Support Capability for In-Theatre Logistics Planning and Sustain Missions – Problem Definition

Jean Berger
DRDC Valcartier

Abdeslem Boukhtouta
DRDC CORA CANOSCOM

Snezana Mitrovic-Minic and John Conrad
MDA Systems Ltd.

Defence R&D Canada – Valcartier
Technical Memorandum
DRDC Valcartier TM 2013-321
November 2012

Canada

Decision Support Capability for In-Theatre Logistics Planning and Sustain Missions – Problem Definition

Jean Berger
DRDC Valcartier

Abdeslem Boukhtouta
DRDC CORA CANOSCOM

Snezana Mitrovic-Minic and John Conrad
MDA Systems Ltd.

Defence R&D Canada – Valcartier

Technical Memorandum
DRDC Valcartier TM 2013-321
November 2012

Abstract

Canadian Forces (CF) are expected to evolve in adaptive dispersed operations characterized by future security environments (FSE) and time-varying, hostile and uncertain contexts which involve major challenges in delivering effective and efficient In-Theatre logistics and sustainment. This document introduces background information on current CF In-Theatre logistics organization and defines a contextual problem setting for the development of new technology concepts for a sustainment management decision support system capability. The proposed supply network distribution problem setting is believed to offer a suitable context for better defining tactical sustainment decision support requirements for adaptive dispersed operations, and developing decision support capability components for In-Theatre logistics planning and sustainment missions. These decision support capability components are mainly aimed at reducing human overload, sense-and-respond cycle, and logistics cost and footprint, as well as closing gaps between information-sharing and decision-making, and between planning and execution monitoring.

Résumé

Les Forces Canadiennes (FC) appelées à évoluer en opérations dispersées adaptatives caractérisées par des environnements de sécurité futurs et des contextes dynamiques, hostiles et incertains comporte des défis importants à assurer une logistique et un soutien efficaces et efficients en théâtre. Ce document présente des informations de base sur l'organisation logistique courante des FC en théâtre d'opérations et définit un cadre de problème contextuel pour le développement de nouveaux concepts technologiques pour une capacité de système d'aide à la décision au soutien des opérations. Le cadre de problème contextuel de distribution proposé pour réseau logistique se veut un cadre approprié afin de mieux définir les exigences tactiques d'aide à la décision pour les opérations dispersées adaptatives, et développer des composantes de capacités d'aide à la décision pour la planification logistique et le soutien de missions en théâtre. Ces composantes de capacités d'aide à la décision visent principalement à réduire la surcharge humaine, le cycle détection-réponse, les coûts et empreinte logistiques, ainsi que combler les lacunes entre le partage d'informations et la prise de décision, et, entre la planification et le suivi d'exécution.

This page intentionally left blank.

Executive summary

Decision Support Capability for In-Theatre Logistics Planning and Sustain Missions – Problem Definition

Jean Berger; Abdeslem Boukhtouta; Snezana Mitrovic-Minic; John Conrad
DRDC Valcartier TM 2013-321; Defence R&D Canada – Valcartier; November 2012.

Introduction or background: Canadian Forces (CF) are expected to evolve in adaptive dispersed operations characterized by future security environments (FSE) and time-varying, hostile and uncertain contexts which involve major challenges to delivering effective and efficient In-Theatre logistics and sustainment (e.g. through asset distribution, inventory management and maintenance).

Results: In-Theatre logistics background information is introduced and a contextual problem setting for the development of new technology concepts for a sustainment management decision support system capability is proposed. We describe CF In-Theatre logistics depicting National Support Element and the tactical supply network components. Main elements, relationships and information flows, current information technology and recent asset visibility capability are briefly described. Some gaps are further highlighted. Based on that information, a limited supply network distribution problem setting is presented, defining increasingly complex nested sub-problems while providing guidance in defining tactical sustainment decision support requirements for adaptive dispersed operations, and decision support capability for In-Theatre logistics planning and mission sustainment.

Significance: The proposed supply network distribution problem setting is believed to offer a suitable context to better define tactical sustainment decision support requirements for adaptive dispersed operations, and develop decision support capability components for In-Theatre logistics planning and mission sustainment. Applicable to Army In-Theatre logistics planning and sustain missions, anticipated technology solutions to be further developed align with some of the objectives stated for the Army of Tomorrow Sustainment concepts for adaptive dispersed operations aimed at providing inter- and intra-theatre asset visibility, adaptive planning and logistics cost and footprint reduction.

Future plans: Future work intends to develop sustain management decision support capability components to address supply network distribution for In-Theatre logistics and mission sustainment. It will consist in further investigating technology concepts revolving around integration platform components to enhance situation awareness and decision support, namely, in providing data access/asset visibility, monitoring, analysis, forecasting, and adaptive planning (distribution, maintenance, supply chain management) respectively.

Sommaire

Decision Support Capability for In-Theatre Logistics Planning and Sustain Missions – Problem Definition

Jean Berger; Abdeslem Boukhtouta; Snezana Mitrovic-Minic; John Conrad
DRDC Valcartier TM 2013-321; Defence R&D Canada – Valcartier; novembre 2012.

Introduction ou contexte: Les Forces Canadiennes (FC) appelées à évoluer en opérations dispersées adaptatives caractérisées par des environnements de sécurité futurs et des contextes dynamiques, hostiles et incertains comporte des défis importants à assurer une logistique et un soutien efficaces et efficients en théâtre (par exemple pour la distribution des actifs, la gestion d 'inventaire et l'entretien).

Résultats: Des informations de base sur l'organisation logistique courante des FC en théâtre d'opérations sont présentées et un cadre de problème contextuel pour le développement de nouveaux concepts technologiques pour une capacité de système d'aide à la décision au soutien est proposé. Le document décrit notamment la logistique des FC en théâtre représentant les composantes d'Élément de Soutien National et de réseau logistique tactique. Les principaux éléments, les relations et les flux d'information, les technologies de l'information actuelle et les récentes capacités de visibilité d'actifs considérées sont brièvement présentées. Certaines lacunes sont également mises en évidence. Sur la base de cette information, un cadre limité de problème de distribution de réseau logistique est présenté, définissant des sous-problèmes imbriquées de plus en plus complexes tout en guidant la définition des exigences tactiques d'aide à la décision pour les opérations dispersées adaptatives, et de capacités d'aide à la décision pour la planification logistique et le soutien de missions en théâtre.

Importance: Le cadre de problème contextuel de distribution proposé pour réseau logistique se veut un cadre approprié afin de mieux définir les exigences tactiques d'aide à la décision pour les opérations dispersées adaptatives, et développer des composantes de capacités d'aide à la décision pour la planification logistique et le soutien de missions en théâtre. Applicables à la planification logistique aux missions de soutien de l'armée en théâtre, les nouvelles solutions technologiques prévus d'être développées s'aligne tout à fait avec certains des objectifs énoncés pour l'armée les concepts de soutien de l'armée de demain pour les opérations dispersées et adaptives et visant à fournir une visibilité des actifs, une planification adaptative, et une réduction des coûts et d'empreinte logistiques inter- et intra- théâtre.

Perspectives: Les travaux futurs viseront à développer des composantes de capacités d'aide à la décision pour aborder la distribution de réseau logistique et le soutien de missions en théâtre. Cela consistera en l'exploration de concepts technologiques, gravitant autour de composantes de plateforme d'intégration pour améliorer l'éveil situationnel et l'aide à la décision, à savoir, fournir l'accès aux données et à la visibilité des ressources, le monitorage, l'analyse, la prévision et la planification adaptative (distribution, entretien, gestion de la chaîne d'approvisionnement).

Table of contents

This page intentionally left blank.

List of figures

List of tables

This page intentionally left blank.

1 Introduction

Canadian Forces (CF) is expected to evolve in adaptive dispersed operations [1] characterized by future security environment (FSE) contexts that involve major challenges to In-Theatre logistics and sustainment. Efficient In-Theatre logistics planning and mission sustainment occurring in dynamic, uncertain and hostile situations demand effective and efficient supply chain management (e.g. through asset distribution, inventory management and maintenance). Current CF technology solutions cannot efficiently support multiple adaptive and distributed missions/operations.

This work presents In-Theatre logistics background information and defines a contextual problem setting for the development of new technology concepts for a sustainment management decision support system capability. Applicable to Army In-Theatre logistics planning and sustainment missions, it aligns with some of the objectives stated for the Army of Tomorrow Sustainment concepts [1] aimed at providing inter- and intra-theatre asset visibility, adaptive planning, logistics cost and footprint reduction. Given reasonable assumptions, problem definition is proposed to further investigate technology concepts revolving around integration platform components to enhance situation awareness and decision support, namely, in providing data access/asset visibility, monitoring, analysis, forecasting, and adaptive planning (distribution, maintenance, supply chain management) respectively. The intended value of the proposed problem setting is to ultimately offer a suitable context to better define tactical sustainment decision support requirements for adaptive dispersed operations, develop decision support components, reduce human overload, sense-and-respond cycle and logistics cost and footprint respectively, and to close gaps between information-sharing and decision-making and, between planning and execution monitoring.

The document is outlined as follows. Chapter 2 and 3 describe CF In-Theatre logistics through the current "as-is" National Support Element and the tactical supply network structure. Main components, relationships and information flows defining the National Support Element and the tactical supply network are briefly presented. We introduce current information technology and recent asset visibility capability in Chapter 4. Based on that information, some limited gap analysis highlighting technology deficiencies is reported in Chapter 5. Chapter 6 proposes an approach to handling key decision problem components to be addressed in the development of a decision support capability for In-Theatre logistics planning and to sustain missions. Based on some assumptions, it focuses on key problems and decision support component solutions to be developed. Finally, a summary is given in Chapter 7.

This work was conducted at DRDC Valcartier between April 2011 and March 2012 through DRDC-ARP DP project 12ss Decision Support Capability for In-Theatre Logistics Planning and Sustain Missions.

This page intentionally left blank.

2 Canadian National Support Element (NSE) Components and Dependencies

This chapter reviews and characterizes the National Support Element (NSE) and its components. It introduces the NSE organizational model including hierarchy components and relationships (with CANOSCOM, deployed units, etc.), respective capabilities, functions/roles and responsibilities. A review of the National Support Element (NSE) and its components and tasks is presented. Next, following sections present a short analysis of the current practices, desirable future directions for the tactical logistic, supporting methodologies and some currently used technologies.

2.1 Current Tactical Logistics in CF: NSE

2.1.1 Logistics Organization and Command Structure

Figure 1 depicts overall organization structure of the CF logistics units involved in operational and tactical logistics in support of CF Joint Task Force (JTF) in theatre. *Operational logistics* in today's Canadian Forces includes/incorporates the procurement, storing and movement of materiel from Canada to an overseas location called A Point of Disembarkation (APOD) or a Seaport of Disembarkation (SPOD). *Tactical logistics* deals with storing and distribution of Materiel from APOD to the deployed CF units. SPODs and APODs are located at a seaport or an airport in theatre by definition.

Operational logistics is the responsibility of the Canadian Expeditionary Force Command (CEFCOM) and Canadian Operational Support Command (CANOSCOM) located in Canada. Tactical logistics is a responsibility of the National Support Element working in tandem with National Command Element J4 staffs as well as battle group/Canadian Task force logistics companies.
To get a rough idea of the size of the support units currently and in the past, we provide two examples:

- Afghanistan: 300-900 support personnel for around 2,500 soldiers
- WWII: 10,000 support personnel at "army level" to support 20,000 soldiers (in one of the four Canadian Divisions)

The following paragraphs describe the main elements of CF involved or partially involved in the logistics activities.

Canadian Expeditionary Force Command (CEFCOM): CEFCOM is the operational command responsible for planning and conducting military operations ranging from humanitarian aid through peace support to combat, in concert with national and international partners - in support of the Government Canada's foreign policy objectives.

Canadian Operational Support Command (CANOSCOM): A departmental organization created in January 2006 to support all military operations - both overseas and here in Canada. Headquartered in Ottawa, although the tiny CEFCOM J4 staff is responsible for initiating

expeditionary logistics planning, CANOSCOM is responsible for adding the wealth of detail to operational logistics plans and delivering national-level operational support, including providing the logistics for theatre activation (setting up in-theatre operation), its sustainment, and for coordinating the logistic support beyond the capabilities of the tactical NSE. Its tasks also include managing the main supply depots in Canada [2]. Although located in Canada, some personnel of some units of CANOSCOM may be located at APOD. The units of CANOSCOM that are designed to telescope support forward may include, for example, 3 Canadian Support Group (3 CSG) in Montréal and the Canadian Forces Movement Control Unit (4 CFMCU) also in Montréal. These CANOSCOM units provide technical SCN and movement support respectively. In truth, any element of CANOSCOM could be tasked into the area of operation (AOO) for technical assistance. This does not mean that full CANOSCOM units deploy in to theatre – not at all. That is not their purpose nor are they equipped or trained for such tactical work.

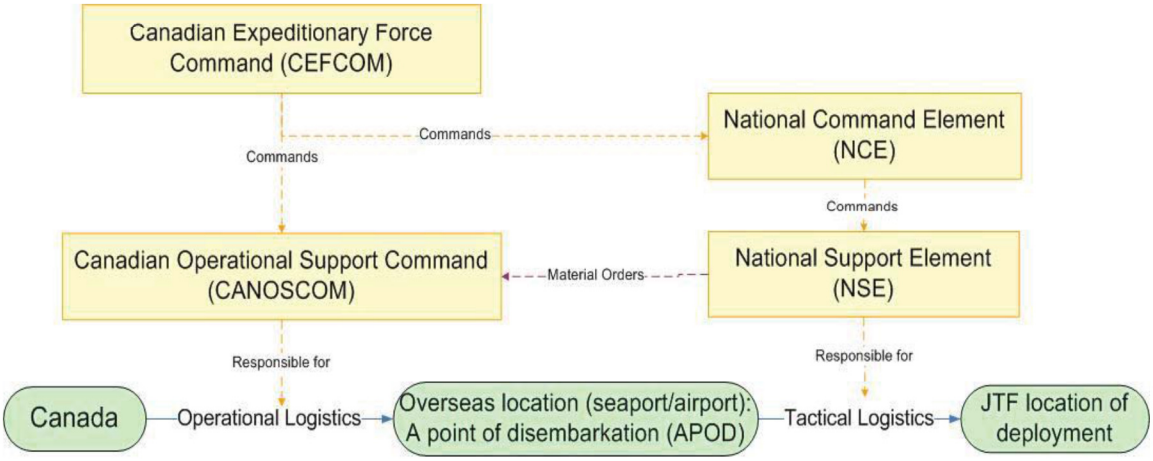

Figure 1. Overall Structure of the CF logistics Units with their Roles and Territorial Responsibilities

National Command Element (NCE): National headquarters in AOO.

NCE J3 Team (Staff): The NCE personnel responsible for the current operations of the Canadian Task Force. As such, J3 has a deep interest in the Canadian-specific aspects of logistics – including, for example, Canadian ammunition holdings in the AOO.

NCE J4 Team (Staff): The NCE personnel with focus on logistics matters.

National Support Element (NSE): Currently, a Canadian Forces unit, based at Kandahar Air Field, consisting of approximately 730 military, civilian, and contract personnel (as per SME's knowledge). It sustains the Task Force Afghanistan combat operations by providing a range of support services, including warehousing and supplies, supply convoys, equipment maintenance, and food services.

NSE also represents the main intermediate point in transferring supplies from Canada (or local suppliers) to the deployed CF units.

Figure 2 shows the dependencies between the CF and the North Atlantic Treaty Organization (NATO) logistics units. One should be aware that the dependencies may run high, and that the units may rely heavily on each other and their efficiencies.

Currently, NATO is in favour of reducing the size of NSE of individual nations/countries in order to increase dependencies and to reduce logistics costs. On the other hand, many countries, including Canada, are in favour in keeping separate and robust national NSEs.

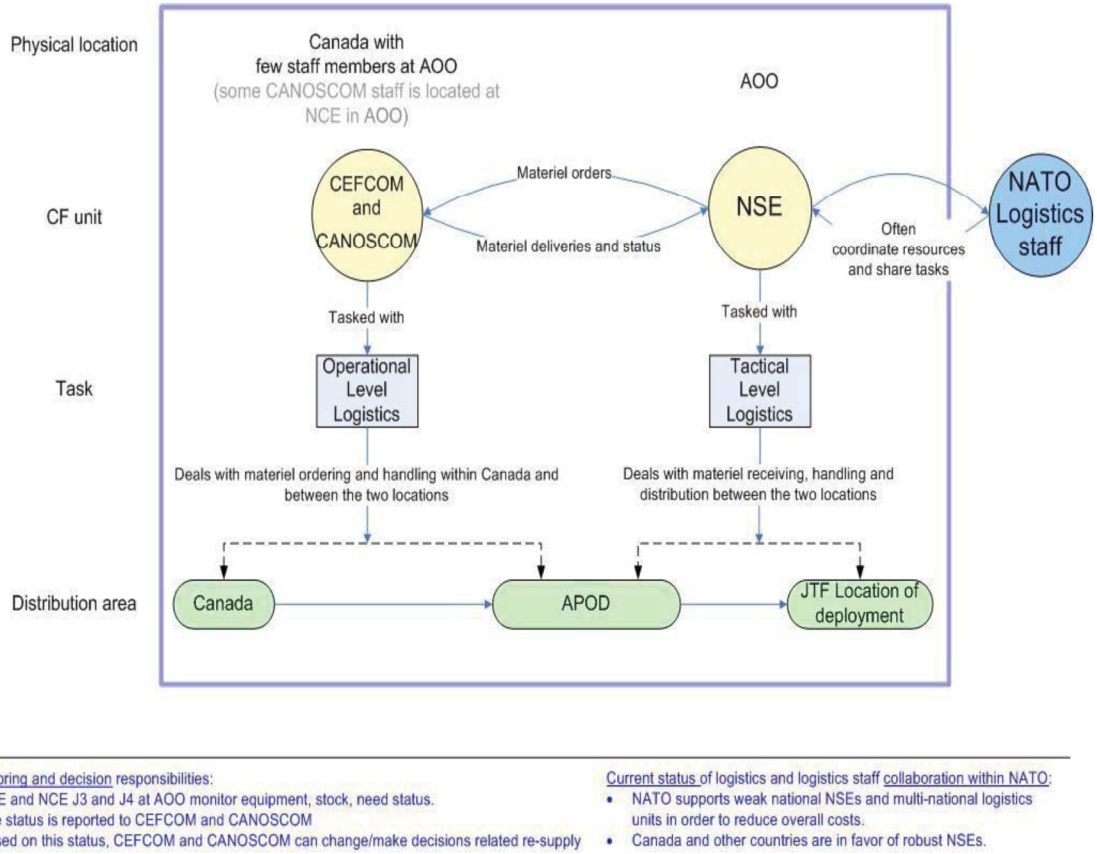

Figure 2 Operational and Tactical Logistics Units (CF and NATO) and their Dependencies

NCE is analogous to the brain of the logistics in AOO, NSE is the 'doer' for the logistics activities in AOO. Having said this, the NCE J4 is always one rank below the rank of the NCE commander. Even though the J4 is the principle staff officer responsible for logistics, the Commander of a logistics unit - be it a service battalion or an NSE is the CSS (logistics) specialist adviser to a Canadian Commander.

The main two staff branches of the NCE related to logistics are the J3 and J4 Branches. However, monitoring stocks, supplies, inventories and needs is done by NSE, NCE J3, and NCE J4. The status is usually reported to CEFCOM and CANOSCOM, where their relationships are similar to NCE and NSE.

A more detailed diagram of the Materiel distribution system is given in Figure 3. Location nodes consist of five tiers and includes the following:

- Military bases, inventories, and factories in Canada (Tier 1)
- Main delivery base in Canada (Tier 2)
- APOD (main base or bases in AOO) (Tier 3)
- Forward Operating Bases (FOB) in AOO where supply will also be kept or that will act as a meeting point between NSE staff and JTF soldiers (Tier 4)
- Location of deployment of JTF units (Tier 5)

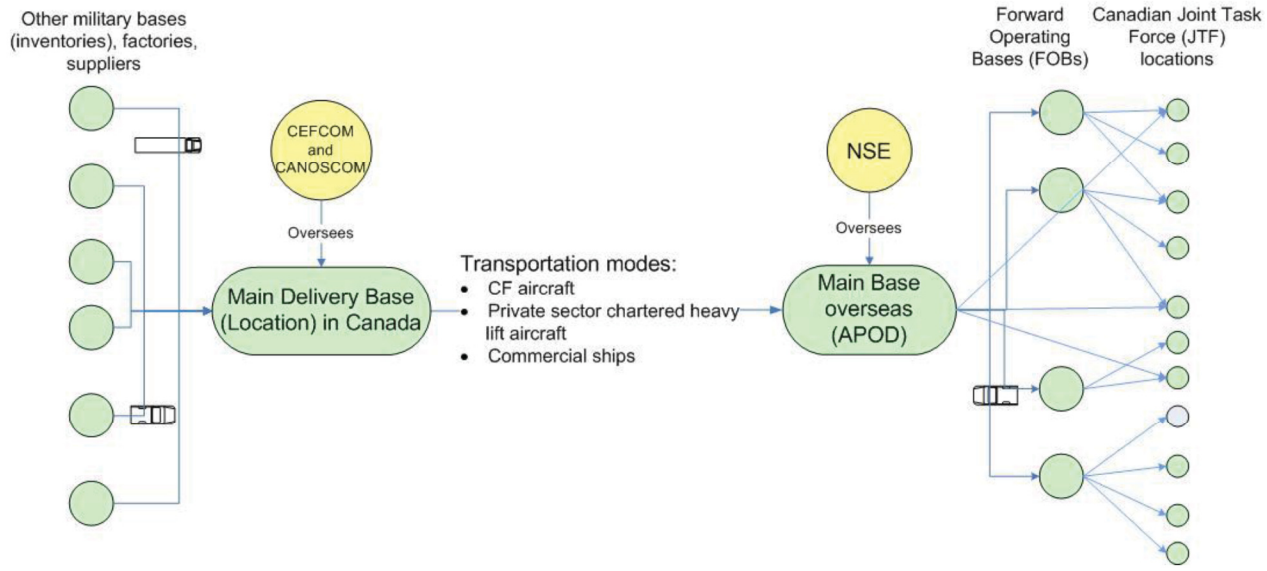

Figure 3 The Nodes of the Materiel Distribution System

The resulting graph consists of the two trees where there is an edge between the tree roots. The only deviation is that the tree on the left-hand side can contain direct edges between the root and the leaf nodes.

Modes of the transportation between Tier 1 and Tier 2 are civilian and military trucks and vehicles. Modes of the transportation between Tier 2 and Tier 3 are CF aircrafts, private sector chartered

heavy lift aircraft, and commercial ships. Modes of the transportation between Tier 3 and Tier 4 as well as Tier 4 and Tier 5 are military vehicles or aircraft.

2.1.2 Materiel

Inventory of supplies:

- Medical supplies, stored in Medical Unit warehouses/major medical installations and hospitals - like the Role 3 Hospital in Kandahar
- Ammunition, stored in the ammunition warehouses (also called ammunition supply points)

Other supplies are stored in several hundreds of sea containers stacked around the base. These supplies include:

- Spare parts
- Personal equipment
- Assorted line items of materiel
- Food (in refrigerated containers, normally sequestered in a separate Ration Supply Point)
- Reserve fleet of equipment – operational stock

Equipment includes:

- Combat equipment: weapons, weapon spare parts
- Support equipment: vehicles (several hundred support vehicles to support around 2,500 soldiers):
  - To transport personnel
  - To move supplies to forward-operating bases
  - To recover damaged equipment
  - To handle materiel at the warehouses

2.1.3 NSE and Related Organizations

The term National Support Element[1] is a NATO one which is applied to the national logistics contribution for a combined NATO operation, a combined joint task force. The NSE is a critical component in the provision of tactical, in theatre support as it provides all nationally specific supplies, ammunition natures and repair parts that are unique to the Canadian Forces and are not NATO common. The NSE is an "undeclared asset" on a NATO operation and as such, neither the logistics soldiers nor the Materiel and services of the NSE are under the command authority of the

[1] NATO in its AJP 4 Document defines the NSE as follows: Any national organization or activity that supports national forces which are part of the NATO force. NSEs are OPCON to the national authorities; they are not normally part of the NATO force. Their mission is nation-specific support to units and common support that is retained by the nation. NSEs are asked to co-ordinate and co-operate with the NATO commander and the Host Nation. If the operational situation allows for a reduction, greater co-operation and centralization of services among NSEs could produce significant savings.

NATO Task Force Commander (for the command structure and dependencies see Figure 4). Instead, the NSE is subordinate to the National Authority (National Command Element or NCE) in the AOO. This command relationship is imperative to understanding the NSE's NATO logistics obligations and the higher operational level linkages that the NSE has with Canada.

The NSE in the current Canadian construct is a tactical unit providing close and limited general support to a Canadian Task Force inside a NATO Combined Joint Task Force.[2] Furthermore the NSE provides integral level support to units of the Task Force that lack organic logistics. The role of the NSE as a tactical unit represents a modification of a doctrine[3] that had formerly seen the NSE as an operational support construct in a large theatre, with the tactical level being well forward of the National Support Element. Doctrine has morphed. Today the big, transformational Headquarters of Canadian Expeditionary Force Command (CEFCOM) and Canadian Operational Support Command (CANOSCOM) are considered to be the operational level headquarters for Canadian deployments. Doctrine still reflects the earlier model and does lead to confusion at times.

As one examines the various tasks of the NSE it is important to note that technical linkages to the operational level headquarters, specifically the logistics staff of CEFCOM and the entirety of CANOSCOM are authorized and in fact the NSE is in a near continuous technical dialogue with CANOSCOM headquarters staff and CANOSCOM units. In terms of making decisions on re-supply and placing demands to the operational level, there are:

- Some items that the NSE can request directly from CANOSCOM units in Canada, and
- Some items that must go through the Canadian Headquarters, or NCE deployed in the AOO

Furthermore, tactical linkages to the logistics staff of the NATO force in theatre are important for the NSE. Even though the NSE is not under NATO command, the NSE shares the task of coordinating resources for the support of the NATO Combined Joint Task Force. In this vein, the NSE may offer some of its support services up for the common good as well as draw support from NATO assets when necessary and where national caveats allow.[4]

---

[2] Combined Joint Task Force refers to a force made up of land, air, sea and special forces (Joint) of several different countries (Combined).

[3] Military doctrine provides a common conceptual framework for a military service of a country, and responds to the following question:

- what the service perceives itself to be ("Who are we?")
- what its mission is ("What do we do?")
- how the mission is to be carried out ("How do we do that?")
- how the mission has been carried out in history ("How did we do that in the past?")
- other questions.

CF Doctrine is stated and described in a number of documents. The Joint Doctrine of the CF library can be found at http://www.cfd-cdf.forces.gc.ca/sites/page-eng.asp?page=3560 (accessed on February 11, 2011). The document most relevant to this report and the project is CFJP 4.0 – Support to CF Operations [DND]. It has been outdated for the last ten years, and John Conrad believes that it is currently in a revision process. Note also, that the Joint doctrine has lagged a long way behind the army doctrine.

[4] National caveats can become real impediments to multi-national logistics.

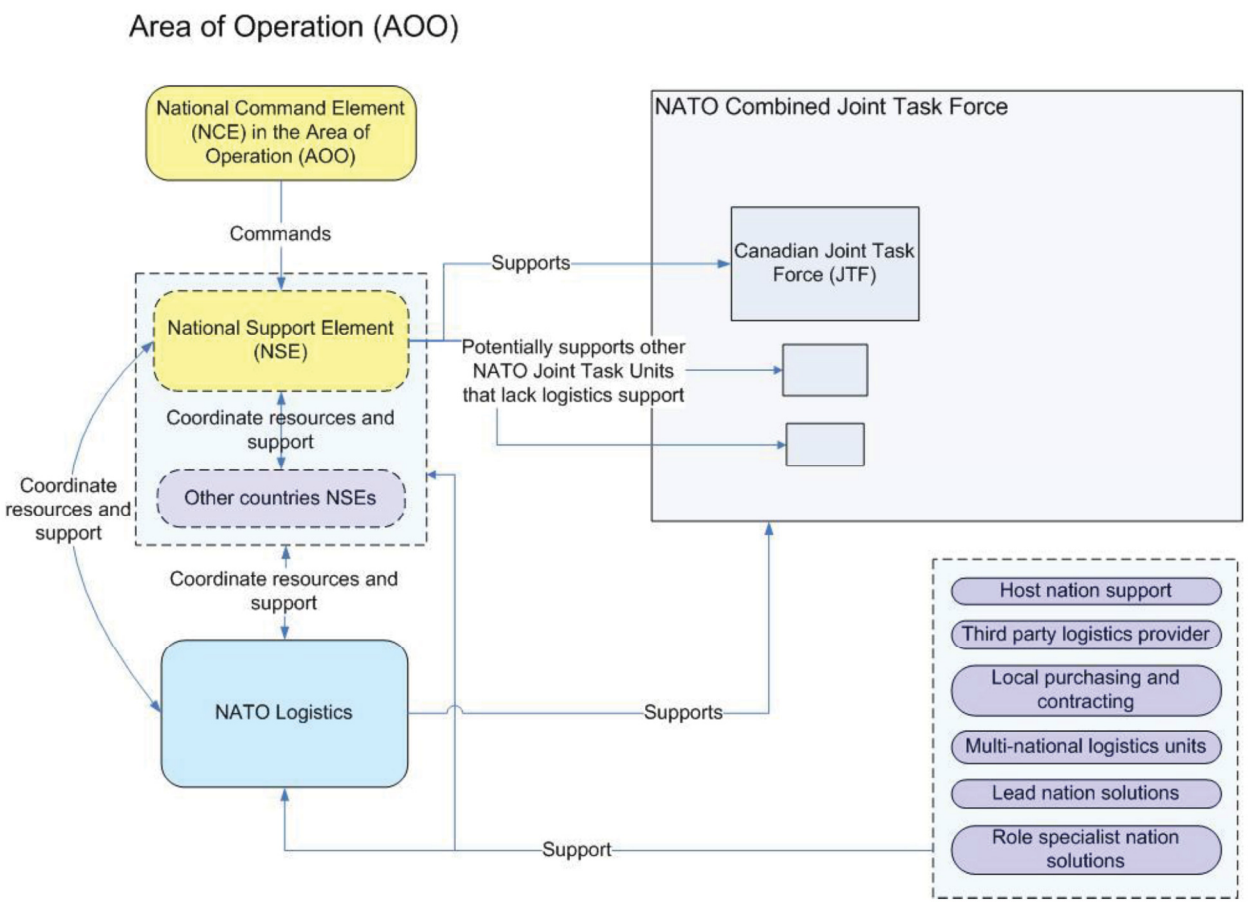

Figure 4 Tactical Logistics Units and their Dependencies in the Area of Operation: Canadian NSE, Other Countries NSEs, NATO Logistics Units, and Other Supporting Units

Finally, NATO, through Military Committee 312, of November 2003,[5] has placed a greater emphasis on multi-national logistics forward of November 2003. The current trend in NATO is to keep these national NSEs as small as possible in order to achieve efficiencies and cost savings and maximize logistic dependency on multi-national solutions. Although supportive of the move to increased multi-national logistics, Canada, along with other selected NATO partners, presently prefers to maintain a robust NSE. Still, NATO forces operating in a coalition or Joint and Combined Task Forces are supported by a number of means including: Host Nation Support, third party logistics providers, local purchase and contracting, Multi-national logistics units, lead nation solutions, role specialist nation solutions and of course NSEs (as depicted in Figure 4). These

[5]It is the Logistics Committee that oversees matters of logistics at the highest level of the NATO Alliance. NATO defines logistics as: The science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, the aspects of military operations which deal with:

a. design and development, acquisition, storage, transport, distribution, maintenance, evacuation and disposition of Materiel;
b. transport of personnel;
c. acquisition, construction, maintenance, operation, and disposition of facilities;
d. acquisition or furnishing of services; and
e. medical and health service support.

different sources for tactical support impact directly upon the complexity of the tactical supply chain for which the NSE commander is responsible.

