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Identification of Decision Support Concepts for the Planning of Air Force Immediate Contingencies Operations

1 March 2010

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Contract number (in full): W7701-054996/009/QCL (W7701-8-3522NP)

Contract Scientific Authority: Micheline Bélanger 418-844-4000 x.4734

Defence R&D Canada – Valcartier
Contract Report
DRDC Valcartier CR 2010-353
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Contract Report

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Abstract

This project was conducted to provide research support to the Command and Control (C2) Decision Support Systems Section of Defence Research and Development Canada (DRDC) – Valcartier in the area of Air Force rapid response planning for immediate contingency operations. To enhance the ability to effectively plan and conduct immediate contingency operations, there is a requirement to understand both where the planning cycle can be optimised, and in what way new concepts, approaches, doctrine, tools, techniques, algorithms and processes (CADTTAP) can support this. This study identifies operational, theoretical and technical requirements for Air Force operational level rapid response planning for immediate contingency operations and applied applicable CADTTAP to design a conceptual roadmap for decision support system development. Use standing CONPLANs as a key element, the proposed roadmap facilitates the generation of planning documents including identifying the optimal course of action while leveraging a single point data entry of information elements and a flexible template system. The envisioned DSS is based on a Service Orientated Architecture (SOA) that will enable flexibility for system integration and web-based to facilitate the distributed collaboration in a Joint, International, Multi-agency and Public (JIMP) context that is becoming the norm in military operations, especial rapid response.

Key words: Air Force, decision support, rapid response, operational planning, immediate contingency operations.

Résumé

Ce projet a été conduit pour fournir un soutien à la recherche de la section des Systèmes de Soutien Décisionnel (SSD) pour le Commandement et Contrôle (C2) de Recherche et Développement pour la Défense Canada (RDDC) – Valcartier dans le domaine de la planification de réponse rapide pour des opérations d'urgences immédiates des Forces aériennes. Pour augmenter la capacité de planification et de conduite des opérations d'urgences immédiates avec plus d'efficacité, nous devons comprendre où le cycle de planification peut être optimisé, et de quelle façon les concepts, approches, doctrine, outils, techniques, algorithmes et processus (CADTTAP) peuvent soutenir l'optimisation du cycle de planification. Cette étude identifie des impératifs opérationnels, théoriques et techniques pour la planification de réponse rapide au niveau opérationnelle des Force aériennes pour que les opérations d'urgences immédiates et les CADTTAP applicables qui puissent être appliquées pour le développement d'un plan conceptuel pour un système de soutien décisionnel. En employant le CONPLANs comme un élément principal, le plan conceptuel proposé facilitera la génération des documents de planification qui comprendra l'identification des plans d'actions optimale par l'utilisation d'une interface unique pour toute entrée d'information, et à l'aide d'un système flexible de modèles. Le SSD envisagé est basé sur une architecture orientée services (« service-oriented architecture) qui permettra une plus grandes flexibilité pour l'intégration de systèmes et de produits en ligne afin de faciliter une collaboration « distribuée » dans un contexte d’opérations conjointes, internationales, multi-agences, et publiques qui deviennent peu à peu la norme au sein des opérations militaires, et particulièrement dans des contextes de réponses rapides.

Mots clés : Forces aériennes, le soutien de décision, réponse rapide, la planification opérationnelle, opérations d’urgences immédiates.

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Executive summary

Introduction:
This project was conducted to provide research support to the Command and Control (C2) Decision Support Systems Section of Defence Research and Development Canada (DRDC) – Valcartier in the area of Air Force rapid response planning for immediate contingency operations. To enhance the ability to effectively plan and conduct immediate contingency operations, there is a requirement to understand both where the planning cycle can be optimised, and in what ways new concepts, approaches, doctrine, tools, techniques, algorithms and processes (CADTTAP) can support this. As directed, the focus of the work was on rapid response planning at the operational level.

Research was conducted on the planning processes in the civilian emergency response domain to obtain a slightly different perspective than that of the military to be used as a basis of comparison to identify best practices for time critical planning. The rapid response/crisis action planning processes in the civilian emergency response communities, particularly those dealing with interagency operations, are relatively new and tend not to be as thoroughly documented or structured as their military counterparts; yet provide insight to the problem space in their relative simplicity and flexibility of application.

Results:
The work was conducted in a series of three tasks:

Task 1: Literature Review;
Task 2: Investigation and Options Analysis; and
Task 3: Conceptual Roadmap.

The research was approached from operational, technological and theoretical standpoints with the Canadian Force Planning Scenarios (FPS) reviewed for operational context. A combination of Canadian military, international military and civilian emergency response concepts, doctrine, techniques, processes and algorithms were studied. The role of standing contingency plans (CONPLANS) was identified as a key element during the literature review and provided a focus for the subsequent investigation, options analysis and conceptual roadmap development.

Outputs from the research include:

1. Operational, theoretical and technical requirements as derived from the literature review;
2. A generic overview of information elements that are contained in an CONPLAN;
3. A process model in the format of a DoDAF Operational View 5 Activity Model product that captures the activities and actors involved in turning a CONPLAN into an Operation Plan for rapid response planning and from which, the identification of generic planning modules was derived for the conceptual roadmap;
4. An options analysis that summarises the various CADTTAP considered for the conceptual roadmap presented using a framework of mechanical, creative and collaborative elements;

5. A conceptual roadmap that outlines the application of a subset of CADTTAP to the rapid response planning environment which address the requirements identified in the literature review and have been analysed in the options analysis; and
6. Integration of the conceptual roadmap components as a DSS is visualised using a use case (Force Planning Scenario 2 (FPS2)) and illustrated as a storyboard.

The proposed conceptual roadmap presents options to be considered for a suite of decision support applications or tools comprising a Decision Support System (DSS) to guide and accelerate the Air Force rapid response operational planning process. The proposed system will aid rapid response planners by pre-developing plans, pre-processing available data to generate required planning information, increasing competency in rapidly generating required information, and integrating the information to develop planning documents including identifying the optimal course of action. The DSS will facilitate the generation of required planning documents, including a completed Operations Plan, while leveraging a single point data entry of information elements and a flexible template system. The envisioned DSS is based on a Service Orientated Architecture (SOA) that will enable flexibility for system integration and web-based to facilitate the distributed collaboration in a Joint, International, Multi-agency and Public (JIMP) context that is becoming the norm in military operations, especial rapid response.

Significance:
The context of the work for this project focused on one force planning scenario, however, as the work was guided but not fully constrained by the FPS, the conceptual roadmap provides a foundation for future DSS design for rapid response planning across the full spectrum of CF operations.

It is highly unlikely that the Air Force will engage in an operation in isolation from any other entity, and it is crucial to overall force effectiveness that the tactical, operational and strategic levels have seamless interoperability. Therefore, instead of looking at operational planning in isolation, this paper suggests options that will promote interoperability as well as address the specific needs of the Air Force operational planners. For example, using a network enabled SOA architecture presents an opportunity to link the operational to strategic and tactical levels as a bridge, increasing overall force effectiveness, not just at the operational level. In addition, as military operations are becoming more joint and often interagency, SOA increases the ability to interface with external entities within the JIMP context that is a critical factor for rapid response.

Future Plans:
In the process of the investigation of the baseline requirement to understand the current full planning cycle, where it can be optimised, and in what ways new concepts, doctrine, techniques, processes and algorithms can support this, the following should be considered for further investigation before defining an updated DSS:

1. Analyse COPlanS trial results;
2. Analyse TOPFAS user evaluation results focussing on documented perceived strengths as well as shortcomings and deficiencies;
3. Validate requirements with user-centric investigation with current planning staffs;

4. Ensure that the design of the system encourages creative thinking during improvisation;
5. Obtain a more in-depth understanding of specific Air Force rapid response planning standard operating procedures (SOPs);
6. Increase technical understanding of system components to be integrated to the DSS;
7. Present information in a intuitive manner, so as to aid the decision making process;
8. Investigate Course of Action (COA) Analysis Based on Fuzzified Semantic Inference (CAFSIN);
9. Expand analysis to Supply Chain Management; and
10. Integration of information from various sources, using a blackboard design concept.

Sommaire

Introduction :

Ce projet a été conduit pour fournir un soutien à la recherche de la section des Systèmes de Soutien Décisionnel (SSD) pour le Commandement et Contrôle (C2) de Recherche et Développement pour la Défense Canada (RDDC) – Valcartier dans le domaine de la planification de réponse rapide pour des opérations d'urgences immédiates des Forces aériennes. Pour augmenter la capacité de planification et de conduite des opérations d'urgences immédiates avec plus d'efficacité, nous devons comprendre où le cycle de planification peut être optimisé, et de quelle façon les concepts, approches, doctrine, outils, techniques, algorithmes et processus (CADTTAP) peuvent soutenir l'optimisation du cycle de planification. En accordance avec les objectifs de ce projet, le focus du travail était sur la planification de réponse rapide au niveau opérationnel.

Les procédés de planification de réponse de secours dans le domaine civil on été analysés afin d'obtenir une perspective différente de celui du domaine militaire. Ceci sera employé comme un moyen de comparaison pour identifier les meilleures pratiques pour la planification à cours délai. Les processus de planification des activités de réponses d'urgences immédiates dans les communautés d'urgences civiles, en particulier ceux qui sont utilisés dans des opérations inter-agences, sont relativement nouveaux et tendent à ne pas être aussi bien documentés ou bien structurés que leurs contreparties militaires. Pourtant, ces processus de planification des activités de réponses d'urgences immédiates sont simples et constituent une source d'idées pour parvenir à une plus grande flexibilité à des fins d'applications militaires.

Résultats :

Le travail a été conduit en une série de trois tâches :

- Tâche 1 : Revue de la littérature ;
- Tâche 2 : Recherche et analyse d'options ; et
- Tâche 3 : Plan conceptuel.

La recherche a été effectuée à partir de points de vue opérationnels, technologiques et théoriques, à l'aide de scénarios de planification des Forces Canadiennes qui ont été utilisés dans un contexte opérationnel. Une combinaison de doctrine, techniques, processus et algorithmes militaires canadiens, militaires internationaux, et de mesures d'urgences dans le domaine civil ont été étudiés. Pendant la revue de la littérature, le rôle des plans d'urgence officiels (CONPLANS) a été identifié comme un élément essentiel, constituant le point de départ pour la recherche et l'analyse d'options qui ont suivi la revue pour le développement du plan conceptuel.

Les résultats de la recherche comprennent:

1. Les prérequis opérationnels, théoriques et techniques dérivés de la revue littéraire;
2. Un aperçu global des éléments qui sont contenus dans un CONPLAN ;
3. Un modèle de processus dans le format d'un document de type « vue des activités opérationnelles » fidèle au DoDAF (« Department of Defense Architecture Framework »), qui représente les activités et personnes impliquées dans la transformation d'un CONPLAN en plan d'opérations de réponses rapides. De ce modèle est dérivée l'identification de la planification des modules génériques pour l'élaboration d'un plan conceptuel;
4. Une analyse des options qui récapitule divers CADTTAP considérés pour le plan conceptuel et présentée en utilisant le cadre des éléments technologiques, créatifs et collaboratifs;
5. Un plan conceptuel qui décrit l'application des sous-ensembles de CADTTAP dans l'environnement au sein duquel la planification des réponses rapides est réalisée, qui rencontre les conditions qui ont été identifiées dans la revue de la littérature, et qui ont été analysées dans l'analyse d'options ; et
6. L'intégration des composantes du plan conceptuel dans le SSD qui sont visualisées en utilisant un cas d'utilisation (scénario de planification des Forces Canadiennes, FPS2), le tout étant illustré comme une séquence de plans (« storyboard »).

Le plan conceptuel proposé est une représentation des options qui doivent être évaluées pour un système de soutien décisionnel qui comporte une suite d'applications ou d'outils de soutien de décision afin de guider et d'accélérer le processus de planification opérationnelle de réponses rapides des Force aériennes. Le système proposé aidera les planificateurs de réponses rapides en offrant plusieurs fonctions telles que le pré-développement des plans, en prétraitant des données disponibles pour produire l'information de planification exigée, en augmentant leur compétence en produisant rapidement cette l'information, et en intégrant l'information pour développer des documents de planification comprenant l'identification des lignes de conduites optimales.

Le SSD facilitera la génération des documents de planification exigés qui comprendra un plan d'opérations complet, par l'utilisation d'une interface unique pour toute entrée d'information, et à l'aide d'un système flexible de modèles (« templates »). Le SSD envisagé est basé sur une architecture orientée services (« service-oriented architecture) qui permettra une plus grandes flexibilité pour l'intégration de systèmes et de produits en ligne afin de faciliter une collaboration « distribuée » dans un contexte d'opérations conjointes, internationales, multi-agences, et publiques qui deviennent peu à peu la norme au sein des opérations militaires, et particulièrement dans des contextes de réponses rapides.

Importance :

Le contexte de travail pour ce projet est concentré sur un scénario de planification des Forces Canadiennes, mais non pas entièrement contraint par le scénario. Le plan conceptuel présente ainsi une base pour la conception du futur SSD pour une planification d'opérations de réponses rapides à travers le plein éventail des opérations des Forces Canadiennes.

Par conséquent, au lieu d'analyser la planification opérationnelle en isolation, ce document propose des options qui favoriseront autant l'interopérabilité que la réponse aux besoins spécifiques des planificateurs opérationnels des Forces aériennes. Par exemple, employer une architecture orientée services reposant sur une infrastructure en réseau présente une opportunité pour lier le domaine opérationnel aux niveaux stratégiques et tactiques tout en augmentant l'efficacité globale des forces, et non pas simplement limité au niveau opérationnel. D'autre part, puisque les opérations militaires deviennent de plus en plus interdépendantes avec d'autres agences au sein d'opérations conjointes, l'architecture orientée services augmente la capacité de se connecter et de communiquer avec des entités externes dans le contexte d'opérations conjointes, internationales, multi-agences, et publiques, ce qui constitue un facteur critique pour des activités de réponses rapides.

Projets futurs:

Dans la poursuite de la compréhension des prérequis de bases du cycle de planification, et de la recherche de façons dont de nouveaux concepts, doctrines, techniques, processus et algorithmes peuvent soutenir l'optimalisation du cycle de planification, les mesures suivantes devraient être considérées comme étant essentielles pour des efforts de recherche futurs avant de définir un système de soutien décisionnel:

1. Analyser les résultats d'essais de COPlanS ;
2. Analyser les résultats d'évaluation d'utilisateurs de TOPFAS, puis documenter les forces perçues ainsi que les imperfections et insuffisances ;
3. Valider les prérequis par une étude orientée utilisateur avec le personnel de planification actuel ;
4. S'assurer que la conception du système encourage la pensée créatrice pendant l'improvisation ;
5. Obtenir une compréhension plus développée des procédures opérationnelles officielles pour des activités de réponses rapides des Forces aériennes ;
6. Augmenter la compréhension technique des composantes des systèmes à intégrer au SSD;
7. L'information doit être présenté d'une façon plus intuitive, afin de faciliter le processus décisionnel ;
8. Examiner l'analyse de plans d'actions à partir d'une approche inférentielle de sémantique floue (« fuzzified semantic inference »);

9. Inclure la gestion de la chaîne d'approvisionnement dans les analyses; et
10. Faciliter l'intégration de l'information de diverses sources en utilisant l'approche architecturale du « système blackboard ».

Greenley, A., Pronovost, S., Kelleher, D., Graham, J., Race, P., Lachance, P. 2010. Identification of Decision Support Concepts for the Planning of Air Force Immediate Contingencies Operations. Report No. XXX . DRDC Valcartier.

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1. Introduction

1.1 Purpose

This project was conducted in order to provide research support to the Command and Control (C2) Decision Support Systems Section of Defence Research and Development Canada (DRDC) – Valcartier in the area of Air Force rapid response planning for immediate contingency operations. The target audience for this series of reports is scientific personnel from DRDC-Valcartier's internal research program who are tasked to support of the Canadian Forces (CF) Air Force operational staff community.

1.2 Background

Traditionally, 1 Canadian Air Division (1 CAN AIR DIV) and the North American Aerospace Defence Command (NORAD) Canadian Region (CANR) Headquarters served as the central point of operational command and control for Canada's Air Force and monitored fulfillment of national NORAD commitments. Early in 2006, in accordance with the implementation of the first phases of the current CF transformation, the CF adopted a new integrated Command structure and stood up a number of national operational level headquarters. Foremost among these was Canada Command, charged with oversight and direction of domestic and continental operations and comprised of six Regional Joint Task Forces (RJTF). With the stand up Canada Command, 1 CAN AIR DIV assumed responsibility as the Combined Forces Air Component Command (CFACC) for all six regions.

Air Force planning has evolved and will continue to evolve to meet continual changes to the new operational environment. The end of the Cold War ushered in a less stable and more complex security environment requiring more agile and responsive planning and operational cycles. Most international operations are conducted as part of a coalition while domestic operations are normally in support of another government department. Both require the ability to collaboratively plan, execute and evaluate complex operations with traditional and non-traditional partners. In addition, Canada has adopted a Whole of Government approach that seeks multi-pronged responses involving a coordinated application of CF military influence and other Canadian instruments of influence, most notably diplomacy, development and commerce [DND (2008)].

Planning of Air Force operations are categorized as either routine planning or contingency planning. Routine operations are force employment activities that are normally recurring in nature and fall within the delegated authority of an appointed standing operational Commander, for example a Commander of a Standing Joint Task Force (JTF). They can usually be deliberately planned for, programmed and conducted with the resources integral to the assigned formation. In contrast, contingency operations are unexpected, often time critical operations where new organizational structures, Command relationships or additional resources may be required. While routine operations would normally have sufficient time for a full deliberate planning process, the same planning timelines may not be afforded contingency operations if they require an immediate and rapid response.

The CF Operational Planning Process (CF OPP) has laid out the necessary activities for engaging in both routine and contingency operations for the CF. While it is ideally suited for deliberate planning, it is often abridged to accommodate rapid response contingency planning due to time constraints. The application of the CF OPP during immediate contingency operations requires the ability to optimize the planning process in order to achieve the best decisions with the least risk in the shortest time possible. To support this effort, there is a baseline requirement to understand the current full planning cycle, where it can be optimised, and in what ways new concepts, approaches, doctrine, tools, techniques, algorithms and processes (CADTTAP) can support this.

The intent of rapid response planning is to move from considering the potential use of formal direction to employ military air power in minimal time. CONPLANS are designed to be partially completed Operations Plan to be used for planning contingency that prior to its event, has been deemed as likely to occur. The utilization of standing CONPLANs, , for immediate contingency operations play a key role in rapid response planning activities as they assist the planner to develop an Op Plan outside the boundaries of "routine operations", enabling rapid force employment that is executed within new or modified Command and Control structures or demanding a significant reallocation of resources.

1.3 This Project

The objective of this work is to identify and assess applicability of new and emerging decision support concepts for rapid response planning of Air Force immediate contingency operations and, based on the results obtained, develop a conceptual roadmap for rapid response DSS focused at the operational level. This project may touch on the tactical level, as the scope of Air Force operations is not always easily delineated, but the spirit of the effort will remain focused on support to planning at the operational level.

Research was conducted on the planning processes in the civilian emergency response domain to obtain a slightly different perspective than that of the military to be used as a basis of comparison to identify best practices for time critical planning. The crisis action planning processes in the civilian emergency response communities, particularly those dealing with interagency operations, are relatively new and tend not to be as thoroughly documented or structured as their military counterparts; yet provide insight to the problem space in their simplicity and flexibility of application.

1.3.1 Project Design

The project was conducted in a series of three tasks:
Task 1: Literature Review;
Task 2: Investigation and Options Analysis; and
Task 3: Conceptual Roadmap.

The research was approached from operational, technological and theoretical standpoints with the Canadian Force Planning Scenarios (FPS) reviewed for operational context. A combination of Canadian military, international military and civilian emergency response CADTTAP was studied. The role of standing contingency plans (CONPLANS) was identified as a key element during the literature review and provided a focus for the subsequent investigation, options analysis and conceptual roadmap development.

1.3.2 Project Deliverables

A Technical Note will be published documenting the results of all of the three tasks. A final summary report will synthesize the research and findings for public consumption. The project deliverables include:

1. Literature Review
2. Investigation and Options Analysis
3. Proof-of-concept Prototype in the format of a Conceptual Roadmap
4. Final Summary Report
5. Summary Presentation
6. Document repository (in softcopy format)

1.4 This Document

This document presents a detailed account of the work that was conducted for the Literature Review, Investigation and Options Analysis and the Conceptual Roadmap. This document presents the following outputs from the research:

1. Operational, theoretical and technical requirements as derived from the literature review;
2. A generic overview of information elements that are contained in a CONPLAN;
3. A process model in the format of a DoDAF Operational View 5 Activity Model product that captures the activities and actors involved in rapid response planning for turning a CONPLAN into an Operation Plan and from which, the identification of generic planning modules was derived for the conceptual roadmap;
4. An options analysis that summarises the various concepts, approaches, doctrine, techniques, processes and algorithms considered for the conceptual roadmap presented using a framework of mechanical, creative and collaborative elements;
5. A conceptual roadmap that outlines the application of a subset of concepts, tools, techniques, processes and algorithms to the rapid response planning environment which address the requirements identified in the literature review and have been analysed in the options analysis; and
6. Integration of the conceptual roadmap components as a DSS is visualised using a use case (Force Planning Scenario 2 (FPS2)) and illustrated as a storyboard.

2. Methodology

The scope of this project is bounded within the realm of providing decision support for the Air Force in the planning, execution and monitoring of immediate contingency operations (rapid response planning). As indicated in this project's Statement of Work, the desired end-state of this project is a proof-of-concept decision support prototype for rapid response planning in situations of severe time constraints.

2.1 Investigative Perspectives

This project has investigated decision support for Air Force immediate contingency operations from three perspectives (as shown in Figure 1 below): operational, technological and theoretical. The first perspective being addressed is from an operational requirements perspective. A better understanding of the problem – both in terms of current operational planning processes and their associated requirements, challenges and constraints – helps to provide the context for the other two perspectives. This was the initial area of examination for the literature review, and it provided the minimal requirements for the investigation and options analysis as well as the development of the prototype.

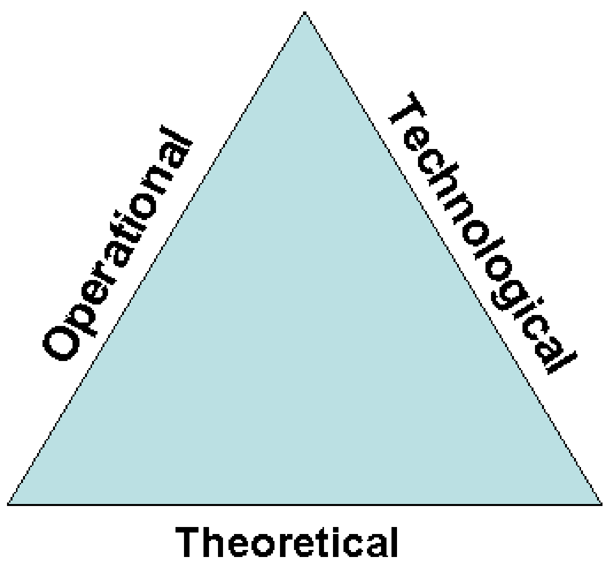

Figure 1. *Research perspectives*

The second perspective, the technological aspect of decision support, is designed to outline at a high level the ongoing development efforts and current state of the art of decision support technologies. The literature review resulted in a snapshot of "what is currently available" and in use across a variety of organizations' approaches to immediate response planning with respect to decision support tools and associated technologies. While focused on the operational perspective, the examination of available technologies included a wide variety of other domains with similar time constraints and functional requirements, such as collaborative planning and interdependent decision-making. As existing systems were identified and functions highlighted, the technological perspective was refined through options analysis. The proof-of-concept prototype was derived from the findings as a part of the technology roadmap.

The third perspective, the theoretical, addressed the underlying principles and approaches to decision-making, decision-support and operational planning. The theoretical aspect was developed largely from indirect examination from the other two perspectives. Keeping the three perspectives in balance, the investigation of theoretical aspects took a more in depth examination of key concepts and provided the backbone of the final conceptual roadmap, including a combination of planning CADDTAP as a basis for proof-of-concept prototype development.

2.2 Design

The project was conducted in three tasks:

1. Literature review;
2. Investigation and options analysis; and
3. Design of a proof-of-concept prototype.

The introduction of planning approaches and their associated concepts, doctrine, processes, techniques and algorithms adhered to the conceptual continuum resulting from a combination of operational, technological and theoretical research investigative perspectives (see section 2.1) to produce an integrated solution tailored to the needs of Air Force rapid response planning. As such, the literature review provided the foundation for the investigation and options analysis which then directed the proof-of-concept/conceptual roadmap design.

2.2.1 Literature Review

The literature review was conducted as a survey of rapid response/crisis action planning as defined by Canadian, US, and NATO Allied Air Forces, Joint and civilian CADTTAP maintaining a balance between the operational, theoretical and technological (OTT) aspects of the study. The first element, operational, involved the identification of target scenarios for Air Force immediate contingency operations. Using scenarios approved by the Canadian Forces Chief of Force Development (CFD), the project's operational context will remain consistent with future planning efforts throughout the CF. Keeping these scenarios in mind, an examination of operational planning process – both doctrinally and practically – provided an understanding of the current approaches for immediate air operations. The operational facet was rounded out through the examination of similar decision-making approaches in place across Allied Forces. The second facet took up the rest of the literature search, with a survey of current and emerging technologies. The theoretical facet has been embedded within the observations section of this literature search.

The following process was followed:

- Received documentation for review from the scientific authority (SA);
- Provided the SA with a list of potential documents for review for feedback;
- Performed literature review; and
- Generated analysis for this report.

A series of subtasks from step 3 above provided the framework for the results presented in this report. These subtasks consisted of:

1. Establish requirements to provide context and boundaries for the subsequent review of other documents, including:
   a) Review Force Planning Scenarios (FPSs) for examples that are representative of "time-critical" environments requiring rapid response planning for immediate contingency operations; and
   b) Develop a minimum set of planning criteria (inputs and outputs as a basis for developing requirements) derived from the FPSs.
2. Identify discrete theoretical / conceptual approaches to the problem within the literature and their relative strengths and weaknesses.
3. Survey current processes in use by militaries, Air Forces and civilian emergency response agencies
   a) Select a representative sample of those processes;
   b) Document the processes and associated decision support tools and structures; and
   c) Analyse each process and assess relative strengths and weaknesses in meeting Canadian Air Force requirements for rapid response planning.
4. Survey S&T approaches that could aid in the planning process and mitigate weaknesses.

The literature review of OTT CADTTAPs considered Air Force rapid response planning in order to discover new information as well as to simply to answer the interrogative what, how and who associated to the task of planning operations for contingency situations with severe time constraints (referred to as rapid response planning). As mentioned above, the initial requirement was to consider rapid response planning across the full spectrum of the FPS. However, in order to set the study boundaries more tightly, the study team, with input and approval from the SA, narrowed the scenarios down to three. The three that were selected provide insight into the operational context and are presented in section 3.1 below.

The study team drew from different sources of information (including the internet, civilian and military bibliographic commercial databases, etc) to establish a list of documents to be approved by the SA and reviewed.

The individual reviews of the documents conducted are presented using a common framework consisting of 3 elements: context, content and observations:

a) Context: Answers questions such as, “What is the complexity of the issue or problem to be solved? What are the time constraints for planning? Who is the audience? When was it written (pre/post 9/11; pre/post CF transformation, etc)? What is the purpose of the document?”

b) Content: Captures the most important themes/aspects of the document with a focus on the elements most relevant to the project.

c) Observations: Describes how the document is relevant to rapid response planning for the Canadian Air Force and why.

The reviews are presented in this report in the format of an annotated bibliography.

2.2.2 Investigation and options analysis

The investigation and options analysis identified key planning approaches and their associated CCADTTAP that provide decision support applicable to AF for rapid response planning within the context of CONPLAN completion or full Operation Plan development using the CF OPP.

Planning at the Operational level was the assigned focus for the task, with emphasis on the role of Standing CONPLANs developed in consultation with the SA. The following process was followed for the investigation and options analysis:

1. Conduct of an investigation of the requirements that were identified by the literature review considering the role of Standing CONPLANs across all three of the operational, theoretical and technological aspects of the study. This included an assessment of a Standing CONPLAN and its information elements and capturing the planning activities associated with generating a rapid response Op Plan;

2. Review of the CADTTAP identified in the literature review in the context of the activities required for CONPLAN adaptation and Op Plan generation in the Air Force rapid response planning environment in order to execute an options analysis of design features;

3. Identification of a framework for the Task 3 conceptual roadmap; and

4. Completion of the project report (this report).

2.2.3 Conceptual Roadmap

The design of the proof-of-concept prototype is presented in the format of a conceptual roadmap, outlining what a tool *should* do and recommending how to get there; it does not present a product. The conceptual roadmap is contextualized in the nature of the project; as an Advanced Research Project (ARP), looking at technology development in the 5+ year range. The following process was followed:

1. Concept development of a multidimensional prototype encompassing the operational, theoretical and tactical aspects of the study in the format of a roadmap;

2. Determination of system implementation recommendations; and

3. Design of a storyboard that will be context-dependent (driven by FPS2 and a selection of vignettes.

2.3 Agreed Terms and Conditions

The following agreed terms and conditions were made for this project:

1. Copies of documentation on extant AF doctrine and CONOPS were provided by the Crown;

2. Literature search was agreed upon through collaboration with the SA and will focus on Military and Air Forces from leading NATO countries such as the United States and the United Kingdom as well as civilian organisations and include a combination of concept papers (20-40 pgs), scientific papers (6-10 pgs), and doctrine (80-200 pgs);

3. The prototype involved is a concept, not an actual product, and includes a developmental roadmap.

2.4 Definitions

The following terms are defined as follows within the context of this project:

- Planning: the process of making plans for something [Oxford University Press (2009)]
- Crisis Action/Rapid Response Planning: Involves the time-sensitive development of plans and generation of an operation order for the deployment, employment, and sustainment of assigned and allocated forces and resources in response to an unexpected imminent crisis/need. Crisis action/rapid response planning is based on the actual circumstances that exist at the time planning occurs. While contingency planning includes planning activities that occur in non-crisis situations, rapid response planning does not [Department of Defence (2001)].
- Routine Operations: Routine operations are those operations for which a given Capability Component (CC) has been specifically tasked, organized and

equipped. Routine operations use existing command and control (C2) relationships and there may be no requirement to use joint terminology. Routine operations normally reflect tasks from the Canadian Joint Task List (CJTL) that have been assigned to a CC in the Defence Plan. Doctrine for routine operations is generally Environmental in nature (i.e., pertaining to Air Force, Navy or Army) [Department of National Defence (2008)].

- Contingency Operation: If an operation does not clearly fall into the routine category, then it is a contingency operation and a grouping, specifically tailored to the operation, is generated [Department of National Defence (2008)]. Contingency operations can be conducted either domestically or internationally.
- Concept: An abstract idea [Oxford University Press (2009)]
- Doctrine: In NATO, doctrine is defined as: “Fundamental principles by which military forces guide their actions in support of objectives.” It represents knowledge gained from experience and, although it is authoritative, it requires judgment in application. As such, doctrine is not rigid and not intended to curtail a Commander’s freedom of action. [Chief of Air Force (2007)].
- Process: a series of actions or steps towards achieving a particular end [Oxford University Press (2009)].
- Technique: A non-prescriptive way or method used to perform missions, functions, or tasks [Department of Defence (2001)].
- Algorithm: a process or set of rules used in calculations or other problem-solving operations [Oxford University Press (2009)].

3. Context and Requirements Definition

This section presents a synthesized discussion of kkey operational design and development considerations as derived at through the literature review in the form of a requirements analysis. Planning processes can be presented as business rule sets, mapping out the essential elements to provide a framework for operational activities required. The associated decision support requires the combined knowledge of multiple domains. The complexity of issues requiring rational decision making in operational planning is grown and thus are becoming more and more difficult. Globalization, interlinks between environmental, industrial, social and political issues, and rapid speed of change all contribute to the increase of this complexity. Advances in methodology and tools for decision support are presented in the literature that take into account the importance of the new era of the information society, where information, knowledge, and ways of processing them become a decisive part of human activities. For example, descriptive knowledge such as survey statistics and expert opinions address the uncertainty of the combined knowledge while the use of expert systems, neural network and belief causal network assist greatly in the implementation of these concepts. The following subsections will provide an overview of the key considerations that drive the requirements for military and civilian emergency response that are applicable to Canadian Air Force rapid response planning. This section presents a context and subsequent requirements from each of the operational, theoretical and technological perspectives as presented in the literature.

3.1 Rapid Response Mission Context

Because it's difficult to predict where and when a crisis will occur, there is a requirement for planners to rapidly respond to problems as they arise. While contingency planning prepares plans in anticipation of future events (Standing CONPLANS), rapid response planning dictates that planners respond to unanticipated, time-sensitive situations based on unique situation specific circumstances that exist at the time of planning. Although rapid response or crisis action planning procedures parallel contingency planning, rapid response planning is more complex due to the fact that there is an increased level of uncertainty and a decreased availability of planning time. Therefore, rapid response planning procedures need to be more flexible and responsive to changing events in order to fully develop and seek approval for Op Plans, either by developing a new plan where no useful Standing CONPLAN exists, or leveraging one or many existing standing CONPLANs.

The Canadian FPS were reviewed in order to provide context for the study regarding situations when the Air Force may engage in rapid response planning for contingency operations. Three of the FPS were highlighted and will provide operational use cases as required in future project tasks. For each of the scenarios, the Air Force would conduct its own contingency planning in order to effectively deal with the situation/task that it is required to deal with. One of the major differences between the scenarios is the agencies/partnering forces that would be involved in each scenario. The scenarios were chosen as a representative sample, but are by no means exhaustive of possible rapid response planning environments. A detailed synopsis of each of the FPS reviewed is presented in Annex A.

The scenarios offered the study team a context for the conduct of the literature review that is specific to the CF operating environment. To this end, the review of planning approaches and their associated CADTTAP followed the review of the three FPSs. The operational, theoretical and technical requirements were thus deduced within the mission context provided by the FPSs.

3.1.1 FPS 2: Disaster relief in Canada

This scenario involves the AF coordinating and working with all levels of government (municipal, provincial and federal). The involvement of other government departments (OGDs) at the federal level will be especially important. In this scenario the CDS is in Command of the domestic operation with the 1 CAN AIR DIV Chief of Staff (COS) Ops being the Air Component Commander. All CF air resources employed in the operation will be under operational command of the Task Force Commander (TFC) (Commander 1 CAN AIR DIV).

This scenario is of primary relevance to this study. The response to domestic crises makes up a significant portion of Air Force and CF rapid response operations. It has a clearly understood end state, and emphasizes the need to coordinate with other agencies in the planning process. As a result, a number of the sources reviewed refer to emergency management (EM) planning and response processes and systems.

3.1.2 FPS 4: Surveillance/control of Canadian territory and approaches

This scenario is related to surveillance & control capability in support to RCMP who leads the operation in the context of illegal activities (counter-drug operation). The areas of operations for this scenario are located on Canada's east and west coasts. The scenario is an inter-departmental effort that will draw on the Canadian Force (CF), Canadian Security Intelligence Service (CSIS), RCMP, the Communications Security Establishment (CSE), the Department of Fisheries and Oceans (DFO), and Canadian Coast Guard (CCG) resources.

This scenario is of interest in providing the immediate response elements in response to a territorial security issue. It is of lower interest, given the number of Memorandum of Understanding (MOUs) and contingencies already in place. The value of this scenario is in the application of agile approaches and systems that promote intelligence-driven operations and the fluid transition between planning and operations.

3.1.3 FPS 11: Collective Defence

This scenario would see the AF working in concert with NATO and United Nations (UN) Forces. Although The CF Air Forces would be part of the NATO Air Contingent, operating under NATO command, the specific scenario would tailor the need to develop recommendations that would drive 1 CAN AIR DIV into the requirement to develop contingency plans in short notice for government decision regarding potential contributions in support of NATO Operational Planning and Force Activation.

This is germane to the effort of identifying coalition planning approaches and considerations. The sources reviewed as a part of this project are related to Canada's most common coalition partners: US, UK, UN and NATO. While working from a single, unified planning process would be ideal, it is not required. Rather, ensuring that planning is complementary to allied efforts ensures interoperability without being driven by external processes.

3.2 Operational Context

The literature review provided sources through which the operational context was characterised. Key elements are included below in order to summarise the operational context in respect to rapid response planning for immediate contingency operations. This discussion sets the stage for understanding of the operational requirements presented in section 3.3 below.

3.2.1 Planning Doctrine

The operational context for planning rapid response immediate contingency operations is provided by two cornerstone doctrines: the National Air Planning Process (NAPP) and the Operational Planning Process (CF OPP).

While there is little resemblance between the CF OPP and the NAPP, there is a definite linkage. The NAPP looks out across all operations horizontally for strategic level resource planning, attempting optimize the full CF aerospace capability. The CF OPP plans the individual operations, without considering the downrange implications beyond the scope of the operation. The Canadian Air Force has a finite capability to be optimized. Therefore, if the long range NAPP output has allocated resources in one manner and there is a new "immediate contingency operation" demanding support from the Air Force, and resources are given a high priority for allocation to the new mission, it will affect previous assumptions on fleet availability. It may also affect lower priority taskings and squeeze them out of the NAPP plan.

The linkage between these two planning processes is resource allocation. When determining resources available for a rapid response operation, the operational planners would consult the output of the NAPP to determine what resources are available. The resulting operation plan for the rapid response operation would, in turn, become an input to the next iteration of the NAPP.

This relationship sets the stage for the "supply versus demand" battle as the planners struggle to meet all the requests for resources, pivoting planning upon the two doctrines in order to conduct horizontal, enterprise wide resource planning and develop event driven operational plans. This operational context for rapid response planning highlights the fact that there is no formalized method of handling requests for resources received outside of the planning cycles (Non-Forecasted Effects (NFEs)). In other words, depending on when the request is received, it could be fed directly into the Monthly, or Weekly Plan or could be fed directly into the current Air Tasking Order (ATO), completely by-passing the Request For Effect (RFE) process making traceability difficult for the fleet managers.

The two planning processes are summarized as follows:

3.2.1.1 National Air Planning Process (NAPP)

The NAPP is in place to ensure that the optimum allocation of air assets to satisfy CF requirements and to achieve desired effects occurs. The NAPP is a continuous process executed via three distinct but inter-related planning cycles (Yearly, Monthly & Weekly) that dictate battle rhythm and use existing command and control relationships. It begins with the collection of requests for aerospace resources, includes the formulation and issuing of Air Tasking Orders (ATOs) for the conduct of operations, and finally culminates with monitoring and performance assessment. Although the NAPP is an operational planning process involving the issuing of orders and the execution of operations, it bears little to no resemblance to the CF OPP.

Systems complement the doctrine, enabling the execution of required tasks. Air Force planners at all levels rely on a number of systems and applications that reside in the Air Force Command and Control Information System (AFCCIS) to plan both routine and contingency operations. These applications include Theatre Air Planning (TAP), Remote Access Mission Planning (RAMP), Execution Management - Replanner (EMR), Joint Defensive Planner (JDP), Mission Management Application (MMA), and Portable Flight Planning Software (PFPS) [Roy (2005)].

3.2.1.2 Operational Planning Process (CF OPP)

Currently, the CF OPP is the central military planning process and includes SOPs for Air Force and CF operational planning. The CF OPP considers that there are two types of rapid response planning: (1) there is an existing standing CONPLAN prepared for such a crisis and, (2) there is no standing CONPLAN. When applied to rapid response planning, the five stages of the CF OPP are the same as in deliberate planning with some activities truncated to meet time constraints. For example:

1. **Initiation**. The initiation is likely to be brief, with minimal guidance. As the situation unfolds either the strategic objectives may change until a political or coalition decision is achieved. This will require the commander to make assumptions from the outset to expedite the process;
2. **Orientation**. This stage remains unaltered, as it is indispensable for effective, efficient planning. The Commander will however, be more concise, even to the point of specifying initial Courses of Action (COAs) in the Planning Guidance. This is necessary to narrow the scope of the staff's work and expedite the planning process;
3. **COA Development**. The staff may have minimal time to check guidance on the priority of factors to analyze the various courses of action. Under very tight timelines, it is unlikely that an Information Brief will be required, since the staff preparing the final staff check, the Commander and subordinate Commanders will all be intimately involved with the details of the situation by this stage;

4. **Decision**. A Decision Brief will be conducted for the same reasons it is conducted during deliberate planning; however, it will focus on the viability of the COAs as well as any significant risks introduced as a result of the necessary acceptance and use of assumptions due to time constraints. While the initiating authority will approve the CONOPS, the urgency of the situation may preclude submission of the detailed plan for subsequent approval. If time is available, the completed plan should be approved by the initiating authority; but if time is short, the task force commander may be granted the authority to carry out the plan once the CONOPS is approved;
5. **Plan Development**. An Op Plan will be produced based on the information provided and the decisions made at the Decision Brief and submitted to the initiating authority for approval. Op Plan approval by the initiating authority is normally a prerequisite for the full development of a plan or OP Order but depending on the nature of the time constrains planning may proceed concurrently as the Op Plan is staffed; and
6. **Plan Review**. This stage is unlikely to be conducted prior to the execution of the plan unless the urgency of the situation decreases.

The following figure outlines the high level tasks associated with each of the OPP process steps [(1CAD (2002)]:

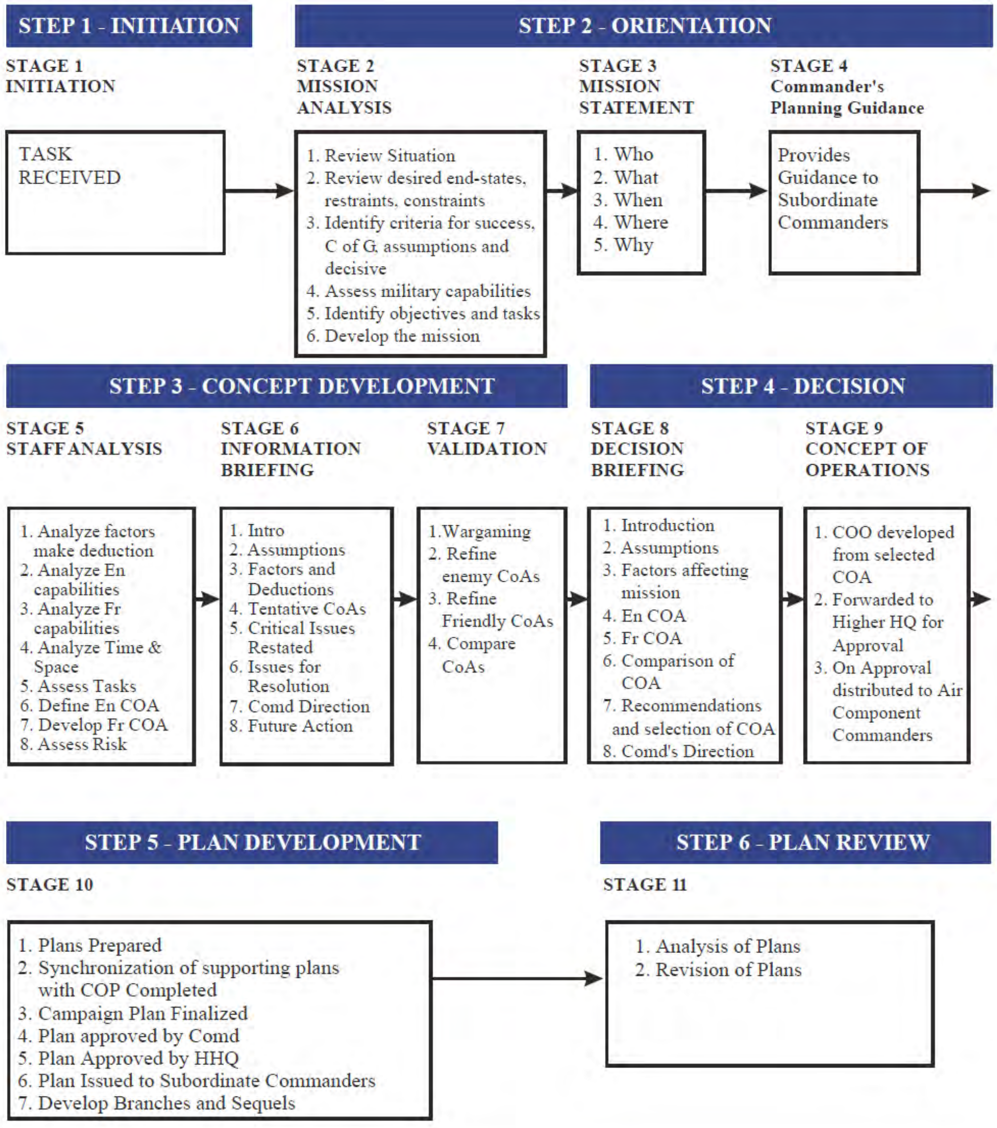

Figure 2 *The CF Operational Planning Process (OPP)*

The intention of the CF OPP is to translate the effects the Commander wants to achieve into a coherent plan at the operational level for execution at the tactical level with available capabilities. It follows the doctrinally proven CF OPP methodology used to plan and support CF operations. The nature of military operations is becoming more complex, more data, information and knowledge intensive and involves a broader range of stakeholders with varied interests and individual objectives. These factors are further complicated by time, location and distance which generate requirements for decision agility and flexibility.

A graphical description of the CF OPP in the format of a business process map (documented using the Department of Defence Architecture Framework (DoDAF) Operational View 5: Activity Model (OV-5) as it pertains to strategic decision making is presented in the literature review (see Cochrane, 2006).

3.2.2 Standing Operating Procedures

Within specific units, Standing Operating Procedures (SOPs) fill the void between doctrine and execution. They evolve with time, location and organization, providing process guidance for the execution of planning tasks. In this light, SOPs describe the unique operating procedures of a particular unit (i.e. 1 CAN AIR DIV A3 staff has their SOPs that may differ to 1 CAN AIR DIV A1 staff SOPs) and are used to provide practical detail that is more in depth than the high level guidance of official doctrine. The use of the word “standing” indicates that the operating procedure in question is said to applicable unless ordered otherwise,

The NAPP and CF OPP provide a process framework and the AFCCIS provides the process tools for the planning of routine operations, and to some extent for the meeting of requirements for the planning of some types of contingency operations which are not time critical. For example, there were no doubt “contingency air operations” conducted in support of the Vancouver 2010 Olympics. Theses would have been contingency operations in that new Command structures were required and the allocation of assets would have been reallocated for a prescribed period of time. These types of special event contingency operations are planned over several months and the NAPP and CF OPP are adequate for the detailed planning that is conducted. It is for “immediate contingency operations” planning that they may not be ideally suited as they are somewhat bureaucratic and labour intensive which takes time they do not in all likelihood have. It’s appropriate to have a baseline solution that can be actioned in time constrained environments rather than a full solution that cannot. For immediate contingency operations existing SOPs are “abbreviated” to enhance the planner’s ability to effectively plan and conduct immediate contingency operations.

Throughout the execution of the NAPP and/or CF OPP, planners employ various SOPs to mitigate errors and/or duplication. For example, NAPP regional Air Battle Plans (ABPs) are created simultaneously by Joint Task Force Pacific (JTFP), Joint Task Force Atlantic (JTFA), and CFACC. They are then merged into a national ABP each Friday. Conflicts are minimized by segregating the regional ABPs in accordance with the respective Area of Responsibility (AOR) for each organization. In both instances, SOPs reduce the possibility of multiple individuals contributing simultaneously to the creation and management of the NAPP outputs (i.e., ATOs and ABPs). This analogy can be applied to the CF OPP SOPs as well. For example SOPs are used extensively during mission analysis and in the preparation of briefings. In fact it is a basic tenant that operational plans be based as much as possible on existing CONPLANS and SOPs.

3.2.3 Bottom-up initiation for response

An operation that is deliberately planned is initiated from the strategic level, with a fully flushed out objective that addresses a higher strategic policy. In rapid response planning, such as emergency operations, while the authority to begin formal planning continues to come from above, the need for planning is often driven bottom-up. This bottom-up phenomenon is characteristic of disaster response as the planning is event driven as it unfolds, with the immediacy and requirement definition originating in the field. T In emergency management terminology, the first responders would engage at the municipal level and when the municipal level is unable to sustain or respond as necessary, planning is then triggered at provincial and federal levels by the receipt of requests for assistance. In essence, this process of bottom-up response, where the response need is initiated by local stakeholders, means that planning is not driven from the top-down (i.e. from strategic decisions) as is the norm for military operations(for more discussion, see [Coffin, W. J. M. (2002)]).

3.2.4 Major stakeholders in Air Force rapid response operations

The major stakeholders in Air Force rapid response include the following groups:

OGDs/Allies

- This stakeholder category would include OGDs, allied and coalition forces, and international organisations and non-government organisations (IOs/NGOs) at the strategic, operational and tactical levels. Their activities would be dictated by their role in the particular mission/issue being addressed. Their input to the Air Force planning process would provide a more detailed SME assessment of specific non-Air Force information.
- The CF is in constant contact with OGDs preceding, during and after any CF domestic operation and in the conduct of planning, decision making and information and intelligence analysis. For example, the Air Force will often engage with civil authorities early in the planning efforts to obtain SA.

