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

DEFENCE R&D DÉFENSE

Identification of Operational Support Picture Concepts

A. Appleton
Tab Lamoureux
CAE Professional Services (Canada) Inc.

Prepared by:
CAE Professional Services (Canada) Inc.

Contractor's document number: 5221-002 Version 01
Contract project manager: Matthew Keown
PWGSC contract number: W7701-5-4996/009
CSA: Abdeslem Boukhtouta, technical authority, 613-971-7670

Defence Research and Development Canada – Valcartier

Contract Report
DRDC Valcartier CR 2013-406
January 2012

Canada

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1135 Innovation Dr.
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IMPORTANT INFORMATIVE STATEMENTS

The scientific or technical validity of this Contract Report is entirely the responsibility of the Contractor and the contents do not necessarily have the approval or endorsement of the Department of National Defence of Canada.

Abstract

Defence Research and Development Canada (DRDC) Valcartier is seeking to provide commanders with a more comprehensive operational support picture to enable decision-making that takes account of significant support problems that could impact on the successful conduct of the mission. This project provided an initial Recognised Operational Support Picture (ROSP) Concept of Operations (CONOPS) that can be improved upon in the future by DRDC Valcartier and ROSP stakeholders. To achieve this aim, this project delivered a literature review of 28 academic papers and documentation provided by the Scientific Authority on CONOPS development methods, ROSP requirements, and supporting information. Of these, 12 documents were found to be highly relevant to CONOPS development and these were reviewed further. After discussion with DRDC Valcartier and Canadian Operational Support Command (CANOSCOM) stakeholders, a single CONOPS development method was selected, based on the Institute of Electrical and Electronics Engineers (IEEE) standard. Nine documents were then reviewed that had relevant ROSP requirements and supporting information. These requirements and information were collected and organized into a high-level framework that was then used to guide the development of a first-draft of a ROSP CONOPS.

Résumé

Recherche et Développement pour la Défense Canada (RDDC) Valcartier cherche à fournir aux commandants une vue d'ensemble de support opérationnel plus complète afin de faciliter des prises de décision tenant compte de problèmes de soutien importants qui pourrait influer le succès d'une mission. Ce projet a fourni un Concept des Opérations (CONOPS) initial pour une Image Reconnue de Support des Opérations (Recognised Operational Support Picture, ou ROSP) qui peut être développée dans de futurs itérations par RDDC Valcartier et autres parties prenantes du ROSP. Afin d'atteindre cet objectif, ce projet a produit une revue littéraire de 28 rapports issus du domaine académique ainsi que de la documentation fournie par l'Autorité Scientifique sur les méthodes de développement du CONOPS, des prérequis du ROSP, et des sources d'information auxiliaires. De ces sources d'informations, 12 documents ont été considérés comme hautement pertinents pour le développement du CONOPS, et furent ainsi étudiés en profondeur. Suite à des discussions avec les parties prenantes de RDDC Valcartier et de Commandement du Soutien Opérationnel du Canada (COMSOCAN), une méthode de développement du CONOPS fut sélectionnée, basée sur le standard de l'Institute of Electrical and Electronics Engineers (IEEE). Neuf documents furent ensuite étudiés en vertu de leur pertinence vis-à-vis des prérequis du ROSP et autres informations de soutien. Ces prérequis et autres informations furent colligées et organisées en un cadre conceptuel de haut niveau qui fut ensuite utilisé afin de guider le développement d'une première ébauche du CONOPS pour le ROSP.

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Executive summary

Identification of Operational Support Picture Concepts:

A. Appleton, Tab Lamoureux; DRDC Valcartier CR 2013-406; Defence Research and Development Canada – Valcartier; January 2012.

Background: Defence Research and Development Canada (DRDC) Valcartier is seeking to provide commanders with a more comprehensive operational support picture to enable decision-making that takes account of significant support problems that could impact on the successful conduct of the mission. This project provided an initial Recognised Operational Support Picture (ROSP) Concept of Operations (CONOPS) that can be improved upon in the future by DRDC Valcartier stakeholders.

Method: To achieve this aim, this project conducted the following major activities:

- Characterization and Review of Methodologies for CONOPS development;
- Identification of Key Operational Support Picture Requirements to Support Decision Making; and
- CONOPS Development for an Operational Support Picture Capability.

Results: A total of 28 documents were identified as having relevant information on CONOPS development approaches and ROSP content information. Of these, 12 documents were judged as highly relevant to CONOPS development and 9 were judged to be highly relevant to the ROSP. These were reviewed to select a single CONOPS development method that was appropriate for use in an R&D environment, and to identify ROSP requirements.

The Institute of Electrical and Electronic Engineers (IEEE) standard for a CONOPS was selected as the framework for CONOPS development in this project. The main parts to the IEEE standard are: Scope; Referenced Documents; Current System or Situation; Justification for and Nature of Changes; Concepts for Proposed System; Operational Scenarios; Summary of Impacts; Analysis of Proposed System; Notes; Appendices; and Glossary.

The ROSP requirements were derived from documents provided by the Contract Scientific Authority (CSA) and a workshop held at Canadian Forces Operational Support Command (CANOSCOM) with SMEs on 13th June, 2011, and organized into five main groups: Interoperability; ROSP Representation; Information and Knowledge Management Processes for Situation Awareness; ROSP Processes; and ROSP Outputs.

These high-level ROSP requirements were used to guide the authors in the development of the initial CONOPS for the ROSP. The initial CONOPS presents an overall system description at a sufficiently high level of detail that all requirements can be satisfactorily addressed. Some figures are provided to illustrate the concepts being proposed.

Conclusions/Recommendations: CONOPS typically do not explicitly make the link between the requirements that have arisen from the description of the current system and the “statement of need” or ”problem statement”. Requirements can be seen to be formalized statements of operational deficiencies within an existing system identified by all force levels (tactical, operational and strategic). Throughout its course of development iterations and improvements, an

effective ROSP CONOPS must always seek to eliminate or mitigate those deficiencies by improving the conduct of the operational support it guides. Emerging operational support requirements and deficiencies are continually being identified through the addition of new lessons learned to various operational support information repositories such as the CANOSCOM and Canadian Forces Joint Service Group (CFJSG) Lessons Learned databases. Therefore, these new requirements are key to the successful refinement and improvement of the ROSP CONOPS. In order to ensure that operational support requirements can be a key component in future ROSP CONOPS development efforts, DRDC Valcartier and CANOSCOM should seek to investigate methods that will ensure that emerging operational support requirements are effectively captured by the CONOPS development team members in a timely manner.

The ROSP CONOPS is simply a framework into which the operational support information is to be placed, in order to provide coherence and clarity. What is needed to move this current version forward is an effective approach to continue building and improving on the CONOPS provided by this project. A graphical method of CONOPS development shows promise, since the user can quickly appreciate the overview of the CONOPs, and the graphic could be integrated with standard descriptive forms or written documentation to permit more opportunistic (i.e. non-linear) approaches to CONOPS development. There is currently no graphical tool that exists to support CONOPS development. Consequently, DRDC Valcartier should continue to work with CANOSCOM to develop an integrated team approach to further develop the concepts for CONOPS development provided by this project and they should further investigate how a graphical method of development should be integrated with the IEEE standard in order to suit the requirements of a R&D environment.

Sommaire

Identification of Operational Support Picture Concepts :

A. Appleton, Tab Lamoureux ; DRDC Valcartier CR 2013-406 ; Recherche et développement pour la défense Canada – Valcartier ; janvier 2012.

Contexte: Recherche et Développement pour la Défense Canada (RDDC) Valcartier cherche à fournir aux commandants une vue d'ensemble de support opérationnel plus complète afin de faciliter des prises de décision tenant compte de problèmes de soutien importants qui pourrait influer le succès d'une mission. Ce projet a fourni un Concept des Opérations (CONOPS) initial pour une Image Reconnue de Support des Opérations (Recognised Operational Support Picture, ou ROSP) qui peut être développée dans de futurs itérations par RDDC Valcartier et autres parties prenantes du ROSP.

Méthodologie: Afin d'atteindre ces objectifs, ce projet a entrepris les activités majeures suivantes :

- La description et analyse de diverses méthodologies pour le développement de CONOPS;
- L'identification des prérequis essentiels pour une image de support des opérations dans le but de soutenir la prise de décision; et
- Le développement d'un CONOPS pour une capacité d'image de support des opérations.

Résultats: Un total de 28 documents furent identifiés comme contenant de l'information pertinente concernant les approches de développement d'un CONOPS ainsi que de l'information à propos du ROSP. De ceux-ci, 12 documents furent jugés hautement pertinents pour le développement du CONOPS et 9 furent jugés hautement pertinents au ROSP. Tous ces documents furent analysés afin de sélectionner une unique méthode de développement de CONOPS appropriée à une utilisation dans un environnement de R&D, ainsi que pour identifier les prérequis du ROSP.

Le standard de l'Institute of Electrical and Electronics Engineers (IEEE) pour le CONOPS fut sélectionné comme cadre conceptuel pour le développement du CONOPS dans ce projet. Les composantes principales du standard de l'IEEE sont : la portée, les documents de références, la situation ou le système actuel, la justification pour des changements ainsi que la nature de ces changements, les concepts du système proposé, les scénarios opérationnels, le sommaire des impacts, l'analyses du système proposé, les notes, appendices, et glossaire.

Les prérequis du ROSP furent élaborés à partir des documents fournis par l'Autorité Scientifique responsable de ce contrat, et à partir d'un atelier de travail tenu au centre de Commandement du Soutien Opérationnel du Canada (COMSOCAN) avec des experts, le 13 Juin 2011. Ces prérequis sont organisés en cinq groupes : l'interopérabilité, la représentation du ROSP, les processus de gestion de l'information et des connaissances pour la conscience de la situation (situation awareness), les processus du ROSP, et les produits du ROSP.

Ces prérequis de haut niveau pour le ROSP furent utilisés afin de guider les auteurs/es dans le développement du CONOPS initial pour le ROSP. Le CONOPS initial présente une description intégrale du système à un niveau de détail suffisamment élevé afin de couvrir tous les prérequis de façon satisfaisante. Quelques figures sont incluses afin d'illustrer les concepts à l'étude.

Conclusions et Recommandations: Un concept des opérations (CONOPS) ne rend habituellement pas explicite le lien entre les prérequis dérivés de la description du système actuel d'une part, et la déclaration des besoins pour un futur système, ou la déclaration du domaine des enjeux d'autre part. Les prérequis peuvent être considérés comme des énoncés formels à propos de déficiences opérationnelles dans un système existant, identifiées à tous les niveaux des forces : tactique, opérationnel, et stratégique. Au cours des diverses itérations de son développement et ses raffinements, un CONOPS adéquat pour le ROSP doit toujours viser à éliminer ou mitiger ces déficiences en améliorant l'exercice de support opérationnel que ce CONOPS guide. Des prérequis et déficiences émergeants du soutien opérationnel sont continuellement identifiés à travers l'addition de nouvelles leçons apprises dans divers dépositaires d'information de soutien opérationnel tels que le COMSOCAN et les bases de données sur les leçons apprises du Groupe de Soutien Interarmées des Forces Canadiennes (GSIFC). Ainsi, ces nouveaux prérequis sont essentiels pour l'amélioration et le raffinement du CONOPS pour le ROSP. Afin de s'assurer que les prérequis de soutien opérationnel soient des composantes essentielles dans de futurs effort de développement du CONOPS pour le ROSP, RDDC Valcartier et le COMSOCAN devraient chercher à étudier les méthodes qui assureraient que les prérequis émergeants du support opérationnel soient efficacement capturés par les membres de l'équipe de développement du CONOPS en un temps opportun.

Le CONOPS pour une Image Reconnue de Support des Opérations (ROSP) est un cadre conceptuel au sein duquel l'information de soutien opérationnel est destinée à être intégrée, afin d'être utilisée de façon cohérente et claire. Une approche efficace visant à la continuation du développement et du raffinement du CONOPS issu de ce projet est nécessaire pour dépasser les capacités du système en place. Une méthode graphique de développement du CONOPS suggère des améliorations, puisque l'utilisateur peut rapidement obtenir une vision d'ensemble du CONOPS, où le graphe pourrait être intégré avec des représentations descriptives typiques et autres documentation écrite, afin de laisser place à des approches plus opportunes (i.e., non-linéaires) dans le développement d'un CONOPS. Il n'existe présentement aucun outil graphique pour aider au développement d'un CONOPS. Conséquemment, RDDC Valcartier devrait continuer à travailler de concert avec le COMSOCAN afin de développer une approche intégrative en groupe pour l'élaboration de concepts de développement de CONOPS à partir des informations produites par ce projet, ainsi qu'explorer comment une méthode graphique de développement pourrait être intégrée au sein du standard de l'IEEE afin de satisfaire les prérequis d'un environnement de recherche et développement.This page intentionally left blank.

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ABSTRACT

Defence Research and Development Canada (DRDC) Valcartier is seeking to provide commanders with a more comprehensive operational support picture to enable decision-making that takes account of significant support problems that could impact on the successful conduct of the mission. This project provided an initial Recognised Operational Support Picture (ROSP) Concept of Operations (CONOPS) that can be improved upon in the future by DRDC Valcartier and ROSP stakeholders. To achieve this aim, this project delivered a literature review of 28 academic papers and documentation provided by the Scientific Authority on CONOPS development methods, ROSP requirements, and supporting information. Of these, 12 documents were found to be highly relevant to CONOPS development and these were reviewed further. After discussion with DRDC Valcartier and Canadian Operational Support Command (CANOSCOM) stakeholders, a single CONOPS development method was selected, based on the Institute of Electrical and Electronics Engineers (IEEE) standard. Nine documents were then reviewed that had relevant ROSP requirements and supporting information. These requirements and information were collected and organized into a high-level framework that was then used to guide the development of a first-draft of a ROSP CONOPS

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Le CONOPS pour une Image Reconnue de Support des Opérations (ROSP) est un cadre conceptuel au sein duquel l'information de soutien opérationnel est destinée à être intégrée, afin d'être utilisée de façon cohérente et claire. Une approche efficace visant à la continuation du développement et du raffinement du CONOPS issu de ce projet est nécessaire pour dépasser les capacités du système en place. Une méthode graphique de développement du CONOPS suggère des améliorations, puisque l'utilisateur peut rapidement obtenir une vision d'ensemble du CONOPS, où le graphe pourrait être intégré avec des représentations descriptives typiques et autres documentation écrite, afin de laisser place à des approches plus opportunes (i.e., non-linéaires) dans le développement d'un CONOPS. Il n'existe présentement aucun outil graphique pour aider au développement d'un CONOPS. Conséquemment, RDDC Valcartier devrait continuer à travailler de concert avec le COMSOCAN afin de développer une approche intégrative en groupe pour l'élaboration de concepts de développement de CONOPS à partir des informations produites par ce projet, ainsi qu'explorer comment une méthode graphique de développement pourrait être intégrée au sein du standard de l'IEEE afin de satisfaire les prérequis d'un environnement de recherche et développement.

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1 INTRODUCTION

The increasingly integrated, networked-based, and effects-driven future operating environment will require sustainment systems that are highly agile, adaptive and flexible, and can contribute to multi-dimensional operations within a comprehensive approach framework. In such a context, the access to timely, accurate and integrated information about assets as well as comprehensive visibility of these assets for Canadian Forces (CF) personnel and Department of National Defence (DND) employees would be considered invaluable. Such information can be obtained from different CF/DND Enterprise Resource Planning (ERP) applications and sensors, as well as Allied and other external information sources respectively.

The Strategic Capability Roadmap 2008 (Chief of Defence Staff, 2008) has identified the inability to obtain asset visibility information from a single point of access as one of the CF deficiencies (a “gap”). The CF/DND currently uses over a dozen non-integrated IT systems, which the operator must access separately to obtain all the desired Asset Visibility (AV) information in order to perform various functions of asset management including logistic support. This process is labour-intensive and inefficient because information must be manually entered, re-entered, and transcribed. Failing to address the integration gap will compel commanders to make operational decisions without updated critical logistics information, which can have a negative impact on mission success.