The amount of support and effort required to keep a combat force effective on sustained operations is large. In the Second World War, each of the Canadian Divisions in Europe (of approximate size of 20,000 soldiers) was supported by approximately 10,000 army level administration and logistics troops. There are very few nations in the west and indeed on the Earth that can afford to provide this level of military support to its forces. As a result, Combined Joint Task Force inside NATO requires theatre level support from a number of sources beyond uniformed logistics soldiers.

Contemporary researchers should note that a unique experiment occurred with the NSE in early 2003 during the deployment of Operation Athena to Kabul. It worked well for the Kabul AOO of 400 square kilometres but did not suit well for the operations in Kandahar province (Kandahar Province itself boasting a surface area of some 225,000 kms). The NSE in 2006 sustained an infantry battle group in Helmand Province for nearly the full month of July at a distance of 300-350 kilometres from the APOD (KAF). This distance is unheard of specifically for the lethal nature of the Kandahar battlefield and it was not completed without casualties. Soldier skills and convoy escort drills have a heightened importance to the NSE with respect to the existing doctrine. The NSE has had to evolve in terms of survivability.

The nature of the battlefield has changed. The current battlefield is non-linear, meaning that there is no declarative "frontline" from which the enemy can be expected. Enemy attacks in the current security environment can occur anywhere and from any direction, usually taking advantage of complex terrain for ambushes. Furthermore the current battle space sees the Canadian Forces operating against a non-uniformed enemy. Future conflicts envision a continued role for non-state actors and insurgent style combat such as the fighting conducted by the Taliban in southern Afghanistan instead of a uniformed, more readily identifiable enemy. Canadian practices, tactics, techniques and procedures have changed to meet the demand of reality but doctrine still reflects the linear, structured style of battlefield that sees an NSE pushing forward some tactical pieces to establish replenishment points. This doctrine seems to be outdated and provides space for improvements.

2.1.4 NSE Components

The NSE is led by the NSE Commanding officer. The main components/capacities of the NSE are:

- Logistics
- Communication and Information Services (CIS)
- Military police
- Military engineer
- Personnel support and finance
- Maintenance workshop
- Contracts
- Health

Figure 5 shows the main NSE components and its subcomponents together with their respective functions/ tasks. The figure emphasizes the components that are:

- Directly involved in the Materiel distribution activities (the bright yellow nodes)
- Influencing the Materiel distribution (the pale yellow nodes) either:
  - By being the origin of the majority of orders/ requests for re-supply, or
  - By supporting the Materiel distribution (contracts)shared;
- Almost non-influential to the materiel distribution (the white nodes) – some provide small percentage of requests

For the components important to the Materiel distribution, the list of subcomponents is as follows:

- Logistics:
  - Supply chain with the receipt and issue section, the warehouse, and the ammunition section
  - Food services
  - Postal
  - Transportation with the road safety section, the vehicle fleet management section, the movement control center, the movement section
- Maintenance workshop:
  - Repair parts inventory
  - Mobile repair teams
  - Technical Assistance Visits (TAV)

Figure 5 also provides summary of the functionalities and tasks (shown in green) of each component and subcomponent. These tasks are described in details in the following section.

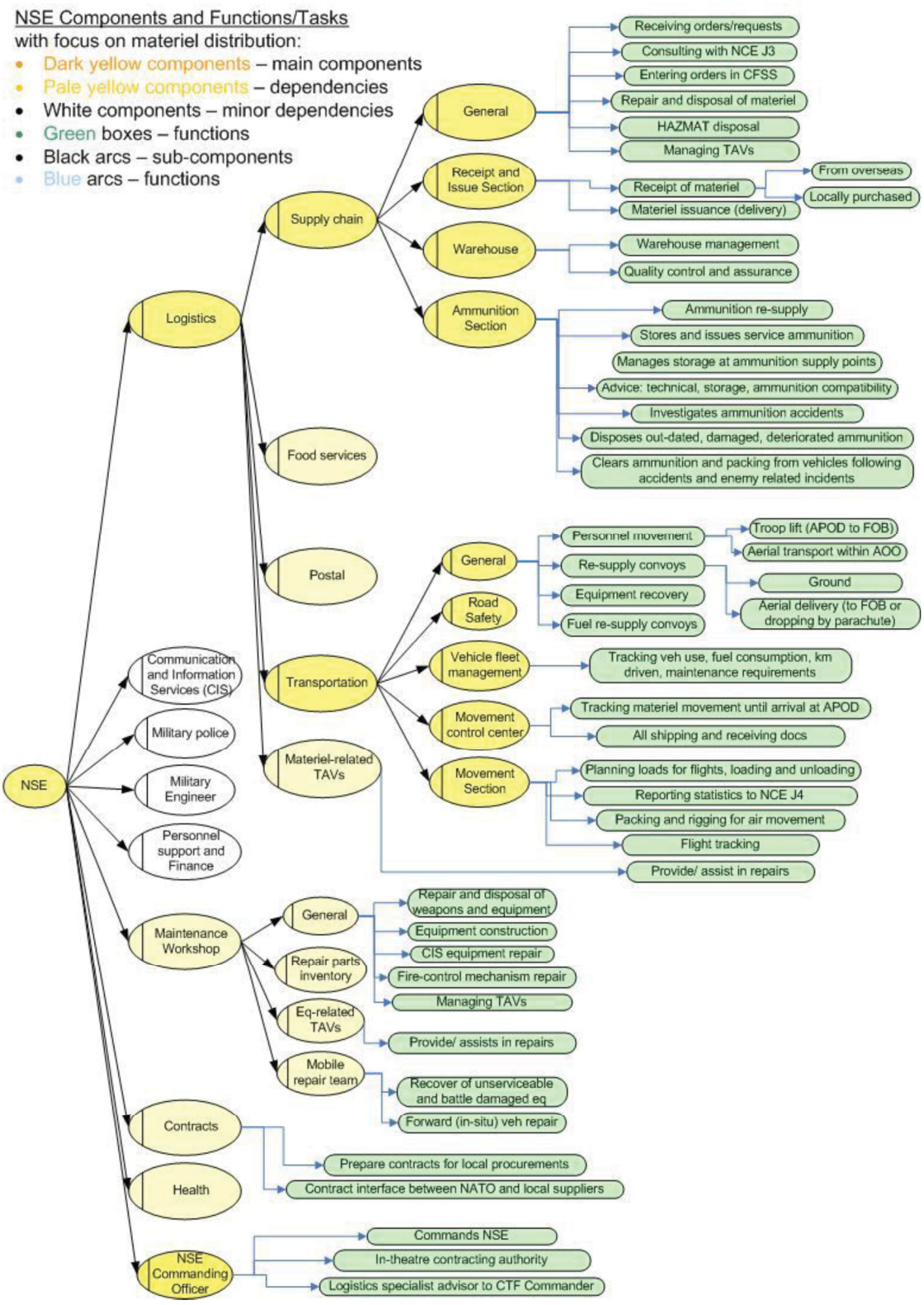

Figure 5 NSE Components and their Functions/Tasks

2.1.5 NSE Tasks

This section provides a summary list of all NSE tasks and then gives more details for each of them. The tasks are grouped as per the NSE components responsible.
The Materiel distribution tasks assigned to the Supply Chain Section include:

- Materiel receipt and issue
- Ammunition resupply and ammunition-related technical support
- Local purchase
- Quality control/ quality assurance
- Materiel repair and disposal
- Hazardous Materiel disposal services

The Materiel distribution tasks assigned to the Transportation Section include:

- Tactical transport services of the Materiel, including ground and aerial/aviation delivery
- Tactical transport services of the personnel, including troop lift, and aerial transport
- Tactical refueling of Petroleum, Oils and Lubricants (POL)
- Military vehicle/ road safety program
- Vehicle fleet management
- Tracking Materiel through the operational supply chain until its arrival at the APOD – done by the Movement Control Centre (MCC)
- For air movements, planning the loads for all flights, as well as executing the loading and unloading of Materiel and passengers – done by the Movements Team
- Packing and rigging of equipment and Materiel for air movement
- Flight tracking of all aircraft due into/out of theatre – done by the NSE Movements Section working closely with the J4 staff of the NCE
- Postal: Mail distribution by the tactical convoys along with Materiel

The tasks related to the Materiel distribution that are assigned to the Maintenance Workshop include:

- Recovery of vehicle and equipment
- Forward vehicle repair, i.e., in-situ repair or “in situation” repair, well forward of the APOD into a combat sub-unit
- Production
- Weapons repair

- Repair parts inventory management – since this inventory is so large, it represents a separate warehouse inside the Maintenance Workshop
- Land command, control and information systems repair including communications equipment repair, i.e., Communication and Information Services (CIS) equipment repairs
- Managing TAVs
- Ancillary services like Materiel fabrication and minor manufacture with textiles, fabrics and metal

The tasks related to the Food Services include:

- Providing military and/or contracted cooks
- Organizing the delivery of fresh rations
- Doing ration accounting
- Quality assurance and control

The Materiel distribution tasks assigned to the Contracts Section include:

- Contracting services
- Contract interface

Other NSE tasks that are related to the Materiel distribution include:

- Force protection tasks for protecting convoys

Other NSE tasks include:

- Financial services including administration of the working capital fund, financial reporting, payments, audits
- Camp services tasks including mortuary affairs and repatriation of remains, technical services function for the Canadian infrastructure at the APOD, infrastructure maintenance
- Welfare services tasks including booking of holiday travel for the mid-tour soldiers' leave, operating Canadian retail outlets for amenities (Tim Horton's), operating a physical fitness service, etc.

2.1.5.1 Supply Chain and Contracting Tasks

Materiel Receipt and Issue. All inventories coming into the theatre are receipted by NSE and taken on charge either in the large NSE Supply Warehouse or issued down out to a JTF unit. This includes receipt of contracted or locally procured items. Once in the warehouse, the given item is managed for retrieval, issuance, shelf-life quality and accountability. This task of accounting and Materiel management is done by the warehousing or storage personnel. The NSE conducts the task of Materiel issuance to either the main NSE Warehouse or one of several military units or

users. The issuance, i.e., the transport of Materiel to the location where it will be used can be done by JTF units coming to the NSE Warehouse at the APOD or by the NSE personnel through ground or aerial tactical delivery. Also, it can be combined: the NSE personnel transporting the materiel to the FOB where it is picked-up by the JTF units. The respective units receiving an item take ownership and accountability for the item when it comes on their unit charge, i.e., when it is given to them at their location or for them to transport it. The Receipts and Issues Section receives waybills (a document issued by a carrier giving details and instructions relating to the shipment of the Materiel) of all items coming into theatre. This is not always done when new projects or capabilities are being introduced into Theatre and has been a source of considerable difficulty.

Ammunition Resupply and Technical Support. The task of ammunition re-supply at the tactical level is predominantly one of coordination. The NSE's role with ammunition is predominantly a *pull system*, relying on the demands of units of the JTF to determine the natures and quantities of ammunition required. The other task of the NSE at this level is the provision of technical expertise and advice to the JTF. Ammunition storage and handling in operational theatres adheres to Canadian regulations and protocols, almost all of which are heavily technical in nature. The NSE Ammunition section provides technical advice on proper storage regulations, ammunition compatibility. Specifically, the NSE receives; stores and issues service ammunition; disposes of out-dated, damaged, deteriorated or time-expired ammunition; clears ammunition from vehicles following accidents and enemy-related incidents; investigates ammunition accidents and incidents involving ammunition and processes the disposal of ammunition salvage (wooden crates, packaging, brass, etc.).

The most crucial aspect of the ammunition task is *forward issuance* which relies on forecasted demand. Again the issuance can be achieved by units coming to the supporting Ammunition Supply Point or NSE convoys can deliver it to the unit location. Theatre level replenishment from the operational level is the responsibility of the National Headquarters (NCE) J3 (Operations) staffs to set quantities and natures required and for the operational level support organization in conjunction with the J4 (logistics staff) to coordinate the movement, tracking and receipt of ammunition into theatre. Doctrine with respect to ammunition is vague at the operational level, adhering still to the "days of supply" model. I believe that with the new study on the Joint Task Force Support Component (JTFSC) a better operational position with respect to ammunition holding and replenishment procedures at the operational level needs to be developed and doctrine for resource distribution and inventory levels in the Canadian logistics system (which has changed very little since 1918) needs to be discarded and replaced with a doctrine that more closely meets contemporary demand and threat..

Demands. The NSE receives demands from the dozens of units that comprise the Canadian JTF, checks (vets) them for accuracy and priority and then inputs the demand electronically into the supply chain – Canadian Forces Supply System (CFSS). At this point the demand is visible in the CFSS and will be matched by an operational level account and earmarked for forward movement to the AOR. Demands are input according to a range of operational *priorities* ranging from:

- mission critical (urgent operational requirement) to
- essential
- routine
- replenishment

For some items, the NSE must coordinate demands with the NCE for collation, and concurrence prior to onward transmission. A prime example of this is ammunition. Ammunition re-supply must be reviewed jointly by the NCE J3 and J3 Ammunition staff. Another example is 'high cost, low density' items (expensive and heavy pieces of major equipment and weapon systems). In many missions, items demanding a priority of mission critical (urgent operational requirement). 'High cost, low density' items are checked for command priority with the NCE prior to submission. The idea being (and it is a correct one) that the NCE commanders need to influence and decide what the mission's *true* urgent Materiel requirements are. Other items that are not among these exceptions the NSE can request directly from CANOSCOM (through CFSS).

Local Purchase. In the long history of warfare there are very few examples of fodder being moved through the military supply chain. It is foolhardy to move anything through the military supply chain that can be readily procured in the AOO or close to "the front." The Auditor General's Report stated that, "Most everything a soldier may need comes through the supply chain,"[6] in Kandahar. This is only accurate if one considers local procurement to be part of the supply chain. For example, almost 90% of the supplies a JTF needs in an AOO are liquid in nature (water, fuels, POL) and almost all of that is purchased locally. Local purchase is fundamental to sustaining a JTF and as such has become a most valuable campaign tool. The NSE is responsible for this task and the NSE local procurement staff initiate procurement action, apply appropriate financial codes and process original invoices to the Comptroller Office for payment.

Quality Control/Quality Assurance. The NSE has the task of ensuring goods received from the Canadian supply chain as well as contracted/ locally procured goods are serviceable in the case of the former and meet the standards of the contract in the case of the latter. If Materiel is not issued to a unit at this point, it is placed in the NSE Supply Warehouse and the task of maintaining the serviceability of the item rests with the NSE supply staff until the item is issued or disposed of.

Repair and Disposal. The task of materiel repair and disposal services is conducted by the NSE Supply organization for all units in the Canadian JTF. Note this repair function does not apply to weapons and equipment which is another NSE task but under the electrical and mechanical engineering sub unit (Maintenance Section).

Hazardous Materiel Disposal Services. CF operations abroad adhere to Government of Canada environmental standards regardless of the country in which they are operating. The majority of hazardous Materiel in the theatre is disposed of through a contractor however the HAZMAT disposal is done by NSE.

Managing Technical Assistance Visits (TAV). TAVs are common to Canadian JTF. The task of coordinating TAVs dealing with Materiel rests with the NSE in conjunction with the NCE J4. This coordination would be with CANOSCOM/CEFCOM staffs but normally involves strategic level organizations like National Defence Headquarters (NDHQ) Assistant Deputy Minister (ADM) Materiel. The task of integrating and facilitating the work of a Materiel TAV team in the AOO resides with the NSE supply organization.

[6] Report of the Auditor General of Canada, May 2008: Chapter 2 *Support for Overseas Deployments*.

The TAVs supplement the military personnel when needed. Their tasks include the replacement of key personnel on leave, performing modifications to vehicles, such as increased armoured protection, introducing new equipment, and helping put warehouse stock records in order.

Contracting Services. Not necessarily a supply task, but one that impacts the tactical supply chain all the same. The contracting function is one of the most under-appreciated by contemporary Canadian doctrine and the one function that our logistics officers are least prepared to deal with by their training system. The ability to forge good contracts that are fully compliant with Government of Canada Internal Trade Regulations has a telling impact on the tactical supply chain and on the wider sinews of a Canadian Campaign that seeks to strengthen development in a fragile economy. This is a vital task of the NSE and it could well go under the Supply Chain function of the JTF. The NSE Contracts Section must be engaged and tender for three quotes The NSE task with respect to contracting has critical operational interface with the Director General of Procurement Services, Public Works and Government Services Canada (PWGSC) as well as the J8 (Financial Services) staff at CANOSCOM and the J4 staff at CEFCOM. The Commanding Officer of the NSE is the Theatre Contracting Authority.

Contract Interface. In addition to preparing new contracts, the NSE has the task of serving as the interface with large contractors of other NATO members from whom the Canadian JTF derives support – for example, the Kellogg Brown & Root Company that provided the fresh rations dining facilities on APOD KAF.

2.1.5.2 Distribution/Transportation Services and Force Protection Tasks

Tactical Transport Services (Materiel)

a) Ground. Ground convoys are the primary means of distribution of Materiel and cargo from the APOD to FOBs. Resupply convoys are normally bundled to achieve multiple purposes including passenger movement and equipment recovery operations in support of a Canadian JTF. Movement by ground in Kandahar Province is analogous to "Battle of the Atlantic" style convoy packaging, with different vehicles providing specific sustainment and force protection roles.

b) Aerial/Aviation Delivery. This type of distribution can be conducted a variety of ways ranging from large transport aircraft delivering direct to forward airstrips, helicopters delivering to forward landing zones inside or near unit FOBs or larger aircraft dropping pre-package bundles of Materiel by parachute in Containerized Dropping Systems (CDS) pallets.

Tactical Transport Services (Personnel)

a) Troop lift. The NSE has the task of passenger transport from the APOD to FOBs. The task is carried out in support of the soldier's leave plan, normally in the middle period of a given six-month tour. This function is bundled with Materiel distribution convoys to the maximum extent possible. Fewer ground convoys in the contemporary security environment exposes soldiers to less risk.

b) Aerial Transport. Whenever possible personnel are transported around the AOO by air or aviation assets. This ranges from transport provided by helicopter through to fixed wing, tactical aircraft like the C 130 Hercules.

Tactical Refuelling of Petroleum, Oils and Lubricants (POL). The NSE has the task of delivering POL forward to units of the Canadian JTF as well as ensuring delivery to the APOD from contracted sources (either contractors/lead nation arrangements).

Military Vehicle/Road Safety Program. The CF runs a robust preventive vehicle safety program that calls for the compilation of statistics, sharing of educational products and awareness and thorough accident investigation and analysis. The Safety Organization has the task of issuing the military driver's license (the DND 404 permit) and recommending suspension of this license depending on accident investigation findings. The task of running the Canadian Vehicle Safety program (entitled the Mobile Support Equipment Safety program by the CF) is carried out by the NSE. This is truly more of a peacetime function but a task that is conducted in theatres as well.

Vehicle Fleet Management. Tracking the use, POL consumption, kilometres driven and maintenance requirements of the various vehicles of the Canadian JTF is an NSE task. Compiling this empirical data enables proactive fleet management in theatre.

Movement. The NSE has the task of providing the MCC. This MCC is the nerve centre of the Materiel distribution system, the organ that tracks the shunting of Materiel through the operational supply chain until its arrival at the APOD. The MCC is the organization that is responsible for processing all inbound and outbound flights into the APOD including all shipping and receiving documentation.

Air Movements. The NSE Movements Team plans the loads for all flights serving the Canadian JTF, creates passenger manifests, loads and unloads Materiel and passengers, and the records/reports the movement statistics to the NCE J4 Movements staff officer.

Rigging for Aerial Delivery. The NSE Movement Platoon does not own aviation but it has the task of providing a traffic service – a singular expertise associated with packing and rigging of equipment and Materiel for air movement. This expertise which is provided to the Canadian JTF implies a detailed knowledge of Allied and Canadian service aircraft, dangerous goods compatibilities and International Civil Aviation Organization (ICAO) and Transport Canada Regulations. The Traffic Technicians prepare loads for transport by helicopter and fixed wing transports. This is an intrinsic and valuable task. Although Canada has been lean on aviation assets in southern Afghanistan (there were no Canadian helicopters during my own tour in 2006) other NATO nations rely heavily on them for tactical distribution. Much of the sinews of Materiel in a Coalition operation like southern Afghanistan are distributed by helicopter.

Flight Tracking. Flight tracking of all aircraft due into/out of theatre in support of the Canadian JTF is a task of the NSE Movements Section working closely with the J4 staff of the NCE.

Postal. The NSE provides the full range of free 'soldiers mail' and the full range of financial postal services to the Canadian JTF. The NSE has the senior CF Post Office (CFPO) in an AOO. Depending on the size of the JTF and its geographical disposition, some major units inside the JTF may have their own subordinate CFPOs as well. Mail is distributed in tactical convoys along with

Materiel. Mail travels in the operational level supply chain out of Trenton, Ontario on a space available basis with Materiel. The operational level organization above the NSE is the CF Postal Unit (CFPU) in Trenton which handles all mail and financial postal services for Canadian units abroad. CFPU is a CANOSCOM unit. Once mail arrives at CFPU Trenton, it is fed into the Canadian Postal system for forward delivery in Canada.

Force Protection Tasks. This task is a relatively new one not forecasted in existing doctrine – the existence of organic combat arms soldiers inside the NSE to escort distribution convoys, and augment point defence of important installations in the theatre. The NSE proves limited convoy escort and limited point defence of installations. The presence of integral combat arms soldiers in the NSE is a function of the current security environment: the non-linear battlefield. To achieve efficiencies in future training and employment, integral force protection assets must be embedded within the NSE as early as possible to conduct collective training and to develop and hone the skills needed to enable the projection (distribution) of combat capable logistics.

2.1.5.3 Electrical Mechanical Engineering Tasks (Maintenance)

Recovery. The NSE extracts out the unserviceable and battle damaged equipment casualties. Battlefield recovery is not merely "getting a tow." Recovery is a complex task which involves moving a machine when it does not have the ability to be towed (battle damage). This implies having the technical knowledge for what amounts to a complex task in harm's way as well as powerful machinery to muscle battle damaged equipment off of the battlefield. Recovery mechanics are highly skilled artists. Recovery operations in Southern Afghanistan, particularly the recovery of battle damaged equipment, elicited some of best examples of soldier ingenuity and resourcefulness.

Forward Vehicle Repair. (Also referred to as in-situ repair or 'in situation' repair in military parlance). The NSE Workshop fixes all unserviceable Canadian vehicles well forward of the APOD/KAF. This task which entails detaching a Mobile Repair Team form the APOD directly into a combat sub-unit is a modification of existing doctrine for the NSE.

Production. The task of conducting the JTF corrective maintenance program is carried out by the Production Section of the NSE Field Workshop. A Control Office monitors the production of the entire Workshop organization. This includes what is entering the workshop, what is waiting for labour, parts or what is being back loaded (returned) to Canada as it exceeds the NSE's ability to repair it.[7] The Maintenance Company Commander of the NSE has full technical communication with strategic level technical staffs. Operational reach back for maintenance issues is also coordinated through CEFCONM J4 and CANOSCOM.

Weapons Repair. The NSE Workshop fixes all weapons and fire control mechanisms in the Canadian JTF.

[7] The Electrical and Mechanical Engineers of the Canadian Forces have a doctrine that divides repairs into 4 levels. The complexity of the repair and time associated with completing it increases as the Level increases. A typical NSE workshop will work on only limited Level 3 repairs and all Level 4 repairs will be returned to the operational Workshop - 202 Workshop in Montreal for completion.

Repair Parts Inventory. The Repair Parts Account for major equipment is an extremely large and complicated supply account that is actually a sub-account of the main NSE Supply Warehouse. The NSE has the task of keeping the inventory in appropriate scale to meet the demands of experiential parts attrition in a given AOO. The Repairs Parts Account is so large that it is normally managed right inside the Maintenance Workshop Company for ease of access. There were well over one million parts of 26,000 types (line items) in the NSE in Afghanistan and this was before the introduction of the TLAV and the Leopard II Main Battle tank. This number of different line items for what amounted to a mechanized infantry battle group is a haunting level of complexity – a clear indicator of the sophistication of the major equipment now.

Land Command, Control and Information Systems Repair. The NSE has the task of repairing unserviceable communications equipment (CIS equipment).

Managing Technical Assistance Visits (TAVs). TAVs are common to Canadian JTF for equipment as well. The task of coordinating TAVs dealing with major equipment or weapons systems rests with the NSE in conjunction with the NCE J4 Maintenance. The NSE Maintenance Workshop integrates and facilitates the work of a TAV team in the AOR. The operational linkages normally extend beyond CANOSCOM and CEFCOM at the operational level into strategic level organizations like NDHQ Director General Land Equipment Program Management (DGLEPM) and individual equipment manufacturers.

Ancillary Services. Tasks like Materiel fabrication and minor manufacture with textiles, fabrics and metal rest squarely with the NSE. The NSE has the task of minor equipment construction. Items ranging from steel targets to practice shooting to fuel racks for the LAV III fighting vehicles were made and installed at the tactical level by the NSE during my Kandahar tour. There are numerous examples of this important task. Requests/requirements are received from units and worked on in the NSE Workshop. Delivery of the manufactured goods can normally be done by convoy in the normal tactical supply chain.

2.1.5.4 Other NSE Tasks

Comptrollership Tasks

Administration of the Working Capital Fund. The NSE manages money (funds) of the Canadian JTF Commander.

Financial Reporting. The NSE generates reports and returns pertaining to the Financial operation and health of the Canadian JTF and offers advice and assistance to the senior leadership related to the appropriate and effective handling of public funds.

Payment. The NSE has the task of paying invoices (Section 34 under the Financial Administration Act) for goods and services received. Examples from Kandahar include Jingle truck services (contracted delivery trucks) and items of recurring need and indefinite quantity like gravel.

Audit. The NSE audits both public and non-public accounts.

Camp Services Tasks

Mortuary Affairs and repatriation of Remains. This includes the coordination of ceremonial duties and services and the coordination of air movement of remains.

Technical Services function for Canadian infrastructure at the APOD. The NSE provides any technical service with regards to Canadian Infrastructure (less construction engineering tasks). This task is more one of coordination and matching an appropriate service response to a requirement.

Infrastructure maintenance. The task of ensuring that the housekeeping of Canadian infrastructure is maintained, cleaning, minor repairs, garbage removal.

Welfare Services Tasks

Although not the focus of this study, the NSE has the large task of providing for the welfare services for the men and women of the Canadian JTF. This is done with civilian personnel and managers from the CF Personnel Support Agency working with NSE officers and non-commissioned members. The services cover a wide range from booking of holiday travel for the mid-tour soldiers' leave, operating Canadian retail outlets for amenities (Tim Horton's), operating a physical fitness service (weight room, gymnasium). The Commanding Officer of the NSE is the Welfare Authority for the Canadian JTF. This task is immense and could only be described in much detail.

Food Services Tasks

The NSE has the task of providing fresh rations/food for the soldiers of the JTF. This task involves providing military and/or contracted cooks to prepare meals in accordance with the Canadian ration scale for the men and women of the Canadian JTF, organizing the delivery of fresh rations, doing ration accounting, quality assurance and control. Operational linkages include, CANOSCOM and the NDHQ Food Staff as well as third party logistics providers who deliver fresh rations to the APOD and direct to some FOBs as well. Note that hard rations (Individual Meal Packs or IMPS0) are handled by the Supply organization of the NSE and not the rations organization.

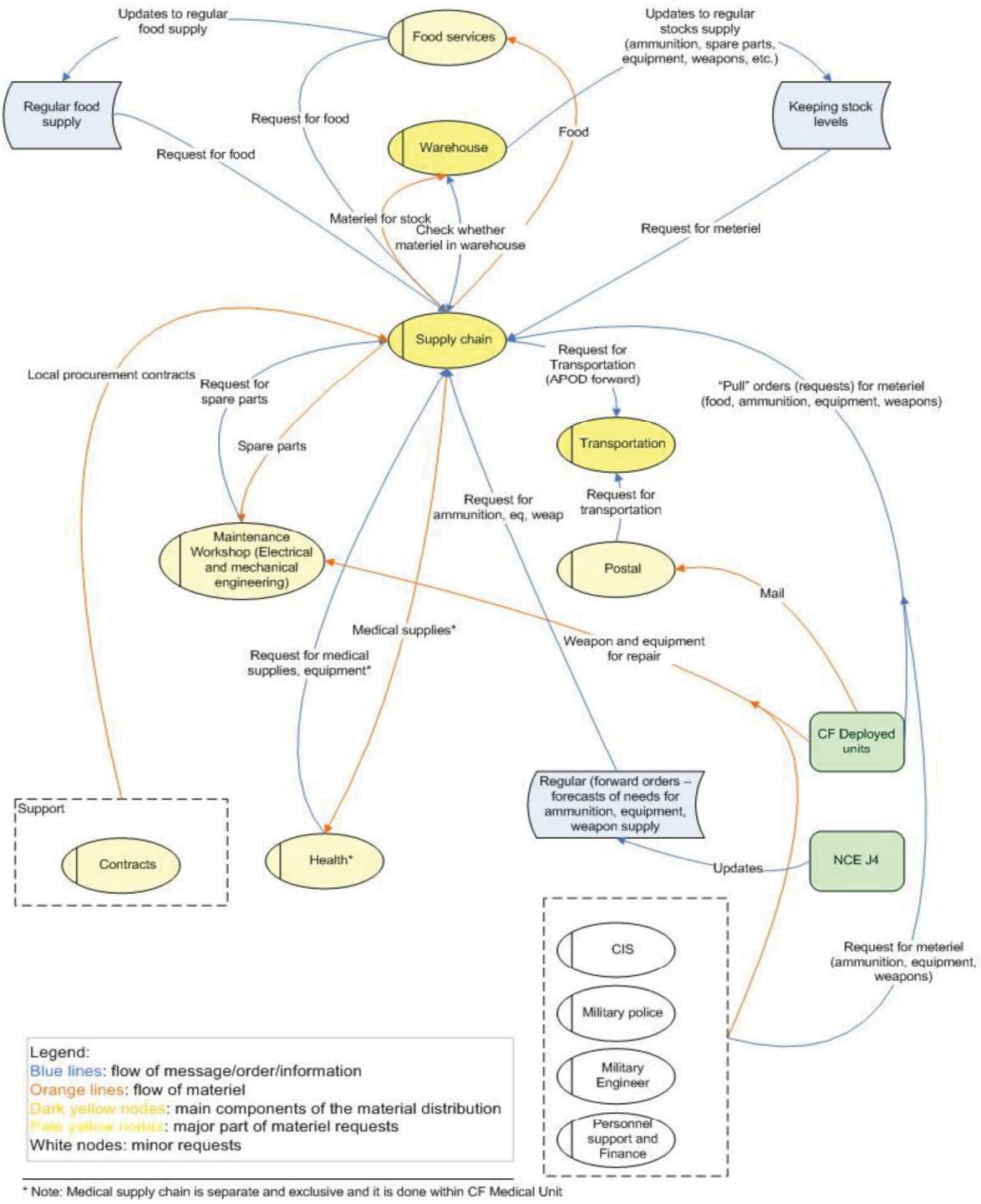

Figure 6 The Dependencies of the NSE Components together with the Materiel and Information Flow

Additional Tasks of the NSE Commander

Logistics Specialist Advisor to the Canadian Task Force Commander. Last but not least, the Commanding Officer of the NSE has the task of serving as the specialist advisor to the Commander on all matters pertaining to logistics. In this key role he or she outranks the J4 principle staff officer for logistics on the Commander's staff.