CF Commands (CEFCOM/CANADACOM)

- Collaboration occurs on many fronts within the CF between the air force, army and navy. This collaboration has many facets. One example is the sharing of resources. The CF maintains designated forces and strategic assets on standby. Interactions with CANADACOM and CEFCOM is not just about receiving direction, it also includes the provision of information regarding Air Force capabilities and offers the opportunity to manage expectations regarding potential Air Force support.

Combined Air Operations Centre (CAOC)

- The Air Operations Centre (AOC) is responsible for monitoring current operations. During working hours, the AOC is manned with a small current operations staff. Additionally, a two-person Duty Watch team also monitors activities on a 24/7 basis throughout the year. As non-routine operations are introduced - a crisis, contingency or conflict - the AOC becomes the focal point for all actions required to plan operations, command and control assigned forces and identify force generation, support and sustainment issues for resolution by the rest of the A-Staff. [1CAD (2002)]

Commander, 1 CAN AIR VIC/CANR

- Commander 1 CAD is a formation commander with the powers and jurisdiction of an Officer Commanding a Command (OCC). In addition to 1 CAD, the Commander also commands the Canadian NORAD Region. [1CAD (2002)]

1 CAN AIR DIV A3

- A3 is responsible to the Commander for coordinating the overall readiness[1] of air force operational elements and for planning, tasking, overseeing, and controlling those operational activities that are the responsibility of the Air Division[2]. Through the AOC and the Air Components, 1 CAN AIR DIV A3 provides the single point of operational tasking authority and "one stop shopping" for all operational level planning, tasking, command and control, and mission monitoring. [1CAD (2002)]
- In conjunction with CANR Deputy Commander Canadian NORAD Region (DCR) and Al/A4 the A3 is responsible for developing and leading the Battle Staff. [1CAD (2002)]
- These responsibilities are executed through the direction of the A3 branch as follows:
    - A3 Force Employment
        - Responsible for Force Employment -to plan, task, direct and monitor air force operations. A3 FE is the 1 CAD point of entry for higher, lower and adjacent headquarters for force employment issues.
        - Responsible for the tasking of all air mobility sorties.
        - Conducts operational level planning and tasking of air force resources and directs, monitors, and coordinates sustainment activities for mission in progress.
        - Directs all activities of the AOC.
        - Ensures the operational readiness of transport and search and rescue resources (air mobility fleets).
        - Tasks include developing and maintaining operational readiness and policy documents; developing and monitoring aircrew standards; coordinating operational and selected pre-deployment training; providing guidance and direction for the development of weapons systems; and managing air mobility resources.
        - Provides oversight of training and proficiency, and aircraft operating procedures for the air mobility fleets.
        - Contributes to the development of weapons systems in the Operational Airworthiness and Test and Evaluation process for the air mobility fleets.
        - Staffs long-term requirements issue that affect the day-to-day readiness of air mobility.
        - Transport, Rescue Standards Evaluation Team (TRSET) located at 8 Wing is directly accountable to A3 FE.
        - TRSET generates standards for transport and search and rescue, which are verified by A3 FE. Wing Commanders are responsible for implementing the standards.

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[1] Coordinating the overall readiness of air force operational elements is ensuring that the "Force Generation" activities are completed and that the required qualifications and certifications are in place to permit operational elements to be employed on operations. Coordination is essential to ensure that the correct mix of operational elements is maintained as at a sufficiently high readiness state so that all elements of an Air Task Forces could be assembled within the prescribed timelines for deployment and employment. This is important in the conduct of "no notice contingency operations" because it is essentially a "come as you are" event and what you have available is what you have to work with.

[2] Readiness is the capability of a unit/formation, ship, weapon system or equipment to perform the missions or functions for which it is organized or designed. May be used in a general sense or to express a level or degree of readiness (

- A3 Combat Readiness
  - Responsible to A3 for duties as A3 Combat Readiness and to DCR for duties as the CANR DO. A3 and DCR maintain close liaison to prioritise activities and assist A3 Combat Readiness in maximizing the effectiveness of his organization.
  - Responsible for tasking routine and training sorties of the assigned combat capability teams.
  - Ensures the operational readiness of air force combat capabilities, which are fighters, tactical aviation and maritime air. Tasks include: developing and maintaining operational readiness and policy documents; developing and monitoring aircrew standards; coordinating operational and selected pre-deployment training; providing guidance and direction for the development of weapons systems; and managing air force combat resources.
  - Provides oversight of aerospace control management, aircrew training and proficiency, and aircraft operating procedures for the three assigned capabilities.
  - Coordinates Electronic Warfare activities.
  - Is the Operational Airworthiness process coordinator and contributes to the development of weapons systems in the Operational Airworthiness and Operational Test and Evaluation process.
  - Staffs long-term requirements issues that affect the day-to-day readiness of aerospace control and the combat capabilities.
  - Combat fleets Standards Evaluation Teams (Fighter Standards and Evaluation Team (FSET), TRSET , Maritime Patrol Standardisation and Evaluation Team (MPSET) and Maritime Helicopter Standardisation and Evaluation Team (MHSET))
  - Located at designated wings, and directly accountable to A3 Combat Readiness, FSET, TRSET, MPSET and MHSET generate standards for each fleet, which are verified by A3 Combat Readiness. Wing Commanders are responsible for implementing the standards.
- A3 Combat Support
  - Is the Force Multiplier as the lead of a cross-functional team of subject matter experts that are intimately involved in air force operations.
  - Provides advice to the Commander on the Operational Readiness of his forces.
  - Responsible for working with external agencies such as NORAD and NATO to ensure that our forces understand and adhere to applicable regulations.
  - Responsible for the Corrective Action and Lessons Learned (CAD CALL) process.
  - Responsible for providing Security and Military Police advice to the Commander.
  - Develops, monitors and maintains training standards for the Airfield Security Force.
  - Provides oversight and advises for generation and readiness of force protection personnel to support deployed commanders, and to ensure

the safety of air force personnel, equipment, and infrastructure anywhere in the world.

- Provides oversight of all exercise coordination matters for all air force resources.
- Provides oversight of air traffic management, meteorological services, NBC training and readiness, and geomatics requirements.
- Provides oversight of the Operations Management functions.
- Provides oversight over the Command and Control Information Systems required by the A3 organization.
- Maritime Air Components Atlantic and Pacific (MAC(A)) & MAC(P)).
- In accordance with agreement between CAS and CMS, Comd 1 CAD has command of all air resources but relinquishes OPCON of specific resources to MARLANT and MARPAC as Joint Maritime Commanders (JMCs) to support their Directorate of Personnel (DP) assigned missions and tasks. This OPCON of assigned air resources is exercised through the MACs who are designated Air Component Commanders for this purpose.
- MAC (A) is co-located with MARLANT in Halifax; MAC (P) with MARP AC in Esquimalt.
- Provide on-site operational liaison and support for the planning and conduct of joint operations at sea.

1 CAN AIR DIV A Staff Cells 1, 2, 4-9 (May include NORAD A Staff)

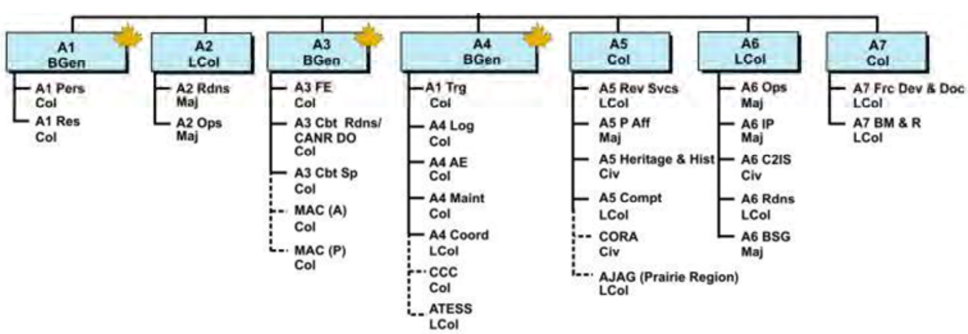


***Figure 3** Air Force Staff [1CAD (2002)]*

- A1 is responsible for the organizational process of Force Generation - Personnel. [1CAD (2002)]
- The A2 is the Commander's principal advisor and staff officer on Intelligence and imagery service matters. The A2 is accountable for planning, co-ordinating and supervising the 1 CAD Intelligence function. [1CAD (2002)]
- A4 is responsible for the provision of support services and training for air force activities. Directly subordinate to A4 are A4 Airfield Engineering, A4 Maintenance, A4 Logistics, A1 Training and A4 Coord. [1CAD (2002)]

- A5 is accountable to the Commander for the administrative coordination and provision of Review Services and Corporate Services (including legal support through Assistant Judge Advocate General (AJAG). [1CAD (2002)]
- A6 is the Commander's principal advisor and staff officer on telecommunications and information management matters. A6 provides advice and guidance to wing telecommunications and information management staff, and coordinates the implementation and support of national and command information systems within 1 CAD. The A6 branch strives to provide timely and effective telecommunications and information services in support of air operations with guidance on management of information resources and use of the Internet and DIN to distribute and manage information holdings. [1CAD (2002)]
- A7 assists the Commander and staff of 1 CAD/CANR and subordinate formations in defining, developing, promoting, and confirming the air force's mission and vision. To accomplish these activities, A7 is accountable for the provision of relevant doctrine, policies, operational level plans, operational requirements, force structure and resource management. In addition, the organization fulfils a Commander's secretariat role in the formulation of guidance and in the resolution of resource management issues affecting the longer-term capability of 1 CAD/CANR. The organization is comprised of two principal components - A7 Force Development & Doctrine and A7 Business Management & Requirements. [1CAD (2002)]

Resources – Wings, HQ Fleet Managers (i.e. Airlift, Fighters, etc)

- The stakeholder group Resources includes the thirteen wings that are located across Canada, from Gander, Nfld. to Comox, BC. The Wings conduct Air Force operations under the direction of 1 Cdn Air Div/CANR.

The requirements of each individual mission will dictate the role of each of the stakeholder groups outlined. For some missions, one individual may participate in the planning process, for another, multiple individuals as representatives of a number of organisations or branches of the stakeholder category may participate. For the purpose of this project, stakeholder representation is presented as a rolled up entity.

3.3 Operational Requirements

The role of decision support during any planning process is to provide information in a usable format to decision makers. This will allow decision makers the ability to make better informed decisions with respect to speed, more complete consideration of all relevant factors and the weighting of unintended as well as intended consequences in a specific operational environment. An initial set of planning requirements was established from the Force Planning Scenarios to provide a context for the operational planning decision making environment in the Air Force for rapid response planning. The set was then enhanced as the literature search was conducted. The final set of operational requirements for a rapid response decision support tool includes:

3.3.1 Constraint mitigation

As planners formalize Government and strategic military direction into Air Force business rules for optimizing resource allocation and highlighting resultant areas of risk, constraints are identified [Raskob, W. and Ehrhardt, J. (2000)]. Resource and mission constrains such as manpower and aircraft are of paramount importance when it comes to rapid response planning, fiscal constrains will, although not without importance, take a back seat. Countermeasures/COA analysis must include factors such as public affairs, legal (i.e. jurisdictional) and policy [Coffin, W. J. M. (2002)] and [Lawlor, B. M. M. G. (2001)].

The actual situation demanding a response and the perceived potential consequences of the scenario will affect the priority weight of constraints. For example, although general policy provides guidance for decision making, often public affairs will take a larger importance in situations such as disaster relief. Another example is provided in FPS 2 where it states that "the availability of Strategic Lift aircraft will be a deciding factor in the ability of the CF units to deploy within the planning timelines".

Constraint mitigation is involved in but not limited to the following planning activities:

3.3.1.1 Planning output development

The CF OPP involves several manual, time consuming steps, tasks and deliverables (outputs). Intermediate planning outputs such as COA options, when developed under time constraints, may be developed in a number of significantly different ways than those developed for deliberate planning operations due to the requirement to rapidly progress through the planning steps.

3.3.1.1.1. COA

The COA development phase of the CF OPP is highlighted due to its pertinent planning role to synchronise mission objectives with the Op O. An in-depth look at COA development provides a more detail of the constraints for rapid response planning that are different than that of deliberate planning.

A COA consists of the following information: why the action is required (purpose); what type of military action is being considered; who will take the action; when the action will begin; where the action will occur; how the action will occur (method of employment of forces) and what are the expected outcomes or effects. Once a valid COA is developed and approved, the staff further develops it into an Op Plan. In situations that do not require a rapid response, optimal COA determination will consist of four primary activities: COA development, wargaming, comparative analysis, and selection / approval [Joint Chiefs of Staff (2001)].

In rapid response situations, based upon time sensitivities, the effort placed on each of the activities will vary. The following provides an example of the COA development activities as could be articulated in an Air Force rapid response environment and has been developed for an example for this project [1CAD AIR DIV (date unknown)].

> When the decision is made by Government to develop military options utilizing Air Force capabilities, a planning directive is issued to 1 CAN AIR DIV initiating the planning process and the development of COAs. Next, a Warning Order (WngO) is issued that describes the situation, suggests command relationships,

and identifies the mission and any planning restraints and /or constraints. In response to the WngO, a review of existing Standing Contingency Plans (Standing CONPLANs) or previous Operation Plans (OPLANS) for applicability is conducted. The feasibility that existing CONPLANs or previous OPLAN could be modified to fit the specific situation is determined by the A3. If the fit is determined appropriate, the included COAs may require modification while if no existing plan fits, entirely new COAs will be developed, analyzed, and compared. In either case, the A3 will review and evaluate the developed COAs in light of the Commanders guidance and formulate a recommended COA based primarily on probability of success versus risk. Regardless of any time constraints, the goal in comparing and contrasting COAs is to identify the strengths and weaknesses of COAs so that a COA with the highest probability of success can be selected for further development. The Commander and staff develop and evaluate a list of important criteria, or governing factors, consider each COA's advantages and disadvantages, identify actions to overcome or mitigate disadvantages, make final tests for feasibility and acceptability and weigh the relative merits of each. Throughout the COA development process staff officers consult the various NAPP products (Monthly Air Operations Directive (MOAD), Weekly Air Operations (WAOD), etc.) in order to obtain visibility into current and planned taskings that impact resource availability. The Commander then selects a COA based upon the staff recommendations or forms an alternate COA. The nature of a potential contingency or the lack of critical information could make it difficult to determine a specific end state. In these cases, the Commander may choose to present two or more valid COAs for approval by higher authority. A single COA can then be approved when specific circumstances become clear. On receiving the Commander's decision, the A3 announces the general course of action selected and develops the detailed Op Plan and associated Op O with support from the A staff using the approved COA. The detailed Op Plan and Op O are presented to the Commander and if approved are distributed for execution. In rapid response environments, plan refinement continues after the Op O has been issued and throughout execution due to the dynamic nature of events until the operation becomes more stable and routine.

The planners use a variety of tools to help them with COA development and selection. Trials on COA processes have revealed that some collaborative tools available can be time-consuming and frustrating. Rather than having tools to analyse information, they would like a means to rapidly sketch and disseminate the base COA [Ross (2004)]. Therefore, tools that make visualization of the battlespace easier can often be more helpful than COA generation and evaluation tools.

3.3.1.2 Time Appreciation

Time appreciation is a tool to aid in military assessment. It is the estimation on how long the window of opportunity to act will remain open and then how to apportion that time into the various activities required before the action is taken. Aspects of time appreciation include the time required, in this case for operational planning, knowing there will also be reaction time before execution can commence.

To conduct a time appreciation, the planner starts with the desired end state and works backwards, fusing current readiness status with mission planning and analysis across the current spectrum of operations that the Air Force is engaged in. The time appreciation also takes into account specifics that are unique to each emergency situation its stakeholders and the operational environment that is demanding the rapid response. In the conduct of a time appreciation, a planner needs to understand how readiness and sustainability are reported, assessed and conceptualized for Air Force capabilities in order to correctly interpret available information on alternatives (see review of JADE: A Tool for Rapid Crisis Action Planning, for discussion on a specific tool in this context [Mulvehill, Alice M. and Caroli, Joseph A. (1999)]).

Time appreciation is challenged by the fact that in rapid response planning, the window of opportunity to execute an Op Plan and achieve the desired effects may be limited. Once the window is closed, the Op Plan is no longer relevant. Preliminary planning activities, such as the time appreciation, help to identify constraints and define the time window for the plan to be developed.

3.3.2 Dynamic, distributed and collaborative planning

The planning processes for rapid response operations are truly dynamic, distributed and collaborative. The requirement for dynamic, distributed and collaborative planning is driven by the interaction required in an environment that must deal with multiple sources of information and a variety of stakeholders. Operational contexts that characterise rapid response involve Joint, International, Multiagency and Public (JIMP) elements demand collaborative decision making and problem solving.

3.3.2.1 Joint, International, Multi-Agency, Public context

Response to security threats as well as man-made and natural disasters in the international level domain where “no one agency, or one nation-state has the resources and expertise to deal with response to such issues alone” [United Nations (2004)] to the local level domain where "the ‘me’ has been turned upside down to say ‘we’… ” [Inspector Karl Erfle, Ottawa Police as quoted in Adam, Mohammed (2004)] requires collaboration which, in turn, necessitates cooperation. As part of a global community, CF personnel must be able to work effectively as part of a team, either in the context of coordinated joint operations or in collaboration with various government and nongovernment agencies and organizations, international organizations, or multinational military forces, embedded in diverse social and cultural settings. This requires engaging with a variety of Joint, Interagency, Multinational, and Public (JIMP) stakeholders for routine and contingency MOOTW in both international and domestic environments. The capacity to be “JIMP-capable” is now an important enabler for the operations, especially immediate contingency operations.

A JIMP-capable force would interact with players in four domains [Gizewski & Rostek (2007)]:

- Joint—involving other national military elements and support organizations.
- Interagency—involving other government departments (OGDs) and agencies (OGAs), both domestic and foreign (these agencies will include: host nation

government departments including security forces; government departments and agencies from support nations; and international government bodies, such as UN agencies).
• Multinational —involving one or more allies or international coalition partners.
• Public—involving a variety of elements including: domestic and international publics, including host nation populations, media agencies, non-governmental organizations (NGOs), public volunteer organizations (PVO), international organizations and commercial interests involved in reconstruction and/or development programs, and private security firms recruited to support the government.

Within the JIMP context of rapid response planning for immediate contingency operations, the military doctrine and approaches tend to recognise the need for flexibility. The requirement for dynamic, distributed and collaborative planning demands flexibility of the CF and is articulated in civilian emergency response concepts that are also designed to be flexible. For example, the UN's Integrated Mission Planning Process (IMPP) is intended to be implemented in a flexible manner, taking into account varying circumstances and timeframes, while ensuring that adequate planning standards, outputs and the key decision points are respected [United Nations (2006)]. The importance of flexibility is evident from the goal and objectives portion down to the assignment of tasks to the tactical level within the type of coalition environment that the UN encourages. The sharing of data between interdependent organisations at various planning stages is a critical factor in driving and maintaining this flexibility.

Collaboration is not new to the Air Force as synchronisation with partners is a requirement for operations conducted as a multi-agency effort with OGDs or a multi-national coalition. This synchronisation requirement is seen in FPS 2 where it is indicated that the CF taskings will include: "transport of CF troops and equipment from bases across Canada to the area of operation and return after completion of the operation" and "provide evacuation for CF personnel" – both tasks that the Air Force will undertake to support non-Air Force resources. More insights are provided through the discussion of an implementation process for lateralization across horizontal stakeholders presented in the review of Burkle FM, Jr. and Hayden, Robin (2001).

The fact that the planning occurs across the strategic, operational and tactical levels concurrently, in a distributed and collaborative manner, provides several challenges for operational planning staffs. For example:

- Rapid response planning may also include the de-aggregation of planning activities, with responsibility extending to the tactical level relying on their position in the field for the most updated information. This could also lead to planning being conducted multiple sites, including theatres where bandwidth is significantly limited.
- The required immediateness of the response demands a link to the tactical level to provide advanced warning of the general plan prior to its approval, to ensure that when approved, it can be executed immediately.

- Information that is requested via a staff check cannot be isolated to one level – the when and what need to be answered for the operational level and the how for the tactical level.
- Often rapid response planning is conducted with emphasis on what resources are available, as opposed to the overall strategic goal. In this case, information from the tactical level is brought up to the strategic level through the operational level for a decision, and the operational level then proceeds to develop a plan.
- There is an interdependency of actions across planning staffs at each level as well as within each staff. For example, proposed actions by the A3 Operations staff officer may impact proposed actions by the A4 Logistics staff officer. Similarly, actions proposed by the A3 staff at the Operational level may impact the available actions for Ops Planning staffs at the Wing level.

A look at the air taskings outlined in the FPS provides more insights to the collaborative working environment: as working with host nations, OGDs and industry partners is the norm (FPS 2, 4 and 11 all have a collaborative element, with the CF support Canadian OGDs or international task forces (i.e. NATO)). Often planning will be initiated as requests for assistance are received and transmitted by a host nation government or a lead government department. Collaborative efforts are the norm as it is rare that one agency has the complete resource set to deal with a crisis. Burkle FM, Jr. and Hayden, Robin (2001), refer to this need as "horizontal planning" or lateralization, where horizontal organisations collaborate to conduct multiagency and multidisciplinary responses. These are also referred to as "whole-of-government" initiatives and are in line with the Canadian "3-D" policy for foreign engagement (defence, development and diplomacy).

Collaboration requires enabling and supporting communication, and the analysis and dissemination of current information across multiple stakeholders. For example, risk assessments are also conducted in a collaborative manner. There needs to be a clean and easy method to quickly identify, evaluate, review and share risks among those involved in the planning process across stakeholders and will need to be updated throughout planning and operations. Coffin, W. J. M., (2002) presents two interesting elements of collaboration that can be observed in the civilian emergency response community more often with time:: (1) interoperability should be placed at a premium, and imposed through the planning framework and (2) legal and policy initiatives are increasingly mandating/encouraging collaboration requirements between the military and OGDs.

3.3.3 Information optimisation

Uncertainty and incomplete information that is characteristic of rapid response planning environments drives the requirement for constant updates and "filling in the blanks" that then leads to changes to operational requirements and thus an operation plan. The number of information elements that need to be dealt with by the planners include but is not limited to: force allocation, infrastructure planning, lift availability, policy, public affairs and legal influences, industrial base support, host nation/lead government department support requests, coalition/partner contributions (including new stakeholder involvement), and attrition planning factors.

In rapid response planning, the operational planner will always have minimum planning criteria for operational planning purposes. This is, of course, a less desirable situation as it requires the planner to work from the assumption that sometimes a partial solution is better than no solution. The requirement for information optimisation is therefore great in the following areas:

3.3.3.1 Requesting information

Information is often incomplete and the planner is dependent upon requests for information to be processed as quickly as possible. There is a need to identify the critical information elements to request and/or prioritise in order to progress the rapid response plan and to determine how the planning process will be executed (as per filling gaps or risk management that are due to incomplete information received).

For example, during a staff check (the document used for a request for information is called a staff check and therefore the act of requesting information is often referred to as a staff check), the CF OPP will be modified to suit the time available, so the depth and detail of information is often sacrificed for speed although accuracy of the information still remains important. A review of the staff check template presents the information elements that are standard to complete required planning inputs and outputs and is considered a key document for this project (see review of the 1 CAN AIR DIV/CANR Planning Guide).

3.3.3.2 Synthesizing information from multiple data sources

Due to the fast changing environment of rapid response, situation updates appear constantly and at times rapidly and/or in abundance. A DSS tool needs to be able to facilitate the synthesizing of information by providing the ability to access in-depth knowledge from multiple data sources. This involves open-ended exploration as well as focused information retrieval. Determining a coherent whole picture of the situation means not just retrieving information, but aggregating the information obtained from the retrieved documents. Operational planners actively collaborate as they retrieve, extract, and analyse information. A DSS must support the collaborative, iterative, interactive information synthesis process used by operators to reach evidence-based conclusions to direct decision making. Therefore there is a strong requirement for a system which integrates the conceptual and procedural dimensions of research synthesis.

Details of the military environment for FPS 4 provide characterisation of the requirement for synthesizing information:

> *Coalition and Theatre Situation;* If appropriate, military authorities of selected allies and other friendly countries may be asked to share surveillance and intelligence information.
>
> *C4I Arrangements:* Cooperation with Canadian OGD's is clearly critical in this scenario. The Public Safety and Emergency Preparedness Canada is the lead agency.

Related information is provided in section 3.7.5 which discusses information abstraction as a technical requirement.

3.3.4 Develop and communicate planning documents

There are multiple documents that are outputs of the planning process. These include Mission Briefs, Commander's Guidance, COAs and Op Os. The completion of the full detailed deliberate planning cycle and all of the associated planning documents may not be possible when responding to an immediate contingency operation. Emphasis on one document vs. another may be part of a series of trade-offs that the planner must make. In rapid response planning, trade-offs maybe driven by an increase in the tempo of decision making. In addition, time pressures may preclude extensive consultations and involvement of key stakeholders that would normally be critical to the plan development process. COA selection, assessment and feasibility analysis are often delayed which further impacts responsiveness, implementation and schedule.

Another important consideration in addition to the content of planning documents, is the presentation of the information. The evolution of the format and presentation of these products is of consideration, especially if it can be auto-formatted and presented in novel ways. For example, video, images, animation and voice communications can often be produced quickly and better communicate command intent and are therefore valid options where bandwidth permits.

3.3.5 Tool/process familiarity

Investment of time and effort to become proficient in the use of a time-critical rapid response planning tool would not provide sufficient value if the same tool could not be used for the development of all planning products, under all conditions. This is supported by the fact that one of the tenets being observed during the development of TOPFAS is that Operational Planning is not a full-time occupation of staff officers – they are in essence "double-hatted". Therefore, tools and processes must be used often, and be simple and intuitive to enable the operational planner to use them effectively; planners can have their attention from deliberate planning suddenly turned by a crisis situation and that requires that they switch their tasks to engage in rapid response planning [NATO (2006)].

Researchers have recognized this and there are more and more attempts to provide similar fit, form and function related to many of the technologies, and tools that are used across all levels of users for planning operations are being emphasised. [Nten (2004)] addresses this requirement when tools are used for all types of planning i.e. routine, contingency and immediate contingency planning and is less frustrating for the planners. Operational staff does not want multiple systems to learn and master. When implemented across all levels of Command, tool familiarity eases transition for selected personnel from tactical service centric focus to higher level Joint operational planning. For example, the use of familiar presentation styles such as a Microsoft project style Gantt chart to display procedures, and their timelines has been applied by the AFCCIS in their critical path tools. The types of tools that therefore need to be available for rapid response planners should be the same as those used for deliberate planning with features that are common to the planners in order to ensure tool/process familiarity when executing in time constrained, and information ambiguity environments.

3.4 Theoretical Context

Decision making under uncertainty, involving risk and complexity, and constrained by time and resources, is at the very core of contingency planning. Applied experimental scenarios such as Baranski and Petrusic's naval radar display threat assessment tasks [Baranski (2005)], Schultz's demonstration of biased decision-making during WWII [Schultz (1997)], the challenges of instance-based decision-making improvement in dynamic, constrained environments [Gonzalez (2003)], and the over-utilisation of resources bias in fire-fighting task scenarios [Valentine (2007)] present what can be learnt from decision-making biases in similarly-constrained environments.

For example, Gonzalez, through a series of experiments found that as decision makers interact with a dynamic task, they recognize a situation according to its similarity to past instances, adapt their judgment strategies from heuristic-based to instance-based, and refine the accumulated knowledge according to feedback on the result of their actions [Gonzalez (2003)]. When Valentine investigated the overutilisation of resources bias as a cause of error in dynamic environments, he concluded that that individual flexibility in the quality of strategic thought allocated to resource usage, or in other words, the degree of metacognitive control, may well be a major predictor of decision-making efficiency in dynamic environments [Valentine (2007)].

The challenge here is to maintain a level of prescriptive decision-making design recommendations that is both necessary and sufficient for the purposes of rapid-response planning in contingency planning operations. The subsections presented below under theoretical requirements are all geared directly towards decision-support systems research, and help translate theoretical issues into design recommendations for a decision-support system taking into account the human factors related to risk, performance, and effectiveness.

3.5 Theoretical Requirements

Considerations of theoretical aspects that frame the dynamic complexity of rapid response planning were apparent in the literature. The following subsections attempt to bring out the most salient for this study.

3.5.1 Overcoming decision-making biases in military operations

Levitin [Levitin (2002)] demonstrated a few decades ago that individual decision-making processes and results can be severely biased towards suboptimal and even intuitive behaviours that cannot be rationalized. Such thought processes are in support of prospect theory. Prospect Theory is the original name of the research program developed by Daniel Kahneman and Amos Tversky (1979), pioneering the field of descriptive decision-making psychology. Descriptive decision-making research is to be contrasted with the traditional normative accounts of decision-making, the origins of which came from areas such as economics, mathematics, and philosophy, under the label of rational choice theory. Normative decision-making research was made of the conceptualization, formal modeling, and analytical framework through which individual agents and small groups were expected to obey very principled axioms and rules (hence the term normative), whereby agents strived for optimal payoffs in game-theoretical and other formalized problem scenarios. Human behaviour and cognition unfortunately do not follow necessarily the imperatives and strict conjectures of normative models, based on a number of phenomena that could not have been studied through the paradigm of rational choice theory and the classical economics of simple yet elegant utility functions.

Descriptive research on decision-making by individual agents and small groups has been investigated by Kahneman and Tversky with a focus on actual performance in decision problems by humans at odds with uncertainty and risk. They conducted a number of experiments to test every tenet of normative decision theory and found that they were often violated. Through this research, they revolutionized decision theory by putting their descriptive accounts directly at odds with rational choice expectations. Tversky and Kahneman found that human decision-makers are fundamentally biased in their assessments, choices, and preferences when it comes to the value of outcomes in wagers for example, and in situations involving risk and uncertainty [Kahneman m (1979)]. The research program is known as prospect theory, but has also spawned a whole paradigm in the experimental psychology of decision-making named “heuristics and biases”.

As stated above, contrary to rational choice theory (from philosophy) and classic utility theory (from economics), which are commonly referred to as **normative** decision-making theories, prospect theory is a **descriptive** approach to decision-making. This entails that attention is focused on actual performance and results from individuals in task environments, commonly experimental settings in cognitive psychology studies. Human decision-makers have been found to use heuristics (rules of thumb, simplest or quickest means to reach an end with whatever method is available) in the face of time-constrained problems and decisions, in a world that is actually far more uncertain and limiting than the artificial problems of the classic mathematical models of economics and philosophy.

A more pragmatic approach of concern here is the **prescriptive** approach to decision-making, which constitutes an effort to reduce the risk of biases for potential decision-makers in applied research. While there are indications that unbiasing is not entirely achievable, even given access to relevant information and choice outcomes, and that not even expertise prevents vulnerability to decision biases, any effort towards reducing the risks of decision biases is an effort towards reducing overall task risk.

3.5.2 Prototypes and exemplars categorization paradigms

The wealth of literature in cognitive psychology on categorization may help further refine the requirements for decision and planning support tools. Mulvehill, Callaghan, and Hyde (2002) promote a template-based, extensible mark-up system from which information can be extracted and shared between domains, software, and users. The end-user should have control over templates and ontology, so that it would be possible to modify and update databases or templates to encapsulate user knowledge. Even decision support system rules and operations should have some level of customization to account for doctrinal, operational, practical changes, etc.

This raises the question of the type of categorization needed in a decision-support tool. The Dynamic Decision-Making paradigm (i.e., the study of decision-making involving multiple, interrelated decision processes changing over time) suggests that instance-based learning (IBL) may provide a better framework to explain how decision-makers learn about and adapt to changes in their problem space [Gonzalez (2003)]. This can be contrasted with the prototype-based approach championed by E. Rosch and her supporters, which claims that category formation is based on approximating a best candidate representation of an entity and fitting novel instances to it [Rosch, E. H. (1973)]. The template approach of Mulvehill et al. (2002) could be said to be the practical equivalent of said prototype-based theory of categorization, while the instance-based learning of Gonzalez et al. (2003) corresponds to exemplars theory in the psychology of categorization.

Instance-based learning provides a more flexible framework to explain the assimilation of novel instances in areas such as decision-making and problem solving, based on factors such as its higher accuracy in explaining the formation of new categories. As hinted at in Gonzalez et al.'s paper and throughout the literature on categorization, there is a strong possibility that prototype and instance-based categorization are geared towards different situations, and thus constitute domain- or problem-specific heuristics. It may turn out that a model of template-based decision-support system design would provide necessary and sufficient conditions for all of a given problem space, but for complex, rapidly changing, and uncertain decision-making, the addition of instance-based learning may provide an opportunity to complement and enhance the template approach by supporting automatic category generation and a better fit in information retrieval.

3.5.3 Distributed cognition

The concept of Distributed Cognition (DC) is introduced in the article Characterising User Interaction to Inform Information- Fusion-Driven Decision Support [Nilsson, M (2008)], where "systems are based on fused information from different resources such as sensors, humans, databases…both automatic and semi-automatics…consist[ing] of different transformations of representational states mediated by technology and humans". As the increase in information alone does not contribute to better decisions, interaction between various systems and humans is required to use the information in a meaningful manner. Tools and technology work in tandem with humans to support the information fusion process. For example, sensors as aids in information collection, and algorithms by assisting the process of creating new knowledge in evidence-based environments such as emergency response by asking the right question, pursuing the unknown and making discoveries, can reduce the complexity and frequency of user-tool interaction. In addition, lower tech tools such as templates, can also assist by providing methods that allow users to manage the data that they are collecting [Mulvehill, A., Callaghan, M., and Hyde, C. (2002)]. However, these tools don't replace the user, they facilitate decision making while increase the importance of cognitive engineering and user interaction with decision support systems as is presented by level 5 of the JDL model (see section 3.5.5 below on user interface).

3.5.4 Deductive Reasoning

Nonmonotonic logic is the study of those ways of inferring additional information from given information that do not satisfy the monotonicity property satisfied by all methods based on classical (mathematical) logic [Kraus (1990)]. In terms of Air Force rapid response planning, human decision makers will draw conclusions from what is known with the knowledge that, when presented new information, previous conclusions may become invalid.

3.5.4.1 Defeasible Reasoning

Reasoning is defeasible when the corresponding argument is rationally compelling but not deductively valid. In other words, the relationship of support between premises and conclusion is a tentative one, potentially defeated by additional information [Koons (2009)]. Defeasible reasoning is similar to hypothesis setting. By definition a hypothesis is a statement expressing a concept that may be either true or false as a means to explain some relationship or behaviour made on the basis of limited knowledge or evidence as a start point for further investigation. From this we can see that as additional facts and knowledge are uncovered, the hypothesis may be discarded or become so accepted that it essentially becomes “fact”.

3.5.4.1.1. Propositional Logic

One area that was explored for Air Force rapid response planning purposes was propositional logic. Propositional logic is a formal system representing the relations between propositions, i.e. between premises and conclusions (such relationships are called inferences). Defeasible logic and non-monotonicity are expressed commonly through the propositional logic model. Planning in propositional logic form tests the satisfiability of a statement (“propositional content” in the field of logic) by representing the conjunctions of initial states, all possible action descriptions, and goals for truth satisfaction. Planning goals for which a set of such actions does not lead to a validation of the propositional logical form are considered to invalidate the model which was thus represented. In the case of an unsolvable planning problem, the propositional logical form of the statement is unsatisfiable. Propositional logic is also known as sentential logic and statement logic. It is the branch of logic that studies ways of joining and/or modifying entire propositions, statements or sentences to form more complicated propositions, statements or sentences, as well as the logical relationships and properties that are derived from these methods of combining or altering statements.

3.5.5 Divergent/Convergent Quality of Creative Problem Solving

Creative problem solving can be seen as a three phased pattern of decision making that includes a cyclical divergent/convergent process in a planning environment once the problem has been defined. Creative problem solving is strengthened by a series of divergent and convergent emphasis as the problem solver goes through each phase of problem solving, which also may include reformatting the problem definition. Both intuitive and analytical techniques come into play to support divergent (intuitive) and convergent (analytical) processes [Couger (1994)].

Convergent and divergent thought processes are the product of studies concerning human intelligence measurements and problem-solving strategies. Guilford (1967) and Hudson (1967) are two such pioneers on convergent and divergent thinking. While attempting to broaden and extend the scope of the psychometrics of human intelligence measurements, Guilford's Structure of Intellect theory posited that intelligence should be measured across different dimensions such as operations, contents, and products [Guildford (1967)]. It is among the first dimension, operations, that convergent and divergent thought processes are found. Convergent production is the ability to deduce a solution for a given problem, by following rules in a strict, analytical process. Divergent production is the ability to draw on multiple sources of information and perspectives in order to provide multiple solutions to a given problem, in a synthetic and creative fashion. The two abilities are complementary and have their strengths and weaknesses given the type of problem to solve and context in which one finds himself or herself. For instance, a convergent production is best advised when dealing with formal and logical problem-solving, or when one is confronted to a familiar problem scenario, to apply already-known types of answers. A divergent production is preferable when rote knowledge and memory is insufficient to tackle a certain problem area, with open-ended and complex outcomes. Brainstorming could be conceptualized as a divergent thought process, where an unorganized, intuitively chosen number of solutions or venues are explored in turn or as a whole, by contrast between themselves and by making unexpected connections, to be investigated with further scrutiny with a more stringent and analytical outlook (a convergent production) in the aftermath.

By creating and organizing ideas in an exploratory fashion such as using lists of questions, mind and concept maps, and brainstorming, a wider and more flexible number of solutions may be derived from a problem space where variables and interactions are initially constraining possible solutions. Another way of framing the distinction between convergent and divergent thought processes is that of solution-oriented vs. goal-oriented design in a problem-solving or planning scenario. Whilst looking for solutions to tackle a problem, based on facts and rules, may be an obvious way to find the best possible outcome, thinking in terms of goals, and conversely exploring a possible set of alternative solutions to meet such goals, may be warranted by more open-ended or complex problems [Gardner (1999)].

Medonça and Hu [Medonça (2008)] recently investigated convergent and divergent thought processes with regards to simulated emergency situations involving group decision-making. Variables under scrutiny were severity and time pressures, and their impact in terms of quality and depth of convergent and divergent thought processes involved in group decision-making. They found that the level of severity of the emergency scenarios did not have an impact to the depth and extent of convergent and divergent thinking in decision-making and problem-solving. Also of interest is that participants maintained a level of effort that was consistent even under more serious time pressures, which raises even more questions on the impact of time pressure on the interactions between cognition and decision processes, according to the authors. Another relevant paper from Culvenor [Culvenor (2002)] investigated the contrasts between individuals and group decision-making processes and outcomes in health and safety scenarios. The author found out that consensus judgment in groups was better than individual average ratings, when participants were first asked to rank solutions to safety problems by themselves, then they were asked to repeat the exercise in groups to reach a consensus. The results suggested that generating ideas might best be achieved individually pre-emptively, from which group decision-making concerning safety and emergencies then benefits from group consensus.

The three phases of creative problem solving thus include:

3.5.5.1 Problem definition

The bulk of the creative steps of analysing and synthesizing in problem solving are begun after the definition of the problem has been established. However, "some facts will need to be acquired and assessed before the problem definition can be developed" [Couger (1994)]. Lyles and Mitroff define problem formulation as a series of three steps: 1) sensing the existence of the problem, 2) identifying the contributing factors, and 3) reaching a problem definition [Lyles (1980)]. Biases and the compartmentalisation of knowledge at this stage may adversely influence the problem definition. Therefore, structure can be provided to ensure that the task is completed effectively, but, at the same time, an "unstructured" view of the problem and all its circumstances should be maintained in order to not confine its definition so narrowly as to sub-optimise" [Couger (1994)].

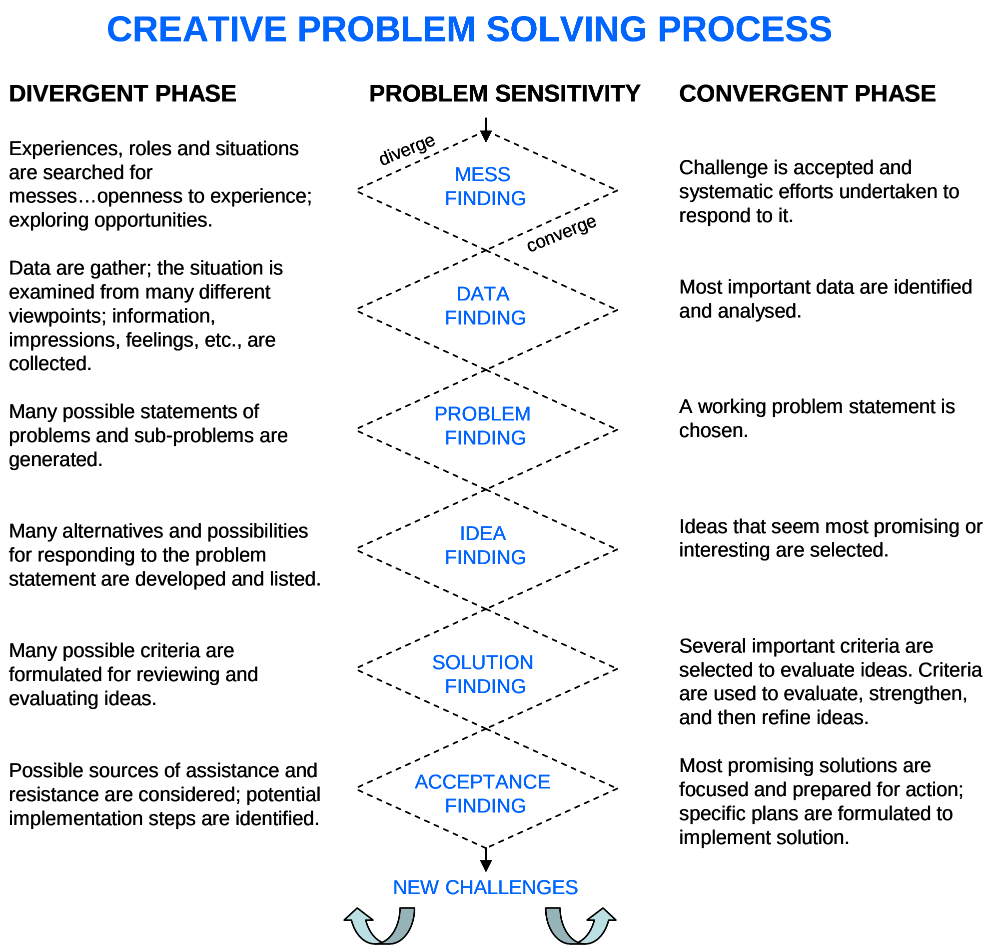
3.5.5.2 Divergent thinking

Expanding the range of options is critical for creative problem solving. Divergence activities such as brainstorming at the start of a problem solving step allows the problem solver to consider various new levels of abstraction and expand the range of the solution set [Couger (1994)]. However at some point, the usefulness of divergent thinking provides diminishing returns and the focus has to be put on the optimal solution as the "good idea cut off point" is reached.

Despite that a large portion of the planning process is determining the realm of the possible, there are inherent constraints on divergent thinking. For example, the extent of this creative, "what can we do" element is determined by the timeline for response. These issues get addressed through convergent thinking as the focus is changed to arrive at an optimal solution.

3.5.5.3 Convergent thinking

Convergence on the best solution is a critical element in problem solving. Convergent thinking identifies the most appropriate option from a wide range of possible solutions. However, analysing a mass of data to determine which are significant for the problem at hand can be a daunting task. Employment of systematic and evaluative techniques assists with weighing all the measures by rating and ranking. Statistic analysis and linear programming are tools that have traditionally helped with convergence. Tools such as simulation are also useful to help when there is incomplete information and assumptions have to be made and help to identify possible scenarios as well as narrow down possibilities [Couger (1994)].



Source: Isaken, S.G. and D.J. Treffinger, Creative Problem Solving: The Basic Course (Buffalo N.Y.: Bearley Ltd., 1985), p.16

Figure 4. Creative Problem Solving Process

3.5.6 Multi-disciplinary research and design

Design approaches that step away from a purely quantitative, software engineering technical methodology are deemed necessary in the domain of complex system decision support, which includes rapid response planning. Integration of efforts to support qualitative research and software engineering principles are demonstrated in [Klashner, R. and Sabet, S. (2007)]. Their research findings suggest that broader and more integrated approaches are necessary to counteract a great deal of the complexity associated with complex domains.

In addition, Gadomski, A. M et al. (1998) put forth a parallel bottom-up and top-down development solution, which demonstrates how bottom-up design and top-down constraints can be combined in a complementary fashion for achieving a more desirable

DSS solution. Their research efforts have determined that “parallel bottom-up and top-down development of a generic IDSS kernel, supported by intelligent multi-agent architecture enables:

- various real-time specialization of the system on the level of tools,
- strong reduction of the design time by parallel execution of project phases, and
- easier verification and validation of the system as independent tasks”.

3.5.7 Recognition Planning

The current emphasis on joint operations (both internal to the military across environments as well as externally including partnering with OGDs) requires planners to collect more data and to involve more stakeholders and subject matter experts in a distributed, collaborative net-centric environment intended to enable shared situational awareness for rapid decision making.

In 1989, Gary A. Klein, Roberta Calderwood, and Anne Clinton-Cirocco presented what they called the RPDM model, which describes how decision-makers can recognize a plausible course of action (COA) as the first one to consider [Klein (1989)]. When faced with a decision, humans use their intuition as they detect clues and search for patterns based on previous experience and personal knowledge. Applied in the military context, a commander’s knowledge, training, and experience generally helps in correctly assessing a situation and mentally wargaming a plausible COA.

Klein’s model illustrates that rather than taking time to deliberately and methodically contrast it with alternatives using a common set of abstract evaluation dimensions, the commander will run an initial COA through a mental simulation determining how it would play out using his knowledge and experience. Furthermore, their work indicates that skilled decision-makers usually develop a good COA on their first try and that intuitive decision processes usually result in higher performances. Following studies conducted by John Schmitt and Gary Klein with the US Army suggested that the traditional CF OPP process that requires generating and evaluating at least three candidate COAs was less productive and less effective than the going with the first COA proposed by experienced decision-makers [Schmitt (1999)]. From this work, Schmitt and Klein developed the Recognition Planning Model (RPM) to codify the informal and intuitive planning strategies employed by skilled Army and Marine planning teams.

Rather than trying to replace the doctrinal CF OPP (referred to as the Military Decision Making Process (MDMP) in the US Army), Schmitt and Klein adapted it to implement the way planners actually work, hence the RPM does not seem strangely different to planners who reported “We’re already doing this” [Schmitt (1999)]. The RPM approach is for commanders to identify their preferred COA so the staff can work adding details and improvements. It found that the RPM yielded an improvement in planning tempo of about 20 percent [Ross (2004)]. Traditionally, once a unit receives a mission from higher headquarters, the commander and staff try to understand the mission while deciding how to proceed. Identifying a baseline COA early will therefore result in enhancing mission analysis.

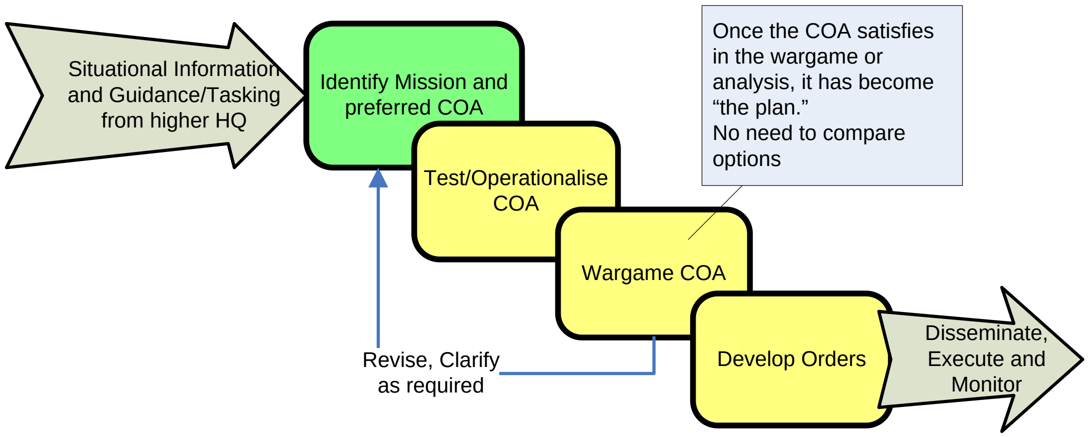


Figure 5. *Recognition-Primed Decision Model [Ross (2004)]*

The baseline COA could be a standing CONPLAN that provides a reasonable match to the Commander's Intent[3] for the mission. The intent of CONPLANS is to prepare them for future use at a time when careful analysis and planning can be done rather than in the heat and pressure of the immediate situation and contain the inclusion of lessons learned in a more analytical, unhurried manner. A CONPLAN can therefore take advantage of time and experience which may not be readily available at the time of the crisis. There is a good match between the intent of preparing CONPLANS, based on experience and strategic planning for future possible events, and the RPM.

3.5.8 Time constraint variance

The dynamic environment of rapid response planning and its varying degrees of time constraints has given rise to two discrete conceptual approaches to decision making: proactive and reactive. These two conceptual approaches give rise to two different requirements for information and knowledge management.