A solution to this problem is an Operational Support Picture (OSP) capability envisioned as an integrated information/knowledge -sharing and decision support environment. It will contribute to AV by providing commanders, staffs and operational support units with timely, accurate and integrated information about geographic locations of support installations, assets, unit and formation readiness status/trends (current and forecasted), courses of actions, transportation schedules, equipment maintenance status, and critical item supply status as well as transaction status. Providing commanders with a more comprehensive operational picture will enable decision-making while cognizant of significant support problems that could impact on the successful conduct of the mission. It will also respond to a key major shortfall frequently reported by deployed support personnel that they lack timely, and accurate process transaction data to do their job properly. As an operational support Situation Awareness (SA) enabler, the OSP is aimed at providing the right supply/resource/support service from the right provider to the right location at the right time.

Defence Research and Development Canada (DRDC) Valcartier has begun a project to demonstrate concepts supporting operational support domain awareness and to assist commanders and staffs in decision-making. A net-enabled demonstration environment will be built leveraging on existing and new net-centric/service-oriented architecture concepts to provide information integration, knowledge management and decision support tools drawing information from all relevant sources of information.

This effort focuses on the value of an Operational Support Picture capability, an integrated information sharing and decision support environment across the CF operational support community, to enable more effective and efficient support service delivery. It will demonstrate how a user-defined operational support picture can contribute to improve operational support domain awareness.

To support this effort this project provides a baseline for a Recognised Operational Support Picture (ROSP) Concept of Operations (CONOPS) that can be improved upon in the future by DRDC Valcartier and other ROSP stakeholders. To achieve this aim, this project conducted the following major activities:

- Characterization and Review of Methodologies for CONOPS development;
- Identification of Key Operational Support Picture Requirements to Support Decision Making; and
- CONOPS development elements for an Operational Support picture capability.

2 CHARACTERIZATION AND REVIEW OF METHODOLOGIES FOR CONOPS DEVELOPMENT

2.1 Literature review

A search for relevant literature was conducted using Google Scholar. This search supplemented documents that were provided by the SA. The aim of the literature review was two-fold. First, the literature review sought to identify and review documents which contained information on the CONOPS development process. This aided the team in identifying effective methods that would be suitable in a Research & Development (R&D) environment. Secondly, the literature review sought to identify and review those documents which contained information on the characteristics of a comprehensive ROSP and the key requirements for an effective ROSP.

2.2 Identification of CONOPS Development Documents

All documents gathered were reviewed for the quantity and quality of information they provided about CONOPS development methods. The review was restricted to only those documents which described the method for creating a CONOPS. This included those documents that described CONOPS content. In order to provide a structure to the information, it was documented in a descriptive form (Table 1) for each paper. This descriptive form captured qualitative data such as the domain in which the method was applied, background on CONOPS developers, and the pros and cons of the method. The completed descriptive forms for these documents are found in Section 2.3.3 below. Section 2.3.4 contains shortened descriptive forms for those documents that were not reviewed in depth as they had limited CONOPS development content that was not deemed relevant to this project. Specific information about each CONOPS development method was then entered into the Global Synthesis Grid (Table 2) and quantitatively scored on a number of aspects relevant to CONOPS development. The completed Global Synthesis Grid and descriptive forms for CONOPS development documents is provided in Section 2.3.5 of this report.

Table 1 - CONOPS Method Descriptive Form

Reference:	
Targeted Domain(s) for Resulting CONOPS:	**Background of CONOPS Developers:**
Main Development Steps:	
Pros:	**Cons:**
Synthesis Grid:	
1. Maturity of method:	
2. Reliance on Existing Structure, Organizations, etc.	Low ☐ Medium ☐ High ☐
3. Includes techniques for 'blue sky' thinking	Low ☐ Medium ☐ High ☐
4. Duration of Development Process:	Yes ☐ No ☐
5. Linearity of development process:	Short ☐ Medium ☐ Long ☐
6. Top down or bottom up approach?	Linear ☐ Parallel ☐ Network ☐
7. Based on operational scenario?	Top-down ☐ Bottom-up ☐
8. Includes specific consideration of:	Yes ☐ No ☐
	Stakeholders ☐
	System use ☐
	Key personnel ☐
	Personnel responsibilities ☐
	Facilities ☐
	Training ☐
	Support ☒
	Logistics ☒
9. Does not list specifics, focuses on requirement	Maintenance ☒
10. Number of developers required	Yes ☒ No ☐
11. Development team has authority to make decisions:	Low ☒ Medium ☐ High ☐
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☒ No ☐
14. Requires interviews with expected users:	Yes ☐ No ☒
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☒ No ☐
18. Provides model of expected system use	Yes ☒ No ☐
19. Includes measures of effectiveness	Yes ☒ No ☐
	Yes ☒ No ☐

Table 2 - CONOPS Method Global Synthesis Grid

	Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7	Method 8	Method 9
Maturity of method:									
Reliance on Existing Structure, Organizations, etc									
Includes techniques for 'blue sky' thinking									
Duration of Development Process:									
Linearity of development process:									
Top down or bottom up approach?									
Based on operational scenario?									
System use									
Key personnel									
Personnel responsibilities									
Facilities									
Training									
Support									
Logistics									
Maintenance									
Does not list specifics, focuses on requirement									
Number of developers required									
Development team has authority to make decisions									
Development team co-located									
Development team has prescripted skills									
Requires interviews with expected users									
Plain language output									
Includes consideration of previous analogous systems									
Includes graphical depiction of system boundaries									
Provides model of expected system use									
Includes measures of effectiveness									

This grid was then used to compile a total score for each of the different CONOPS development methods. This allowed each method's total score to be compared which aided in identifying which methods were assessed to be most helpful in developing a ROSP CONOPS.

A total of 28 documents were identified and collected which had relevant information on CONOPS development approaches and ROSP requirements and content information.

2.3 CONOPS Development Documents

A total of 18 documents were initially identified as having information relevant to CONOPS development methods.

After a more in-depth examination of these documents, 12 were identified as being highly relevant to CONOPS development and worthy of more detailed review.

The completed descriptive forms for these documents are found in Section 2.2.3 below.

2.4 CONOPS Development Documents Reviewed

<table>
<tr><td colspan="2">Reference:
Investigation of a Graphical CONOPS Development Environment for Agile Systems Engineering Final Technical Report SERC-2009-TR-003. October. Cloutier, R. & Mostashari, A. (2009).</td></tr>
<tr><td>Targeted Domain(s) for Resulting CONOPS:
Systems Engineering</td><td>Background of CONOPS Developers:
Academic</td></tr>
<tr><td colspan="2">Main Development Steps:
Proposes the following three-stage process for agile CONOPS development:
Three stages of development:
1. Conceptual Stage
2. Specification Stage
3. Design and Implementation Stage
Each of these stages has defined steps. Completion of the steps is non-linear.</td></tr>
<tr><td>Pros:
Engages stakeholders at front end of development.
Encourages both top-down and bottom-up development.
Provides tools and methods for use during development.</td><td>Cons:
Encourages both top-down and bottom-up development.</td></tr>
</table>

Synthesis Grid:	
1. Maturity of method:	Low ☐ Medium ☐ High ☒
2. Reliance on Existing Structure, Organizations, etc.	Low ☐ Medium ☒ High ☐
3. Includes techniques for 'blue sky' thinking	Yes ☒ No ☐
4. Duration of Development Process:	Short ☐ Medium ☒ Long ☐
5. Linearity of development process:	Linear ☐ Parallel ☐ Network ☒
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☒
7. Based on operational scenario?	Yes ☒ No ☐
8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☒ No ☐
10. Number of developers required	Low ☐ Medium ☐ High ☐
11. Development team has authority to make decisions:	Yes ☒ No ☐
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☒ No ☐
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☒ No ☐
18. Provides model of expected system use	Yes ☒ No ☐
19. Includes measures of effectiveness	Yes ☐ No ☒

Reference: Guidelines for Developing a Product Line Concept of Operations. Cohen, S. (1999).	
Targeted Domain(s) for Resulting CONOPS: Software development	**Background of CONOPS Developers:** Manufacturing
Main Development Steps: The chapters of this report represent a template for the chapters of an actual CONOPS. For preparing a CONOPS, this report presents chapter-by-chapter guidelines and practical examples of their application. **1 Overview** **2 Approach** Product line concepts and guidelines for describing the product line Guidelines for describing the approach for fielding products in the product line **3 Product line background** Outline for presenting information on existing systems or other motivation for the product line **4 Organizational considerations** Guidelines for establishing the product line approach and management structure **5 Technical considerations** Guidelines for establishing process steps, methods, and assets including architecture **6 Recommendations** Guidelines for setting up initial organizations and assigning responsibilities	
Pros: Provides good outline of the CONOPS document	**Cons:** Does not provide good information on the CONOPS development process.
Synthesis Grid: 1. Maturity of method:	Low ☒ Medium ☐ High ☐
2. Reliance on Existing Structure, Organizations, etc.	Low ☐ Medium ☐ High ☒
3. Includes techniques for 'blue sky' thinking	Yes ☐ No ☒
4. Duration of Development Process:	Short ☐ Medium ☒ Long ☐
5. Linearity of development process:	Linear ☒ Parallel ☐ Network ☐
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☐
7. Based on operational scenario?	Yes ☐ No ☒

8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☒ No ☐
10. Number of developers required	Low ☐ Medium ☒ High ☐
11. Development team has authority to make decisions:	Yes ☒ No ☐
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☐ No ☒
14. Requires interviews with expected users:	Yes ☐ No ☒
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☐ No ☒
18. Provides model of expected system use	Yes ☐ No ☒
19. Includes measures of effectiveness	Yes ☐ No ☒

<table>
<tr><td colspan="2">Reference:
The Concept of Operations: The Bridge from Operational Requirements to Technical Specifications History of the ConOps Approach. IEEE, 40-47. Fairley, R., et al. (1994).</td></tr>
<tr><td>Targeted Domain(s) for Resulting CONOPS:
Software-intensive system</td><td>Background of CONOPS Developers:
System Engineering</td></tr>
<tr><td colspan="2">Main Development Steps:
(1) Determine the objectives, roles, and team members for the ConOps process. This will on an outline for the ConOps document. This is important so that everyone knows the agreed-upon format and content areas of the document.
(2) Tailor the document format and obtain agreement of the current system. Also determine and document the overall objectives for the new or modified system. If there is no current system, describe the situation that motivates development of a new system.
(3) Describe the overall objectives and shortcomings normally be determined by the situation that motivates development of the ConOps document.
(4) If there is an existing system, describe the scope and boundaries of that system, and identify any external systems and the interfaces to them. Also establish and describe in general terms the scope and boundaries for the new or modified system, and identify the major external systems and interfaces to it.
(5) Describe the features of the current system or situation. This includes the system's operational characteristics, operational environment and processes, modes of operation, user classes, and the operational support and maintenance environments.
(6) Describe operational policies and constraints that apply to the current system or situation and any changes to those policies and constraints for the new system.
(7) State the operational policies and constraints that will apply to the new or modified system.
(8) Determine the operational characteristics of the proposed system, i.e., describe the characteristics the proposed system must possess to meet the users' needs and expectations.
(9) Document operational scenarios for the new or modified system. Scenarios are specified by recording, in a step-by-step manner, the sequences of actions and interactions between a user and the system. The following approach can be used to develop and document operational scenarios:
(a) Develop a set of scenarios that, to the extent possible, covers all modes of operation, all classes of users, and all specific operations and processes of the proposed system.
(b) Walk through each scenario with the appropriate users and record information concerning normal operating states and unusual conditions that are relevant to</td></tr>
</table>

<table>
<tr><td colspan="2">
the operation of the proposed system.
(c) During the walkthroughs, establish new scenarios to cover abnormal operations such as exception handling, stress load handling, and handling of incomplete and incorrect data.
(d) Establish new scenarios whenever a branch in the thread of operation is encountered. Typically, walking through the "normal" scenarios will uncover additional scenarios. Different users may also have different views of some scenarios. If these variations are significant, include them as separate scenarios.
(e) Repeatedly develop scenarios until all operations, and all significant variations of those operations, are covered.
(f) For each operational scenario, develop an associated test scenario to be used in validating the operational aspects of the delivered system. Establish traceability between operational scenarios and test scenarios.
(10) After the scenarios have been developed, validate the description of the proposed system and the operational scenarios by walking through all of the scenarios with representatives from all user groups and all classes of user for all modes of operation.
(11) Obtain consensus on priorities among the operational scenarios and features of the proposed system. Group scenarios and features into essential, desirable, and optional categories; prioritize scenarios and features within the desirable and optional categories. Also describe scenarios and features considered but not included in the proposed system.
(12) Analyze and describe the operational and organizational impacts the proposed system will have on users, buyer(s), developers, and the support/maintenance agencies. Significant impacts on these groups during development of the system.
(13) Describe the benefits, limitations, advantages, Also include and disadvantages of the proposed system, compared to the present system or situation.
</td></tr>
<tr><td>Pros:
Well outlined and detailed CONOPS development process</td><td>Cons:</td></tr>
<tr><td>Synthesis Grid:
1. Maturity of method:</td><td>Low ☐ Medium ☐ High ☒</td></tr>
<tr><td>2. Reliance on Existing Structure, Organizations, etc.</td><td>Low ☒ Medium ☐ High ☐</td></tr>
<tr><td>3. Includes techniques for ‘blue sky’ thinking</td><td>Yes ☒ No ☐</td></tr>
<tr><td>4. Duration of Development Process:</td><td>Short ☐ Medium ☒ Long ☐</td></tr>
<tr><td>5. Linearity of development process:</td><td>Linear ☐ Parallel ☐ Network ☒</td></tr>
<tr><td>6. Top down or bottom up approach</td><td>Top-down ☒ Bottom-up ☒</td></tr>
</table>

7. Based on operational scenario?	Yes ☒ No ☐
8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☒ No ☐
10. Number of developers required	Low ☐ Medium ☐ High ☒
11. Development team has authority to make decisions:	Yes ☒ No ☐
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☒ No ☐
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☐ No ☒
18. Provides model of expected system use	Yes ☐ No ☒
19. Includes measures of effectiveness	Yes ☐ No ☒

Reference:

Software Engineering Standards Committee of the IEEE Computer Society (2007). IEEE Guide for Information Technology — System Definition — Concept of Operations (ConOps) Document.

Targeted Domain(s) for Resulting CONOPS:	**Background of CONOPS Developers:**
Software development	Systems Engineering

Main Development Steps:

This guide does not specify the exact techniques to be used in developing the CONOPS document, but it does provide approaches that might be used. Each organization that uses this guide should develop a set of practices and procedures to provide detailed guidance for preparing and updating ConOps documents. These detailed practices and procedures should take into account the environmental, organizational, and political factors that influence application of the guide.