2.1.6 NSE Component Dependencies

The NSE components and their daily operations are highly inter-dependent. They either rely on each other, or closely support each other. Delays or problems at one component can cause malfunctioning or total blockage of another. For example, when the equipment at the warehouse receiving is not working, all the downstream NSE components will be influenced: transportation, maintenance workshop, food service (potentially) and at the end of the chain – the deployed CF soldiers. Thus, smooth running of each component is necessary for the overall success of the logistics supply chain and for the success of the mission.

The dependencies of the NSE components are shown in Figure 6. The color coding of the components is the same as in Figure 5. The edges between the component nodes represent information/ order flows (blue edges) and Materiel flows (orange edges). Blue boxes represent databases or documents where the information and potentially schedules for the regular (forecasted) re-supplies are kept.

Shown in the figure, for the sake of completeness, the health component is actually the part of the separate and exclusive medical supply chain which is managed by the CF Medical Unit. Nevertheless, most often the medical supplies are moved and distributed together with other Materiel.

2.1.7 Workflows

The majority of the tasks of a certain NSE component are done in a sequential manner or following certain priorities. However, many of the NSE functions are very complex given that many parties (NSE and other CF units, contractors, etc.) may take part in their execution. In terms of the Materiel distribution, it seems important to present the sequence of the activities done by the collaborative effort of NSE, NCE and other CF units. We have chosen to present the ammunition re-supply workflow and major equipment re-supply workflow as we consider these functions to be more complex than others (food or POL re-supply).

Current ammunition re-supply is mostly done based on the 'pull' system that relies on waiting for the demand requests from the deployed JTF units to arrive at NCE when the delivery will be planned and executed. There are some so called 'forward issuance' which provides regular deliveries of ammunition. However the system is in its early stage of the development and often done by determining the amount of re-supply depending on the number of days and the number of soldiers. More sophisticated forecasting based on the future combat actions, tasks, and missions has been proposed and potentially will be used in the future missions.

Figure 7 shows simplified sequence of tasks of the ammunition resupply activity (as per SME's knowledge[8]). More detailed workflow for the same activity/ function is given in Figure 8.

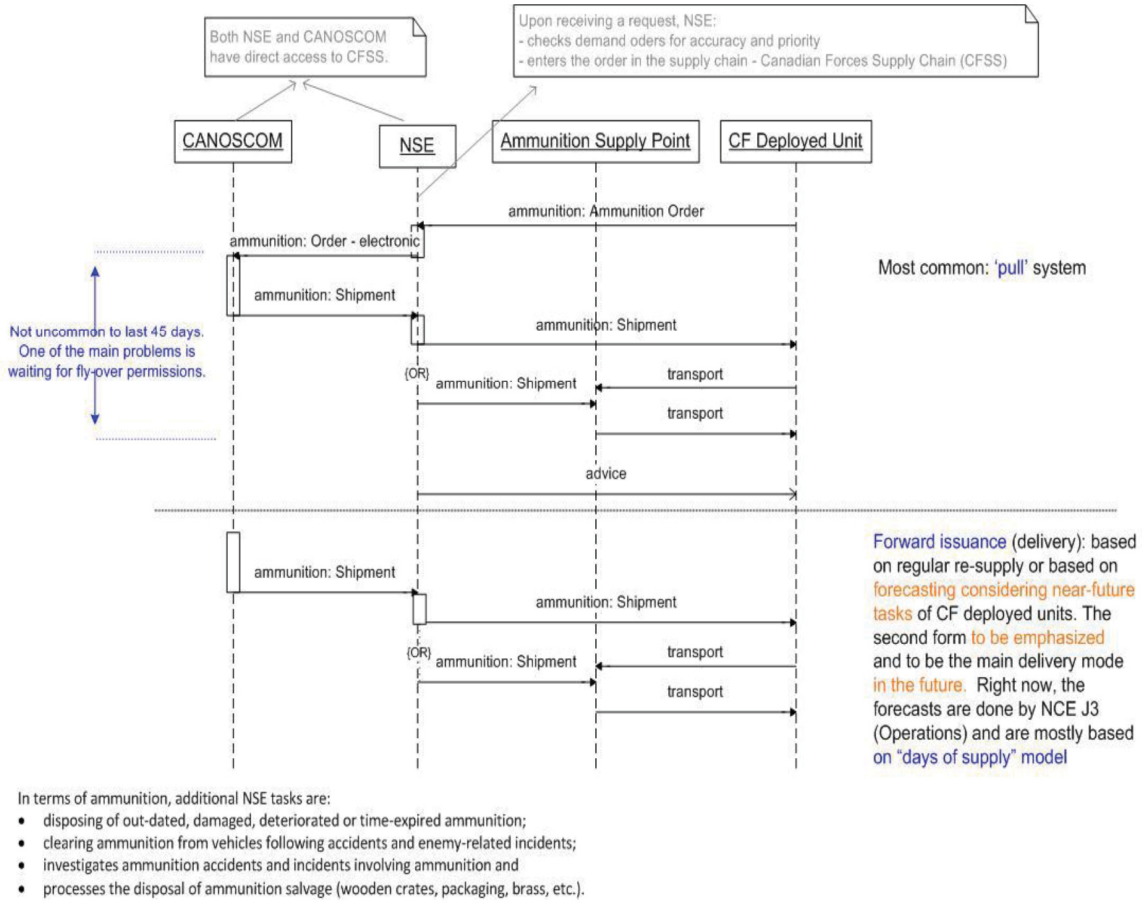

Figure 7 Sequence of Tasks Related to the Ammunition Re-Supply

The advantage of the sequence diagram representation is that the duration of the tasks and/or between the tasks can be depicted by the changing the size of the small rectangular box positioned along the dashed vertical lines. The dashed vertical lines represent units responsible for the tasks. This figure also stresses that there are two modes used in re-supply: pull mode and forward issuance based on the forecasts. Both workflows are presented in the figure: the first one in the upper half of the figure, and the second in the lower part.

[8] This project's SME, John Conrad, has served in two NSEs and as an NSE commanding officer in 2006. He has also taught operational sustainment at the Canadian Forces College in Toronto for three years. Potential reference is the logistics section of the manual on Canadian Forces Operations. Joint doctrine has lagged for years behind the doctrine of the Canadian Army. For example, the book - Canadian Forces Operations precedes the stand up of the new CANOSCOM and CEFCOM HQs. Further reference materiel for Figure 7 may be found in the army publication CFP 3000-4 Sustainment, a portion of which is written by John Conrad in 1997.

The workflow depicted in Figure 8 shows more details of the sequential order between the tasks/actions. The lanes (so-called swim lanes) entitled CANOSCOM, NCE, NSE, etc., show the responsible parties for the tasks. Precedence constraints between the tasks are depicted by the blue arrow (arcs).

The events that may trigger the distribution (movement) of ammunition and small arms are presented in red-blue hexagonal boxes in the given workflow:

- Fundamental changes to mission, mission nature, force size, or structure
- Updates to JTF Operational Plan
- A need for ammunition/ small arms encountered at the JTF deployed units
- Time to send forecasted (regular) resupply from Canada to APOD
- Time to send forecasted (regular) resupply from APOD to the location of JTF units

The rectangular boxes in the workflow represent activities/tasks/actions, while the diamond-shaped boxes represent decision points. From the diamond, two arrows (arcs) come out, representing the flows for the two possible decisions: the decision-maker answering *Yes* to the question in the diamond box, and the decision-maker answering *No*.

The cylinder in the upper left corner of the diagram represents the computer CFSS system. The calculations of the forecasted re-supply for APOD and for Battle Group are made in the following way:

- For APOD: The CFSS is a database that supports in-theatre Materiel Management process. Stock levels (max and mins), controlled stores, and rationed stores are all set by the NSE/ NCE J4 staff considering the needs of the theatre and current operations. Once the stock holding policy of the theatre Materiel Management system are set, the CFSS supports it. NSE/ NCE J4 staff establish it regularly and manage it; the CFSS is just a database support. When the stock levels become low, an NSE technician orders materiel from CANOSCOM.
- For Battle Group: The amount of re-supply depends on the number of days and the number of soldiers in a unit, as decided by NSE/ NCE J4 staff (see previous bullet).

Forecasting based on dynamic demands and operation plans is not done automatically. More sophisticated forecasting procedures and support tools would be welcomed, since – as per John Conrad's experience – CF have struggled with this. In a sense, it is a relatively new challenge for CF (with the mission in Kandahar), after almost forty years of CF being deployed following the principles of "30" days of theatre supply or "90 days of ammunition". As shown in practice in Afghanistan, these predictions are not accurate and not useful in a combat scenario. Details of problems and challenges related to these practices and struggle to improve forecasting may be found in [3].

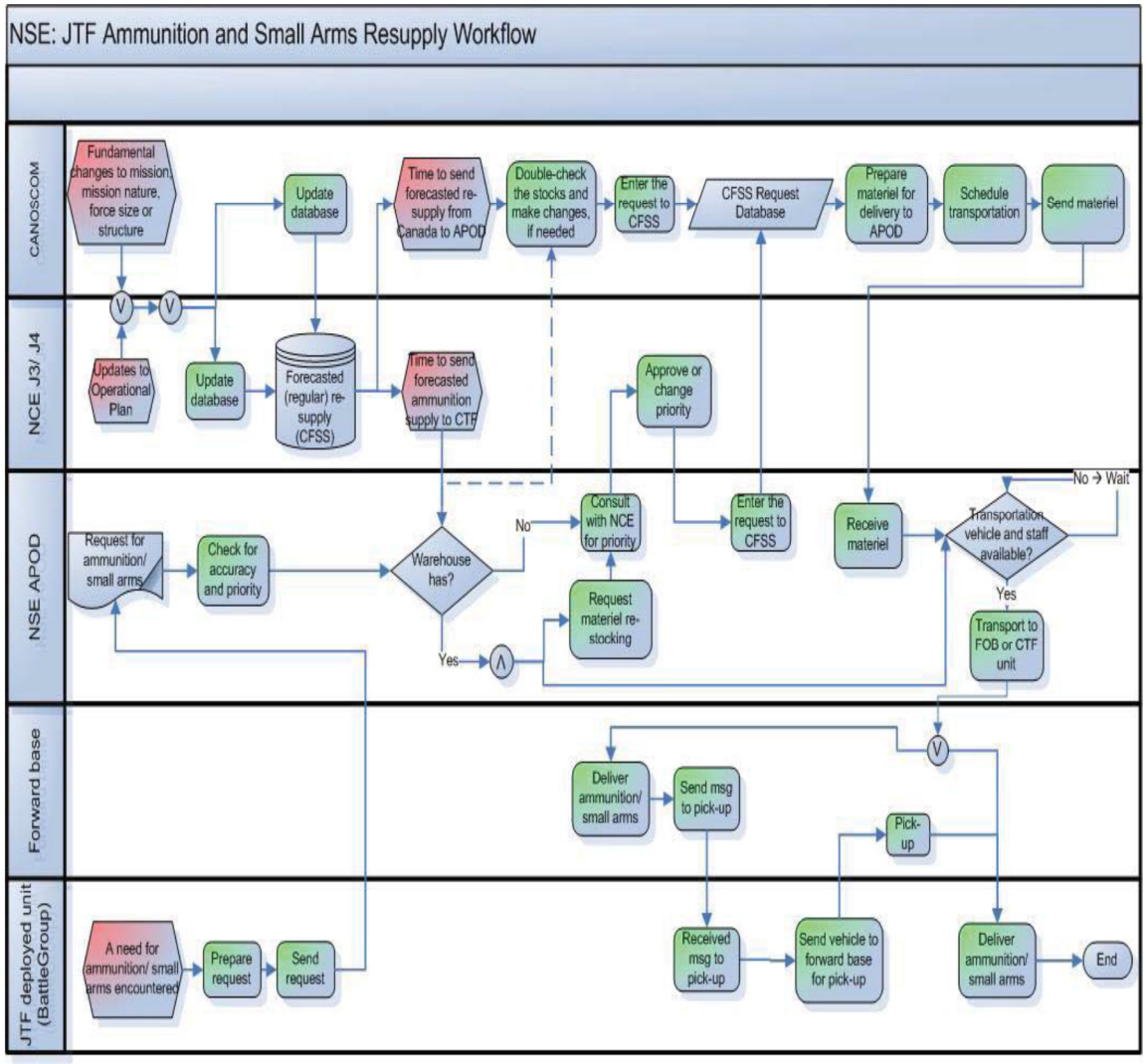

Figure 8 Ammunition and Small Arms Re-Supply Workflow

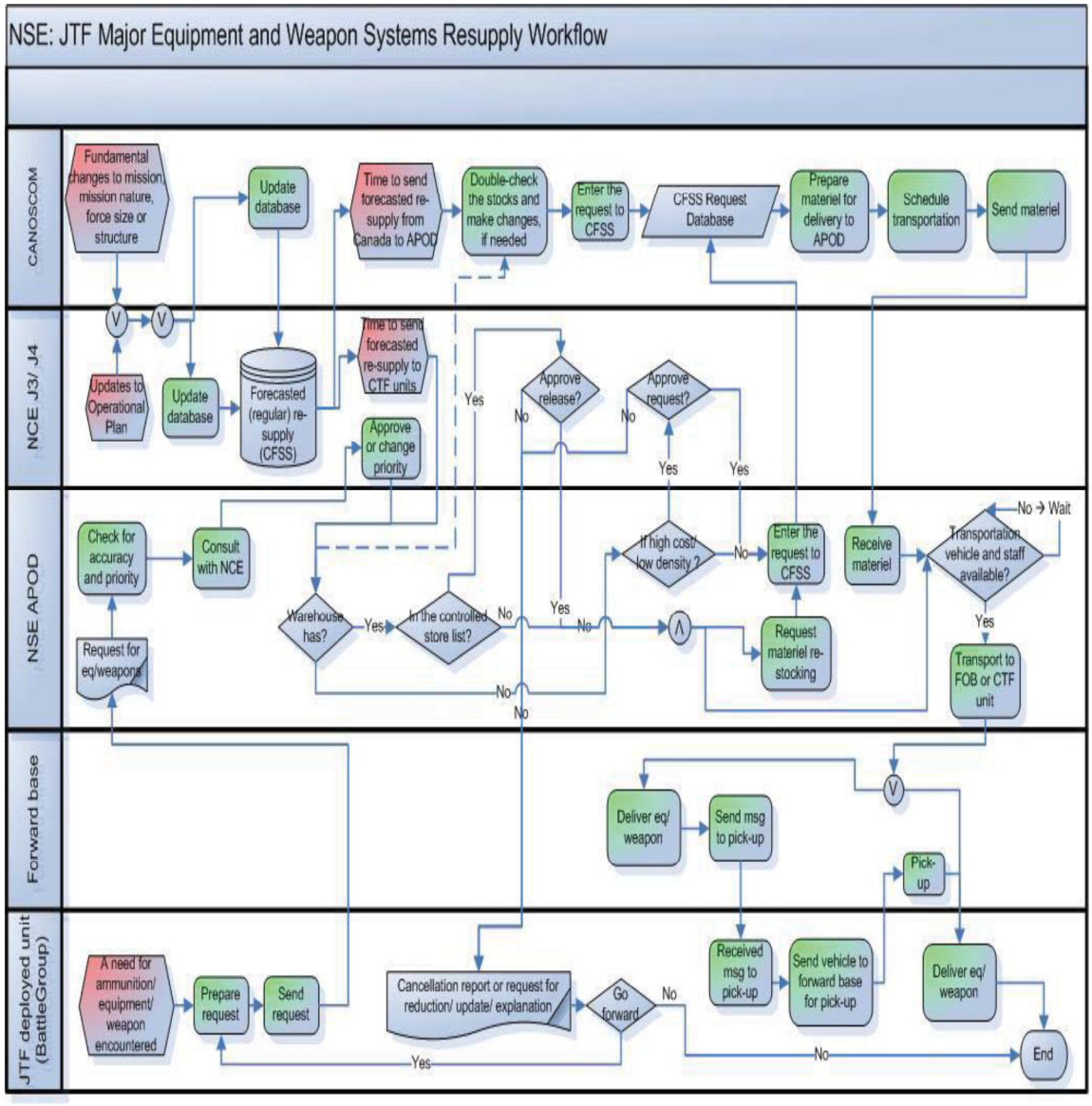

Figure 9 Major Equipment and Weapon Systems Re-Supply Workflow

The reality is that the NCE J4 staff in tandem with the NSE and CANOSCOM work hard and – based on their experiences – make the best preparation possible for stock levels. This forecasting has very much evolved as CF time in southern Afghanistan has gone on. As per operations plans, the crucial information is the regular updates from Battle Group on their ammunition levels, for example. If the information is inaccurate or not updated regularly and properly, the re-supply may happen to be not adequate, to the point that mission may even fail.

The circles in the diagram represent the logical *and* ($\wedge$) and *or* ($\vee$) operations. If two arrows (arcs) are coming to an *or* operation, for example (see the small circle in the upper left corner of the diagram), this denotes that if either one of the events, or both, at the source of the arrows happen, the action following the arrow coming from the circle has to be executed. If two arrows (arcs) are

coming out from an '*and'* operation, for example (see the small circle in the middle of the diagram), this denotes that both actions following the two arrows coming from the circle have to be executed.

Figure 9 gives the workflow for the major equipment and weapon systems ordering or re-supply. The work flow is slightly different from the previous one in decision making whether the equipment will be delivered immediately, whether it will require additional explanations, and whether its priorities need to be collated with the priorities of requests coming from other CF and JTF units. These differences are more visible in Figure 10 where only boxes that differ are shown in bright colors while the other boxes are pale.

The food/water, fuel re-supply, and medical supply workflows can be derived from the two presented workflows by removing certain tasks and boxes.

Medical logistics and medical materiel use the same operational level pipeline (supply chain) but they do not integrate at the tactical level. The tactical medical unit in coordination with the Canadian Contingent surgeon oversee the replenishment of the AOO/theatre. Medical supplies are transported via ambulance/medical assets to the supporting Unit Medical platoons and sections that provide Health care and medevac (medical evacuation) to the arms units.

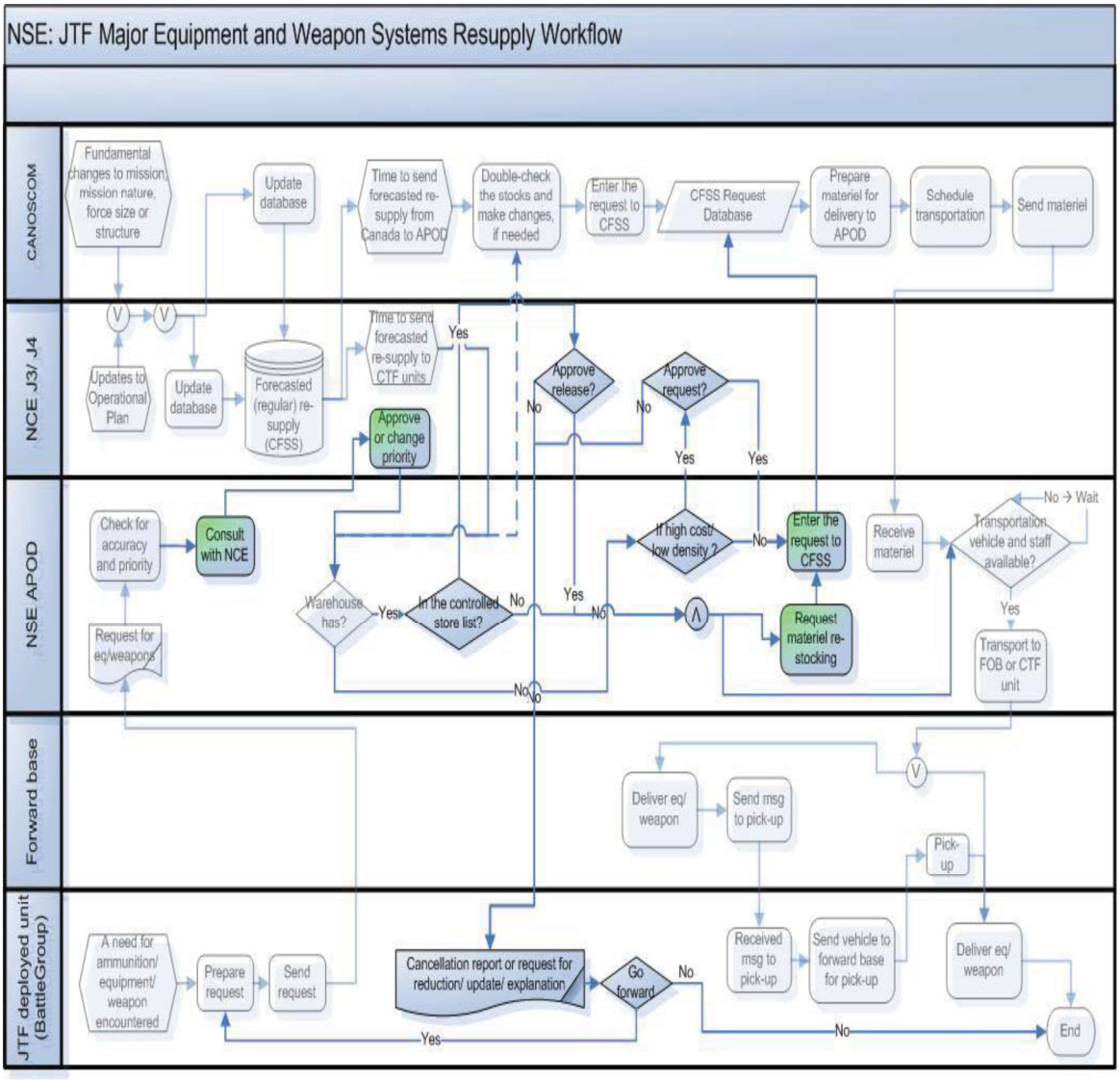

Figure 10 Emphasising the Differences between the Workflows Shown in Figure 8 and Figure 9

2.2 Analysis of the Current Practices

2.2.1 Logistics Metrics/ Measures of Performance

In logistics, the most commonly used metrics are:

- Service level
- Customer satisfaction
- Lead time
- Speed

- Distance
- Materiel quality

2.2.2 Encountered Problems

An Auditor General Report [2] devoted one chapter to the NSE and its functionalities and analysis of the data collected in Afghanistan. In Chapter 2, the National Defence supply chain was examined in terms of its ability to respond to the needs of the deployed CF units by maintaining adequate stocks for the repair and maintenance of military equipment, tracking and controlling supplies as they move to theatre through the supply chain, and delivering items to those who need them when they are needed.
Problems encountered during Afghanistan mission include:

1. Delays in moving needed supplies to the overseas location
2. The supply system does not provide enough information to track the arrival and whereabouts of all goods
3. Shortages of spare parts for key equipment

Some of the related statistics on latency provided in [2] are listed in Figure 11. For example, the expected time for deliveries from Canada to CF units, counting from the time the order is placed, had been 10-20 days, whereas in practice it happens to take more than 20 days from the main base in Canada to APOD. The main causes for such delays have been: transportation delays to the main base in Canada, waiting for fly-over permissions, failures of loading/unloading equipment at the APOD, etc. Further discussions of the problems encountered in the CF supply chain are given in the next section.

2.2.3 Discussion

Problem (1) most likely belongs to operational level logistics. However, if the delays are due to late ordering then the problem lies between tactical and operational level logistics planning and in forward planning and forecasting.

One aspect of Problem (2) represents deficiency in the links between the operational and tactical level logistics.

In order to resolve the listed issues, both operational and tactical logistics planning should be considered in one supply chain, although, in the CF doctrine the responsibilities are defined as follows:

- Operational level logistics planning: Canada to APOD
- Tactical level planning: APOD to CF deployed forces

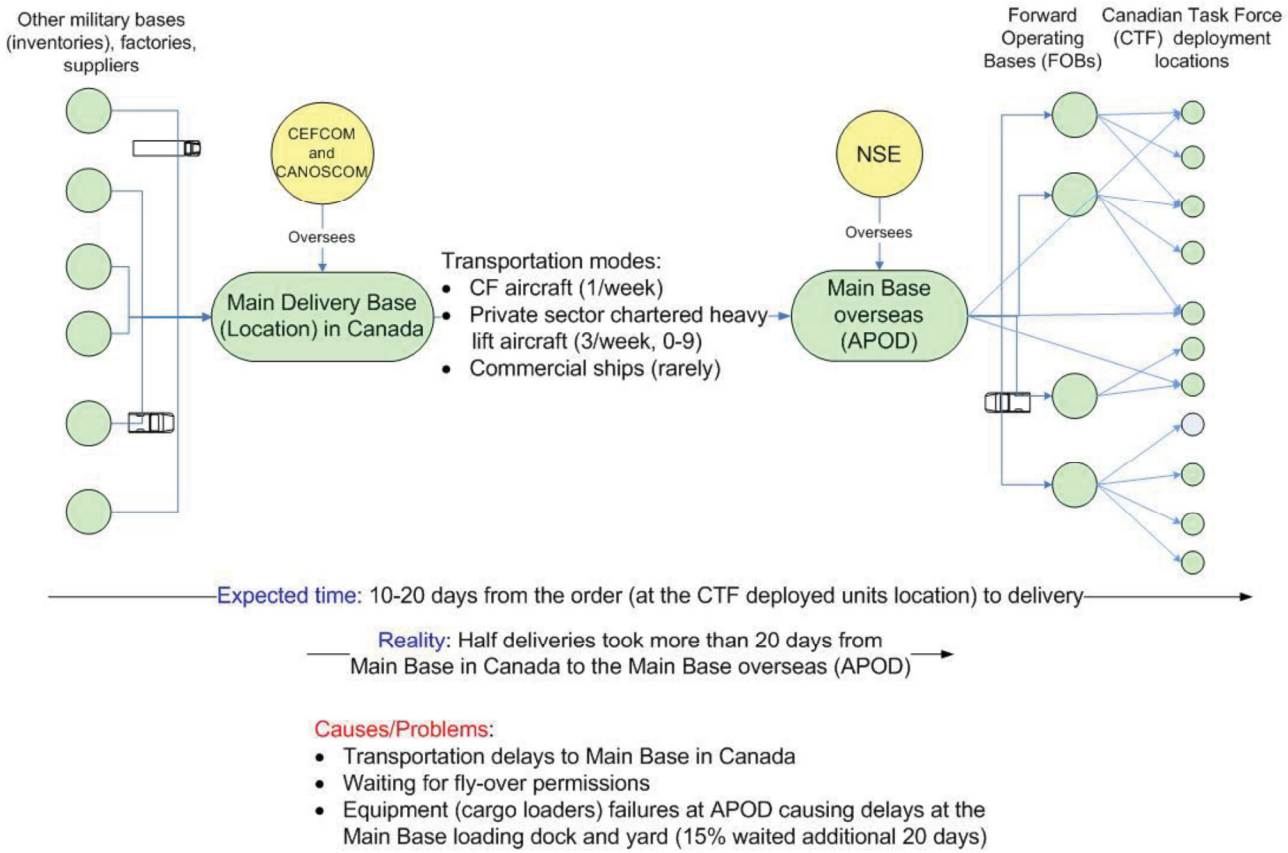

Figure 11 The Materiel Distribution System Together with the Statistics on some of the Performance Measures (Time, Speed) and Causes of the Encountered Problems

Combined supply chain network would monitor and control the entire spectrum of activities – from the 'source (raw materials)' to the 'consumer' and would provide more and easier asset visibility. In the military environment the source and the consumer terms related to the following:

- Source (raw materials):
  - In the short-term military operations, the source can be considered to be the inventory location in Canada
  - In long-term military operations (years), the source should be considered to be production facilities
- Consumer is represented by the CF deployed forces – battle group

Problem (3) is just a consequence of the malfunctioning of certain parts of the supply chain system.

It seems that the NSE had staff shortages [2], [3], and that majority of its own (NSE's) requests have been constantly assigned to lower priority. In the long term each one of those two practices can jeopardize the proper functioning of the NSE and – further in the future – the proper functioning of the CF units.

Potential remedies:

- Proper staffing of NSE (proper number of personnel)
- Proper and proactive planning including serious forecasting
- If delays occur, a prompt and proper increase in delivery assets and staff is needed to recover from the vicious circle of delay mode

Note also that additional difficulties with materiel distribution are due to the multi-modal transportation present at all levels as well as bundled transportation of the Materiel and passengers. Although it is the best approach to transportation in support of the military operations, bundled transportation increases the complexities and needs serious planning to show all its benefits. Bundled transportation means transporting different things/people with the same vehicle. Some of the things/people that need transportation and are bundled include:

- Materiel (food, water, POL, spare parts, ammunition, small arms, weapon systems, major equipment, combat and non-combat vehicles)
- Disposed materiel, equipment, vehicles
- Passengers (combat and supporting)
- Medical supplies
- Recovered equipment/ vehicles
- Hard rations (Individual Meal Packs or IMPS0)

2.3 Support Methodologies

2.3.1 Currently Used

Experiential data and consumption metrics are required for logistics decisions. The challenge in any AOO is how to acquire good data in the shortest possible time in order to develop sound sustainment or re-order schedules.

Following is the list of currently used tools by the NSE (and some other units) as a support in decision-making:

Table of Organization and Equipment. A compendium of all of a unit's subordinate organizations and all of their major equipment, weapons systems and personal weapons. It is a bank of data used by logisticians and commanders for force generation of units and also for movement planning. It is a thick document full of the essential ingredients that comprise a given unit.

The Canadian Campaign Design/NDHQ Level Order for the Operation. This order will lay out the framework sustainment architecture for Canadian Forces in the mission area as well these documents outline the places where sustainment and the NSE can and should have a catalytic impact on the campaign.

The Canadian and Combined Joint Task Force Operation Orders. The NSE will need these tools in order to prepare the sustainment plan for the Canadian Task Force and to predict the: who, what, where, when, and why of the logistics requirements.

Stock levels/Inventories. The rise and fall of holdings in the AOO drives the decisions that need to be taken by the NSE. Factors like distance and time impact when the decisions must be taken for certain commodities. The CFSS is a good tool for this "behind" the NSE at the operational level. For forecasting, the NSE commander relied on his own judgment using experience and the information available.

Political/Sovereignty Considerations. The requirements and protocols of sovereign countries impact the lines of communication. For example, it takes on average, 45 days for ammunition to flow into the Kandahar AOO from Canada based on the various over flight permissions that various countries have for the transportation of dangerous goods in their air space.