In application, these two concepts are presented in the US Joint Operation Planning Process (JCF OPP) [National Defense University, (2007)]. The JCF OPP presents a planning process that considers both proactive and reactive planning. Proactive planning, planning that is intelligence-driven, is *contingency planning*. Reactive planning, planning that is event-driven, is *crisis action planning*. Within the JCF OPP the planning process for both are the same, though different products are produced. Contingency Planning supports Crisis Action Planning (CAP) by anticipating potential crises and operations and developing contingency plans that facilitate execution planning during crises. CAP activities are similar to Contingency Planning activities, but CAP is based on dynamic, real-world conditions vice assumptions. CAP procedures provide for the rapid and

[3] A commander's intent is defined in terms of the goal and the end state. The goal is what the military campaign is expected to achieve. The end state is what the conditions are expected after the military campaign is over.

effective exchange of information and analysis, the timely preparation of military COAs. These concepts can take on a different dynamic during the course of an operation as the situation may require elements of both proactive and reactive decision making as events unfold. Integration of these different approaches for decision support is a challenging problem in a dynamic environment such as emergency response/military operational planning.

3.5.8.1 Reactive

Reactive systems have been defined by Harel and Pnueli as systems that are supposed to maintain an ongoing relationship with their environment, their behaviours being reactions to external stimuli [Jia (2005)]. Thus, the role of reactive systems is to react continuously to external inputs by producing outputs.

In many emergency response environments, decision making occurs as the event occurs and is based on how the event is unfolding. When time is at a premium, a decision support system should be able to provide information that utilises a C4ISR feedback loop that would enable the decision maker to arrive at a solution quickly (i.e. enabling reactive decision making).

3.5.8.2 Proactive

Proactive doesn't mean stepping in harm's way, but rather taking positive steps to raise the level of preparedness and to enhance the speed and decisiveness of a response mechanism. The key to being proactive is in gathering and sharing intelligence and responding in a coordinated manner, addressing any ambiguity while arriving at agreed upon plans.

Although the civilian emergency response process is traditionally event-driven, there is a current thrust in leveraging the military intelligence-driven tools and methodologies to provide for intelligence-driven decision making when time is less constrained. As the dynamics change and present an opportunity for proactive decision making, decision makers can leverage decision support systems that enable the them to drill down through layers of details (i.e. decision trees) and use M&S tools to help anticipate and establish plans (i.e. enabling proactive decision making).

3.6 Technological Context

The literature review included documentation on tools and techniques that are both currently in use and under development. Factors such as the approach to the development of technologies as well as the advancement of technologies were discussed. Three thrusts were demonstrated. The fact that:

1. new technologies are being developed (transformational technologies);
2. changes in technologies make existing tools more accessible and new combinations of existing technologies possible; and
3. tool application can transcend the domain for which they were developed.

While technological advancement may have an enormous impact on planning processes as new tools may reveal the answer to long standing questions, a re-look at tools already developed is of merit. Sometimes the information we need is the synthesis of two or more previous functional relationships, creating a solution embedded in a new complex functional relationship or demonstrating some new functional relationship.

3.6.1.1 New technologies

The decision-making process has grown more complex in recent years with the increased complexity of information management brought about by the rapid growth of access to information via the internet and communications systems. Counter-balancing the increased complexity is the increased CF opportunities for decision support tools. "The combination of artificial intelligence, operations research and data mining techniques to mention a few, and web-based and information technologies, offer a great opportunity to address new planning system design and integration requirements" [Boukhtouta (2004)].

3.6.1.2 Changes in technologies

Technological advancement does not come from new technologies alone. Technology changes make tools more accessible and the consideration of new combinations of existing technologies possible. Thus both the adoption of and the improvement of technology can stem from changes that occur external to a specific development program.

For example, situational awareness for crisis planning has evolved considerably in the last several years due to the advancement of technologies that make older technologies more accessible either economically or technologically. "Major factors in this development have been the emergence of a new suite of technologies that allow near real-time imaging of disasters and the integration of these technologies with sophisticated decision-making software tools" in configurations that are affordable and manageable within the confines of specific environments (i.e. an emergency operation centre/control room) [Mehrotra, S. et al (2004)].

In addition, technological advancement has made new combinations of existing technologies possible. For example, due to technologies that increase bandwidth, we are now able to access Geographic Information Systems (GIS). GIS has evolved from a mainframe to a desktop-computing environment, easing its integration into IT infrastructure to support decision making in emergency operation centre/control room environments [Mehrotra, S. et al (2004)].

3.6.1.3 New application of technologies

Technologies developed for one domain can often be relevant to another. Another aspect of technology application is re-use in a similar environment. This study uncovered a number of these applications that are relevant to rapid response planning. For example:

- scheduling techniques [Guitouni, A. and Belfares, L. (2008)];
- workflow management [Mak, Hing-Yin et al. (1999)];
- information discovery and knowledge management software [Oak Ridge National Laboratory (year unknown)]; and
- manufacturing supply chain logistics planning [Sheremetov, L.B., Contreras,M, and Valencia, C. (2004)].

3.7 Technological Requirements

The complexities of this dynamic, distributed and collaborative environment as presented above require unique approaches to decision support solution development. A variety of tool features and development considerations were observed in the literature. These are presented in the following subsections.

3.7.1 Modular

Tools developed to manage information in modular format permit the incorporation of data relevant to a wide variety of scenarios including threats, environmental factors, geography etc, enabling the application of the technology in multiple areas of operations (AOOs). For example, the RODOS system has been developed so that models and data bases can be customized to different site and plant characteristics and to the geographical, climatic and environmental variations in Europe [Raskob, W. and Ehrhardt, J. (2000)]. In a similar vein, in their discussion of Intelligent multi-agent support for the contingency management system, Sheremetov et al. promote modular frameworks as “decomposition of the large system into smaller knowledge-based units associated with knowledge sources reduces the system’s control complexity and results in a lower degree of coupling between components [Sheremetov, L.B., Contreras,M, and Valencia, C. (2004)].

Services-oriented architecture (SOA) is based on reusable building blocks called business services, enabling a very adaptive and modular system, promoting agility within an organisation with a focus on business processes rather than technical components. The ability to operate through a SOA platform is valuable to rapid response environments as they allow a greater degree of modularity and interoperability [Schoenharl, T et al. (2006)].

The SOA permits the design of an architecture within which components participate on-demand only. The later is technically useful for very complex systems which is made of a set of specialized tools and makes it easy to scale down complexity for earlier development phases like a proof-of-concept. SOA technologies can also help manage the problem of how legacy applications, built on disparate technology platforms, talk to each other. They can provide a means by which legacy systems participate in end-to-end business processes without major internal rework, prolonging the life of existing assets.

In this environment, software applications can be built as collections of collaborating services that interact without regard to each other’s platform, data structures, or internal algorithms. Technology, such as web services, support interoperability, enabling a business system with underlying services that require only a minimal knowledge of each other.

3.7.2 User Interface

In their discussion of the JDL, [Blasch, E and S. Plano (2002)] highlight the importance of refinement in any fusion model which gathers information. Sensor data that acts in continuous collection mode can easily become useless through information overload. Human involvement contributes to alleviate this problem by intelligent decision making and selective attention. The authors suggest that the optimal approach to Information Fusion is one where human and machine work together in a continuous cycle (e.g., the machine reduces and provides relevant information, and the human interacts with the system to further refine which information to gather or enhance).

For example, the MERMAIDS project [Nten, Celestine, A. (2004)] describes the application of cognitive engineering methods to the design and analysis of a decision support system for training of C2 functions in emergency response organizations and documents a survey of decision support systems conducted for the project. The project found that most of the existing decision support systems for emergency management are based on restricted context applications and ad hoc simulation techniques, and determined that "the common thread in the surveyed decision-support systems was the lack of a computer interface that allows users the access to the right information in the right context and time" [Nten, Celestine, A. (2004)]. The MERMAIDS system takes the importance of the human-computer interaction to the next level by embedding metrics for measuring human operator performance within the application.

Much attention in the NATO DSS TOPFAS has been placed on a Planning Wizard to address this need. The TOPFAS Planning Wizard guides usage of the tool through the planning process [NATO (2006)].

3.7.3 Accessibility

Tools that are high cost in terms of personnel and deployment (i.e., PDAs and wireless infrastructure that must be purchased, personnel trained and both need to be sent to crisis sites) are not as valuable as low-cost, highly available systems (see review on Schoenharl, T et al. (2006), WIPER: A Multi-Agent System for Emergency Response).

Web-based applications are one such example as a facilitator to distributed, low footprint solutions that are accessible using a hand held PDA or mobile phone, laptop or stand alone computer. The technology encourages collaboration across the strategic, operational and tactical levels as well as with external OGD and allied partners due to its ease of access.

3.7.4 Data push and pull

"By definition, "wicked" problems, such as those often encountered by rapid response planners, do not have solutions, only best possible resolutions" [Klashner, (2007)]. The ability to operate in a world of incomplete information demands the ability to both push and pull data, enabling a higher utility for the user. With this functionality, planners then interact with the information, providing a greater degree of clarity with the ability to not only receive but to retrieve as well. Many emergency management tools, such as WIPER, have been developed to support this functionality [Schoenharl, (2006)]. An enabler of data push and pull is Service-oriented architecture (SOA). SOA is discussed in the next subsection.

3.7.5 Service Oriented Architecture

NATO standards policies require technologies and approaches for enabling interoperability across a wide spectrum of political, geographical, and organizational levels, e.g. coalition, federal, state, tribal, regional, non government, and private. "Global Interoperability Using Semantics, Standards, Science and Technology" (GIS3T) is a concept that is predicated on the assumption that the semantic integration, frameworks and standards that support information exchange, and advances in science and technology can enable information-systems interoperability for many diverse users [Watersa (2009)].

Service Oriented Architecture (SOA) is a tool that addresses this requirement. SOA is based on reusable building blocks called business services, enabling a very adaptive and modular system, promoting agility within an organisation with a focus on business processes rather than technical components. In this environment, software applications can be built as collections of collaborating services that interact without regard to each other's platform, data structures, or internal algorithms. Technology, such as web services, support interoperability and enables a business system with underlying services that require only a minimal knowledge of each other.

The SOA permits the design of an architecture within which components participate on-demand only. The later is technically useful for very complex systems which is made of a set of specialized tools and makes it easy to scale down complexity for earlier development phases like a proof-of-concept. SOA technologies can also help manage the problem of how legacy applications, built on disparate technology platforms, talk to each other. They can provide a means by which legacy systems participate in end-to-end business processes without major internal rework, prolonging the life of existing assets. The ability to operate through a SOA platform is valuable to rapid response environments as they allow a greater degree of modularity and interoperability [Schoenharl, (2006)].

3.7.6 Information Abstraction

Whether it be filtering in order to display the most useful information in simplified models in an adaptive fashion using fuzzy mining [G¨unther (2007)], or the ability to retrieve information incrementally as a situation or a person's knowledge base dictates, tools providing an ability to deal with information in non-standard ways reflects real-world decision making. Addressing the latter, DCAPES presents data in such a way that the user can drill down for added complexity in areas that required as the scenario dictates. For example, first it can tell you what pallets are on a truck, and then it can tell you the inventory of what is actually in a pallet by accessing further levels of detail [Gullett (2003)]. The MERMAIDS system is useful in presenting emergency planning scenarios at various levels of information complexity as manifested in emergency courses of action (COA) planning, analysis, and execution [Nten (2004)].

When considering the information requirements of the rapid response planning process three distinct types of data exist:

1. Real time, or live "situational awareness" information such as data from other interoperable communication systems [Department of National Defence (2005)], or status current assets & utilization data [Lawlor (2001)]

2. Distilled or processed information stored in a database in a meaningful manner [Nilsson (2008)] such as aircraft performance, maintenance schedules, political structure, leaders, and contact information. Information stored in databases is easier for computer system analysis, interpretation, and synthesis of situational information.
3. Natural language information such as:
    a. News reports
    b. Operational procedures an plans from other agencies
    c. Relevant documents such as “lessons learned”, or CONPLANS.

    Besides textual documents, this category would include video or audio communications [Da (2007)].

    This type of information/data contains more “subjective info” [Nilsson, M (2008)] that is harder for computer algorithms to interpret. The Institute for Human-Machine Studies shows that it is possible to “distill” such information, and extract meaningful information. [Nten (2004)].

3.7.7 User Customisable

Tools may provide information, but expert operators must still interpret the information: “IS can obviously process the huge volume of domain data, but only a fraction of the needed information exists on computers; the vast majority of a firm’s intellectual assets exist as knowledge in the minds of its employees” [Klashner (2007)].

The requirement for flexibility in the operational context drives the need for an ability for the user to have control over aspects of the rule-sets that drive the decision support tool analysis, being able to adapt the rule sets, and suppress certain rules to optimise solution space. For example, in Tracker, a template tool, the flexibility in its application includes the ability of planners to author a plan as they like, linking the elements of the plan to the sources and applications that they find useful for their work [Mulvehill (2002)]. Another example is discussed in Gadomski, A. M et al. (1998), in relation to user defined scenarios and associated emergency procedures.

Another element that can be adapted with user input is the user interface. The DCAPES system uses permissions and privileges tools to restrict planning data to those with a need to know [Gullett (2003)]. Similarly, the RODOS system has a number of interfaces that are defined by the level of interaction of the user with the information [Raskob, (2000)].

4. Investigation

The information gathered during the literature review was analyzed in terms of the application of a standing CONPLAN to a new immediate contingency operation and the development of the associated Air Force rapid response Op Plan. This section will:

1. identify the information elements that contribute to CONPLAN development,
2. present a process model in the format of a DoDAF Operational View 5 Activity Model product,
3. discuss three key drivers of the Op Plan development process for rapid response,
4. identify operational requirement priority areas; and
5. summarise the planning process in generic modules.

This section will assist in focusing the discussion of CADTTAPs for the conceptual roadmap in the options analysis.

The following definitions will facilitate the understanding of this discussion and clarify terms that can be confusing to the reader:

Standing CONPLAN – Standing contingency plans that are developed to have on hand for anticipated missions

Op Plan – the Op Plan is the specific operation plan for a mission. The Op Plan can be updated and

Op O - An Op O is the legal authority to conduct the operation and is the output of the Op Plan development process. The Op O is the medium currently in place for communicating the Op Plan.

4.1 Role of CONPLANS

Contingency planning includes planning activities that occur in non-crisis situations. The CF uses contingency planning methodology to develop operation plans for a broad range of contingencies based on requirements identified in planning directives. Standing CONPLANS support rapid response planning in crisis situations by anticipating potential crises and their associated operational requirements and developing CONPLANS that then facilitate the execution of an Op Plan in time constrained environments. The ability to re-use existing plans (standing CONPLANS) may demand significant inputs and updating to ensure the plan is sufficiently modified to match a current situation and requirements to turn it into the Op Plan for a specific rapid response immediate contingency operation.

4.1.1 CONPLAN Analysis, and breakdown

Examples of developed national standing CONPLANs are considered sensitive in nature, and are therefore not available for public distribution. From analysis of an unclassified standing CONPLAN and previous experience of team members, the following information elements are typically addressed in CONPLANs:

1. Event Impact
   1.1. What happened
   1.2. Who is effected
   1.3. Why is assistance requested / desired
2. Reporting structure
   2.1. Who is commanding mission
   2.2. Who is the ultimate customer
3. Assumptions
   3.1. Reasonable aspects of the operation
      3.1.1. e.g. Military relief operations will take priority over commercial ventures
      3.1.2. Expect de-graded communication systems
4. Execution
   4.1. Timelines
      4.1.1. Starting
      4.1.2. Timely replacement/roster shift
         4.1.2.1. Immediate response
         4.1.2.2. Sustained response
         4.1.2.3. Re-deployment
      4.1.3. Ending
   4.2. Boundaries
      4.2.1. Areas of operation
      4.2.2. Areas of interest
      4.2.3. Areas of responsibility
   4.3. Sections
      4.3.1. Which sections involved
      4.3.2. What resources from which sections
      4.3.3. Who to communicate with
      4.3.4. ...be prepared to... future task expectations
   4.4. Service support
      4.4.1. HQ Locations
      4.4.2. Command and Signals
         4.4.2.1. Command & control concepts
      4.4.3. Maintenance Support Concepts
      4.4.4. Movement support
      4.4.5. Airfield engineering support
      4.4.6. Logistics support
5. Supporting documentation
   5.1. Reference to other CONPLANS
   5.2. Contact information
      5.2.1. Organization
      5.2.2. Name
      5.2.3. Phone
      5.2.4. Rank
      5.2.5. Duties

5.2.5.1. Logistics
5.2.5.2. Public Affairs
5.2.5.3. Air traffic services
5.2.5.4. Intelligence
5.2.6. Location
5.3. Suggested reporting structure
5.3.1. Evolving support structure during the phases of the operation.

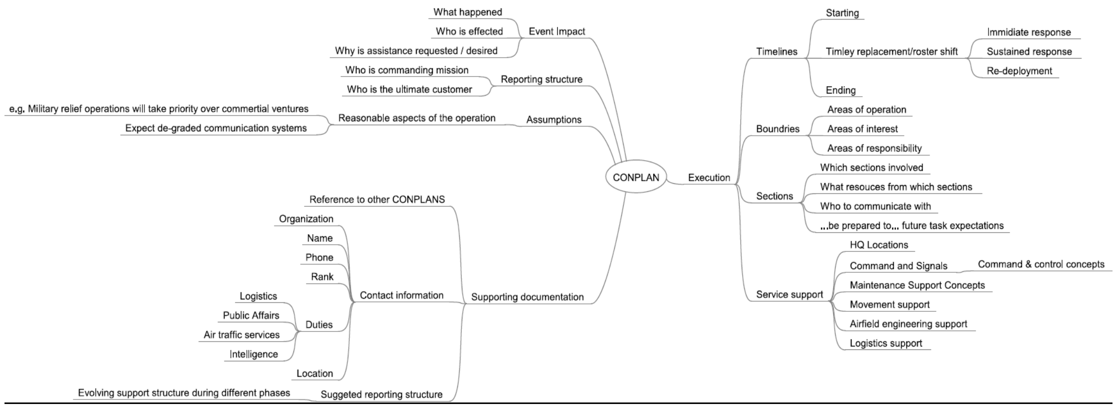


Figure 6. *Standing CONPLAN Breakdown*

4.1.1.1 Aspects and considerations when creating an Op Plan

The stated intent of the CF OPP is to facilitate collective reasoning and synchronize activities across all levels working toward a common goal. From a very general perspective, military planning is based on a desire to move toward some future circumstance, defined by Government as being in the national interest.

The key questions to be answered through any planning process are indicated below, and are denoted as mechanical, creative or collaborative processes (adapted from [NATO (2006)], [DND (2005)] and SME professional knowledge):

1. What is the current or projected undesirable situation to be avoided? (mechanical / creative process)

2. What has or will cause it to develop? (creative process)

3. What is the alternative targeted desired outcome? (mechanical / creative process)

4. What sort of interventions or actions could move the current situation toward the desired outcome? (collaborative/creative process)

5. Are there any specific assigned tasks? (mechanical process)

6. What are the implied tasks? (mechanical process)

7. Are there any associated critical subordinate tasks? (mechanical/creative/collaborative process)

8. What capabilities would be required to complete these tasks? (creative/collaborative/mechanical process)

9. What are the imposed timelines for initiating the tasks? (creative process)

10. What capabilities are currently available? (mechanical process)

11. What capabilities could be made available within the imposed timelines? (mechanical/creative process)

12. What would be the implication(s) of re-rolling or re-tasking those capabilities? (creative/collaborative process)

13. What is the recommended course of action that provides the optimal balance between achieving the desired outcome while assuming the minimum risk? (creative process)

14. Based on the selected course of action, ensure the required capabilities are allocated, organized, assembled and delivered to the location where they are required. (mechanical/creative/collaborative process)

If we apply the general sequence of questions above to Air Force immediate contingency planning there are several general strategies that could be used to ensure the most complete consideration of all planning factors affecting the probability of success of the approved Op Plan and Op O in meeting the assigned strategic objectives (adapted from [NATO (2006)], [DND (2005)] and SME professional knowledge):

1. Increase the available time by:
    a. Earlier initiation of planning activities from HQ (Canada Command (CanadaCOM), Canadian Expeditionary Force Command (CEFCOM) or Canadian Operational Support Command (CANSOFCOM)) to 1 CAN AIR DIV by either[4]
        i. Formal means of
            1. Planning order
            2. Warning order

[4] Note that this is outside the control of the Air Force but within the solution space for this discussion

3. Strategic direction

ii. Informal means of

1. Provision of government assessments of developing situations of national interest to 1 CAN AIR DIV

2. Sharing of related government discussions regarding potential interventions

b. Provide proactive informal initiation by Commander 1 CAN AIR DIV by

i. Specific targeted RFI seeking updates to understand evolving situation and implications for Canada

ii. Direct increased liaison by staff with HQ align collective thinking on potential intervention strategies

iii. Inform subordinate Commanders of potential tasking (including possible subordinate taskings to them)

iv. Monitor and confirm Air Force capability readiness status

2. Accelerate and increase the flow of available information

a. Educate and train staff members on the concept and implementation status of an Air Force common information environment

i. what information is currently resident and available in existing databases

ii. how to access the data and

iii. how to manipulate the data to meet their specific planning needs

b. Increase and expand the use and confidence of currently reported Air Force capability readiness levels with respect to

i. Equipment including all aircraft fleets and supporting AMSE

ii. Personnel including

iii. Logistics support

3. Identify the requirement for new information to support a shift in current tasking priorities to accommodate an immediate contingency operation such as

a. What assets that could meet the operational requirements of the potential or assigned tasking are currently engaged in non-discretionary activities (must be pre-defined to be optimally effective examples being NORAD or Search and Rescue (SAR) commitments, theatre support to International Security Assistance Force (ISAF)

b. What assets are currently engaged in discretionary activities (i.e. training)?

c. What would be the recall time of those assets current engaged in discretionary activities (within the constraints of the immediacy of the situation)?

d. What would be the downrange cost with respect to overall capability readiness (what would be the downrange risks related to recall and re-tasking of the assets)?

4. Automate key elements of current activities and "business rules" of the current planning process in an attempt to provide a decision support tool to:

a. identify gaps in current knowledge and facts or critical assumptions in use;

b. permit of knowledge gaps and assumptions to HQ and subordinate units that may have additional pertinent information;

c. dynamically generate recommended COAs as a function of available information and various prioritizations of risks;

d. permit transparency to HQ and subordinate units of most current intermediate planning outputs;

e. support & logistics resources & planning;

f. maintenance schedules for current operational fleet and forecasts for new deployment duties for the entire unit, not just individual entities; and

g. risk factors such as weather, geography, political/social aspects.

5. Familiarise the use of vertical and horizontal automated channels of communication for universally required information elements to build confidence in the outputs and permitting focussed attention on non-standard time-critical information requirements necessary for planning immediate contingency operations such as

a. New C2 structures (chop to Force employer);

b. Relationships with non-military partners (supported or supporting);

c. Potential forward deployment basing considerations;

d. Establishments of new (ideally integrated) lines of communications; and

e. Exit strategy. This would ideally include probabilistic consideration for the next deployment.

This discussion illustrates how, with effective collaborative decision support, it is possible that when humans and computers collaborate, they can arrive at decisions that are superior to the ones determined independently of the other. An unfortunate aspect of decision making is that early on in the process 80-90% of time is spent by organising and collecting data (clerical tasks) in order to gain insight and make decisions (cognitive tasks). The origin of the internet was to provide significant computer power to do the clerical tasks as a decision support tool as it was realised that decision making is easy if data can be organised. Attempting to organise the data and automate clerical tasks (i.e., presenting information in a graph or co-relating information, etc.) to facilitate decision making is key to DSS development. In other words, it is the functionality of decision support, not decision making, to rapidly organise and compile information to *prepare the commander to make the decision*, not the tool to make the decision. In this way, the tool is being used for deterministic tasks allowing humans to look at anomalies, etc. Adopting this strategy pairs two skill sets of the human and the computer to realise the benefits of the strengths of both, overcoming the inherent human weakness that the human mind cannot program as much info as much as a well structured computer program.

4.2 Operational View 5 (OV-5) Operational Activity Model

The Department of Defense Architecture Framework (DoDAF) Operational View 5 (OV-5) Activity Model was developed to support the investigation and options analysis of section 4, and is discussed further in section 6 to provide components of a storyboard. The activity model captures the planning process and associated SOP activities, resource visibility, collaboration partners and influences, risk management and time constraints. The OV-5 activity model facilitates the discussion of both the *as-is* and *to-be* processes of the Air Force rapid response planning environment at a high level.

The OV-5 Operational Activity Model is described by DoDAF as the following [Department of Defense (2004)]:

1. Product Definition. The Operational Activity Model describes the operations that are normally conducted in the course of achieving a mission or a business goal. It describes capabilities, operational activities (or tasks), input and output (I/O) flows between activities, and I/O flows to/from activities that are outside the scope of the architecture. High-level operational activities should trace to (are decompositions of) a Business Area, an Internal Line of Business, and/or a Business Sub-Function as published in the US Office of Management and Budget (OMB) Business Reference Model[5].

2. Product Purpose. OV-5 can be used by the analyst to:

- Clearly delineate lines of responsibility and authority for activities when coupled with OV-2 (Operational Node Connectivity Description) view;
- Identify related activities with dependencies and interdependencies;
- Uncover unnecessary operational activity redundancy;
- Make recommendations on streamlining, combining, or omitting activities; and
- Define or flag issues, CF opportunities, or operational activities and their interactions (information flows among the activities) that need to be scrutinized further.

[5] For more in depth information, see US Office of Management and Budget, Business Reference Model, June 2003. http://www.whitehouse.gov/omb/egov/documents/fea-brm2.PDF

4.2.1 OV-5 Elements

The focus of the OV-5 activity modelling effort was to gain an understanding of the role and activities performed by Air Force operational planners involved in rapid response activities. To meet this objective, the following approach was taken:

1. Generate High-Level Activity Model: Specific OV-5 Activity Models depict the rapid response planning activities conducted by the Air Force operational planners at a high level.

2. Generate Detailed-Level Activity Model: The swimlane diagram format was used to illustrate roles and responsibilities of the Air Force operational planners while showing linkages between each of the stakeholders involved in rapid response planning across the Air Force operational level (A Staff) as well as external collaborators. Swimlanes provide a format for organising an activity diagram – each swimlane corresponds to an operational node involved in the activity diagram.

The products are visual aids to increase the understanding of rapid response processes and the activities involved in developing event specific contingency plans, and to reveal the interdependencies of stakeholders and thus outline the collaboration required. The OV-5 products also facilitate understanding of the overlap between the operational, theoretical and technological components of the study.

4.2.2 OV-5 Product

The OV-5 product is a series of diagrams that depict AS-IS activities conducted in rapid response planning in two levels of abstraction, high level and detailed.

4.2.2.1 Planning Activities Capture

As stated earlier, the CF OPP is the process that is currently in use for Air Force and CF operational planning therefore there is requirement for the decision support tools being considered to be able to support the production of CF OPP products such as a Mission Analysis, Commander's Estimate, Decision Brief, and Concept of Ops where time is limited, unspecified or when the operation is already underway and major changes to plans are required. The challenge is to achieve the same degree of accuracy and completeness regardless of the time constraints.

This project focuses not on the specific phases of the CF OPP but instead of the tasks associated with the CF OPP across all phases. An examination of the CF OPP to isolate tasks in order to facilitate a more generic representation for the conceptual roadmap resulted in looking at the CF OPP from a different perspective.

4.2.2.2 *High Level OV-5 Activity Model:*

The high level model introduces the AS-IS activities that are carried out when planning a rapid response operation. The model illustrated that the applicability of a standing CONPLAN optimises the planning process as a full CF OPP does not have to be conducted. In its place, a standing CONPLAN which is partially completed is used, and planning activities are focused on filling in the gaps or validating information in order to develop the Op Plan. (See section 3.3.3.1 for more discussion on staff checks and section 3.3.1.2 for more discussion on time appreciation).

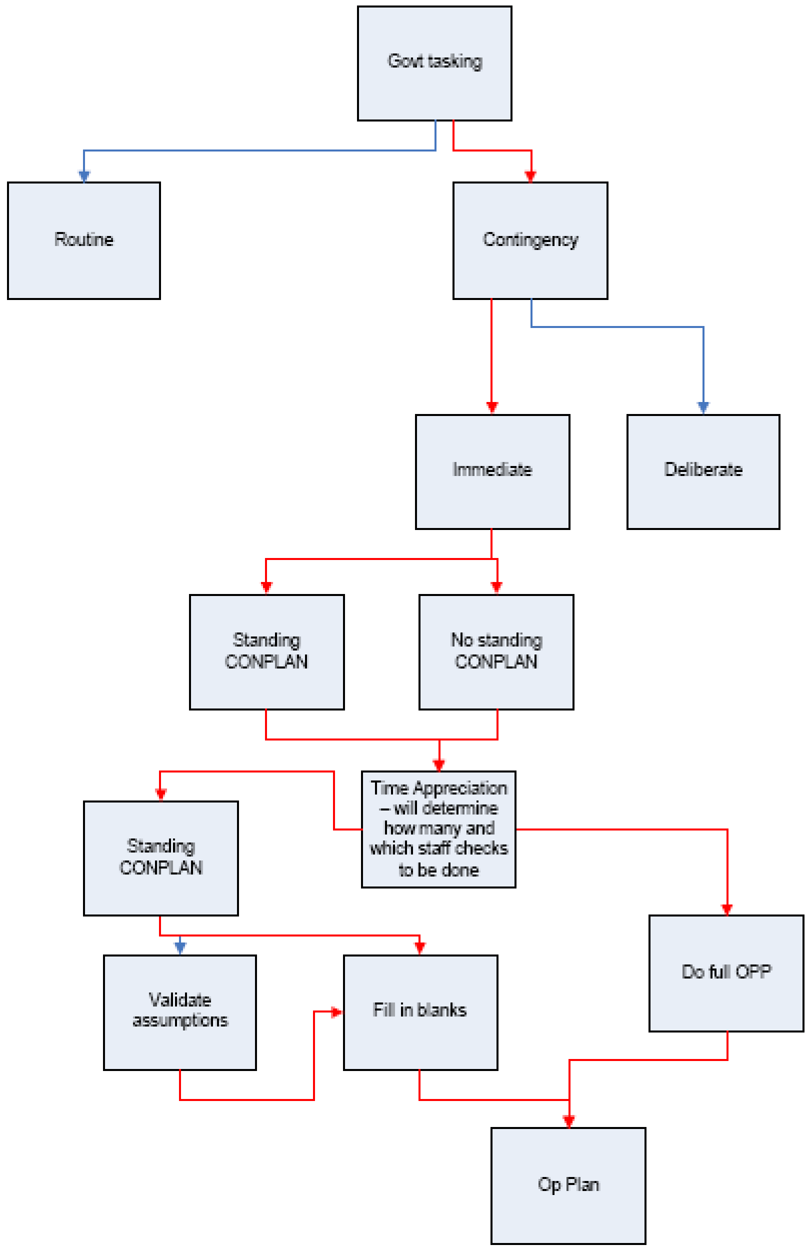


Figure 7. *High Level OV-5 Activity Model: High Level Air Force Rapid Response Operation Activities*

4.2.2.3 Detailed OV-5 Activity Model

The detailed activity model illustrates the actors involved (operational nodes) in the planning process and the associated activities to depict the roles and responsibilities of each node. The actors included provide a high level example of the collaborating entities for Air Force rapid response planning.

The operational nodes captured in the detailed OV-5 include:

i) Commander 1 CAN AIR DIV/CANR

(1) The Commander is the overall decision maker for the air operation centre.

ii) 1 CAN AIR DIV A Staff Cells (may include NORAD A Staff)

(1) Each Canadian Forces headquarters, be at the tactical, operational or strategic level, is equipped with a staff that performs military staff duties in support of the Commander. These duties are traditionally organised according to areas of expertise relevant to supporting the Commander and create “cells” of SMEs that make up the staff. Within the Air Force, these HQ staffs are referred to as the A Staff. The 1 CAN AIR DIV A3 Operations Staff coordinates the contributions of the other A Staff while leading the planning process. The A3 Staff are responsible for the development of the operations plans and other planning associated deliverables. The A3 Staff reach out to the other Staff to obtain information regarding their areas of expertise. The A staff includes:

(a) A1 – Personnel

(b) A2 – Intelligence

(c) A3 – Operations

(d) A4 – Logistics

(e) A5 – Policy/Legal/Public Affairs

(f) A6 – Information Management

(g) A8 – Finance

iii) 1 CAN AIR DIV Combined Air Op Centre (CAOC)

(1) The CAOC is the physical location of the co-located A Staff. It is centralised operations centre and is staffed with duty officers that perform the role of formally receiving and sending information on behalf of the A staff.

iv) Resources (tactical level HQ fleet managers, Wings, etc).

(1) The A Staff will collaborate with resource owners to determine asset availability and fleet readiness.

v) CF Commands (CEFCOM/CANADACOM etc)

(1) Air Force taskings are executed according to directives from the CF Commands. The Commands both determine what operations the CF will engage in and what role each environment (i.e. Army, Navy, Air Force) will play. In addition, as a new rapid response tasking comes in, Air Force elements that are engaged may be re-tasked according to the prioritization of operations at the strategic level.

vi) OGDs/Allies

(1) Both domestic and international operations can be executed in an environment that supports OGDs and/or allied objectives, not just those of the CF. Collaboration occurs for a number of reasons, for example:

(a) Requests for Assistance (RFAs) from OGDs/Allies may initiate a CF operation that will have an air component; and

(b) Requests for information from the Air Force may be necessary for planning purposes.

The execution of the CF OPP provides the framework for planning activities. The CF OPP has five phases as outlined in section 3.2.1.2. Within each of these phases there are a number of activities that support the planning process for each tasking. The detailed OV-5 captures the activities that are conducted for each of the five CF OPP phases.

The following points were difficult to capture in the activity model but merit mentioning:

- The CF OPP is a complex adaptive system, articulated perpetually between the Strategic, Operational and Tactical levels. Planning activities do not exist as an independent entity at one level and as such, collaboration is inherent in its structure.
- CONPLAN implementation is driven by information access. The use of staff checks are the primary means through which information is obtained to enable the

planners to go from a partially populated standing CONPLAN to a fully developed Op Plan.

- Concurrent activities, while they may be capable of being isolated and executed, will likely rely on interdependent decisions. This is difficult when isolated planning activities need to be governed by a tight cycle.
- Each of the phases of the CF OPP must be observed however these phases may be combined or modified depending on the time available – i.e. the CF OPP will be modified to suit the time available

The depth and detail of information is often sacrificed for speed although accuracy of the information still remains important.

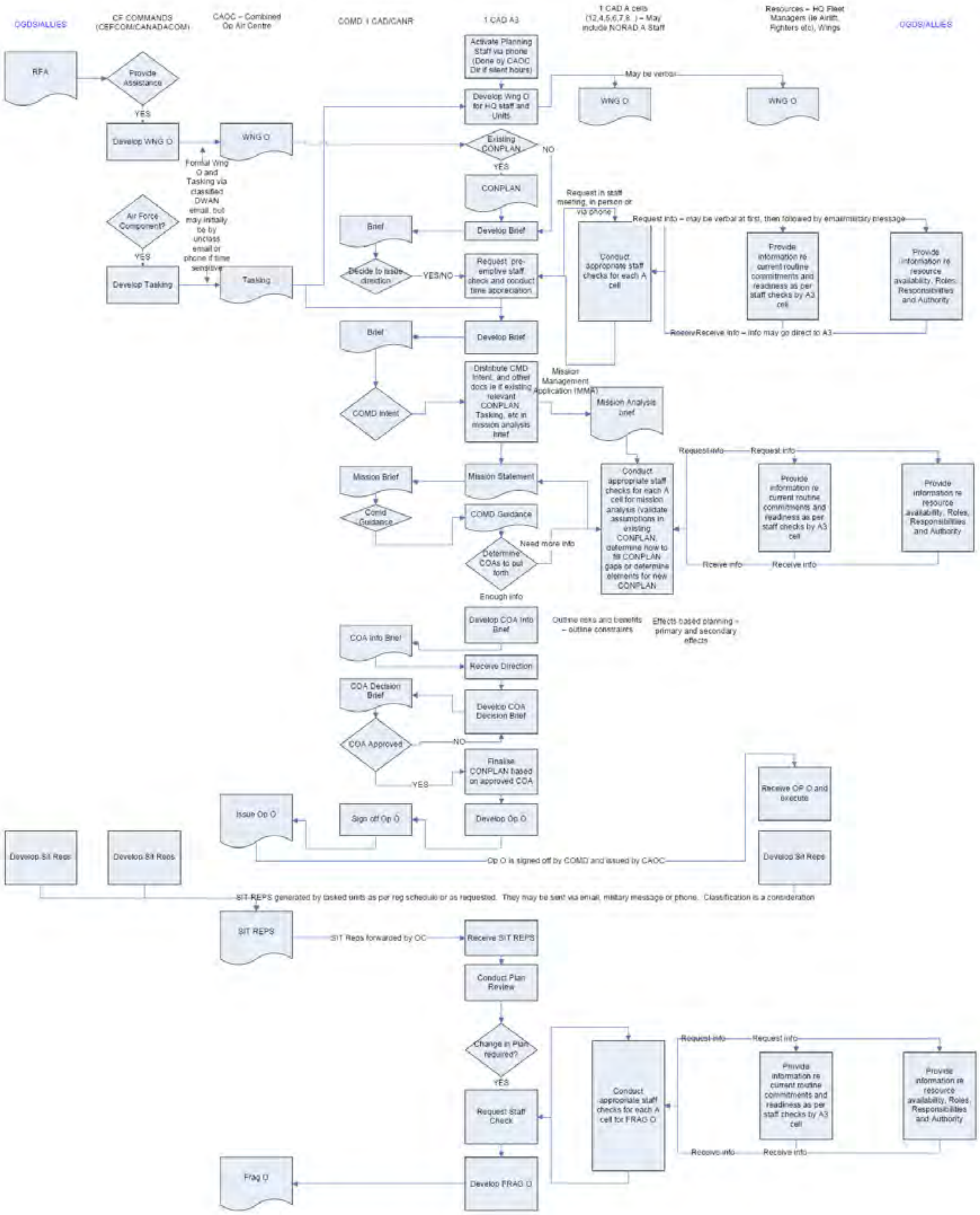


Figure 8. *Detailed Level OV-5 Activity Model – AS IS Air Force Rapid Response Operation Activities*

4.3 Key Drivers for Operation Plan Development

Based on the discussion above, three key drivers feed the Op Plan development process for rapid response immediate contingency air operations can be deducted as:

1. The existence of standing CONPLANS partially developed in advance for operations that are determined to be relatively likely and/or represent critical no fail tasks. They remain on file with some information missing or requiring validation in the event of its rapid activation in response to higher direction;

2. The rapid validation of planning assumptions within an existing standing CONPLAN for an immediate rapid response operation; and

3. The development of an entirely new Op Plan for an immediate rapid response operation that was totally unexpected and does not fit the application of an existing CONPLAN.

4.4 Operational Requirement Priority Areas

The CONPLAN investigation has also revealed that the following elements of rapid response Op Plan development are central and thus can be identified as operational requirement priority areas:

- Flexibility in planning process & SOPs:
    - Urgency suggests that you may be required to accept a higher number of planning assumptions regarding information that is either difficult to access or generate under the restrictive timelines. As a result there may be additional risks which will need to be highlighted, justified and accepted by the Commanders as necessary to issue the CONPLAN while the window of opportunity for success remains open. Key will be the ability to justify the need to deviate from /modify SOPs in order to accelerate the planning process but not introduce avoidable risks; i.e., keeping in mind the critical business rules, how to optimize effectively.
- Resource visibility:
    - Operational planners will require asset / resource visibility. This will entail an understanding of what is currently tasked, what is the priority of the tasking as well as what are the capabilities available within the immediate timeframe required considering both equipment and personnel readiness
- Collaboration partners and influences:
    - Air operations will seldom be conducted in isolation but will normally be part of a larger effort. The ability to identify and gather necessary planning information will be influenced on whether the CF, and the Air Force in particular, is the supporting or supported entity. Influencing factors on the collaboration environment include overall role of Air Force (directive (lead) vs. taking direction (support); strategic direction (always need to get authorization/validation from strategic level, this includes the policy/legal/public affairs constraints outside of force generation of AF assets that is dealt with by the strategic level).

- Risk Management:
  - Any plan will assume risks because of time constraints relevant to planning. Planners need to fully utilize all risk management and mitigation strategies for optimisation and consider that there are different risks associated with each operations' constraints or information needs.

4.5 Generic Planning Modules

It is important to note that the operational planning process in itself is a highly creative process, including brainstorming techniques and the application of human cognitive concepts that are not easily translated into bits and bytes as observed by the NATO C3 team during the development of TOPFAS [NATO, 2006]. In other words, the operational planners engage in a number of different ways during the execution of tasks within the planning process. These can be summarised as three dimensions – mechanical, creative and collaborative.

The OV-5 activity model presented above captured the activities associated with operational planning for rapid response operations in the air force. Analysis of the activity model OV-5 enabled the study team to isolate groups of activities that are often repeated into modules. The modules were determined according to groups of activities that are repeated in a number of sequences and/or throughout the CF OPP. These modules were then examined independent of the CF OPP to guide the development of the conceptual roadmap. The framework developed in Task 2 was then used to discuss how the modules can be instantiated to build a DSS application. This simplified representation of the Air Force Rapid Response Planning domain.

Each module that has been isolated is described as a subsection below with a short discussion on the mechanical, creative and collaborative aspects to be considered for optimization and system design as per the framework developed in Task 2.

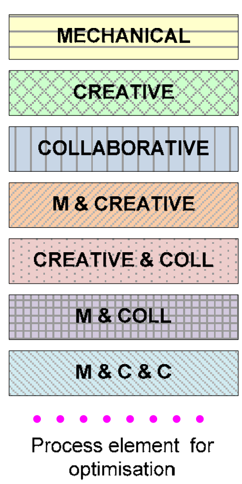


Figure 9. *Module Legend*

4.5.1 Receive Information Planning Module

The following graphic depicts the process Receive Information and characterises it as a mechanical process:

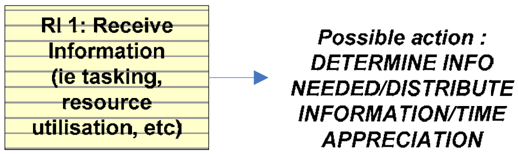


Figure 10. *Receive Information Planning Module*

The information received is in the form of a request (for contingency planning operations or request for effects from Air Force clients, etc.) or it can be information received as an output from another system providing status updates (i.e. of asset availability from NAPP) or an intelligence product such as a Sit Rep.

4.5.2 Request/Distribute Information Planning Module

The following graphic depicts the process Request/Distribute Information and characterises it as a mechanical process:

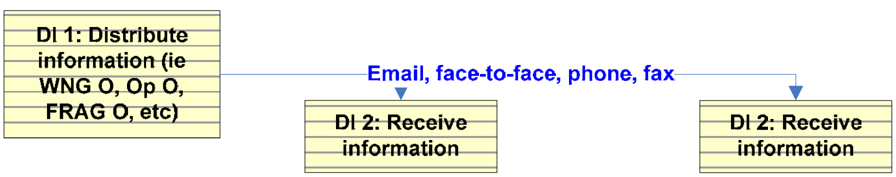


Figure 11. *Request/Distribute Information Planning Module*

Request/distribute information could be conducted using a variety of communications systems such as email, face-to-face, phone, fax, chat, etc. For the interest of tracking the decision making process, the outcomes (sender/receiver/means of communication) should be logged. Requesting/distributing information such as RFIs, Wing O, Op O, FRAG O, etc. requires the same interfaces, and features as for information reception

4.5.3 Time Appreciation Planning Module

The following graphic depicts the process Time Appreciation process and characterises it as a creative process:

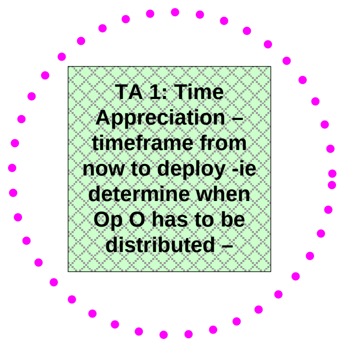


Figure 12. *Time Appreciation Planning Module*

Time appreciation is conducted in an ad-hoc and formal manner depending on the place in the planning process that it occurs. The number of times that a time appreciation is conducted is dependent upon the rate of change in the crisis situation. Time appreciation is a highly creative process and leverages the planners' experience in similar situations and is very context dependent.

4.5.4 Analyse New Tasking/Direction Planning Module

The following graphic depicts the process Analyse New Tasking/Direction (ATD) and characterises it initially as a creative and collaborative process, progressing into separate mechanical and creative processes.

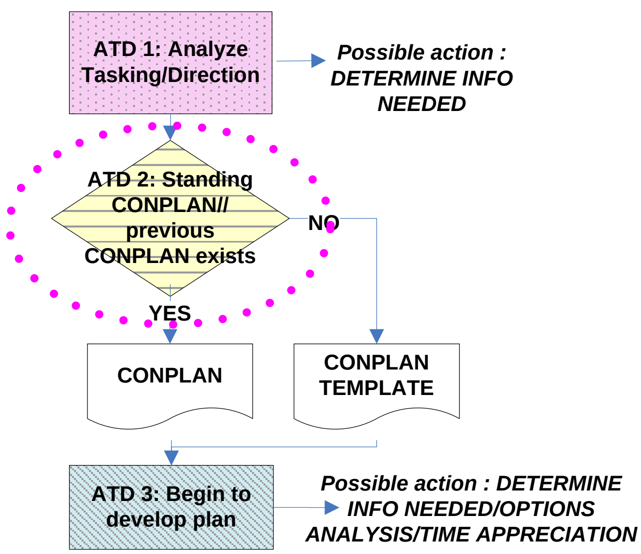


Figure 13. *Analyse New Tasking/Direction Planning Module*

Analyzing new tasking/direction requires creative, collaborative, mechanical, and data processing components. The mechanical component of analysing new tasks is defined in sections ATD2 and ATD3. ATD2 requires the ability to find relevant information from previous CONPLAN, and lessons learned. Once a CONPLAN is selected, at stage ATD3, the system will then assist in operational plan development using the selected CONPLAN elements as a starting point. As the planner meshes the known information with the historical and standing CONPLAN, mechanical, creative and collaborative elements come into play to determine the path for plan development.

4.5.5 Determine Information Needed Planning Module

The following graphic depicts the process Determine Information Needed and characterises it initially as a creative process: progressing to include mechanical and collaborative processes:

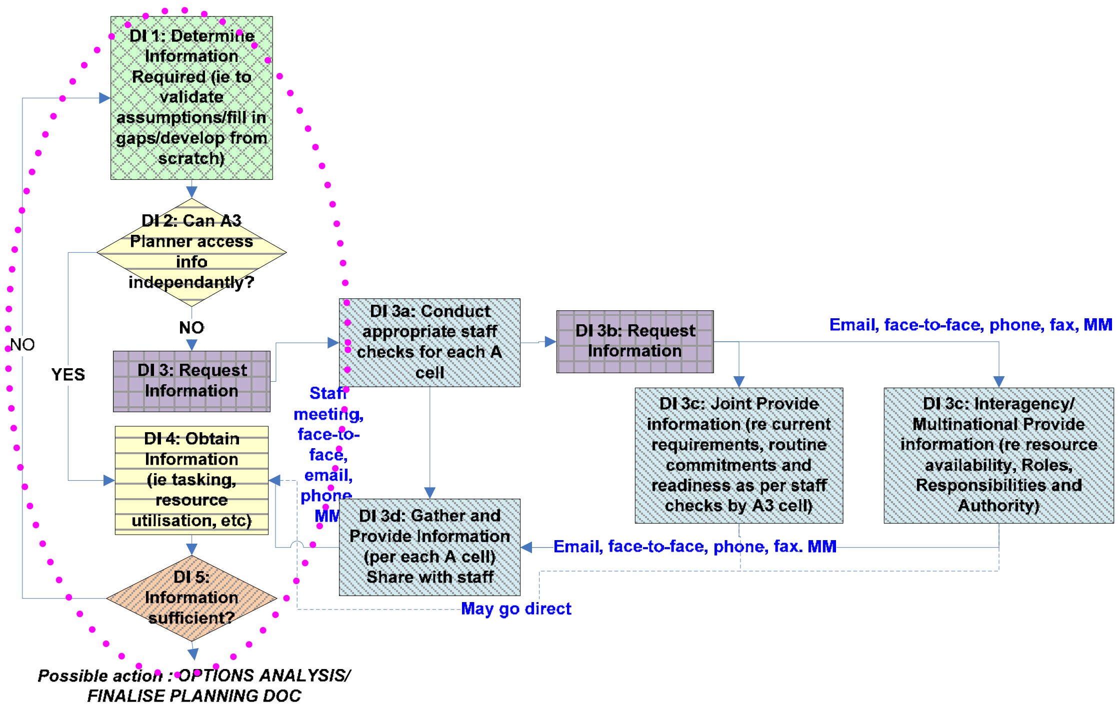


Figure 14. Determine Information Needed Planning Module

When confronted with the task to determine what information is needed, the A3 planner must first determine what information he requires for the task at hand, i.e., creating a briefing, deciding on a COA. The gaps in his information are then sent out to the appropriate A staff team member as information requests. He will then receive information back in order to address the information gap. This process is not linear and is very dynamic. The re-aggregation of the information retrieved via the A staff is a huge challenge to monitor and assess in terms of risk. For example, information from each of the A staff may impact another A staff in such a way that their input must then be updated. In addition, in a domain of incomplete information, understanding where the information gaps are critical to defining and mitigating risk.