1. Scope
    - 1.1 Identification
    - 1.2 Document overview
    - 1.3 System overview
2. Referenced documents
3. Current system or situation
    - 3.1 Background, objectives, and scope
    - 3.2 Operational policies and constraints
    - 3.3 Description of the current system or situation
    - 3.4 Modes of operation for the current system or situation
    - 3.5 User classes and other involved personnel
    - 3.6 Support environment
4. Justification for and nature of changes
    - 4.1 Justification of changes
    - 4.2 Description of desired changes
    - 4.3 Priorities among changes
    - 4.4 Changes considered but not included
5. Concepts for the proposed system
    - 5.1 Background, objectives, and scope
    - 5.2 Operational policies and constraints
    - 5.3 Description of the proposed system
    - 5.4 Modes of operation
    - 5.5 User classes and other involved personnel

5.6 Support environment 6. Operational scenarios 7. Summary of impacts 7.1 Operational impacts 7.2 Organizational impacts 7.3 Impacts during development 8. Analysis of the proposed system 8.1 Summary of improvements 8.2 Disadvantages and limitations 8.3 Alternatives and trade-offs considered	
Pros: From the CONOPS document outline it does infer the basic processes that can be used to develop the CONOPS	**Cons:** Does not explicitly outline processes for developing a CONOPS document.
Synthesis Grid: 1. Maturity of method:	Low ☐ Medium ☐ High ☒
2. Reliance on Existing Structure, Organizations, etc.	Low ☐ Medium ☒ High ☐
3. Includes techniques for 'blue sky' thinking	Yes ☒ No ☐
4. Duration of Development Process:	Short ☐ Medium ☒ Long ☐
5. Linearity of development process:	Linear ☐ Parallel ☐ Network ☒
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☐
7. Based on operational scenario?	Yes ☒ No ☐
8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☒ No ☐
10. Number of developers required	Low ☐ Medium ☒ High ☐

11. Development team has authority to make decisions:	Yes ☒ No ☐
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☐ No ☒
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☐ No ☒
18. Provides model of expected system use	Yes ☐ No ☒
19. Includes measures of effectiveness	Yes ☐ No ☒

Reference: ConOps: The Cryptex to Operational. Systems Engineering, 13-16. Retrieved from http://www.stsc.hill.af.mil/crosstalk/2007/10/0710Jost.html, Jost, A. C. (2007).	
Targeted Domain(s) for Resulting CONOPS: Engineering	**Background of CONOPS Developers:** Systems Engineering

Main Development Steps:
Uses IEEE standard for developing CONOPS document:
• Section 1: Scope.
• Section 2: References.
• Section 3: Definitions.
• Section 4: Elements of a ConOps document.
  ○ 4.1 Scope (Clause 1 of the ConOps document).
  ○ 4.2 Referenced documents (Clause 2 of the ConOps document).
  ○ 4.3 Current system or situation (Clause 3 of the ConOps document) .
  ○ 4.4 Justification for and nature of changes (Clause 4 of the ConOps document).
  ○ 4.5 Concepts for the proposed system (Clause 5 of the ConOps document).
  ○ 4.6 Operational scenarios (Clause 6 of the ConOps document).
  ○ 4.7 Summary of impacts (Clause 7 of the ConOps document).
  ○ 4.8 Analysis of the proposed system (Clause 8 of the ConOps document).
  ○ 4.9 Notes (Clause 9 on the ConOps document).
  ○ 4.10 Appendices (Appendices of the ConOps document).
  ○ 4.11 Glossary (Glossary of the ConOps document) [1].	

Pros: Follows IEEE Standards Good outline of document content	**Cons:** Not a lot of detail on CONOPS development processes or approaches.
Synthesis Grid: 1. Maturity of method:	Low ☐ Medium ☒ High ☐
2. Reliance on Existing Structure, Organizations, etc.	Low ☒ Medium ☐ High ☐
3. Includes techniques for 'blue sky' thinking	Yes ☒ No ☐
4. Duration of Development Process:	Short ☐ Medium ☒ Long ☐
5. Linearity of development process:	Linear ☐ Parallel ☐ Network ☒
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☒

7. Based on operational scenario?	Yes ☒ No ☐
8. Includes specific consideration of:	Stakeholders ☐ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☒ No ☐
10. Number of developers required	Low ☐ Medium ☒ High ☐
11. Development team has authority to make decisions:	Yes ☒ No ☐
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☐ No ☒
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☐ No ☒
18. Provides model of expected system use	Yes ☐ No ☒
19. Includes measures of effectiveness	Yes ☐ No ☒

Reference: Assisting ConOps with Storyboards Concept of Operations Storyboard Tool. Thronesbery, C. et al. (2009)	
Targeted Domain(s) for Resulting CONOPS: Software Engineering	**Background of CONOPS Developers:** Software Engineering
Main Development Steps: 1. Use storyboards to develop CONOPS framework 2. Elicit system requirements from end users 3. Elicit user-task information through direct user interaction 4. Iterate the process of completing steps 1-3 in order to build the CONOPS	
Pros: This report is very good at describing the overall CONOPS development process. Method explained is software engineering centric but very adaptable across other domains. Does recognize the importance of requirements and user involvement to build the CONOPS.	**Cons:** The method explained is macro in nature with minimal clarifying details
Synthesis Grid: 1. Maturity of method:	Low ☐ Medium ☒ High ☐
2. Reliance on Existing Structure, Organizations, etc.	Low ☒ Medium ☐ High ☐
3. Includes techniques for 'blue sky' thinking	Yes ☒ No ☐
4. Duration of Development Process:	Short ☐ Medium ☒ Long ☐
5. Linearity of development process:	Linear ☐ Parallel ☐ Network ☒
6. Top down or bottom up approach	Top-down ☐ Bottom-up ☒
7. Based on operational scenario?	Yes ☐ No ☒
8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☒

	Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☐ No ☒
10. Number of developers required	Low ☐ Medium ☒ High ☐
11. Development team has authority to make decisions:	Yes ☐ No ☒
12. Development team co-located:	Yes ☒ No ☒
13. Development team has prescripted skills	Yes ☒ No ☐
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☐ No ☒
18. Provides model of expected system use	Yes ☐ No ☒
19. Includes measures of effectiveness	Yes ☐ No ☒

<table>
<tr><td colspan="2">Reference:
Development and Use of Conceptual Documents. United States Air Force Space Command. (1996).</td></tr>
<tr><td>Targeted Domain(s) for Resulting CONOPS:
Military – US Air Force Space Command</td><td>Background of CONOPS Developers:
Military</td></tr>
<tr><td colspan="2">Main Development Steps:
CONOPS Development Process:
Six phases in the process of developing a conceptual document:
1. Initiation Phase:
a. tasking for the conceptual document is originated
b. Concepts requested on a specific aspect of an operational system, subsystem, or support system (e.g. training, communications, logistics) will be developed by the functional agency most knowledgeable in that area
2. Drafting Phase
a. Conduct extensive research to determine the scope of the conceptual document and its objectives
b. Working groups should be formed to develop a strawman concept
i. Group members are identified to focus on their area of expertise when contributing to the development of a CONOPS
c. Once a workable draft is completed, it is reviewed and modified. This process may go through a few iterations before a good working draft is sent out for initial coordination.
d. Key CONOPS Elements:
i. Capacity: Address how the system will optimize assigned resources, support mission growth, and meet surge requirements
ii. Command and Control: Address how the system will integrate into the existing command and control structure. Identify clear lines of communications to meet the proper command and control requirement.
iii. Operability/Flexibility: Address how the system will transition from peacetime operations through all levels of conflict to include, when necessary, post-war operations. Address to what extent the system will be self-contained
iv. Survivability/Endurability. Address the level of conflict the system will survive/endure to assure mission accomplishment
v. Standardization/Interoperability. Address how the system will be standardized and interoperate with existing infrastructure. Identify procedural and technical interface standards to be incorporated into the system or operational design to ensure the required degree of</td></tr>
</table>

<table>
<tr><td colspan="2">
interoperability between the system or operation. A system should be designed to conduct normalized operations and maintenance consistent with the mission and responsibilities delegated to it. Areas to address may include how standard commercial-off-the-shelf (COTS) hardware/software may be utilized for mission execution and for enhancing commonality of replacement parts with other like units. Address considerations for government-off-the-shelf and non-developmental item (NDI) hardware and software. This commonality of hardware/software will enable systems with compatible and/or similar missions to share the same resources.
vi. Reliability/Maintainability. Address any reliability/maintainability issues which may include single point failures, common maintenance support, and operation and maintenance (O&M) or life-cycle costs
vii. Manpower/Basing/Strategy/Force Structure. Address basing and manning constraints and identify expected force structure. Areas to consider may include automation to minimize manning requirements and collocation with other units to take advantage of economies of scale. Facility considerations must also be addressed.
3. Coordination Phase
a. The document should receive the widest coordination and dissemination possible, but be coordinated only with those offices having possible inputs or being impacted by the document
4. Approval Phase
a. At this point, all comments should have been resolved and incorporated into the document for final approval and signature.
5. Distribution Phase
a. The signed document is ready for reproduction and distribution to all applicable agencies
6. Review Phase
a. Reviews are normally conducted biennially or at the beginning of each new milestone, as applicable
</td></tr>
<tr><td>Pros:
The approach proposed is very detailed and follows methodology and rhythm that is comprehensive.</td><td>Cons:
Because of the military guidance orientation of this document it can be viewed as being too stringent in its approach to be applicable in an R&D environment.
More focused on administrative process than CONOPS development</td></tr>
<tr><td>Synthesis Grid:
1. Maturity of method:</td><td>Low ☐ Medium ☒ High ☐</td></tr>
<tr><td>2. Reliance on Existing Structure, Organizations, etc.</td><td>Low ☐ Medium ☐ High ☒</td></tr>
</table>

3. Includes techniques for 'blue sky' thinking	Yes ☐ No ☒
4. Duration of Development Process:	Short ☐ Medium ☒ Long ☐
5. Linearity of development process:	Linear ☐ Parallel ☐ Network ☒
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☐
7. Based on operational scenario?	Yes ☒ No ☐
8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☒ No ☐
10. Number of developers required	Low ☐ Medium ☐ High ☐
11. Development team has authority to make decisions:	Yes ☒ No ☐
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☒ No ☐
14. Requires interviews with expected users:	Yes ☐ No ☒
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☐ No ☒
17. Includes graphical depiction of system boundaries	Yes ☐ No ☒
18. Provides model of expected system use	Yes ☐ No ☒
19. Includes measures of effectiveness	Yes ☐ No ☒

<table>
<tr><td colspan="2">Reference:
Development of a Concept of Operations. Flash Flood Early warning System Reference Guide (Chapter 9). Flash Flood Early Warning System Reference Guide (2007).</td></tr>
<tr><td>Targeted Domain(s) for Resulting CONOPS:
Engineering</td><td>Background of CONOPS Developers:
Public Utility</td></tr>
<tr><td colspan="2">Main Development Steps:
ConOps development is the first step in the System Engineering Life Cycle process

“A Concept of Operations (ConOps) describes the likely operation of a future or existing system in the terminology of its users, providing important information for the acquisition and/or development of that system.
It may include identification and discussion of the following:
1. Why the system is needed and an overview of the system itself;
2. The full system life cycle from deployment through disposal;
3. Different aspects of system use including operations, maintenance, support and disposal;
4. The different classes of user, including operators, maintainers, supporters, and their different skills and limitations;
5. The environments in which the system is used and supported;
6. The boundaries of the system and its interfaces and relationships with other systems and its environments;
7. When the system will be used, and under what circumstances;
8. How and how well the needed capability is currently being met (typically by existing systems):
9. How the system will be used, including operations, maintenance and support; and
10. Scenarios illustrating specific operational activities involving the use of the system.”

A CONOPS addresses the following issues:

• Scope
• Knowledge References
• Operational Description
• System Overview
• Operational and Support Environment
• Operational Scenarios</td></tr>
<tr><td>Pros:
Places the CONOPS in the system</td><td>Cons:</td></tr>
</table>

engineering process Lists common mistakes to avoid when developing a CONOPS Provides requirements checklist for CONOPS	Is not based on CONOPS standard Provides little detail on process/method
Synthesis Grid: 1. Maturity of method:	Low ☒ Medium ☐ High ☐
2. Reliance on Existing Structure, Organizations, etc.	Low ☐ Medium ☐ High ☒
3. Includes techniques for 'blue sky' thinking	Yes ☐ No ☒
4. Duration of Development Process:	Short ☐ Medium ☒ Long ☐
5. Linearity of development process:	Linear ☒ Parallel ☐ Network ☐
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☒
7. Based on operational scenario?	Yes ☒ No ☐
8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☐ No ☒
10. Number of developers required	Low ☐ Medium ☐ High ☒
11. Development team has authority to make decisions:	Yes ☐ No ☒
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☒ No ☐
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐

16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☐ No ☒
18. Provides model of expected system use	Yes ☐ No ☒
19. Includes measures of effectiveness	Yes ☐ No ☒

Reference:

Developing and Using the Concept of Operations in Transportation Management Systems Final Report. Security (p. 186) Smith, B. (2005).

Targeted Domain(s) for Resulting CONOPS: Transportation Management	**Background of CONOPS Developers:** Transportation

Main Development Steps:

Organizes the steps to develop a CONOPS in three stages:

- Concept Incubation Stage: Where do I begin?
  - Concept – flush out the concept for the system Writing Team – gather the members of the core writing team
  - Organizational support – assure that the owning agency is behind the effort
  - Stakeholders – consider who should be involved in the system and their level of the involvement
  - Resources – consider the human resources necessary to put together the CONOPS
- Document Development Stage
  a. Scope — outline the contents of the document, set the scope of the system, describe the purpose of the system, highlight the goals and objectives for the system, identify the intended audience of the system, and convey a vision for the system .
  b. Reference Documents — identify supporting references
  c. User-Oriented Operational Description — explain the operations of all the various aspects of the system Operational Needs — tie system function to organizational needs
  d. System Overview — summarize the system, preferably through a diagram
  e. Operational and Support Environments — describe the world in which the system operates
  f. Operational Scenarios — develop operational scenarios using a wide variety of user classes and system functionality
- System Engineering Lifecycle Stage
  a. CONOPS to Requirements (the 2nd step) – use to determine precisely what the system need be able to do
  b. CONOPS to System Validation (the last step) – use to validate the system's existence and performance
  c. CONOPS through the life cycle – use to "keep your eye on the ball"

Pros: Provides extensive case study examples of content	**Cons:**

Synthesis Grid:	
1. Maturity of method:	Low ☐ Medium ☐ High ☒
2. Reliance on Existing Structure, Organizations, etc.	Low ☒ Medium ☐ High ☐
3. Includes techniques for 'blue sky' thinking	Yes ☒ No ☐
4. Duration of Development Process:	Short ☒ Medium ☐ Long ☐
5. Linearity of development process:	Linear ☐ Parallel ☐ Network ☒
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☒
7. Based on operational scenario?	Yes ☒ No ☐
8. Includes specific consideration of:	Stakeholders ☐ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☒ No ☐
10. Number of developers required	Low ☒ Medium ☐ High ☐
11. Development team has authority to make decisions:	Yes ☒ No ☐
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☐ No ☒
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☒ No ☐
18. Provides model of expected system use	Yes ☒ No ☐
19. Includes measures of effectiveness	Yes ☒ No ☐

Reference: What is a CONOPS anyway? International Council on Systems Engineering. (2002).	
Targeted Domain(s) for Resulting CONOPS: Systems Engineering	**Background of CONOPS Developers:** System Engineering
Main Development Steps: 1. Establish Goals 2. Collect Facts 3. Induce Concepts 4. Determine Needs 5. State the problem While conducting these steps, consider the following: • Intended use • Actors involved • Scenarios in which system is to be used • Operational Requirements	
Pros: Follows a lot of the steps and ideas for CONOPS development that are highlighted by other papers	**Cons:** General, high level details only
Synthesis Grid: 1. Maturity of method:	Low ☒ Medium ☐ High ☐
2. Reliance on Existing Structure, Organizations, etc.	Low ☐ Medium ☒ High ☐
3. Includes techniques for 'blue sky' thinking	Yes ☒ No ☐
4. Duration of Development Process:	Short ☐ Medium ☒ Long ☐
5. Linearity of development process:	Linear ☒ Parallel ☐ Network ☐
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☐
7. Based on operational scenario?	Yes ☒ No ☐

8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☐ Facilities ☐ Training ☐ Support ☐ Logistics ☐ Maintenance ☐
9. Does not list specifics, focuses on requirement	Yes ☒ No ☐
10. Number of developers required	Low ☐ Medium ☐ High ☒
11. Development team has authority to make decisions:	Yes ☒ No ☐
12. Development team co-located:	Yes ☒ No ☐
13. Development team has prescripted skills	Yes ☐ No ☒
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☒ No ☐
18. Provides model of expected system use	Yes ☐ No ☒
19. Includes measures of effectiveness	Yes ☐ No ☒

Reference: Data Item Description - Operational Concept Description. United States Department of Defense. (2000).	
Targeted Domain(s) for Resulting CONOPS: Military systems	**Background of CONOPS Developers:** US DoD
Main Development Steps: CONOPS document will contain the following content: 1. Scope 1.1. Identification 1.2. System Overview 1.3. Document Overview 2. Referenced Documents 3. Current System or situation 3.1. Background, objectives and scope 3.2. Operational policies and constraints 3.3. Description of the current system or situation 3.4. Users or involved personnel 3.5. Support concept 4. Justification for and nature of changes 4.1. Justification for change 4.2. Description of needed changes 4.3. Priorities among the changes 4.4. Changes considered but not included 4.5. Assumptions and constraints 5. Concept for new or modified system 5.1. Background, objectives and scope 5.2. Operational policies and constraints 5.3. Description of the new or modified system 5.4. Users/affected personnel 5.5. Support concept 6. Operational scenarios 7. Summary of impacts 7.1. Operational impacts 7.2. Organizational impacts	