Spare Parts Scale. All repair parts for equipment in the task force are held in specific quantities referred to as scales. These set scales are designed to meet the demands of known wear and tear in the AOO where uniqueness of climate and geography cause consumption data on spare parts to vary – in some instances widely, as we have seen in Afghanistan and Iraq. The repair part scale is a tool, developed with educated guesses and empirical data to for fine tuning.

A lot of these decisions are taken by experience and gut feel but good decision support tools are available in industry to help the next generation of combat logisticians. Total asset visibility, and in particular, in transit visibility would be most useful tools supporting more precise decisions.
There have been plans to develop and employ the following tools for improving inventory management:

- Asset Visibility Project (Total Asset Visibility): the capability to track consignments moving to and from an oversea location. Planned to be deployed in Dec 2008. It will provide awareness of location, quantity and condition of assets from manufacture, transit, usage and disposal.
- Visibility of items in transit both within Canada and aboard. Planned to be deployed in 2009.
- Real-time visibility of assets throughout their lifecycle. Plan unknown.

It has been planned to develop and employ the following tools for improving forecasting related to the combat equipment spare parts:

- Distribution Resource Planning Tool for ongoing identification of inventory requirements. Planned to be deployed in the spring of 2008.

It would be most efficient if all those support tools were integrated into one system. Or, if they could be linked through certain interfaces – or at least compatible file input/outputs.
Other future distribution features may include 100[1]:

- Autonomous platforms with the precision service delivery capabilities.
- Pre-configured loads: as early as possible within the supply chain.

- Precise and fully networked asset tracking.
- In-transit visibility.
- Self-protecting, armed and armored logistics units.
- Increased vehicle recovery capability.
- Increased resources to meet acceptable medical evacuation times.
- Reduced double-tasking aircraft and only with proper task prioritization.
- Pro-active planning and forecasting: combat task based planning.
- Attempt to move from centralized NSE system to dispersed echelon, service-oriented Combat Support Services (CSS).
- Vehicles with build in sensors and self-diagnostic modules.

Other minor tools that can improve planning and forecasting – if not already used – include:

- Categorization of spare parts based on the importance of the equipment at question.
- Time-dependent ordering: as time passes the equipment begins to wear-down more often than at the beginning of the mission.
- Provide assets re-routing in order to react to unexpected demands (Although note that this is a highly reactive approach).

2.3.2 Forecasting and Supply Chain Management Revisited

Supply Chain Management (SCM) is the management of a network of interconnected businesses involved in the ultimate provision of product and service required by end customers (Harland, 1996). Supply Chain Management spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption (supply chain).

Translated to military environment and logistics, SCM is the management of a network of interconnected components involved in the ultimate provision of supplies and services required by the Canadian JTF deployed in an Area of Operation (AOO). Supply Chain Management should span all movement and storage of raw materials, work-in-process inventory, and finished Materiel from point of origin to point of consumption (location of the deployed JTF units).

SCM encompasses the design, planning, execution, control, and monitoring of supply chain activities with the objective of providing infrastructure for distribution and delivering of Materiel (medical supplies, food, equipment, spare parts, fuel, etc.) to deployed military units, synchronizing supply with demand and measuring performance globally.

The main goal and advantage of applying the supply chain is to shorten the time between the need being generated at the customer (JTF unit) level and source (inventories in Canada), so that system can respond faster to demand. For this to be facilitated, the CFSS system has to be expanded to encompass JTF units as well.

Another important advantage of SCM is data collection and the potential for more accurate forecasting in support of more proactive distribution. Currently, forecasting is not used enough, or so it seems. Forecasting may provide more prompt system response to requests, thus reducing the delays.

Providing distribution based solely on demand has proved to be insufficient. Waiting for requests may result in the overuse of air-based transportation because the CF units in the field cannot know how much in advance they have to provide their orders. Since they are often late, high priority orders have to be delivered using the fastest possible mode – by air. This situation is completely understandable, because everybody in the combat situation is stressed and busy with other more burning issues so they not able to spend time on prediction and forecasting of their needs for several days or weeks in advance.

2.4 Discussion

Potential improvements to the CF support include:

- Proper size of NSE, *i.e.*, JTFSC
- Proper application of the SCM throughout the entire range of operational and tactical logistics activities
- Advanced forecasting and corresponding proactive planning of all the activities (even those very slightly related)
- Advanced sensors, tools, and information systems for monitoring consumption/usage of materiel
- Training and professional education on military logistics inside the Canadian Forces

JTFSC Size and Funding. As per the Auditor General's analysis, it seems that the current NSE size is insufficient. (Another supporting argument may be found in the past – during the WWII the ratio between the number of support staff and the number of soldiers was around ½; it seems that currently this ratio is smaller). Furthermore, the Dispersed Adaptive Operations are likely to require even larger CSS. As stated at the beginning of the document, although not completely obvious at the first sight, the entire CF mission actually depends on functional JTFSC.

Supply Chain. The interdependencies between the two logistics planning levels are high. Thus, in order to be efficient, the supporting supply chain should spread over the entire range of logistics activities including both operational and tactical level. It is also a necessity for supporting forecasting and future pro-active CSS.

Based on the analysis of the operations and logistical support activities, it may be concluded that advanced implementation of the supply chain methodologies may be beneficial. Only the facts that: (a) there is high lead time, and (b) almost all requests are of urgent priority, means that the system is in overall late mode without the possibility to recover.

Forecasting is Crucial and Critical. Although just-in-time is emphasized in recent DND documents, it is important to notice that just-in-time may be in conflict with proactive support and use of forecasting. Also, the regular daily/weekly/monthly operational re-supply will not become redundant. Even when a system has only several days between ordering and delivering, the system has to support regular deliveries. Thus, there will always be need for the regular operational re-supply and maintenance of certain levels of Materiel in stock.

Pre-configured loads will restrict re-routing – unless division to smaller units is possible and easy-to-do. Also, it may also restrict the potential benefits of proposed re-routing and re-distribution.

Double-tasking an aircraft has to be done very carefully. Note that double-tasking has high likelihood of failing to achieve either goal (especially when mixing non-combat and combat tasks). No matter which priority system is incorporated, the combat task will always prevail as more urgent. However the delays of non-combat tasks may create near-future situations that are also unacceptable.

Only when the three listed concepts are properly addressed and implemented, can one consider and deal with the cost-effective delivery capability mentioned for the second (2) aspect/capability of Focused Logistics.

Cost-effective delivery capability requires the modeling and solving of optimization problems: namely, how to optimize a dynamic delivery system in which requests change. Optimization would involve routing, re-routing, transshipment, diversions, etc. It would model request priorities.

Overall, the need for forecasting, serious proactive pre-planning, and the use of a much larger number of transportation resources (at least for a short period of time) to catch-up on late deliveries seems to be high. Only after catching-up can the system function properly by delivering the Materiel on time.

The later the Materiel is to arrive, the more urgent the requests that will be submitted, and the more delayed the system will be (because it was designed to deal with only a certain amount of urgent requests). The longer the system is in this "being late" state, the higher the demand, pressure and stress on the logistics personnel and the more often that personnel will not be able to attend to low priority tasks (that are also essential), which in turn will cause problems at the later stage such as finding the right materiel within a reasonable time, which will in turn cause further delays and urgent requests to enter an already clogged system. It is a vicious cycle.

The clogged system would also cause lower priority level requests dealing with the equipment at APOD to never be delivered on time, causing breakages and further delays. Combat equipment will always be of higher priority than background equipment, but in the long run this can seriously damage JTFSC operations.

A proper system dynamics model of the NSE logistics and materiel distribution might be able to vividly present the described delays and resultant clogging of the system through time.

3 Tactical Supply Chain Network

This chapter reviews the tactical in-theatre supply chain network for coalition, North Atlantic Treaty Organization (NATO), and dispersed operations. It provides a review of a general supply chain network, the CF tactical in-theatre supply chain network, a short overview of the NATO logistics and NATO supply chain activities, as well as a brief discussion.

3.1 Supply Chain Network and Management.

3.1.1 Supply Chain (SC)

A *supply chain* (SC) is a set of organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer.

More recently, the loosely coupled, self-organizing network of businesses that cooperate to provide product and service offerings has been called the Extended Enterprise. Firms in the extended enterprise may operate independently, for example, through market mechanisms, or cooperatively through agreements and contracts. Alternatively referred to as a "supply chain" or a "value chain", the extended enterprise describes the community of participants involved with provisioning a set of service offerings [4]. How the Extended Enterprise is organized and structured and its policies and mechanisms for the exchange of information, goods, services and money is described by the Enterprise Architecture [5].

3.1.2 Supply Chain Network (SCN)

The *Supply Chain Network* (SCN) is the supply chain enhanced with the use of technologies such as wireless and internet networks, connective product marking technologies like radio-frequency identification (RFID) and emerging location standards such as Global Location Number(s) [6]. SCNs emerged recently as a consequence of the following changes in the business environment:

- Globalization and the explosion of multinational companies, joint ventures, strategic alliances and business partnerships
- Further developments related to just-in-time, lean manufacturing and agile manufacturing practices, and
- Technological advancements including the fall in information communication costs [6].

New terms related to supply chain network structures include Keiretsu, extended enterprise, virtual corporation, global production network, and next generation manufacturing system. In general, each of these structures can be defined as "a group of semi-independent organizations, each with their capabilities, which collaborate in ever-changing constellations to serve one or more markets in order to achieve some business goal specific to that collaboration" [7].

Systems that can facilitate the management of the SCN include: Order Management Systems, Warehouse Management System, Transportation Management Systems, Strategic Logistics Modeling, Inventory Management Systems, Replenishment Systems, Supply Chain

Visibility, Optimization Tools and more. Furthermore, new technologies are making possible even a real-time automation of the SCNs.

3.1.3 Supply Chain Management (SCM)

Supply chain management (SCM) integrates supply and demand management within and across organisations and companies. According to the Council of Supply Chain Management Professionals, the SCM encompasses the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management. The SCM also includes the crucial components of coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers (contracted logistics) and customers [6].

Logistics management deals with planning, implementation, and control of the efficient and effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements.

3.1.3.1 SCN Characteristics

SCM must address the following SCN issues:

- **Distribution Network Configuration**: a number and location of suppliers, production facilities, distribution centers, warehouses, cross-docks and customers.
- **Distribution Strategy** that includes:
  - Operating control: centralized, decentralized or shared;
  - Delivery scheme: direct shipment, pool point shipping, cross docking[9], direct store delivery, closed loop shipping, and third-party logistics;
  - Mode of transportation:
    - Motor carrier including full truckload, less-than-truckload (LTL), parcel
    - Railroad
    - Ocean freight
    - Airfreight
    - Intermodal transport;
  - Replenishment strategy: pull, push, or hybrid; and

[9] Cross-docking is a practice in logistics of unloading materiel from an incoming semi-trailer truck or rail car and loading this materiel directly into outbound trucks, trailers, or rail cars, with little or no storage in between. This may be done to change type of conveyance, to sort materiel intended for different destinations, or to combine materiel from different origins into transport vehicles (or containers) with the same, or similar destination. Cross-Dock operations were first pioneered in the US trucking industry in the 1930s, and have been in continuous use in LTL (less-than- truckload shipping) operations ever since. The US Military began utilizing cross-dock operations in the 1950s. Wal-Mart began utilizing cross-docking in the retail sector in the late 1980s.

- Transportation control including owner-operated, private carrier, common carrier, contract carrier, or third-party logistics provider (3PL).

- **Trade-Offs in Logistical Activities**: The logistics activities must be well coordinated in order to achieve the lowest total logistics cost. For example, full truckload (FTL) transportation rates are more economical on a cost per pallet basis than LTL shipments. However, a FTL of a product may increase inventory holding costs which may result in an overall increase in the logistics costs. Taking a systems approach when planning logistical activities may result in the trade-offs leading to the most efficient and effective logistics and SCM strategy.
- **Information Flow**: the integration of processes through the SC for sharing valuable information, including demand signals, forecasts, inventory, transportation, potential collaboration, etc.
- **Inventory Management**: Quantity and location of inventory, including raw materials, work-in-progress (WIP) and finished goods.
- **Cash-Flow**: Arranging the payment terms and methodologies for exchanging funds across entities within the supply chain.

Supply chain execution means managing and coordinating the movement of materials, information and funds across the supply chain. The flow is bi-directional.

3.1.3.2 Strategic, Operational and Tactical Activities

Supply chain activities can be broken down as follows:

- Strategic,
- Operational, and
- Tactical levels.

Strategic supply chain activities represent long term planning and require resource commitments. The activities involve: strategic network optimization, including decisions on number, location, and size of warehousing, distribution centers, and facilities. Communication channels are created for critical information transfer between suppliers, distributors, and customers. Strategic supply chain activities also include planning for the product lifecycle management so that new and existing products can be optimally integrated into the supply chain and capacity management activities. Potential information technologies that can support supply chain operations are indicated. Also, aligning overall organizational strategy with supply strategy is done.

Operational Level activities include:

- Production and distribution planning, including all nodes in the supply chain.
- Production scheduling for each manufacturing facility in the supply chain.
- Demand planning and forecasting, coordinating the demand forecast of all customers and sharing the forecast with all suppliers.

- Sourcing planning, including current inventory and forecast demand, in collaboration with all suppliers.
- Inbound operations, including transportation from suppliers and receiving inventory.
- Production operations, including the consumption of materials and flow of finished goods.
- Outbound operations, including all fulfillment activities, warehousing and transportation to customers.
- Order promising, accounting for all constraints in the supply chain, including all suppliers, manufacturing facilities, distribution centers, and other customers.
- From production level to supply level accounting for all transit damage cases and arranging settlement at customer level by maintaining company loss through an insurance company.

Tactical Level activities include:

- Sourcing contracts and other purchasing decisions.
- Production decisions, including contracting, scheduling, and planning process definition.
- Inventory decisions, including quantity at each location and quality of inventory.
- Transportation strategy, including frequency, routes, and contracting.
- Benchmarking of all operations against competitors and implementation of best practices throughout the enterprise.
- Milestone payments.
- Focus on customer demand.

3.1.3.3 Historical Developments of the SCM

Six major movements can be observed in the evolution of the supply chain and SCM: Creation, Integration, and Globalization, Specialization (Phase One and Two), and SCM 2.0 [6].

Creation Era: The term supply chain management was first coined by a U.S. industry consultant in the early 1980s. However, the concept was initiated in the early 20th century with the creation of the assembly lines. The characteristics of this era of include large-scale changes, re-engineering, downsizing driven by cost reduction programs, and widespread attention to the Japanese practice of management.

Integration Era: Starting with the development of Electronic Data Interchange (EDI) systems in the 1960s and developing through the 1990s with the introduction of Enterprise Resource Planning (ERP) systems, this era has continued to develop into the 21st century with the expansion of

internet-based collaborative systems. It is characterized by both increasing value-adding and cost reductions through integration.

Globalization Era: Characterized by the global systems of suppliers and the expansion of supply chains over national boundaries and into other continents, this era started in the late 1980s in most industries (with the exception of the oil industry where globalization stared earlier).

Specialization Era – Phase One: Outsourced Manufacturing and Distribution: In the 1990s industries began to focus on "core competencies" and adopted a specialization model. This was characterized by management extending across specialized supply chain partnerships, and the need for supply base visibility, WIP visibility and inventory visibility. The specialization model creates manufacturing and distribution networks composed of multiple, individual supply chains specific to products, suppliers, and customers.

Specialization Era – Phase Two: Supply Chain Management as a Service: Specialization within the supply chain began in the 1980s with the inception of transportation brokerages and warehouse management, and has matured into aspects of supply planning, collaboration, execution and performance management. Supply chain specialization enables companies to improve their overall competencies by assembling networks of specific, best-in-class partners to contribute to the overall value chain. The ability to quickly obtain and deploy this domain-specific supply chain expertise without developing and maintaining it in-house is the leading reason why supply chain specialization is gaining popularity.

Supply Chain Management 2.0 (SCM 2.0): Term SCM 2.0, coined after Web 2.0, describes both the changes within the supply chain as well as within its processes, methods and tools. Web 2.0 is defined as a trend in the use of the World Wide Web that is meant to increase creativity, information sharing, and collaboration among users. At its core, Web 2.0 supports the navigation of the vast amount of information available on the Web. It is the notion of a usable pathway. SCM 2.0 follows this notion into supply chain operations. It is the pathway to SCM results – a combination of the processes, methodologies, tools and delivery options to guide companies to their results quickly as the complexity and speed of the supply chain increase due to the effects of global competition, rapid price fluctuations, surging oil prices, short product life cycles, expanded specialization, near-/far- and off-shoring, and talent scarcity. Thus, SCM 2.0 follows the Web 2.0 concept. There is no real sharp boundary between SCM and SCM 2.0: for example, if an SCM system has advanced searching and management tools it could be declared to belong to the SCM 2.0 era.

3.1.3.4 SCM Processes

According to [8], operating an integrated supply chain requires a continuous information flow. However, in many companies, management has reached the conclusion that optimizing product flow cannot be accomplished without implementing a process approach to the business.

The key supply chain processes [9] are:

- Customer relationship management
- Customer service management

- Demand management
- Order fulfillment
- Manufacturing flow management
- Supplier relationship management
- Product development and commercialization
- Returns management

Additional critical processes could include:

- Physical distribution
- Outsourcing/partnerships
- Performance measurement
- Warehousing management

Regarding Performance measurement, according to experts, internal measures include: Cost, Customer Service, Productivity measures, Asset measurement, and Quality. External performance measurements include customer perception measurement, and best practice benchmarking.

The most relevant processes for military application are: Demand management, Order fulfilling, Physical distribution, Performance measurements, Outsourcing partnerships and Warehousing management. Outsourcing partnerships refers to the sharing of logistics responsibilities with NATO nations inside a coalition and also the practice of procuring goods and services locally.

3.1.3.5 The Integration Components of SCM

The literature on business process re-engineering, buyer-supplier relationships, and SCM suggests various possible components that must receive managerial attention when managing supply relationships. Reference [8] identified the following components:

- Planning and control
- Work structure
- Organization structure
- Product flow facility structure
- Information flow facility structure
- Management methods
- Power and leadership structure
- Risk and reward structure
- Culture and attitude

Adding more management components or increasing the level of each component can increase the level of integration of the SCM.

3.2 Tactical In-Theatre SCN

The tactical SCN provides the main sustainment activities of deployed elements of the CF. Since our project is focused on materiel distribution, this document focuses on the SCN dealing with this aspect of CF Logistics and related NSE activities.

Military deployment instances are dissimilar. As a result, the structure and topology of the tactical SCN will vary from one CF mission to another. A detailed first principles approach to thorough planning of the SCN for each discrete mission is essential. In this way the SCN is even more complex because learning from previous operations and mistakes can only be done in a limited manner. A logistic solution, for example, worked very well when the CF operational A00 Area comprised 400 square kilometres in the city of Kabul from 2003 to 2005. The same hub and spoke logistics model that worked so well in Kabul was ill-suited for the SCN that was demanded by the CF elements operating in Kandahar in southern Afghanistan from 2006 to 2011. Useful comparisons are best restricted to fundamental components. The key components, capabilities and roles are common to all Canadian Forces SCNs, but the manner in which the components are furnished can vary dramatically.

The simplified structure and the topology of the operational and tactical SCNs for the current CF mission in Afghanistan is shown in Figure 12. The nodes on the left side of the figure are the components of the Operational SCN, while the nodes on the right side belong to the Tactical in-theatre SCN. In Canada, the biggest building represents the Main Military Base in terms of delivery of the materiel from Canada to the TOO (Theatre of Operations). The buildings of the same shape, but smaller, represent other military base inventories from where the materiel can be supplied. Also, factories can be suppliers – of which one is shown in the figure. Commercial suppliers are shown in blue (foreign) and gray (domestic) and are all linked to the Main Delivery Base. From the Main Delivery Base materiel is either flown or shipped to the TOO, more precisely to APOD. In addition, the APOD can receive goods from the local suppliers (shown as a light brown building). In the TOO, the APOD is shown as a large tent, FOBs are smaller yellow tents, and deployed CF units are small green tents. The corresponding links are showing the flow of materiel. The positioning and the number of nodes are fictional and just represent a potential example.

Figure 12 Topology of the Distribution Network Configuration including Operational and Tactical Supply Chain Network components.

3.2.1 Desirable Characteristics of SCN

In order to be able to respond to evolution of supply, demand and resource conditions in the right manner and in the right time, the CF tactical in-theatre SCN should be:

- Dynamic
- Flexible
- Agile
- Robust
- Simple
- Self-sufficient/ redundancy.

A dynamic system is the system that changes through time. A flexible system is one that is able to react in the case of changes, whether predicted or unpredicted. Agile systems assume the capability of rapidly and efficiently adapting to changes. A robust system provides the ability to cope with errors during execution, the ability to continue to operate despite errors in input, calculations, and the ability to withstand a certain amount of enemy interference.

Although complex in its nature, the CF planners of the tactical SCN usually strive for simplicity, in order to keep the structure less brittle.

The principles of self-sufficiency and redundancy seek to keep materiel dispersed. This reduces risk from a survivability stand point. Units in the AOO all maintain 3-days' worth of materiel. The tactical SCN seeks to top up the units every 24 hours (by doctrine). This can be a wider interval in reality.

3.2.2 Tactical SCN Components

The main components of the tactical SCN include:

- The APOD: The airfield of disembarkation that receives the materiel from the operational level SCN.
- The NSE: The close support unit (second line) which receives, sorts (bulk breaks) commodities and delivers them forward to the A2 Echelon.
- Third Party Logistics Providers: Contractors in the AOO that can provide SCN services beyond the APOD.
- Forward Operating Bases (FOBs). The A2 Echelon locations of a given combat arms battalion to which materiel is delivered by the NSE for use by the combat arms.
- Battle group: Echelons A2, A1, and F. The F echelon is the most forward echelon where the fighting is, the A1 echelon the Company Quartermaster Sergeant (CQMS) – provides moment to moment SCN needs to F, and the A2 echelon of the quartermaster provides daily needs to the CQMS.
- NATO Logistics Assets: The SCN assets of NATO or Coalition partners that can be accessed for us in the Canadian SCN.

The tactical SCN components and structure can be seen in Figure 13, with the exception of NATO Logistics Assets. (The relation between NATO Logistics Assets and NSE responsible for tactical logistics and tactical SCN is depicted in Figure 4.) Some icons in Figure 13 have the same meaning as the icons in Figure 12. The yellow triangles represent inventories, the blue document file represents contracts for transportation services, and the purple document file represents purchasing contracts. In this figure the organization in echelons is also shown. The materiel replenishment of the battle group is organized in such a way that the 3-day basic supply is spread over echelons A2, A1, and F. A2 echelon is responsible for daily supply to A1, and A1 is responsible for supply to F. Occasionally, a materiel item can be flown directly from APOD. The figure also show the times that are expected for certain deliveries. Urgent deliveries do not wait at APOD. If needed, a convoy will be set up immediately to transport high priority urgent items. They will be delivered in a matter of hours, if they can be found within AOO. Less urgent deliveries will be delivered within the next 2-3 days.

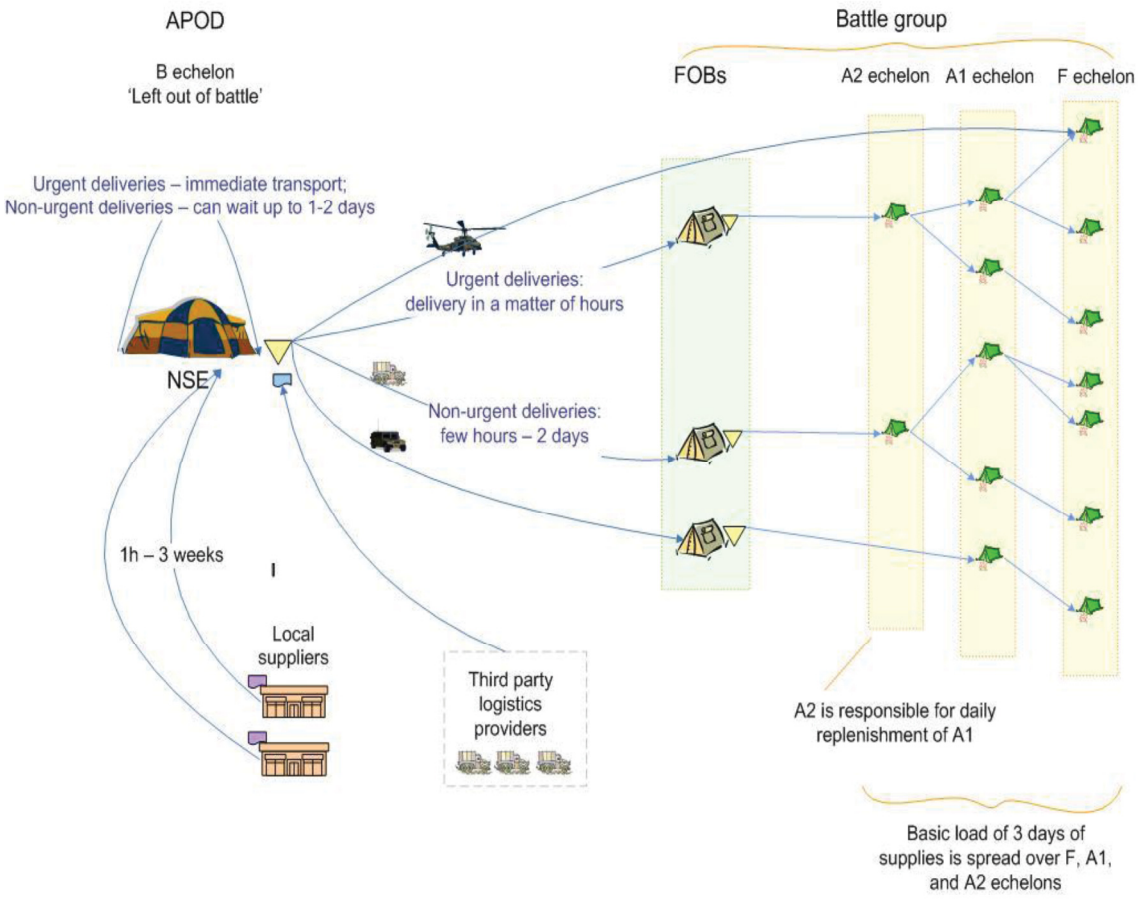

Figure 13 Tactical Supply Chain Network

3.2.2.1 Component Capabilities and Roles

Infantry battalions in battle look nothing like the box organization charts in a doctrine manual [10], [11][10]. Tactical army units organize themselves into echelons for fighting and sustainment. The echelons range from the "sharp-end" or F echelon through to an administrative B Echelon where administration and unit governance can occur in a position of relative safety. The B Echelon is where the 'left out of battle' components of a unit reside, like the unit orderly room, clerical staff, and Adjutant. There is no SCN activity resident in the B Echelon. In the contemporary theatre of Southern Afghanistan the B Echelon is located on a FOB. The Battle group consists of the F, A1, and A2 echelons.

[10] CF Doctrine is stated and described in a number of documents. The Joint Doctrine of the CF library can be found at http://www.cfd-cdf.forces.gc.ca/sites/page-eng.asp?page=3560 (accessed on February 11, 2011). The document most relevant to this report and the project is CFJP 4.0 – Support to CF Operations [DND]. It has been outdated for the last ten years, and John Conrad believes that it is currently under revision.

The F Echelon is the forward edge of the battle area/combat operations. In Canadian doctrine, every battalion/battle group maintains a Basic Load of three-days of supply (see comment on Self Sufficiency above). This doctrine is a rough guideline and depending on the commodity, the three-day figure may be woefully under subscribed or over stocked. The three-day Basic Load of unit-held supply is spread between the F, A1 and A2 Echelons.

A1 Echelon – this echelon positions itself in close physical proximity to the F Echelon. It may be a FOB or a collection of vehicles projected forward of a FOB. The A1 Echelon is responsible for the moment to moment replenishment of the combat team (Company Quartermaster Sergeant (CQMS) to the various platoons). The A1 and A2 echelons exist inside the battle group. The A1 consists of the CQMS ensuring that the various platoons in the company have their immediate SCN needs met and maintained. The CQMS is responsible for consolidating requests for his company and submitting them to the Regimental Quartermaster Sergeant (RQMS) at the A2 for submission to the NSE.

A2 Echelon – this echelon is responsible for the daily replenishment of the A1 Echelon. The A2 Echelon is led by the Quartermaster/RQMS who ensures that the Companies of the battle group and CQMSs are well stocked. The NSE tops up the A2 Echelon/Unit Quartermaster. The NSE connects with the A2 Echelon by either ground or aerial delivery of materiel as described in previous sections and in Chapter 3.

For the transportation vehicles available at each echelon, see Annex A.

3.2.2.2 SCN Operator Role

Figure 14 shows the Canadian Forces Supply System (CFSS), inventories, and the SCN technician interactions with CFSS. It covers the receiving and issuance tasks of the SCN technician.

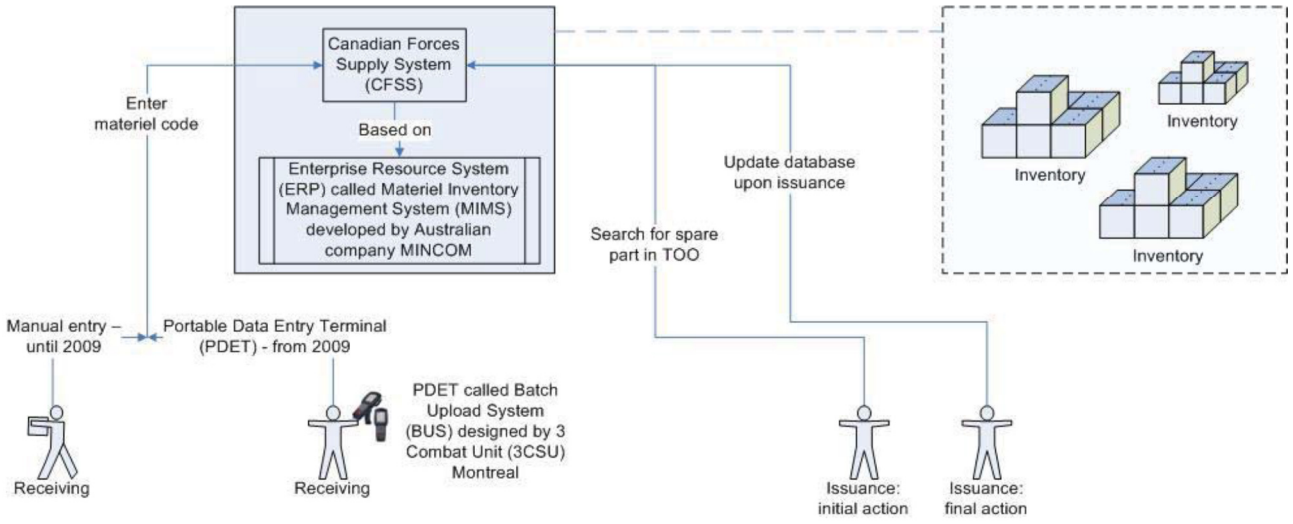

Figure 14 Canadian Forces Supply System (CFSS) and the SCN technician interactions.

Roles of the SCN technicians:

- Receipt of materiel
- Logging the receipt of materiel
- Deciding where to put the materiel
- When request arrives, checking whether the materiel is at TOO and where (in which inventory)

For the receiving task, a manual entry was required by the end of 2008. Since 2009, Portable Data Entry Terminal (PDET) has been in use by the SCN technicians. It has been called the Batch Upload System (BUS). The BUS is capable of supporting all three key processes of SCM: Receipt, Issue, and Stock Tracking. However the Assistant Deputy Minister– Information Management (ADM-IM) approved only Receipt has to be turned On.