4.5.6 Options Analysis Planning Module

The following graphic depicts the process Options Analysis and characterises it initially as a creative process. However, as a planner steps through the process, it evolves to include mechanical and collaborative elements:

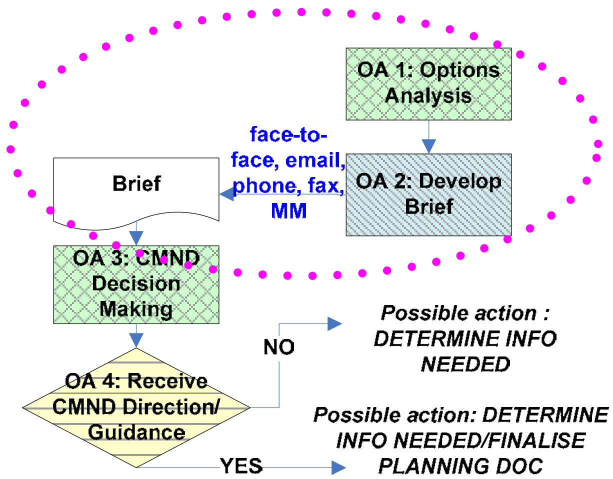


Figure 15. *Options Analysis Planning Module*

As discussed in section 3.3.1.1.1, a key analysis activity in operations planning is COA development and evaluation. There are several factors to be considered in evaluating candidate COAs:

1. Suitability: the proposed COAs must be examined by the staff to determine if it is aligned with the Commander's intent and the degree to which can accomplish the mission and achieve the desired end state, and as such relates to the semantic inference on whether the COA matches the commander's intent;

2. Feasibility: the candidate COAs must be examined to determine if sufficient resources are sufficiently available and logistically accessible over the period required to sustain the operation, in other words, scheduling and sequencing given whatever resources are available;

3. Acceptability: COAs must be evaluated to determine the degree to which the likely results justify the estimated costs and potential losses in terms of time, materiel and personnel. A COA is considered acceptable if it can accomplish the mission and it is considered to be worth the risks.

4. Adequacy: COAs must be evaluated in terms of scope and planned activities and identified force capabilities to determine if they are sufficient to accomplish the assigned tasks and the commander's intent.

5. Compliance: COAs must be evaluated to ascertain that planned activities will comply with CF doctrine and applicable policies, regulations, and legislative constraints and guidelines;

6. Exclusivity: proposed COAs must propose alternative means to achieve the mission that are fundamentally different and distinguishable from each other. This requires that all COAs be well defined;

7. Completeness: proposed COAs must be examined to ensure they clearly identify the force requirements, tasks, scheduling, sequencing and objectives necessary to achieve the mission. All the elements of a COA must be described and integrated into a coherent plan.

There are two fundamental issues in addressing COA analysis. The first is the suitability analysis. A COA is suitable if it is in alignment with the commander's intent. The second is the feasibility analysis. A COA is feasible if it can be achieved with the given resources. The first issue relates to the semantic inference on whether the COA matches the commander's intent while the second issue relates to the COA scheduling and sequencing given whatever resources available.

The brief produced in OA2 should be a product of the system itself, not an externally-generated document from which modifications or novel constraints or requirements would have to be re-input in the system. Developing the brief should be a dynamic process. Note the potential of added confusion or combinatorial explosion of information though if not approached properly, which should be avoided.

4.5.7 Finalise Planning Document Planning Module

The following graphic depicts the process Finalise Planning Document and characterises it as a mechanical, creative and collaborative process:

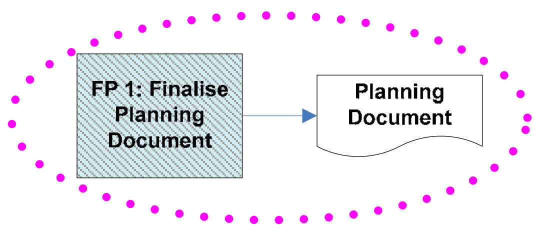


Figure 16. *Finalise Planning Document Planning Module*

All outputs of the planning system are planning documents. These could be briefs or Op Plans or Op Os or Frag Os etc. The planning document would be easily disseminated to all relevant stakeholders using methodology outlined in the distribute information planning module.

5. Options Analysis and Resulting Framework

A generic representation of the problem space helps the analyst to step back, disconnect from known constraints and encourage brainstorming for complex problems such as Air Force rapid response contingency planning. It is apparent from the investigation and options analysis that there are mechanical, creative and collaboration aspects of all three of the study perspectives: operational, theoretical and technical.

A detailed table of the options analysis is contained in Annex B. The following section presents the results of the options analysis in a textual discussion, bringing together design processes and features that would address the requirements to lay the foundation for the conceptual roadmap. The framework that it is presented in identifies mechanical, creative and collaborative aspects of the CADTTAP examined, providing a foundation for the conceptual roadmap. One way to see the process of building a framework is that one must first come up with a model and then implement it. However, the study team for this project has adopted a more incremental or “agile" point of view: it was the process of designing the framework that actually ended-up defining the DSS. As a result, in each section of the framework, main issues and concepts that form the DSS are discussed, thus presenting a classification of concepts to be used for the roadmap.

5.1 Mechanical aspects of rapid response planning and an associated DSS

The following elements have been selected to contribute to optimising the rapid response planning process from a mechanical perspective:

5.1.1 CONPLAN database

- Maintain a database of all available approved Standing CONPLANS as well as all previous approved CF OP Plans including lessons learned for those executed.
    - Embed with capability to search for common elements within Standing CONPLANs to correlate relevant information elements of in the databases
        - Provide a list of warnings may be required for a given standing CONPLAN that should not be avoided. E.g., don’t fly over the Northern Domestic Airspace without proper navigational equipment.

5.1.2 Blackboard

The blackboard concept enables the users to access a number of different knowledge sources using one interface. The blackboard interface gets info from various places and translates the information in such a way that it is coherent to all other users. Blackboard draws information from KM system and deposits processed information back into KM system. Blackboard and

KM systems interact seamlessly to the user. Multi-user data manipulation would enable distributed users to access and contribute to blackboard information.

5.1.2.1 Control Shell

Blackboard information is transferred via a control shell [Corkill (2003)]. A control shell is a repository for AI experts/agents to identify constraint violations (i.e. of COAs) and suggest alternatives. It would be designed for modular selection enabling parallel execution within the DSS (in support of multiple users). A key function would be the use of different predictive models (consisting of algorithms, operators, parameter settings) to compare options. Supporting characteristics would include:

1. Rule-based: enables the analysis of effectiveness of solution (supports effects-based planning principles);
2. Metadata repository: as an intelligent interface, it decreases the workload of users by providing data integration of heterogeneous data structures and interfaces and assists the user to frame queries; [Chinthamalla, D. (2002)]
3. Logic visibility: shows the logic behind how the conclusion was derived (this would be optional as per user requirements); and
4. Parameterised: users can select a variety of parameters to solve a problem.

5.1.2.2 Types of data for the Control Shell

- Mechanical technologies include rule based and database based systems where data searches and suggestions have to happen in real-time, so that the computer system is in-step, if not ahead, of the users (i.e. Google search vs. searching your hard-drive for information). The difficulties encountered in planning problems requires system designers to find means to exclude irrelevant knowledge via proper knowledge representation strategies [G¨unther, Christian W. and van der Aalst, Wil M.P. (2007)]
    - Representing knowledge related to planning problems involves representations of actions and states, and can be framed via propositional and 1st order predicate logic [Guttenplan (1971)], in the simplest situations. The broad categories of a planning ontology are:
        - representation of states;
        - representation of goals; and
        - representation of actions (further specifiable into preconditions and effects) [Da, (2007).]
    - some example planning languages:
        - STRIPS (Stanford Research Institute Problem Solver)
        - ADL (Action Description Language)
        - a standardization effort for planning problems syntax: PDDL (Planning Domain Definition Language)
    - Domain-independent heuristics are necessary for flexible, intelligent planning agents, as it would be impractical to design heuristic functions for each case problem (the intelligent agent would lack autonomy) [Mulvehill (2002)]. The algorithms need to be abstract enough that they can adapt to different situations and crisis, i.e. don’t want to re-implement for every instance.

- planning algorithms and heuristics for the CONPLAN planning problem should be scalable depending on the problem environment features. [Russell, S., Norvig, P. (2003)] mentioned some technologies that should be investigated further:
  - planning with **state-space search** (“totally-ordered plan searches”)
    - forward state-space search algorithm (progression planning)
    - backward state-space search (regression planning)
  - **partial-order** planning (accounts for problem decomposition shortcomings, delaying choices during search by using a “least commitment” strategy, then re-ordering partial plans via linearization)
  - planning **graphs** approach (a graph consisting of sequence of levels, with level 0 being the initial state, and subsequent levels representing other time steps in the plan. Levels are representing literals (state representation) and a set of possible further actions. This heuristics is meant to leverage knowledge representation of the planning problem-solving space to mitigate the negative interactions between sub-goals, with the help of information visualization techniques, as well as the inclusion of mutual exclusion or “mutex” relationships between goals)
  - planning in **propositional logic** form tests the satisfiability of a statement (“propositional content” in the field of logic) by representing the conjunctions of initial states, all possible action descriptions, and goals for truth satisfaction. Planning goals for which a set of such actions does not lead to a validation of the propositional logical form are considered to invalidate the model which was thus represented. In the case of an unsolvable planning problem, the propositional logical form of the statement is unsatisfiable. Propositional logic is also known as sentential logic and statement logic. It is the branch of logic that studies ways of joining and/or modifying entire propositions, statements or sentences to form more complicated propositions, statements or sentences, as well as the logical relationships and properties that are derived from these methods of combining or altering statements. (See section 3.5.4.1 and the discussion on defeasible reasoning).

5.1.2.3 NLP - Understanding unprocessed information

- Natural Language “Document Understanding”, or “Text REtrieval" research:
  - As mentioned in [Li (2009)], a yearly conference has been held “with the aim at generating a brief, well-organized, fluent summary for multiple documents”. Contestants are given a series of articles, or news reports, and are challenged to create a 250 word summary of the article. An interesting observation is that teams where English is their second language, are more

successful (http://www.nist.gov/tac/publications/2008/papers.html) at the conference.
    - The type of "understanding logic" that is presented in Natural Language would greatly benefit parsing of, and extracting data in complex documents such as doctrine [CANR (2003)], or national policies. Ideally, one should be able to apply document understanding technology to comparing policies from different agencies, or countries, and highlight the differences.
    - The conversion of Natural Language information into processed information can be automated, but technology is not yet mature, and better quality results if guided by human operators. [Nilsson, M (2008)].

5.1.2.4 Configuration

The system may be set up with one or multiple blackboards. Multiple blackboards could be function specific and be set up at the strategic, operational and tactical levels, or by subject area, for example, economic data, geophysical data etc. Regardless of how a multiple blackboard system may be set up, they can be designed to interface with each other and share information in a way that is seamless to the user as one solution space.

5.1.3 Web interface

National defences as well as many key allies such as NATO and the US are all migrating to and demanding networked capabilities that are web-based and built upon an SOA[6]. They understand that the outputs of tools such as this must be able to interface with superior and subordinate peer applications in order to be effective. To not use these standards would render any tool less effective. In addition, web-powered SOA interface is becoming a popular standard with external non-defence agencies and its adoption would simplify interfacing partners.

Web interface design should consider the ability:

- to link into and effectively leverage existing specialized software tools for supporting activities (i.e. intelligence, logistics, etc.)
- to create a collaborative workspace across all levels of command from strategic through the operational to tactical to provide shared SA
- to provide disposition and availability of Air Force resources
    - This may leverage the NAPP or take the form access to databases currently in existence for capability element readiness (i.e. generation of hard numbers related to fleet management, personnel status) permitting operational level planners to continuously generate readiness reports based on current data
- to link the CF to OGDs to accelerate the RFE process and enable synchronisation of planning activities and outputs such as COA and Op Plans.

[6] Most defence R&D projects must be in conformance with national defence policy and the C4ISR campaign plan to be funded - see C4ISR Campaign Plan, Director General Joint Force Development, 2003.

5.1.4 Intuitive user interface

- To effectively support the CF OPP, a DSS must be able to clearly present information in a meaningful manner [Nilsson, M (2008)]
    - seamlessly integrate human-computer collaboration on improvisatory task using simple, pragmatic methodology that makes the human-computer interaction mechanical so creative efforts focused on improvisation of say COAs, not expending effort making the tool work
    - permit access tools in a user friendly way with a focus on error reduction and single point data entry
    - Planning guide tool in format of planning wizard [NATO (2006)]
        - Integrate with template generation tool (Tracker) for all planning output document creation, ex:
            - Operational analysis briefs for the Commander, outlining possible courses of action to meet stated objectives based on the above rule sets, and optimizations. Highlight decision making process, ambiguities, and lessons learned for Commander's consideration and resolution using a pheromone matrix [Wang (2007)]
  - Facilitate single data entry point
  - Synthesise event-driven information (reactive) requirements with standing CONPLAN details (proactive)
  - Used for deliberate and contingency planning so in rapid response planner is already familiar with tools
- As mentioned by [Mehrotra (2004)], the goal of a DSS system is to assist "their ability to collect, store, analyze, interpret, share and disseminate data". The theory behind creating an effective DSS system include mechanical aspects of creating logical algorithms; defining data models, structures, access methods and decision trees to support this using AI:
    - AI literature suggests many approaches to planning problems, from search-based algorithms to particular heuristics for different planning problem environments, such as the Virtual Information Processing Agent Research technology [Oak Ridge National Laboratory (date unknown)].
    - Planning combines two factors of typical AI domains: search and logic [Russell (2003)]

5.1.5 Iterative developmental process

The system should be configured so that developers may change algorithms and add others as technologies develop;

- Being web-enabled and under SOA, it implies that the various components are modular and that they will evolve according to needs. You cannot just provide a DSS and say it will meet the AF needs for the foreseeable future. But if constructed properly, can monitor changes required for components and allow spiral development in a continuous process
- Algorithms for the complex DSS domains will keep improving just like search algorithms for Google have (i.e., 5 years ago searches were not as good as they are

today). To this end, the system should be designed expecting that better algorithms for DSS will emerge as the technologies are continually developed.

- Problem space will continually evolve therefore the decision space will continually evolve therefore development process has to be iterated and based upon lessons identified in DSS scenarios - it's a cat and mouse game; an evolving problem space. Therefore, if the DSS is desired to be up to date and relevant for the long term, considerations for iterative development need to be acknowledged.
- NATO as an example – NATO has automated information system programs all exclusively using iterative spiral development over a number of increments – it has been implemented for Air C2IS, NATO common operating picture, NATION NC3A procurement strategy.

5.2 Creative aspects of rapid response planning and an associated DSS

Rapid response/crisis action planning requires flexibility to handle high information requirements in an environment with stakeholders that have diverse information requirements and organisational structures [Burkle (2001)]. Therefore, not all portions of the process are obvious, and can be automated in a mechanical fashion. The DSS must be designed to assist in the decision making process by processing data and presenting information in such a way to highlight ambiguities that can be creatively resolved by humans in Command and Staff positions. For example, to develop the Op Plan, the Staff must consider and present to the Commander issues related to risk management and mitigation, time appreciation; and uncertain, ambiguous and contradictory information (more difficult to automate).

The DSS should not be designed to make decisions [Mulvehill (1999)], but rather to facilitate decision making by:

- presenting a good understanding of the environment in which decision-making is to take place
- assisting by projecting likely outcomes from multiple possible courses of action, and,
- recommending a specific course of action based on optimizing the achievement of multiple goals and objectives [Mak (1999)].

The decision will always be the Commander's, and even if a Commander were to essentially delegate that authority to an expert system, the DSS cannot assume the accountability for the decision. As mentioned in [Mak (1999)],

> "…it is unrealistic to expect to create a 'fully' automated workflow system because a whole series of negotiations, dialogue, coordination and communications between individual experts, groups of experts, and systems manual or computerized are involved."

Most tools with facilitate both convergent and divergent elements of decision making. In order to simplify the DSS, the design will need to use the same tools. Divergent processes are often thought processes that support brainstorming like tasks, and as such occur internal to the human brain. The information is then entered into the tool to conduct analysis to reach convergence. To support this, the tool should allow one to clarify criteria and identify tradeoffs. The convergent aspect is thus the hard analytical component – comparing, contrasting and recommending. The DSS is thus designed to establish criteria and automate compare and contrast the inputs from the divergent phase.

The following elements have been selected to contribute to optimising the rapid response planning process from a creative perspective:

- support the divergent aspects decision making process by assisting in breaking down the situation into discrete work packages (heuristic assistance provided through the thought process for each package) and then permit re-aggregation of the constituent work package outputs to ensure coherence and transition to convergent aspects to determine a way ahead or outcome of the task.
    - Supporting tools: modular architecture, data push and pull capability
    - Bio-philosophy is increasing being used to understand structures of behaviour and define realms that contain a number of contextual relationships of activities. The theory of emergence and the analysis of swarm behaviour and ant systems are examples. This perspective can provide solutions for optimization which are more 'bottom up' rather than 'top down'. In crisis environments, the situation evolves from the bottom up, and as such, these perspectives warrant investigation for rapid response planning. In this light, leveraging supply chain management techniques such as Clonal Selection Algorithm (CSA), an important branch of the Artificial Immune Systems (AIS) and Ant Colony Optimization (ACO) algorithm and applying them to the optimisation of information elements for COA selection or using a pheromone-based meta-heuristic elitism and hieratical search strategy for identifying information gaps for risk mitigation may warrant investigation for the context of rapid response planning (see [Wang. X. (2007)]).
  - Not all problems are decomposable into subsections, which would present an ideal situation where the solutions are in linear relationship with the level of decomposability of the overall planning problem. Some heuristic approaches to the problem decomposability issue are partial-order planning and serialisable sub-goals, to rule out negative interactions between goals (i.e. acting on one sub-goal causing the undoing of another sub-goal), akin to the Critical Path Method [Grotte (2009)] approach in project management.
- Modelling and Simulation of events for the possible COAs is desirable for complex operation plans [Schoenharl (2006)], [Klashner (2007)]. Simulation allows the planning team to:
    - Validate CF O Plans before implementation [Raskob (2000)]
    - Visualization of COAs for all team members [NATO (2006)]
    - Assist in highlighting unknown dynamics when information in synthesised/re-aggregated
    - Provide training on DSS systems before crisis happens.[Gonzalez (2003)]
- Assistive, flexible components – there should be no requirement to adhere to a rigid process
    - Wizard and Tracker (see above mechanical discussion) rule-sets are user configurable for maximum flexibility
- leverage user knowledge (both explicit and tacit knowledge)

- employs intuitive symbology: the formatting and presentation of information is a necessary aspect of any planning, and any tool should seek to simplify and automate as many aspects of this as possible [DND (2008)]
- design for Recognition Planning
    - prospect theory [Tversky & Kahneman (2002)], the descriptive approach to decision-making outlines that human decision-makers have been found to use heuristics (rules of thumb, simplest or quickest means to reach an end with whatever method is available) in the face of time-constrained problems and decisions, in a world that is actually far more uncertain and limiting than the artificial problems of the classic mathematical models of economics and philosophy. This limitation in natural processing can be aided if the information can be abstracted to an understandable level, as described in section 3.7.5 and 5.1.2.3.
        - supports the application of RPM as outlined in section 3.5.6 to codify the informal and intuitive planning strategies employed by skilled Army and Marine planning teams.
- Use modern GUI aspects for modular, user interfaces
- Representation of goals over cost ratio
- Simplify tasks with analytical tools to provide you with quick access to information, and present it in different formats [Chief of Force Development (2008)], i.e. framing information into graphs, and tables, or map-plots.

5.3 Collaboration aspects of rapid response planning and an associated DSS

Both the Canadian [Chief of Force Development (2008)] and the US [Coffin, W. J. M. (2002)] military recognise the need to facilitate a collaborative working environment. This includes interacting with existing technologies by plug and play interfaces to other applications and sharing information across tools (i.e. systems integration).

Training is the backbone to rapid response planning and a number of activities, such as exercises are conducted as part of an expansive training program for rapid response planners. Most military events and/or exercises are in collaboration with other agencies [Department of Homeland Security (2004)], [Chief of Force Development (2008)] and as such joint operational environments are the norm. Factoring this in presents collaboration of a key foundational concept for the DSS framework.

Whether in training or in real-time, the different agencies should have the ability to communicate effectively and have access to and share information. The following elements have been selected to contribute to optimising the planning process for rapid response from a collaboration perspective:

- "Groupware", and teleconferencing abilities between the different stakeholders that are easily changed as the situation and stakeholders change.
- Collaboration is a group activity that is designed to compare and contrast information elements

- It is an intellectual activity that uses information as its basic building block. So when looking at shared information, it will either reinforce commonly held views, provide a means to challenge differing views in an effort to resolve differences and provide a common view of the situation. From that collaboration can continue on and focus on future states and the efforts that would be required to achieve them. You will not get collaboration if you do not share/exchange information. One of the most important outputs is an agreement on either a commonly held view or an agreement on harmonisation of COA to achieve overall goals/objectives.
  - in terms of information exchange between stakeholders requires the collection, and fusion of information from different sources, and of different data types.

- Ability to use tool that accesses external system outputs with confidence, i.e., promotes the idea of information reliability [Blasch (2002)]
- Knowledge management (tailored to need of specific user i.e., US Army Battle Command Knowledge System is designed so each team has access to the information that it needs but discounts that that is not relevant to their needs) [Nilsson, M (2008)]
- Technical requirements for collaboration lend themselves to a network enabled system where information is automatically passed between systems, rather than manual manipulation and multiple re-entering of data. To ensure that network enabled solutions can communicate, a DSS environment [Department of National Defence (2005)] must contain modular open-architecture software, with an ability to add additional capabilities. Currently, popular protocols include TCP/IP, and Service Oriented Architectures (SOAs). Other protocols may evolve within the next five years.
- Computer-to-computer via technology such as SOA protocols that are quickly implemented, and adaptable as the need arises.
- Even when the data is present, need to homogenise data from a "heterogeneous collection of knowledge" [Sheremetov (2004)]. This can be done mechanically and some of the tools listed above in the mechanical aspects (section 5.1) are applicable.
- Blackboard system solution not only offers creative, open-ended data gathering and analysis capabilities, it also serves as an infrastructure for collaborative project management that can be applied for plan development. For example, in terms of enhanced project management the blackboard system can scale the environment to support increased usage, implement upgrades, and tweak the database for optimal performance as well as maintain day-to-day knowledge of all plans, activities and support issues; offer enhanced communication while providing transparency and visibility; and can document and report on plan status.
- Blackboard system provides an electronic environment to present different information elements and identify where there are discrepancies and agreements. Necessary precondition for collaboration – when identify discrepancies - ability to drill down and identify the incompatible assumptions in order to align things during collaboration .

    - Palma et al (1998) have extended the traditional blackboard to develop a fractal blackboard architecture. This concept consists of a set of distributed blackboard systems organised in a hierarchical way where each blackboard system is a specialist in charge of a specific domain task.

      > “In its more general form, each specialist consists of a control mechanism, a temporal blackboard, a blackboard interface (which include a temporal consistency maintenance system), a communication module and a set of sub-specialists. So, the specialists can be recursively decomposed on other specialists with the same internal structure. We call agents to the terminal elements in this hierarchical structure. This decomposition makes possible to carry out a hierarchical planning of tasks in different abstraction levels.” [Palma, (1998)]

- Surface computing as a collaborative user interface: Horizontal surfaces invite users to interact and engage differently than vertical displays. When findings such as “research on digitally augmented desks supports user activities that are focused tasks, such as writing, editing, calculation, design and drawing” is combined with the fact that “table setting encourages collaboration and coordinating as well as simultaneous and parallel problem solving among multiple people”, surface computing in the format of a table top is promising application for operations planning.
    - A Dutch study published in 2008 tested the surface computing concept in an emergency response environment and assessed the technology for applicability. Users responded positively in their evaluation of the utility and ease of use of another MERL product the Diamond Touch and the associated software for basic GIS tasks and it was concluded that the potential of the technology for practical application was very high [Mitsubishi (2009)].
    - Another example, and more applicable to this study due to the necessity to “plug and play” with coalition allies with whom Microsoft is the most common application, is Microsoft’s’ Surface computer. Like the MERL UbiTable, Surface sets out to change the way people interact with information. However, the Surface technology is more constraining than the MERL technology and its features are less developed for multi-user interaction. For example, it does not ‘remember’ what is done by which user.

Figure 17. *Microsoft's Surface Computer*

Microsoft's' Surface computing technology currently consists of the following four components:

1. Screen: A diffuser turns the Surface's acrylic tabletop into a large horizontal "multi-touch" screen, capable of processing multiple inputs from multiple users. The Surface can also recognize objects by their shapes or by reading coded "domino" tags.
2. Infrared: Surface's "machine vision" operates in the near-infrared spectrum, using an
850-nanometer-wavelength LED light source aimed at the screen. When objects touch the tabletop, the light reflects back and is picked up by multiple infrared cameras with a net resolution of 1280 x 960.
3. CPU: Surface uses many of the same components found in everyday desktop computers including a Core 2 Duo processor, 2GB of RAM and a 256MB graphics card. Wireless communication with devices on the surface is handled using WiFi and Bluetooth antennas (future versions may incorporate RFID or Near Field Communications). The underlying operating system is a modified version of Microsoft Vista.
4. Projector: Microsoft's Surface uses the same DLP light engine found in many rear-projection HDTVs. The footprint of the visible light screen, at 1024 x 768 pixels, is actually smaller than the invisible overlapping infrared projection to allow for better recognition at the edges of the screen.

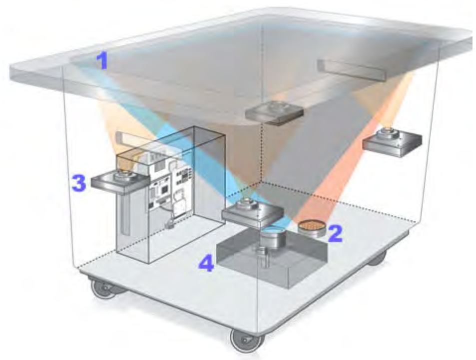


Figure 18. *Microsoft's Surface Computer - Components*

- The technology senses not only where a finger touches the table, but the entire hand. Therefore providing directional information via the user interface.
- One nice feature of the system is that uses projectors, rather than LCD, or plasma technology to display the images. Therefore the image is clear from all directions around the table. LCD's have an issue with viewing images[7].
- The Surface Computing technology is on display at trade shows, such as CANSEC 2009, and is available for purchase.
- Behind the scenes of the surface computing hardware is groupware support software to enable multi-user multi-input desktop environments. Groupware Windowing Systems (GWWS) support legacy applications, custom built Single Display Groupware (SDG) applications and supports the execution of multiple applications simultaneously [Hutterer (2007)].
- It is important to note that there are significant functional and technical differences between surface computing and traditional desktop computing which should be highlighted, and must be acknowledged and accepted when considering the shift in technology. As a result of multiple users positioned around the table:
  - each user has a different point of view with the associated preferred orientation for readable content;
  - as they intend to work together users may want to interact at the same time with the system;
  - users may use different interaction devices: fingers, hands or tools (stylus, eraser, ruler, and even wireless mice/keyboards);
  - a single user may want to use two interaction devices at the same time (right and left hand driven);
  - the same document may appear multiple times in the same interface;

[7] Additional technical information is available at http://www.monolitic.com/esp/Notas/def_angulos_vision.pdf

    - hand(s) over the table hide partially the object of interaction;
    - fingers are less precise than mice at touch time (but almost as precise for drag & drop); and
    - there may be a shadow of the hand(s) if the tabletop interface is video-projected toward the table from the top [Mitsubishi (2009)].

    Notwithstanding these potential challenges, the advantages of this new technology, at least according to some reports, seem to be worth the effort for its ability to facilitate collaboration.

- Collaborative Project Management Tools (CPMT) are designed to maximize the efficiency of teamwork in synchronous and asynchronous, remote or proximal contexts. A collaborative project management tool approach applies the use of Gantt charts and scheduling techniques which are critical in a time sensitive environment that highlights the critical path for achieving the desired objective.

- Collaborative work environments, such as Lotus Collaborative Software from IBM, Grouputer (http://www.grouputer.com/), NORTEL's web.alive, Google Docs, Microsoft Office Groove, Apple's iWork.com, Cisco's Webex, etc. are all platforms that enable and facilitate collaborative work.
    - Collaborative software in general is also known as "groupware"
    - useful services and features made available via collaborative software tools found in various taxonomies of collaborative endeavours include[8]:

[8] http://en.wikipedia.org/wiki/Collaborative_software

Collaborative Project Management Tools	Collaborative Management Tools
In addition to most CMT examples, CPMT also includes: - HR and equipment management - Time and cost management - Online chat - Instant messaging - Telephony - Videoconferencing - Data conferencing - Application sharing - Electronic meeting systems (EMS) - Synchronous conferencing - E-mail - Faxing - voice mail - Wikis - Web publishing - Revision control - Charting - Document versioning - Document retention - Document sharing - Document repository - Evaluation and survey	CMT facilitate and manage social or group activities. Examples Include: - Electronic calendars - Project management systems - Workflow systems - Knowledge management - Prediction markets - Extranet systems - Social software - Online spreadsheets

Figure 19. *Collaborative Project Management Tools*

- An example of a tool is Qtask. Qtask:
  "provides a hosted application for managing not just work products, such as Word files, project code, and Excel spreadsheets, but also for assigning people tasks, tracking their progress, managing approval, and coordinating the chain of ownership as projects go through the various experts who need to work in it. The application has several roles, including that of a watcher, which lets executives and others track a project without being the direct manager. And every action -- from who worked on what when to who last read a file -- is tracked. The goal is universal visibility, for both accountability and easier ability to adjust the project based on its actual state" [Grunman (2008)].

  While Qtask does manages the communication across team members through its repository of communications, (the discussions, e-mails, and so on remain available to all participants, as well as for use later on), it does so only as long as they communicate within the system. It does not integrate with e-mail systems like Exchange and Lotus Notes, other than being able to send and receive messages via POP or IMAP.

- Knowledge management systems such as those of a blackboard facilitate the sharing of information vertically and horizontally within a platform that allows tailoring for relevant information for user groups to help reduce information overload. Elements to be considered are those that deepen the trust of the information contained, reach and encourage a broad audience and access informal and formal information feeds. A comprehensive solution will include an analytical function to increase reachback, to broaden environmental assessments (i.e. improve ability to factor in elements such as economic and social impacts without having to have planners build competence in these areas), and to enable synthesis of relevant information quickly and succinctly.

    - An example of this is the recently implemented US Army Battle Command Knowledge System (BCKS) to improve soldiers' abilities to search the Army's Warrior Knowledge Base (WKB) (http://www.theappgap.com/us-army%E2%80%99s-battle-command-knowledge-system-bcks-moves-to-xml-based-platform.html). The system is based on the MarkLogic Server, an XML-based content platform designed to allow for granular database searches, efficient document delivery, and knowledge and information sharing. The users are often operating with a slow speed link as they are deployed in a hostile forward area, under pressure and time constraints to gather necessary information in preparation for battle. The system enables soldiers to find the most up-to-date information that may assist them in the field. It now is available to 90,000 Department of Defense personnel in the US and overseas.
        - BCKS Characteristics:
            - Soldiers can assemble electronic documents in minutes, pulling together the most relevant content from many search results, such as lessons learned, reports and articles written by experienced soldiers, as well as Department of Defense and Army civilians and contractors.
            - BCKS forum members can actively search and access relevant content in the WKB and then link to it within a discussion area for further refinement of the discussion topic.
            - Metadata assignment methodology that permits content to be actively searched, accessed and viewed page-by-page without having to download the entire file, allows transmission of only the relevant content in low bandwidth network environments
            - BCKS has the capability to store and manage content in 37 different languages.
            - By using metadata assignment based on the DOD Metadata Specification (DDMS), content is managed automatically by applying metadata properties such as the 'Valid Until' date enabling the MarkLogic Server to manage the work flow

until the file is transferred to archives or deleted by the content manager.

6. Conceptual Roadmap

The operational level decision making environment is one that looks at trends, examining the art of the possible within the constraints of strategic direction and tactical resource utilization. For example, once a COA is determined and an Op Plan defined, it is the role of the tactical level to execute and make it work. It is within this context that a DSS would be leverage to assist the operational level planners define the Op Plan for rapid response immediate contingency operations.

In an ideal situation, the CF OPP would be completed in its entirety in all cases. When time constrained, an increase in the number of assumptions may be required. However, consideration of all planning aspects will continue, even if it is a quick assessment that a particular factor is not important for the assigned immediate task(s). This dichotomy of increasing information requiring more sophisticated tools to manage the information was discussed in section 3.7.5. The proposed roadmap is for a decision support tool(s) / system to guide and accelerate the operational planning process by pre-developing plans, pre-processing available data to generate required planning information or increasing competency in rapidly generating required information.

This section presents a conceptual roadmap that outlines the application of a subset of CADTTAP to the rapid response planning environment which address the requirements identified in the literature review and have been analysed in the options analysis. Integration of the set as a DSS is then discussed and further visualised using a use case (FPS2) and illustrated as a storyboard in Section 8.

6.1 The Application of CADTTAP

The planning modules developed in the Investigation (section 4.3.3) are used below to discuss the application of CADTTAP to the rapid response planning environment. The text description of each of the modules was presented in section 4.5.

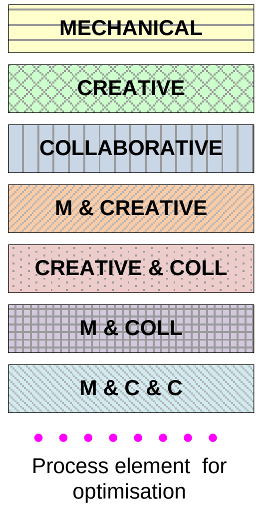


Figure 20. *Module Legend*

6.1.1 Receive Information Planning Module

The following graphic depicts the process Receive Information and characterises it as a mechanical process:

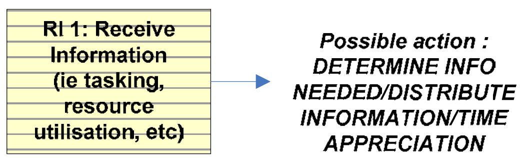


Figure 21. *Receive Information Planning Module*

6.1.1.1 Application of CADTTAP to Receive Information Planning Module

The following CADTTAPs should be employed in a DSS to assist with decision making tasks associated with receiving information:

- Enter information received into DSS tool once – reduce “fat fingering”, i.e. repeated typing/data entry of information
- Automatic notification when a field is populated. Reports run to determine which fields still need information so A3 can target what to follow up on or make a decision to proceed based on knowledge of what information they have and what is missing
- Multiple, high bandwidth utilisation activities such as textual and live data feeds, text parsing, and blackboard utilization need to be prioritised to reduce bandwidth on often limited communications networks.

6.1.2 Request/Distribute Information Planning Module

The following graphic depicts the process Request/Distribute Information and characterises it as a mechanical process:

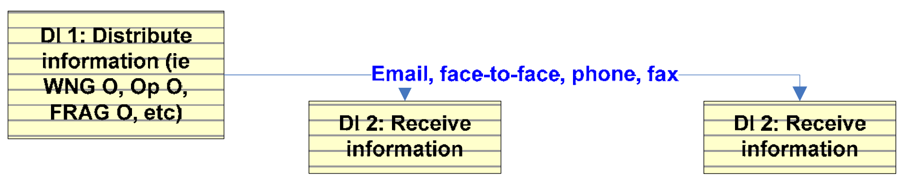


Figure 22. *Request/Distribute Information Planning Module*

6.1.2.1 Application of CADTTAP to Request/Distribute Information Planning Module

The following CADTTAP should be employed in a DSS to assist with decision making tasks associated with requesting and/or distributing information:

- Communicate information in a variety of ways: email, face to face, meetings, telephone, fax etc. The tool would support individual person to person communication or collaboratively as a group including in A-staff "battle-staff" meetings, formal or ad-hoc as the situation dictates.

6.1.3 Time Appreciation Planning Module

The following graphic depicts the process Time Appreciation process and characterises it as a creative process:

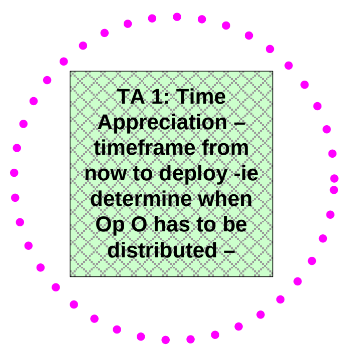


Figure 23. *Time Appreciation Planning Module*

6.1.3.1 Application of CADTTAP to Time Appreciation Planning Module

The following CADTTAP should be employed in a DSS to assist with decision making tasks associated with options analysis:

- Outputs of automated information management tools providing resource availability and associated timelines, etc.
- Information-visualization tools such as Gantt charts
- Information dissemination

6.1.4 Analyse New Tasking/Direction Planning Module

The following graphic depicts the process Analyse New Tasking/Direction and characterises it initially as a creative and collaborative process, progressing into separate mechanical and creative processes:

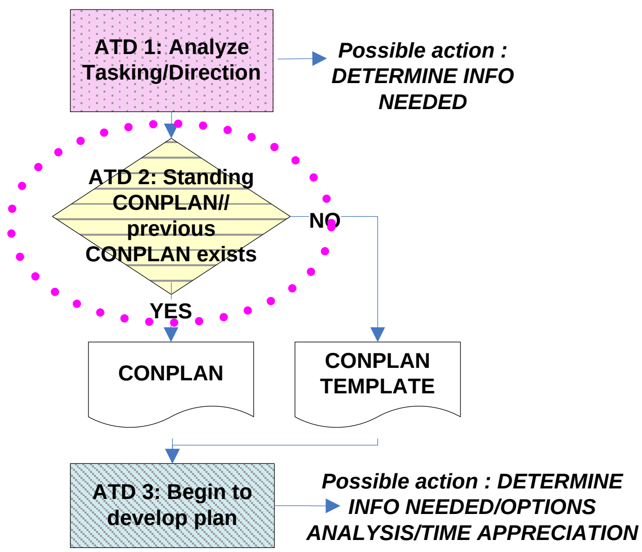


Figure 24. *Analyse Tasking/Direction Planning Module*

6.1.4.1 Application of CADTTAP to Analyse Tasking/Direction Planning Module

The following CADTTAP should be employed in a DSS to assist with decision making tasks associated with analysing new tasking/directive:

- When a new tasking arrives, the decomposition of the task in such a way that the problems can be dealt with at smaller scale is possible if there are serialisable sub-goals. It is then feasible to breakdown a problem into objectives, sub-objectives, remaining risks, and associated costs involved. Realistically, however, subdivision is not a trivial task. When we dissect processes for analysis for automation we need to:
  - identify dependencies between each task,

- Rule- out negative interactions; otherwise when take an action and then further action will undo what you did,
- Consider the entire DSS process
  - the way a system represents knowledge
  - the way a system comes across solutions given initial conditions and the above mentioned knowledge representations
  - parallel vs. sequential processing

- Conversion of Blackboard's information into computer-processable format such as PDDL (Planning Domain Definition Language), a new standard based on Stanford Research Institute Problem Solver (STRiPS), and the Action Description Language (ADL). The PDDL would help divide the situation into state, goals, and action representations.
- Open-ended repository of partial solutions and ideas to be indexed and retrievable via a control shell (i.e. the DSS search engine).
- Blackboard system to provide creative, open-ended data gathering and analysis capabilities to conceptualise and conduct divergent thinking. Information visualization tools such as Gantt charts allowing similar information to be displayed by different users, at different agencies.
- Planning wizard initiated – inputs linked to it and new iteration opened for operation. Single point data entry means linked information to all associated templates. Tracker like template management system develops planning outputs.
- Database of standing CONPLANS, historical Op Plans and lessons learned searched and outputs are inputs into wizard and Op Plan template
  - Employ RPM methodology to help select elements from Standing CONPLANs
  - There may be a case that there is no Standing CONPLAN if the situation is novel and too different from Standing CONPLAN in the database, however, multiple CONPLANS or previous Op Plans may contain information that when merged provide a starting point to planning. There will most often be some information that can be used as a starting point.
- The following require consideration for development of historical data and CONPLAN analysis
  - database component
  - CONPLAN are represented in a PDDL- (Planning Domain Definition Language) compliant format
  - while historical/case-based information in the system is also retrievable via keywords or through an assistive "wizard", but secondary to the standing CONPLAN using:
    - Personal Digital Historian (PDH)
    - Case based reasoning
- Harmonization of OGD policy would be done by Canada Command, however a review of specifics may be needed by 1 CAN AIR DIV. If system is integrated across all command levels, operational staff can search KM repositories for specific details of OGD policy/doctrine as required
- Search DSS KM repositories for DND Standing CONPLANS, lessons learned and previous Op Plans

6.1.5 Determine Information Needed Planning Module

The following graphic depicts the process Determine Information Needed and characterises it initially as a creative process. As the planner processed, activities also include mechanical and collaborative processes:

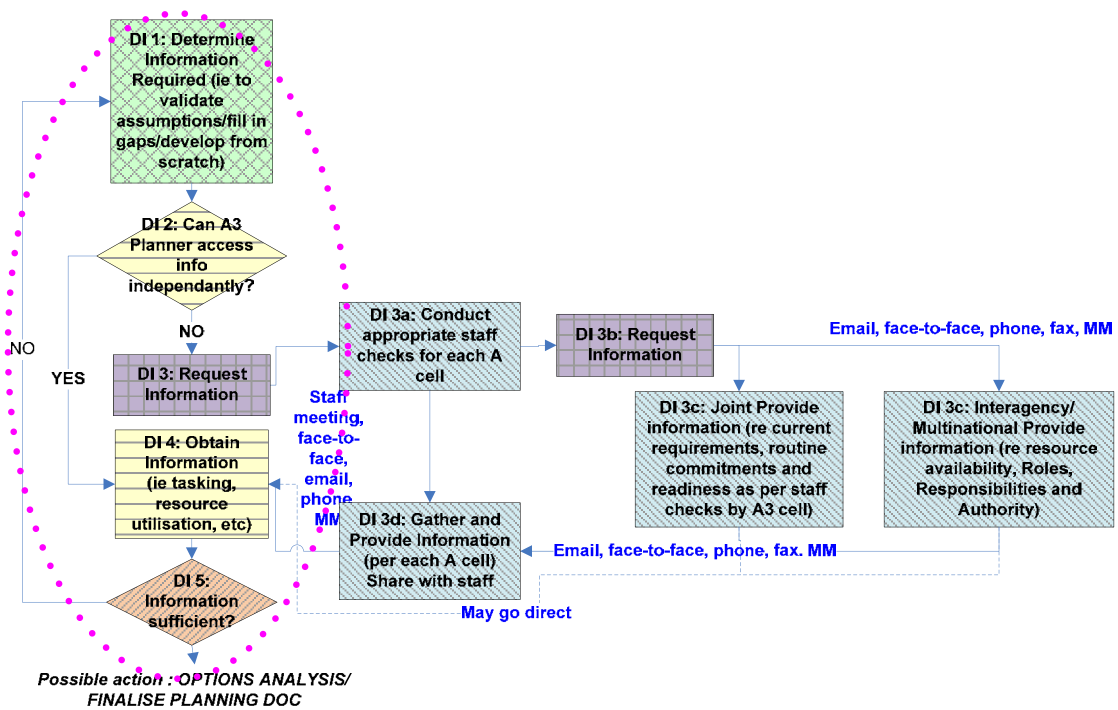


Figure 25. Determine Information Needed Planning Module

6.1.5.1 Application of CADTTAP to Determine Information Needed Planning Module

The following CADTTAP should be employed in a DSS to assist with decision making tasks associated with the Determining information needed planning module:

- Synthesizing current on-hand internal and external information leads to the determination of what information is needed as situation is assessed:
  - Planning wizard takes inputs and compares them to information element requirements in planning templates, i.e. Op Plan and determines where info gaps are
  - Utilize a pheromone matrix as information is re-aggregating from multiple sources, identifying information gaps to facilitate risk mitigation [Wang, X.(2007)]
  - The level of detail required and extent to which information is accessible to A3 determines turn around.
  - A3 defines fields needing information elements in flexible CONPLAN template in planning wizard – “single data entry point”

  - A3 would consult fleet database and run resource availability reports – tool link to databases retrieve data and populate planning wizard
  - A3 request missing information from appropriate A staff. If they did not have it they would consult OGD partners via LO or direct.
  - New information requirements would be indicated in planning wizard as planning process is executed
- Once a request for information has been extended, the re-aggregation of information to determine what information has been received and what is missing can't be done until the actual planning output is complete in deliberate planning (i.e. if information needed for Commander's Guidance, need to wait for all information requested to be received before developing the Commander's Guidance. But for rapid response, re-aggregation of information is possible at any time due to the large number of assumptions that the planners are dealing with. Re-aggregation identifies gaps, highlighting incomplete information and thus identifying risks. It also shows what A cells may need more personnel resources to assist in the planning process and can help Commander reallocate resources as required.
- Communication tools, such as chat and email, should be able to operate synchronously, or asynchronously, all logged and notified
- Information from outputs of systems would be gathered automatically and summarized using NPL employing AI techniques such as fuzzy logic, text parsing etc. For example initial information regarding availability and booking of air assets would be found in NAPP outputs and maintenance checks and unservicability reports found in the Aircraft Maintenance Record Set would be brought into the planning wizard. Real-time data management techniques such as chat would then be employed in the areas that require additional information, such as when an asset in maintenance would be serviceable.
- Shared surface computing and computer-computer Groupware: Surface computing technology would provide a table top display interface to pull up documents, access maps, weather feeds etc. to enable the A3 to determine what information they have and what is needed and indicate CONPLAN fields requiring information elements to be populated together or collaborative COA analysis. Computer-computer Groupware will enable distributed collaboration, bringing in units (i.e. COMOX) or Canada Command, or Army or Navy to the planning realm. Any unknowns will be action items for the A-Staff to address and feed info to A3.

6.1.6 Options Analysis Planning Module

The following graphic depicts the process Options Analysis and characterises it initially as a creative process. However, as a planner steps through the process, it evolves to include mechanical and collaborative elements:

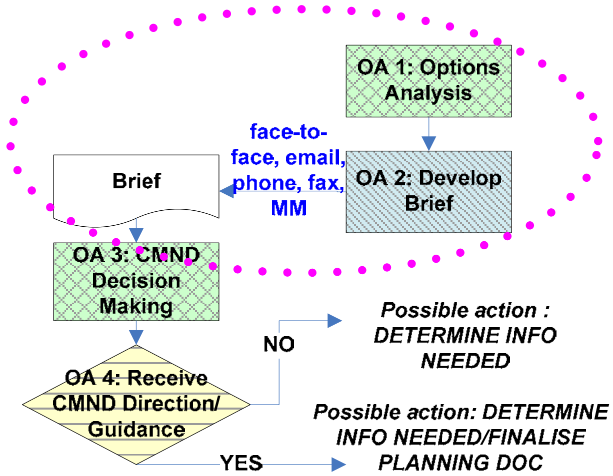


Figure 26. *Options Analysis Planning Module*

6.1.6.1 Application of CADTTAP to Options Analysis Planning Module

The following CADTTAP should be employed in a DSS to assist with decision making tasks associated with options analysis:

- Specialized modules displaying databases information via visualization tools
  - Visualize in more-than-one format
- Control shell supporting the DSS search and planning algorithms
- DSS repository of standing CONPLANs and relevant case-based information made available for COAs development
- Presenting the results of the mechanical process aids in the format of a matrix to aid the creative decision making processes
  - system must present relevant information in systematic way
- it could involve a checklist system and customisable, form-fillable placeholders with suggestions for each field, based on the CONPLAN of interest.
- Utilize a pheromone matrix as information is re-aggregating from multiple sources, identifying a way ahead that is support by information gathered as was as indicate information gaps to facilitate risk mitigation [Wang, X.(2007)]
- RPM
- A M&S module would then take the information for each of the options and the high level environmental info and run simulations (wargaming). Characteristics would include:

  - working with live data
  - input info from planning wizard
  - 3rd party optimization algorithms (i.e. iLog in Deploy)
  - Computer Generated Forces (i.e. One SAF)
  - highlight the assumptions and measure the risk
  - considering various levels of complexity – can drill down

- considering NAPP prioritization – effects of “re-rolling” assets

6.1.7 Finalise Planning Document Planning Module

The following graphic depicts the process Finalise Planning Document and characterises it as a mechanical, creative and collaborative process:

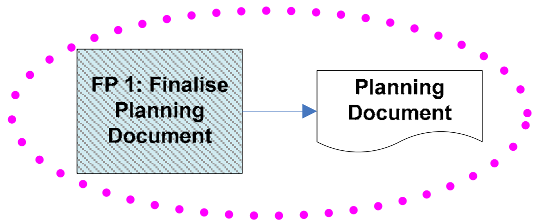


Figure 27. *Finalise Planning Document Module*

6.1.7.1 Application of CADTTAP to Finalise Planning Document Module

The following CADTTAP should be employed in a DSS to assist with decision making tasks associated with finalising planning documents:

- Planning wizard includes capability to automate generation of any planning document (documented outputs of the planning process such as briefs, Op Plans, COA etc.) as a power-point presentation using template
- All finalized planning documents should be a product of the system itself, and any tools, techniques or processes should address the side effects of “fat fingering” while optimising a single data entry point methodology.
- A template checklist might be a safeguard against involuntary omissions, errors, and typos but not prohibit the execution of the document to enable maximum flexibility.
- Any final planning document should be added as a case-based document source in the system repository for future reference
- All outputs are automatically treated as inputs to KM repository for that operation. This includes final log and any associated metrics such as turnaround times, that they system may generate as part of the project management tool functionality.