7.3. Impacts during development 8. Analysis of the proposed system 8.1. Summary of advantages 8.2. Summary of disadvantages/limitations 8.3. Alternatives and trade-offs considered 9. Notes	
Pros: Describes the contents of an Operational Concept Description, which are similar in nature to other reviewed documents that had CONOPS development guidance.	**Cons:** Did not contain any specific information on the CONOPS development process.
Synthesis Grid: 1. Maturity of method:	Low ☐ Medium ☐ High ☒
2. Reliance on Existing Structure, Organizations, etc.	Low ☒ Medium ☐ High ☐
3. Includes techniques for 'blue sky' thinking	Yes ☐ No ☒
4. Duration of Development Process:	Short ☐ Medium ☐ Long ☒
5. Linearity of development process:	Linear ☐ Parallel ☐ Network ☒
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☒
7. Based on operational scenario?	Yes ☒ No ☐
8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☒ No ☐
10. Number of developers required	Low ☐ Medium ☐ High ☒
11. Development team has authority to make decisions:	Yes ☐ No ☒
12. Development team co-located:	Yes ☐ No ☒

13. Development team has prescripted skills	Yes ☐ No ☒
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☐ No ☒
18. Provides model of expected system use	Yes ☒ No ☐
19. Includes measures of effectiveness	Yes ☐ No ☒

<table>
<tr><td colspan="2">Reference:
System Concept of Operations: Standards, Practices and Reality. Roberts, N.& Edson, R. (2008).</td></tr>
<tr><td>Targeted Domain(s) for Resulting CONOPS:
Military</td><td>Background of CONOPS Developers:
Systems Engineering</td></tr>
<tr><td colspan="2">Main Development Steps:

Author recommends following ANSI/AIAA CONOPS development Standard

1. Introduction
2. References
3. Problem Statement
4. Program or System History
5. System Use
6. System Boundaries
7. System Environment
8. Constraints
9. System Models
10. System Peripherals
11. Expected Output
12. Acronyms and Definitions</td></tr>
<tr><td>Pros:
Based on a survey of CONOPS developers and theirs products

Includes process guidelines

Includes evaluation criteria</td><td>Cons:</td></tr>
<tr><td>Synthesis Grid:
1. Maturity of method:</td><td>Low ☐ Medium ☒ High ☐</td></tr>
<tr><td>2. Reliance on Existing Structure, Organizations, etc.</td><td>Low ☐ Medium ☐ High ☒</td></tr>
<tr><td>3. Includes techniques for ‘blue sky’ thinking</td><td>Yes ☐ No ☒</td></tr>
</table>

4. Duration of Development Process:	Short ☒ Medium ☐ Long ☐
5. Linearity of development process:	Linear ☒ Parallel ☐ Network ☐
6. Top down or bottom up approach	Top-down ☒ Bottom-up ☒
7. Based on operational scenario?	Yes ☒ No ☐
8. Includes specific consideration of:	Stakeholders ☒ System use ☒ Key personnel ☒ Personnel responsibilities ☒ Facilities ☒ Training ☒ Support ☒ Logistics ☒ Maintenance ☒
9. Does not list specifics, focuses on requirement	Yes ☐ No ☒
10. Number of developers required	Low ☐ Medium ☒ High ☐
11. Development team has authority to make decisions:	Yes ☐ No ☒
12. Development team co-located:	Yes ☐ No ☒
13. Development team has prescripted skills	Yes ☐ No ☒
14. Requires interviews with expected users:	Yes ☒ No ☐
15. Plain language output	Yes ☒ No ☐
16. Includes consideration of previous analogous systems:	Yes ☒ No ☐
17. Includes graphical depiction of system boundaries	Yes ☒ No ☐
18. Provides model of expected system use	Yes ☒ No ☐
19. Includes measures of effectiveness	Yes ☒ No ☐

2.5 CONOPS Development Documents Not Reviewed

The following 6 documents were reviewed but were not found relevant to CONOPS development. As such, their descriptive forms contain only cursory information and no scoring in the synthesis grids. The "Main Development Steps" section contains justification for non-review and scoring.

Reference: Joint Command Decision Support for the 21st Century (JCDS 21) Technology Demonstration (TD) Project CONOPS, Hales, D. and Scipione, A. (2008).	
Targeted Domain(s) for Resulting CONOPS: R&D	**Background of CONOPS Developers:** Capability Engineering/Human Factors
Main Development Steps: This document was not reviewed. This document describes the CONOPS for an R&D TDP. It does not describe methods of developing a CONOPS.	

Reference: Schmitt, F. (2002). A Practical Guide for Developing and Writing Military Concepts	
Targeted Domain(s) for Resulting CONOPS: Military	**Background of CONOPS Developers:** United States Marine Corps
Main Development Steps: This paper is not as helpful as we originally hoped, focusing instead on the development of military concepts, rather than the development of concepts of operation. The paper differentiates and discards CONOPS and its development as topics of discussion right at the start.	

Reference: Joint Command Decision Support for the 21st Technology Development Environment, . Paquet, R. (2009).	
Targeted Domain(s) for Resulting CONOPS: R&D	**Background of CONOPS Developers:** General Engineering
Main Development Steps: This document does not provide any novel or concrete information regarding CONOPS development process. It simply lays out the CONOPS for the JCDS21 TDP.	

Reference: Thronesbery, C. et al. (2008). Concept of Operations Storyboard Tool Refinements Based on Practical Experiences.	
Targeted Domain(s) for Resulting CONOPS: Aerospace	**Background of CONOPS Developers:** Aerospace
Main Development Steps: This PPT was not reviewed as it contained general, high level thoughts regarding CONOPS development. In addition, some of these ideas were elaborated on more fully in one of the paper that was reviewed : "Investigation of a Graphical CONOPS Development Environment for Agile Systems Engineering Final Technical Report SERC-2009-TR-003" This PPT's main focus was on describing how a graphical tool could be used for aiding the development of a CONOPS.	

Reference: Concept of Operations Storyboard Tool Refinements Based on Practical Experiences. Thronesbery, C. et al. (2008).	
Targeted Domain(s) for Resulting CONOPS: Aerospace	**Background of CONOPS Developers:** Aerospace
Main Development Steps: This paper was not reviewed as it was a more detailed discussion of the graphical CONOPS ideas given in the PPT presentation "Assisting ConOps with Storyboards Concept of Operations Storyboard Tool". As well, the information provided in this paper was elaborated on more fully in one of the paper that was reviewed : "Investigation of a Graphical CONOPS Development Environment for Agile Systems Engineering Final Technical Report SERC-2009-TR-003"	

Reference: Thompson, T. (2002). Development of Operating Concepts.	
Targeted Domain(s) for Resulting CONOPS: Aviation	**Background of CONOPS Developers:** Aviation Regulation
Main Development Steps: This paper was not reviewed as it had a narrow scope of discussion relating to developing operational concepts and deriving operational requirements, both related to system development. The paper did not discuss the CONOPS development process.	

2.6 CONOPS Development Synthesis Grid

The 12 papers found to contain information on CONOPS development process and methods, and their contained methods, are synthesized in the comparative grid in Table 3 below. Based on this comparison, the IEEE standard is identified as one of the best approach to be kept as the framework for newer versions of the ROSP. This is a proven standard for CONOPS development that is widely accepted by military, industry and academic communities. Furthermore DRDC should investigate how a graphical method of development should be integrated with the IEEE standard in order to suit the requirements of a R&D environment.

Table 3 - Comparative Synthesis Grid

	Graphical CONOPS	Product Line CONOPS	Bridge to Tech Spec	IEEE Standard	Cryptex	Storyboard Tool	Develop Conceptual Documents	Flash Flood EWS	Transport Mgmt CONOPS	What is a CONOPS	DoD DID	System CONOPS
CONOPS Standard Applied												
Maturity of method:												
Reliance on Existing Structure, Organizations, etc												
Includes techniques for 'blue sky' thinking												
Duration of Development Process:												
Linearity of development process:												
Top down or bottom up approach?												
Based on operational scenario?												
Stakeholders												
System use												
Key personnel												
Personnel responsibilities												
Facilities												
Training												
Support												
Logistics												
Maintenance												
Does not list specifics, focuses on requirement												
Number of developers required												
Development team has authority to make decisions												
Development team co-located												
Development team has prescripted skills												
Requires interviews with expected users												
Plain language output												
Includes consideration of previous analogous systems												
Includes graphical depiction of system boundaries												
Provides model of expected system use												
Includes measures of effectiveness												

2.7 CONOPS Development Findings

Overall, there was very little detail provided regarding process; authors focused more on content of a CONOPS document. Any information regarding the method of process was incidental to the description of the content. Even then, there was very little information about the 'form' of that content beyond occasional exhortations to provide graphical depictions and overviews. The most useful papers reviewed for this effort typically described the author(s) experience(s) during the development of CONOPS and provided case study examples to illustrate points and provide additional frames of reference.

Two documents provided an extensive review of a variety of CONOPS exercises. These papers (Cloutier & Mostashari, 2009; Roberts & Edson, 2008) also focused more upon the content than the process, but served to show how universal the 'standard' CONOPS approach is. One of the papers (Smith, 2005) led the reader through the content to be included in a CONOPS in great detail, and made extensive reference to CONOPS case-studies. For an inexperienced person, tasked with developing their first CONOPS, this would be an important reference document. The three papers referred to here all elaborated on standard approaches (i.e. IEEE – Cloutier & Mostashari, 2009 and Roberts & Edson, 2008; or American National Standards Institute (ANSI)/American Institute of Aeronautics and Astronautics (AIAA) – Smith, 2005), resulting in them scoring most highly when compared to other papers.

Also very useful were the efforts to develop a graphical or storyboard approach to CONOPS development (Thronesbery et al., 2009), which necessarily included some description of the method to be followed. The graphical method involves creating a functional graphic that can be used to structure more detailed graphical and text representations. In this way, the graphic structures and guides the development of the CONOPS. A storyboard approach is more limited in that it only explains how the proposed system is meant to work, rather than describing the current system, providing analyses, and providing supporting references. Graphical methods of CONOPS development show promise, since the user can quickly appreciate the overview of the CONOPS, and the graphic could be integrated with standard descriptive forms or written documentation to permit more opportunistic (i.e., non-linear) approaches to CONOPS development. However, there is currently no graphical tool that exists to support CONOPS development.

Another observation from this review is that CONOPS typically do not explicitly make the link between the requirements that have arisen from the description of the current system and the "statement of need" or "problem statement", etc. This could be a useful addition to the CONOPS development process to ensure the adequacy of a new CONOPS assist in the development of CONOPS metrics.

No CONOPS development method was targeted at an R&D environment. Although a graphical method seems preferable for a number of reasons (overview, non-linear development) there is no such tool currently. CONOPS development methods also did not address the issue of large, geographically-distributed teams. With specific reference to this project, the presence of core team members at DRDC Valcartier and CANOSCOM in Ottawa makes this a relevant concern.

2.8 Selection of CONOPS Development Method

By implication, it is apparent that CONOPS development is focused on the output, and the default method is one of iterative writing and review. This method does not, however, account for the non-linear aspects of CONOPS development (e.g., the opportunistic identification of ideas, needs, requirements, etc.). Written methods are also not efficient in providing the reader an overview of the CONOPS. Several methods make more use of graphical methods for CONOPS documents.

No CONOPS development method was specifically intended for an R&D environment. Although a graphical method seems preferable for a number of reasons (overview, non-linear development) there is no such tool currently. Instead, it is recommended that the IEEE standard be implemented in such a way to facilitate collaboration by large, geographically-distributed teams. The IEEE standard does recommend that graphics be used as much as possible to describe concepts, but it does not describe the type of tool that should be used to execute on the standard. Ideally, the IEEE standard could be followed using a graphical approach to structuring the CONOPS and describing the details contained therein.

Table 4 below contains the IEEE standard for CONOPS development. The IEEE method describes a comprehensive document that includes detail on how the current system is designed and operates, how it may not be adequate for the demands placed upon it (effectively a Statement of Operational Capability Deficit [SOCD]), how it should be designed and operate, and how successful the alternative design will be.

Table 4 - IEEE Standard for CONOPS Development

Scope Identification, Document Overview, System Overview
Referenced Documents
Current System or Situation Background, objectives and scope; Operational policies and constraints; Current system or situation; Modes of operation for current system or situation; User classes and other involved personnel; Support environment
Justification for and Nature of Changes Justification; Description; Priorities; Changes considered but not included
Concepts for Proposed System Background, objectives and scope; Operational policies and constraints; Current system or situation; Modes of operation for current system or situation; User classes and other involved personnel; Support environment
Operational Scenarios
Summary of Impacts **Operational impacts; Organizational impacts; Impacts during development**
Analysis of Proposed System Summary of improvements; Disadvantages and limitations; Alternatives and trade-offs considered
Notes **Appendices**
Glossary

3 IDENTIFICATION OF KEY RECOGNIZED OPERATIONAL SUPPORT PICTURE (ROSP) REQUIREMENTS TO SUPPORT DECISION MAKING

3.1 Methodology

3.1.1 Identification of ROSP Documents

After selecting those documents which provided information on how to develop a CONOPS, the remaining documents were reviewed to identify those which discussed the requirements for a ROSP which could help to construct the CONOPS. These documents were then reviewed and a number were found to be helpful to the aim of developing a ROSP CONOPS.

3.1.2 Formulation of CONOPS Development Approach

The team used the data gathered via the descriptive form and synthesis grid as a starting point for identifying valid and comprehensive CONOPS development methods. These methods were then presented to DRDC Valcartier and CANOSCOM stakeholders at a working group held at CANOSCOM Headquarters. This discussion validated the presented method which allowed the team to use it as a framework for building the ROSP CONOPS. The resulting ROSP CONOPS is provided in Section 4.2.2 below.

3.1.3 Collection of ROSP Requirements

A number of relevant documents supplied by DRDC Valcartier were reviewed and any ROSP requirements were noted. Further, if these documents proposed categorizations for the requirements, this was also noted. Additionally, a workshop with CANOSCOM was held in order to further explore their requirements for a ROSP. These requirements were also added to the complete list of requirements. The origin of the requirements (i.e. the report from which they were taken, or the workshop) was noted. Requirements were then considered as a whole and a top-level organization was developed based upon categorizations found in reviewed documents. This categorization scheme was then presented to the DRDC Valcartier CSA and the decision was made to use it as the means of organizing the numerous ROSP requirements in a coherent manner. The high-level requirements scheme is depicted in Figure 1 below.

3.2 Results

3.2.1 ROSP Requirements Documents

A total of 9 documents were received from the CSA which were felt to provide detailed information on the requirements of the ROSP. These documents were extremely detailed and provided a significant amount of information that can be drawn into a

ROSP CONOPS. This contract only represents an initial attempt to understand the requirements and organize them for use in the development of a ROSP CONOPS.

3.2.2 Resulting ROSP Requirements

A number of requirements were distilled from the various references and a CANOSCOM workshop held on June 13th, 2011 at CANOSCOM Headquarters.

3.2.2.1 High Level ROSP Requirements Categorization

A ROSP requirements categorization was consequently developed and used in this project. It is shown in Figure 1 below.