3.2.2.3 Component Command Hierarchy and Relationships

Formation Level

Commander of Coalition Joint and Combined Task Force/Multinational Brigade. The top military authority who devises the operational plan and creates a SCN requirement for his command. The SCN solution that supports the plan will come from a number of sources in modern coalition operations.

Brigade/Coalition G4 Staff Officer. The senior logistics staff officer of a formation who provides the Commander of the Combined Joint Task forces with logistics advice. The G4 assists the various NSEs with the coordination and provision of SCN services for a given operation.

NSE

Commanding Officer NSE. A Logistics officer, Lieutenant Colonel who is in charge of the Second line support (close support) to all units in a Canadian Task Force. The NSE delivers materiel to the A2 echelon of a given unit (see Section 0).

Canadian Combat Arms Unit(s)

Combat Arms Commanding Officer(s). These officers devise their tactical plans for a given operation and create unique SCN demands for their units that must be met.

Unit Quartermaster. Every combat arms unit in the Canadian Forces has a Logistics Branch supply officer (captain) who is responsible to the Combat Arms Commanding officer for the supply chain function inside the battle group/battalion. This officer provides the Combat arms commanding officer with SCN advice and participates in the administrative planning of tactical operations.

Regimental Quartermaster Sergeant (RQMS). This individual is a Logistics Chief Warrant Officer supply specialist subordinate to the Captain Quartermaster. This senior soldier is the top SCN technical authority of the given combat arms battalion. Responsible to the Quartermaster for the good order of supply accounts and the quality/serviceability of materiel, the RQMS provides both

technical expertise and guidance to the Company Quartermaster Sergeants (CQMS) who are combat arms warrant officers in each of the companies of the infantry/arms battalion.

Technical Quartermaster Sergeant. This individual is a Logistics sergeant responsible to the RQMS for the technical/qualitative state of the battalion's supplies. He or she has a wide range of functions focussed mainly on the technical aspects of the unit stocks and holdings.

Company Quartermaster Sergeants (CQMS). There is one CQMS in each infantry/combat arms company; the armoured corps and artillery have variations on this theme. In the Armoured units the combat arms squadron sergeant major and the combats arms captain, second in command have the primary responsibility of moment to moment replenishment of the tanks. The CQMS is the main point of contact for combat team/company replenishment. CQMS rank is normally a combat arms Warrant officer. They are normally senior warrant Officers with good infantry experience. They must be proficient in the intricacies of the combat team/company, how it organizes for battle, what its normal rate of expenditure and consumption habits are. Planning for operations involves interfacing with the Company Commander and Second in Command, the RQMS and Quartermaster to ensure the needs of the fighting echelon are planned and met.

3.2.3 SCN Processes and Procedures

The replenishment cycle is the chief biorhythm of the tactical SCN. In doctrine this cycle is a daily top up of combat arms units by the logistics unit of a given formation. Key to the cycle is the submission of a demand from the "customer" to the logistics unit which contains the items required for replenishment and the detailed quantities. The replenishment cycle contains a host of procedures (routine demands, emergency resupply demands and supplemental demands, confirmation of delivery methodology – air, ground. etc.) to be followed by both the customer and the logistics provider to effect the replenishment. In Afghanistan, the replenishment cycle did not follow the strict 24 hour/daily cycle for a number of reasons – not the least of which was to avoid a pattern of predictability for the enemy to exploit.

3.2.4 SCN Characteristics

3.2.4.1 Tactical In-Theatre Supply Chain for Dispersed Operations

The characteristics of the tactical in-theatre supply chain for coalition, NATO and dispersed operations are as follows:

- **Distribution Network Configuration**:
  - Suppliers are: APODs and Local suppliers
  - Production facilities are almost non-existent, if not encountering for small production activities at Maintenance Workshop of NSE,
  - Distribution centers are at FOBs and elements of Echelons A1 and A2
  - Warehouses are almost always (in close proximity to) or at APODs and FOBs,
  - Cross-docks could happen at APODs, FOBs and anywhere security measures are put in place. This could include a wide open field, the

middle of a road or in a built up area. Maximum security of camouflage and concealment is used in these cases.

- Customers: main customers are the Quartermasters of units deployed beyond the APOD, although staff at FOBs and APODs can be counted as customers as well (for some materiel)

- **Distribution Strategy**:
  - Operating control is centralized under the NSE Commanding Officer
  - Delivery scheme is cross-docking using the echelon structure. Sometimes there are direct shipments (from APOD to deployed unit) made by either NSE or battle group staff. Also, often third-party logistics is used (from local suppliers to APODs or beyond APOD). For example, diesel fuel delivery is made directly to a FOB by a third party logistic provider (jingle truck). In addition, services like sewage removal, the cleaning of infrastructure, garbage removal are services delivered to FOBs by local contractors.
  - Mode of transportation depends on the geography, infrastructure and operation. Most often it is motor carrier / convoys. Sometimes, aircrafts are used, or the intermodal transport including motor carrier and airfreight.
  - Replenishment strategy is hybrid consisting of:
    - Pull (when CF units provide orders) and
    - Forward issuance according to forecasted demand
  - Transportation control is done by NSE.
- **Trade-Offs in Logistical Activities**: In the military environment, the most commonly sought objective is to fulfill all requests on time and according to set priorities. The costing comes only after that. (Money is a tertiary concern in the tactical SCN. Financial efficiency is more applicable to decisions taken at the operational level of the SCN.)
- **Information Flow**: These procedures are routinely established, but improvements are always welcome.
- **Inventory Management**: Done by the units that is in charge of the item. The largest inventory is at APOD.
- **Cash-Flow**: This is not the topic of this project.

3.2.4.2 Operational and Tactical Supply Chains: Merged

Operational supply chain encompasses all CF units/ organizations and activities that provide flow of materiel from its source in Canada (or in a foreign country) to the APOD. Tactical supply chain encompasses all CF units/ organizations and activities that provide flow of materiel from the APOD to deployed CF units (battle group).

It is the author's opinion is that the two supply chains have to be considered as parts of one larger supply chain in order to achieve proper effectiveness and efficiency. It is very likely that such a structure would make it easier to maintain the agility, robustness and flexibility of the SCN.

An overview of the distribution network configuration encompassing both operational and tactical supply chains is given in Figure 3. More detailed elements of the SCN related to the materiel distribution are given in Figure 15. The suppliers, production facilities, distribution centers (Main base in Canada, and APOD), warehouses, and customers are shown. Warehouses are depicted with the yellow inverted triangle beside a building/ tent. The division into the Operational and Tactical SCNs is shown by the orange vertical line.

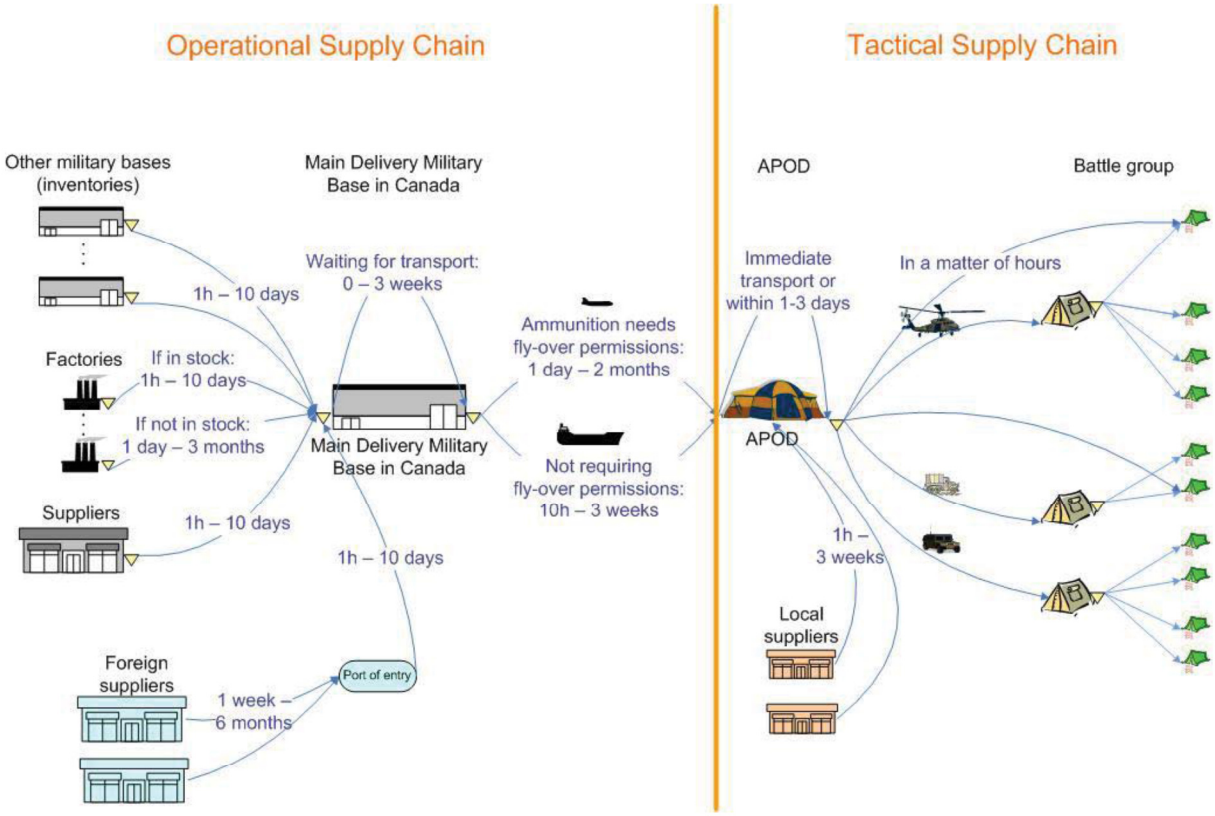

Figure 15 Distribution Network Configuration: Operational and Tactical Supply Chain with Estimated Transportation Times

The figure also provides some examples of potential times, in operational SCN, needed for transportation of materiel along certain links (edges). Although the times are very rough estimates, they show that delays in delivery can be very large. In the tactical SCN the times can vary widely due to the uncertainties of the in-theater environment. However, the urgent items will be delivered in a matter of hours provided they are within AOO. Non-urgent items will be delivered within 2-3 days. Tactical supply chain and its components are described in great detail in Section 3.2.2.

In the operational SCN, the average time for transportation also depends on the availability of the item and the operational importance that the theatre has assigned to the particular item. If items

have high priority and are available in industry or in Canada, the delivery time is normally a matter of days not weeks. Ammunition, as noted in Figure 16 is often an exception, as specific fly-over permissions are required from other nations.

Note that when determining how far in advance a request has to be submitted, one has to account for the time the request information needs to reach the location where the specified good is positioned/stored.

If we add to the picture the third-party logistics contracts and purchasing contracts, the entire SCN becomes very complicated. Thus, currently existing problems become more understandable (see Figure 16 for contracts and problems).

The characteristics of this merged SCN are as follows:

- **Distribution Network Configuration**:
  - Suppliers are: the nodes in Figure 16 without incoming edges: Canadian suppliers, factories, military bases, and foreign suppliers, as well as local suppliers in AOO.
  - Production facilities are factories in Canada.
  - Distribution centers are Main delivery military base in Canada, APOD, FOBs and elements of Echelons A1 and A2.
  - Warehouses are at military bases in Canada, APODs and FOBs.
  - Cross-docks could happen at APODs, FOBs and anywhere security measures are put in place. This could include a wide open field, the middle of a road or in a built up area. Maximum security of camouflage and concealment is used in these cases.
  - Customers: main customers are the Quartermasters of units deployed beyond the APOD, although staff at FOBs and APODs can be counted as customers as well (for some materiel).

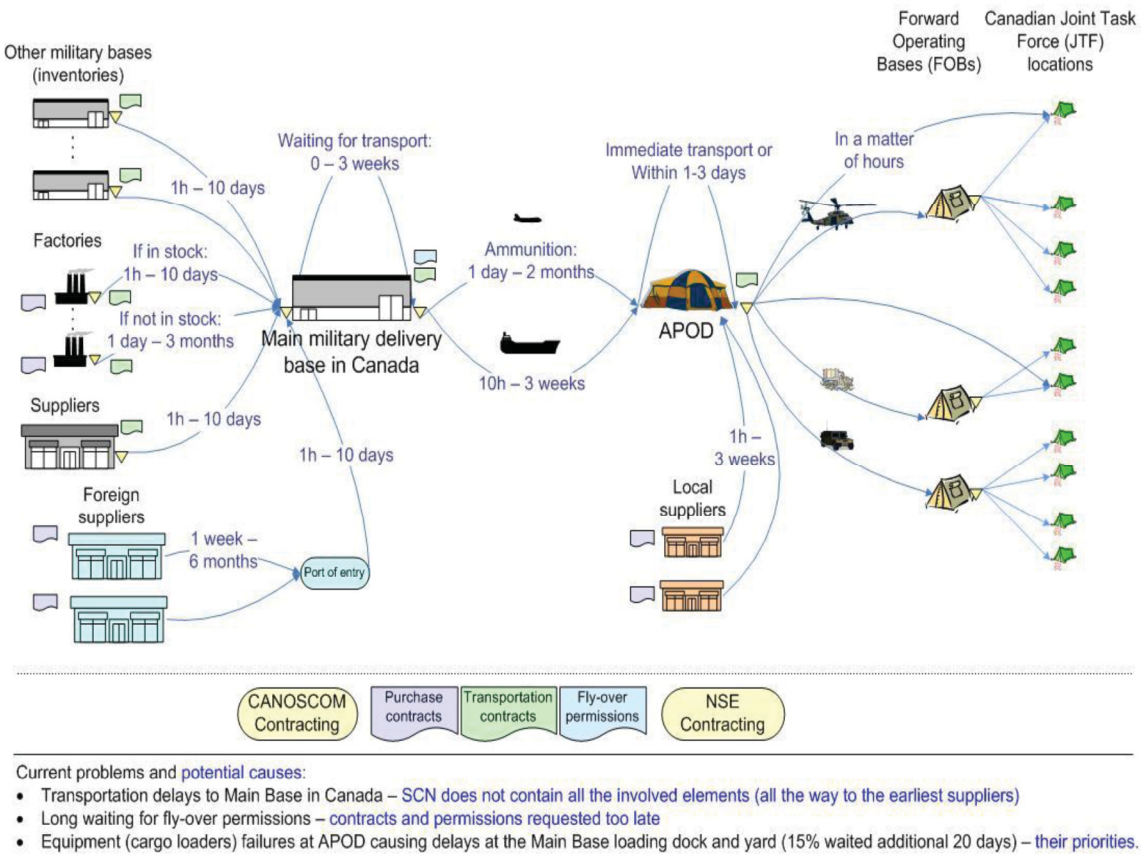

Figure 16 Merged Operational and Tactical SCNs with Contracting Activities

3.2.5 Mission Risks Related to SCN

Potential SCN failure to adequately respond to changes that influence demand, supply, and materiel/ assets state would increase the risk of the CF mission failure.

Apart from:

- Unexpected enemy activities
- Unexpected weather changes
- Natural or man-made disasters

that would influence all aspects of the tactical SCN, the following elements and events would influence:

- Demand:
  - Changes in the mission operational plan
  - Changes in force size
  - Changes of mission type or nature
  - Fundamental changes in force structure

- Materiel/assets state:
  - Support equipment problems
- Supply:
  - Unexpected business failures or substantial changes at sub-contractors or factories providing materiel

The SCN should react positively to un-forecasted losses (enemy activity) and deal with sudden increase or decrease in demand by the applying following measures:

- Changing the forecasted demands
- Increasing/ decreasing staff and transportation resources
- Changing the structure of the SCN, in the case of major changes

Failure to apply these measures (or its subset) and to properly and in timely fashion respond to the changes, represents a risk to the efficient functioning of SCN. This could result in improper support for the Canadian Joint Task Force (JTF) battle group and – in the worst case – in the failure of the battle group actions or even the entire mission.

The SCN will be able to respond to these changes in time if it is agile, simple, flexible, and robust. These SCN features could be maintained by implementing the mitigation procedure that will ensure the following:

- Suppliers have not reached their maximum capacities
- Backup suppliers (local, domestic, and foreign)
- Backup support equipment and vehicles
- Additional personnel for planning and executing the SCN changes
- Possibility of increasing transportation capacities on the short notice
- Possibility of increasing transportation capacities (on the short-term basis) to deal with backlogs
- Possibility of increasing CF logistics staff (on the short-term basis) to deal with backlogs
- Backup plans for any of the major changes / risks

3.2.6 SCN in Coalition, NATO, and Dispersed Operations

Troop contributing nations inside a Coalition (NATO or otherwise) each maintain their own national SCN which is governed by their NSE. These SCNs will try to share, to the maximum extent practicable, common suppliers for common classes of supply. Good examples of this are Class III fuels or Class IV construction materials. Current NATO emphasis is on multi-national solutions to SCN challenges. Because of unique equipment and weapons holdings, troop contribution nations need to maintain these SCNs. The concept of assured delivery is a concern that makes some nations reluctant to rely too widely on the SCN of other nations.

3.2.7 SCN Evaluation Processes

There are a number of tools used at the tactical level to evaluate and perfect the SCN process.

1. The Logistics Brief (LOGBRIEF). This is a conference attended by unit supply chain staff, specifically the Quartermaster and the RQMS. It is hosted by the Formation (Brigade G4 – Logistics Staff Officer – and the Commanding Officer of the supporting logistics unit – a service battalion in Canada or the NSE in an operational theatre. The LOGBRIEF is a forum for instant customer feedback and evaluation aimed at achieving efficiency and eliminating problems quickly. This conference reviews the past and the near future i.e., the logistics and SCN activity in the previous period (e.g. twenty four hours) and the next period (e.g. twenty four hours). Problems, poor performance, and issues are all addressed and analysed as well as potential improvements. The LOGBRIEF is a vital part of the evaluation and management side of the tactical SCN. The frequency of the meeting can vary – daily, weekly, monthly, depending on operational tempo and command preferences. For example, the Canadian LOGBRIEF in Kandahar was held weekly while LOGBRIEFs on other operations and certainly on major Canadian concentrations and exercises have been held daily.
2. War Gaming/Rehearsals. War games are used to measure the weak points and tricky parts of a given plan. In terms of tactical SCN activity, each turn of the game takes a look at the SCN aspects. This is a plan evaluation process that pre-dates the Persians and it always leads to findings and revelations that make great improvements to the SCN before a given operation. War gaming is conducted in varying levels of detail in Kandahar at the battle group, multi-national brigade, and even Division level. These war games always include supply chain (replenishment) evaluation and consideration.
3. After Action Reviews (AAR). These reviews are tremendous evaluation tools usually focussed on tactical lessons and not so much SCN considerations. The Canadian Forces would profit tremendously by inserting SCN considerations into the AAR process for combat arms units. A culture of logistics governance and responsibility is not yet well invested across all elements of the Canadian Forces.
4. Stocktaking. Stock takings are an immediate means of evaluating the effectiveness of the tactical SCN. The logistics health of a unit can be quickly assessed by wide variance in the holdings of supplies – both surpluses and deficiencies. It is an excellent tool for evaluating supply discipline. Stock takings for operations like Kandahar are normally only performed at the end of a tour prior to a rotation of soldiers.
5. Technical Inspections. Self-explanatory, inspections are usually aimed at trouble shooting tech problems. They invariably inform the SCN process and therefore have an evaluation impact. Technical inspections are a useful way to evaluate how well materiel is kept in a given theatre or location. Technical inspections can investigate storage problems, quality control problems; monitor shelf life of time sensitive materiel and problem solving in general.

3.3 NATO SCN

3.3.1 Introduction

During the Cold War, NATO followed the principle that logistics was a national responsibility [12]. In 1996, the downsizing of military resources increased the need for co-operation and multinational logistic support. Additional new challenges included the need for supporting Crisis Response Operations (CRO) on non-NATO soil far away from the supporting national and industrial bases. Additional needs included the integration of non-NATO military forces and their logistic support.
NATO logistics should be:

- Responsive,
- Flexible, and
- Interoperable.

Collective responsibility in logistics between NATO and the allied nations is to be attained through close co-ordination and co-operation between national and NATO authorities during both planning and execution, and includes greater consideration of the efficient use of civil resources. Still, each nation is responsible for ensuring, either individually or through co-operative arrangements, the provision of the logistic resources required to support its own forces.
In NATO Logistics Handbook 'supply chain' term is mentioned only in the case of petroleum supply [12][11].

3.3.2 NATO Logistics

"Logistics is the bridge between the deployed forces and the industrial base that produces the weapons and material that the forces need to accomplish their mission" [12]. NATO therefore defines logistics as the science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, logistics covers those aspects of military operations that deal with:

- Design and development, acquisition, storage, transport, distribution, maintenance, evacuation and disposal of materiel;
- Transport of personnel;
- Acquisition or construction, maintenance, operation and disposition of facilities;
- Acquisition or furnishing of services; and
- Medical and health service support.

Spanning the life cycle of logistic resources, logistics has three aspects:

[11] The NATO Logistics Handbook is not a formally agreed document, and should not be quoted as a reference. It does not necessarily represent the official opinion or position of NATO, the nations, commands or agencies on all the policy issues discussed.

- **Production logistics**, or acquisition logistics concerned with the research, design, development, manufacture and acceptance of materiel; the responsible authority is the Conference of National Armaments Directors (CNAD) in coordination with the International Staff (IS) Defence Investment Division (DI) and the Armaments Branch of the Logistics and Resources Division (L&R) in the International Military Staff (IMS).
- **In-service logistics**: bridges production and consumer logistics and comprises those functions associated with procuring, receiving, storing, distributing and disposing of materiel that is required to maintain the equipment and supply the force; The NATO Maintenance and Supply Organisation (NAMSO) is the principal NATO organisation responsible for this area
- **Consumer logistics** or operational logistics concerning reception of the initial product, storage, transport, maintenance (including repair and serviceability), operation and disposal of materiel.

Two additional aspects related to the way in which logistics functions are performed:

- **Co-operative Logistics**: bilateral and multilateral consumer and production logistics arrangements to optimize in a coordinated and rationalized way, logistics support to NATO forces. It is facilitated by the use of NATO Production and Logistics Organisations (NPLOs), particularly the NATO Maintenance and Supply Agency (NAMSA).
- **Multinational Logistics**: a tool to enhance efficiency and effectiveness

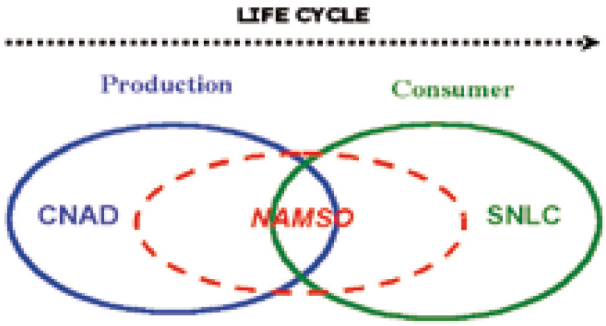

Figure 17 Logistics Lifecycle, Logistics Aspects, and their Lead Bodies [12]

The main functions of logistics include: supply, materiel, services, logistic information management, equipment maintenance and repair, movement and transportation (M&T), reception, staging and onward movement (RSOM), petroleum logistics, explosive ordnance disposal (EOD), infrastructure engineering for logistics (IEL), medical support, contracting, and host nation support (HNS). Related functions include civil-military cooperation (CIMIC), NATO standardization and interoperability, and environmental protection.

3.3.3 Tactical Level NATO SCN – National Vs Multinational

Military expert John Conrad provided the following view of the relationships between the NATO and CF SCNs.

To understand the NATO tactical supply chain as it applies to Canadian Forces operating inside a NATO Combined Joint Task Force, one must understand the Canadian tactical SCN described in Chapter 3.2 of this report. Canada, among NATO partners, maintains a strong reliance on the national SCN and the NSE and harbours some prejudice against fully embracing the principle of multinational logistics on NATO operations. There are good reasons for this. Inside NATO despite emerging trends that are moving towards multinational solutions, the logistics of the Alliance remains a national responsibility and national supply chains do make up a significant part of the "quilt" that becomes tactical support/SCN. The *NATO AJP 4, Allied Joint Logistics Doctrine* makes the point that support concepts have had to change for a number of reasons with the evolving mission spectrum of the Alliance and the move to Non-Article 5 (Crisis Response Operations as opposed to operations on NATO home turf under Article 5). Non- Article 5 missions take NATO forces beyond NATO's normal area of responsibility and therefore challenge existing logistics arrangements and more comfortable solutions that can be applied under a traditional Article 5 mission.

NATO today seeks to encourage a principle of collective responsibility for logistics support. This has taken the form of the coordination of contracting for goods and services, fuels and materiel that are common to all nations. This is encouraged for reasons of effectiveness, streamlining and, of course, cost savings for cash strapped NATO members.

The requirement to interoperate logistically with non-NATO forces (like the battle-proven Afghan National Army) and emerging Partners for Peace Nations drives the need for collective NATO solutions. Many of these countries have combat forces but lack the logistics SCN to sustain themselves. Romania is a good example of this from NATO ISAF. Fine soldiers, old Soviet era equipment and next to no SCN.

The emergence of multinational structures such as Multinational Joint Logistic Centre (MJLC), Lead Nation (LN), Role Specialist Nation (RSN), Multinational Integrated Logistic Unit (MILU) and Third Party Logistic Support Services have emerged as components in the tactical SCN "quilt." They join the Canadian NSE and SCN Echelons as parts of the tactical SCN. These NATO SCN components can be described in greater detail in subsequent tasks should they prove of interest. The formation J4 logistics principle staff officer has a true challenge in coordinating tactical SCN. He or she is in the business of gaining cooperation and building consensus between NATO assets and the various national NSEs to weave the tactical quilt.

3.4 Discussion

Potential improvements to the Canadian tactical in-theatre SCN include:

- Merging Operational and Tactical supply chains.
- New technologies and methodologies should be reviewed regularly and considered for implementation (if they seem beneficial):
  - Faster collection of requests (via radio),

- Better forecasting (including consideration of future mission plans),
- Improved inventory management (incorporating automated systems),
- Transportation (improved planning, routing and scheduling).

- Transportation services for materiel and personnel have to be considered together, e.g., re-configurable ferries.
- Cultural changes to the mind set and approach to the tactical SCN would greatly enhance its continued refinement and operation on Canadian operations. Logistic matters are all too often left out of AAR and fundamental training of the officers and non-commissioned members of the CF.

This page intentionally left blank.

4 InformationTechnology for In-Theatre Logistics

This Chapter presents a brief survey of information technology to support In-Theatre logistics and sustainment and discusses some existing and promising asset-tracking technology solutions to enable sense-and-respond logistics.

4.1 Information Technology

4.1.1 NSE Information System Technologies

> *"Data needed to track and manage equipment availability are incomplete, often inaccurate and sometimes not compiled in the same way. This makes it very difficult - if not impossible - for management to know the true state of its major equipment platforms. …" [4]*

As the Auditor General quote suggests, the Canadian Forces (CF) has suffered from a number of independent partitioned information systems over the past four decades. The incompatible software systems have not been able to 'talk' to each other. In addition, they often required numerous inputs from the tactical end which was not that easy to accomplish.
To overcome these drawbacks, a number of initiatives have ensued including:

- Supply System Upgrade in the late 1990s (CFSSU),
- Total Asset Visibility program,
- MASIS, and
- DRMIS.

MASIS and DRMIS are certainly moving towards an "enterprise or holistic approach" for the Supply Chain Network (SCN). Also, their aim has been to provide Total Asset Visibility. The MASIS system has already been functional and operational and the DRMIS is to be fielded in the near future.

Apart from the references provided throughout this section, the material presented on DRMIS, CFSS and FMS also relied on interviews, e-mails and discussions between John Conrad and with Capt. Ross Weatherbee, LCol Tim Marcella (latest NSE Commander), Major James Debruin and Maj. Charles Jansen. The Canadian Army fielding Instruction on DRMIS--3350-(G4 DRMIS) dates 12 August 2010 UNCLAS and the Frag Order on DRMIS 0001 dated 19 October 2010 have also been consulted.

4.1.1.1 Processes

The central processes in Tactical Logistics are:

- Supply chain management process,
- Life-cycle management process,
- Movement planning and execution process.

Supply Chain Management process defines procedures for equipment repairs as well as other procedures related to the activities of the Supply Chain Section.

Materiel Life-cycle management Process is indirectly linked to supply chain management through its potential ability to predict when an equipment part might fail or break [13]. These predictions are made by the life-cycle material manager. "Knowledge of when parts are expected to fail would help supply chain managers ensure replacement parts are available when needed. Today, a life cycle materiel manager monitors things such as mean time between failures (MTBF) of key components, essentially defining their life expectancy. As the MTBF of a specific component decreases, the preventative maintenance schedule of a capability will proportionally be modified so the part in question is replaced before it fails but, hopefully not too long before the end of its life, to ensure the capability remains operational when needed and maintain operators' trust in the equipment" [13].

4.1.1.2 Distributed Resource Planning

The aim of the Distributed Resource Planning (DRP) tool is to improve forecasting related to combat equipment spare parts. The deployment of DRP was planned for Spring 2008. The authors are not aware of the current status of this tool. It is possible that its functionalities will be part of DRMIS. More details on the NATO DRP – based on the experience and research of the team's SME, John Conrad – can be found in Annex B.

4.1.1.3 Information Systems

The main current information systems of interest and short-term expected upgrades systems are depicted in Figure 18 and Figure 19 respectively.

4.1.1.3.1 Canadian Forces Supply System Upgrade (CFSSU)

The CFSSU is a custom built, proprietary Asset Procurement and Inventory Management System (Warehouse Materiel Information Management System MIMS). It works well for the assets in the system. It seems that it is not that good on the procurement end due to the embedding of procurement inside political process and Department of National Defence (DND)/Treasury Board regulations.

The CFSSU completed its second level (and final) roll out in 2002 and was in full operational use in tactical logistic units. However, the upgrade has not been robust enough and several CFSS features have not been improved (refreshed). Inputs into CFSS can only be done by trained CF

Supply Technicians – not combat arms soldiers working in a battle group echelon. Even reserve force Supply Chain Technicians must have supplemental training to be able to access and use CFSS. Thus, rather like a new house built on an old foundation, with not very successful management (the project ran out of money and time), the CFSSU represents only a marginal victory. Furthermore, the MIMS software – produced by Australian company MINCOM – will no longer be supported after 2011. DND has decided to integrate the supply information system into the wider enterprise solution with MASIS and DRMIS by 2020.

The main functionalities of the CFSS are:

- Collecting and storing information related to materiel:
  - Materiel arrived to A Point of Disembarkation (APOD)
  - Materiel issued to battle group, maintenance engineer
  - Materiel required to replenish the stocks in APOD warehouses
  - Material orders/ requests with priority such as 'immediate operational requirement' (IOR)
- Allowing search for an item (materiel piece) within:
  - APOD
- Providing alert messages to Supply Chain technician that:
  - An item (materiel) needs to be ordered due to low stock levels

The main users of the CFSS are:

- SC technicians of NSE at APOD
- Technicians inside Battle group like RQMS and CQMS

4.1.1.3.2 Plann Expert

Plann Expert is a vehicle maintenance and production information system. It is a comprehensive system used by the Electrical and Mechanical Engineers for entering work orders for repair jobs. As per the research and confirmatory interviews conducted by John Conrad, it seems that Plann Expert has been absorbed into the MASIS that was deployed recently or is to be deployed in the near future. Initially, the NSE users of Plann Expert in Area of Operations (AOO) have experienced extremely long wait times (as per John Conrad's experience as NSE Officer in 2005) but it was a step forward for this functional area. These problems have been resolved and Plann Expert is an efficient tool.