7. Technical Implementation

The planning modules presented in Section 6 present a conceptual roadmap that outlines the application of a subset of CADTTAP to the rapid response planning environment. The flow of the planning process through the modules is not set – it is a fluid process of which there is no pre-determined path – the dynamics of each situation will set that path. In addition, to ensure ease of use of a tool, the planning modules need to share technological elements as much as possible. As such, process is driven by the rapid response event and implementation of a tool set is driven by the need to centralise the planning function and thus, information/knowledge.

As all users of a rapid response DSS are information providers as well as information receivers in a dynamic, multi-stakeholder, real-time environment, the study team had the following requirements at the forefront of the technical design:

- The technology must enable the operational planners to reach out to and access information outputs at the strategic and tactical level as well as integrate operational outputs as inputs to strategic and tactical level decision aids.
- Limit the amount of “fat fingering/data entry” by ensuring single point data entry – once data is entered, it should be reused in each template that it is required in
- The military is a structured environment, therefore tools must be flexible yet conform to the rigid requirements of command structures
- Enable a variety of collaboration methods in line with habitual non-technological formats/forums (i.e., table top discussions using surface computing technologies; whiteboarding, etc) that align with other tools used on a day-to-day basis, such as COPlanS [Chief of Force Development (2008)]
- Support maximum collaboration and divergent thinking
- DSS tool is used for all deliberate and contingency planning enable ease of use due to familiarity.

This section presents the assumptions, key design components, system architecture, system integration and future research considerations that will assist with a design concept for technical implementation to support the execution of the planning models meeting the needs of a collaborative and dynamic rapid response environment. The planning modules and tools involved in the DSS are then discussed and further visualised using a use case (FPS2) and illustrated as a storyboard in Section 8.

7.1 Assumptions

The Air Force resources are kept up to date in a database populated by the Fleet/Resource Managers in real time with system synchronisation happening on a scheduled basis (i.e. twice daily) with an option to synchronise at any time to facilitate rapid response planning real time data management requirements. System synchronisation would occur similar to an enterprise resource planning (ERP) system that is used in many industries including manufacturing using “just-in-time” supply chain management principles.

7.2 Key Design Components

The study team proposes a DSS that consists of four components: a blackboard, a user interface (consisting of a surface computing device, web-based portal and planning wizard), COA analysis (through the implementation of a RPM ontological engine), a tracking, log and critical path functionality (provided by web-based project management tools), an AI specialist expert control shell and a knowledge management system. These components are described below as part of the system architecture description.

7.2.1 System architecture

The integration of the DSS functions and data resources is illustrated in the following high level DoDAF Systems Interface Description (SV-1) diagram (see figure 28). These functions and data resources are made available to stakeholders through a user interface that contains web based portal technologies and a planning wizard content management system.

7.2.1.1 Systems Interface Description (SV-1)

The Systems View (SV) is a set of graphical and textual products that describe systems and interconnections providing for, or supporting, business functions (such as rapid response planning). SV products focus on specific physical systems. The relationship between architecture data elements in the SV-1 to the OV-5 (see section 4.2.2) can be exemplified as systems that are procured and fielded to support organizations and their operation. The SV-1 is described by DoD Architectural Framework, Volume II as the following:

1. Product Definition. The Systems Interface Description depicts systems nodes and the systems resident at these nodes to support organizations/human roles represented by operational nodes of the Operational Node Connectivity Description (OV-2). SV-1 also identifies the interfaces between systems and systems nodes.

2. Product Purpose. SV-1 identifies systems nodes and systems that support operational nodes. Interfaces that cross organizational boundaries (key interfaces) can also be identified in this product. Some systems can have numerous interfaces. Initial versions of this product may only show key interfaces. Detailed versions may also be developed, as needed, for use in system acquisition, as part of requirements specifications, and for determining system interoperability at a finer level of technical detail.

The SV-1 developed for this project illustrates the DSS components that have been identified and their interconnectivity. The SV-1 has been developed at a high level to facilitate integration conceptualising with an understanding that there is more work needed to define the DSS SV-1 in lower levels of decomposition.

The workflow and function of the DSS is logically distributed across the planning staff according to individual role and is distributed geographically according to the location of knowledge resources and human resources. The web-based technologies allow the technology to be the supporting part and the humans to be the supported. The tools would thus be distributed to the planning social network via the web-based technologies through the computer technical network. The components that are captured in the product illustrate the systems that would be in place to form the DSS and illustrates how the entities connect with each other to execute the DSS capabilities.

For the purpose of this project, there is an assumption being made that both classified and unclassified interoperability will be dealt with. Elements that facilitate this would appear in a lower level decomposition that would support a variety of levels of interconnections, most frequently classified and unclassified is beyond the extent of this project.

The conceptual roadmap suggests that the systems employed in the DSS will facilitate interconnections at the tactical, operational and strategic level. In addition, command centres belonging to partner agencies operating in the domestic and/or international domain will be able to interconnect with the tool in an information push/pull scenario using the web. System elements required to support this collaborative capability would also appear in a lower level decomposition that is beyond the extent of this project.

The following Figure 28 is a concept diagram which illustrates the main element s of conceptual components discussed in the report and their relationships.

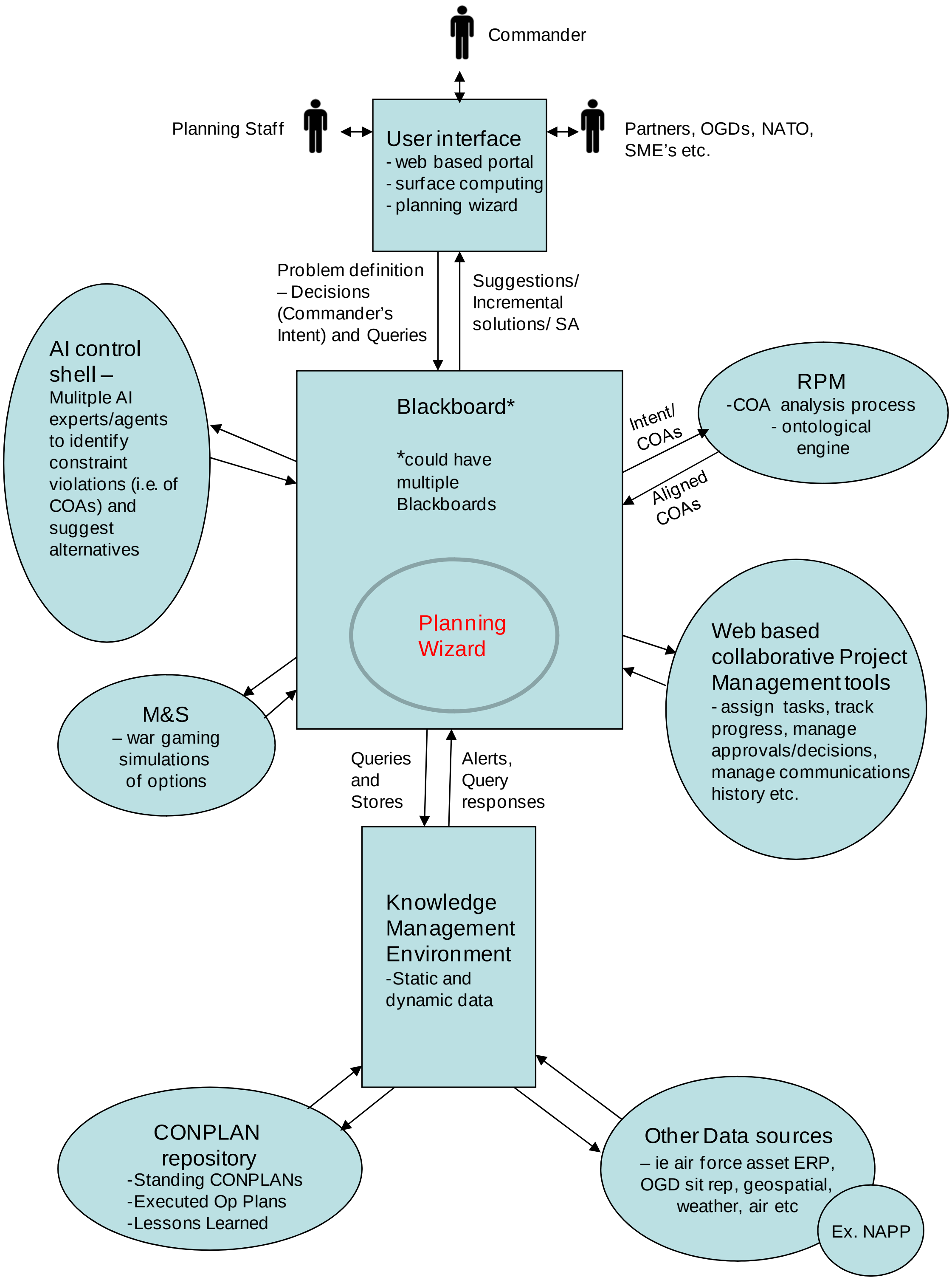


Figure 28. System Architecture – Integration SV-1

The system components are defined as:

7.2.1.2 Blackboard

As mentioned earlier, the blackboard concept enables the users to access a number of different knowledge sources using one interface. The blackboard interface gets info from various places and translates the information in such a way that it is coherent to all other users. Blackboard draws information from KM system and deposits processed information back into KM system. Blackboard and KM systems interact seamlessly to the user. Multi-user data manipulation would enable distributed users to access and contribute to blackboard information. This is a key concept for the implementation of an effective DSS.

Blackboard technology has proven particularly effective for solving complex, but well characterized problems such as Threat Evaluation and Weapons Assignment (TEWA) and for managing complex process control problems. These types of problems exhibit well defined logic based on constraints and rules. The Blackboard provides a means for integrating multiple experts to contribute partial solutions leading incrementally toward a possible solution that is "good enough" but maybe not optimal. In that sense, Blackboard technology may be a good component for operations planning for well defined components such as logistics and perhaps sequencing of activities.

The use of blackboard technology encourages web-based, multi-user, peer-to-peer (P2P) information ambiguous environments. "The significant increase in the availability of information from a variety of information sources, not all of which are mutually consistent or equally reliable…these information sources are often databases, but many foresee a future in which some of them will be deductive databases, logic programs, or even full fledged logical reasoners" [Binas (2007)]. . Rapid response planning is a very dynamic environment and as the situation evolves, some of the hypotheses and their associated conclusions obtained during the mission analysis may be invalidated. Thus, in the context of this project, the AI behind the blackboard concept presents a key challenge.

A solution for this challenge has been proposed by [Bikakis (2009)] based on what he refers to as the "Multi-Context Systems paradigm"

> "in which local context knowledge of ambient agents is encoded in rule theories (contexts), and information between agents is achieved through mapping rules that associate concepts used by different contexts. To handle imperfect context, we extend Multi-Context Systems with non-monotonic features, such as local defeasible theories, defeasible mapping rules, and a preference ordering over the system contexts. "

In addition to the model, Bikakis (2009) developed an argumentation framework that exploits context and preference information to resolve potential conflicts caused by the interaction of ambient agents through their mappings and provide an operational model in the form of a distributed algorithm for query evaluation, as well as three alternative versions of the algorithm, each of which implements a different strategy for conflict resolution [Bikakis (2009)].

7.2.1.3 User Interface

In order to math real-world interaction and to make the DSS easy to learn, easy to use and marketable to planners, the following elements are considered:

7.2.1.4 Surface computing

Through surface computing technologies, the users would interact with the data that is contained on the blackboard (this includes the information that is in the KM system, as stated above the computer interacts via blackboard and then the user would interact via surface computing technologies).

The surface computing technologies would support sharing information with various devices including PDAs, cameras, laptops using automatic document transfer via wireless technology. In addition, the technology would enable multiple documents to be manipulated at a time supporting simultaneous multi-user interaction.

7.2.1.5 Planning wizard

The main use of the planning wizard is to centralize and institute a content management system. The web-based planning wizard would be key component for this function and reside on the blackboard platform. The planner would start by opening up planning wizard to start inputting data fed from planning directive and would end with an Op Plan. As such, the Op Plan will "fall out" of the planning wizard. In this way the planner will have a single data entry point for information – once data is entered in once, the information is inputted/outputted to different templates as appropriate as dictated by tool parameters or as formatted by planners. Key concepts include:

- Wizard is a plug-in using a web-based portal through which the Team Lead guides the operation specific planning activities through the planning wizard with high level control over blackboard.
- Planning wizard deals with various levels of complexity. If a recommendation comes to the commander and he has a gut feel that it's right, he will not ask for explanation. However, if the recommendation comes as a surprise or he requires explanation of specific elements, the planning team needs to be able to reach back and trace their decision making that reached the recommendation. This causes a requirement for drilling down (and up) through a decision tree, with links to information and documentation to portray the rational and logic in a very transparent method.
- When defined as Rapid Response Planning – max flexibility allowed in tool for CF OPP phase outputs – can be skipped or incomplete (this is not allowed under deliberate planning).

7.2.1.5.1. Proposed solution

One such solution to provide a Planning Wizard functionality within the DSS could be the use of :

1) MindManager "mind mapping" technology that unlike the linear-based approach of many productivity tools, it uses mind-mapping technology to let users capture, organize, and communicate information using an intuitive visual canvas. Consolidate vast amounts of data and ideas from multiple sources onto a single map including

adding dynamic content from customer databases, internal applications and other company resources. Within the application, the user can drill down to various levels of decomposition of any of the nodes, wading up and down revealing dependencies and correlations and providing traceability through the logic[9].
2) MS OneNote or similar technology that integrates all MS Office applications (the DND standard), allowing the user to browse through a shared working space that integrates all MS Office applications with a powerful search capability as the engine of the Planning Wizard[10].

As of 2007, these two applications (MindManager and OneNote) work together due to the efforts of MindJet, the company that makes MindManager. There is now a synergistic relationship between two applications, Microsoft Office OneNote 2007 and Mindjet MindManager Pro 7. For example, users are now able to use OneNote for project/plan tracking and gathering, storing, and managing information (including text, pictures, digital handwriting, audio and video recordings, etc.) in a single location (convergent tasks) while also using MindManager for planning and brainstorming (divergent tasks).

7.2.1.6 User Configurable

The interface would be configured by the user to best suit their needs and working styles. Parameters would also be configurable such as database retrieval methodologies and information source priorities. For example, each Air Force Battle Staff A cell would have a module to interface with the tools that they use for their specific function. A1 would interface with outputs from resource management tool (i.e., people soft), A2 would interface with intelligence tool outputs, and A4 with enterprise resource planning tools

7.2.1.7 Web-based technologies

Web based technologies in the format of a portal interface to receive outputs from other systems and prepare planning wizard outputs as inputs to other systems.

7.2.2 Tracking, Log and Critical Path Functionality

The collaborative project management tool approach is paramount to streamlining the efficiency of the whole Blackboard framework, each agent involved in the planning process must have access database inputs and outputs related to their respective role (e.g. airlift, ERM teams, etc.) and be amenable to providing information to the commander via the communication tools. As such, the web-based collaborative project management tools can assign tasks, track progress, manage approvals/decisions, and manage communications history etc. for each of the planned operations in its entirety from receipt of first WngO to Lessons Learned.

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[9] More information on MindManager can be found at: http://www.mindjet.com/products/mindmanager/default.aspx
[10] More information on MS OneNote can be found at: http://office.microsoft.com/en-us/onenote/HA101656661033.aspx

7.2.3 COA Analysis

COA analysis is one of the cornerstones of rapid response planning. It brings together divergent and convergent thinking processes to arrive at the best possible solution for action that will be then captured in the Op Plan.

7.2.3.1 RPM

When faced with a decision, humans use their intuition as they detect clues and search for patterns based on previous experience and personal knowledge. Applied in the military context, a commander's knowledge, training, and experience generally helps in correctly assessing a situation and mentally wargaming a plausible COA. As discussed in Section 3.5.7, the Recognition Planning Model (RPM) is employed as an ontological engine to codify the informal and intuitive planning strategies employed by skilled planning teams. RPM is a "seed" possibility for COA development and should be considered as a candidate technology for complementing Blackboard technology for those planning elements that are more constraint-based.

7.2.4 AI Specialist Experts

The development of expert systems enables computers to make specific judgments and give advice to users by incorporating human expertise. The goal of applied AI, or advanced information processing, is to program computer expert systems ("smart" systems)—those that can, for example, recognize a fingerprint for security purposes, recognize voices, interpret information and solve problems. An important feature of expert systems is that they are able to work cooperatively with their human users, enabling a degree of human-computer symbiosis.

7.2.5 Knowledge Management System

A knowledge management system will provide a reference component for the DSS. It is a base of information for reference. Once data can be stored, it can be reused or referenced to create knowledge. According to Ross Pigeau, "knowledge is a piece of information that you have received and assimilated and you have a level of confidence about it such as that you will act upon it". Accessible to distributed team members, the DSS system will integrate information from a variety of repositories for planning purposes.

7.2.5.1 CONPLAN Repository

A database repository of standing CONPLANs, executed Op Plans and lessons learned will form a key part of the DSS.

7.2.5.2 Other Data Sources

Additional data sources would include information such as resource availability (outputs of other systems and/or tools such as the NAPP), geospatial data, weather conditions, infrastructure (i.e. airport runway parameters).

7.3 System Integration

There will be an overall requirement for the integration of the multiple technologies required for the mechanical, creative and collaborative CADTTAP of rapid response planning decision support.

Various issues that are important for integration of embedded systems will have to be addressed at the technical level in detail. The topics include component technology, integration testing, compositional scheduling, RTOS, formal methods and tools, programming languages for embedded and real-time systems. The goal is to understand the problem space, current practice and principles. Concepts such as autonomic services (cloud computing), ubiquitous computing environments and grid computing may be useful to consider at the high level integration. The following points highlight two areas that are key to system integration into the larger Air Force domain: workflow analysis and enterprise interoperability.

7.3.1 Workflow analysis

As discussed in section 3.2, the role of decision support during any planning process is to provide information in a usable format to decision maker allowing them to make better informed decisions with respect to any combination of speed, consideration of all relevant factors and weighting of unintended as well as intended consequences in a specific operational environment. Observation will enable the design team to be aware of anything that was added to the human operator processes, or inversely, removed from it, for design purposes or optimization, but that the end user may not be aware of and therefore unable to communicate it effectively verbally.

7.3.2 Enterprise interoperability

The DSS should be the centre-piece in solving the planning problem - this is where information will be inputted and outputted. Considering the scope of the project, and the probability of continued development of interfaces (with other users, as well as other computer systems), and algorithms, a design team should consider developing in house application to ensure that can be adapted appropriately. Using a JAVA based solution would provide a healthy number of technical personnel available to work with the system. A JAVA application would also be interactive, interoperable, platform agnostic, and portable to other systems; can use algorithms that can be implemented into the software at a later date, and will allow interfacing with a 3rd party/COTS tools for optimization.

The DSS must be accessible and useable, and presentation of the information needs to be filtered appropriately for multiple types of users and deal with users with diverse interests. This is especially true if it will be a true enterprise solution and span tactical to strategic level users. For example:

- Political/economic/public affairs info may be very relevant at Strategic level but not given consideration at the tactical or operational level as they follow Commanders' guidance. However, impacts may still trickle down as the constraints are felt. The following need to be considered to deal with information that is loosely coupled, or not directly related data which may have an impact could be included:
    - need to accommodate issues and limitations outside of mechanical process
    - need to have it as a placeholder so tool can be used at all levels

- means for end user to communicate with strategic level or OGDs that have constraints that may limit interactions

7.4 Areas for further research

This has been a high level report to address the SOW. This is the high level view and future work could investigate the application of the proof-of-concept in the development of a workable prototype and include the development of functional architectures as articulated in DoDAF SV products.

The following factors need to be considered for further research to confirm the approaches, CADTTAP to be implemented as subsections of the five components.

7.4.1 Situational Awareness

There is a great need for tools and infrastructures that focus on increasing SA. Consideration of the following for tool selection for SA is critical:

- Automatically gather data of different agencies,
- Merge information with blackboard and wizard templates to ensure display of information in a format that will assist the user, in his own "working language/ontology"
- Be able to share the information on a distributed network with other agencies.
- Pushed service of updates of anything asked for (i.e. Mac GROWL, push services are customisable and come with automatic notification services for a variety of applications)
- Support unified system for notification that facilitates collaborative communication requirements –instant messenger/smart-boards/hand-held/email/Twitter[11]/SMS/satellite (if land line downs

7.4.2 Classified Domain

Collaboration represents a technological challenge from multiple perspectives, from resources, to implementation, support, and services and functionalities. Any implementation of collaborative tools should take in to consideration ability to share selected information without being overly-burdened by the security requirements of individual agencies. Burkle & Hayden in [Burkle (2001)] mention that when there is a body of knowledge, some of which is classified, or considered "sensitive", the distribution of such information causes delays. This, in part, relates to concerns regarding the classified information environment in which the military plans and operates, as well as the inherent reluctance to share information:

- System can't be completely open
  - Ability to handle classified information, and obscure that portion of the information on a need-to-know basis
  - Fuzzy matrix based reasoning / Fuzzy associative matrix based reasoning
  - Align with the blackboard concept

[11] twitter provides updates in simplest format

7.4.3 Surface computing interface

Potential enhancements of for investigation as to their feasibility for integration:

- Improved resolution, so that documents can be clearly viewed (e.g. >75dpi)
- Combine with capability to remotely control someone else's screen. Thus allowing for multi-user collaborative applications on single display groupware.
- Permit content annotation, retrieval and presentation, visualization of and user interaction with images, audio, video and data, as well as the recording how people collaboratively use the single display interface. This would:
    - allow people to easily utilize this digital data in a face-to-face conversational or group setting.
    - develop content organization and retrieval methods that are easy and understandable for the users, and can be used without distracting them from their conversation. This is accomplished using natural visual query formulation with minimal menu-driven interaction and freeform strokes.

7.4.4 Artificial intelligence and algorithmic process (Control Shell)

A number of AI techniques can be considered. The following need to be highlighted as AI techniques are analysed for suitability:

1. Optimisation of a number of very different functionalities will require a number of search engines each with various qualities for knowledge representation:
    - Forward/backward searches –progression vs. regression planning start with data you have or start with goals (desired end state)
        - Different strategies based on type of problem, environment and planning approach
        - Heuristic – rules of thumb
        - Propositional logic planning – represent variables in terms of symbolic logic (inferential thinking) (see section 3.5.4.1).
        - Planning graphs – network analysis
        - Partial order thinking
    - Partial matching algorithm to search CONPLAN database that can give fit with
        - standing CONPLANS
        - historical Op Plans
        - lessons learned
2. Ensure mitigation against false positives, for example:
    - if get false positives, that is fine, you can have risky algorithms like fuzzy
    - if have things not presented when they should have been (false negative), more serious than a false positive
    - Possible algorithms
        - Fuzzy logic – but not closed form
        - Bayesian logic - mathematical, predictable result that can be calculated choose this, rather than Fuzzy logic, or Neural Networks as don't want something that is accidentally way out there.
        - Fuzzy matrix based reasoning / fuzzy associative matrix based reasoning
        - Rule-Based System
        - Genetic Algorithms

        - Logical Condition
        - Causal Probabilistic Network
3. The specific application of and requirement for real time data, template data and case based data
4. The logic part (DSS algorithm) could change as more appear in next 5 years and whole system can be adapted.
    - Reduced number of false +yes
    - Search out more relevant information

7.4.5 Human factors

The purpose of the DSS is intentionally limited to presenting data and to give guidance, without making decisions [Mulvehill (1999)]. The data should be presented in an easily understood manner, without overwhelming the user, and highlighting significant effects [Tryan (2008)]. As such, it needs to be highly integrated with the user in fit, form and function.

When any technology is to be integrated with human process, the system must be designed with the user in the design process. This requires the following considerations:

- User "buy-in"
    - It has to be a tool that the user wants to use in order to maximize not only the fit between system automation and operator task, but also the proper interpretation of what may or may not happen
    - designing a system of any kind often benefits greatly from involving the end users in the design process by creating an "emotional" attachment to the project through participation and contribution.
- User familiarity
    - if used in time constrained activities, need to know it well, so need to not have a new tool for rapid response
    - Tools should be same for both - need to know how to use the tools under time constraints, so new tools just for contingency planning don't make sense
    - Often the same data is accessed for deliberate and contingency planning
    - Utilise existing logistics/resource management, GIS etc tools, rather than reinventing applications.
- needs to support creative thinking but be mechanical and enable both divergent and convergent thinking processes
- be flexible to allow change in communication or collaboration patterns as these will be determined by the specifics of each event
- minimize risk by giving minimal level of implicit information
    - either known or its made non-retrievable for sake of abstraction
    - when implicit aspect, means not shared in proportional way
- information must be filtered appropriately for the user
    - don't want to give too much info so it overwhelms the user

7.4.6 Technical Standards

A number of technical standards must be considered to ensure compatibility domestically, i.e. for Canada /US NORAD Air Ops, and internationally, i.e. NATO Air Ops.

8. Storyboard

Integration of the conceptual roadmap components as a DSS is visualised using a use case (FPS2) and illustrated as a storyboard. The OV-5 developed in section 4.2 has been further refined with the application of the FPS2 elements and conceptual roadmap components. The following demonstrate the layout and is a sample of the presentation of the storyboard. Due to its size (it has been developed as a large format graphic), a softcopy in pdf and MS Visio is provided to accompany this report.

8.1 Storyboard Presentation

In order to facilitate navigation through the storyboard the following subsections present an outline of its layout and contents.

8.1.1 Scenario Event Elements

The FPS2 scenario event elements are presented in the left hand column to present a storyline. These elements have been taken from FPS2.

8.1.2 Stakeholders/Actors and activities

Similar to the OV-5 in section 4.2, the storyboard is presented in a swimlane format. The stakeholders/actors are presented as operational nodes as headings across the top of the storyboard. The associated activities are then presented the columns under the stakeholder/actor headings as they relate to the timeline presented by the scenario elements.

An outline of the major stakeholders in Air Force rapid response planning environments is presented in section 3.2.4. These stakeholder groups are represented as the headings of each of the swimlanes in the storyboard and include:

- OGDs/Allies
- CF Commands (CEFCOM/CANADACOM)
- Combined Air Operations Centre (CAOC)
- Commander, 1 CAN AIR VIC/CANR
- 1 CAN AIR DIV A3
- 1 CAN AIR DIV A Staff Cells 1, 2, 4-9 (May include NORAD A Staff)
- Resources – Wings, HQ Fleet Managers (i.e. Airlift, Fighters, etc)

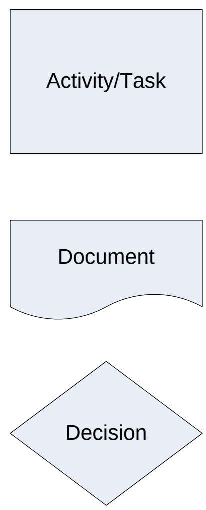
8.1.3 Applicable CADTTAP

The applicable CADTTAP are presented in the final right hand columns. These are presented using a discussion of the applicable planning modules as defined in the conceptual roadmap. The discussion is presented under two headings, divergent and convergent highlighting the planning module elements which correspond with divergent vs. convergent decision making processes (see sections 3.5.5.2 and 3.5.5.3).

8.1.4 Storyboard Graphic

The figure below is a condensed snapshot of the storyboard. The complete storyboard is provided as a separate pdf and MS Visio file.

Symbology:



Swimlanes

The activities are presented in “swimlanes”, with each stakeholder name indicated at the top of each swimlane.

The storyboard is available in PDF to enable legibility. The following graphic presents the storyboard in its entirety.

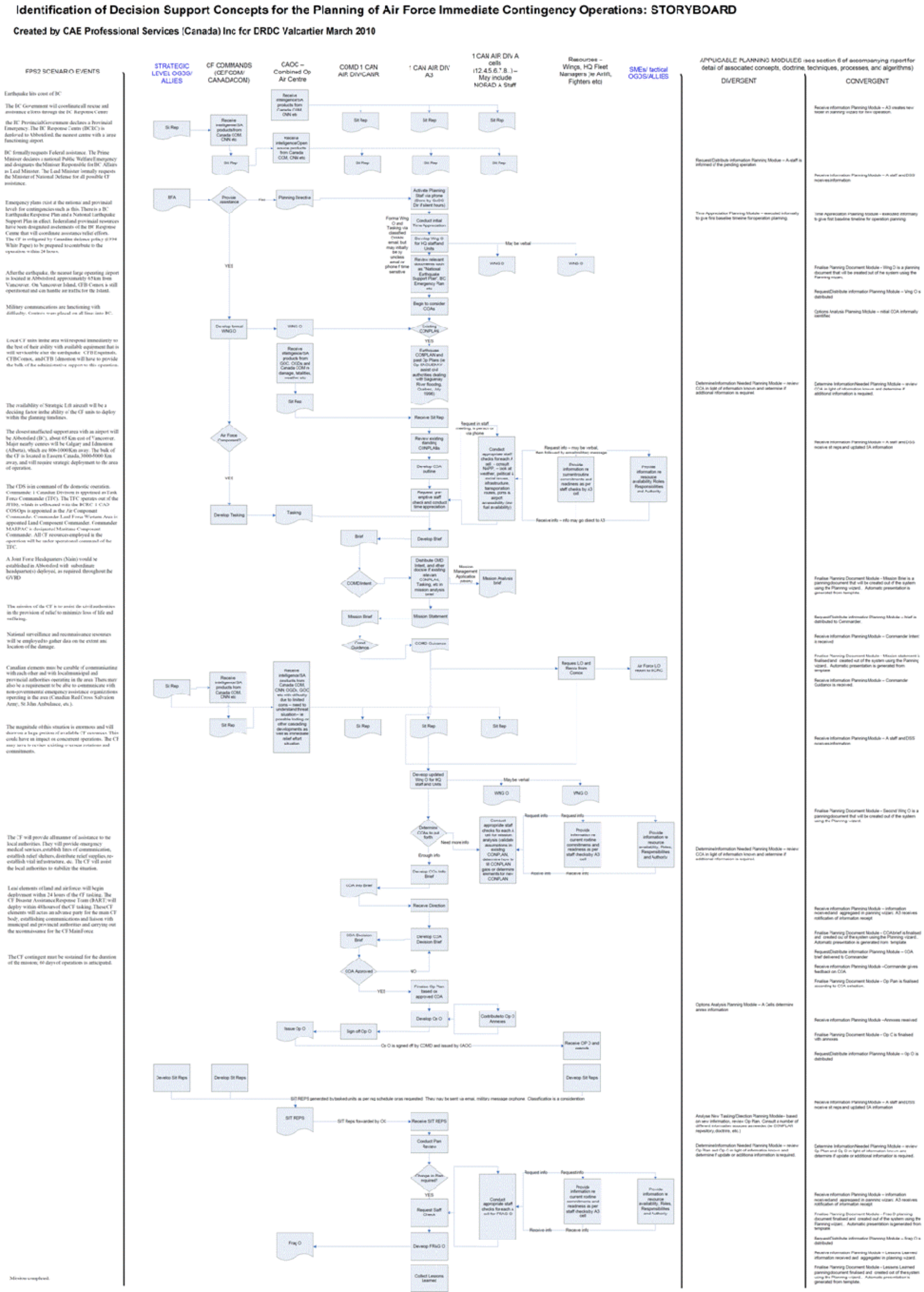


__Figure 29.__ Air Force Rapid Response DSS Storyboard

9. Conclusion/Recommendations

9.1 Conclusion

The proposed conceptual roadmap presents options to be considered for a suite of decision support applications or tools comprising a DSS to guide and accelerate the Air Force rapid response operational planning process. The proposed system will aid rapid response planners by pre-developing plans, pre-processing available data to generate required planning information, increasing competency in rapidly generating required information, and integrating the information to develop planning documents including identifying the optimal course of action. The DSS will facilitate the finalising of required planning documents, including a completed Operations Plan, while leveraging a single point data entry of information elements and a flexible template system. The envisioned DSS is based on a SOA that will enable flexibility for system integration and web-based to facilitate distributed collaboration.

The context of the work for this project focused on one force planning scenario, however, as the work was guided but not fully constrained by the FPS, the conceptual roadmap provides a foundation for future DSS design for rapid response planning across the full spectrum of CF operations.

9.2 Recommendations

In the process of the investigation of the baseline requirement to understand the current full planning cycle, where it can be optimised, and in what ways new and novel CADTTAP can support this, the project team has extracted a number of recommendations. These include:

1. Analyse COPlanS trial results:

Another interesting factor is that a pilot/trial of COPlanS was planned for both 1 CAN AIR DIV and CEFCOM from May to December 2008. Before development of any future operational planning and decision support tools, feedback on the trial should be examined [Chief of Force Development (2008)].

2. Analyse TOPFAS user evaluation results:

A TOPFAS user evaluation exercise was conducted by DND in May 2009. The results should be reviewed with the COPlanS trial results as part of immediate next steps.

3. User-focused requirements gathering:

Obtain user input on the design and interfaces for the DSS. The design and development of the DSS should be user focused in order to ensure:

- the greatest ease of use;
- integrates with existing people, processes and technologies
- satisfies real needs of operational staffs.

4. Ensure that the design of the system facilitates creative thinking early in the planning cycle:

Research should include more in-depth look at the specification of cognitive processes involved in improvisation for the purpose of more seamlessly integrating human-computer collaboration on an improvisatory task. The employ of Cognitive Task Analysis (CTA) to gain in-depth access to the mental processes that underlie performance of tasks would be beneficial.

5. Obtain a more in-depth understanding of specific SOPs:

SOPs guide the way in which each of the A staff interact with the doctrine and existing toolsets that assist in their planning activities. A greater understanding of how the operational community engages with the SOPs would refine the requirements for the DSS. Consideration of the fact that SOPs work under standard operating environments but rapid response planning is often conduced under non-standard operating environments and thus the SOPs need to be optimised is essential to this investigation. As such, SOPs will need to be modified or adapted accordingly. The resulting analysis would complement a CTA.

6. Investigate COA Analysis Based on Fuzzified Semantic Inference (CAFSIN)

In joint environments, decentralized support adds new dimensions to the problem space and the distributed, collaborative planning team with more players, who bring more experience to the planning environment and much more information streaming in. What we see emerging in complex situations at the strategic joint force level, involving OGDs, NGOs and civilian responders, are all multiply related COAs fitted for the diverse roles of the stakeholders involved in a specific operation, each with a wide range of capabilities, resources and constraints.

Recognizing the value of CONPLANS, the solution for a whole-of-government (or multi-national coalition) response to a situation requires not a single COA developed from the experience of a single commander, but a range of COAs for the responding stakeholders that facilitates rapid alignment of planning and synchronized execution of activities. A suite of ontologies associated with the variety of activities and capabilities of the stakeholder organizations is required to express a coherent set of COAs that could lead to a synchronized set of actions, civil and military.

A library of contingency operations plans, and previous operations, based on the suite of ontologies might provide the means to establish a shared knowledge base that can be searched to determine possible COAs that align with the command intent in order to quickly establish a preferred COA to initiate the distributed collaborative planning effort. Contingency operations plans can be generated automatically, for a broad range of mission scenarios. But for a given specific mission only those in alignment with Commander's Intent should be selected for investigation. What is required is a method for determining the extent of alignment and the suite of ontologies representative of the activity domain of each stakeholder organization. Duane Gilmour at the U.S. Air Force Research Lab has reported on a proof-of-concept ontology for rapid COA evaluation:

> “The challenge is that given a specific pair of commander's intent and COA, there is always a semantic gap: the two not only differ syntactically, but also semantically. In this research, we have made two specific contributions towards developing a solution to this problem. First, we have discovered that the classic symbolic reasoning does not work in developing such a solution, as the semantics involved are always fuzzy and inexact. Second, under the assumptions that both the commander's intent and the COAs are represented in a low level in a semantic hierarchy (such that there is a syntax to represent them in terms of languages), we have developed a specific solution as a method to identify whether a specific pair of commander's intent and COA is in alignment and if not, how far they divert from each other. We have done proof-of-concept testing on a small, hand-crafted ontology”[12] .

This specific method is called CAFSIN, standing for COA analysis based on fuzzified semantic inference. The specific algorithms used to search the databases can vary, and may be improved as technology matures, however as a starting point there should be an initial search engine based on clearly defined Bayesian Logic, with the optional addition of fuzzy logic techniques that may provide other relevant information. The danger of only using fuzzy/inexact logic is the risk of false negative search results. False positives are less hazardous because it allows the human operators the option of pruning the occasional irrelevant result.

Moving forward, it is recommended that future research investigate the CAFSIN method in more detail to help assist with aligning COA with response partner entities.

7. Expand analysis to include Supply Chain Management:

This project focused on an investigation of current military and civilian emergency response. An extension to the field of supply chain management and the associated Enterprise Resource Planning (ERP) systems and their DSS CADTTAP may add insight to ways in which the supply of information elements to produce an Op Plan may be optimised from a different perspective:

> “The creation of value is managed through what has been referred to as the supply chain (Houlihan, 1987), value chain (Porter, 1985), or customer chain (Schonberger, 1990), each of which refers to a series of integrated, dependent processes through which specifications are transformed to finished deliverables. Emphasis is placed on the integration of activities while focusing on increasing value for the customer.”[Al-Mudimigh (2004)]

8. Increase technical understanding of systems that will share information artefacts as integrated to the DSS:

The key to an operational level planning DSS is that it will link to outputs of other systems including those at the strategic and tactical level. Any system-to-system technical interface design will need to be determined with knowledge of all the various systems outputs that it

[12] Gilmore, Duane (2005). Real Time Course of Action Decision Support, Air Force Research Lab, Rome, New York; AFRL-IF-RS-TR-2005-363

will interact with. In addition, this would enhance a thorough investigation of information requirements, ensuring that the information that is needed will be technically accessible.

9. Determine methods to track the evolution of decisions within the DSS AI control shell while addressing the principles of defeasible reasoning.

Two areas of further investigation have been identified:

a) Consistency-based approaches (such as default logic) to understand the application of priority relations and reliability;
b) Non-monotonic consequence relations to understand artificial non-monotonic reasoning [Kraus (1990)]; and
c) First-order predicate logic and the subset description logics. First-order predicate logic is far more powerful and expressive than propositional logic, but it is also more fallible. First-order predicate logic is more interesting than propositional logic with regards to defeasible and non-monotonic logic and is worthy of more in-depth study. Description logics (DL) are a family of knowledge representation languages which can be used to represent the concept definitions of an application domain (known as terminological knowledge) in a structured and formally well-understood way. Description logics is a kind of knowledge representation (computational model for logical manipulations, of which a decision-support system can be considered a subset), and form a middle ground solution: including some more expressive operations than propositional logic and having decidable or more efficient decision problems than first order predicate logic. In other words, description logics have most of the benefits of first-order predicate logic without some of its flaws.

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Note:

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Annex A: Force Planning Scenarios

Force planning scenarios describe a representative spectrum of operations in which the Canadian Forces may be called upon to act. They provide the context for assessing tasks which must be done, and to what degree the Canadian Forces might reasonably anticipate being required to undertake each task.

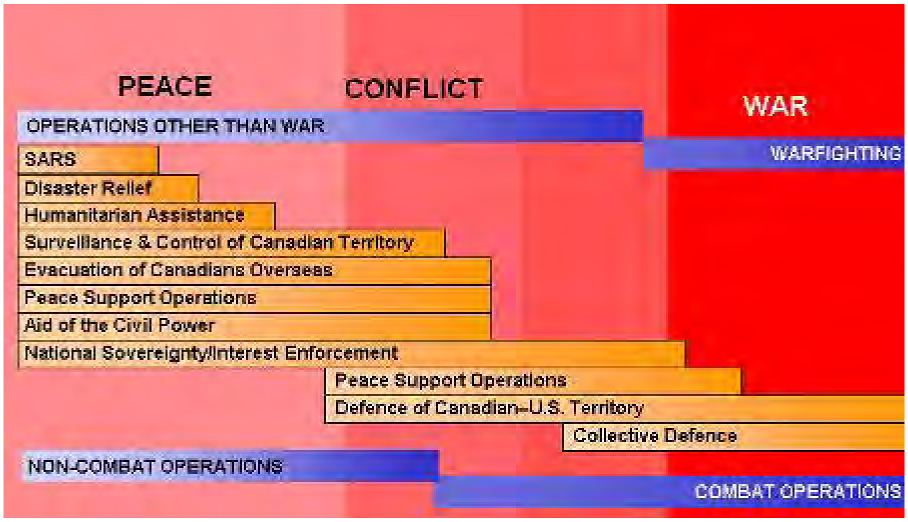

Figure 30. *DND Force Planning Scenarios*

The following scenarios present those reviewed for this project. More information and additional scenarios can be found at :
http://vcds.mil.ca/dgsp/pubs/dp_m/intro_e.asp

FPS 2: Disaster Relief

(This entire scenario, its characteristics and details are totally fictional. While the details of the scenario are offered as plausible, no indication of the likelihood of occurrence is implied.)

A. Background
A. 1. Authorities/Strategic Context

> The Defence White Paper 1994: "The Canadian Forces play a key role in responding to natural and man-made disasters. Not only is the Minister of National Defence also the Minister responsible for Emergency Preparedness, but, ...the administration of emergency preparedness...has been absorbed by [DND]." (p. 18)

The Defence White Paper 1994: Protection of Canada "...the Canadian Forces will...be prepared to contribute to humanitarian assistance and disaster relief within 24 hours, and sustain this effort for as long as necessary." (p. 19)

A Strategy for 2020: "The Defence mission is to defend Canada and Canadian interests and values while contributing to international peace and security. Within this mission, Defence is responsible to: … provide emergency humanitarian relief." (p. 2)

A. 2. Relevant Documents

a. The Defence White Paper 1994

a. Shaping the Future of Canadian Defence: A Strategy for 2020, June 1999

b. Defence Planning Guidance

c. Defence Publication B-GG-005-004/AF-000, Canadian Forces Operations

d. Defence Publication B-GL-313/FT-001 Medical Services in Battle

e. Defence Publication B-GL-314-001/Af-001 The Land Maintenance System (LMS)

f. Headquarters Deployment Plan 800

g. Headquarters Deployment Plan 291, OPLAN AGILE

h. Operation RECUPERATION After Action Report, Lessons Learned Information Warehouse Version 9.0

i. Operation ASSISTANCE After Action Report, Lessons Learned Information Warehouse Version 9.0

j. Exercise CANATEX 2 Final Report, Emergency Preparedness Canada, 1994

k. "Operation SAGUENAY", Airforce, October 1996, pp. 15-17

l. Emergency Preparedness Digest: Special issue on the Saguenay Disaster January-March 1997

m. "National Earthquake Support Plan", Emergency Preparedness Canada

A. 3. Examples of Similar Operations

Op SAGUENAY - assist civil authorities dealing with Saguenay River flooding, Quebec, July 1996

Op ASSISTANCE - - assist civil authorities dealing with Red River flooding, Manitoba, April 1997

Op RECUPERATION - assist civil authorities responding to ice storms in eastern Ontario and western Quebec, 1998

B. Intelligence

B.1. Situation Awareness

General

On 2 November 2018, at 2300 hrs UTC, a magnitude 8.5 subduction type earthquake occurred approximately 100 km. off Vancouver Island and the Washington coast (see Figure 1). The quake ruptured about 400 to 600 km. of the Cascadia subduction front. Surface ground shaking on Vancouver Island and the lower mainland of BC lasted approximately 5 minutes. Numerous aftershocks occurred in the hours following the initial quake, ranging from 3.4 to 6.1 in magnitude.

Damage is widespread in the lower mainland of BC. Electric power has been lost over a large part of the Greater Vancouver Regional District (GVRD) and essential services are severely disrupted. Transportation routes are blocked in many areas due to damage to roads and bridges, debris and abandoned vehicles. Gas pipelines are broken and several serious fires have broken out. Fire fighting efforts are hindered by blocked routes and by the inability of many fire fighters to get to their fire stations. Fuel storage tanks have ruptured along with toxic chemical storage facilities in the manufacturing sector of Vancouver causing a chemical hazard as well as fires in the area. Telecommunications are severely restricted and the surviving telephone systems are overwhelmed. Casualties are believed to be heavy. There has also been severe damage to the states of Oregon and Washington, including the Seattle area where conditions are similar to the GVRD.

The west coast of Vancouver Island has been hit hard but the Victoria area, although damaged, somehow escaped major devastation. Provincial government offices are able to function, although telecommunication to the mainland is limited.

Landslides have occurred on steep slopes in the Fraser and Pitt River valleys and in coastal areas of Howe Sound, Burrards Inlet, West Vancouver, and parts of Vancouver Island. North Vancouver has been badly damaged by landslides and flooding.

Liquefaction and subsidence occurred on Lulu Island, Sea Island, the Ladner-Tsawassen area and other low-lying areas in the lower mainland. The Municipality of Richmond received severe damage because of soil conditions. Dikes were broken in the Richmond area and to some extent in the area of Vancouver International Airport.

About 30 minutes after the earthquake, tsunamis struck the west coast of Vancouver Island, the BC mainland in the Queen Charlotte Sound area, and the west coast of Washington, with waves of about 2 metres. In the lower mainland, the water level reached about 1 metre above the normal high tide mark, approximately 40 minutes after the quake.

Casualties are numbered in the thousands. There are shortages of skilled utility technicians, medical personnel and emergency response personnel, as some are casualties and others are unable to report to their place of duty because of blocked routes. Mass casualties exist where older high-rise dwellings and hospitals collapse:

a. Fatalities. From casualty projections for catastrophic earthquakes approximately 100 deaths per 100,000 population are expected as a minimum. Hence in the Vancouver Area some 2,000+ immediate deaths are anticipated.

b. Injuries Requiring Hospitalization. Injuries requiring hospitalization versus fatalities: 8,000+ casualties requiring hospitalization are estimated.

c. Injuries Requiring Medical Treatment. There could be up to approximately 60,000+ casualties seeking treatment at clinics, doctors' offices, and emergency wards, as well as Red Cross and St. John Ambulance centres.

d. Casualty Dispersion. Casualties tend not to be created evenly throughout the affected area but rather are concentrated at likely sites such as collapsed buildings, collapsed bridges/overpasses, tunnels and the like.

e. Homeless. Hundreds of thousands of people are likely to be homeless in the GVRD alone. More victims are likely to be found along the west coast of Vancouver Island and in the Queen Charlotte Sound area.

The lateness of the season and the expected onset of wet winter weather to the region are expected to add further casualties to the disaster. Lack of clean fresh water due to destroyed water systems and purification plants may add disease to the burden of the populace. Lack of electricity and heat for a large percentage of the population will aggravate the immediate disaster.

By midnight of 2 November, having received sketchy reports on the magnitude of the disaster, the BC Provincial Government declares a Provincial Emergency. The BC Response Centre (BCRC) is deployed to Abbotsford, the nearest centre with a large functioning airport.

On the morning of 3 November, BC formally requests Federal assistance. The Prime Minister declares a national Public Welfare Emergency in the morning of 4 November and designates the Minister Responsible for BC Affairs as Lead Minister. The Lead Minister formally requests the Minister of National Defence for all possible CF assistance.

Political

British Columbia has a parliamentary form of government. Executive powers rest with the premier, who is a member of the legislature and leader of the majority party. The premier appoints about 20 ministers to the executive council (cabinet). British Columbia has 48 district municipalities. Typically, each municipal unit is governed by a mayor and four to eight councillors, all popularly elected for three-year terms.

The BC Government will coordinate all rescue and assistance efforts through the BC Response Centre.

Economic

GVRD is Canada's most important west coast high capacity port. The bulk of Canadian goods and resources headed for the Pacific Rim passes through it. Ripple effects caused by the damage and shut down of the GVRD will dramatically impact the Canadian economy, particularly in Western Canada. Consequently, it is imperative to restore the situation as rapidly as possible primarily to minimize loss of life, but also to prevent serious damage to the nation's economic well-being.

Vancouver also has a significant manufacturing industry, with products including wood and metal items, refined petroleum, processed food and printed materials.

Sociological

Approximately 2.3 million people reside in the GVRD. It is the cultural hub of the province. Included among the many ethnic groups of Vancouver is a burgeoning Chinese community, which is one of the largest Chinese communities in North America. Chinese immigrants continue to arrive in Vancouver.

There are no sociological factors that could seriously impact the relief operation in a dramatic way.