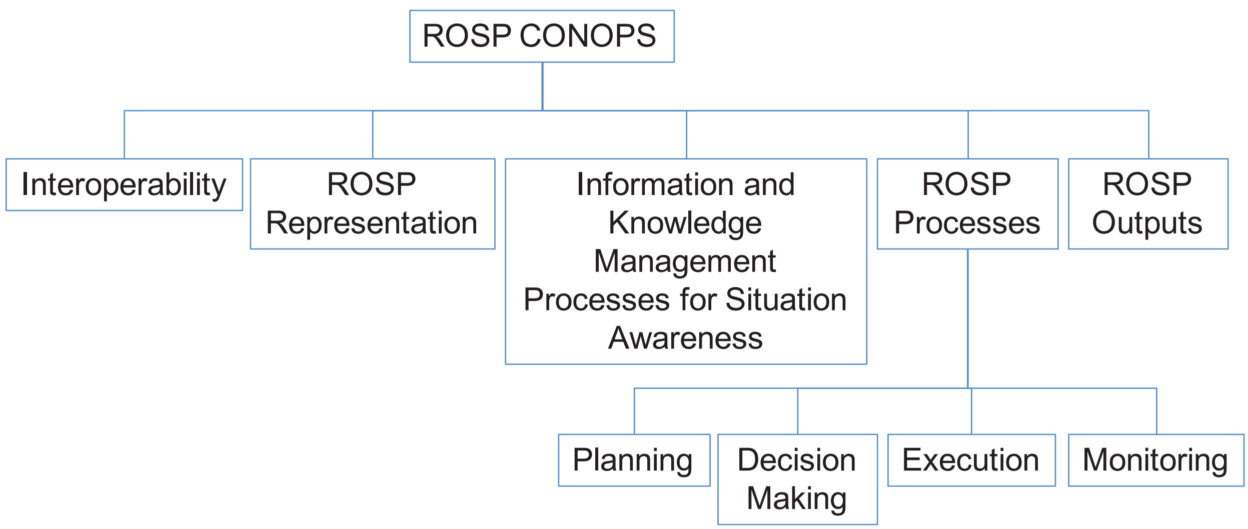

Figure 1: High Level ROSP Requirements

The categories are felt to represent sufficient coverage of the ROSP requirements from both a process and technology perspective that any single requirement will map easily to at least one category.

3.2.2.2 Low Level ROSP Requirements

Several hundred requirements were gathered from the documents reviewed for this project. A distillation of these requirements resulted in the compilation of high level general requirements that will require further definition in future ROSP CONOPS development efforts.

The high level requirements are presented in Table 5 to Table 12 below, organized by the ROSP requirements categorization shown in Figure 1 above. These requirements are being reflected in the CONOPS for the future ROSP.

Table 5 – ROSP Requirements – Interoperability

With respect to Interoperability, the ROSP…	Reference
1. Should provide asset (equipment and vehicle) location and movement reports in standard formats as decided by NATO and coalition forces. (Some STANAGs deal with the information systems and data that NATO forces are supposed to use.	Mitrovic-Minic, S. & Conrad, J. (2011)
2. Should be compatible with NATO logistics support systems, including RFID. (The current systems to be analysed before the ROSP design and implementation.)	Mitrovic-Minic, S. & Conrad, J. (2011)
3. Should provide reports and statistics in several different standard file formats. Also, minimise the use of acronym to enhance common understanding.	Mitrovic-Minic, S. & Conrad, J. (2011)
4. Should be able to import several different standard file formats for reports and statistics. The file formats to be supported should also include those used by NATO and coalition forces.	Mitrovic-Minic, S. & Conrad, J. (2011)
5. Should support export of the real-time information of the current status and location of transportation assets. The export files should in the format easily readable by the IT systems of NATO and allied forces. Also, export of schedules for the transportation assets may be considered.	Mitrovic-Minic, S. & Conrad, J. (2011)
6. Should support importing real-time information of the current status and location of transportation assets of the allied forces. The export files should in the format easily readable by the IT systems of NATO and allied forces.	Mitrovic-Minic, S. & Conrad, J. (2011)

Table 6 – ROSP Requirements – ROSP Representation

With respect to Representation, the ROSP…	Reference
1. Should provide dynamic multi-layered graphical representation of the distribution network (Visualisation).	Mitrovic-Minic, S. & Conrad, J. (2011)
2. Should allow the user to portray available data and information influencing Command designated area of interest (Representation).	Mitrovic-Minic, S. & Conrad, J. (2011)
3. Shall allow the user to geographically display the location and status information of: infrastructures (bridges, churches, etc.); facilities (Storage, servicing, emergency response teams etc.); sea ports; airports; lines of communication; Forces (Red, Blue and Neutral); significant events (Battlespace Geometry).	Hales et al. (2011)
4. Shall portray available data and information on any force influencing Command designated area of responsibility (Represent Force Disposition).	Mitrovic-Minic, S. & Conrad, J. (2011)

Table 7 – ROSP Requirements – Information and Knowledge Management Processes for Situation Awareness

With respect to Information and Knowledge Management Processes for Situation Awareness, the ROSP…	Reference
1. Shall provide current operational support picture.	Ajilon Consulting (2010)
2. Shall automatically provide the status of human resources.	Hales, Cochran, and Race (2011)
3. Shall automatically provide the status of human resources by identifying the details (current location, period of qualification validity, period of availability) on resources satisfying the requirements.	Hales et al. (2011)
4. Shall automatically provide the status of equipment.	Hales et al. (2011)
5. Shall automatically provide the status of facilities.	Hales et al. (2011)
6. Shall automatically provide the status of strategic movement assets.	Hales et al. (2011)
7. Shall automatically provide line of communication information.	Hales et al. (2011)
8. Shall provide capability to continuously monitor inventory levels for consumables.	Hales et al. (2011)
9. Shall automatically provide the status of communication and information management facilities.	Hales et al. (2011)
10. Shall input to and access to other enterprise systems such as MASIS, CFFS, HRMS and FMAS.	Hales et al. (2011)
11. Should be connected (wireless) to the sensors for monitoring of stock levels and state to allow near-real time (within minutes or hours) transfer of collected information.	Mitrovic-Minic, S. & Conrad, J. (2011)
12. Should have such a telecommunication infrastructure that information from battle group can reach NSE at APOD.	Mitrovic-Minic, S. & Conrad, J. (2011)
13. Should provide means of automatic or man-to-man transfer from battle- group to the NSE at APOD of the information about the	Mitrovic-Minic, S. & Conrad, J. (2011)

status and stock level of consumable materiel.	
14. Should provide visibility of its information, reports and statistics to CANOSCOM personnel.	Mitrovic-Minic, S. & Conrad, J. (2011)
15. Shall be able to import data or reports from the information system(s) used by CANOSCOM personnel. Statistics and current data are required.	Mitrovic-Minic, S. & Conrad, J. (2011)

Table 8 – ROSP Requirements – ROSP to Support Planning

With respect to Planning, the ROSP…	Reference
1. Shall allow taking of operational planning requirement and defining OS requirement.	Ajilon Consulting (2010)
2. Shall allow for storage of operational plans, directives, and lessons learned.	Race, P. & Appleton, A. (2011)
3. Should store dependencies between events, conditions and situations that caused increase or decrease in demand for material or for transportation in order to improve forecasting.	Mitrovic-Minic, S. & Conrad, J. (2011)
4. Shall provide tools to allow for planning of strategic movement of asset and human resources based on input movement requirement.	Mitrovic-Minic, S. & Conrad, J. (2011)
5. Shall have a tool for forecasting the regular maintenance/ repair jobs for each piece of equipment and for each asset.	Mitrovic-Minic, S. & Conrad, J. (2011)
6. Shall have a tool for forecasting the food, water, and medical supply needs.	Mitrovic-Minic, S & Conrad, J. (2011)
7. Shall have a tool for converting forecasts and historical data on transportation and repair job requests to the lists and schedules for replenishments orders.	Mitrovic-Minic, S. & Conrad, J. (2011)
8. Shall have a tool for forecasting consumable materiel needs.	Mitrovic-Minic, S. & Conrad, J. (2011)

Table 9 – ROSP Requirements – ROSP Decision Making

With respect to Decision Making, the ROSP…	Reference
1. Should provide Decision support analysis and course of action evaluation.	Mitrovic-Minic, S. & Conrad, J. (2011)
2. Should have tools/algorithms that provide real time/dynamic lists of transportation requests based on forecasts, demand, and min/max stock levels at each node of the distribution network.	Mitrovic-Minic, S. & Conrad, J. (2011)
3. Should have tools for supply chain network analysis.	Mitrovic-Minic, S. & Conrad, J. (2011)
4. Should have tools/ algorithms that support the design and re-design of the distribution network at all force levels.	Mitrovic-Minic, S. & Conrad, J. (2011)
5. Should have tools/algorithms for dynamic routing and scheduling of the heterogeneous fleet of vehicles to satisfy requests for transportation of people and materiel. Optimization and multi-criteria decision making should be included. The tools have to provide multiple solutions/ alternatives among which a decision maker will choose.	Mitrovic-Minic, S. & Conrad, J. (2011)
6. Should be tightly integrated with Operational Logistics Decision Support System, or the data/ information/ message should be exchanged between the two systems over the permanent information and telecommunication infrastructure.	Mitrovic-Minic, S. & Conrad, J. (2011)
7. Should provide calculation of statistics for the stored information related to distribution, transportation, repair, difference between forecasts and actual demands.	Mitrovic-Minic, S. & Conrad, J. (2011)

Table 10 – ROSP Requirements – ROSP Execution

With respect to Execution, the ROSP…..	Reference
8. Shall allow for coding and prioritization of requisitions.	Mitrovic-Minic, S. & Conrad, J. (2011)
9. Submit materiel request to CANOSCOM.	Mitrovic-Minic, S. & Conrad, J. (2011)
10. Shall provide services to support all activities of tactical logistics, i.e., all NSE activities.	Mitrovic-Minic, S. & Conrad, J. (2011)
11. Shall be interactive.	Mitrovic-Minic, S. & Conrad, J. (2011)
12. Should provide the capability to deal with security levels relative to users/ groups and services.	Mitrovic-Minic, S. & Conrad, J. (2011)
13. Shall allow user access from different platforms (i.e. computer, hand- held device).	Mitrovic-Minic, S. & Conrad, J. (2011)
14. Shall have a system for tracking materiel in-transit and as part of an inventory in a warehouse.	Mitrovic-Minic, S. & Conrad, J. (2011)
15. Shall allow the collection and storage of information relevant to transportation, repair requests, maintenance requests, contractors' requests.	Mitrovic-Minic, S. & Conrad, J. (2011)
16. Should provide a service to search any database of passed transportation requests, material request, or repair requests.	Mitrovic-Minic, S. & Conrad, J. (2011)
17. Should have tools for arranging and re-arranging the containers in the receiving yard at APOD.	Mitrovic-Minic, S. & Conrad, J. (2011)

Table 11 – ROSP Requirements – ROSP Monitoring

With respect to Monitoring, the ROSP…	Reference
1. Shall provide the ability to the user to identify alert parameters.	Ajilon Consulting (2010)
2. Shall automatically provide alerts when alert parameters have been met.	Ajilon Consulting (2010)
3. Shall provide the ability to generate usage trend charts.	CGI Information Systems and Management Consultants Inc. (2008)
4. Shall provide the ability to generate demand trend charts.	CGI Information Systems and Management Consultants Inc. (2008)
5. Shall provide the ability to display usage trend charts.	CGI Information Systems and Management Consultants Inc. (2008)
6. Shall provide the ability to display demand trend charts.	CGI Information Systems and Management Consultants Inc. (2008)
7. Shall support categorization and prioritization of all operational support requests.	Ajilon Consulting (2010)
8. Shall allow the monitoring of all aspects of operational support for all operational support domains.	Hales et al. (2011)
9. Shall maintain a log of user activities, decisions, and reasoning behind them.	Mitrovic-Minic, S. & Conrad, J. (2011)
10. Should detect changes in near real-time that could influence the forecasted data.	Mitrovic-Minic, S. & Conrad, J. (2011)

Table 12 – ROSP Requirements – ROSP Outputs

With respect to Outputs, the ROSP…	Reference
1. Needs to generate information that can be shared with other organizations.	Race & Appleton (2011)
2. Shall provide the ability to generate Logistics and other operational support related reports.	CGI Information Systems and Management Consultants Inc. (2008)
3. Shall provide the ability to share operational support information with OGDs, IOs, NGOs and Industry Partners and other defence partners.	CGI Information Systems and Management Consultants Inc. (2008)
4. Shall allow the user to share operational support information with other DND commands.	CGI Information Systems and Management Consultants Inc. (2008)

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4 CONCEPTS FOR CONOPS DEVELOPMENT FOR AN OPERATIONAL SUPPORT PICTURE CAPABILITY

The CONOPS development method chosen was used to provide the framework for developing the ROSP CONOPS for the current project. The ROSP content information and requirements gathered during the literature review as well as the feedback provided by stakeholders were used to provide the content for the CONOPS. The resulting ROSP CONOPS is provided in Section 4.2.2 below.

It should be noted from the outset that the concepts described in this section refer to the ROSP, an initiative within CANOSCOM to build a new version of the operational support picture.

4.1 Development of ROSP CONOPS

Based on the findings from the current analysis, the IEEE standard CONOPS outline was used as the framework for the ROSP CONOPS. The content of the CONOPS was derived from the information and requirements gathered from all documents reviewed during this project.

The CONOPS identified two primary sets of stakeholders: the users and the administrators. The work of the administrators is necessary to enable the work of the users, therefore their needs must be addressed in the CONOPS and any subsequent design. The CONOPS for the users is envisaged to be as visual as possible to enable the user to quickly appreciate the overview of the ROSP and be able to see the relationships from one part of the ROSP to another. The user should also be able to effect change in the ROSP through the visualization, and should not have to enter the same data in many places. In other words, changes are promulgated throughout the ROSP.

The ROSP CONOPS was described as servicing the needs of the Strategic, Operational, and Tactical decision maker by exploiting the capabilities of a dynamic visualization. Dynamic visualizations will present an abstracted overview for the Strategic decision maker, and will provide successively greater detail as the view is zoomed, to support the increasing information needs of the Tactical decision maker.

Using the IEEE standard framework introduced in Section 2.2.7 above, the baseline ROSP CONOPS developed during this project is presented in Section 4.2.2 below.

4.2 Proposed Concepts for ROSP CONOPS

4.2.1 Scope

The CANOSCOM working definition of a ROSP is "“a Recognized Operational Support Picture (ROSP) is a common representation of relevant support information that provides situational awareness to the Commander and is shared with support organizations at all levels. This information is drawn from recognized, authoritative sources and sensors and provides temporal, spatial, condition, readiness and support process service delivery information.”(Cloutier & Mostashari, 2009)

This section describes a future ROSP concept. In particular, CONOPS describes the manner in which information is presented to members of CANOSCOM, Canadian Expeditionary Force Command (CEFCOM), and Canada Command (CANADACOM). This will ensure that they can attain Total Asset Visibility (TAV) as well as operational support SA.

4.2.2 Concepts for Proposed System

There are two primary perspectives for the ROSP: that of the user community and that of the maintainer (i.e. developer) community. Each perspective will be described in turn, starting with the user community.

4.2.2.1 User Community

The user community is the primary target of a ROSP and must therefore be well-served by the ROSP. To this end, a primarily graphic representation of data is proposed, supplemented by numerical and text data, in order to exploit the natural abilities of the human visual system to identify changes, patterns, anomalies, and groupings. To this end, a description of the ROSP from the user’s perspective will begin with a description of the representation approach, followed by other facets of the ROSP that must be represented.

4.2.2.2 Representation

The representation of the ROSP, as mentioned above, will rely primarily on graphic means, taking advantage of increases in the capability of graphic computing and the availability of information visualization toolkits for presenting data and information.

The visualization will provide a dynamic and multi-layered graphical representation of the ROSP (see Figure 2 and Figure 3 for examples). This graphical representation will be reconfigurable such that some views may be overlaid on geography, others against time, others on distances, others on sequences, and others on numbers. The chosen configuration will depend upon the nature of the ROSP parameters being considered.

The user will not be limited in terms of the data that can be displayed on the same visualization. By allowing the user to superimpose different types of data and not restricting this ability, the ROSP will accommodate problem solving, decision making, and discovery for unanticipated situations.