Interfacing with the CFSS inside MASIS was a real step forward. Inputs are to be done by the soldiers who work in the maintenance workshops.

The main functionalities of the Plann Expert are:

- Implementing and supporting the CF Supply Chain Management Process and Life-Cycle Management Process

- Collecting and storing information related to repair and production requests with their priorities. For the repair request, the equipment current location is also provided:
  - At APOD
  - At some other location in AOO

The main users of Plann Expert are:

- Electrical and Mechanical Engineers of NSE at APOD
- J4 personnel at APOD Headquarters (HQ) to set repair task priorities

Other operational and strategic level personnel can access the system to get data.

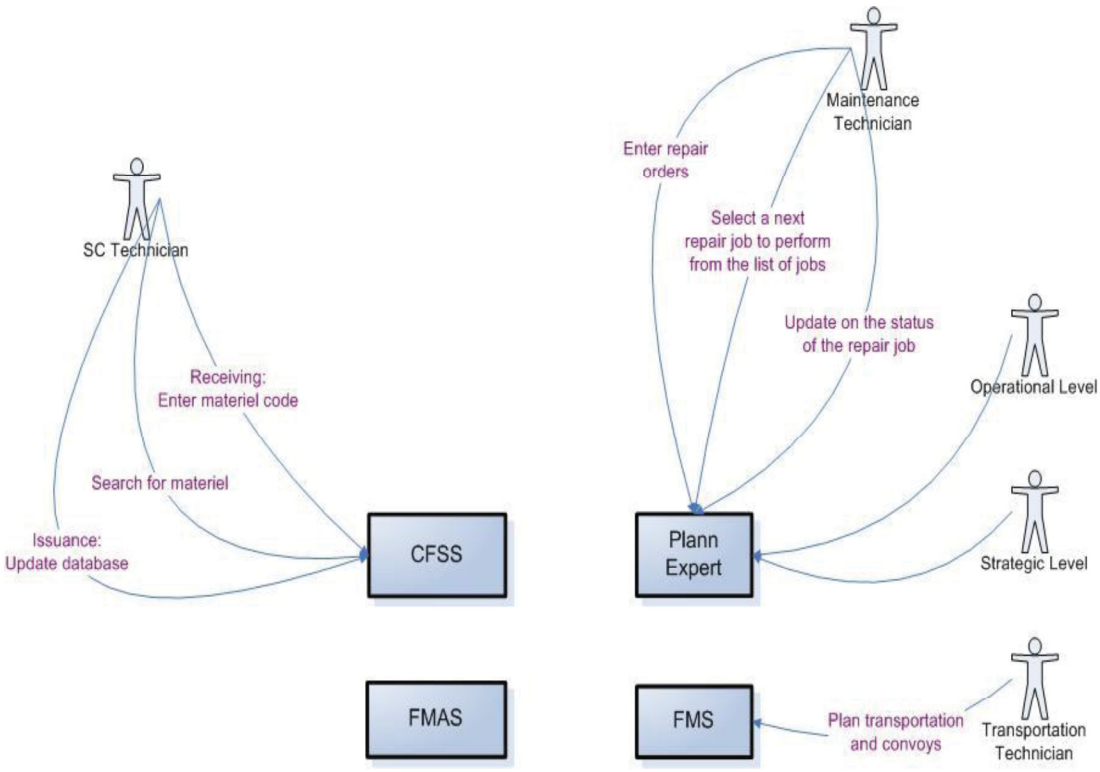

Figure 18 Information Systems for the Support of the Tactical Logistics: Until Recently

4.1.1.3.3 Financial Management Accounting System (FMAS)

FMAS is the main financial information system of the Canadian Forces supported by SAP, a German software company. FMAS has now merged with MASIS under the new DRMIS Information System. FMAS will remain the financial system of record for Fiscal Year 2009/2010. After that DRMIS will be the system of record. Forward of April 2011, FMAS will be available only for display of historical data. Resource Managers (those responsible for a specific Cost Centre) had access to FMAS to manage their Cost Centre.

4.1.1.3.4 Fleet Management System (FMS)

FMS is a vehicle fleet management information system that became operational October 2005. This information system brought the vehicle transportation management data into a centralized database (Data Centre Borden), which operates over the intranet (has a Web portal).

This is a vast improvement over the decentralized approach previously used which was heavily reliant on pen and pencil scribing and scribbling over dispatch logs. An earlier attempt at automating dispatch function in the late eighties (BATOPS) took forever to develop and then proved too costly to implement. Now, with a few keystrokes on FMS the visibility of data on the vehicle fleet is available for all units in Canada and for several overseas locations.

The FMS applies both to civilian pattern vehicle fleets as well as Standard Military Pattern Fleets (tactical military vehicles). "User statistics, operator qualifications, collision reports, asset valuation and distribution, etc. are now visible in real-time, greatly simplifying the fleet analysis and optimization task for all managing authorities. It enables single database reporting on fleet activities in compliance with Treasury Board policy." [14].

The main functionalities of the FMS are:

- Implementing and supporting the Transport Planning and Execution Process
- Collecting and storing information related to transportation requests for materiel and personnel (origin, destination, time)
- Providing distribution of the assets (current location)

The main users of the FMS are:

- Transportation unit of NSE at APOD

4.1.1.3.5 Materiel Acquisition Support Information System (MASIS)

"The cutting-edge information technology behind MASIS enables a shift in focus from maintenance recording to maintenance planning. This is a key enabler, helping decision makers at all levels to understand the status of their weapon systems ranging from guns to tanks and aircrafts - as well as the availability of personnel responsible - for the end-to-end maintenance process" [15].

MASIS is an information system that sought to integrate engineering maintenance equipment fleets. The roll out of MASIS began in 2009 and was to take place over the next few years in the army (the Navy fielded it first).

MASIS is an enterprise system (fully deployable) system, linking the front-line to individual units, headquarters, and industry. Kevin Radford, a very Senior Manager with Assistant Deputy Minister (ADM) Materiel summed up the value of MASIS to the Army as follows: "Without MASIS, the army had no capability to provide basic information on inventory readiness of fleets, vehicles, and weapon systems, which would significantly impact DND's ability to support the Afghanistan mission." (ADM Materiel is the top official inside DND for material procurement – the strategic side of logistics.) Inputs are done by many different sources at the tactical, operational, and

strategic level in the fields of supply and equipment maintenance. The authors are not aware of the availability of access beyond the NSE (e.g. FOBs).

Besides Plann Expert functionalities, the MASIS features also include:

- Allowing search for a spare parts by SC technician

4.1.1.3.6 Defence Resource Management Information System (DRMIS)

Rollout commenced in April 2010 [16], so this new system has really just come on line. DRMIS is an enterprise solution which links the financial management, supply chain, and maintenance information systems. (In other words FMAS +MASIS= DRMIS) [17].

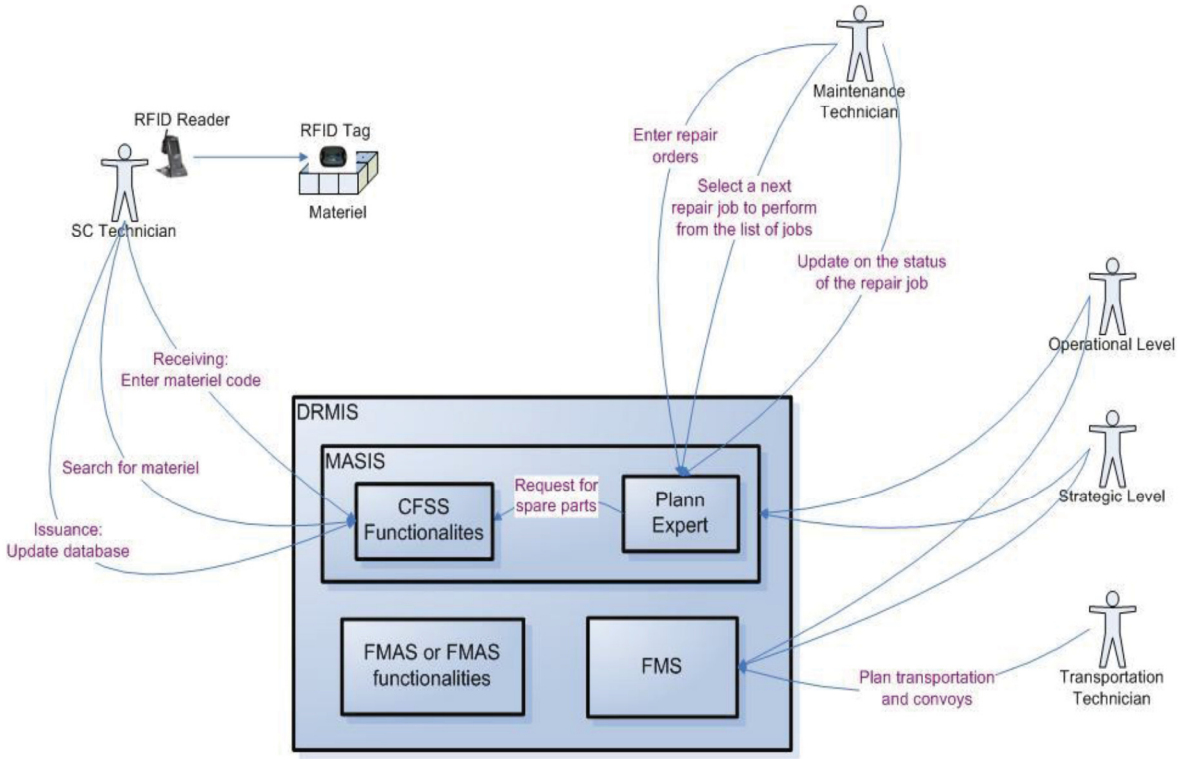

Figure 19 Information Systems for the Support of the Tactical Logistics: Near Future, According to the Current Plans

The system is a main plank of the Canadian Forces Enterprise Resource strategy, identified in the Information Management Campaign Plan of 2009 [17]. DRMIS will allow for full integration of consolidated end-to-end business processes, improving visibility, efficiency, management practices and decision making across the Department. It remains to be seen and confirmed how this visibility will bear out on deployed operations. Further, DRMIS will provide DND/CF with a unified and expandable software platform able to include other business areas in the future, serving as a backbone for the Defence Enterprise Resource Planning (ERP) strategy to optimize support of operations. This is a large step forward for the Canadian Forces in terms of the resulting holistic picture and may well close off significant gaps for the tactical Supply Chain and the NSE with respect to the asset visibility. Inputs are done by many different sources at the tactical, operational

and strategic level in the fields of financial management, supply, and equipment maintenance. Authors are not aware of availability access beyond the NSE (e.g. FOBs)

DRMIS represents a single system for inputting and accessing financial, materiel, workforce and equipment data [18]. It will allow a user to order parts, track delivery, liaise with maintainers and drivers and close the file.

The "City of Winnipeg" Squadron of the CF Air Force started live testing of the new DRMIS on August 9, 2010, before it becomes fully operational across the entire CF.

"Once the initial rollout is completed, DRMIS is going to be quite a time-saver because right now we frequently report things such as repair costs in more than one application. For example, we have our Vehicle Off the Road report on a spreadsheet, our work orders in Plann Expert and our parts costing in an Access database. All of this is redundant information entry. One advantage of DRMIS is the one-time data entry that is shared between supply, maintenance, transport, operators and higher headquarters staff, so everybody sees the same information at the same time." [18].

4.1.1.3.7 BattleView

> *As the CF transitions from operations in Afghanistan, lessons learned from our 'operationalised' application architecture need to influence the evolution of our Land Command Support System and our joint Canadian Forces C2 systems. It is clear that the investments made in BattleView, the ODB (Operational data Base) and other Canada–specific applications are not paying dividends on operations."*
>
> *Major General Guy Thibault, Canadian Forces J6*

As the quote above from a November 2010 reconnaissance report affirms, BattleView has underachieved on operations in Kandahar. BattleView is an application that forms a key component of the Army's Land Command Support System (LCSS). The system combines GIS capabilities furnished by sensors like satellite/GPS with battle management software. It has the appearance of an electronic map that is very realistic and permits any number of electronic overlays to be applied to the electronic map.

BattleView is designed to be deployed at the unit/battle group headquarters level and above and it is heavily focused on tactical, F echelon information. The specific BattleView capabilities do not hold logistics or sustainment data as a core requirement or capability. It is very much a tactical battle management tool that makes marginal room for sustainment reporting. In fact the platform has negligible logistics functionality at best. It seems that it has been assumed that logistics data would be reported/rolled up on the Brigade Administrative net at unit/battle group level. Thus, the reporting on the real-time logistics consumption below battle group was not a requirement of the BattleView system.[12] The core capabilities of BattleView include:

[12] This is not an unprofessional decision. There are pros to leaving logistic inputs out - regardless of the tactical gap it makes in situational awareness for logistics. BattleView is reliant on user input and the first level capable of putting logistics data in the system would be at the unit/battle group level. Historically, the army has maintained a separate radio net for passing logistics data on VHF - the Brigade Administrative Net. The real-time reporting of battle progress and logistic requirements of a fighting unit have never been

- Situational Awareness
- Battle management
- Battle Planning
- Intelligence
- Information Exchange
- Other useful data such as weather, NBC state, etc.[13]

BattleView is used at the Canadian Army Command and Staff College in Kingston. It is very reliant on human/user input.

There has been a dire inability to provide BattleView to Brigade level and above in Afghanistan. The reasons for this range from system instability, lack of technical support, and sheer usability/functionality. Also, it seems that BattleView has failed when compared to FalconView, an American product. FalconView has been battle proven and has inspired user confidence in Canadians serving both at Battle Group and Brigade level.

Even if BattleView had worked out well in Kandahar it would not have closed the logistics gaps identified between the F and A2 echelons of a fighting unit. There is a near total lack of logistics information ensconced in the capabilities of the tool.[14] There is little to no information available in BattleView on the sustainment/administrative status of a combat sub-unit - platoon or combat team (company plus). The team's SME believes that it is possible to prepare a logistics overlay that outlines the locations of logistic installations on the battle field but this is the extent of capability. The system is simply not designed to contain this type of battle data. Moreover, the system would require an operator at the fighting end to input the logistics data even if the system did cater for it. This study has emphasized the need for accurate logistics reporting between the F and A2 echelon to be as automated and user friendly as possible in order to be relevant and accurate

The army will be focusing very intently on what worked and did not work well over a decade of operation in Afghanistan. All future applications will be designed and procured with these hard won lessons learned in mind. It is the perfect time to integrate a non-invasive logistics consumption data into the next generation of the LCSS. In a way, the failings of BattleView in Kandahar present us with a tremendous opportunity to close some gaps in sustainment reporting.

---

intermixed on one electronic platform beyond the unit level. Perhaps this historical set up of tactical and administrative radio nets is a true source of one gap.

[13] Document No 1334c.07-01914 Rev. 01-20 June 2007. PowerPoint presentation provided by Thales Canada, Systems Division.

[14] Possibly an indication of the cultural prejudices the Canadian army has carried with respect to sustainment since the Korean War in 1952. We firmly believe that many of the gaps found are the result of cultural problems and biases inside the Canadian Forces.

4.1.1.4 NSE Tasks and Support Tools

Support tools for the Maintenance Tasks include:

- Combat Net Radio/Broadband data. In standard operating procedures, there are pre-defined pro-formas (standardized format) for demanding vehicle repair and/or recovery services. These forms can be submitted by voice over Combat Net Radio or as data.
- Telephone - line and wireless.
- Plann Expert Production Information System.
- Canadian Forces Supply System (CFSS) - for spare parts. CFSS is now a component of MASIS which is a component of DRMIS.
- Computer assistance tools like Microsoft Word, Excel and Outlook.

Support tools for the Transport Tasks include:

- Combat Net Radio/ broadband data transmission. Set pro-formas for demanding vehicle transport requests/troop lift exist in the standard operating procedures. These forms can be submitted by voice over Combat Net Radio or as data.
- Telephone Line and Wireless.
- The Fleet Management System (FMS) for dispatch.
- Computer assistance tools like Microsoft Word, Excel and Outlook.

Support tools for the Supply Chain Tasks include:

- Canadian Forces Supply System (CFSS), a component of Materiel Acquisition Support Information System (MASIS) which is now a component of DRMIS
- Combat Net Radio/ Broadband data transmission. Set pro-formas for demanding vehicle tactical replenishment services exist in standard operating procedures. These forms can be submitted by voice over Combat Net Radio or as data.
- Telephone Line and Wireless.
- Computer assistance tools like Microsoft Word, Excel and Outlook

4.1.1.5 Information and Databases

The information that is consumed, processed and produced by the described information systems includes:

- Repair and production requests
- Materiel requests (food, ammunition, fuel)
- Transportation requests

- Stock replenishment requests
- Requests for spare parts
- Requests for medical supplies
- Requests for medical intervention

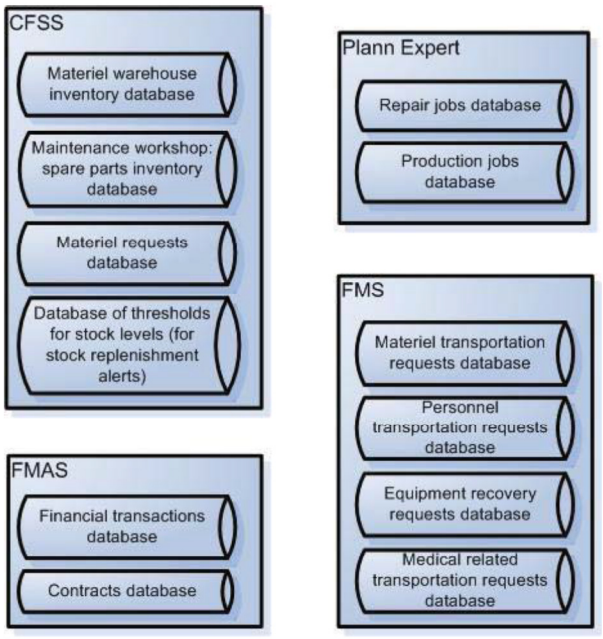

Figure 20 Information System Databases

This information is entered into the system by members of the CF personnel - most often by the members of the NSE personnel. The main processing done by systems is storage in various databases. We are not aware which databases exist, but from the list of information we can assume that there are the following databases, as partially sketched in Figure 20 :

- Materiel warehouse inventory
- Spare parts inventory
- Requests for materiel
- Thresholds for stock levels (for stock replenishment alerts)
- Repair jobs (waiting, in-process, done)
- Production jobs (waiting, in-process, done)
- Transportation requests (waiting, in transport, done): materiel, personnel, equipment recovery, medical related
- Medical supplies warehouse inventory
- Medical interventions (wait list, in progress, finished)

4.1.2 SCN Support Technologies: NATO

4.1.2.1 NATO Logistics

"New NATO" as per [19] is to be characterized with:

- Leaner force structure
- Diversity of operations
- Visibility of operations
- Secure supply chain/consignment tracking
- NATO wide interoperable, practices and technology
- Adequate supply
- Effective movement and monitoring
- Creating and maintaining infrastructure
- Supporting/responding to medical requirement
- Maintenance and repair

Effective logistics is seen as a 'force multiplier', ensuring mission success. Synchronization of activities, through visibility of capabilities - inventory and consignments, transport capabilities, etc. - creates that effective capability.

For NATO, to achieve highly deployable capabilities, correctly supplied interoperability is a necessity - in terms of processes, weapons systems, personnel training, communications systems and information technology. To attain interoperability, NATO countries have been setting up their own RFID networks to keep up with the joint standards [19].

4.1.2.2 NATO SCM

A general NATO SCM view in Joint Operations is pictured in Figure 21. The fundamental principles of Supply Chain Management (SCM) are: define and measure, and drive performance improvement [20] which is very similar to the aim of analytics in general. (SCM is one application of analytics to logistics.)

"An effective SCM concept within NATO is based upon analysing the end-to-end logistics processes to gain a complete understanding of interdependencies, relationship and linkages, and their impact with respect to

- Time,
- Distance,
- Size,
- Cost, and
- Resources."

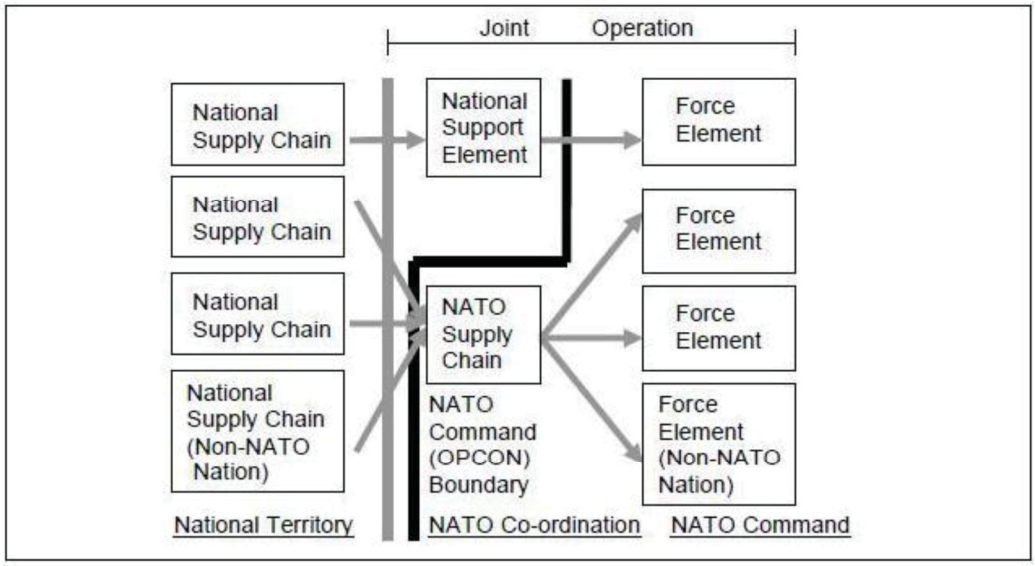

Figure 21 NATO SCM in Joint Operations [21]

Those five items may be seen as performance measures and they will help in determining whether leveraging and expanding commercial SCM practices across NATO makes good business sense [21].

The phrase end-to-end in NATO does not imply a fixed definition as it is very much situation dependent. For example, for NAMSA (NATO Maintenance and Supply Agency) end-to-end could literally be from factory to foxhole. For NATO operations, end-to-end may only cover from the Port of Embarkation to the end user.

Successful SCM relies on knowledge and information sharing, cooperation, trust and trusted routines. The NATO supply chain consists of both processes and resources such as strategic lift, transportation, warehousing and distribution centres, prioritisation and Information Systems. The supply chain must cover both process and resources.

4.1.2.2.1 LOGFAS

Logistics Functional Area System (LOGFAS) includes a

- Logistics Database (LOGBASE),
- Allied Development and Movement System (ADAMS),
- Effective Visibility Execution (EVE),
- Allied Commands Resources Optimisation Software System (ACROSS), and
- Logistic Reporting System (LOGREP).

These systems address coherent but discrete functions related to planning and reporting that need to be integrated into a more comprehensive system. Some of the key new functionality required

will be Consignment Tracking and eventually Total Asset Tracking [21]. LOGBASE is the common database which links all four subsystems.

ADAMS and EVE

Allied Deployment and Movement System (ADAMS) – a LOGFAS subsystem – performs transportation and relocation planning.
ADAMS is used for planning, evaluating and simulation of movement and transportation operations in support of NATO missions.

ADAMS is used with EVE (Effective Visibility Execution) which is a recent add-on to LOGFAS, intended to coordinate the execution of NATO movements for the ISAF mission.

ACROSS

ACROSS is used to calculate strategic munitions requirements.

LOGREP

Logistic Reporting (LOGREP) – a LOGFAS subsystem – compiles and evaluates logistics data for all force elements used. It provides visibility for all key logistic capabilities supporting NATO missions for commanders, and for planning purposes.

Report [22] examines LOGREP and its in-theatre application. It provides factors obstructing the optimum use of the system, and discusses how other reporting procedures successfully bridge the data gap to maintain a useful flow of information. The report analyses LOGREP application for the logistics support to International Security Assistance Force in Afghanistan (ISAF) mission related to supply of the following materiel:

- Class I (Food & Water),
- Class III (Petroleum / Fuel, Oil and Lubricants), and
- Class V (Ammunition) logistics support to the ISAF mission.

Data collection efforts for the LOGREP analysis included research of NATO logistics doctrine, operational reports, and conference reports as well as interviews with Logisticians on ISAF in order to determine past and current practices. Questionnaires and other techniques were used to pre-screen candidates for interviews to facilitate data gathering.

Logistic Operations in ISAF involve several multi-national headquarters to support over 50,000 military personnel from around 40 troop contributing nations. Cooperation, coordination and data sharing between NATO and non-NATO member nations are essential. However, gaps in the visibility and transparency of national assets in ISAF are a concern which could impact operational decisions affecting the mission.

Apart from LOGREP reports are called LOGUPDATE, there were other two reports (LOGASSESSREP and MOVASSESSREP) that were expected to be filled by national NSEs in support of NATO supply chain. Table 1 provides characteristics of these reports.

Table 1 ISAF Logistics Reports [22]

ISAF Logistics Report	Logistics Function	Reporting Format
LOGUPDATE	Supply (National Equipment)	LOGFAS
LOGASSESSREP	Supply (Classes I to V)	MS Word
MOVASSESSREP	Movement &Transportation	MS Word

The LOGUPDATE provides NATO Commanders "with a dynamic update of changes to core database information on stockpiles of specific equipment and consumable material held by National Forces declared to NATO."

LOGASSESSREP provides a "standardized method of informing superior headquarters of the command's logistics status including areas like Battle Damage, Lines of Communication / Route Information, Infrastructure, Communications and Interoperability.

MOVASSESSREP is "a standardized method for informing on the movements and movement infrastructure situation". It covers the general situation of lines of communication, and provides an assessment of the Related Movement Infrastructure and key movement plans.

Advantages: the last two reports do not require any training; anybody can write, anybody can read (plain language); they can be imported to any other document. It has been shown that this simplicity has improved operability.

Disadvantages: LOGFAS requires training; it is not an intuitive system. It also requires installation, version control and management. The status is that very few countries are using LOGFAS. Preparing reports and maintaining current data takes staff time, and since the readiness of national elements or their equipment for the mission is largely a national issue, reporting to NATO is perceived as not providing direct benefit to the units. Reporting national data multiple times - through a national system and through LOGREP - has been seen as an unnecessary duplication of effort.

Other restricting factors: shortage of personnel at each NSE, no direct benefits, time required, English language skill. These factors decrease the usage of the LOGFAS, which thus cannot provide a complete picture of the logistics assets that could be used in planning.

4.1.2.2.2 HQ Web page

HQ ISAF Secret Webpage offers transparency and visibility of Class III support. This information is updated daily, and is available on demand to ISAF and the entire NATO Chain of Command.

4.1.2.2.3 RFID

NATO has already built a Radio Frequency Identification (RFID)-based network solution from Central Europe through to Afghanistan (for International Security Assistance Force (ISAF) supply chain), as well as in the United States, the United Kingdom, Denmark, France, Australia, [19].

> "This network enables appropriate coalition forces to 'see' their own consignments or joint-force consignments wherever they are located in the extended supply chain. The physical network is composed of active RFID and other auto/id technologies, used to secure, identify and track assets. A reader network is placed at key transportation nodes along the logistic routes. This information can then be communicated – from even the remotest locations, to management systems at other nodes, or headquarters type systems." [19].

4.1.2.2.4 CMS

Consignment Management Solution (CMS), developed by Savi Technology, is an online software platform that provides information on real-time feeds from consignments (materiel) affixed with wireless devices as they move through the physical supply chain [19]. Savi is a division of Lockheed Martin.

The CMS-like systems can be used as In-Transit Visibility solutions by each separate nation, for example, in their Emergency Response multi-organizational operations. In 2008, Savi gained approval from NATO's Infrastructure Committee to continue rolling out the global visibility solution [19].

A summary of the reported information systems is provided in Table 2 and Table 3:

Table 2 Information Systems used by CF in Support of In-Theatre Tactical Logistics

System Name	Enter-prise system	Decision Support (DS), Analysis (A), or Transaction (T) system	Web portal	Database	NATO compatible	Description	Producer
CFSS	✕	T, A (some)	✕	Materiel Warehouse Thresholds for low stock levels Materiel Requests	✕	CF Supply Chain System	Australian company MINCOM
Plann Expert	✕	T, A	✓	Repair requests, Production requests, Repair jobs done, Production jobs done	✕	Tactical Maintenance (Repair and Production) Management System	IFCS

System Name	Enter-prise system	Decision Support (DS), Analysis (A), or Transaction (T) system	Web portal	Database	NATO compatible	Description	Producer
FMAS	✗	T, A	✓	Financial transactions contracts	✗	Financial Management Accounting System	SAP
FMS	✗	T, A	✓	Transportation requests	✗	Fleet Management System	
MASIS	✓	DS	✓	Same as CFSS and Plann Expert	✗	Materiel Acquisition Support Information System	SAP
DRMIS	✓	DS	✓	All above	✓	Defence Resource Management Information System	Based on SAP

Table 3 Information Systems used by NATO in Support of In-Theatre Tactical Logistics

System Name	Enterprise system	Decision Support (DS), Analysis (A), or Transaction (T) system	Web portal	Database	Description	Producer
LOGFAS	✗	T	✗		Logistics Functional Area System: reporting system	
RFID	✓	T	✗		Radio Frequency Identification System	Savi, Lockheed Martin
CMS	✓	T	✓		Consignment Management System (compatible with RFID)	

4.2 Asset Visibility

In other respects, anticipated supply chain and asset visibility solutions and in particular asset tracking are ideally expected to address end-to-end supply chain of the CF, from domestic procurement supply (production) node to end customer nodes in theatre covering operational and tactical levels. While tracking assets transiting along the lines of communication from suppliers to the theatre of operations may be sufficient for most consignments, asset sensitivity to

environmental factors such as temperature, humidity, light, vibration, etc. (e.g., food supplies, electronics), its value to an operation and its relative cost (e.g. ammunition and/or vehicles) may impose further requirements. This may consist for instance in dynamically adjusting sensing/monitoring frequency or communication bandwidth allocation to enable near-real time in-transit visibility whenever required, to maximize the value of information necessary to optimize or revisit a logistics solution plan. The value of information gained and the resulting quality solutions expected from gathering (sense/monitor) additional information weigh against incurred cost.

Asset visibility technologies are numerous, from bar coding, passive/active/ radio-frequency identification (RFID) mesh, wireless, global positioning and satellite systems, mobile *ad hoc* networking, to hybrid sensor networking technology. Warehouse asset visibility has been traditionally ensured through bar coding, passive RFID, portable Data Entry Terminal (PDET) or active wireless protocol such as RuBee, designed for harsh environment, high security asset visibility applications. The numerous potential interferences within depots and warehouses rendered the PDET capability ineffective and unreliable, so once again most supply locations set the PDET capability aside. RFID and WiFi based technologies were recently prohibited within the Afghan theatre of operations, including at camp, for security and risk purposes, namely against potential Improvised Explosive Device (IED) triggering. Potentially exploitable in operational theatre due to its intrinsic security/safety certification, RuBee's technology would still require further investigation with Director Information Management Security (D IM Secur) before definite approval for its implementation.