B.2. Geography

Topography

The GVRD occupies a comparatively low lying delta at the terminus of the Fraser River. The region is surrounded by the Coast Mountains to the north and the Cascade Mountains to the east (2000 to 3000 metres high), the Georgia Straits on the west, and delta south to the United States border.

Hydrography

Vancouver proper is on an peninsula surrounded on three sides by the Narrows, the Fraser River, and the Georgia Straits.

Climate/Weather

The climate of the GVRD is characterized by mild, wet winters and warm summers. Precipitation is around 2000+ mm per annum, with less than 100 cm of snowfall in the winter. Temperatures range from 5 to 10 degrees centigrade in the winter and 20 to 30 degrees in the summer. November is characterized by overcast skies with cool temperatures. Prolonged drizzle is common. Drizzle interspersed with heavy rain is normal in the Vancouver area. Snow accumulates in the higher mountain areas and remains for the duration of the winter.

B.3. Infrastructure

General Aspects

Severe damage to the infrastructure is widespread within the GVRD. Electricity and potable water systems are likely to remain unserviceable for a significant time, creating the potential for serious health problems.

Transportation

Ground failures, liquefaction and shaking result in the collapse of some road surfaces, and structural damage to bridges and overpasses, rendering some unsafe for use. In the GVRD, approximately one - third of steel frame bridges are severely damaged and unusable and all concrete bridges built before 1975 have received about 40% damage. The Lion's Gate Bridge is unusable due to ground collapse at the northern approaches. The Second Narrows Bridge is damaged but usable, with its capacity reduced by about 50%. Many streets are blocked as a result of downed electrical cables, and, in older areas, by debris. Road communication to the United States is cut off due to road collapses and damaged bridges at White Rock/Blaine, Bellingham, Sumas and Nooksack Rivers. All bridges over the Skagit River are out. Roads are blocked by severe landslides in the Sumas Lookout and Chuckamut Mountain areas.

Railway lines are cut by landslides in the Sumas Mountain area, between Deroche and Dewdney, between Minaty Bay and Horseshoe Bay, and by extensive ground deformation in the Langley area, Boundary Bay and other low-lying areas. The New Westminster Railway Bridge is jammed in the open position. Many railroad bridges are damaged.

Ports and Airports

Facilities are damaged in all ports and cargo handling capacity is reduced in the area. Some large cranes are inoperable due to track damage. Wood piers and wharves suffer only 10% damage; concrete piers about 25% damage. Settlement of fill material reduces access to docks. About 40% of bulk fuel storage tanks suffer serious damage with some being breached.

Runways are rendered unusable, due to breaks in the surface resulting from liquefaction and differential movement of runway slabs. Control towers and terminal facilities received from 10 -20% damage. Inbound flights are diverted and outbound traffic halted. Aircraft on ground are damaged. There is a possible crash of a passenger aircraft, which was taxiing on landing when a section of runway collapsed. Aviation fuel tanks are damaged with some spills and at least one major fire. Thousands of people are stranded at the Vancouver airport as road communication to Sea Island is cut off. Limited operations may be restored in 24 - 48 hours after the restoration of road access.

After the earthquake, the nearest large operating airport is located in Abbotsford, approximately 65 km from Vancouver. On Vancouver Island, CFB Comox is still operational and can handle air traffic for the Island.

Communications

Lack of electrical power results in very limited telecommunications within the affected area. Damage to the substations providing power to Vancouver Island results in total loss of power to the Island for several hours, with 50% of the normal power requirement being restored after 24 hours. In addition, the damage to repeater stations results in a temporary loss of communications between the Vancouver area and east of the Rockies. In the GVRD, the central switching office is destroyed and the backup in New Westminster is severely damaged. The nearest operational switching station is in Kelowna. Liquefaction results in breaks of underground cable, and many poles carrying aerial cable are down. Military communications are functioning with difficulty. Controls were placed on all lines into BC.

Transmitters in mountain areas and low -lying areas are damaged. The FM transmitter on Mt. Seymour is lost in a landslide. The AM transmitter at Steveston is badly damaged due to wave action and subsidence and is inoperable, at least temporarily.

One cable linking Vancouver Island to the mainland is functioning.

Industrial Capacity

GVRD possesses modern industrial capacity focused on transportation, manufacturing, and service industries.

B. 4. Enemy Forces/Threat Situation

There are no true "enemy forces" in this situation. There is a possibility that the breakdown in civil authority might produce a situation in which gang activity might rise, potentially threatening the safety of the citizenry. Looting is probable but likely disorganized. Most looters will be unarmed but small arms could be encountered.

B. 5. Host Nation/Coalition Forces

Emergency plans exist at the national and provincial levels for contingencies such as this. There is a BC Earthquake Response Plan and a National Earthquake Support Plan in effect. Federal and provincial resources have been designated as elements of the BC Response Centre that will coordinate assistance/relief efforts.

C. Miscellaneous Factors

C. 1. General Factors

Domestic disaster situations have occurred several times in the past 50 years from coast-to-coast across Canada. Predictability varies considerably depending on the nature of the disaster. Such situations requiring the assistance of the Canadian Forces could potentially occur anywhere in Canada.

C. 2. Specific Factors

None.

D. National/Coalition Mission Concept

D. 1. Mission Statement

Emergency medical and relief support to minimize loss of life and suffering must be provided. Basic infrastructure to support the local population must be restored.

CF Mission

The mission of the CF is to assist the civil authorities in the provision of relief to minimize loss of life and suffering.

D. 2. Concept of Operation

CF Contingent Concept

Lead elements of land and air forces will begin deployment within 24 hours of the CF tasking. The CF Disaster Assistance Response Team (DART) will deploy within 48 hours of the CF tasking. These CF elements will act as an advance party for the main CF body, establishing communications and liaison with municipal and provincial authorities and carrying out the reconnaissance for the CF Main Force. The DART will carry out tasks of immediate medical relief. Detailed tasks for DART will be carried out as directed by the CF Force Commander in accordance with direction for DART laid out in (Headquarters Defence Plan) HQDP 800.

A CF main force will deploy as quickly as possible and remain for the duration of the planned mission. Local CF units in the area will respond immediately to the best of their ability with available equipment that is still serviceable after the earthquake. After deployment of the main force, the DART will disengage.

The CF will provide all manner of assistance to the local authorities. They will provide emergency medical services, establish lines of communication, establish relief shelters, distribute relief supplies, re-establish vital infrastructure, etc. The CF will assist the local authorities to stabilize the situation.

D. 3 Marshalling and Sustaining the National Will

Sympathy for those affected by the disaster will be expressed across Canada and internationally. Financial and material support will be offered from all areas. Sustaining the national will is not an issue in this situation.

Contingency Options

The magnitude of this situation is enormous and will draw on a large portion of available CF resources. This could have an impact on concurrent operations. The CF may have to review existing overseas rotations and commitments.

E. Assessment of Tasks

E. 1. Assigned Tasks

The CF will:

a. coordinate civil and military efforts,

b. evacuate casualties,

c. provide medical assistance,

d. assess infrastructure damage,

e. distribute relief supplies,

f. provide emergency shelters,

g. perform Search and Rescue, and

h. provide communications support to the civil authority.

E. 2. Implied Tasks

The CF contingent must be prepared to:

a. arrange transport of CF troops and equipment from bases across Canada to the area of operation and return after completion of the operation,

b. provide medical support, health support services to Level Two (see B-GL-313/FT-001) and evacuation for CF personnel,

c. provide maintenance/repair to the Second Line level (see B-GL-314-001/AF-001) for Canadian equipment,

d. provide storage facilities for supplies at staging areas under CF responsibility,

e. establish casualty reception areas and victim relief shelters,

f. provide rations and quarters for stationed personnel,

g. repack/reload supplies for transport at the staging areas,

h. provide periodic Intel assessment of the situation in the operating areas,

i. provide tactical command and control for the Canadian Forces operation,

j. provide the co-ordination with municipal and provincial authorities, and

k. provide protection for the CF troops, if required.

E. 3. Constraints and Restraints

The availability of Strategic Lift aircraft will be a deciding factor in the ability of the CF units to deploy within the planning timelines.

E. 4. Interoperability

Canadian elements must be capable of communicating with each other and with local municipal and provincial authorities operating in the area. There may also be a requirement to be able to communicate with non-governmental emergency assistance organizations operating in the area (Canadian Red Cross, Salvation Army, St John Ambulance, etc.).

E. 5. Capabilities of Own Forces

CF capabilities will be determined from the analysis of the scenario.

E. 6. Sustainment Requirements

The CF contingent must be sustained for the duration of the mission; 60 days of operations is anticipated.

F. Mission Success/Extraction Criteria

F. 1. End State Conditions

The end state from the CF perspective is when the situation has been stabilized to the point where municipal/provincial authorities and the non-governmental assistance organizations can handle it on their own.

F. 2. Success Criteria

From a Canadian military perspective, the mission will be considered successful overall when the following criteria have been met:

a. Land and Air Force lead elements and the DART are deployed within planning timelines,

b. the mission analysis and estimate is completed before the development of the CF main contingent options,

c. the CF contingent and its equipment are generated according to the Operational Plan and associated timelines,

d. the deployment of the CF main contingent is accomplished within the planning timelines,

e. the deployed CF units are sustained for the duration of the mission,

f. the accepted CF mandate is accomplished, and

g. the CF contingent is repatriated within the planning timelines.

F. 3. Extraction Criteria

All CF units will be extracted when the end state is achieved.

G. Association of Time Space and Mass
G. 1. Critical Times

The CF is obligated by Canadian defence policy (1994 White Paper) to be prepared to contribute to the operation within 24 hours.

The lives of Canadians are at great risk and lives lost will depend on the time taken to provide assistance. There is an urgent need to have the CF contingent deploy as quickly as possible.

G. 2. Critical Distances

The closest unaffected support area with an airport will be Abbotsford (BC), about 65 Km east of Vancouver. Major nearby centres will be Calgary and Edmonton (Alberta), which are 800-1000 Km away. The bulk of the CF is located in Eastern Canada, 3000-5000 Km away, and will require strategic deployment to the area of operation.

F. Command, Control and Communications
F. 1. Organizational Hierarchy

The British Columbia Response Centre is established at Abbotsford and is responsible for coordinating all provincial and federal response efforts.

The CDS is in command of the domestic operation. Commander 1 Canadian Division is appointed as Task Force Commander (TFC). The TFC operates out of the JFHQ, which is collocated with the BCRC. 1 CAN AIR DIV COS Ops is appointed as the Air Component Commander. Commander Land Force Western Area is appointed Land Component Commander. Commander MARPAC is designated Maritime Component Commander.

All CF resources employed in the operation will be under operational command of the TFC.

F. 2. Administrative

CFB Esquimalt, CFB Comox, and CFB Edmonton will have to provide the bulk of the administrative support to this operation.

F. 3. Intelligence

National surveillance and reconnaissance resources will be employed to gather data on the extent and location of the damage.

F. 4. Security

Relief supplies will be highly valued by the population in the affected area. Adequate security will be required at all supply holding areas.

F. 5. Specific Support to Operations

All required information has been covered in other sections of this document.

F. 6. HQ Requirements

A Joint Force Headquarters (Main) would be established in Abbotsford with subordinate headquarter(s) deployed, as required, throughout the GVRD.

FPS 4: Surveillance/control of Canadian territory and approaches

A. Background

The 1994 Defence White Paper states "Sovereignty is a vital attribute of a nation-state. For Canada, sovereignty means ensuring that, within our area of jurisdiction, Canadian law is respected and enforced. The Government is determined to see that this is so. Maintaining Canadian sovereignty can take on many forms including the provision of peacetime surveillance and control and the securing of our borders against illegal activities. The following example has been selected as representative of the requirement.

B. Situation

Incidents of drug smuggling and landings of illegal immigrants on both East and West coasts have resulted in calls for the Canadian Government to "do something". The Public Safety and Emergency Preparedness Canada sought Cabinet agreement for additional resources; however, the Cabinet directed other government agencies, particularly the CF, to assist in stemming the tide of illegal activities. An Order-in-Council has been enacted to provide the legal basis for the CF involvement in law enforcement aspects. An MOU has been signed by the Solicitor General which provides CF units (not otherwise employed) to assist the RCMP identify, track, and, if necessary or required by law enforcement agencies, intercept "platforms of interest" before or after reaching Canadian territory.

C. Physical Environment

Canadian territory, and the air and sea approaches to Canada.

D. Military Environment

a. Threat Information. The overall threat environment is very low. The targets of the operation are independent surface vessels or small aircraft seeking to avoid interception and effect covert transit to a Canadian destination. It is considered likely that the platforms will be equipped with technically sophisticated equipment (ESM, ECM) and armed with small arms.

b. Mission. Canadian Forces are to cooperate with the appropriate OGDs (RCMP, DFO, Revenue Canada, Citizenship and Immigration) to conduct surveillance of appropriate approaches to Canada and identify platforms of interest. If necessary, the CF should be prepared to intercept them prior to their reaching Canadian territory.

c. Mission Success Criteria:

    1. Ability to detect and identify platforms of interest,
    2. Ability to track platforms of interest,
    3. Ability to respond to situation (intercept, board surface vessels/force landing of small aircraft) as per requests from OGDs, and
    4. Ability to meet timing criteria.

d. Partial Listing of Tasks involved in the Accomplishment of the Mission:

    1. Contribute to threat assessment,
    2. Contribute to surveillance of Canadian approaches,
    3. Contribute to C2 process as requested,
    4. Contribute to tracking of platforms of interest, and
    5. Be prepared to intercept and board/force landing of platforms of interest.

e. Own Forces. To be drawn from the existing CF. Resources from OGD's are to be included where appropriate.

f. Coalition and Theatre Situation. If appropriate, military authorities of selected allies and other friendly countries may be asked to share surveillance and intelligence information.

g. C4I Arrangements. Cooperation with Canadian OGD's is clearly critical in this scenario. The Public Safety and Emergency Preparedness Canada is the lead agency.

h. Sustainment Information. Duration: A heightened state of surveillance for up to 30 days may be required (longer possible but unlikely).

D. Civil Environment

Normal, day to day operations continue.

E. Assumptions/Notes

F. References/Resources:

- 1994 Defence White Paper
- Public Safety and Emergency Preparedness Canada (PSEPC)
- Royal Canadian Mounted Police (RCMP)
- Doctrine of Canadian Forces operations
- Past example: Operation Semaphore (1999)

G. Disclaimer

Some of the information on this section has been provided by external sources. The Department of National Defence and the Canadian Forces are not responsible for the accuracy, reliability or currency of the information provided by external sources.

FPS 11: Collective Defence

A. Background

a. The 1994 Defence White Paper re-affirmed Canada's commitment to have the Canadian Forces contribute to international security. Canada will continue to play an active military role in the United Nations (UN), the North Atlantic Treaty Organization (NATO), and the Organization for Security and Cooperation in Europe (OSCE). As a demonstration of resolve, Canada has made the commitment to deploy sizable land, maritime and air forces to support NATO military operations.

b. For the foreseeable future, NATO will face no military threat to its territory. This is due to no small extent to the fact that NATO forces represent a formidable deterrent. The alliance also provides a valuable transatlantic security link and allows for a most useful flow of military ideas between allies as well as an effective forum to address critical security issues. This scenario is fictional and is intended to be illustrative of the nature of collective defence operations in which Canada may be involved.

B. Situation

a. A NATO nation and its non-NATO neighbour have a long-standing dispute over a border – in part because of national minorities resident in each other's countries. Although there is an extensive "contested" history surrounding the border dispute, the current borders, with the disputed territory within the boundary of the NATO nation, have been recognized by the international community. A recent natural resources discovery within the area has rekindled the dispute.

b. With a faltering economy, growing national debt, and diminishing standard of living, the neighbouring nation has resurrected territorial claims for lands adjacent to the disputed border. Tension has increased over time and there have been a growing number of actual incursions by the neighbouring nation. NATO protests and sanctions have had the unfortunate impact, however, of increasing regional sympathies for the neighbouring nation to the point where it has developed a loose, informal military alliance with a number of local dictatorial regimes. Intelligence has now learned that they plan to hold a very large military exercise in a few months near the disputed area despite considerable diplomatic and UN efforts to head off a confrontation. . The NATO nation under pressure has, under Article 5, called upon its NATO allies to provide a credible deterrent force.

c. The Canadian government has been aware of the situation from its onset. Upon learning of the impending exercise, the government agreed with the MND's proposals to initiate Mobilization Stage 3 and that preparations be started to enable replacement of combat losses in the Contingency Force to be made from existing forces.

d. Following invocation of Article 5 the Government agreed to deploy the lead elements of the contingency force. The arrival of NATO forces prompted the non-NATO forces to rapidly cross the border and take control of the disputed lands. This prompted the Canadian Government to deploy the remaining contingency forces and initiate Mobilization Stage 4.

C. Physical Environment

The land mass involved includes a wide variety of terrain, including plains, highlands, mountains, coastal areas and urban centres. Both countries possess a coastline with deep water approaches and several port facilities.

D. Military Environment

a. Threat Information. The enemy forces include a full range of combat capability, with modern tactical doctrine and current generation equipment for its land, naval and air forces. Enemy C4I assets are assessed to be state-of-the-art. Use of NBC weapons against NATO forces is assessed as being unlikely, but cannot be completely discounted.

b. Mission. The CF, as part of the NATO forces, will, in the first instance, mount a formidable show of force and conduct operations to stop hostilities as soon as possible and restore and return control of the invaded territory, waters and airspace to the NATO nation.

c. Mission Success Criteria:

    1. Ability to field mission-mandated forces and capabilities,

    2. Ability to meet mission-deployment timelines,

    3. Achievement of the Canadian-specific component of the mission, and

    4. Sustainability of the CF response for the required duration.

d. Partial Listing of Tasks involved in the Accomplishment of the Mission:

    1. Deploy forces to theatre,

    2. Secure the rear area for the assembly and deployment of NATO forces,

    3. Defend territory not yet occupied by the invading nation,

    4. Eject enemy forces from invaded territory,

    5. Establish a buffer zone along the internationally recognized border,

    6. Assist in the restoration of civil authority in the occupied territory, and

    7. Sustain forces as long as required.

e. Own Forces. In support of the NATO operation, Canada will deploy forces in accordance with the 1994 White Paper and NATO DPQ commitments. This force will initially include the IRF (L) Battalion and the Vanguard Component to be followed by the remainder of the Main Contingency Force. Prolongation of the conflict would result in full mobilization of Canada (Stage 4 of Mobilization plans).

f. Coalition and Theatre Situation. NATO commences its operation with the deployment of the Rapid Reaction Force (Air) (RRF(A)) and Immediate Reaction Force (Land) IRF(L). Subsequent deployment of the NATO Rapid Reaction Corps (ARRC) is undertaken. The non-NATO alliance's forces include a full range of combat capability, with modern tactical doctrine and current generation equipment for its land, naval and air forces.

g. C4I Arrangements. NATO C4 arrangements apply. Public Safety and Emergency Preparedness Canada is coordinating the provision of civil support with OGDs.

h. Deployment Information. NATO has firm control of the ports and airfields in the rear areas of the nation to support the deployment of NATO military forces. NATO deployment would commence with the IRF(L) and RRF(A) forces, and thirty days following the deployment of the IRF, preparations would begin for the deployment of the ARRC.

i. Sustainment Information. CF elements would have to be sustained for as long as required.

E. Civil Environment

The majority of the civilian population is still in place.

F. Assumptions/Notes

a. NATO's strategy is to amass sufficient force to deter and if necessary contain any attack on NATO territory and conduct restoration operations.

b. Military operations will be confined to the territories, airspace and waters of the two involved nations.

c. The specified preparation times are for planning purposes. The impact of longer and shorter warning times should be investigated.

G. References/Resources:

- 1994 Defence White Paper
- Canadian Forces Joint Doctrine for Mobilization
- Contingency Force
- North Atlantic Treaty Organization (NATO)
- Canada and NATO
- NATO Allied Rapid Reaction Corps (ARRC)
- Doctrine of Canadian Forces operations
- Recent example: Operation Apollo (2001-2003)

H. Disclaimer

Some of the information on this section has been provided by external sources. The Department of National Defence and the Canadian Forces are not responsible for the accuracy, reliability or currency of the information provided by external sources.

Annex B: Options Analysis

The following table was completed during the options analysis activities, details of which are included in Section 5 of this report.

Note: mechanical/creative/collaborative = M/CR/COL

CADTAP	Type	M/CR/COL	Pros for Rapid Response Planning	Cons for Rapid Response Planning	Comment	Reference
Ant Colony Optimisation (ACO) algorithm	algorithm	CR/COL	optimise information analysis		assist in risk mitigation	Wang (2007)
Asset visibility	concept	M			see resource visibility	Defence Research and Development Canada (DRDC) Valcartier (various) - see #12 in Annotated Bibliography
backward state-space search algorithm	algorithm	M	useful when the goal conditions of a planning problem are well-defined	may be hard to tie in with initial constraints of operation	regression planning	Refanidis, Ioannis and Ioannis Vlahavas (2006)
Blackboard	concept	M/CR/COL	enables the users to access a number of different knowledge sources using one interface			Chinthamalla, D, Muthyala, H., Porter, W.D. (2002); Corkill, Daniel D. (2003)
Bottom up response	technique	CR	Mimics how an emergency situation unfolds	Military is structured top down		Coffin, W. J. M. (2002)
Clonal Selection Algorithm (CSA)	algorithm	CR/COL	optimise information analysis		assist in risk mitigation	Wang (2007)
Collaboration	technique	COL	More refined, focused information	distributed team, information overload if all share with all - just need to know what is relevant for you	Horizontal planning/lateralization, de-agregation of activities	Burkle, F.M., Jr., and Robin Hayden (2001); Coffin, W. J. M. (2002); Corkill, Daniel D. (2003); Mulvehill, A., Callaghan, M., and Hyde, C. (2002)
Collaborative Project Management Tools (CPMT)	tool	COL			see QTEST	Grunman (2008)
Collaborative work environments	concept	COL			see Groupware	
CONPLAN	tool	M/CR/COL	provide starting point for planners	each emergency has situation specific requirements	Maintain in a database with lessons learned and historical Op Plans	Department of National Defence (DND) (2008)
Constraint mitigation	technique	CR	Reduces risk	Uncertainty is a challenge		Raskob, W. and Ehrhardt, J. (2000); Coffin, W. J. M. (2002); Lawlor, B. M. M. G. (2001)
Control Shell	algorithm	M/C	indexes, retreives and synthesises data as defined by user set parameters and constraints	AI has many variables, is not a linear thought process that can be de-bugged	AI engine	Corkill (2003)
convergent thinking	concept	M/CR/COL	identifies the most appropriate option from a wide range of possible solutions	may bounds group opinion in one outcome/decision that is not suitable		Couger, Daniel J. (1994).
COTS	tool	M/CR/COL	quality insurance high due to testing for large customer base	may need to be talored to integrate with existing toolset and in-house proces		
Critical Path Method	technique	M/CR	highly compatible with business or process models, Gantt charts, etc. Emphasize time appreciation	their kind of generality may not be suited for all types of decision-making and problem-solving domains, in which case alternative algorithms or heuristics are to be pursued	see partial order planning and /or GANTT Chart	Grotte (2009)

CADTAP	Type	M/CR/COL	Pros for Rapid Response Planning	Cons for Rapid Response Planning	Comment	Reference
Data push and pull	technique	M/CR/COL	users can interact with tool as a information retriever and sharer	not compatible with certain other types of services (such as legacy "fetch" services)		Schoenharl, (2006); Klashner, (2007)
Descriptive decision making	approach	CR	inutitition and experience utilised	information bias can increase risk	Heuristics (rule of thumb)	Mulvehill (2002); Russell, S., Norvig, P. (2003); Tversky & Kahneman (2002)
distirbuted cognition	concept	CR	sensors and algorithms that assist in creating new knowledge in evidence-based environments reduce complexity and frequence of user-tool interaction	increased difficulty to use information in a meaningful manner; require information fusion techniques		Couger, Daniel J. (1994).
divergent thinking	concept	CR	allows the problem solver to consider various new levels of abstraction and expand the range of the solution set.	may introduce red herrings		Couger, Daniel J. (1994).
forward state-space search algorithm	algorithm	M	useful when the initial conditions of a planning problem are well-defined	may be hard to tie in with stated goals	progression planning	Russell, S., Norvig, P. (2003)
GANTT Chart	tool	M	communicates critical path; familiar tool	not all people may know how to read	visual display of critical path methodology	Grunman (2008)
Groupware	tool	COL	enables collaborative work environments	need all to be familiar with and equiped with tool	Lotus Collaborative Software, Grouputer, Web Alive, Goole Docs, etc	Hutterer, Peter and Bruce H. Thomas (2007).
GROWL	technique	CR/COL	push services are customisable and come with automatic notification services for a variety of applications		Mac product	Apple Computer Inc (2009)
Information abstration	concept	M/CR	manipulate information	needs to be focused or cause information overload	ability to retrive information in different levels of complexity	Couger (1994)
Information optimisation	approach	M	address information uncertinty	information access may be restricted - incomplete information means that information can never be 100% optimised		Couger (1994)
information reliability	concept	COL	able to use information from other systems with confidence			Blasch (2002)
Information synthesizing	approach	M	address information uncertinty			Couger (1994)
instance based learning (IBL)	approach	CR	enable users to learn from experiences and adapt to changes	could too closely shape the realm of the possible	customisable templates and categorisation; domain or problem specific heuristics; exemplars theory	Gonzalez, C., Lerch, J.F. and Lebiere, C. (2003)
intuitive symbology	technique	M/CR/COL	reduces errors, increases processing of information in mental models	requires additional training to initially familiarize oneself with the adopted symbology	assists with formatting and presentation of information to the users/clients of tool outputs	DND (2008)
JAVA	tool	M	modern language widely used			
knowledge management	approach	CR/COL	provides flexibility and user customisable applications		principles deal with information the way the user defines their requirements for it, no predetermined structure	Nilsson, M (2008)
Log	tool	M	can use metrics to help determine lessons learned; provide tracibility for decision making	only works if there is dedicated task assigned to create and manage log	System must log all decisions and activities - date, time, user etc	Mulvehill (2002)
Modular architecture	approach	CR/COL	incorporate wide variety of data sources	integration challenges	see SOA	Section 5.2
multi-disciplinary R&D	approach	CR/COL	help address complexity	becomes intractable if the focus is lost in the pursuit of alternative means of tackling the problem space	qualitative software engineering principles - parallel bottom-up and top-down development	

CADTAP	Type	M/CR/COL	Pros for Rapid Response Planning	Cons for Rapid Response Planning	Comment	Reference
NAPP	Doctrine	M/CR/COL	provides resource/asset visibility	forecasted usage; real-time validation necessary	Strategic level resource planning	DND, Source unknown.
Natural Language Processing	technique	COL	ability to take information which is in free-form text/natural language that is easily understood by a computer for seraching, cross referencing, indexing etc.; ideally can translate from multiple languages	this is an evolving technology and will not always capture the sultities of the text and might not get implied concepts	understanding logic	Filippova et al (2008)
ontology	approach	M	a strict domain definition that is nevertheless extensible may help searches and queries from both operators and machine to provide best matches	if the definition of the domain becomes too liberal and duplicates or poorly defines entries, searches and matches may rapidly become intractable	user customisable	Da, (2007), Gilmore (2005).
OPP	Doctrine	M/CR/COL	Complex adaptive system - used across all levels (tactical, operational and strategic) and all enviroments (army, navy, airforce) making joint operations easier	Following each step is laborous; designed to be executed step by step but concurrent activities and interdependent decisions occur in rapid response		Department of National Defence (DND) (2008)
Order N problem	concept	M	using this concept, by understanding constraints, problems can be reduced so that they are not order N problem;		every extra variable you add into a problem makes it N times more complicanted	
Partial order planning	approach	M	rule out negative interactions between goals	their kind of generality may not be suited for all types of decision-making and problem-solving domains, in which case alternative algorithms or heuristics are to be pursued	accounts for problem decomposition shortcomings, delaying choices during search by using a "least commitment" strategy then re-ordering partial plans via linearization; uses serialisable sub-goal heuristics	Russell, S., Norvig, P. (2003)
PDDL (Planning Domain Definition Language)	tool	M	The PDDL would help divide the situation into state, goals, and action representations.	its kind of generality may not be suited for all types of decision-making and problem-solving domains, in which case alternative algorithms or heuristics are to be pursued	a new standard based on Stanford Research Institute Problem Solver (STRiPS), and the Action Description Language (ADL).	Ghallab, Malik (1998)
Personal Digital Historian (PDH)	tool	M	retreives historical/case-based information in the system		Case-based reasoning	Shen, Chia et al (2001)
pheromone matrix	technique	CR/COL	consider options in non-linear fashion		see Ant Colony Optimisation (ACO) algorithm	Wang (2007)
Planning graphs	approach	M	leverage knowledge representation of the planning problem to mitigate negative interactions between subgoals	may not be suited for all types of decision-making and problem-solving domains, in which case alternative algorithms or heuristics are to be pursued	graph consisting of sequence levels; heuristics us visualization techniques as well as the inclusing of mutual exclusion or "mutex" relationships between goals	Russell, S., Norvig, P. (2003)]
Planning Languages			exclude irrelevant knowledge via proper knowledge representation strategies	their kind of generality may not be suited for all types of decision-making and problem-solving domains, in which case alternative algorithms or heuristics are to be pursued	STRIPS, ADL or PDDL are examples	Ghallab, Malik (1998)
Planning Wizard	concept	M/CR/COL	guides planners through process, linking outputs and inputs for single point data entry	unfamiliarity results in wasted time or frustration - tool needs to be same as that used for deliberate and contingency planning, not just for rapid response	needs to be flexible	NATO (2006)

CADTAP	Type	M/CR/COL	Pros for Rapid Response Planning	Cons for Rapid Response Planning	Comment	Reference
Portal	tool	COL			see web-based services	
Prescriptive decision making	approach	M	pragmatic, reduces bias	intutition not fully utilised		Mulvehill (2002); Russell, S., Norvig, P. (2003); Tversky & Kahneman (2002)
Proactive	approach	M/CR/COL	intelligence driven	based on assumptions	contingency planning	
Propositional logic	approach	M	determines validity of complex relationships	may "abstract away" some domain-dependent details, may complicate the implementation of non-qualitative data structures		Couger (1994)
prospect theory	concept				see descriptive decision making	Mulvehill (2002); Russell, S., Norvig, P. (2003); Tversky & Kahneman (2002)
prototype-based learning	approach	M	provide best macthes when features of interest are evaluated based on similarity metrics, not identity relations	dynamic situations may be restricted	rigid templates and automatic categorisation	
QTEST	tool	M	logs all activity for each project/operation	it manages communication as long it occurs within the system. It does not integrate with e-mail systems like Exchange and Lotus Notes, other than being able to send and receive messages via POP or IMAP.	a hosted application for managing not just work products, such as Word files, project code, and Excel spreadsheets, but also for assigning people tasks, tracking their progress, managing approval, and coordinating the chain of ownership as projects go through the various experts	Grunman (2008)
Reactive	approach	CR/COL	event-driven	based on real-world events	crisis response	Jia (2005)
Recognition planning	process	CR	utilises intuition and experience; aligned with natural decision making processes	staff turnover in posts is great, often positions are staffed with people who don't have experience; feedback (experience) is key, but many ignore or don't obtain/give feedback after a mission is completed		Tversky & Kahneman (2002)
Resource visibility	concept	M	updated information on resources at the planners' fingertips	run the risk of information overload if level of detail is not appropriate; information is only good if current and accurate at the time of viewing - main issue is data reliability		Defence Research and Development Canada (DRDC) Valcartier (various) - see #12 in Annotated Bibliography
Risk management	concept	CR	prioritised areas to focus on	way risk is measured depends on questions being asked	see constraint mitigation	Raskob, W. and Ehrhardt, J. (2000); Coffin, W. J. M. (2002); Lawlor, B. M. M. G. (2001)
SOA	approach	CR/COL	good tool for integration of specialised tools and/or legacy systems	de-emphasizes design constraints, which may incur more design hurdles along the way	modular, open-architecture software with an ability to add additional capabilities	Schoenharl, T. et al. (2006); Nten, C. A. (2004)

CADTAP	Type	M/CR/COL	Pros for Rapid Response Planning	Cons for Rapid Response Planning	Comment	Reference
SOPs	Process	M	Standardises task execution	in time constrained envrionments, sometimes need to cut corners, SOPs don't tell how to cut corners		
surface computing	tool		aligns with habitual non-technical formats/forums	need physical pressence to gain benefit		Mitsubishi (2009)
templates	approach	M	checklist system and customisable, form-fillable placeholders with suggestions to ease use and facilitate completeness of information	categorisation	needs to be user customisable for situation	Mulvehill, A., Callaghan, M., and Hyde, C. (2002)
Text Retrevial	technique	COL			see Natural Language Processing	
Time Appreciation	technique	CR	Assist in priority setting	time appreciation cannot be considered in isolation from other dependent variables when analyzing courses of action. Multiple ways of presenting constraints are desirable in order to appreciate their interactions		Defence Research and Development Canada (DRDC) Valcartier (various) - see #12 in Annotated Bibliography
Tracker	tool	M	increased flexibility if customisable rule-set; inter-related templates promote single data entry point			Mulvehill, A., Callaghan, M., and Hyde, C. (2002)
Training	technique	M	increase user familiarity with tool set, processes, etc.	takes time and money; when personnel change postion the lessons are lost		
User control	approach	CR	increased flexibility		user customisable; control over rule-sets	
User interface	tool	M/CR	enable users to access the right information at the right time	not all designed for ease of use		
Visualisation	technique	CR	Gives another perspective to problem	visualisation does not make certain relationships or presentation design choices explicit, the end user must know what is involved in the way the information is framed or risk missing some information		
web-based services	approach	M/COL	support interoperability and accessibility in distributed environments	potential security constraints		Nten, C. A. (2004)
whiteboarding	tool	CR/COL	aligns with habitual non-technical formats/forums			Chief of Force Development (2008)
workflow management	technique	M	streamline workflow	need to ensure that workflow repects the concepts that rapid response planning requires agilility and that set structures can confine		Defence Research and Development Canada (DRDC) Valcartier (various) - see #12 in Annotated Bibliography

Annotated Bibliography

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<u>Context:</u>
The purpose of this document is to serve as a guidance and familiarization tool for members who are new to the National Aerospace Planning Program (NAPP) and, specifically, the Air

Tasking Order (ATO) planning process. The National Air Tasking Order for Dummies Guide was created by 1 Canadian Air Division – Combat Plans Air tasking Order Cell.

The broad aim of the NAPP is to ensure optimum allocation of air assets to satisfy CF requirements and achieve desired effects.   NAPP "success" can be viewed in both in terms of effectiveness (e.g., timely tasking, provision of sufficient detail to support mission planning) and efficiency (e.g., agility/responsiveness to change, resource requirements).

<u>Content:</u>
The NAPP is a continuous process executed via three distinct but inter-related (Yearly, Monthly & Weekly) planning cycles that dictate battle rhythm. It provides a construct for integrating and coordinating activities beginning with the collation of requests for aerospace resources to produce an effect, through options analysis and the planning process to the distribution of taskings culminating in monitoring and performance assessment.

This document presents a detailed description of the NAPP components from the initial collection of requests, to the production of the Yearly Air Operations Directive (YAOD), the Monthly Air Operations Directive (MOAD), the Weekly Air Operations Directive (WAOD) and the Air Operations Directive (AOD) to the issuance of the Air Tasking Order (ATO) and the subsequent assessment of the effectiveness of the execution of the taskings issued.
Yearly planning gives a long-term forecast of operating tempo of the air force. This planning cycle is known as the Total Aerospace Resource Management (TARM) process and it outputs the Yearly AOD (YAOD) that includes details on Yearly Flying Rate (YFR) and the priorities applied to the use of aerospace resources. The YAOD and TARM processes are closely linked to the Business Plan.

Monthly planning gives a more concrete forecast of events for which aerospace resources are allocated. This planning cycle adds more granularity to the YAOD and outputs the Monthly AOD (MAOD). The MAOD is used to authorize the activity carried out by planners which cannot be captured in the ATO cycle.

Weekly planning is used for day-to-day operations, unexpected changes, emergencies **(i.e. AF Immediate Contingencies Operations)** and exercises. The weekly plan outputs the Weekly AOD (WAOD) and this is used to produce the National ATO. The National ATO Production team uses RFE and other IT to ensure that the ATO is as accurate and up to date as possible prior to 'sending' it to the 'execute' mode not later than 1600Z Fri.

The weekly Air Tasking Order (ATO) is a classified document which contains all approved aerospace missions derived from the signed Weekly Air Operations Directive (WAOD). Once the planning phase is complete, the document becomes valid and is no longer considered as being in 'Planning' but as 'Current Operations'. It is normally produced on a weekly basis and is valid from Mon 0000Z to Sunday 2359Z.

It should be noted that in the case of the requirement to conduct an Immediate Contingency Operation a separate ATO would be issued to facilitate the conduct that operation.

Conceptually, when the National ATO is completed, it can and should be used to support an assessment process (i.e. tasking execution can be cross-referenced to the original plans in order to apply validation and correction) at present, there is little feedback to the CAOC Current Ops and virtually no immediate feedback to Combat Plans.

Observations:
This document is of interest to the planning of AF contingencies operations in that it provides an insight into exactly how the planning process is currently being conducted at 1 Canadian Air Division. The NAPP is well suited to the planning of routine operations however it does not, at present, contain the tools required to be effective in the planning of contingency operations in a time constrained environment.

[2] Canadian Air Division (1 CAN AIR DIV)/Canadian NORAD Region (CANR) (2003). Planning Guide, August 2003, 1 Canadian Air Division (1 CAN AIR DIV)/Canadian NORAD Region (CANR), Winnipeg, Canada. Pages: 32.

Context:
This document is designed to address the specific needs of CF Air operational planning. It is intended to aid air staff in the application of the Canadian Forces Operations Planning Process and augments the other existing doctrines, *Canadian Forces Operations* (B-GG-005-004/AF-000), *Canadian Forces Operational Planning Process* (B-GJ-005-200/FP-000), and *Risk Management for CF Operations* (B-GJ-005-502/FP-000). As such its audience is Air Force planners at the operational level, and while it can be read as a standalone document, the text is written on the assumption that the above texts are already common knowledge. It is designed as a guide, and as such contains more specific detail than the CF OPP doctrine.

Content:
The planning guide is largely a parsing of the data in the CF OPP doctrine, including the overview of the phases and factors of the planning process. It outlines specifics on format and content of documents and presentations, such as the mission analysis brief and the Concept of Operations (CONOPS). The major value of the document from the perspective of this project is the discussion on Staff Checks:

> Frequently, NDHQ CAS and J- staffs require a rapid execution of the CF OPP in order to determine the ability of 1 CAN AIR DIV to support or execute an operation. This is colloquially known as the "staff check," and may also be tasked by 1 CAN AIR DIV HQ to a subordinate formation. During a staff check, the CF OPP will be modified to suit the time available, so the depth and detail of information is often sacrificed for speed. Accuracy of the information still remains important. Tasking for a staff check will be an Initiating Directive (ID) issued by D Air FE, on behalf of CAS, to A3 Ops. By agreement between CAS and Comd 1 CAN AIR DIV, this is considered a formal tasking. The AOC Director will normally lead an IAT composed of the appropriate SMEs given the nature of the ID, along with A3 Contingency Planners, in the execution of the CF OPP. The final product of the staff check process is normally a written or PowerPoint presentation to the Comd, for his approval prior to delivery to D Air FE (J3 Air). The final product resembles a Mission Analysis. This is intentional, as it is important that the mission be clearly understood by all the planners, so that an accurate assessment of the possible and recommended COAs can be made.

The document also includes the format for the Staff Check (abbreviated Mission Analysis):

File Number

Date

<u>Staff Check on 1 CAD Support to Op XXX</u>

Ref(s): A.
B.

Situation

1. General or Background.

2. Higher Comd Intent:

    a. CDS/CAS (from ID); and

    b. Comd 1 CAD.

3. Centre(s) of Gravity.

4. Critical Timings.

Mission

5. Who, What, Where, Why, When.

Assumptions

6. From HHQ (ref ID).

7. Own.

Constraints/Restraints

8. From HHQ (ref ID); and

9. Own.

Tasks

10. Assigned (ref ID).

11. Implied:

a. to 1 CAD elements; and

b. to other formations that will be required to support 1 CAD.

Courses of Action

12. General.

13. COA 1.

14. COA 2.

15. COA 3. (etc…)

COA Summary/Comparison Table (Factors can be Pros and Cons, viability test items, or those issues salient to the staff check). The "stop-light" format will frequently be used (Green/Yes = possible; Yellow/Yes- = possible, but with an impact; Red/No – not possible)

	Factor 1	Factor 2	Factor 3	Factor 4, etc
COA 1				
COA 2				
COA 3				

Risk Assessment:

16. Desciption of the risk that is being assessed (mission failure, impact on future ops, force generation, etc) The table will be colour-coded as per para 43.

	Probability				
Severity	Frequent	Frequent	Occasional	Seldom	Unlikely
Catastrophic					
Critical	COA 2		COA 3		
Marginal				COA 1	
Negiligible					

COA 1 – A description of the causes of the probability and severity that led to the assessment.

COA 2 – Etc…

Conclusion

16. The issues that have been addressed above are summarized, and should lead to the recommendation.

Recommendation

17. One COA is recommended.

Issues Requiring Resolution

18. Frequently, there are unresolved issues, or further information is required from HHQ. These should be stated, as the response may change the recommended COA.

Prepared by: The responsible staff officer (surname, initials, rank, position, local)

Responsible Director: Dircetor or branch head

Prepared for: MGen, Comd 1 CAD, 5368

Observations:
This document is illuminating in defining the process and actors involved in typical Air Force planning activities and what they aim to achieve. The mission analysis, designed as both a brief and a document, are required outputs. Given the importance of the orientation phase, there should be a greater inclusion of comand intent and analysis, including end state and criteria for success. The staff check highlights the address of immediate and critical pieces of information, and efforts should be focused towards how best to capture these pieces in the most effective and efficient manner. For example, the risk assessment and how it is achieved requires input from the best available sources. There needs to be a clean and easy method to quickly identify, evaluate, review and share these risks among those involved in the planning process and will need to be updated throughout planning and operations.

Considered with other documents, the template above is an operational tool for Air Force contingency operations and should be considered an initial step-off point for tool development. It provides a foundation for future in-depth design to developing the CF OPP.

[3] Barr & Sharda (1997). Effectiveness of decision support systems: development or reliance effect? Decision Support Systems 21 (2), 133-146.

Abstract:
Despite the large number of empirical investigations of DSS on decision outcomes, very few studies have incorporated longitudinal designs to assess DSS effectiveness. This study proposes that effects of DSS on decision outcomes develop over time. The study evaluated whether improvements in decision quality typically associated with DSS were due primarily to 'development' or 'reliance' effects. Using an add-on and take-away design, we examined whether introduction of DSS contributes to decision quality after controlling for task familiarity. We also evaluated decision-makers' performance after removing the DSS. Results indicated that although DSS contributed to decision quality after controlling for task familiarity, increased decision performance of DSS-aided decision makers may be due to reliance rather than better conceptual understanding of the decision problem. Implications of these results for design and implementation of DSS are discussed.

Content:
This research effort consists of a longitudinal study on DSS effectiveness, interested in assessing whether DSS contribute to decision quality, after controlling for task familiarity. Performance was counterbalanced in tasks including or excluding DSS, as well as repeated measures after removing the DSS on different trials. Results indicated that DSS likely bias users towards technology reliance instead of a proper understanding of decision problems.

Observations:
This type of research makes a good case about the importance of the efforts that have to be made to overcome reliance effects. In the authors' words: "*reliance effects suggest that the use of DSS may lead to deferring the decision process to 'let the computer do it'. The development effect suggests that the DSS assists the decision makers in understanding complex relationships between decision factors. Clearly, long run decision effectiveness in organizations is improved primarily by the latter. We found evidence of both effects, suggesting that while DSS did increase decision performance, this increase was due primarily to the efficiency of the DSS compared to the decision makers and not because of an increased*

understanding of the relationships between the decision factors by DSS aided decision makers."

The authors detected a reliance effect by removing the DSS, whereby task performance decreased significantly. Recommendations stemming from this effect are numerous: in a first suggestion, it is mentioned that a DSS should be built to accommodate and assist decision-makers at a higher level of cognitive processing, that is, assisting the decision makers to conceptualize the problem, beyond computing optimal choices. The authors also emphasize that increased 'interactiveness' of the DSS may be crucial to the extent of usage of such technology. They recommend that the users themselves should participate in the development of the DSS to leverage the 'fit' between the conceptualization of decision processes by users, the tasks at hand, and the inner workings of a DSS, in order to maximize the benefits of DSS usage. Consistent with much of the literature in decision-making psychology, the authors appear to promote a view of observing decision *processes* as CF OPPosed to merely being interested in decision *outcomes*, in order to better understand how DSS technology influences the decision making process.

[4] Blasch, E and S. Plano (2002). JDL Level 5 fusion model: user refinement issues and applications in group tracking, Aerosense, SPIE Vol 4729, pp. 270 – 279. Pages: 9.

<u>Context:</u>

This article falls within the Information Fusion (IF) community of research and focuses specifically on revising a 1999 Joint Director of Labs (JDL) model of fusion methodologies. The authors indicate that “User Refinement”, or user interaction with existing computer models of information gathering is required to truly take advantage of information fusion from various sources. Specific consideration is given to human fusion of information with respect to user trust, workload, attention and situation awareness. Information Fusion is discussed in the context of target tracking and group tracking within a military context such as a Tactical Operations Centre (TOC).

<u>Content:</u>

An overview of previous related research is provided as background and to segway to the current JDL approach of information fusion. Generic reference to Human-Machine Fusion models are covered, including Information Fusion Models, User Models, and User Designed Fusion Models. All of these models are reviewed to provide a brief comparison of how information is handled by each approach. In general, this discussion contrasts the approaches used to fuse information by applying levels of refinement which serve to perceive, interpret, and decide/act on the information.

The JDL model is addressed by outlining its 5 levels of information refinement, with particular attention to the 5th level (User Refinement). A simulated target tracking exercise involving automated detection (AT) as well as user interaction was used to investigate aspects of user workload, attention, trust and situational awareness. In some cases, the authors discuss application of specific metrics to quantify results in a standardized manner (e.g., workload metrics such as SAGAT, SART, and NASA-TLX; categorical belief metrics for group tracking such as spatial, temporal, kinematic, and allegiance attributes).

<u>Observations:</u>

A notable point made within the article highlights the importance of refinement in any fusion model which gathers information. Sensor data that acts in continuous collection mode can easily become useless through information overload. Human involvement contributes to alleviate this problem by intelligent decision making and selective attention. The authors suggest that the optimal approach to Information Fusion is one where human and machine work together in a continuous cycle (e.g., the machine reduces and provides relevant information, and the human interacts with the system to further refine which information to gather or enhance).

It should be noted that this paper focuses primarily on the application of Information Fusion in the context of target localization, group tracking, and identification. It would be interesting to verify if other scenarios of information fusion involving less visual oriented information could apply similar principles such as information refinement and user interaction (e.g., EMS radio dispatch for medical, police, or fire services).

[5] Boukhtouta, A., et al. (2004). A Survey of Military Planning Systems, presented at the 9th annual Command and Control Research and Technology Symposia (ICCRTS), Washington: DoD CCRT.

<u>Context:</u>
As the title implies, this paper is a defence research survey of a number of existing military planning systems. While dealing with some of the underlying conceptual issues, the paper is designed to review the tools, their applications within the context of different planning activities. The paper focuses most closely on Air Force requirements, with some focus on joint and maritime needs as well. Its intended audience is the R&D community, though the report is accessible to those with some knowledge of decision support tools.

<u>Content:</u>
The paper is broken down into five sections. The first section, the introduction, outlines the problem environment and the potential CF opportunities of decision support tools: "The combination of artificial intelligence, operations research and data mining techniques to mention a few, and web-based and information technologies, offer a great opportunity to address new planning system design and integration requirements." The second section is a review of CF OPP. The third section involves an overview of existing military planning paradigms, including artificial intelligence (AI), data mining and other decision-theoretic planning approaches.

The fourth section focuses on providing a taxonomy of planning systems, mostly devoted to air operations. 27 different systems are outlined, organized under four headings:

1. Deployment and Battle Operations Systems;
2. Airlift Resource Allocation and Transportation Systems;
3. Flight Planning Systems or Route Planning; and
4. Other Specific Military Planning Systems.

The range of systems is extensive, and includes a degree of assessment on applicability to different aspects of military planning.

Observations:
The review of Commercial Off-the-Shelf (COTS) tools provides a general understanding of the state of the art. It is a desirable introductory text for identifying what tools should be explored for replication, extension or interfacing/integration. Based on this article, most systems are relevant to air force immediate contingency operations:

1. Contingency Theater Automated Planning System (CTAPS);
2. Joint Assistant for Development and Execution (JADE);
3. Anticipatory Planning Support System (APSS);
4. Collaborative Operational Planning System (COPlanS);
5. Joint Operations Planning and Execution System (JOPES)
6. System for Operations Crisis Action Planning (SOCAP)
7. Airlift (or AMC) Deployment Analysis System (ADANS)
8. Consolidated Air Mobility Planning System (CAMPS)
9. Contingency Operations/Mobility Planning and Execution System (COMPES)
10. Knowledge-based Adaptive Resource Management Agent (KARMA)
11. Decision Scheduling System (DSS)
12. In-Flight Planner (IFP)
13. Mission Support System -Computer Aided Mission Planning at Air Base Level (MSS/CAMPAL)
14. Portable Flight Planning System (N-PFPS)
15. Tactical Automated Mission Planning System (TAMPS)
16. SAIC Mission Planning System (SAIC//MPS)
17. CINNA
18. Air Force Mission Support System (AFMSS)
19. The Rochester Interactive Planner System (TRIPS)
20. Deliberate Crisis Action Planning and Execution Segment (DCAPES).