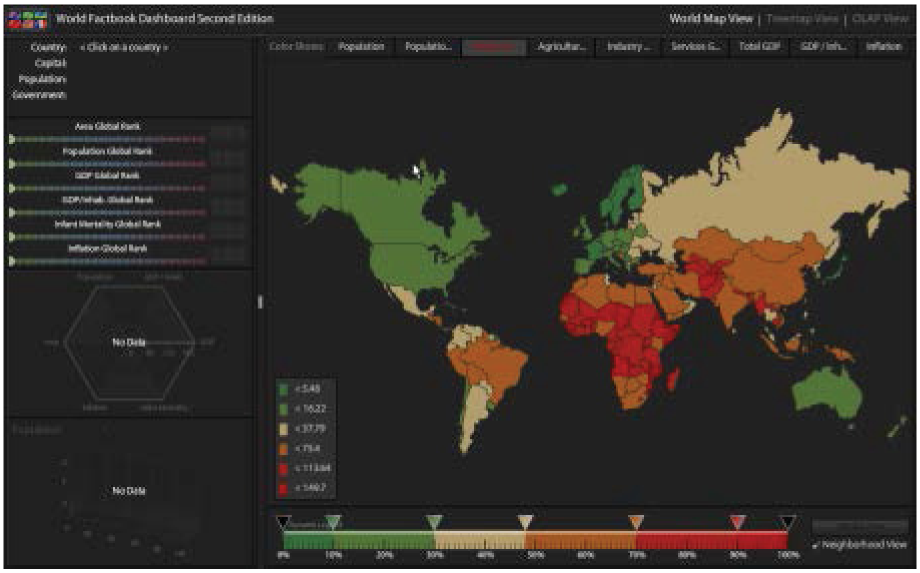

Figure 2: IBM iLog Elixir World Factbook Information Visualization

Referring to the examples here, Figure 2 shows a main view of the world, allowing the user to zoom in or out and select specific countries to obtain more detailed information. The buttons along the top allow the user to select different views, organized by relevant properties. Countries are colour coded according to threshold levels of the currently selected property. Additional graph objects are provided to show trends and comparative data. Figure 3 shows routes between locations, colour coded according to the type of delivery, and plotted on a time axis (such that lines plotted lower reflect routes that occur earlier). The routes are also annotated with significant events (e.g. pick up, drop off).

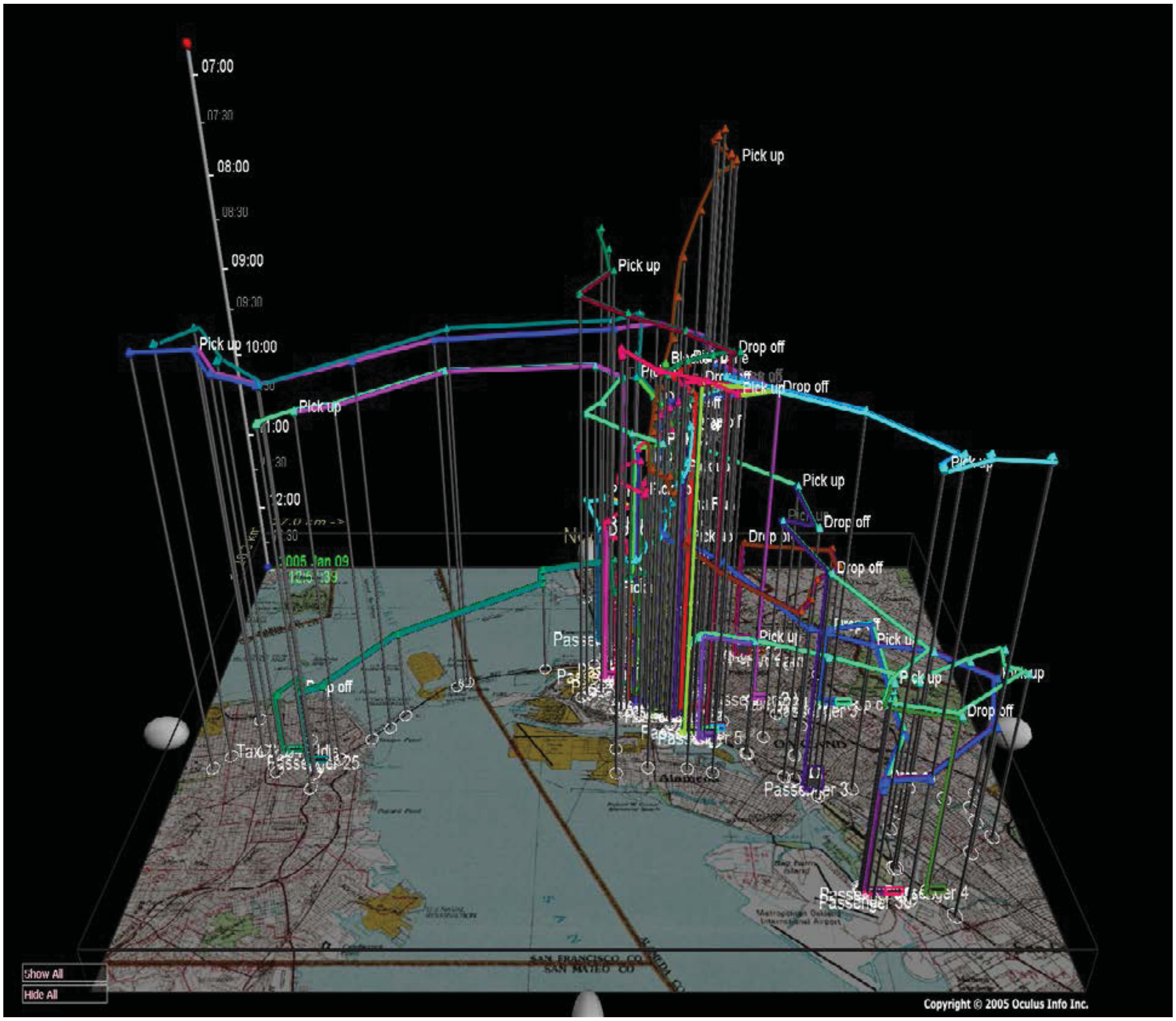

Figure 3: Information Visualization Created for Courier Company showing routes, activities, and time

The ROSP representation should include the disposition of the CF. In particular, it should present force location, force composition, force capabilities, force intentions, force readiness, and force sustainment data. Much of this can be combined in composite display items. For instance Figure 4 shows a specific segment of the world (South America) and has an additional 'polar star'-style graphic on the left comparing a specific country's (in this case, Brazil) rankings on a variety of parameters (e.g. infant mortality, gross domestic product, inflation), and a bar chart showing how that country compares to other countries on a single parameter (population). Given the requirement to display data concerning force disposition, it is conceivable that the force location can be plotted on the world view, with composition available if the world view is zoomed in.

Sensing and kinetic capabilities may also be plotted on the world view, with other capabilities (engineering, CIMIC, medical, etc.) being provided through icons. Intentions, readiness and sustainment could be plotted using the polar star graphic, representing whether or not a mission 'H-hour' is approaching, readiness is high, and sustainment is adequate and not challenged in the mission (sensing and kinetic) area. If the user chose, an axis on the polar star could be clicked in order to access more data concerning the parameter in question.

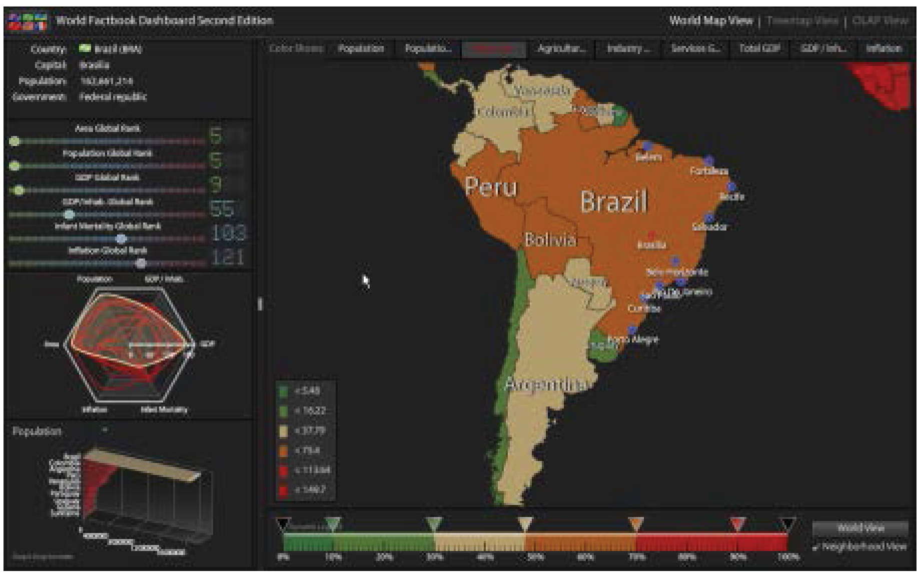

Figure 4: IBM iLog Elixir Showing Polar Star

The ROSP should also permit access to data concerning the battlespace geometry. Given that the CF operate worldwide, this data effectively covers the whole world and, at a minimum, those areas in which CF units are active. This data would include weather, topography, socio-political circumstances, infrastructure (bridges, churches, etc.), facilities (storage, servicing, emergency response teams, etc.), sea ports, airports, lines of communication, red, blue and neutral forces, and other significant events (placed on the world view according to location and dated accordingly in a pop-up window).

The representation should also represent time. This would probably involve the provision of a slider at the base of the world view. The slider would normally be positioned in the middle, denoting 'now'. However, the user would be able to move the slider to a time before 'now' in order to review previous information and play it forward to see how it involved. The user could also play it into the future to gauge how a parameter will change in the future. Two examples are good to demonstrate the time concept. A logistics officer planning a move may wish to avoid areas of likely IED emplacement. By moving the slider back in time and playing forward the officer can consider the historical locations of IED attacks and whether the 'popular' locations have moved over time. Another logistics officer may wish to understand how personnel readiness will degrade over the next two months without cycling personnel out for training and rest. By playing the slider forward, the officer can observe how readiness (perhaps represented by simple traffic lights) changes from green to yellow to red. The time representation assumes the ability to 'play' at a rate greater than real-time. The user will also have the capability to choose a segment of time (e.g. 4 weeks) and plot all pertinent data in that time. In the case of IEDs, this might show clusters of locations to avoid, although it won't show if the bombers are moving locations over time.

4.2.2.3 Interoperability

In conducting international missions, the Canadian Forces will continue to work cooperatively with NATO and coalition forces. As such, the ROSP visualization tool will interface with the operational support systems currently employed by NATO and coalition forces. In particular, it will provide reports in standard formats as decided by NATO and coalition forces. These reports will be provided in several different standard file formats and will minimize the use of acronyms to enhance common understanding.

The system will support the export of real-time OS information in the format easily readable by the IT systems of NATO and allied forces. In addition, the system will support the import of real-time OS information of NATO and coalition forces.

4.2.2.4 Decision Making

The ROSP visualization tool will be highly interactive, allowing users at all force levels (Strategic, Operational, and Tactical) the flexibility to input and display operational support information that is critical to their decision making level. The multi-layered graphical representation of the ROSP (see Figure 2 and Figure 3 for examples) will allow the user to choose the view and type of operational support information representation that will enhance their decision making. As an example, at the Strategic level, users will be able to utilize a global view to affect and monitor strategic movement of troops, equipment, supplies, transport, and ammunition en-route to operational theatres through waypoints can be monitored quickly through this global view. In contrast, the operational level user will have different demands on the ROSP and will require a theatre level view to make decisions within their scope such as confirmation of in-theatre arrival of troops, vehicles and equipment will be important to the Operational user to arrange transport and movement of such assets forward to the Regional Command Centres (RCC). Lastly, but of equal importance, the tactical level user will have different decision making needs and will need to view and interact with the ROSP system in order know the stock levels of ammunition and food at the RCC as well as the status of their delivery to the Forward Operating Bases (FOB). Having the flexibility to interact and view different types of information will greatly enhance decision making for all users.

To enhance decision making at all levels, effective planning and forecasting of operational support will be required. These system attributes are discussed immediately below.

4.2.2.5 Planning

The various operational support needs at all levels of force application is highly dynamic. As such, OS staff must be able to provide support in a pro-active rather than reactive manner. The key will be having a ROSP tool that effectively forecasts future requirements in all aspects and functional areas of operational support. Forecasting during the planning stage will be enhanced by the ROSP tool. This tool will store dependencies between past events, conditions and situations that caused increase or decrease in demand for operational support. It will also have a tool for converting these forecasts and historical data into logical future requests. It will detect changes in near real-time that could influence that forecasted data such as changes in replenishment levels, stock levels, or travel times for requested equipment, personnel. To aid in this, the tool will provide the ability to generate and display demand and usage trend charts which will aid in planning for future campaigns, operations or tactical missions. Lastly, it will provide calculation of statistics for the stored data, allowing for an appreciation of the difference between forecasts and actual demands.

Scheduling of OS assets will be possible with the information provided by the ROSP tool. The ROSP will contain templates with quick cost estimates for rough order of magnitude (ROM) budgeting of OS options that will aid in influencing the planning process, and will be tied into a greater Operational Planning Process (OPP) schedule management tool. This capability will enable an integrated Table of Organization & Equipment and the Task Force Movement Table to aid planners.

Figure 5 and Figure 6 provide graphical examples of statistical tools that will be useful in planning as well as decision making. Figure 5 shows a tree map breaking down the relative contribution of different countries to the overall population of a region, such that a user can easily see which regions are most highly populated, as well as which countries in that region have high populations. Figure 6 shows bar charts describing statistics for different regions for different factors. The ability to aggregate information at a level that strikes the best balance between detail and overview will be useful to logisticians.

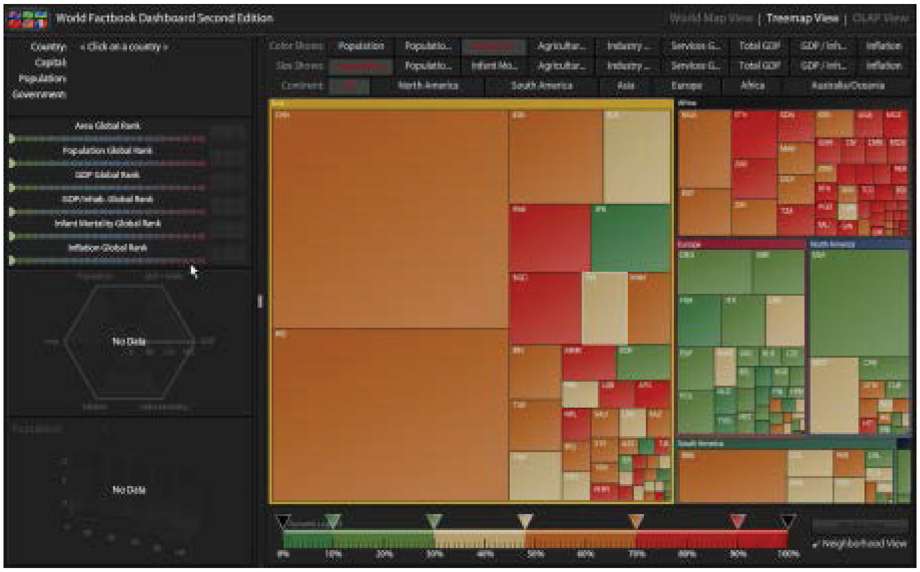

Figure 5: IBM iLog Elixir Alternative Quick View (Tree Map)

Figure 6: IBM iLog Elixir Alternative Quick View (OLAP View)

4.2.2.6 Execution and Monitoring

It is anticipated that users at the different force levels (Strategic, Operational and Tactical) will each have unique aspects of operational support that are of interest to them. Therefore, the ROSP will have a high degree of interactivity and flexibility that will allow them to do so. The multi-layered graphical representation of the ROSP (Figure 2 and Figure 3) will allow the user to quickly display timely and relevant operational support information and will allow the user to access it from different hardware platforms (i.e. computer, hand- held device) in non-office environments such as sea ports, storage depots or Forward Operating Bases. In addition, the ROSP software and hardware will have a built-in capability to deal with information security levels relative to users/ groups and services.

The ROSP interface will allow the user to efficiently initiate and monitor all operational support requests in a timely manner. This will include aspects such as ammunition, food, personnel, equipment, transportation, facilities, repairs and contracted services. In addition, these requests will also be in all operational support functional areas (Logistics, Military Engineering, Land Equipment Maintenance Services, Communications and Information Services, Health Services, Military Police, and Personnel).