In-transit visibility capability has recently contemplated different technology solutions, such as active RFID capability in which a sensor can be interrogated and controlled to provide near real-time consignment visibility of materiel. However, the initial perception of the active RFID rested on duplication of the current manual movement and distribution data entry process, resulting in apparent personnel overload. In addition, as generally noticed for most new systems, low confidence user levels in the system made consignment not officially accounted for until its bar code was explicitly scanned. Insufficient leadership and governance enforcing the use of active RFID to materialize expected benefits of near-real time in-transit visibility, also explains the limited diffusion of the active RFID capability. The under-utilization of the RFID system has resulted in a shortage of trained RFID personnel as they have since either been reassigned to new tasks or have retired. This consideration raises concerns regarding large scale technology implementation. As a result, near real time visibility could not be satisfactorily maintained.

On the other hand, an alternate technology called Track24's Whisper providing positional tracking recently drew some particular attention. Track24 proposes a number of Global Positional System (GPS) and Global System for Mobile communications (GSM) based trackers, each with their respective characteristics and applications. The GPS-based trackers relay their positions via the Iridium satellite constellation providing complete coverage basically anywhere in the World, while GSM-based trackers utilize more economical cellular phone communication networks. Some tracking devices default to the GSM network and automatically switch to the Iridium connection whenever cellular phone connectivity is compromised.

The Canadian Army has also developed a Blue Force tracking (BFT) -like capability called the Situation Awareness System (SAS), which is fully integrated into the Land Command Support System (LCSS), CA's command and control (C2) system. However, SAS is not interoperable with CF Allies BFT systems, thereby reducing its value or usefulness in operational coalition contexts.

From a logistics perspective a BFT-like system including route planning capability would be very helpful in resupplying convoys, reducing risk of ambushes or modifying planned routes dynamically, as IEDs events or damaged bridges are promptly reported during transit. More details on these and alternate asset visibility and tracking technology may be found in [23].

A key question remains: What is the asset visibility technology return on investment targeted in order to guide specific technology acquisition? A partial answer to this question would presumably need to define and properly characterize the suitable "value of information" (differential solution gain vs. cost) function associated with asset visibility mission and combat service support requirements.

5 Some Limited Gap Analysis

Based on the information mentioned above, we now present some limited gap analysis highlighting technology deficiencies.

5.1 Information Systems – Current Situation

5.1.1 Military Experts – 2009

As per one member of the NSE personnel who returned to Canada in 2009, the systems being used include the legacy systems like CFSS, Plann Expert, FMS and FMAS. The big gap is the same one that existed in 2006 (as per John Conrad) – no information systems exist forward of APOD, owing to bandwidth issues. Everything forward of the NSE, inside the A2, A1 and F echelons is done by hand or with the assistance of computer programs like Microsoft Word and Excel. Most of the units created their own repositories and reports using Excel or Access to manage what they had.

The tactical networking system has been so poor in performance and bandwidth that most of the legacy software systems would not run. This is a significant black hole in terms of asset visibility and materiel accountability at the end of a tour.

5.1.2 Military Experts – 2010

As per an interview with a NSE Commander who just returned from Kandahar, neither MASIS nor DRMIS are in use for the in-theatre tactical logistics at this point. The Canadian Army Fielding instruction on DRMIS was only released in August of 2010 with an additional supplementary instruction that came out in October 2010.

The limitations of DRMIS, the enterprise solution for the military supply chain, translate as persisting visibility gaps for sustainment.

Also, bandwidth problems forward of APOD continue.

5.1.3 Legacy Systems

Plann Expert:

- **Alerts:** Plann Expert has no automation nor prompting associated with it at all. It is a fairly passive information repository. The system will not tell a mechanic how long he has to do a job and it will not remind the mechanic or prompt him or her along the way.
- **Reports:** Plann Expert is capable of data extraction and creating reports like the number of vehicle still down (broken), the number of transmission jobs in a given period, etc.
- **Scheduling:** Plann Expabert has no automation regarding scheduling tasks or assigning tasks for the maintenance technician.

- **Enterprise:** Not being used forward of APOD, not only because of the bandwidth problems but also because the tactical focus is to fix a casualty on site or drag it back to APOD. Either way, there is not enough time to input data into an information system. Also, a complicated repair will not be entered into the system until it reaches the NSE workshop at APOD.

A similar situation prevails for **FMS**.

CFSS is, however, visible from operational logistics units and it has enterprise architecture. However, it also lacks decision support tools in terms of automatically generating transportation, routing and/ or scheduling solutions.

Figure 22 shows who are the producers and consumers of the information for the existing information systems. The green arcs show personnel producing information and entering them into the system. The orange arcs shows personnel consuming information stored in (or generated by) the information system. The blue arcs show information flow between personnel, and they are mostly information produced by personnel.

Figure 23 shows which systems have been used for which NSE activity. The activities supported by Plann Expert are coloured in violet, the activities supported by CFSS are coloured in orange, the activities supported by FMS are coloured in green, and the activities supported by FMAS are coloured in pink. Activities that are supported by telecommunication technologies (radio, phone, etc.) are coloured in blue. The white activities are not supported by any of the software systems/ technologies.

All NSE users of FMAS, FMS, Plann Expert and CFSS are located at APOD. The FMAS use has not migrated to forward operating bases, because money does not get tied in until the security of the APOD is reached. The people most concerned about FMAS are the NCE J8 Staff Officer and the NSE Financial Officer and staff – both are located at the APOD. Also, people well beyond theatre also have access to FMAS at CEFCOM J8, CANOSCOM and NDHQ.

The main users of FMS are also located at APOD. There is no practical requirement for the FMS controlled dispatch when one is in contact with an active opponent. Also, the perennial bandwidth problems would nullify FMS forward of the super FOB, or APOD. The same situation stands for Plann Expert and the CFSS. However, people working in logistics behind the operational theatre in CANOSCOM and CEFCOM will have visibility on CFSS, Plann Expert and FMS. Specifically, big CANOSCOM units, like 3 CSG in Montreal, CEFCOM HQ, and CEFCOM J4 and J8 staffs have visibility on the systems.

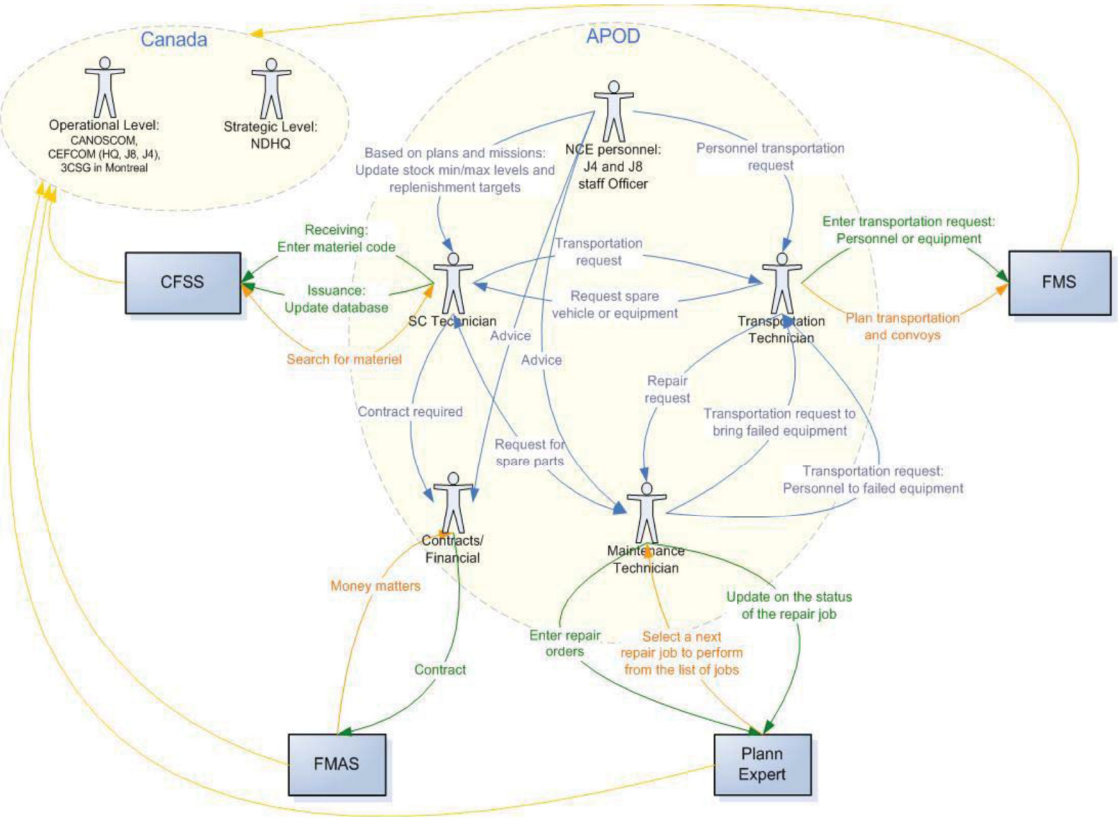

Figure 22 Currently Used Systems, Their Operators, and Existing Information Flow

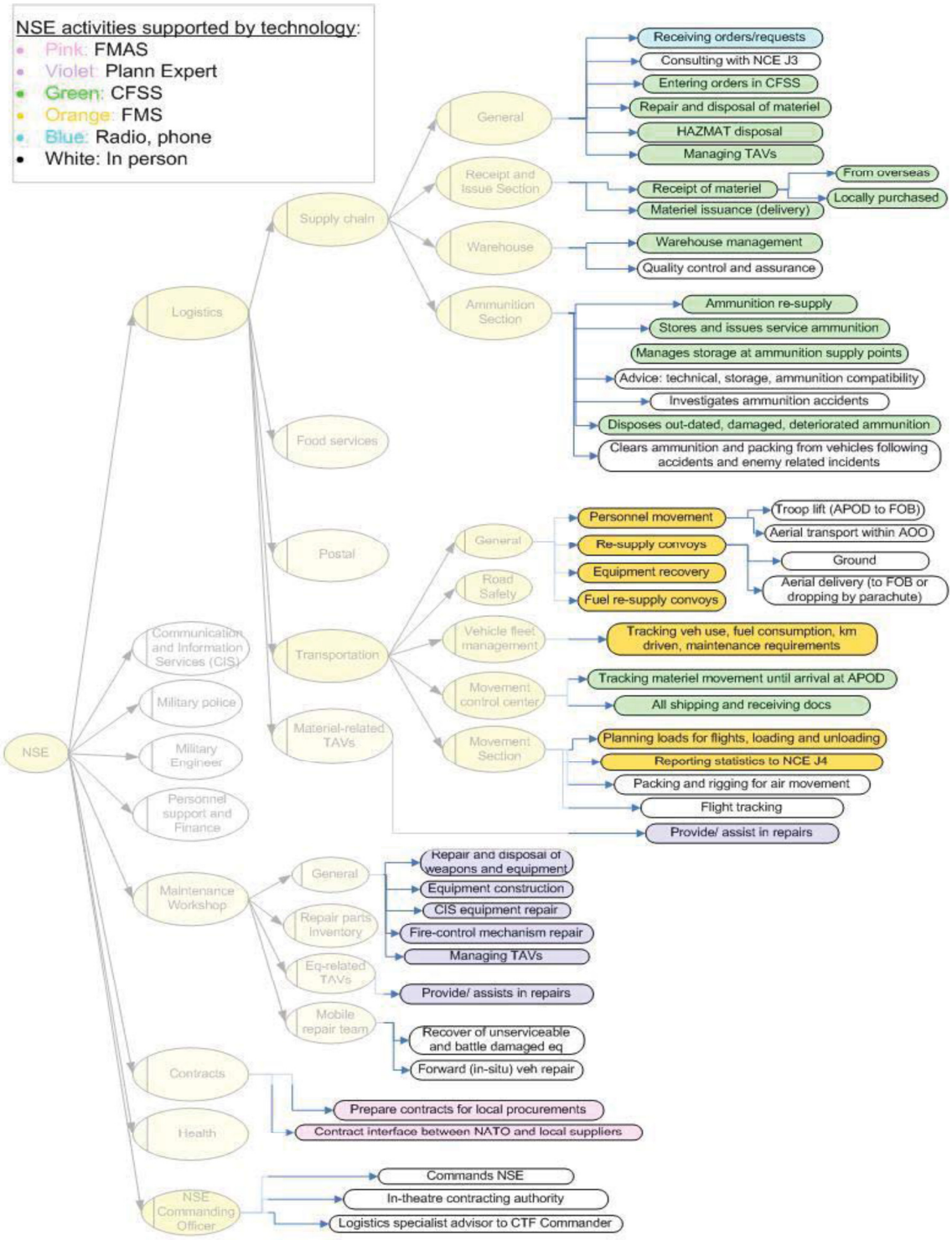

Figure 23 Indication of the NSE Activities Supported by a Technology or Software System

5.2 High-level Gaps

From a high-level perspective, identified gaps can be categorized as follows:

- G1. Enterprise system
- G2. Total asset and materiel visibility
- G3. Advanced forecasting and corresponding proactive planning of all activities
- G4. Improved decision-support for supply chain management (distribution management and inventory management) and repair-shop management by incorporating solver-based, simulation-based or knowledge-based components

5.2.1 Enterprise System

The enterprise system tackles both aspects – data collection and analytical decision-making – needed for efficient and effective tactical logistics.

Note that the combination of reactive and proactive logistics is needed, because no matter how much one plans and how sophisticated one's forecasts are, there will always be a possibility of unforeseen circumstances arising.

The enterprise system is needed to support both reactive and proactive logistics. In addition, proactive logistics is part of focused logistics as well as sense-and-respond type of logistics.
The enterprise system would provide integrated information systems that in turn would promote information sharing, and even allow automatic information sharing (see Figure 24). Furthermore, this will allow the proper application of the SCM throughout all operational and tactical logistics activities, or the merging of the two SCNs.

Current gaps related to the enterprise system include:

- G1.1 Very few of the existing information systems are overarching operational and tactical SCN or entire CF
- G1.2 Existing information systems are not talking/communicating (see Figure 24 for the desirable communication between the components of the integrated information system)

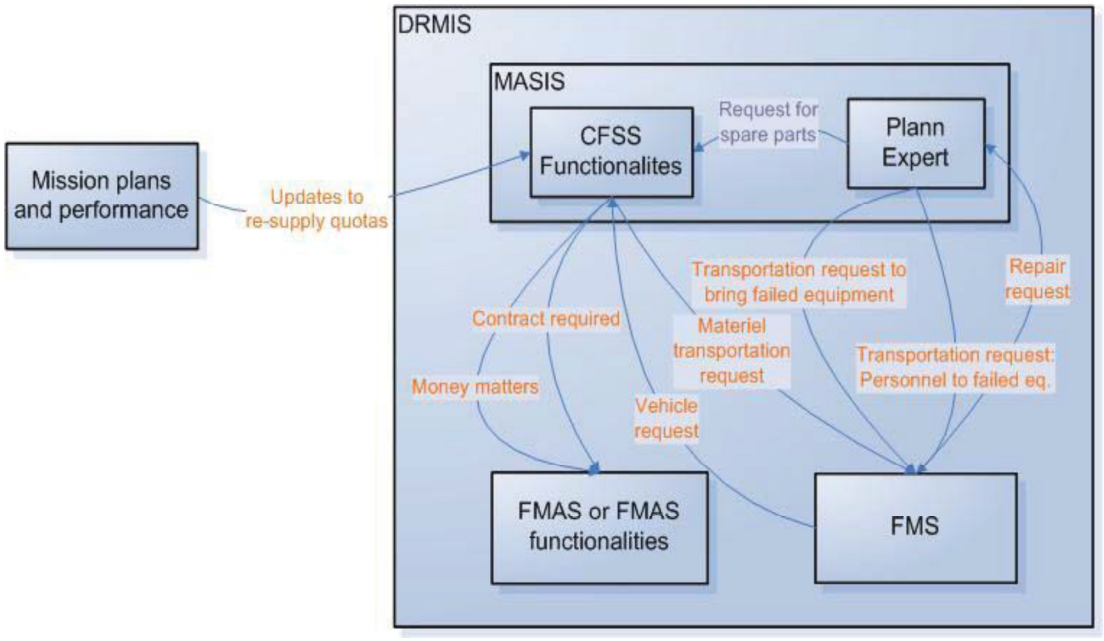

Figure 24 Information Flow between the Components of the Enterprise System

5.2.2 Visibility and Interoperability

The visibility of materiel, assets and resources tackles the 'data collection' aspect needed for an improved tactical logistics.

Total visibility includes improved data collection and information flows, with the aim of sharing valuable information, including demand signals, forecasts, inventory, transportation, potential collaboration, etc.

Total visibility gaps include:

- G2.1 Data collection gaps:
  - G2.1.1 Automatic collection of the stock levels
  - G2.1.2 Automatic collection of the quality/state of the consumable[15] materiel
  - G2.1.3 Automatic collection of the status/state of the equipment
  - G2.1.4 Vehicles with built-in sensors and self-diagnostic modules
  - G2.1.5 Near real-time[16] data collection

[15] **Consumable** materiel includes: food, fuel, ammunition

[16] The term **near real-time** in computing pertains to the delay introduced, by automated data processing or network transmission, between the occurrence of an event and the use of the processed data, e.g., for display or feedback and control purposes. Typically, near real time is between 15 to 20 seconds. For this document, near real-time can have a delay of up to an hour or few hours.

G2.2 Information flow gaps:

- G2.2.1 Information flow facility structure (bandwidth, etc.)
- G2.2.2 Near real-time visibility, i.e., information transfer
- G2.2.3 Visibility of updates on the status and level of the materiel stock in the battle-group to the NSE; Producer: Battle-group; Consumer: NSE (see Figure 25)
- G2.2.4 Visibility of updates on the status and level of the materiel stock and materiel demands/ requests in the tactical SCN from the operational SCN; Producer: NSE; Consumer: CANOSCOM
- G2.2.5 NSE APOD warehouses – inventory visibility; Producer: NSE; Consumer: NSE (see Figure 25)
- G2.2.6 Visibility of transportation time and delay (late delivery) statistics in the operational SCN. This information needs to be provided to NSE – the tactical SCN and further to the battle-group. Producer: operational SCN (CANOSCOM); Consumer: tactical SCN (NSE) and battle-group (see Figure 26)
- G2.2.7 Currently encountered transportation delays from suppliers; Producer: operational SCN (CANOSCOM); Consumer: tactical SCN (NSE) and battle-group (see Figure 26)
- G2.2.8 Links to mission planning tools or personnel for setting min/max stocks and priorities; Producer: NCE; Consumer: NSE
- G2.2.9 In-transit visibility of transportation assets
- G2.2.10 In-transit visibility of materiel

G2.3 Interoperability:

- G2.3.1 Providing asset location and movement of the other allied nations, in order to share resources
- G2.3.2 DRMIS compatibility with NATO systems
- G2.3.3 Reports and statistics that can be exported in some standard file format
- G2.3.4 Ability to import reports from NATO systems to improve visibility of the NATO shared resources

The remainder of this section will discuss the gaps that seem of the highest priority, whose closing would be the most beneficial as per military experts' opinion.

The most pressing aspects of the tactical logistics (Gaps G2.2.3, G2.2.5, G2.2.6 and G2.2.7) that require improvements/ enhancements are shown in Figure 25 and Figure 26. Figure 25 shows the improvements within the AOO (within NSE), while Figure 26 shows interactions with other elements of CF outside AOO (interactions between with operational SCN, i.e., CANOSCOM). All of these aspects are related to data collection and timely (hourly) information sharing.

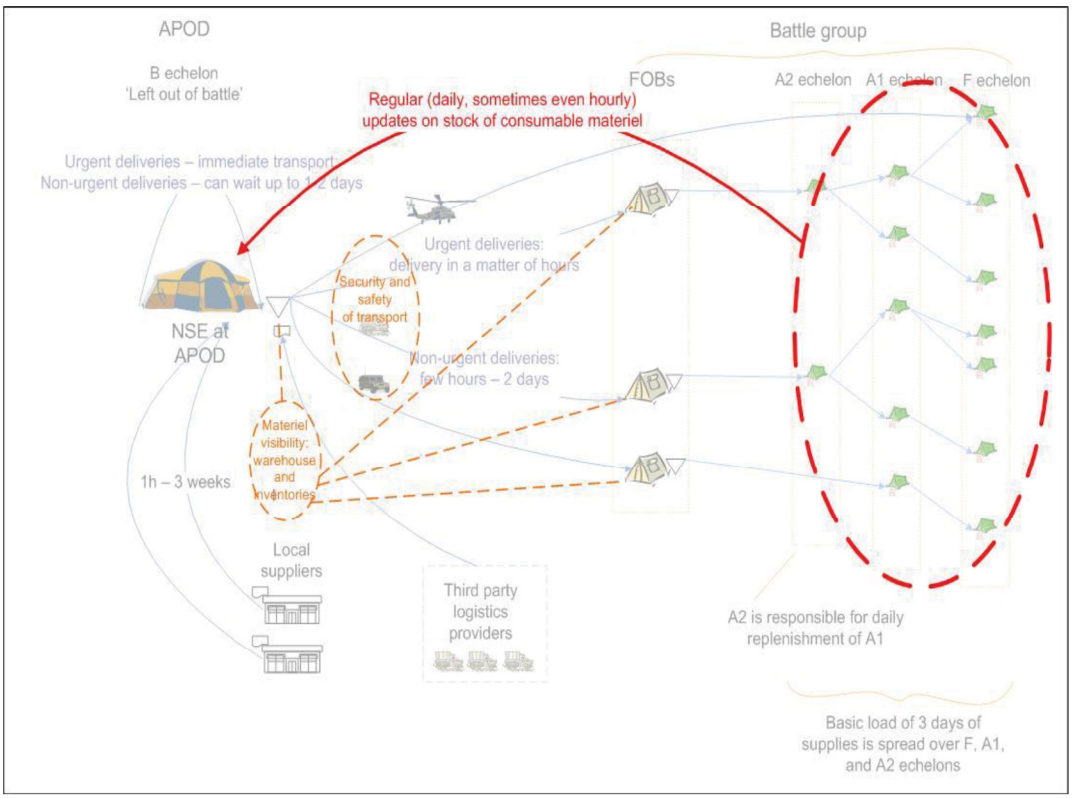

Figure 25 The Most Pressing Gaps Related to Visibility and Information Sharing. (For the Background Figure on Tactical Supply Chain see Figure 13.)

The red circles represent the highest priority gap, and orange circles represent slightly lower priority gaps.

Regular (daily, sometimes even hourly) updates of the stock and status of the consumable materiel at the battle-group – all echelons – is crucially needed. This is the largest gap and the one that would bring the most benefits if resolved.

The safety of convoys has been an important issue and it will be even more important in the future, as a result of the modern warfare characteristics. As stated in [3]: "The logistics has become part of combat operations when there are no such words as *front* and *rear* anymore. The line between the combat arms and combat logistics soldiers on the modern battlefield has become blurred."

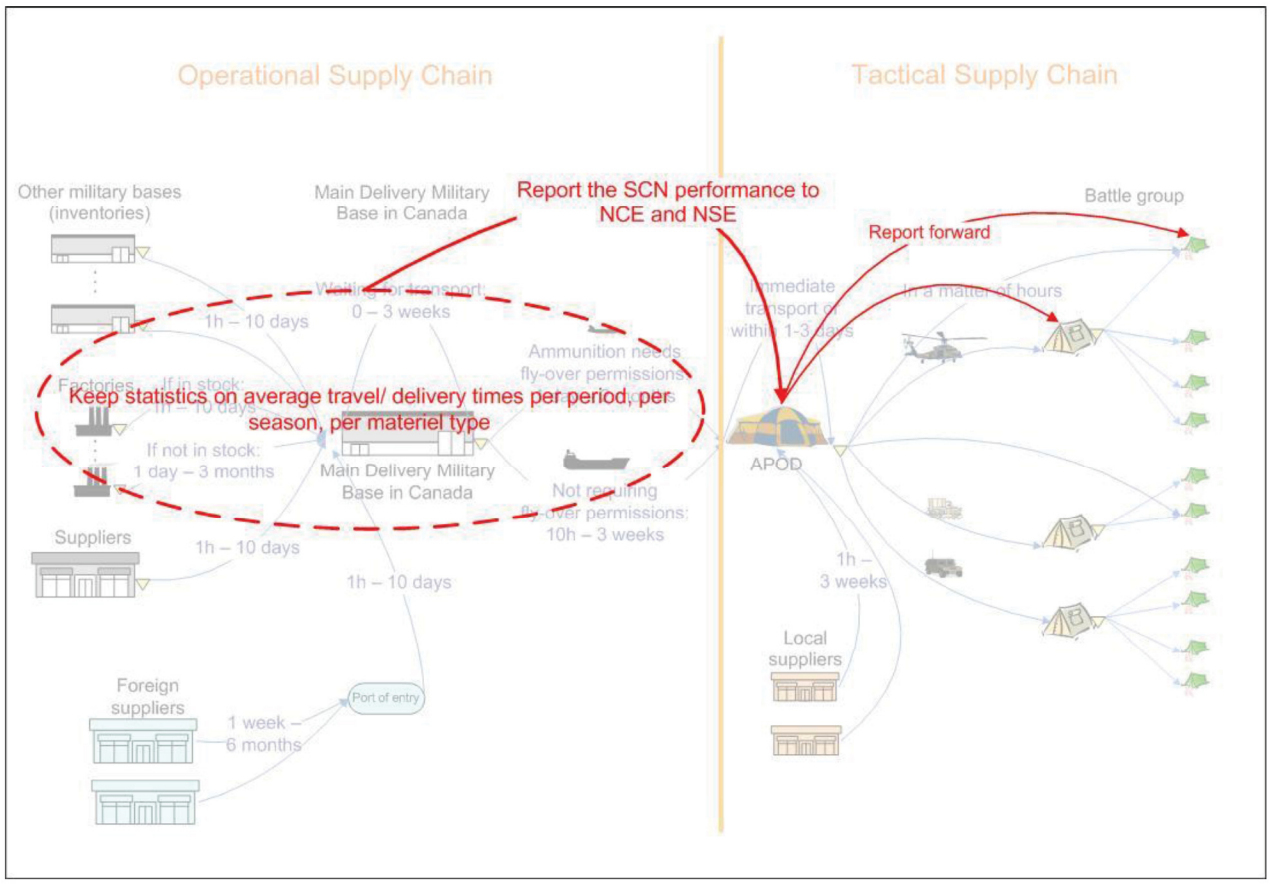

Figure 26 The Main Links between Operational SCN and Tactical SCN that Need Improvements/Enhancements. (For the Background Figure on Supply Chain see Figure 15)

5.2.3 Forecasting

Forecasting, as already stated, is necessary for focused logistics, that is, to support adaptive and dispersed military operations.

In addition, since the military environment is highly dynamic, forecasting that would support proactive logistics needs to be done regularly, so that re-supply demand can be changed and updated to reflect the current situations.

Forecasting gaps include:

- G3.1 Collection of historical data and performance measurements: measures include time to deliver, cost vs. request priority/urgency, and materiel quality reaching customers
- G3.2 Tools for supporting forecasting demand of consumable materiel
- G3.3 Tools for supporting forecasting demand for other materiel
- G3.4 Spare parts demand forecasting

G3.5 Time-dependent demand: as time passes the equipment begins to wear-down more often than at the beginning of the mission

5.2.4 SCM and Repair-shop Management

Although decision-support for SCM (distribution and inventory management) and repair-shop management exists, it could still be improved. For example, components and algorithms that optimize certain measures including time to deliver, distance, risk, materiel quality, costs, and provide several alternative solutions to a decision-maker would be beneficial.

G4.1 Distribution management gaps:

- G4.1.1 Distribution planning, including all nodes in the combined operational and tactical supply chain
- G4.1.2 Computer support for routing and scheduling in order to fulfill transportation requests; or in order to optimize balancing time, distance and risks; heterogeneous fleet, heterogeneous loads; pre-configured loads
- G4.1.3 Real-time distribution planning
- G4.1.4 Dynamic routing with re-routing capabilities in order to react to unexpected demands (Although note that this is a highly reactive approach)
- G4.1.5 Replenishment cycle changes (Section 3.2.3)
- G4.1.6 Automatic support for the re-design of the distribution network configuration: in terms of moving FOBs, battle-groups echelon A1 and A2, and ammunition supply point locations

G4.2 Inventory management gaps:

- G4.2.1 Better keeping track of the materiel and their place/ location
- G4.2.2 Categorization of spare parts based on the importance of the equipment in question
- G4.2.3 Re-arranging the containers
- G4.2.4 Optimizing resource share with allied nations
- G4.2.5 Re-supply
- G4.2.6 Crucial warehouse equipment failing and spare parts not in AOO

G4.3 Repair-shop management gaps:

- G4.3.1 Collecting time of repairs
- G4.3.2 Generating schedules for the repair jobs, thus providing predicted time when the equipment will be ready
- G4.3.3 Engineer-task assignment maximizing the skill-task compatibilities

5.3 Information Flow Gaps

A projected desirable information flow is provided in Figure 27. For the sake of simplicity, Figure 28 depicts the current gaps in this information flow - between human interactions and systems, and among legacy systems per se.