Many of the systems listed above are examined as a part of this initial research (i.e. COPlanS, JADE). Others should be examined as system specifications are delineated as part of an options analysis.

[6] Burkle, F.M., Jr., and Robin Hayden (2001). The concept of assisted management of large-scale disasters by horizontal organizations. Prehospital Disaster Medicine,16(3):87–96. Pages: 9.

Context:
Many countries are poorly equipped to develop a comprehensive national disaster response system because of the vertical structure that exists within their key response organizations. This becomes most evident when governmental organizations and agencies are required to optimize coordination and communication during large-scale disasters. Vertical constraints have plagued nongovernmental relief and assistance organizations (NGOs), international aid organizations (IOs), and military peacekeeping forces in complex emergencies in which a lack of coordination and communication may paralyze response capacity and capability. Similar problems affect multiagency and multidisciplinary responses to radiological, chemical, and biological accidents and acts of terrorism, decreasing the capacity of these agencies and disciplines to meet the requirements of collaborative decision-making.

Horizontal (also referred to as lateral) organizations can be defined as organizational architectures or structures that optimize coordination, communication, and collaboration of functional components within and/or between organizations. The purpose of this concept paper is to introduce and discuss horizontal management options to existing disaster management approaches, especially to large-scale disasters.

Content:
The paper discusses vertical and horizontal organisations and posits that vertical organizations are at their best when standardized functioning is applied to familiar routine tasks; however, organizations are at their worst in unusual situations requiring initiatives, such crisis action planning for emergency response.

Crisis action planning requires flexibility to handle high information requirements in an environment with stakeholders that have diverse information requirements and organisational structures. As militaries become more involved in operations other than war, entities such as the Air Force requires the capacity to function as a facilitating, collaborative, horizontal organization conducive to solving operational level concerns with multiple partner stakeholders; there is a real demand for horizontal planning.

Horizontal planning and management traditionally occurs after the fact and on an ad hoc basis, and as such often fails to identify beforehand, the body of information, classified and unclassified, required for coordinating and collaborating organizations to work safely together to meet both humanitarian and security requirements. This delay is related, in part, to concerns regarding the classified information environment in which the military plans and operates, as well as the inherent reluctance to share information. Additionally, military function by legal mandate, and restrictions on their relationships with other agencies often are mandated by law.

An implementation process for lateralization across horizontal stakeholders is presented as follows:

Internal	Collaborative
• Identify functions that require internal lateralization • Identify personnel that require internal lateralization • Identify equipment that requires internal lateralization • Identify open-source information that is to be shared internally during emergencies • Identify closed-source information that is to be shared internally during emergencies • Identify legal and authority processes for above contingencies • Identify decision-making protocols and guidelines for internal lateralization process	• Identify functions, personnel, equipment and information resources that are needed to collaborate externally • Identify external organizations, agencies and lateral organizations (e.g., CMOC) in which collaborative relationship is required. • Match functions, personnel, equipment and information sharing requirements with emergency event and external organizations • Identify legal and authority requirements for all of the above • Ensure security requirements, legal authority and criteria for sharing of all potential closed-source information • Identify decision-making protocols and guidelines for collaborative process
If above contingency process requires establishment of a separate internal Group or Unit • Develop internal charter with clear and well defined scope of work, authority and decision-making process • Ensure organization-wide acceptance and understanding of lateralization process • Develop contingencies that ensure smooth functioning of parent organization	**If above contingency process requires establishment of a separate external group or unit** • Develop internal charter with clear criteria, defined scope of work, authority and decision-making process allowing for collaboration to take place • Ensure internal and external acceptance and understanding of the collaborative process • Ensure transparency of collaborative process to all potential participants • Ensure that process is shared with all factions before entering a conflict situation • Ensure compatibility of security, evacuation, and information technology plans • Ensure compatibility under existing international humanitarian laws, treaties and covenants
Implementation process • Educate, train, and exercise lateralizing process internally • Develop contingency protocols • Establish as annex to standard emergency plans • Publish and distribute plans to appropriate internal offices	**Implementation process** • Educate, train, and exercise with civil-military organizations • Train and exercise for contingencies and for potential future emergencies • Publish and distribute plans for collaboration to appropriate agencies and organizations

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Figure 31. *Implementation process for lateralization across horizontal stakeholders*

Observations:

Involvement in emergency response requires information sharing and collaboration from diverse stakeholders such as government- and military-level decision-makers, emergency managers, tactical scientists (professionals) and justice-level decision-makers. Planning must include input from these stakeholder groups. In terms of crisis action planning, traditional Joint military command structure does not allow coordination with civilian organizations, such as IOs and NGOs, to occur until late in the planning process or after the deployment of military forces to the field.

The paper puts forth a table of factors to consider for developing an implemention process to promote lateralization. Consideration of some of these factors and the role lateralization plays early in the planning process (i.e. orientation/mission analysis) would benefit the development of a decision support tool for Air Force rapid response planning.

[7] Chief of Force Development (2008). Statement of Requirements: Canadian Forces Collaborative Operational Planning System, Department of National Defence/Canadian Forces, Canada.

Context:
This is an internal DND document focusing on requirements for the development of the Collaborative Operational Planning System (COPS/COPlanS) in support of CF OPP. The target audience is the COPS project participants and CFD, designed as a living document to guide development process. It is quite recent, though it may have evolved beyond the June 2008 iteration at the time this document is released.

Content:
The focus is on the COPlanS requirements. COPlanS is focused on achieving decision superiority through more rapid and effective CF OPP implementation. As a tool under development, the assumptions, deficiencies being addressed and requirements are all rooted in the context of current operations with a view to meeting these requirements through the project. While there is significant discussion of the CF OPP within the central sections of the document, the Capability Deficiency and System Effectiveness Requirments sections carry the greatest relevance. Key assumptions include:

a. limited ability to collaborate between HQs, share information externally and synchronize functional staff activities in particular across different time zones;

b. lack of a common set of applications for operational planning within the CF OPP framework, in part due to the lack of standardized tools as well as staff not being well versed in operational planning;

c. challenges to exploit information available within Command Net applications for operational planning without error-prone manual transfer;

d. limited ability to maintain common awareness, unity of thought and synchronize staff activities within a HQ staff;

e. manual generation of planning documents and presentations requires excessive staff attention at the expense of core planning;

f. limited ability, other than the use of graphics, for commanders to impart intent, disseminate planning guidance and rapidly collaborate commander to commander;

g. inability to monitor the status of plans or measure the quality of planning products;

h. decision cycle is long and risks failure in achieving decision superiority;

i. commanders and staff lack analysis tools, decision-making aides and bilingual formats;

j. planners lack ready access to planning data, including experience from previous operations or other contingencies, and the ability to replay decision paths for lessons learned and forensics; and

k. lack of standardization for document management, production, sharing and remote access by planners to version-controlled working document.

Requirements are organized under the following categories:

1. Operability;
2. Survivability;
3. Maintainability;
4. Availability;
5. Reliability;
6. Environmental Sustainability;
7. Security;
8. Safety and Health; and
9. Delivery.

The requirements are further captured at the end of the document in the form of a table for monitoring progress.

<u>Observations:</u>
The focus is on support of Joint, Inter-agency, Multinational and Public (JIMP) interoperability, which includes Air Force communications with other elements, OGDs and allies. As a result, these sections provide the foundation for an initial SOR for an air force decision support tool for immediate contingency operations. In addition, any effort to create an Air Force planning tool should be designed to align with the development schedule of COPlanS to reduce redundancy. A Service-Oriented Architecture approach to creating decision support tools would allow focus on specific services and thus reduce this type of overlap.

Another interesting factor is that a pilot/trial of COPlanS was planned for both 1 CAN AIR DIV and CEFCOM from May to December 2008. Before development of any future operational planning and decision support tools, feedback on the trial should be examined.

[8] Chinthamalla, D, Muthyala, H., Porter, W.D. (2002). Information Integration Using The Blackboard Technique. Proceedings of the 40th Annual ACM Southeast Conference, pp. 39-44, April 26-27, 2002, Raleigh, NC

<u>Context:</u>
The paper discusses two parts of implementing a Blackboard system. (1) Information Integration Systems, and (2) Query Controllers to communicate with remote data sources (a.k.a. *Knowledge Sources*).

According to the authors, “This world is becoming highly information-intensive. Information is available from various sources, including databases, knowledge bases, and the World Wide Web… …The most important factor… is that the integration of information from different sources should be transparent to the user. What this means is that the user should not be forced to know how, and when each of the background sources are used".

The paper provides an overview of some of the Intelligent Information Systems (IIS) that exist, including:

- Federated Database Systems
- Mediator-Wrapper Architecture
- Ontology based Architecture
- Agent based Architecture
- Description Logics based Systems
- Metadata repositories
- Query processor technique.

The author describes their implementation using a Query processor, which is an adaptation of an Agent Based Architecture.

<u>Content:</u>
This concept is an ideal state for a well architected DSS. The different information can come from various databases, and intel from various agencies. Having the ability to determine where the information comes from is useful at times, but a homogenization of data would best de-clutter the solution space, and aid the creative process.

[9] Coffin, W. J. M. (2002). The Operational Framework for Homeland Security: A Primary Mission for the National Guard. Ft. Leavenworth, Kansas, USA: US Army Command and General Staff College. Pages: 78.

<u>Context:</u>
This document is written in the context of the post-9/11 security environment. The U.S. military's responsibilities for homeland security focused on providing support to civilian authorities during the aftermath of natural and manmade disasters. That said, the focus of this framework is broadened to include the role of the U.S. military in taking the lead in "shaping and fostering unity of effort among the many federal, state and local agencies with homeland responsibilities."

<u>Content:</u>
The U.S. military's homeland security responsibilities at the tactical level flow from the traditional support to civilian authorities in disaster relief operations and the Office of Homeland Security's mission to detect, prepare for, prevent, protect against, respond to, and recover from the terrorist attacks. The Department of Defense's goal is to establish an operational-level structure within the U.S. Northern Command to tie these tactical missions to the President's strategic objectives for homeland security.

The document outlines that an effective operational-level framework for the land and maritime homeland security requirements within US Northern Command is a joint, multi-component command and control organization structured at the national, regional and state level. The U.S. National Guard draws on its historical experience in support to civilian authorities and established relationships in the local communities to provide the leadership for this operational framework.

At the national level, a joint task force (JTF-USA) aligns with the Federal Emergency Management Agency (FEMA) and develops the land and maritime campaign for homeland security. At the regional level, ten Regional Homeland Security Commands (RHLSCOM) align with the ten FEMA regions and develop region-specific homeland security operation plans and facilitate interagency coordination. At the state level, each state National Guard establishes a Homeland Security Command (HLSCOM) under the governor's control to provide first response capabilities for terrorist attacks and natural disasters. Once the President declares a federal emergency or disaster, the Secretary of Defense federalizes the state HLSCOM so it can take operational control of all U.S. military assets committed to response and recovery missions.

<u>Observations:</u>
The report cites that recommendations to meet the U.S. military's homeland security responsibilities fall under three areas; doctrine, operational structure, and force structure and cross multiple jurisdictions. Recommendations include:

- The Chairman of the Joint Chiefs of Staff should develop a definition for homeland security and revise joint doctrine for domestic support and interagency coordination.
- The Commander-in-Chief for U.S. Northern Command should establish the JTF-USA operational structure for the land and maritime homeland security mission.
- Congress should authorize at least one Weapons of Mass Destruction-Civil Support Team for each state
- Director of Army National Guard should develop a force structure plan to provide each state with sufficient combat service and combat service support units.

The main value of this document is its outlining of the way in which the military supports local, state and federal agencies and their requirements to interact in crisis response. The requirement to act in a joint environment in support of domestic government departments and across multiple jurisdictions has led to a number of initiatives that promote interoperability through doctrine, operational structure and force structure and address the fact that the US military provides a top-down planning process that evolves from the bottom-up. In addition, legal and policy initiatives that mandate/encourage collaboration impact the planning requirements of both the military and OGDs. The crux of the article is the fact that for rapid response during domestic emergencies, interoperability is placed at a premium, and must be imposed through the planning framework.

[10] Corkill, Daniel D. (2003), Collaborating Software, Blackboard and MultiAgent Systems & the Future. Department of Computer Science, University of Massachusetts.

<u>Context:</u>
AI researchers have used the paradigm of Collaborating Software systems to tackle large and difficult problems. Blackboard systems were the first attempt at integrating ”cooperating”

software modules. The goal was to achieve the flexible, brainstorming style of problem solving exhibited by a group of diverse human experts working together to address problems that no single expert could solve alone. Multi-agent systems research is revisiting the collaborating-software paradigm from an agent-centric orientation. Again the goal is to achieve effective collaboration with a group of independent software entities, but in a way that appears to be markedly different from the approach taken in blackboard systems.

Content:

This paper compares and contrasts these two approaches. There is a good discussion examining collaborating software from both perspectives provides insights, and diagrams into the nature of collaboration tools. The author claims to "reveal unresolved problems in integrating disparate contributions, and underscores issues in coordinating collaborative activities.", but the strength of the paper is in his easy-to-read descriptions of "What is a blackboard".

A blackboard is a methodology of merging information from disparate *Knowledge Sources* into a single unified database (the *Blackboard*). The information if transformed via a *Control Shell.*

The paper mentions that Bayesian networks are popular AI systems that are implemented in Blackboards to incorporate more principled integration of various "knowledge systems" into the solution. The main motivation for moving to a principled representation of blackboard data is to make the integration of disparate KS results well founded. This can only be achieved by creating accurate models of how these results are generated and relate to one another.

[11] Da, Shimin et al. (2007). Research on Case-Based Reasoning Combined with Rule-Based Reasoning for Emergency. In IEEE International Conference on Service Operations and Logistics, and Informatics, SOLI 2007, (1-5). Pages: 5.

Context:

This paper proposes an emergency group decision support system based on the combination of CBR and RBR in order to overcome the bottleneck of knowledge acquisition that is a result of the fact that decision-making based on pre-event planning has the following limitations: 1) inconsideration of the lack of information; 2) possible inconsistency of the situation and decision environment described in the plan with that of the actual event; 3) possible inconsistency between the desired purpose of the plan and that of the required current decisions; 4) inconsideration of the dynamic evolution of events that is characteristic of crisis situations.

Content:

Through searching and reusing the accumulated past experience, CBR is used to solve existing problems to reduce the difficulty of obtaining knowledge. It is especially useful in a complex and changing environment, such as the decision-making environment where the domain knowledge is difficult to structure. However, as CBR conducts historical case searching and matching based on similarities, the searched history cases are not always correct and not always fitting for the present decision environment. Rule-based Reasoning (RBR) is combined to CBR to address this deficiency. RBR can make the dominant domain knowledge and decision makers' special requests structured, and realize the symbol attributes' matching. Examples cited that combines both CBR and RBR include a real-time expert system (RTEST) which is currently used in a NASA control system as a real-time fault diagnosis system, and in the development of a city emergency response system where CBR is used to analysis when there are similar cases matched up and RBR is deployed to the DSS program when no similar case has been successfully found.

Observations:
The paper states that the application of CBR and RBR in EDM process can increase the effectiveness and efficiency of decision-making through proposing a novel iterative EDM process model based on the combination of CBR and RBR. This method (1) provides solutions of similar cases to decision makers in a timely manner; (2) forecasts COAs using if then rules and summarizing historical case knowledge and (3) incorporates follow-up or feedback information to generate a new round of RBR to help decision makers timely adjust plans as necessary.

The discussion in this paper extends basic business process modelling tools with the inclusion of historical data and the addition of a rule-based reasoning which fill gaps when no relevant historical data is available. For those with a background in decision support tool development, this article does not provide new information, yet it does state a concept which is critical for the development of decision support tools for rapid response planning.

[12] Defence Research and Development Canada (DRDC) Valcartier (various). Distributed Collaborative Operations Planning System (COPlanS) Workflow Management Based Support System for the Operations Planning.

Content:

The Collaborative Operations Planning System (COPlanS) is a computer-based suite of planning, decision aid and workflow management tools aimed at supporting a distributed team engaged in the Canadian Forces Operational Planning Process (CF OPP). The system provides the ability to plan an operation in a net-centric environment using integrated, flexible and collaborative tools to support a more inclusive, agile and adaptive planning process.

COPlanS provides users with the ability to stay abreast of the status of the development of an Operations Plan following the CF OPP. Users can log on and see what exactly the HQ is working on and at what stage the planning staff are at in the CF OPP.

COPlanS provides a distributed collaborative planning support capability through the use of decision aids, visualization and synchronization tools. It helps synchronize the staff workflow, documents automatically key aspects of the decision-making process which permits subsequent review of the decision-path. In essence, the aim of COPlanS is to allow staff members to spend more time on the high value processes of human creativity through collaboration and analysis and less time on the more mechanical processes plotting and calculating data for further consideration.

Context:
COPlans consists of the following modules or elements:

- Workflow Management;
- Operational Planning Process; and
- Collaboration.

Workflow Management

- The workflow designer attribute gives the planners access a predefined list of activities and the ability to modify these actives. The activity components can then be linked to create a desired logical workflow which can then be saved as a workflow template. The Chief Planner can then initiate the workflow described by the template assigning specific staff to activities. The workflow can then be tracked and managed while in progress (e.g. re-assign staff, skip activities, etc.). Staff are sent e-mail notifications and updates.

- The consultation centre displays graphical views of the workflow evolution showing the status for each activity. Documents resulting from or associated with the workflow can be displayed.

- The document repository has the capacity to simultaneously access multiple documents related to a workflow or activity. Documents can be displayed added or removed.

Operational Planning Process

- COPlanS supports sketching COAs on maps, providing an ability to make rudimentary assessments related to time and space synchronization, management of capabilities and ORBAT, and logistics analyses. The system provides decision-aid tools to improve COA evaluation and selection as well as the capability to automate the preparation of documents to support the Commander's ability to understand the situation and then make and communicate decisions.

- COPlanS supports the CF OPP in the Initiation and Orientation stages with the capability to rapidly make the required time appreciations, automatically produce a mission analysis briefing and publish the Warning Order.

- COPlanS provides Gant planning (scheduling) and hierarchical task decomposition to assist in COA development. The system synchronizes maps with the Gant planning/scheduling tool. The planner can access and display all available ORBAT information on assigned resources. In addition, visibility into the ORBAT allows the planner to assign resources to potential tasks.

- COPlanS has the capability to search for past planning activities and associated COAs that are similar to the current assigned mission as a baseline to develop and display new COAs based on the current mission.

- The system then conducts a COA comparison by analyzing the decision criteria and fine tuning the criteria importance and the modified criteria values compared to the initial values. The system will then compute and display a COA ranking based on a global evaluation or according to a particular criteria.

- At the completion of this process COPlanS produces a decision brief for the Commander and generates a COA SOR.

- At the Plan Development stage, COPlanS parses the selected COA into mission requests and generates the Warning Orders and the OPLAN. The OPLAN once approved is sent to the Theatre Battle Management Core System (TBMCS) via the Theatre Air Planning (TAP) application for subsequent issue to subordinate units.

- During Plan Development, COPlanS utilizes a CF OPP Profiler which is a case-based reasoning tool that checklists, templates and proposes SOPs based on mission initial and updated parameters and tasks.
- The Cost Calculator, a querying tool, that extracts accurate manning, elements and cost figures from the Table of Organization and Equipment (TO&E) also aids in the development of the plan.

Collaboration

- Chat provides a means for conducting collaborative sessions for each mission, workflow or activity in addition to private chat and instant messaging. Users can be invited to join a session which can then be tagged and saved for later reference.
- Geo-referenced White Boarding affords an on-map overlay drawing capability with whiteboard drawing tools. Text and military symbology may be placed on the whiteboard and saved as a whiteboard snapshot for later reference and re-use.
- On-Map Collaborative Planning utilizes the Luciad GIS tool, LuicMap, which supports military symbology. LuciMap is compliant with Open GIS Standards and offers fully-integrated functions to support COPlanS requirements. COPlanS integrates with other DSS tools such as :Operations Planning Process Advanced Decision Support (CF OPP-ADS) and
- Total Resource Visibility Tool (TRV).

Observation:

Any new tools that may be developed need to consider integration of existing tools. If COPlanS is to be adopted, this is one of the tools to be analysed. It would also be worth the effort to understand the lessons learned from the process of COPlanS development and document them for future DSS tool development reference.

[13] Department of Homeland Security (2004). National Incident Management System (NIMS), Washington, DC: Department of Homeland Security. Pages: 152.

This review was aided by the discussion and graphical depiction of the *ICS Initial Response and Operational Planning Process* presented in the Federal Highway Administration Office of Administration's Simplified Guide to the Incident Command System for Transportation Professionals (http://ops.fhwa.dot.gov/publications/ics_guide/index.htm#chapt5).

Context:

The National Incident Management System (NIMS) provides a consistent nationwide approach for governments at all levels to work together to prepare, prevent, respond and recover to all- hazard emergencies. This document acts as a reference to many in the civilian emergency response arena, for example elements can be seen in the Australian Incident Management System (AIMS) and the British Columbia Emergency Response documentation.

Content:

The NIMS adopts the Incident Command System (ICS) structure for emergency response command and control. The ICS consists of 5 functional sections. A Command Section, which could be either a consortium of partners under a Unified Command (UC) or an individual Incident Commander (IC) receives support from the remaining 4 functional sections of: Operations Section, Planning Section, Logistics Section and Finance/Administration. Personnel work collaboratively to develop courses of action (COA) for the UC/IC.

The ICS operational planning process is overseen by the planning section. The Planning Section Chief oversees the gathering and analysis of all data regarding incident operations and assigned resources, developing alternatives for tactical operations, conducting planning meetings and preparing the incident action plan for each operational period.

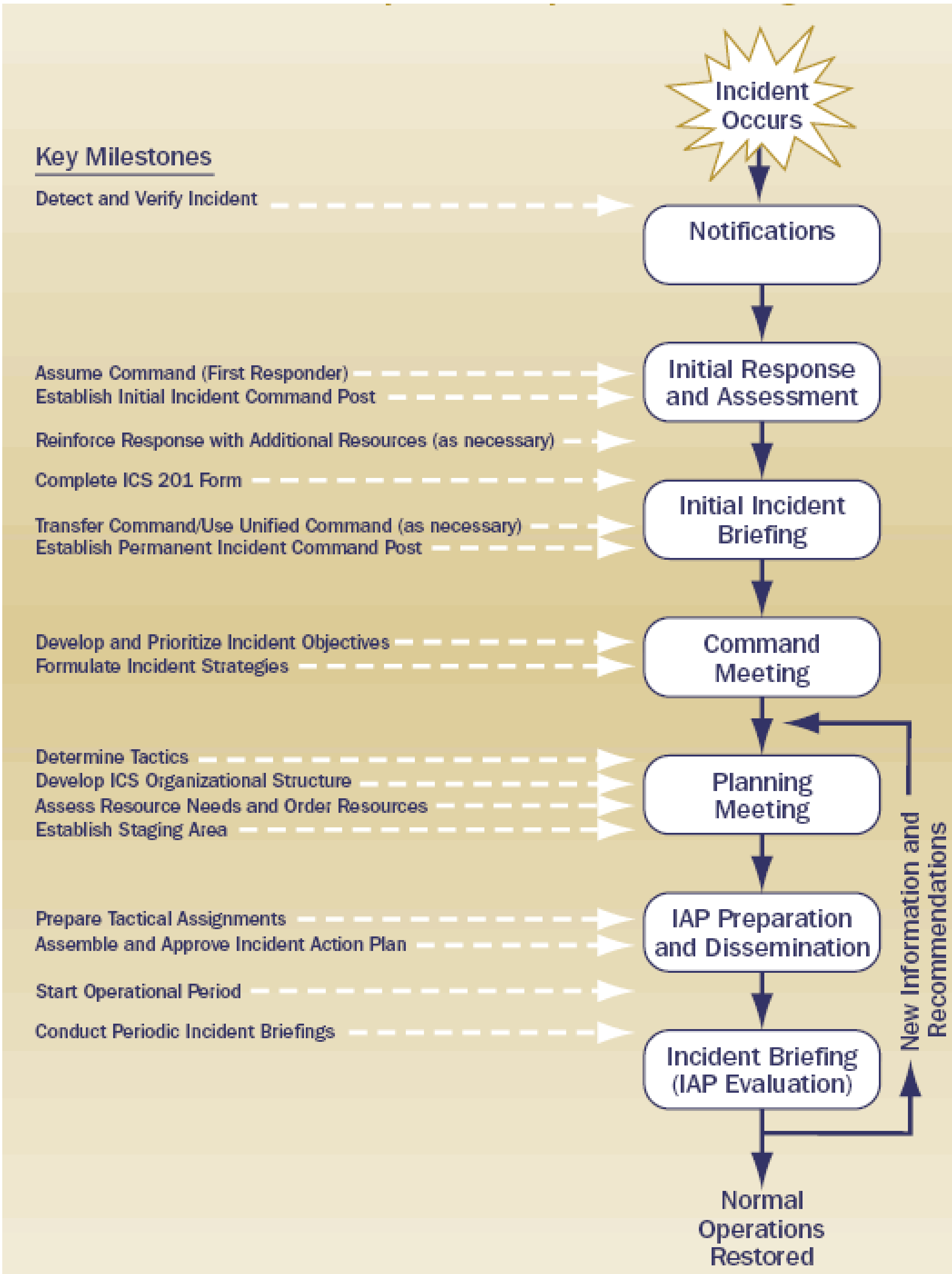

Figure 32. *ICS Initial Response and Operational Planning Process*

Of particular interest is the initial response and development of the Incident Action Plan (IAP) and their relationship to the ICS driven operational planning process. The Planning Section is responsible for developing and documenting the IAP, however the Operations Section provides key inputs as it is responsible for the reduction of the immediate hazard, saving lives and property, establishing situational control and restoration of normal operations.

The IAP includes the overall incident objectives and strategies established by the IC or UC and must adequately address the mission and policy needs of each jurisdictional agency involved as IC or UC, as well as interaction between jurisdictions, functional agencies and private organizations. The IAP also addresses tactical objectives and support activities required for one operational period, generally 12 to 24 hours. The IAP also contains provisions for continuous incorporations of "lessons learned" as incident management activities progress. An IAP is especially important when:

- resource from multiple agencies and/or jurisdictions are involved;
- multiple jurisdictions are involved;
- the incident will effectively span several operational periods;
- changes in shifts of personnel and/or equipment are required; or
- There is a need to document actions and/or decisions.

The IAP will typically contain a number of components, as shown below:

Components	Normally Prepared By
Common Components	
Incident Objectives	Incident Commander
Organization List or Chart	Resources Unit
Assignment List	Resources Unit
Communications Plan	Communications Unit
Logistics Plan	Logistics Unit
Responder Medical Plan	Medical Unit
Incident Map	Situation Unit
Health and Safety Plan	Safety Officer
Other Potential Components (Scenario dependent)	
Air Operations Summary	Air Operations
Traffic Plan	Ground Support Unit
Decontamination Plan	Technical Specialist
Waste Management or Disposal Plan	Technical Specialist
Demobilization Plan	Demobilization Unit
Operational Medical Plan	Technical Specialist
Evacuation Plan	Technical Specialist
Site Security Plan	Law Enforcement Specialist
Investigative Plan	Law Enforcement Specialist
Evidence Recovery Plan	Law Enforcement Specialist
Other	As Required

Figure 33. *Sample IAP Outline*

Observations:

The NIMS and the IAP presents a generic, high level depiction of civilian emergency response planning based on the ICS. The ICS is a simplified version of the more detailed military planning process (such as the CF OPP) and due to the nature of civilian emergency response, has been designed to facilitate multi-jurisdictional collaboration. The simplified process focuses the analysis of the more detailed military CF OPP on components that are essential emergency planning and may be relevant for condensing processing for Air Force rapid response planning. In this vein, an interesting analysis would be to compare the components of the IAP with those of a military operational plan/order, the outcome of a mission analysis.

[14] Department of National Defence (DND) (2008).The Canadian Forces Operational Planning Process, B-GJ-005-500 April 2008, Department of National Defence, Canada. Pages: 142.

Context:

The Canadian Forces Operational Planning Process (CF OPP) is the doctrine designed to guide all CF operational planning activities. It outlines the method and sequence of planning for CF operational-level command and supporting staff.

The document, originally drafted in 2002 with updates dating to 2008, evolved from the *Force Employment Manual* and was updated in part to meet changes in allies' (US, NATO) planning processes while providing a common Canadian model for operational planning. The document is written within the context of the post Cold War, post-9/11 complex security environment and is designed to support a "whole of government" approach where the CF would be required to act in conjunction with other Canadian resources (diplomatic, political, economic, etc).

The planning process is shaped by the operational cycle as identified in *Canadian Forces Operations*, but is a standalone document that can be read and learned in separation. That said, it is written in a tone that suggests users of this document have at least a degree of operational experience that shapes their judgment in areas where the doctrine is not explicit.

Content:

The CF OPP is outlined according to the phases of the planning process:

1. Initiation;
2. Orientation;
3. Course of Action (COA) Development;
4. Plan Development; and
5. Plan review.

For each section, the document goes into detail in terms of how these stages are applied. Particular emphasis is placed on the importance of the Orientation and COA Development phases:

> Proper orientation of the planning process is critical to the success of the plan. It is therefore essential that clear direction from the strategic level be provided and that political/strategic goals be articulated before planning commences. The planning process should provide maximum freedom to the staff to consider ideas and concepts in order to develop a wide range of COA.

The document goes into specific detail regarding Rapid Response Planning, where timing provides only short-notice planning. It mentions that for emergency operations, the initial action is often driven bottom-up, originating at the municipal level in the case of domestic operations. It indicates that there are two types of rapid response planning, where there is an existing Contingency Plan (CONPLAN) prepared for such a crisis or where there is not. It outlines the five phases and how they differ from deliberate planning:

7. **Initiation**. The initiation is likely to be brief, with minimal guidance. As the situation unfolds either the strategic objectives may change until a political or coalition decision is achieved. This will require the commander to make assumptions from the outset to expedite the process;

8. **Orientation**. This stage remains unaltered, as it is indispensable for effective, efficient planning. The commander will, however, be more concise, even to the point of specifying initial COAs in the Planning Guidance. This is necessary to narrow the scope of the staff's work and expedite the planning process;

9. **COA Development**. The staff may have minimal time to check the guidance provided by the commander. Therefore, following staff checks, an abridged analysis of the factors is produced to analyze the various courses of action. It is unlikely that an Information Brief will be required, since the staff preparing the final staff check, the commander and the component commanders will all be intimately involved with the details of the situation by this stage. A Decision Brief will be conducted for the same reasons it is conducted during deliberate planning; however, it will focus on the viability of the COAs. A CONOPS will be produced based on the information provided and the decisions made at the Decision Brief. The CONOPS will be submitted to the initiating authority for approval. CONOPS approval by the initiating authority is normally a prerequisite for the full development of a plan or OP O but depending on the nature of the time constrains planning may proceed concurrently as the CONOPs is staffed;

10. **Plan Development**. While the initiating authority will approve the CONOPS, the urgency of the situation may preclude submission of the detailed plan for subsequent approval. If time is available, the completed plan should be approved by the initiating authority; but if time is short, the TF Comd will normally have the authority to carry out the plan once the CONOPS is approved; and

11. **Plan Review**. This stage is unlikely to be conducted prior to the execution of the plan unless the urgency of the situation decreases.

Observations:
This document is the centerpiece of Air Force and CF operational planning. The CF OPP makes specific reference to crisis planning within the context of domestic emergency response, and so it is fitting that this project adopts a similar scenario through the use of CF Force Planning Scenario #2: Disaster Relief in Canada. It reflects the factors that must be understood in developing any proof of concept:

1. Collaborative planning: The planning cycle may already be initiated from the bottom-up, and so must be able to work with other government departments (OGDs) both as a lead and as a support agency. This includes enabling and supporting communication, and the analysis and dissemination of current information. It also includes the de-

aggregation of activities, with the ability to place significant responsibility on the support staff level. The tool should support distributed planning, with the assumption that the tool will be used in a theatre where bandwidth is significantly limited.

2. Assessment of alternatives: The system should place focus on the assessment of potential courses of action. Information on available alternatives should be readily available, complete and easy to manipulate and interpret, allowing time to be allocated less on calculation and more on analysis.
3. Plan development: A good deal of emphasis is placed on the Op O. This is the medium currently in place for communicating information about the operation, and all efforts are driven to contribute to its completion. The in addition to the content of such a document, the presentation of this information should be considered. Video, images, animation and voice communications can often be produced quickly and better communicate command intent, and should be evaluated as options where bandwidth allows. The formatting and presentation of information is a necessary aspect of any planning, and any tool should seek to simplify and automate as many aspects of this as possible.

Any tools that are acquired to assist with operational planning thus need to to fit within the framework of the CF OPP. The phases can be abridged and adjusted, but not removed and overhauled.

While not specifically Air Force doctrine, this document provides the foundation for Air Force planning documents and presentation. Documents created after the initial publication of this document are of most relevance.

[15] Department of National Defence (DND) (2005), Canadian Forces Operations, B-GJ-005-300/FP-000, J7 Doctrine 2 Department of National Defence, Canada.

<u>Context:</u>
This CF doctrine provides the fundamental tenets for the employment of military forces to translate the CF mission and strategic objectives into action. More specifically, it provides commanders with underlying principles to guide their actions in planning and conducting operations. While CF and Environment specific doctrine are separate bodies of doctrine, the two must be compatible. All CF plans and operations will be based on the doctrine contained in this publication.

<u>Content:</u>
The document is most useful in providing valuable definitions and explanations of terms that bound operational planning. For example:

- An operation is a military action or the carrying out of a strategic, operational, tactical, training or an administrative military mission; the process of carrying on combat, including movement, supply, attack, defence and manoeuvres needed to gain the objective of any battle or campaign.

- A CF Operation is defined as the employment of an element or elements of the CF to perform a specific mission.

The document covers the need to link policy to operational objectives. It states:
The military response to conflict must be consistent with national policy objectives. The translation of policy goals into military action must be done in a manner which ensures clarity and preserves unity of effort.

As a result, effective operational planning fills the need to communicate up to political objectives and down to operational tasks.

All CF operations are conducted in five broad phases. These phases are: (1) warning; (2) preparation; (3) deployment; (4) employment; and (5) re-deployment. Each phase is discussed at a high level, with specific areas such as warning and preparation being covered in more depth through the CF OPP.

The document decomposes strategic, operational and tactical levels of operations. The operational level of conflict, most relevant to this project, is the level at which campaigns and major operations are planned, conducted and sustained to accomplish strategic objectives within theatres or areas of operations. Activities at this level link tactics and strategy by establishing operational objectives needed to accomplish the strategic objectives, sequencing events to achieve the operational objectives, and initiating actions and applying resources to bring about and sustain those events.

One of the guidelines for the effective employment of force is to ensure that Communications and information systems (CIS) are interoperable, survivable, and complemented by standardized formats. The document defines a CIS as:

> An integrated system comprised of doctrine, procedures, organizational structure, personnel, equipment, facilities and communications which provides authorities at all levels with timely and adequate data to plan, direct, and control their activities. This comprehensive command, control and information system enhances C2 which, in common military usage, describes the process by which commanders plan, direct, control and monitor any operation for which they are responsible.

Observations:
As the doctrine this document outlines the underlying principles for CF operations, and thus CF operational planning. It outlines the CF operational planning process at a high level, placing it in the context of the phases of an operation. Its value thus lies more in providing context than on defining specific requirements for a decision support system.

For the air force perspective, operational considerations are directly linked into the planning process. Of relevance are command's planning considerations:

Commanders must determine the forces required, the arrival sequence, and what level of risk they are willing to expose the airfield operations forces. Additionally, deployed airfield operations forces must be prepared to be self-sufficient during the early stages of an operation because the logistics system may not be in place. Initial airfield operations should plan to deploy with adequate capability and supplies to maintain operations until the theatre is capable of supporting operations and the re-supply pipeline is established.

The understanding of the quick deployment nature of air operations indicates that any decision support tool needs to be able to unfold an optimal plan in relatively few iterations, and wit the expectation that plans can be modified as the operation unfolds, as air operations may be well underway before all necessary operational capabilities are active in theatre.

[16] Katja Filippova, Margot Mieskes, Dr. Vivi Nastase, Simone Paolo Ponzetto (2008) Topic Driven Multi-Document Summarization. pg 75 – 79. EML Research Annual Report.

Context:

One of the goals of Natural Language Processing is helping people cope with the huge amount of information that we have to process every day. To this end, the National Institute of Standards and Technology (NIST) sponsors competitions focusing on developing technologies for compressing information from multiple sources into a short summary. This paper presents an overview of the summarisation task that was completed for the Document Understanding Competitions (DUC) in 2007.

Content:

The platform on which the system was built is MMAX, developed by Christoph Mueller. MMAX is the base and collaborative medium through which that data is pre-processed with partial processing results being made available. Pre-processing is the foundation for all the subsequent activities. Several types of low-level processing were performed – text segmentation, part-of-speech tagging, parsing, lemmatization – as well as more complex ones, notably co-reference resolution. This last module will be further developed and adapted to the DUC summarization task in the 2008 version of the system. The next step in our summarization strategy was sentence selection using word-similarity measures and lexical-chain methodology. New algorithms from research on summarizing the minutes of meetings were adapted and implemented. The final step in the system consists of stricter sentence-filtering based on syntactic and semantic matching between the given topic and the pre-filtered sentences and producing the final summary by reordering and/or rephrasing them; this pertains to language generation.

Observations:

This paper’s research was rewarded with above-average results in the DUC 2007 competition, the experiments found numerous avenues to explore in future research, as well as methods for improving on our first summarization system. They plan on re-competing in the future years.

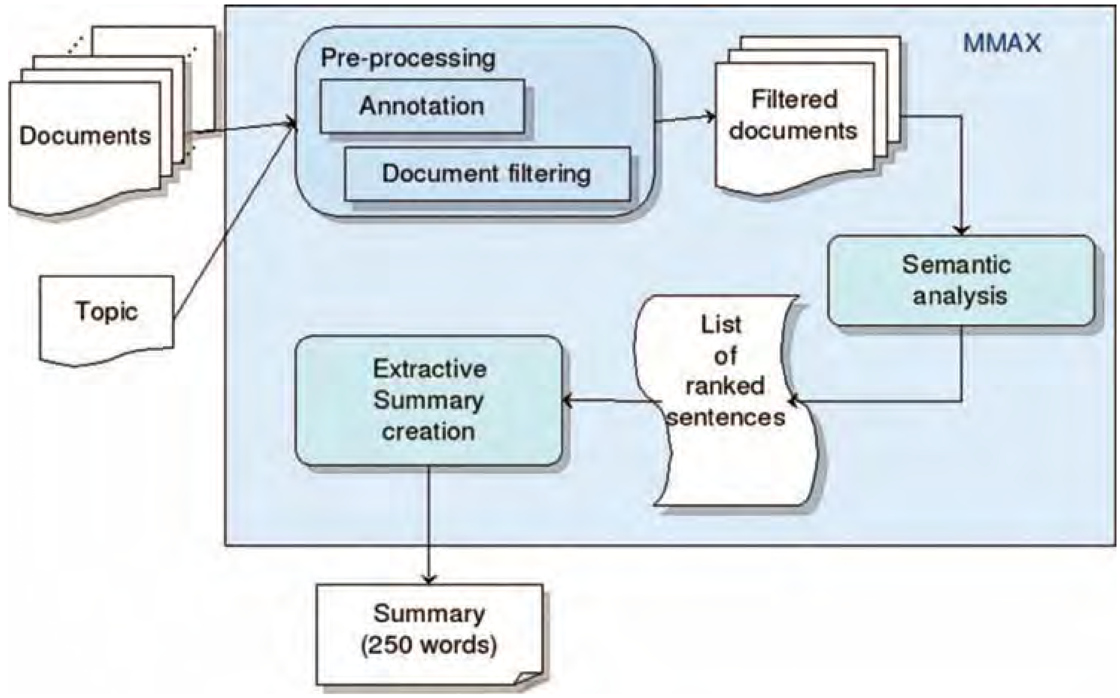

Figure 34. *Topic Driven Multi-Document Summarization Architecture*

[17] Gadomski, A. M et al. (1998). Integrated Parallel Bottom-up and Top-down Approach to the Development of Agent-based Intelligent DSSs for Emergency Management, presented at The Fifth Annual Conference of The International Emergency Management Society, TIEMS98: Disaster and Emergency Management: International Challenges for the Next Decade, Washington, D.C.

<u>Context:</u>

This paper is a continuation of the ENEA's studies related to the development of a multipurpose Intelligent Decision Support System (IDSS). The project is realized under the umbrella of the ENEA's long term MINDES Program synchronized with other worldwide programs and accepted as an Italian contribution to the GEMINI (Global Emergency Management Information Network Initiative) of the G7 Committee. The main objective of MINDES is to develop a multipurpose intelligent Decision Support Systems for industrial emergency management. The technology involved is based on an intelligent agent approach that not only provides data (selected according to situation assessment and intervention procedures from emergency plans) but also provides an active decision support related to the choices of adequate actions.

<u>Content:</u>

During development, the project team discovered that the first difficulty in the design of IDSSs for emergency managers, are not referred to software technologies but to the vagueness and incompleteness of end-user requirements. The potential users of IDSSs are practitioners and they have serious problems with mental structuring and description of their own activity in the form of a complete set of abstract categories covering the representation of an emergency domain, as well as, their various temporal and permanent constrains.

The design of IDSS can be performed top-down or bottom-up. Bottom-up design is an incremental approach applicable for the development of qualitatively new systems where their application range and complexity of functions can not be defined on the base of their future user requirements. This approach has a strong explorative character and it is relies on the verification of the utility and applicability of new software methods and technologies for never yet implemented particular functions. The project team found that to improve the bottom-up design, some top-down constructed constrains were required.

For the project presented, the emergency management problem was thus initially analyzed top-down, from the perspective of the general functional requirements of Intelligent Decision Support Systems (IDSS). IDSS functions, identified tasks for emergency planners that represent those activities which are possible to formalize, were first determined using a top-down analysis. The top-down approach was integrated with bottom-up incremental prototyping. It was found that such parallel bottom-up and top-down development of a generic IDSS kernel, supported by intelligent multi-agent architecture, enables:

- various real-time specialization of the system on the level of tools,
- strong reduction of the design time by parallel execution of project phases, and
- easier verification and validation of the system as independent tasks.

<u>Observations:</u>

The integrated parallel bottom-up and top-down approach was deducted from the development of an Emergency Management Active Tool-Kit (EMAT). The toolkit itself is representative of a DSS that includes a menu-driven user interface to user configurable Emergency Scenarios and an editing tool that allows the user to design and implement emergency procedures and to connect procedures to the different types of configured emergency events. It is suggested that the approach will facilitate a reduction in the design time of IDSSs' prototyping.

[18] Gonzalez, C., Lerch, J.F. and Lebiere, C. (2003). Instance-based learning in dynamic decision making, Cognitive Science, 27 (2003) 591–635.

<u>Context:</u>

This paper presents a learning theory pertinent to dynamic decision making (DDM) called instance based learning theory (IBLT).

<u>Content:</u>

IBLT proposes five learning mechanisms in the context of a decision-making process: instance-based knowledge, recognition-based retrieval, adaptive strategies, necessity-based choice, and feedback updates. IBLT suggests in DDM people learn with the accumulation and refinement of instances, containing the decision-making situation, action, and utility of decisions.

<u>Observations:</u>

As decision makers interact with a dynamic task, they recognize a situation according to its similarity to past instances, adapt their judgment strategies from heuristic-based to instance-based, and refine the accumulated knowledge according to feedback on the result of their actions. The IBLT's learning mechanisms have been implemented in an ACT-R cognitive model. Through a series of experiments, this paper shows how the IBLT's learning mechanisms closely approximate the relative trend magnitude and performance of human data. Although the cognitive model is bounded within the context of a dynamic task, the IBLT is a general theory of decision making applicable to other dynamic environments such as rapid response planning

[19] Greenley, A and Cochran, L. (2006). JCDS 21 Operational View 5 Activity Model, from Modelling Joint Staff Business Processes For Domestic Operations, Project Report – Draft, prepared for Joint Command & Decision Support for the 21st Century (JCDS 21) Technology Demonstration Project.

Context:
A DoD Architectural Framework (DoDAF) Operational View 5 (OV-5) Operational Activity Model of the CF OPP as articulated through the activities of Canada Command was developed for JCDS21 in 2006. An Operational Activity Model describes the operations that are normally conducted in the course of achieving a mission or a business goal. It describes capabilities, operational activities (or tasks), input and output (I/O) flows between activities, and I/O flow s to/from activities that are outside the scope of the architecture

The focus of the JCDS 21 activity modeling effort was to gain an understanding of the role and activities performed by Canada Command in domestic operations, capturing detail of decision making, collaboration and information and intelligence analysis activities.

Content:
The Operational Planning Process (CF OPP) is the formal process which structures the activities of the Canada COM staff. As an activity model, the OV-5 captures decision making, collaboration and information and intelligence analysis as they are conducted throughout the stages of the CF OPP.

The swim lane diagram format was used to create the scenario to illustrate roles and responsibilities while showing linkages between each of the stakeholders involved in operations planning for domestic incidents. The models are structured to show Canada Command interactions with various stakeholders, such as OGDs from different levels of government (municipal, provincial, federal), international governments and agencies and internal DND departments.

The following is the "swim lane" format employed by the OV-5. This figure is not intended to be legible; it is included to show the OV-5 presentation format.

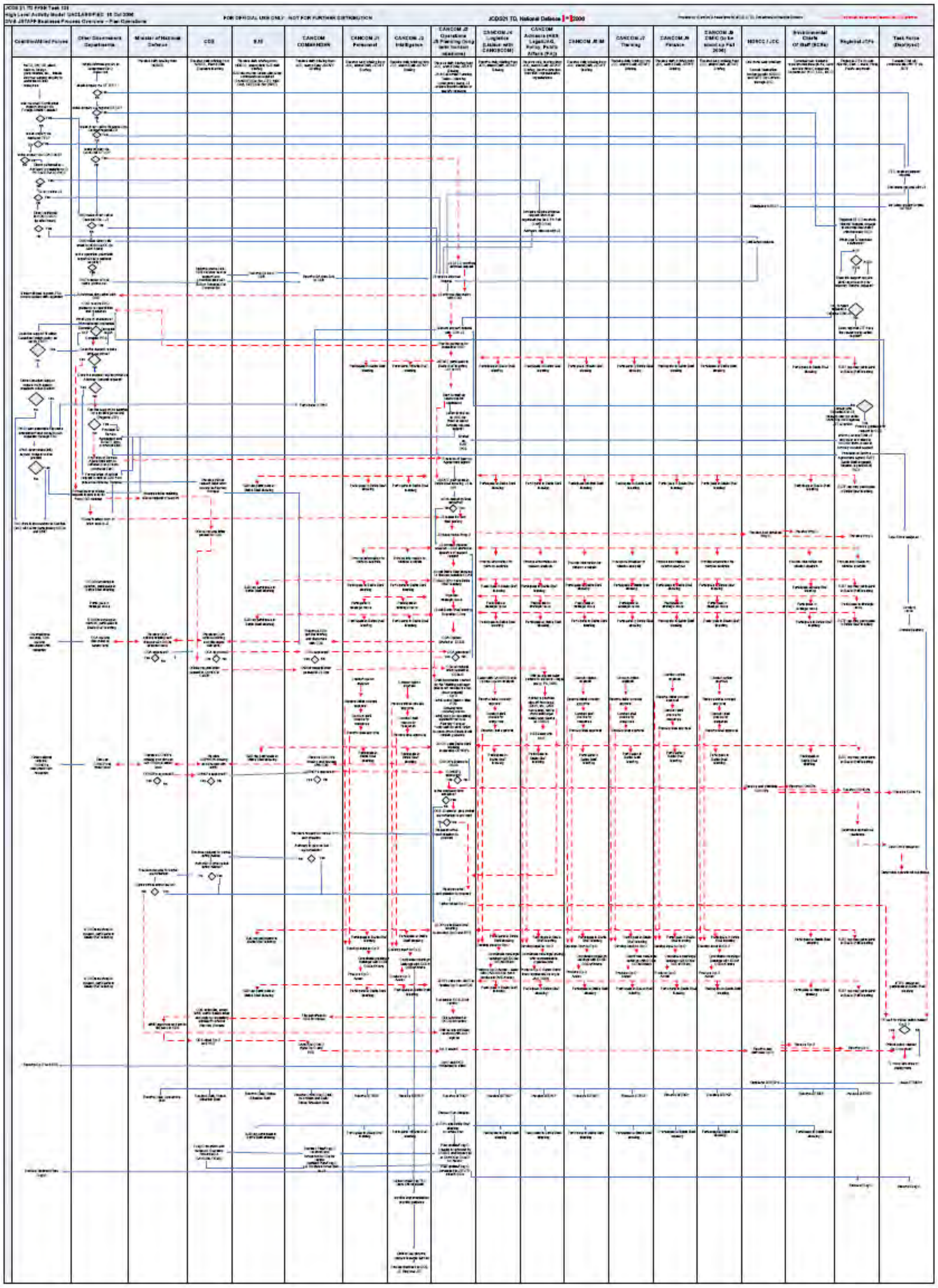

***Figure 35.** JCDS21 OV-5 Activity Model: Canada Command Compressed CF OPP (2006)*

Observations:
The OV-5 provides a starting point for compressing the CF OPP as required in rapid response planning. It is a level of refinement below the doctrinal discussions, broken down according to activities, inputs and outputs. The understanding of which activities occur concurrently is valuable in understanding which elements of a decision support system should be modular.