The system will allow for the coding of requests to identify their nature (type of materiel, personnel, equipment, transportation, facilities, repairs, or contracted services). Such coding will allow the user to quickly query the system and locate the request of interest. Thereafter, users will be able to check on the status of such requests, recalling information such as time the request was made, by whom, the priority of the request as denoted by the originator

Timely and effective monitoring of the ROSP will be achieved through a robust alerting capability. The system will allow the user to establish alerts for those operational support parameters (for e.g., rations, ammunition, available personnel, equipment stocks) that are of importance to them. Once those pre-determined alert levels have been reached, the system will automatically alert the user, allowing them to take appropriate remedial action. This monitoring capability will not only allow the user to maintain good situational awareness of the ongoing operational support activities but will also aid in forecasting future needs as data input into the system will automatically populate the database which can be used for forecasting methods.

4.2.2.7 ROSP Outputs

All data entered into the ROSP by all users will be retained in a database of information that will be drawn upon to produce outputted information in various formats (reports, statistics, messages) that can be shared between users at the different force levels (strategic, operational and tactical) and different commands. Users at the various force levels and commands will also have the capability to selectively share OS information with other Canadian governmental departments (DFAIT) and non-governmental organizations (International Red Cross).

4.2.2.8 Information and Knowledge Management Processes for Situation Awareness

The key to a successful ROSP is the provision of excellent SA for Operational Support matters, DND/CF resources and assets, and current states of readiness as an enabler for accurate and effective decision making at the Strategic, Operational and Tactical levels of activity. In order to achieve this, the ROSP must supply a variety of perspectives on Operational Support data to the user, and must allow the user to vary their perspective on the data easily and quickly. Traditionally the User must manage this change in perspective internally; that is, in their brain. By externalizing the perspectives on the computer display the user is able to take advantage of more perspectives, keep track of data points between those perspectives, and thereby have stronger SA and make better decisions.

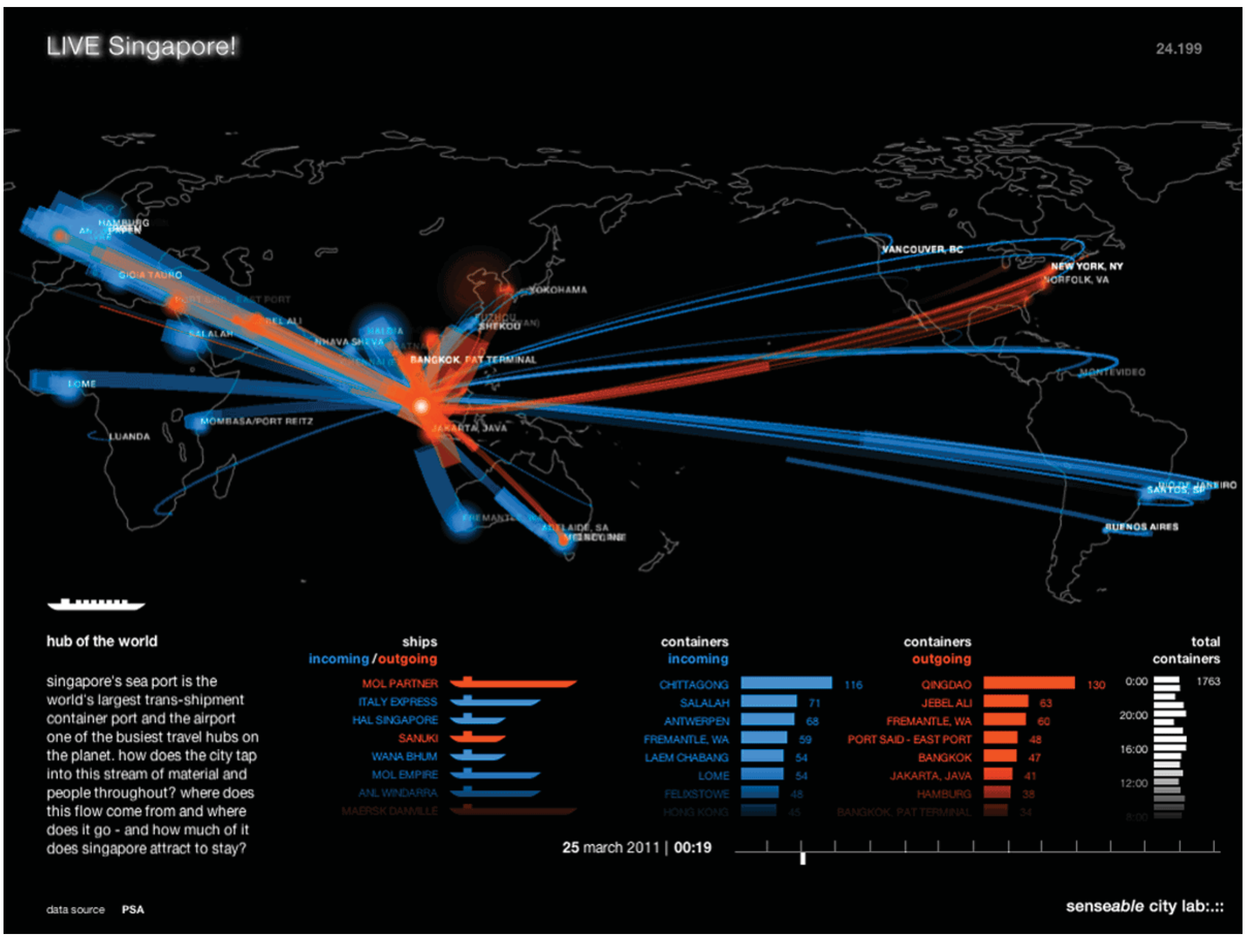

Figure 7: Global Logistics Picture

The ROSP will provide a variety of initial ‘views’ that will be tailored to the needs of the user. This tailoring will correspond to their particular area of responsibility, their level in the hierarchy, the activity horizon in which they operate (i.e. tactical, operational or strategic), and other nuances to be defined by the user himself. Typically, however, the user would be expected to take a top-down view of their perspective. Thus the first view presented would be an overview. As an example, see Figure 2). This screen shows the world, with a number of specific parameters displayed down the left hand side and along the bottom. These specific parameters could be Key Performance Indicators (KPI) for the particular area of responsibility.

Also represented in Figure 2 are quick view buttons along the top. These would change the ‘focus’ (i.e. the thing that is of interest) of the overview. In effect, this would be equal to opening a different file in a database or spreadsheet, except the data would be represented graphically. These quick views could change the perspective from a geographic one, to a human resources view, to a vehicle view, to a power view, to a food view, to a consumable view, etc. The views could also be configured to show activities in progress, such as repairs, transportation (e.g. Figure 7), training, telecommunications, construction, sub-contracts, etc. Developing these views as they are identified as required by users would be the job of the maintainer community. Some additional examples are provided in Figure 8 and Figure 9.

Depending upon the quick view chosen, manipulation of entities in the view will result in different outputs. For instance, in a transportation view, movement of an entity will result in a summary of the assets, personnel, etc. required to achieve the move, how long the move will take via various modes of transportation, and the route the movement should follow (at least as an initial plan; the user will be able to modify all of the summary data). The user would also be able to schedule the movement (which, itself, would be planned against existing commitments for the assets) and commit it to the system. This would then promulgate the plan to the affected parties so that preparations could begin.

The user would also be able to select a location, or an asset, etc. and open a ‘search’ dialogue. The user could then type in something required by the asset and the system would automatically search the inventories of all warehouses or (for example) scheduled courses and locations to present a list of available options and the lag associated with supplying that item/course/etc. to the asset. This would be equally applicable to gas, bullets, spare parts, repair services, translation, etc.

Figure 8: IBM iLog Elixir Entity Statistics

As the user manipulates the main view, the surrounding views would change to present more detail about the focus of the user's activity. For instance, if the user selected a telecommunications view, the dashboard (Figure 2) might show the hubs, the bandwidth of each, the number of faults on the system, the peak bandwidth demanded (in case it exceeded the maximum available), the average bandwidth, branches that had exceeded capacity, dates and times, etc. The main view may allow the user to recommend how to route data to avoid choke points. The graph view (Figure 6) may show trend information, or show how interconnected variables will affect each other if one is manipulated. Other specific information that may be desirable might be delays, readiness, time-on-task, remaining time, outstanding requests, new requests, etc.

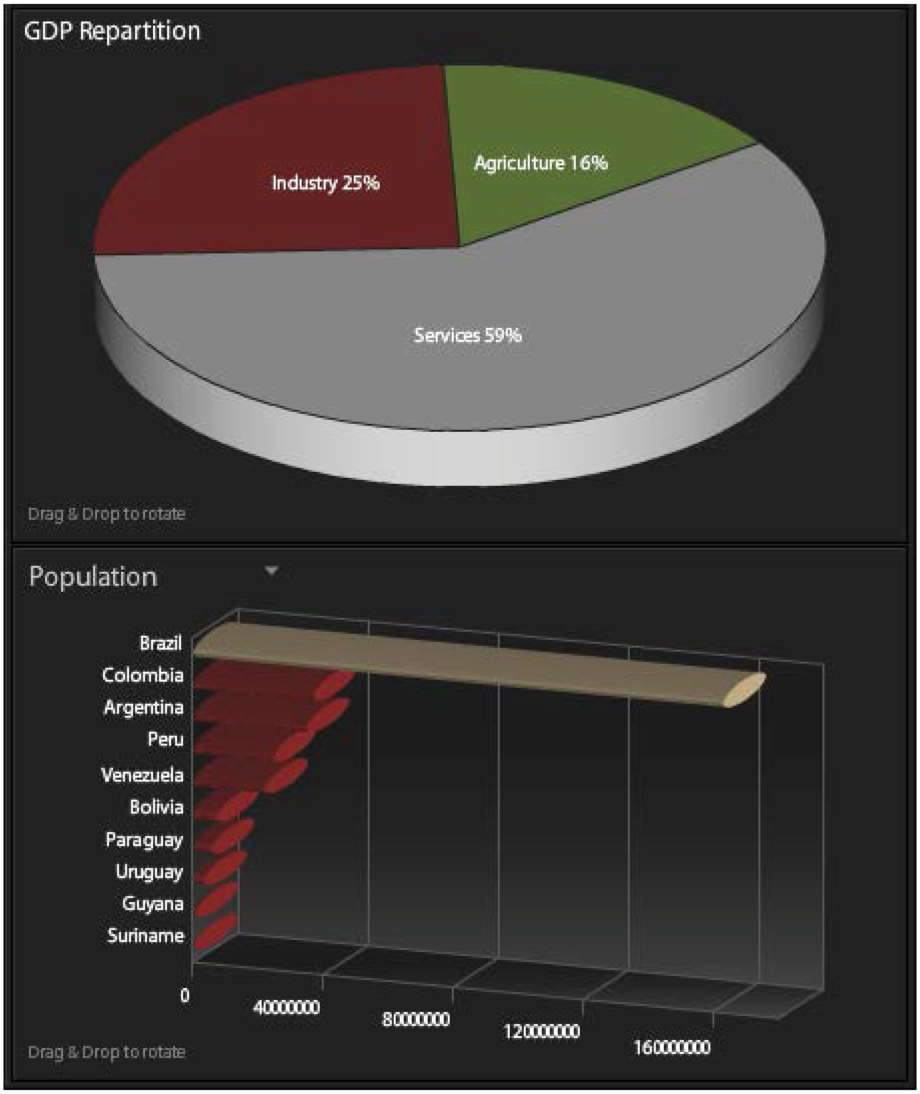

Figure 9: IBM iLog Elixir Comparative Statistics

The user should also be able to open a view that shows what available data parameters there are for the selected quick view. Since the quick view will open with certain pre-defined data creating the visualization, the user will be able to use this list of available data parameters to drag onto the visualization, or drag onto a specific entity, in order to enhance and elaborate the visualization. When released onto the visualization, a dialogue will appear asking the user to define the appearance of the data. For instance, the user may want the data to appear as a pop-up when the entity or the view is hovered over (Figure 9). Or the user may want the data to vary the size of the symbol, or appear as an associated bar chart, or change the colour of the symbol, or the border, or the fill. The user may also want to open a view showing available data for the other quick view options. This way the user can integrate different elements of the ROSP through the desktop application. This activity will need to change the nature of the configuration file for the visualization tool, but be applied only for that user. For this reason, users will need to be able to log-in to the system in order to retrieve their personal settings and views.

The user will also have an area in which they can construct graphical analyses of operational support activities. For instance, they will be able to drop an entity or location into the analysis area, then add an operation (e.g. add, subtract, divide, multiply), then add another data parameter (e.g. another entity, or time, or date). The system will then output the required answer. This would allow the user to quickly develop summary statistics for the selected quick view.

Figure 10: IBM iLog Elixir Data Pop-Up

4.2.2.9 Administrator Community

The back-end of the ROSP will consist of the various databases, applications, and ERP elements which currently hold the data that contributes to the ROSP. These databases will include LOGFAS, GCCS-J, CAPRED, CPOF, DRMIS, NMDS, etc. For interoperability, these databases will need to produce outputs that are readable and usable by the visualization tools that present the ROSP to the user. These components and data fields may include (for example):

- Component Level – “Repair Request”
  - Data level – “Unique identification number”

- Data Level – “time request is generated”
- Data Level – “person creating request”
- Data Level – “time request is input to system”
- Data Level – “person inputting the request”
- Data Level – “time by which equipment must be repaired”
- Data Level – “the priority of the request”
- Data Level – “the location of the equipment “
- Data Level – “special equipment requested for repair”
- Data Level – “specialized technician is needed”
- Data Level – “the time repair has started”
- Data Level – “the time repair has finished”
- Data Level – “to whom the repair job has been assigned”
- Data Level – “the people worked on the repair job”
- Data Level – “the time the equipment left the repair shop”
- Data Level – “the time the equipment reached its user’
- Data Level – “the cost of repair”
- Data Level – “special issues or risks remained”

To de-risk the development of the ROSP, to validate the concept, and to facilitate the phasing of the project to build the back-end of the ROSP it is recommended that a modular approach be adopted. That is, ROSP developers should seek to draw from a) a single database per build or b) a single component type per build. Thus, the first phase of building the ROSP would involve verifying that the requirements listed above are correct and exhaustive in order to develop a the ‘modules’ to be implemented in each phase of the build. Then the second and subsequent phases of the build would involve ensuring the validity and exhaustiveness of the requirements concerning the module of interest, examining the code structure of the database, and then creating a database output that can be read into the ‘middleware’ of the ROSP.

As implied above, the raw data from the databases will have to be readable by the visualization tool that will present the ROSP to the user. Data may already be in a readable format or may need to be processed by a translator. Depending upon the front-end visualization engine used, a variety of industry-standard XML formats have already been defined and are easily followed (e.g. graphML, treeML). The advantage of a standardized format is that the complexity of the ROSP tool would be reduced by not having to accommodate many different input formats. This would make maintenance and updating easier. The standardized format would allow the engine to parse the data and identify the various ‘classes’ of data as well as the data itself, permitting the visualization engine to present the user with control over how to view the data, what to view, etc.

A number of commercial and open-source information visualization ‘toolkits’ exist that are suited to the presentation of the ROSP. These toolkits are intended to present information and data that has been traditionally displayed as numeric values in tables, or bar charts, scatter plots, line graphs etc., as graphic forms that exploit innate capabilities of the human visual system to identify anomalies, patterns, and groupings. Examples of information visualization include maps, especially those with annotations, graphic explanations found in newspapers, and many other forms. These have typically been created by hand or at least mediated by human analysis. Information visualization toolkits include a variety of standard forms to which the data is applied. The visualizations can also provide multiple simultaneous views, as well as being re-drawn to reflect the perspective being taken by the user. The visualization can also be used to edit, change, and create logical expressions to act upon the data. Some static examples are presented below.