To summarize issues related to the legacy information systems, Plann Expert, FMS, and CFSS (or their functionalities) should be improved by enhancing them with:

- Forecasting components
- Sophisticated algorithms/ components that would support decision-making by providing alternative solutions to distribution problems, evaluation, simulation, what-if analysis
- Vigilant system characteristics

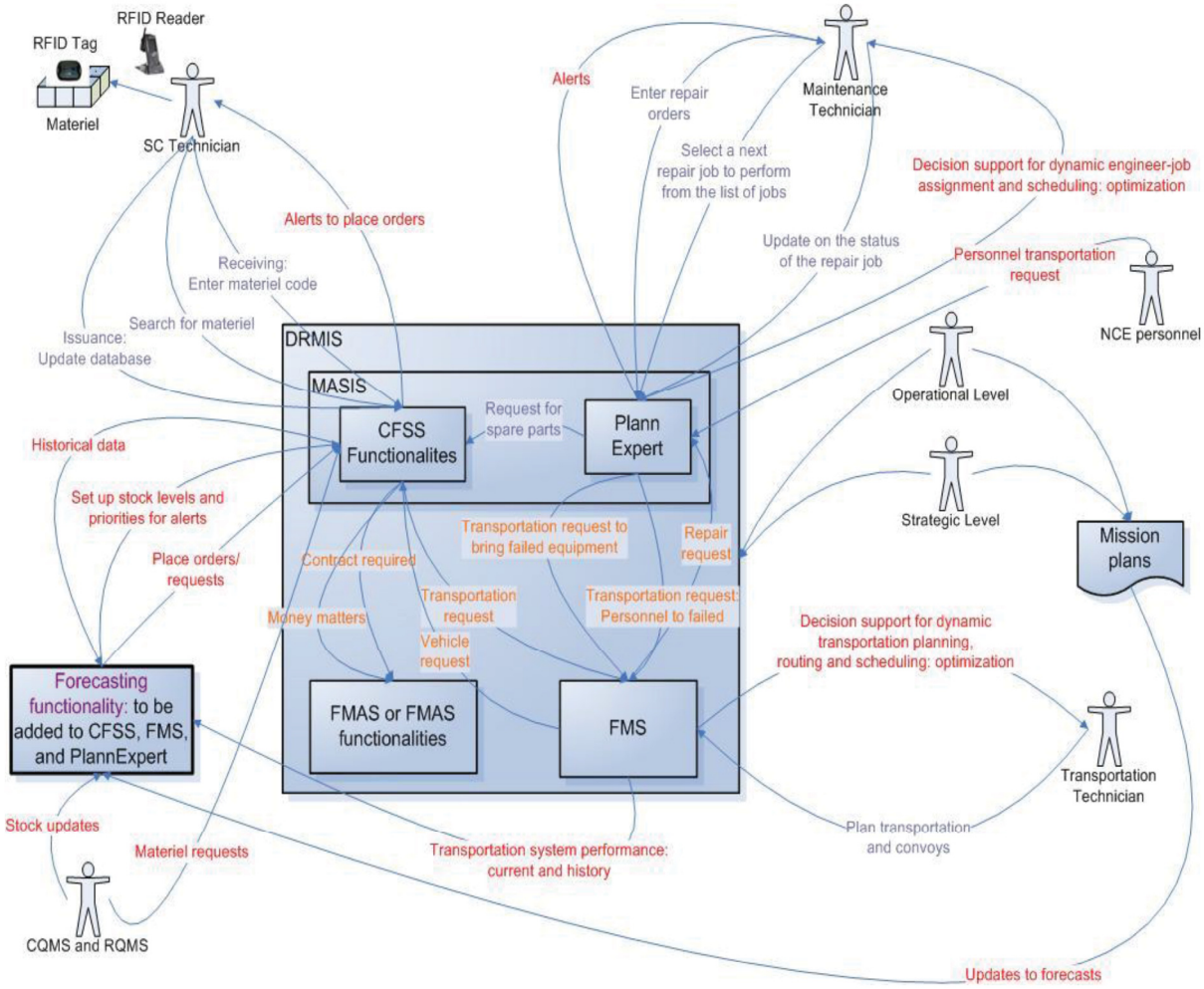

Figure 27 Desirable Information Flow between the Information Systems and Actors

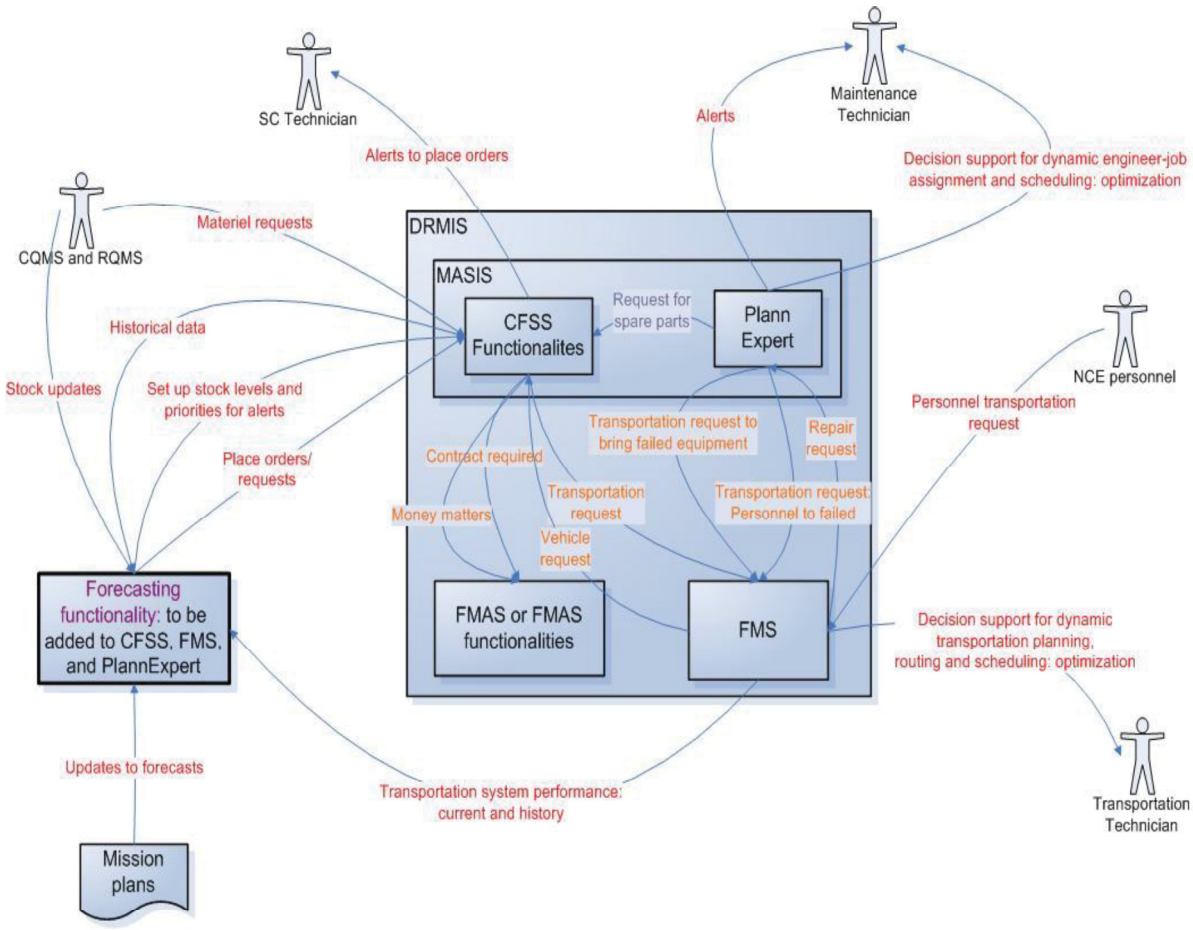

Figure 28 Gaps Related to Information Flow and Decision Support

5.4 Gaps Summary

A summary of the gaps reported in 5.2, their current status and priorities is reported in Table 4. Note that the data are provided as per our current knowledge, and they may be updated by the end of this project.

Table 4 Gaps, Status, and Priorities

Gap category	Gap	Description	Research in progress	Implementation in progress	Fielding in progress	Currently operational	Improvements needed	Achieved	Priority/ importance	Potential technology for enhance-ment	HW/ SW
G1. Enterprise system	G1.1	Systems including oper. and tactical SCN	×	×	×	×					HW, SW; Infrastructure
	G1.2.	Existing systems integration	✓	✓	✓	×					SW
G2. Visibility G2.1. Data collection	G2.1.1 G2.1.2	Consumable materiel: stock levels, quality	✓	✓	×	×				Telemetry, cameras	HW, SW
	G2.1.3 G2.1.4	Vehicles/ eq. health sensors and self-diagnostics	✓	×	×	×				HMS	HW, SW
	G2.1.5	Near real time data collection	Will be achieved when other G2.1 are achieved								
G2. Visibility G2.2 Inf. flow	G2.2.1	Infrastructure	✓	✓	✓	✓	✓				Tele-communication
	G2.2.2	Near real-time information flow	✓	✓	×	×	✓				Tele-communication
	G2.2.3	BG →NSE	✓	✓	✓	Radio	✓				HW, SW
	G2.2.4	NSE → CANOSCOM	✓	✓	✓	✓	✓				SW
	G2.2.5	Within NSE	✓	✓	✓	✓	✓				HW, SW
	G2.2.6 G2.2.7	CANOSCOM →NSE →BG	✓	✓	✓	×	✓				SW, HW
	G2.2.8	COPlans (?) →CFSS	✓	✓	✓	×					SW
	G2.2.9 G2.2.10	In-transit visibility	✓	×	×	×					HW, SW
G2. Visibility G2.3 Inter-op.	G2.3	Interoperability with NATO systems	✓	×	×	×					SW
G3.Forecast	G3.1	Historical data and performance analysis	✓	✓	×	×				Analytics	SW
	G3.2 G3.3 G3.4 G3.5	Demand forecasting	✓	×	×	×				Forecasting models and tools	SW
G4. SCM and Oper. Mgmt.	G4.1	Distribution mgmt	✓	×	×	×				Optimization tools	SW
	G4.2	Inventory mgmt	✓	×	×	×				Optimization tools	SW
	G4.3	Repair shop mgmt	✓	×	×	×				Optimization tools	SW

This page left intentionally blank

6 Problem Definition

This Chapter proposes a contextual problem setting for the development of new technology concepts for a sustainment management decision support system capability.

Despite the commitment of CF and many supporting DND organizations, initiatives aimed at developing a suitable comprehensive asset visibility (e.g. anytime automated identification technology, tracking, monitoring) and logistics picture capability relying on a stable enterprise information integration platform involving integrated data sources (e.g. ERPs under DRMIS) and applications are still evolving at a slow pace. In order to avoid duplication, our effort focuses on advanced supply chain network management concepts, assuming available or limited capability technology solutions to feed required information.

Applicable to Army In-Theatre logistics planning and sustainment missions, the proposed problem setting aligns with some of the objectives stated for the Army of Tomorrow Sustainment concepts for adaptive dispersed operations [1], aimed at providing inter- and intra-theatre asset visibility, adaptive planning, logistics cost and footprint reduction. It is believed to be a relevant problem domain defining suitable areas for further investigation of Sense-and-Respond logistics decision support technology concepts, revolving around integration platform components, to enhance situation awareness and decision support, namely, in providing data access/asset visibility, monitoring (including condition-based asset monitoring capability), analysis, forecasting, and adaptive planning (distribution, maintenance, supply chain management) respectively.

The problem will primarily focus on In-Theatre supply chain management, namely, on the distribution dimension, representing a key element of the supply chain network in terms of planning and execution cost and uncertainty. We propose deconstructing a problem using a phased approach. Accordingly, nested sub-problems will progressively expand a two-echelon supply chain network to include centralized/distributed:

- Transportation (e.g. vehicle routing),
- Inventory management,
- Demand forecasting (supply/service/maintenance) and
- Maintenance

In addition, we intend to examine asset and readiness tracking/monitoring explicitly guided by and subordinated to logistics planning and asset control and management (e.g. sensor network allocation to gather high-value/mission-critical information, or dynamically/opportunistically revisiting sensing/monitoring rate to enhance plan solution quality or improve forecast) and, condition-based monitoring to perform predictive and anticipatory asset maintenance management, both aimed at improving combat support service and logistics planning. Naturally represented as a high-level configurable parameter to capture delayed information, network latency will be modeled to reflect the impact of various network configuration/contingencies on performance and identify degradation thresholds.

The main assumptions defining sustainment problem boundaries include:

- A distributed, dynamic, uncertain, hostile (risky) in-theatre environment (dispersed operations in future security environment)

- Network connectivity and interoperability: end-to-end supply chain network
- Asset visibility capability: mesh RFID, AIT, sensor networking/querying/resource allocation
- Support picture: assumed to derive from an eventual ROSP capability (supported by CoROSP TDP,DRMIS) (CF COP layer) → enterprise information integration/ intra, inter, extra -organizational
- availability of data sources to address transportation/inventory management and maintenance logistics planning and asset control/management

These assumptions are based on likely solution technology projections expected to occur over the next few years. Despite the generality of these assumptions some constraints and specific requirements regarding connectivity, asset visibility, dynamic distribution, security, and coordination may still be unrealistic in practice.

Cost-effective solutions to the stated problem ultimately apply to various In-Theatre logistics sustainment/combat service support domains such as tactical airlift, convoy/route protection, medical/casualty evacuation and support over the last tactical mile in achieving supply/service delivery (e.g. petroleum/oil/lubricants, spares, repair and overhaul, escorting, security). The problem model to be developed may even contemplate future perspectives in analyzing the impact and value of innovative ideas. For instance, the multi-role unmanned aerial vehicles (UAVs) concept [24], [25] in which single or multiple UAVs might separately or concurrently achieve multiple tasks including reconnaissance (e.g. routes), package/cargo delivery (routing), refuelling and alternate combat service support assignments over a variety of situations/domains, might be easily explored to conduct comparative performance analysis or assess possible service level gains and logistics cost and footprint reduction.

A decision support integration platform incorporating shared situation awareness, planning, monitoring, demand forecasting, simulation and analysis (e.g. "what-if") solutions will incorporate the developed solutions for the proposed contextual problem. This will involve planning (vehicle routing, inventory management and maintenance), asset readiness characterization, asset/ plan execution monitoring, the planning of asset monitoring (e.g. through entropy/uncertainty/belief divergence minimization over resource allocation, forecast/estimate maximization, maintenance/readiness -driven). Developed as an advisory decision support prototype, the information integration solution platform will deliver network-centric sustainment management capability components that can respond to changing demands. The platform will be suitable for proof-of-concept demonstration and scenario-based validation purposes. The approach aims to provide the following output and desired outcomes:

Output:

Tactical sustainment decision support requirements for adaptive dispersed operations

Adaptive planning/monitoring/forecasting/analysis models and algorithms (e.g. distribution) – decision support components

Tactical asset readiness function characterization

Proof of concept advisory decision support prototype

Outcomes:

- ‘Smart sustainment decision support system’ capability component - integrated information-sharing and decision support environment (planning, monitoring, analysis)
- Logistics cost and footprint reduction, service level improvement (optimality and visibility)
- Sense-response cycle reduction (improved responsiveness), human overload reduction
- Close gaps between information-sharing and decision-making, planning and execution monitoring

This page left intentionally blank

7 Conclusion

This document presented the main components and characteristics of the current National Support Element and the structure of the tactical supply network defining CF In-Theatre logistics. It described current information technology and recent asset visibility capability. Some limited gaps underlining technology deficiencies were also reported. An approach to deconstructing a problem was then proposed to tackle In-Theatre logistics distribution as part of a two-echelon supply chain network. The approach proposes handling key nested supply chain network decision sub-problem components through the development of a decision support capability for In-Theatre logistics planning and sustainment missions.

Future work will consist in developing technology concept solutions leading to the development of sustainment management decision support capability components for the proposed distribution problem. Emerging proof-of-concept advisory decision support components will ultimately be used to advise decision-makers on comparative solution plan quality and alternatively explore the value of new concepts against selected or user-defined objectives and requirements.

This page left intentionally blank

References

[1] Directorate of Land Concepts and Design (2009), Chapter 9: An operating concept of sustainment for the Army of Tomorrow" in Toward Land Operations 2021: Studies in support of the Army of Tomorrow – Force Employment Concept, Kingston, Ontario, Canada.

[2] Auditor General of Canada (2008), "Chapter 2: Support for overseas deployments – National Defence" in Report of the Auditor General of Canada to the House of Commons.

[3] Conrad, J. (2009), What the thunder said: Reflections of a Canadian officer in Kandahar, Dundurn Press.

[4] Auditor General of Canada (2001), Chapter 10: National Defence – In-Service Equipment" in Report of the Auditor General of Canada to the House of Commons, http://www.oag-bvg.gc.ca/internet/English/parl_oag_200112_10_e_11831.html.

[5] Ross, J. et al. (2006) Enterprise Architecture as Strategy: Creating a Foundation for Business Execution, Cambridge, Harvard Business School Press. ISBN 1-591398-39-8. http://en.wikipedia.org/wiki/Extended_Enterprise.

[6] Wikipedia: definitions of SC, SCM, SCN Accessed on January 10, 2011.

[7] Akkermans, H.A. (2001), RENGA: A systems approach to facilitating inter-organizational network development", System Dynamics Review 17 (3), http://www.tilburguniversity.edu/research/institutes-and-research-groups/center/staff/akkermans/Publications/024.pdf.

[8] Lambert, D.M. and M.C. Cooper (2000), Issues in Supply Chain Management, Industrial Marketing Management 29 (1), 65-83.

[9] Lambert, D.M. (2008), Supply Chain Management: Processes, Partnerships, Performance, 3rd edition.

[10] Canadian Forces Joint Publication (CFJP) 01 – Canadian Military Doctrine (2009), Joint Doctrine Branch, Canadian Forces Experimentation Center, DND, http://dsp-psd.pwgsc.gc.ca/collection_2010/forces/D2-252-2009-eng.pdf.

[11] "CFJP 4.0 – Support to CF Operations, listed in CF Joint Doctrine Publication at http://www.cfd-cdf.forces.gc.ca/sites/page-eng.asp?page=3560.

[12] NATO Logistics Handbook, (2007).

[13] Lessard, M. and Mrad, N. (2010), Land Tactical Sustain Sensing Technologies and Concepts: Asset Tracking, Monitoring and Visibility and Data Management and Security, DRDC-Atlantic CR 2010-09.

[14] The wheels of change: latest on fleet management system, (2007), Maple Leaf Vol. 10, No. 11, 25 http://www.forces.gc.ca/site/Commun/ml-fe/article-eng.asp?id=3216.

[15] Rollout of MASIS for Army begins in fall 2009, (2009), CF Army News, January 27, 2009, http://www.army.forces.gc.ca/land-terre/news-nouvelles/story-reportage-eng.asp?id=3185.

[16] DRMIS, http://drmis-sigrd.mil.ca/.

[17] FMAS + MASIS = DRMIS, (2010), Maple Leaf, Vol. 13, No.2, 20 January 2010, http://www.forces.gc.ca/site/Commun/ml-fe/article-eng.asp?id=5854.

[18] DRMIS: If they can do it, you can (2010), Maple Leaf, Vol. 13, No.26, 18 August 2010, http://www.forces.gc.ca/site/commun/ml-fe/article-eng.asp?id=6369.

[19] Marsh, A.G. (2008), NATO's challenge in multinational logistics: Interoperability: How NATO meets multinational logistics challenges, EE Times, Supply Network.

[20] Bolstorff, P. and Rosenbaum, R. (2007). Introduction in Supply Chain Excellence: A Handbook for Dramatic Improvement Using the SCOR Model, Second Edition. AMACOM.

[21] Senior NATO Logisticians' Conference, (2007), Supply Chain Management Concept and Prospect for Implementing within NATO, Document EAPC(SNLC)D(2007)0001.

[22] NATO Logistics Support to ISAF, (2009), Joint Analysis and Lesson Learned Center (JALLC) Report.

[23] Lessard, M. (2012), State of Asset Visibility Tracking and Monitoring, Aequilibrium Management Inc., DRDC A, CR 2012-088.

[24] US Army, Logistics Innovation Agency, https://lia.army.mil/initiatives.html

[25] Williams, J.T., (2010), Unmanned Tactical Airlift - A Business Case Study, A FIT/IMO/ENS/10-16, Air Force Institute of Technology, Wright-Patterson Air Force Base, OH, USA.

Annex A TRANSPORTATION VEHICLES AT NSE AND BATTLE GROUP

F Echelon. For the transportation to F echelon, CF uses fighting /combat vehicles such as Leopard 2 Tanks, the LAV III Infantry fighting vehicles and other vehicles designed for engaging the enemy. They report to a platoon and company commander for their tactical command and control. They are replenished by a platoon asset in the A1 echelon on a moment to moment basis. These F echelon vehicles return to the FOBs for their detailed sustainment – A2 echelon support and crew rest as required. Sometimes they stay out beyond the FOBs overnight as the tactical situation warrants. The number of fighting vehicles in a company or squadron varies, but a typical company will have in the range of 15 to 19 LAV III vehicles. (One LAV carries a section of soldiers and there are nine sections in a typical Infantry company.)

The A1 Echelon vehicles are usually "A Vehicles", similar in kind to the actual fighting vehicles of the F Echelon. They draw their material from the A2 Echelon (Admin Company) at the FOB and they follow the F Echelon staying back one tactical bound, poised to deliver any moment logistics required. The A1 vehicles report to the FOBs for their sustainment and to draw more supplies from A2. A1 vehicle numbers are small – one vehicle per platoon, and thus probably 2 to 3 vehicles dedicated to A1 sustainment in a typical Kandahar Company. This can vary based on command preferences.

The A2 Echelon Vehicles are "B Vehicles" – army trucks like 16 Tonne Logistics truck. It is at the A2, where echelon vehicles change in type from hardened armour to standard military trucks. Although, in Kandahar this has not been the case always due to need for protective measures and escort requirements. A typical Administration Company could have 100 to 150 vehicles.

The vehicles of the NSE at APOD (also called Close Support Logistics) top up the A2 echelon (Battle Group Administration Company). These NSE vehicles are also "B Vehicles" or trucks although in Kandahar more often would happen that additional armoured vehicles like the BISON LAV II are being introduced into the NSE vehicle holdings. The NSE vehicles take goods and services from the inventories on the APOD and transport them forward to the A2 elements at each FOB. The NSE has around 75 to 100 vehicles, although the number can vary widely between the missions depending on a number of factors.

Beyond the FOBs, there are no "depots" in the classical sense. Materiel is delivered through the echelon system and vehicles are almost always on the move or waiting to provide next delivery.

This page left intentionally blank

Annex B A BRIEF SME'S NOTE ON DISTRIBUTED RESOURCE PLANNING IN NATO

Logistics operational planning is part of the overall NATO operational planning process. It aims to get what is effectively needed in the field of logistics for a specific operation, whereas logistic planning aims to ensure the availability of logistics in general[17].

NATO Distributed Resource Planning (DRP) probably pertains to the former aspects of the above description – operational necessities for a specific operation.

After the team's SME John Conrad checked on DRP with his contacts in Canada and overseas, and after he went through the most recent NATO documents including the *NATO Logistics Handbook*, the minutes of the NATO Logistics Committee (responsible for NATO logistics governance), and AAP 6 – *The NATO Glossary of Terms*, we concluded that there are no specific references to Distributed Resource Planning (DRP).

What follows is the SME's opinion on what NATO DRP refers to: a methodology for logistics operational planning.

DRP as part of the NATO OPP

In my opinion DRP can only refer to the optimum sustainment solutions that NATO logistics planners develop for a specific area of operations through the routine course of the operational planning process (OPP). There are of course, three key documents produced during OPP: the Concept of Operations (CONOPS); the Operation Plan (OPLAN) and its attendant operational orders; and Contingency Plan (COP). The NATO OPP ensures that the NATO logistics construct caters to the unique aspects of geography and demography in a given AO. In addition to these three documents, logistic support guidelines are produced that include considerations such as the geography of the theatre and the political and military situation. Other issues are also taken into account such as the use of multinational logistics, movement planning, medical planning, the role of the host nation and coordination with international organizations and non-governmental organizations.[18]

[17] http://www.nato.int/cps/en/SID-21C1768C-6A0C0F72/natolive/topics_61741.htm
[18] http://www.nato.int/cps/en/SID-21C1768C-6A0C0F72/natolive/topics_61741.htm?

Inventory Management

The current offerings on the NATO Logistics webpage talk about the need for sound logistics planning across national lines through the entire breadth of an AO. This speaks to good inventory management in an operational theatre – having the right amount of material in the right places at the right time regardless of sourcing in the multi-national quilt that comes to make up an operational logistics system in a NATO operation – a logistics preparation of the battlefield in other words. I recall NATO taking over form Operation Enduring Freedom in Kandahar in July 2006 and suddenly, the NATO staff in Kabul was very concerned about the amount of materiel we held inside our various FOBs. The NATO staff sought to establish set numbers and quantities of resources at each FOB and the numbers were different depending on role and geography. When a certain FOB dropped below a certain level it went from Green to Yellow or Red in terms of stock holdings. I believe this was an example of this new DRP concept. In reality, it is an operational application of our own basic and maintenance loads in the Canadian echelon system described earlier in this project. *Stockpiling is closely linked to the principles of logistic readiness and sustainability. National and NATO logistic plans must ensure that sufficient quantity and quality of logistic resources are available at the same readiness and deployability levels to support forces until a re-supply system is in place. In addition, combat power must be sustained for the foreseen duration of operations, which implies that there are sufficient stocks or that there is assured access to industrial capabilities, agreements, contingency contracts and other means, including contractor support to operations, to guarantee that requirements are met.*[19]

The DRP concept, incipient as it appears to be, should be monitored by Canada in terms of next generation information systems that deal with sustainment. The sensors would need to be tied to relevant FOB inventories to be pertinent to a NATO coalition member.

[19] http://www.nato.int/cps/en/SID-21C1768C-6A0C0F72/natolive/topics_61741.htm?

List of symbols/abbreviations/acronyms/initialisms

AIMS	Ammunition Inventory Management System
AIT	Automated Identification Technology
AJOP	Agile Joint Operations Picture
APOD	Airport Points of Disembarkation
APOE	Airport Points of Embarkation
APS	Advanced Planning and Scheduling
AV	Asset Visibility
AVIMS	Automated Vehicle Information Management System
BCS3	Battle Command Sustainment Support System
BI	Business Intelligence
CAMMS	Canadian Automated Medical Movement System
Canada Com	Canada Command
CANOSCOM	Canadian Operational Support Command
CANSOFCOM	Canadian Special Forces Command
CCIR	Commander's Critical Information Requirements
CEFCOM	Canadian Expeditionary Force Command
CF	Canadian Forces
CFD	Chief Force Development
CFAD	Canadian Forces Ammunition Depots
CFJSG	CF Joint Support Group
CFJSR	CF Joint Signal Regiment
CFJTF	CF Joint Task Force
CFSD	CF Supply Depots
CFSS	Canadian Forces Supply System
CFTPO	Canadian Forces Task Posting Order
CIS	Communication and Information System
C2	Command and Control
CJTL	Canadian Joint Task List
CMSG	Canadian Materiel Support Group
CONOPS	Concept of Operations
COP	Common Operating Picture

CSG	Canadian Support Group
CV	Command View
DGMSSC	Director General Materiel Systems and Supply Chain
DII	Defence Information Infrastructure
DMIS	Director Material Information Systems
DND	Department of National Defence
DRDC	Defence Research & Development Canada
DRDKIM	Director Research and Development Knowledge and Information Management
DISB	Defence Information Services Broker
DRMIS	Defence Resource Management Information System
DRP	Distribution Resource Planning
DTAV	Defence Total Asset Visibility
ECS	Environmental Chief of Staff
EII	Enterprise Information Integration
ERP	Enterprise Resource Planning
ESU	Engineer Support Unit
FMAS	Financial Management Accounting System
FMS	Fleet Management System
GCSS	Global Combat Support System
GIS	Geographical Information System
HRMS	Human Resource Management System
ICAT	Integrated Capability Assessment Team
IC2	Integrated Command and Control
IC2S	Integrated Command and Control Information System
IMR	Integrated Managed Readiness
IMS	Incident Management System
IOC	Interim Operational Capability
ISCOE	Information Sharing Centre of Excellence
JCOP	Joint Common Operating Picture
JIIFC	Joint Information and Intelligence Fusion Capability
JOA	Joint Operational Area
JSG	Joint Support Group
JTF	Joint Task Force

JTFSG	Joint Task Force Support Group
LOGFAS	Logistic Functional Area Services (NATO)
MASIS	Materiel Acquisition and Support Management Information System
MILIS	Military Integrated Information System
MOC	Military Occupation Code
MST	Mission Support Teams
MV	Mission View
NATO	North Atlantic Treaty Organization
NCOP	NATO COP
NMDS	National Movement Distribution System
NSG	National Support Group
OGD	Other Government Department
OLAP	On-Line Analytical Processing
OS	Operational Support
OSP	Operational Support Picture
OSCC	Operational Support Coordination Centre
OSU	Operational Support Units
RFID	Radio Frequency Identification
ROSP	Recognized Operational Support Picture
RSOMI	Reception, Staging, and Onward Movement Integration
SA	Situational Awareness
SC	Supply Chain
SCN	Supply Chain Network
SJS	Strategic Joint Staff
SOA	Service-Oriented Architecture
SPOD	Sea-port Points of Disembarkation
SPOE	Sea-port Points of Embarkation
S&RL	Sense-and-Respond Logistics
TAT	Theatre Activation Team
TAV	Total Asset Visibility
TF	Task Force
UDOP	User-defined Operational Picture

This page intentionally left blank.

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's report, or tasking agency, are entered in section 8.)

Defence R&D Canada – Valcartier
2459 Pie-XI Blvd North
Quebec (Quebec)
G3J 1X5 Canada

2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.)

UNCLASSIFIED
(NON-CONTROLLED GOODS)
DMC A
REVIEW: GCEC April 2011

3. TITLE (The complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S, C or U) in parentheses after the title.)

Decision Support Capability for In-Theatre Logistics Planning and Sustain Missions – Problem Definition

4. AUTHORS (last name, followed by initials – ranks, titles, etc. not to be used)

Berger, J.; Boukhtouta, A.; Mitrovic-Minic, S.; Conrad, J.

5. DATE OF PUBLICATION (Month and year of publication of document.)	6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)	6b. NO. OF REFS (Total cited in document.)
November 2012	128	25

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Technical Memorandum

8. SPONSORING ACTIVITY (The name of the department project office or laboratory sponsoring the research and development – include address.)

Defence R&D Canada – Valcartier
2459 Pie-XI Blvd North
Quebec (Quebec)
G3J 1X5 Canada

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
12ss	

10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.)	10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)
DRDC Valcartier TM 2013-321	

11. DOCUMENT AVAILABILITY (Any limitations on further dissemination of the document, other than those imposed by security classification.)

Defence departments

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

Defence departments

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

Canadian Forces (CF) are expected to evolve in adaptive dispersed operations characterized by future security environments (FSE) and time-varying, hostile and uncertain contexts which involve major challenges in delivering effective and efficient In-Theatre logistics and sustainment. This document introduces background information on current CF In-Theatre logistics organization and defines a contextual problem setting for the development of new technology concepts for a sustainment management decision support system capability. The proposed supply network distribution problem setting is believed to offer a suitable context for better defining tactical sustainment decision support requirements for adaptive dispersed operations, and developing decision support capability components for In-Theatre logistics planning and sustainment missions. These decision support capability components are mainly aimed at reducing human overload, sense-and-respond cycle, and logistics cost and footprint, as well as closing gaps between information-sharing and decision-making, and between planning and execution monitoring.

Les Forces Canadiennes (FC) appelées à évoluer en opérations dispersées adaptatives caractérisées par des environnements de sécurité futurs et des contextes dynamiques, hostiles et incertains comporte des défis importants à assurer une logistique et un soutien efficaces et efficients en théâtre. Ce document présente des informations de base sur l'organisation logistique courante des FC en théâtre d'opérations et définit un cadre de problème contextuel pour le développement de nouveaux concepts technologiques pour une capacité de système d'aide à la décision au soutien des opérations. Le cadre de problème contextuel de distribution proposé pour réseau logistique se veut un cadre approprié afin de mieux définir les exigences tactiques d'aide à la décision pour les opérations dispersées adaptatives, et développer des composantes de capacités d'aide à la décision pour la planification logistique et le soutien de missions en théâtre. Ces composantes de capacités d'aide à la décision visent principalement à réduire la surcharge humaine, le cycle détection-réponse, les coûts et empreinte logistiques, ainsi que combler les lacunes entre le partage d'informations et la prise de décision, et, entre la planification et le suivi d'exécution.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

In-Theatre logistics; tactical supply chain; supply chain management, sustainment, decision support

Defence R&D Canada

Canada's Leader in Defence
and National Security
Science and Technology

R & D pour la défense Canada

Chef de file au Canada en matière
de science et de technologie pour
la défense et la sécurité nationale

www.drdc-rddc.gc.ca