Figure 11: Comment Trends on The Economist Website

Figure 11 shows the topics subject to the most comments on The Economist's website. The size of the circle and the font reflects the number of comments concerning a topic and, perhaps more interestingly, the proximity of the circles' centres to each other (sometimes augmented by lines) indicates the degree of relatedness between two (or more) topics. The user can 'hover' over a topic to see a highlight of the topic and its most closely-related topics as well as the most recent comments recorded concerning that topic. If the topic is clicked on, the view changes to show only that topic and its related topics (and the most recent comments if the user places their mouse over the circle). The user is also presented with a 'reset' button, and control over the presence/absence of the circle, the zoom on the view, the number of words (topics) in the view, and the font size used. The user can also see the representation change as additional information is added to the underlying data.

The Guardian newspaper in the United Kingdom actively collects data and produces information visualizations on topical issues. The paper's 'Datablog' (http://www.guardian.co.uk/news/datablog) uses a variety of visualization toolkits to create their visualizations, including those produced by Google, IBM, and smaller boutique software companies. A good example of a multiple-view visualization can be found in their map of the influences on the manifesto of Anders Breivik (Norwegian bomber and shooter):

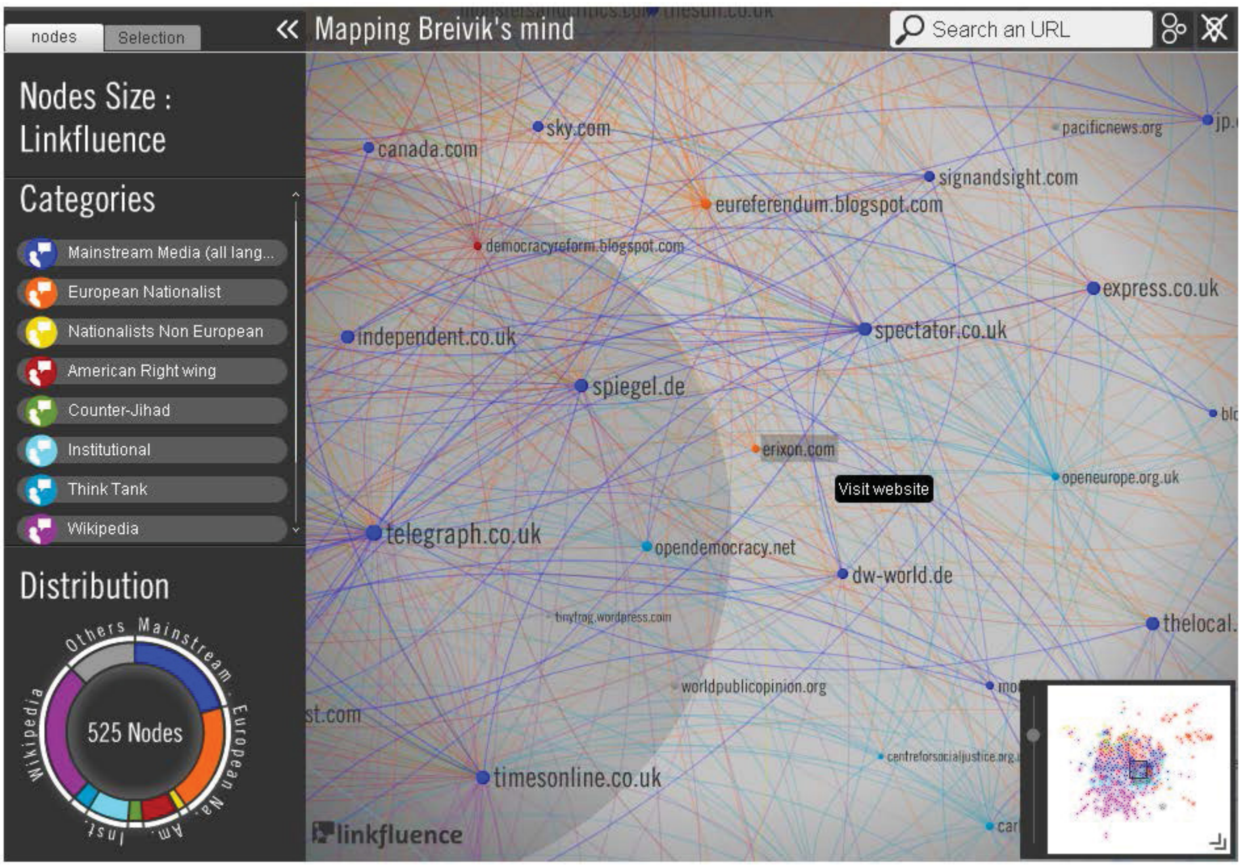

Figure 12: The Guardian Maps the Influences of Anders Breivik

As noted above, the user should be able to edit the ROSP data through the visualization. This means that the data behind the visualization will be revised which must then be translated into an update to the originating database. Ideally, this will be accomplished in real-time, although in practice it is more likely that updates will be made in batches scheduled to occur when the system is experiencing its least demand. This process too will require some analysis during the ROSP build phase to settle upon the most effective strategy for maintaining the best level of congruity between the code serving the visualization and the database serving the ROSP.

Once the ROSP visualization engine is created and in use, the data contained in the various databases could be edited, updated, deleted, and otherwise managed at the front-end through the visualization and at the back-end directly through the database tables themselves. Work by maintainers after this point would be focused on new visualization forms and the addition of decision-support tools such as logistics optimization tools, time and capability-based sliders, and adding other user-requested functionality.

4.3 A ROSP Prototype: A Testbed Perspective

A ROSP prototype should only present the user's perspective, and should be very visual and interactive, as per the figure examples given in Section 4.2 above. The visualization should present data on one particular type of asset that is widely distributed around the world but is few enough in number to easily track. The asset should have a variety of parameters, for instance:

- Fuel;
- Repairs;
- Route;
- Scheduled maintenance;
- Current status;
- Available personnel;
- Daily schedule;
- Weekly schedule;
- Monthly schedule;
- etc.

The data serving the visualization should not be live; rather, it should be augmented for the specific purpose of demonstrating the ROSP prototype.

The visualization should allow the user to edit data in the underlying database and automatically update the database. The database should serve multiple visualizations, such that any update is immediately reflected on another user's visualization. The visualization should also be reconfigurable according to the view desired by the user. For instance, the default view may be the asset of interest, but the user should be able to refocus the view on fuel stores, or personnel, etc. The visualization that results from such a refocusing should be based on dummy data to avoid the necessity of extending the scope of the prototype's dataset.

The data serving the visualization should be based on the data currently held by CANOSCOM on the selected asset. This data should be augmented as required to serve the visualization. The activities associated with the asset should also be mapped to an associated database, as per the list of parameters outlined in Section 4.2.2.9. The visualization should also support the following functions:

- The ability for the user to define alert parameters;
- Automatically provide alerts when alerts parameters have been met;
- Provide the ability to generate usage trend charts;
- Provide the ability to generate demand trend charts;
- Provide the ability to display usage trend charts; and
- Provide the ability to display demand trend charts.

The development of a prototype for the ROSP should be subject to specific design and development activities to fully define the data structures and associated performance factors, as well as to develop the visualization for presentation to end users.

5 CONCLUSIONS AND RECOMMENDATIONS

DRDC Valcartier is seeking to provide commanders with a more comprehensive operational support picture to enable decision-making while remaining cognizant of significant support problems that could impact on the successful conduct of the mission. To support this effort this project aimed to provide an initial ROSP CONOPS that can be improved upon in the future by DRDC Valcartier and other ROSP stakeholders. To achieve this aim, this project conducted the following major activities:

- Literature review of academic papers on methodologies that can be used to develop a CONOPS;
- Identification of Key Operational Support Picture Requirements to Support Decision Making; and
- Development of Concepts for Operational Support Picture.

It is recommended that DRDC Valcartier implement the IEEE standard framework for CONOPS development. The IEEE standard is a proven standard for CONOPS development that is widely accepted by military, industry and academic communities.

A graphical method of CONOPS development shows promise, since the user can quickly appreciate the overview of the CONOPS, and the graphic could be integrated with standard descriptive forms or written documentation to permit more opportunistic (i.e., non-linear) approaches to CONOPS development. There is currently no graphical tool that exists to support CONOPS development but the development of a ROSP CONOPS for CANOSCOM should attempt to use graphical representations as much as possible. Ideally, graphical descriptions of ROSP components could be supplemented by hyperlinked text descriptions, or even appear when a part of the graphic is selected. This implies that CONOPS development should be done collaboratively at a whiteboard and then documented graphically (e.g. using MindMap) and distributed to all stakeholders for review and comment. To facilitate this, DRDC Valcartier should continue to work with CANOSCOM to develop an integrated team approach to further develop the CONOPS concepts provided by this project and they should further investigate a graphical method of development that is suitable to the R&D environment.

A key observation noted when reviewing CONOPS development approaches was that CONOPS typically do not explicitly make the link between the requirements that have arisen from the description of the current system and the statement of need/problem statement. This traceability of requirements is necessary to show that all necessary steps have been taken to deliver a system that equals and improves upon the existing system and that any requirements that have not been met have been excluded for valid reasons. If begun at the outset of a program, requirements traceability will not be an excessive additional task; it will be a minor additional step that can provide significant value. The traceability exercise has been completed for the requirements captured during this contract and will continue as the ROSP CONOPS evolves and new requirements are generated. DRDC Valcartier and CANOSCOM should seek to investigate methods that will ensure that emerging operational support requirements are effectively captured by the CONOPS development team members in a timely and accurate manner. By documenting requirements and feeding them forward into design and development the ROSP solution will be more likely to address the needs of all stakeholders.

The ROSP CONOPS presented in this report is a baseline framework into which further operational support information should be added, enhancing the baseline version and providing coherence and clarity.

The ROSP must be scalable to the audience. That is, it must support high-level strategic awareness of the state of operational support, as well as allowing the individual operator to make fine, tactical alterations to data or parameters concerning operational support. The same operator may be concerned with both tactical and strategic views simultaneously. Current approaches to information visualization (under investigation by DRDC) are well-suited for this purpose.

The ROSP also needs to be as up-to-date as possible. This is unlikely to be achieved automatically, in particular given small consumable items such as ammunition, rations, etc. but can be managed in a distributed fashion by stores men and quarter-masters in deployed locations such as Forward Operating Bases, assuming these static (if temporary) locations are networked within the overall ROSP system. DRDC Valcartier should continue building and improving on the CONOPS concepts provided by this project.

Having begun the process of developing the ROSP CONOPS, the work should continue by further defining the requirements to progressively finer levels of detail. This will suggest the further evolution (again to a finer level of detail) of the proposed system. The work should also develop a detailed mission scenario that can be used to baseline the performance of the current system and measure the performance of the proposed ROSP as and when components of the ROSP are developed. These tests can be done on functional systems, or in table-top exercises. It is important, however, that the same tasks under carried out in the experimental condition as in the baseline condition. Work should also be done to develop measures of performance and measures of effectiveness. Combined with a mission scenario, measures of performance and effectiveness will help to ensure that direct comparisons can be made between the current level of performance by the operational support element and a future ROSP. Using this iterative approach development of a ROSP CONOPS will satisfy both the R&D needs that have to underpin the ROSP, as well as the development of a practical solution to the needs of CANOSCOM.

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7 LIST OF ABBREVIATIONS/ACRONYMS

AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
APOD	Aeriel Port of Debarkation
AV	Asset Visibility
CANADACOM	Canada Command
CANOSCOM	Canadian Operational Support Command
CAPRED	Capability Readiness
CEFCOM	Canadian Expeditionary Forces Command
CF	Canadian Forces
CFFS	Canadian Forces Fleet School
CFJSG	Canadian Forces Joint Service Group
CIMIC	Civil-Military Cooperation
CONOPS	Concept of Operations
COSPC	Concept for Operational Support Picture Capability
COTS	Commercial-Off-The-Shelf
CPOF	Command Post Of the Future
CSA	Contract Scientific Authority
CSA	Scientific Authority
DA	DRMIS Advanced
DFAIT	Department of Foreign Affairs and International Trade
DFAIT	Directorate of Foreign Affairs and international Trade

DND	Department of National Defence
DRDC	Defence Research and Development
DRMIS	Defence Resource Management Information System
DRMIS	Defence Resource Management Information System
ERP	Enterprise Resource Planning
FMAS	Financial Management Accounting System
FOB	Forward Operating Base
FOB	Forward Operating Base
GCCS – J	Global Command and Control System - Joint
HRMS	Human Resources Management System
IED	Improvised Explosive Device
IED	Improvised Explosive Device
IEEE	Institute of Electrical and Electronics Engineers
IO	Information Operations
IT	Information Technology
JCDS	Joint Command Decision Support
LOGFAS	Logistic Functional Areas Services
MASIS	Materiel Acquisition and support Information System
NATO	North Atlantic Treaty Organization
NDI	Non-Developmental Item
NGO	Non-Governmental Organization
NMDS	National Materiel Distribution System
NSE	National Support Element

O&M	Operation and Maintenance
OGD	Other Government Department
OPP	Operations Planning Process
OS	Operational Support
OSP	Operational Support Picture
PWGSC	Public Works Goods and Services Canada
R&D	Research and Development
RCC	Regional Command Centres
RCC	Regional Command Centre
RFID	Radio Frequency Identification
ROM	Rough Order of Magnitude
ROSP	Recognized Operational Support Picture
SA	Situation Awareness
SERC	Science and Engineering Research Council
SOCD	Statement of Operational Capability Deficit
STANAG	Standardization Agreement
TAV	Total Asset Visibility
TDP	Technology Demonstration Project
XML	Extensible Mark-up Language

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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.)

Identification of Operational Support Picture Concepts

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

Appleton, A.; Lamoureux, T.

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.)
January 2012	106	28

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.)

Contract Report

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

Defence Research and Development 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.)
15ai	W7701-5-4996/009

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.)
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Defence Research and Development Canada (DRDC) Valcartier is seeking to provide commanders with a more comprehensive operational support picture to enable decision-making that takes account of significant support problems that could impact on the successful conduct of the mission. This project provided an initial Recognised Operational Support Picture (ROSP) Concept of Operations (CONOPS) that can be improved upon in the future by DRDC Valcartier and ROSP stakeholders. To achieve this aim, this project delivered a literature review of 28 academic papers and documentation provided by the Scientific Authority on CONOPS development methods, ROSP requirements, and supporting information. Of these, 12 documents were found to be highly relevant to CONOPS development and these were reviewed further. After discussion with DRDC Valcartier and Canadian Operational Support Command (CANOSCOM) stakeholders, a single CONOPS development method was selected, based on the Institute of Electrical and Electronics Engineers (IEEE) standard. Nine documents were then reviewed that had relevant ROSP requirements and supporting information. These requirements and information were collected and organized into a high-level framework that was then used to guide the development of a first-draft of a ROSP CONOPS.

Recherche et Développement pour la Défense Canada (RDDC) Valcartier cherche à fournir aux commandants une vue d'ensemble de support opérationnel plus complète afin de faciliter des prises de décision tenant compte de problèmes de soutien importants qui pourrait influer le succès d'une mission. Ce projet a fourni un Concept des Opérations (CONOPS) initial pour une Image Reconnue de Support des Opérations (Recognised Operational Support Picture, ou ROSP) qui peut être développée dans de futurs itérations par RDDC Valcartier et autres parties prenantes du ROSP. Afin d'atteindre cet objectif, ce projet a produit une revue littéraire de 28 rapports issus du domaine académique ainsi que de la documentation fournie par l'Autorité Scientifique sur les méthodes de développement du CONOPS, des prérequis du ROSP, et des sources d'information auxiliaires. De ces sources d'informations, 12 documents ont été considérés comme hautement pertinents pour le développement du CONOPS, et furent ainsi étudiés en profondeur. Suite à des discussions avec les parties prenantes de RDDC Valcartier et de Commandement du Soutien Opérationnel du Canada (COMSOCAN), une méthode de développement du CONOPS fut sélectionnée, basée sur le standard de l'Institute of Electrical and Electronics Engineers (IEEE). Neuf documents furent ensuite étudiés en vertu de leur pertinence vis-à-vis des prérequis du ROSP et autres informations de soutien. Ces prérequis et autres informations furent colligées et organisées en un cadre conceptuel de haut niveau qui fut ensuite utilisé afin de guider le développement d'une première ébauche du CONOPS pour le ROSP.

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