The briefing sessions outlined in the OV-5 are valuable in demonstrating the operational tempo that is common to operational planning. This tempo needs to be adjustable based on time constraints.

This OV-5 was validated for the Canada COM JSTAFF as a generic activity model (OV-5 architecture product). While there may be changes since its creation, it provides a snapshot of the operational implementation of the CF OPP and can provide a case study for validation of a new approach or system.

[20] Guitouni, A. and Belfares, L. (2008). Comparison and Evaluation of Multi-Objective Genetic Algorithms for Military Planning and Scheduling Problems, (DRDC Valcartier TR 2003-372) Defence R&D Canada - Valcartier.

Context:
This document is written for an audience with at least an intermediate knowledge of Multi-Objective Evolutionary Algorithms (MOEAs), and a focus on future defence research. As such, it takes a critical approach to the literature for the purposes of developing a tool involving MOEAs, specifically multi-objective genetic algorithms (MOGAs) for military Course of Action (COA) analysis.

Content:
The purpose of this document is to identify the best way to support Course of Action (COA) development. Translating the Commander's guidance and intent into comprehensive and flexible plans within the time available, taking into account multiple objectives. The focus is on multi-objective evolutionary algorithms, and specifically on the use of genetic algorithms. The paper reviews different types of MOEAs as represented in the figure below:

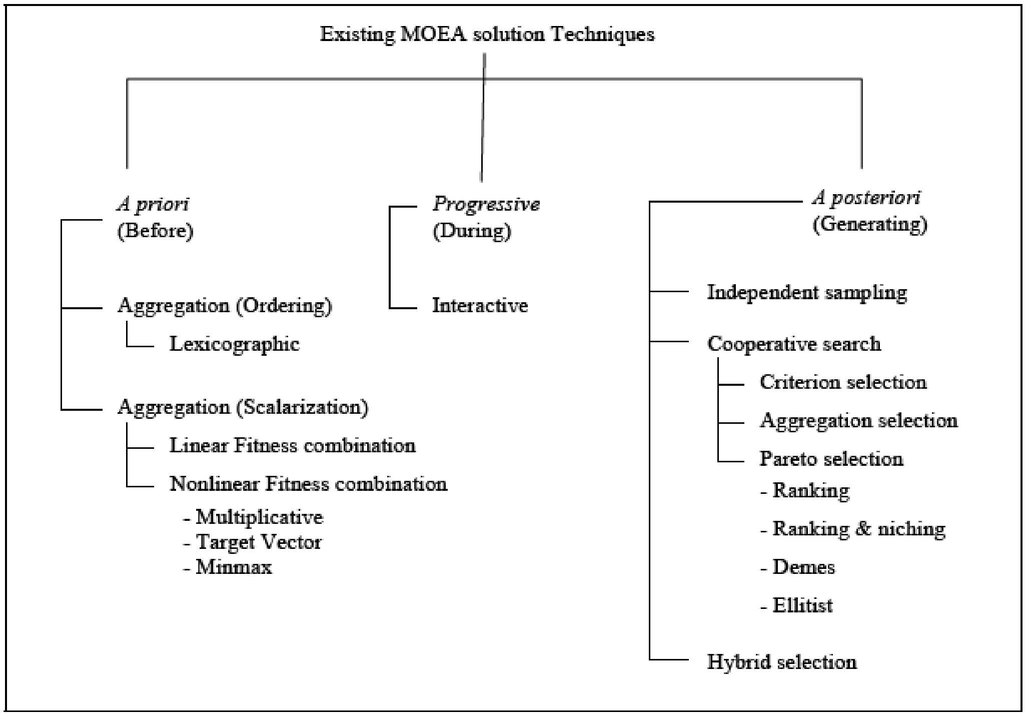

Figure 36. *Types of MOEAs*

The algorithms are taken from a wide expanse of literature, providing both an overview of the theory and application of each and an assessment on their respective strengths and weaknesses. The end state is a comprehensive survey and comparison of algorithms using metrics.

COAs "should answer the fundamental questions of when, who, what, where, why and how". Each COA should be suitable, feasible, acceptable, exclusive and complete. A good COA positions the force for future planned operations and provides flexibility to meet unforeseen events during its execution. The "who" in a COA does not specify individual units, but rather uses generic assets and capabilities. During the development phase, staffs analyze the relative combat power of friendly and enemy forces, and generate comprehensive COAs.

This article approaches modelling a COA planning as a multiple mode resource-constrained project-scheduling problem (MRCPS). The model decomposes generic activities (tasks with specific combination of capabilities) into elementary (or simple) inter-related actions to accomplish the objectives of the mission. The approach is based on the assumption that a complex mission is decomposable into granular simple activities with appropriate dependencies. This process implies the identification of the tasks (what) as well as their dependency relationships (when and where), the pool of available capabilities (how) with their location, and finally the objectives of the mission (why).

Observations:
This document focuses primarily on the strengths and weaknesses of different algorithms. The value of the document is its currency in reviewing this particular field for the specific function of scheduling and COA development. However, there is on a high-level examination of how GAs would be applied to a COA analysis tool. More research should be applied to looking at GAs within the specific context of how a COA tool would function. It is unclear whether GAs would be effective for immediate contingency operations, unless previously-defined CONPLANS were already modelled and available to define the activities and tasks involved in the COA. The development of additional activities and tasks would have to be simple to construct and properly formatted to allow additional resources and tasks to be included from both OGDs and allies in the event of domestic multi-agency or coalition operations.

The target audience of this paper is outside the operational community. To make the allpication of GAs relevant, there needs to be a more operator-friendly explanation of the application of GAs in COA selection. This will prevent over or under-confidence in the selected COA, as the underlying premises would be better understood.

[21] Gullett, Jon (Maj) and Kresek, John (LtCol) (2003). Deployment and Deliberate Crisis Action Planning and Execution Segments (DCAPES), powerpoint presentation, US Air Force, HQ USAF/DPPR. Pages: 35.

Context:
The Deliberate Crisis Action Planning and Execution Segments (DCAPES) supports the deliberate and crisis action planning and execution functions for the mobilization, deployment, employment, sustainment, and redeployment of Air Forces (AF) forces with a goal of providing integrated war planning and execution. A Global Command and Control System–Air Force (GCCS-AF) application, the first increment was fielded in March 2002. Program objectives include

- Replace legacy service planning and execution systems
- Enable rapid OPLAN development
- Support deployment, redeployment, sustainment, mobilization, reconstitution
- DII COE level compliant
- Deliver shared data using interoperable
- Joint processes with “common look and feel” tools that benefit all echelons

Content:
DCAPES was designed to interact with existing systems, such as JOPES and GSORTS, allowing for service flexibility at unit level, while ensuring standards & uniformity within Joint process.

The DCAPES supports the deliberate and crisis action planning and execution functions for the mobilization, deployment, employment, sustainment, and redeployment of Air Forces (AF) forces. Global Command and Control System–Air Force (GCCS-AF) DCAPES provides four Strategic Server Enclaves (SSEs). GCCS-AF/DCAPES SSEs provide connection and data distribution of AF resources between Air Combat Command (ACC) and NCR, Air Mobility Command (AMC) and USTRANSCOM, Pacific Air Forces (PACAF) and USPACOM, and United States Air Forces in Europe (USAFE) and USEUCOM. Throughout the entire planning and execution process, DCAPES provides users the capability to create and maintain Unit Type Codes (UTCs) to support the build of Time-Phased Force and Deployment Data (TPFDD) for resource movement. DCAPES also produces standard and ad hoc reports and processes feedback reports. DCAPES is built on the JOPES foundation and extends the JOPES functionality to support AF lower-level detail planning and execution capabilities.

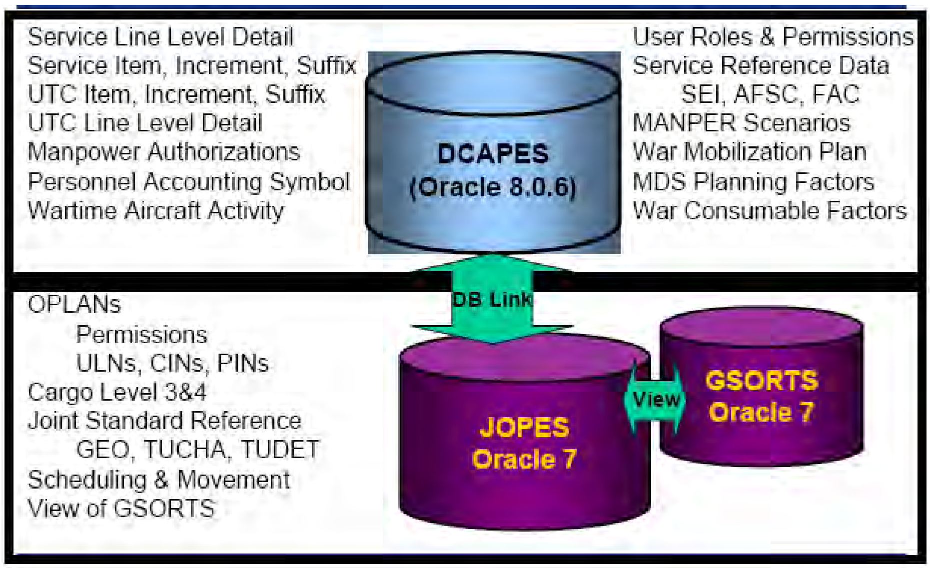

Figure 37. *DCAPES Database Contents*

Observation:
The focus on the synchronization with unit-level data is key for rapid response planning, while promoting standardization is critical for interoperability. This tool claims to do both. As the information on the tool is somewhat dated (2003), it would be of interest to this project to conduct further investigation of the status of tool development and its implementation. The objectives of DCAPES within the execution environment address many of the operational requirements determined by this study. These include a focus on the operation plan and rapid assessment capability.

[22] G¨unther, Christian W. and van der Aalst, Wil M.P. (2007) (Netherlands) Fuzzy Mining – Adaptive Process Simplification Based on Multi-Perspective Metrics, in Business Process Methods, Lecture Notes in Computer Science, Volume 4714/2007, Springer: Berlin, p. 328-343. Pages: 16.

Context:
Process Mining is a technique for extracting process models from execution logs. A number of process mining approaches have been developed, which address the various perspectives of a process (e.g., control flow, social network), and use various

techniques to generalize from the log (e.g., genetic algorithms, theory of regions). Applied to explicitly designed, well-structured, and rigidly enforced processes, these techniques are able to deliver an impressive set of information, yet their purpose is somewhat limited to verifying the compliant execution. However, most processes in real life have not been purposefully designed and optimized, but have evolved over time or are not even explicitly defined.

Existing algorithms thus often fail to provide insightful models for less structured processes. The phrase "spaghetti models" is often used to refer to the results of such efforts. The problem is that the resulting model shows all details without providing a suitable abstraction. This is comparable to looking at the map of a country where all cities and towns are represented by identical nodes and all roads are depicted in the same manner. The resulting map is correct, but not very suitable.

Using the concept of a roadmap as a metaphor, this paper proposes a new process mining approach that is not only configurable, but is also not limited to re-discovering what we already know, but it can be used to unveil previously hidden knowledge.

Content:

The problems traditional mining algorithms have with less structured processes are analysed in section 2. The authors present two assumptions of traditional process mining techniques that are not applicable to unstructured environments : Assumption 1: All logs are reliable and trustworthy and Assumption 2: There exists an exact process which is reflected in the logs.

The metaphor of roadmaps to derive a novel, more appropriate approach is presented in section 3, deriving a number of valuable concepts from cartology:

- Aggregation: To limit the number of information items displayed, maps often show coherent clusters of low-level detail information in an aggregated manner.
- Abstraction: Lower-level information which is insignificant in the chosen context is simply omitted from the visualization.
- Emphasis: More significant information is highlighted by visual means such as color, contrast, saturation, and size.
- Customization: There is no one single map for the world. Maps are specialized on a defined local context, have a specific level of detail (city maps vs highway maps), and a dedicated purpose (interregional travel vs alpine hiking).

Two fundamental metrics were identified to develop appropriate decision criteria used to simplify and properly visualize complex, less-structured processes such decisions: (1) significance and (2) correlation. The resulting multi-perspective set of log-based process metrics (log-based metric or derivative metric) is proposed in section 4 as a configurable and extensible framework based on three primary types of metrics: unary significance, binary significance, and binary correlation.

A flexible approach for Fuzzy Mining, i.e. adaptively simplifying mined process models, is demonstrated in section 5 focusing on high-level mapping of behavior found in the log, while not attempting to discover typical process design patterns based on behaviour mapping. Once the simplified process map has been derived, three transformation methods are applied to the process model, which will successively simplify specific aspects of it. The first two phases, conflict resolution and edge filtering, remove edges (i.e., precedence relations) between activity nodes, while the final aggregation and abstraction phase removes and/or clusters less significant nodes. For example, the initial model contains deceptive ordering relations, which do not correspond to valid behavior are discarded by removing edges:

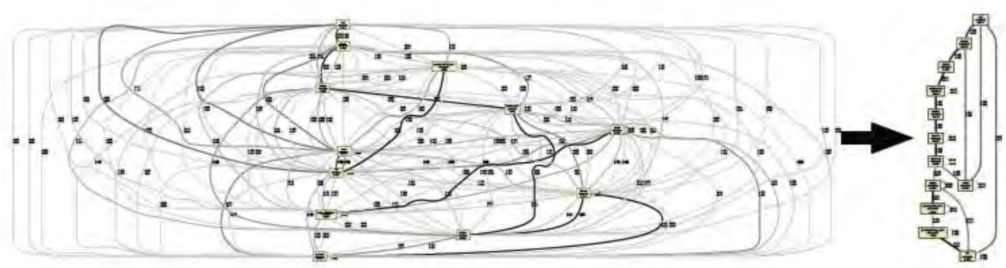

Figure 38. *Example of a process model before (left) and after (right) edge filtering.*

The authors' next steps will concentrate on deriving higher-level parameters and sensible default settings, while preserving the full range of parameters for advanced users. Further work will concentrate on extending the set of metric implementations and improving the simplification algorithm.

Observations:
The basis of the approach is abstraction – filtering in order to display the most useful information in simplified models in an adaptive fashion. The filtering based on two metrics, significance and correlation of graph elements, which are based on a wide set of process perspectives. It integrates abstraction and aggregation, and is also more specialized towards the process domain. Its ability to characterize and analyse the unstructured nature of real-life processes is applicable to rapid response planning environment. Specific to this environment, the framework of multi-perspective metrics, i.e. looking at all aspects of the process at once, that gives fuzzy mining an interactive and explorative character and the integrated simplification algorithm are worthy of further investigation.

[23] Heuthorst, Theo (Maj) (unknown). Canadian Forces Operational Planning Process, Presentation at 1 CAN AIR DIV Headquarters, Winnipeg, Canada. Slides: 77.

Context:
While there is no date on this presentation, the references used are as recent as 2003 and is therefore within the relevant time period. The author and intended audience is the A3 Plans, and is intended to both contextualize the CF OPP within the realm of air operations and provide a more candid understanding of the aspects involved in the employment of the CF OPP.

The presentation appears to be written to allow others to gain an understanding of the presenters' points through the slides alone, but the nature of PowerPoint presentations is the content is in bulleted form and thus loses much of the nuance of the presentation content.

Content:
The presentation is largely a breakdown of the CF OPP phases with bulleted notes related to the author's experience in its application. Below is a selection of some of the relevant points:

- In applying the CF OPP, the author suggests the user must know the process intuitively;
- In describing the changes to CF planning, the author indicates a current state of "more tasking, less funding", indicating a premium on resource availability;
- Lack of time as the critical issue:
    - Time may be unspecified
    - Op may already be running
    - You will be overcome by events
- Other factors included lack of information and the need to identify assumptions early, the dangers of inaccurate staff checks developed based on external assumptions and the need for flexibility so that plans can adapt to changes.
- The author indicates that mission analysis is often where operational planning processes begin to get derailed, and that they are typically the trigger for execution of an international operation; and
- The author emphasizes the need to thoroughly understand the CF OPP in order to support it.

Observations:
The presentation's value is that of an operator's perspective of planning requirements, and is valuable in its criticisms of the CF OPP. The presentation accepts that the CF OPP is both necessary and functional, but mentions the tendency of planning to become derailed. Tool development needs to account for the requirement to keep plans flexible while providing sufficient structure to ensure that planning continues on track. The emphasis of both time and resource constraints requires that the system be able to inform the commander of resource availability and allocation options. This will likely require interfacing or integration with operational support tools.

There is a need to get the appropriate information from the Mission Analysis into the tool quickly and easily. This is a key element to planning, drawing out the assumptions and initial state. This should be the focus of initial development of an immediate contingency decision support tool.

[24] Kerr, J. (2001). Managing Information in a Time of Crisis. Gazette . 63: 20-21, Ottawa, Canada: Royal Canadian Mounted Police. Pages: 2.

Context:
Written shortly after the events of 9/11, this article addresses the role of the National Operations Centre (NOC) and crisis information flows. The NOC acts as coordination centre, the central point of contact for information, funneling intelligence within Canada and to US counterparts. This article discusses how, on September 11, 2001, as the RCMP's high-tech communications command post, the NOC in Ottawa took the lead within hours of the attack to manage the massive flow of information and to make sure that in addition to the RCMP's provincial Emergency Operations Centres, U.S. counterparts the Department of National Defence, Citizenship and Immigration, and other government agencies were kept up to speed, while getting legitimate tips to investigators across Canada for follow-up.

Content:
As a support service, the NOC co-ordinates information flow to the government and to RCMP senior management, focusing on ensuring that there is no duplication of effort.

Observations:
This article articulates the benefits of central coordinating points such as the NOC for information gathering and assessment and funneling intelligence within Canada and to US counterparts and the role of liaison officers to facilitate planning. A physical space such as the NOC allows members to sit side-by-side with partners from other agencies and may expose such OGD liaison officers to decision support tools that will aid in their information sharing between their home departments/agencies and the department running the operations centre. In addition, the key role of the laision officer could be one that is investigated further to see what type of tools could mimic the role and provide the support when resources are constrained and it is difficult to have a physical liaison officer present for all partner agencies.

[25] Klashner, Robb and Sabet, Sameh (2007). A DSS Design Model for complex problems: Lessons from mission critical infrastructure, Decision Support Systems, Volume 43, Issue 3, Pages: 23.

Context:
This paper presents a new DSS Design Model for complex, mission critical decision-making situations and its technical, conceptual, and partial empirical evaluation. The new model was derived from conceptual design research and through a deep qualitative field research study at an electric power utility control center—a typical arena for "wicked" problems

Integrating DSS with Information and Communication Technologies (ICT) capabilities in light of information-rich domain dynamics creates a richer design and will provide needed capabilities for agility in decision-making. These capabilities will better address the "wicked" aspects and problems associated with complex decision-making due to ever changing domain constraints. As such, the authors claim that a co-evolutionary approach to design is needed: If a DSS is designed to evolve and grow in parallel with the operator's knowledge capital, intuitive capabilities/features can facilitate the dynamic parsing and reintegration of large volumes of knowledge.

Content:
A new generation of DSS can ultimately counteract a great deal of the complexity associated with this sort of wicked problem. DSS designed to be adaptive will facilitate knowledge capture and reuse for overwhelmed operators. To be adaptive, there must exist a direct connection to the domain variety causing the confusion.

The authors assert that the lack of adaptation to nondeterministic domain variety is a limitation in classic DSS design approaches that is reflected in the Systems Development Life Cycles (SDLC) used to conceptualize the design process. This research is essentially premised on concepts from design research, various qualitative theoretical and methodological approaches, and Complex Adaptive Systems (CAS) theory. The resulting synthesized DSS Design Model utilizes approaches from various research disciplines such as Software Engineering (SE), Information Systems (IS), and sociology for data collection.

Examples of the later include Grounded Theory and ethnography. Grounded theory facilitates the understanding of previously unnoticed sociotechnical relations surrounding a group task or activity. The data captured from ethnographic methods are useful for scenario, goal-oriented, and use-case research. The utility of these qualitative approaches in conjunction with traditional SE techniques, such as software architectures, is demonstrated.

The model presented also includes iterative and incremental methodology, i.e., concurrently modifying model, domain analysis, and tool design based on new data. Iteration allows for analysis either with prior results based on the same theoretical baseline or differing theoretical perspectives. The following figure is a visual representation of the model that infers both iteration and incremental activities, but no predetermined pattern is inferred—only a general morphogenic process contained within the CAS theoretical framework. Key elements include:

1. The relation between the theory component and domain is maintained to continuously integrate emerging data and update the theory (e.g., if a Grounded theoretic approach is utilized) (Phase I: data–theory interaction)
2. simulation output (which typically resulted in an evolutionary prototype) is analyzed (Phase II: simulation–theory interaction)
3. The cumulative effect of the theoretical analysis and/or simulation can combine to dynamically influence the design decision-making process (Phase III: decision/design interaction)
4. design decisions impact the built information infrastructure

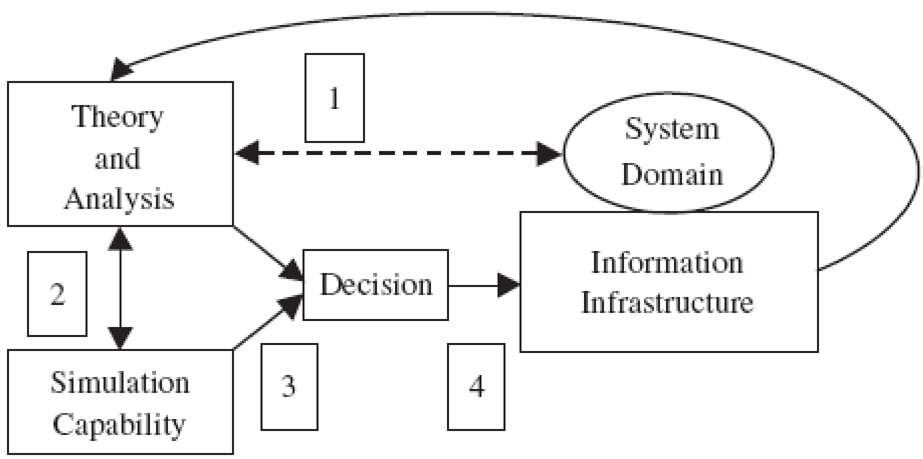

Figure 39. *DSS Design Model.*

The DSS Design Model is validated using a tool instantiation, microgrid mini-case, and current research of a KMDSS for telecommunications. Main findings suggest that broader and more integrated approaches are necessary to design DSS for complex domains.

<u>Observations:</u>

The proposed model suggests an iterative process of theory, simulation, and decision-making interactions. The model places emphasis on non-technical input for the design of DSS including for requirements definition. The iterative process and non-technical emphasis is beneficial to complex environments such as Air Force rapid response in order to operationalise S&T effectively, and is similar to R&D approaches implemented at DRDC. The inclusion of the application of software engineering architectures in the design model supports the current use of the DoDAF or DNDAF within the Department of National Defence.

[26] Kometer, Michael W. (2007). Centralized Versus Decentralized Control of Air Power, Command In Air War, US Air University Press, Alabama. Pages: 347.

<u>Context:</u>
This paper presents the views of Lieutenant Colonel Kometer who was currently actively serving in the USAF at the time of writing (2007). In this work he develops a picture of the various ways airpower is controlled.

Lieutenant Colonel Kometer examines the military's decision-making process by reviewing actual scenarios, focusing on command and control. He scrutinizes not the way people make decisions as much as the interaction of the many such decisions determined in different parts of the system that employs airpower in combat, how policy is turned into military actions that achieve desirable political goals, and whether these factors have changed during the information age.

This study looks at these arguments as separate but related issues concerning the control of combat airpower, as CF OPPosed to land or sea power, since airpower's speed and range make it especially affected by the debate between centralized and decentralized control. While focusing on developments in the US Air Force, the service that has been most active in defining the doctrinal architecture for C2 of combat airpower, this study also captures differences in the way other services prefer to function. Finally how technology and control have affected each other in this, the age of information is discussed.

The ultimate question addressed in this paper is what has been the impact of the information age on the US Air Force's doctrinal tenet of "centralized control and decentralized execution"?

<u>Content:</u>
This work develops a picture of the various ways airpower is controlled in combat, and their subsequent consequences, by presenting airpower as a system, placing various theories in their proper context within that system, and accounting for the interaction among them. While using primarily historical concepts to illustrate types of control, this study attempts to add to the body of knowledge on human-technology systems and about the airpower system in particular. The questions it attempts to answer are:

- How has the information age affected C2 of combat airpower?
- Have technological changes impacted the military's adherence to the doctrinal tenet of centralized control and decentralized execution?
- Is there a general formula that better characterizes the system's C2?

- Where are these changes heading?

The paper first lays a historical foundation and outlines the issues involved. It recounts the control of combat airpower from World War II (WWII) through Vietnam, showing how the control of airpower has varied among different types of wars and even among different missions within the same war. In the process it exposes confusion about the terminology of the arguments and attempts to lay them out in plain language.

After laying the historical foundation the paper goes on to clarify the approach for the rest of the document. It defines the necessary terms, explains the Complex, Large-scale, Integrated, Open System (CLIOS) framework, and clarifies the Combat Air Operations System (CAOS) concept, who the important stakeholders are, and what the subsystems are.

The paper then discusses the relationships between policy makers and military commanders throughout the 1990s, analyzing the methods of control at this level. It then illustrates the effect of these different methods on the ability of the various military organizations to work together.

The author examines the CAOS framework's ability to put together information from various places to form a bigger picture of the world. This paper shows how the AOC has become a centre of calculation, using sensor-communication loops to plan, direct, and assess airpower missions during operations Desert Storm, Allied Force, Enduring Freedom, and Iraqi Freedom. These four conflicts are navigated five times, each time telling a slightly different but related story to analyse different issues.

The book concludes with an analysis of the potential for accidents in the CAOS and a discussion of the potential implications for the future of the control of combat airpower.

<u>Observations:</u>
The main point of this manuscript is to define the tradeoffs commanders must consider, the variables involved and their potential consequences as they wrestle with how much control to delegate and how much to retain. In addition it discuss hoe technology has enhanced the visibility of this imperative making it increasingly important to determine who can make decisions.

The discussion of a wide range of issues relating to the C2 of Air Power in the context of operations Desert Storm, Allied Force, Enduring Freedom, and Iraqi Freedom although interesting has limited value added to the development of decision support concepts for the planning of AF immediate contingencies operations.

[27] Lawlor, B. M. M. G. (2001). Military Capabilities and Domestic Terrorism. Perspective on Preparedness 2 (Executive Session on Domestic Preparedness), Cambridge, USA: Department of Justice and John F. Kennedy School of Government, Harvard University. Pages: 2.

<u>Context:</u>
State National Guard units, under the direction of governors, and federal military units, under the direction of the Department of Defense (DoD), can render significant assistance to civil

authorities in dealing with the aftermath of chemical, biological, radiological, nuclear, or high yield explosive (CBRNE) incidents. This article describes some of the military capabilities that the National Guard and DoD can bring to bear, assuming that a proper request for assistance has been made, a legal review conducted, civilian oversight approval obtained, and appropriate military orders issued.

The procedures used to obtain military support following a CBRNE incident are the same as those used to obtain such support to battle fires, floods, hurricanes, and other natural or man-made disasters. Both the state and the federal governments have military units able to provide a variety of capabilities, and they work cooperatively to make available significant consequence management assistance.

Content:
This article describes some of the military capabilities that the National Guard and DoD can bring to bear, assuming that a proper request for assistance has been made, a legal review conducted, civilian oversight approval obtained, and appropriate military orders issued. The author is a Commander of Joint Task Force-Civil Support, a standing joint military headquarters responsible for planning and integrating the Department of Defense's (DoD) support to civil authorities following a domestic chemical, biological, radiological, nuclear or high-yield explosives (CBRNE) incident.

Planning and allocation of resources for domestic emergencies need consideration of:

- Requirements for specialized expertise in areas such as CBRNE;
- Critical response time; and
- Jurisdiction, legal and policy frameworks.

Observations:
The article explains considerations that are relevant for joint military planning for crisis/contingency operations that will be conducted in support of another government department. The scenario presented may involve an element of the Air Force and require rapid response planning.

This article's advocacy for what amounts to a capability-based approach to planning indicates a need to understand what resources are available, their status and availability. The capability based approach has been adopted by the Canadian Forces and decision support tools should be developed considering required capabilities for rapid response planning rather than stand alone platform specifics

[28] Sujian Li, You Ouyang, Wei Wang, Bin Sun (2009), Multi-document Summarization Using Support Vector Regression, Inst. of Computational Linguistics, Peking University.

Context:
Most multi-document summarization systems follow the extractive framework based on various features. While more and more sophisticated features are designed, the reasonable combination of features becomes a challenge. Usually the features are combined by a linear function whose weights are tuned manually.

Content:

In this task, Support Vector Regression (SVR) model is used for automatically combining the features and scoring the sentences. Two important problems are inevitably involved. The first one is how to acquire the training data. Several automatic generation methods are introduced based on the standard reference summaries generated by human. Another indispensable problem in SVR application is feature selection, where various features will be picked out and combined into different feature sets to be tested.

With the aid of DUC 2005 and 2006 data sets, comprehensive experiments are conducted with consideration of various SVR kernels and feature sets. Then the trained SVR model is used in the main task of DUC 2007 to get the extractive summaries.

Observations:

Document Understanding Conferences (DUC) have been held yearly with the aim at generating a brief, well-organized, fluent summary for multiple documents with topic query guided. Due to the immaturity of the text generation techniques, most summarization systems are still designed with a summary extractive framework. The key of such a system is sentence extraction, to extract important sentences which can both represent the content of the documents and answer the questions users are interested in.

[29] Mak, Hing-Yin et al. (1999). Building online crisis management support using workflow systems, Decision Support Systems, 25, 209–224. Pages: 16.

Context:

This document introduces the concept of workflow management for the analysis and development of crisis management support systems. The principal concept in workflow management is the coordination of tasks in the business process. The medium through which these are conducted might include verbal information, human gesture, documents, images, graphics, sounds and/or any type of ‘information’.

Content:

Workflow management is a flexible analysis tool that can aid emergency response tools:

- successful crisis management support systems (CMSS) require a good understanding of the environment in which decision-making is to take place
- within a CMSS quick feedback on the results of previous decisions is critical to help decision makers monitor the outcome of their actions
- Untimely delays could negate the usefulness of even the most sophisticated system.
- CMSS need clear, timely, reliable, valid and wide-ranging information – filtering assists with this
- We have adopted the Action Workflow (AW) approach for process analysis and design as it not only includes the capacity for generating and managing forms, as with traditional workflow approaches, but also makes use of action workflow loops. The latter are grounded in the dimension of business process structure, and allow individuals to deal directly with the consequences of their work for

completion and satisfaction. Each workflow loop involves two actors, customer and performer and four phases: 1. request phase: a customer asks the performer for an action, 2.commitment phase: the performer then agrees to the action, 3. performance phase: the performer then fulfills the work and reports it done, 4. evaluation phase: the customer accepts the report and declares satisfaction. Workflow loops can be embedded into any of the phases to show lower level activities, incorporating a wide range of tasks.

Observations:

The workflow loops have been defined hierarchically to take into account the variety of tasks necessary for crisis management. It accommodates the fact that for each workflow loop specific human and technology elements may be unique – for example, a support system has been developed for maintaining contact information of collaborators/partners using the software product, Netcalc.

The workflow model must allow for a large degree of human interaction. Therefore, it is unrealistic to expect to create a 'fully' automated workflow system because a whole series of negotiations, dialogue, coordination and communications between individual experts, groups of experts, and systems manual or computerized are involved. Thus the methodology is not a single solution but could be part of a solution.

The AW software used for this research provides only internal organization routing, not external - the main emphasis future work is to investigate the design and development of a web-based workflow framework, which allows for the support of multiple Intranets and individual users into an Extranet.

This article is straightforward and introduces a concept that is the basis for any business process, including that for operation planning.

[30] Mehrotra, S. et al. (2004). Project Rescue: Challenges in Responding to the Unexpected. SPIE, Vol. 5304, pp. 179-192. Pages: 13.

Context:

This paper provides an overview of the 'Responding to Crises and Unexpected Events' (RESCUE) project, which aims to enhance the mitigation capabilities of first responders in the event of a crisis by dramatically transforming their ability to collect, store, analyze, interpret, share and disseminate data. The multidisciplinary research agenda incorporates a variety of information technologies: networks; distributed systems; databases; image and video processing; and machine learning, together with subjective information obtained through social science. While the IT challenges focus on systems and algorithms to get the right information to the right person at the right time, social science provides the right context.

Project RESCUE involves researchers from six universities (University of California, Irvine; University of California, San Diego; University of Colorado, Boulder; University of Illinois, Urbana Champaign; University of Maryland, College Park; and BYU) and a Long Beach based advanced technology company, ImageCat, Inc.

Content:

The focus of the RESCUE Project is to radically transform the speed and accuracy with which information flows through disaster response networks, networks that connect multitudes of response organizations as well as the general public. The team is working to develop information technology solutions that dynamically capture and store crisis-relevant data as it is generated, analyze this data in real-time, interpret it, and disseminate the resulting information to decision makers in the forms most appropriate for their various tasks. Challenges in realizing such IT solutions arise due to the scale and complexity of the problem domain, the diversity of data and data sources, the state of the communication and information infrastructures through which the information flows, and the diversity and dynamic nature of the responding organizations.

Incorporating a multidisciplinary approach, research is organized along four inter-related activities that together capture the information flow process during crisis response: information collection, information analysis, information sharing, and information dissemination.

Three test beds are being employed to deploy the technologies developed by the research team and determine the extent to which the information- and organizationally-based strategies result in demonstrable improvements in response effectiveness:

a. Mobile Incidence Level Response (MILLR) Testbed

b. Crisis Assessment, Mitigation, and Analysis System (CAMAS) Testbed

c. Advanced Traffic Rerouting for Unplanned Events (TRUE) Testbed

One of the integral components of the research is an end-to-end data analysis system that captures and analyzes multimodal data (e.g., voice and video input from in-field officers and cameras, GPS, sensor data), extracts meaningful events/information from transcriptions, populates key databases, and uses this information in real-time as input into a damage and impact assessment system.

Observations:
This is an interesting paper on how to better collect, analyze and distribute information during a crisis.

The salient points to be highlighted for this project are:

(1) the elements of Project RESCUE that benefit from the multi-disciplinary research that adds depth and breadth to the technology development; and
(2) the functionality to manage multi-modal data streams (audio, speech, text, video, etc.) including human-generated input (e.g., first responders' communications, field reports, etc.) during or after a disaster.

Additional information highlighting a new element of the project was found at: http://www.itr-rescue.org/research/projects.php : The new element of the program encompases five major multidisciplinary research projects that have been established to together enable the RESCUE team to pursue focused research to explore novel interdisciplinary research ideas that have the possibility of "high impact" – approaches that are usually difficult to follow when PIs work in isolation along narrowly defined disciplinary boundaries:

- Situation awareness (SAMI)
- Information sharing (PISA)

- Robust communications (ENS)
- Information dissemination
- Privacy

The first one, SAMI, builds on the two points mentioned above (multi-disciplinary research and multimodal data streams) SAMI is expected to produce two major scientific achievements: (1) an event-oriented situational data management system that seamlessly represent activities (their spatial, temporal properties, associated entities, and events) and supports languages/mechanisms/tools to build situational awareness applications, (2) a robust approach to signal analysis, interpretation, and synthesis of situational information based on event abstraction. Two artefacts will be developed -- an information reconnaissance system for disaster data ingest, and an integrated situational information dashboard that aids decision making. Further investigation of these two artefacts as they are developed would be applicable to Air Force rapid response planning decision support tool development.

[31] Mulvehill, Alice M. and Caroli, Joseph A. (1999). JADE: A Tool for Rapid Crisis Action Planning. www.dodccrp.org/1999CCRTS/pdf_files/track_6/041carol.pdf (15 Jan 2002). Pages: 15.

<u>Context</u>
Joint Assistant for Deployment and Execution (JADE) offers a new technique for rapid force deployment planning, especially in crisis situations. In order to support the command and control needs of planners today and in the twenty-first century, several challenges are currently being met to transition JADE from a research prototype to a fully operational system. These include integrating various data systems, seeking user input and buy-in, porting to new computing environments, assuring compliance with the Defense Information Infrastructure Common Operating Environment, and testing in exercise scenarios.

The purpose of this paper, which was produced in 1999, is to bring up to date those responsible for planning force deployment activities of joint military campaigns, in other words the end users of JADE.

<u>Content</u>
This document presents a detailed overview of JADE along with a synopsis of plans for technology transition. JADE is a knowledge-intensive planning technique that employs case-based and generative planning methods to handle large-scale, complex plans in minimal time. The tool is capable of rapid retrieval and reuse of previous plan elements and employs an easy to use map oriented drag and drop interface.

JADE demonstrates breakthrough technology that enables a military planner to build a force deployment plan, including a Time Phased Force Deployment Data (TPFDD) package in less than one hour. JADE is a knowledge-intensive planning technique that employs case-based and generative planning methods to handle large-scale, complex plans in minimal time. The tool is capable of rapid retrieval and reuse of previous plan elements and employs an easy to use map oriented drag and drop interface. Force modules from previous plans whose force capabilities and composition satisfy the current situation can be dragged from the plan library (casebase) and dropped onto a geographic destination. Constraint checking is conducted during plan development and the user is automatically reminded of ways to modify and improve the plan in real time. JADE provides advanced capabilities for military planners, and a solution to the challenge of rapidly producing force deployment plans and TPFDDs.

JADE's three major technology components (ForMAT, Prodigy, and PARKA) that are utilized to support the user in modifying force compositions, describing force capabilities, and in tailoring the evolving force deployment plan to changing mission requirements are described here in detail.

Users interact with JADE through a user interface that is directly connected to the ForMAT (Force Management and Analysis Tool) module. ForMAT provides an environment for building force modules (FMs). A FM describes a force or set of forces that can be used to satisfy some mission requirement. FMs can be linked with other FMs to create a Time Phased Force Deployment Data (TPFDD) package. ForMAT employs case-based reasoning (CBR) technology to enable a user to make use of past experience (past planned FMs) to rapidly solve new problems. The JADE interface enables users to construct a new plan by simply dragging one or more FMs from the casebase directly to a location on a map where it is to be deployed.

Guidance is provided to the user on how FMs need to be tailored to fit the new mission. This guidance is provided through ForMAT's link to the Prodigy system. Prodigy is a multi-strategy planning and learning architecture that can solve planning problems in a number of different ways. In JADE, we developed a Front End that links ForMAT to the Prodigy planner. The Front End collects information such as mission goals and state information about the planning context through ForMAT and presents it to Prodigy for use in planning. Prodigy then provides guidance through the Front End back to the user about how to modify or create a deployment plan. Although Prodigy is capable of generating the entire deployment plan, in JADE Prodigy can only provide suggestions to the user who has the ultimate decision in what gets deployed to where and when.

Another component of the JADE architecture is the PARKA knowledge base (PARKA-KB). PARKA-KB is a high performance knowledge base management system. Although it is similar to a relational database, it uses technology that supports and takes advantage of data hierarchies. In JADE, several PARKA KBs are used to support plan retrieval and the retrieval of the associated data that support deployment plan generation. Using these PARKA-KBs, the JADE user can retrieve the desired FMs or information about the geographical location that forces are to be deployed to.

The vision is for JADE to become a component of the GCCS. GCCS currently performs many important command and control mission functions including force deployment planning. JOPES is the component of GCCS now used for both deliberate and crisis action planning, including TPFDD generation. While JOPES is widely used by the Joint Planning and Execution Community (JPEC), the speed at which TPFDDs are generated by JOPES is a shortcoming noted by operational users. Additionally, current TPFDDs do not provide explicit links to the course of action (COA).

<u>Observations:</u>

Although this paper is somewhat dated (dated 1999) it does facilitate the identification of decision support concepts by providing, via a description of JADE, an insight into advancements being made to provide advanced capabilities to military planners and develop solutions to the challenge of rapidly producing force deployment plans. JADE will contribute to achieving Joint Vision 2010 by focusing on solving a dilemma which has been confronting force deployment planners for years, i.e., rapid TPFDD generation with explicit links to the mission objectives.

[32] Mulvehill, A., Callaghan, M., and Hyde, C. (2002). Using Templates to Support Crisis Action Mission Planning. Presented at Command and Control Research and Technology Symposium, Monterrey, CA, USA.

Context:

The challenge of getting data from the web into a format that is useful extends across organisations and environments. Extracting specific values from a web site is difficult because the HTML markup for web pages describes visual presentation and not semantic content. Many researchers are actively investigating methods that allow data from web pages to be accessed and used more easily, however, Tracker developers have instead concentrated on developing methods that support access to multiple heterogeneous data sources such as: remotely executing programs, data text files, graphics files and programs, and a variety of databases. They have also concentrated on providing methods that allow users to manage the data that they are collecting. To date, templates that have been developed by Tracker support tax preparation, traveling, project management, and crisis action planning.

Content:

This paper describes some of the features of Tracker, a software system called Tracker being developed under the DARPA Active Templates research program, that have been developed to support problem solving in multiple domains. At a high level, Tracker allows users to define and use templates to support problem solving, e.g., crisis action mission planning.

Templates are employed in the aim to simplify problem solving by (a) providing flexible ways to make and record decisions, (b) reminding users to perform certain tasks, (c) encapsulating experience and domain knowledge, and (d) constraining task specification and language. The vision of the project is that templates, when filled in and linked, can represent entire plans. In other words, the overall plan context may be embodied in a pre-existing template model that specifies how other more detailed templates are associated with each other.

The objective of the tool for crisis planning is to allow planners at different levels of the command and control (C2) structure to use the templates to support crisis action mission planning. For example, Tracker is currently being used to support military planners in the generation of mission planning folders. These folders can be developed to describe the state, objectives, resource availability and other aspects of a mission. The crisis action mission planning process or workflow can also be described and incorporated. Key features include:

- Authoring tools: Tracker provides the user with three modes of use: author, user, or collaboration. Tracker's authoring tools allow users to author templates on-the-fly or with the support of specific data models (like a workflow diagram). Templates can be simple or complex and can be developed using a number of tools that are incorporated in the software.

- A data model based on a combination of two input factors: (a) doctrine or protocol, and (b) domain scenarios: this feature facilitates the authoring of the templates and increases the likelihood that the resulting templates will meet the needs of the end user. For example, a scenario, when provided by a user, can be used to identify what templates need to be built, how the templates should interact and what external data sources should be accessed in order to support information usage.
- Communication protocols: When a workflow process indicates not only what information must be collected, but, how it needs to be disseminated to specific team members, Tracker supports a number of communication protocols to enable each of the team members to collaborate and/or share template data and will support a set of local users or external users and/or systems as outlined below:

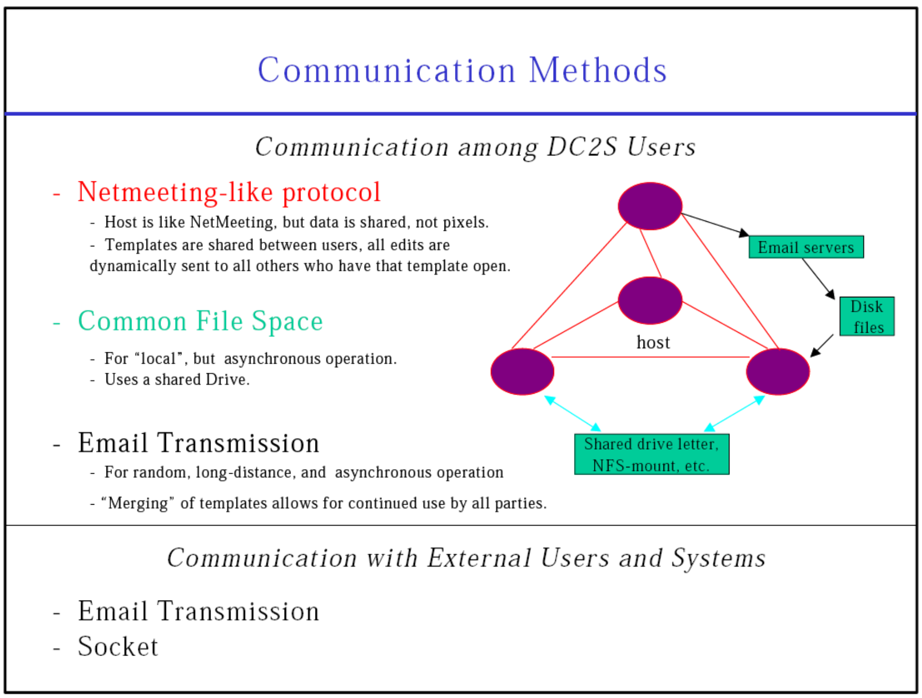

Figure 40. *Tracker Communication Protocols*

- Modify Properties Menu: A user can choose or modify how data is to be accessed or displayed, e.g., text, graphics, URL, databases. The "modify properties" menu also allows the user to specify if a field is essential and what edit role is associated with a field.
- Attachments: the user can add attachments to any field.
- Template Browser: a template browser enables the user to search through a mission, a folder of mission data, or a folder of mission folders. This includes the ability to view the XML tree and make queries for any XML name or field value.

Observations:
Tracker developers have involved military crisis action mission planners in the tool development process and have found that it is useful in facilitating the development of electronic mission folders and in allowing a group of planners to concurrently use those folders to develop a plan.

Its flexibility in application includes the ability of planners to author a plan as they like, linking the elements of the plan to the sources and applications that they find useful for their work. Efforts have been made to ease the authoring function, to facilitate communication and collaboration among a group of planners, to ensure data propagation in a changing data environment, and to support the management of data in this environment.

Plans for future development that would benefit its application to crisis planning and relevant to Air Force rapid response planning include: investigating methods to generate external reports such as basic text files, PowerPoint presentations, or Microsoft Word documents directly from the XML data; to support the exporting of data to other tools such as route planners, temporal display tools, and mapping tools, in essence, any 3rd-party tool that contains some known or inferable external interface; and to extend data management capability to allow the user to not only locate data, but to perform some limited “trend analysis” of that data.

[33] National Defense University, (2007). Joint Operation Planning Process, Campaign Planning / Operational Art Primer AY 07, Joint Forces Staff College, Norfolk Virginia. Pages: 215.

Context:
This document was published in 2007 to assist Joint Advanced Warfighting School (JAWS) students at the Joint Forces Staff College (JFSC) during their Operational Art and Campaigning instruction.

This paper presents an analysis of the Joint Operation Planning Process (JCF OPP) and the two related but distinct categories of Joint Operation Planning, Contingency and Crisis planning.

Content:
This document examines the two related but distinct categories of Joint Operation Planning; Contingency Planning and Crisis Action Planning (CAP). Contingency Planning’s focus is on hypothetical situations in the future, while CAP deals with actual or near term emerging events that may involve the use of military force. These two categories differ in their respective products and may differ in the time available to plan. The Contingency Planning process is highly structured to support iterative, concurrent, and parallel planning throughout the planning community to produce thorough and fully coordinated contingency plans when time permits. However, the process is shortened in CAP, as necessary, to support the dynamic requirements of time sensitive/constrained events. During actual military operations, the process adapts to accommodate greater decentralization of joint operation planning activities. Contingency Planning and CAP share common planning activities (processes, collaborative tools, data bases and info grid) and are interrelated.

To set the stage the paper firsts explains the structure of Joint Military Planning including strategic direction and strategic communication as well as Joint Strategic Planning focusing on the joint strategic planning system.

The document then examines Contingency Planning which is planning that occurs in non crisis situations. A contingency is a situation that likely would involve military forces in response to natural and man-made disasters, terrorists, subversives, or military operations by foreign powers. Contingency Planning is an iterative process and is adaptive to situational changes within the operational and planning environments it facilitates the transition to Crisis Action Planning (CAP).

Contingency Planning as it is explained here encompasses four levels of planning detail, with an associated planning product for each level. First the Commander's Estimate which reflects the supported commander's analysis of the various COAs available to accomplish an assigned mission and contains a recommended COA. The next step is the development of the Base Plan which describes the CONOPS, major forces, concepts of support, and anticipated timelines for completing the mission. This followed by the production of a CONPLAN which is an operation plan in an abbreviated format. Finally the CONPLAN is expanded to become an OPLAN that is a complete and detailed joint plan containing a full description of the CONOPS.

The paper then presents a detailed comparison between Contingency and Crisis Planning. The planning process for both are the same, though different products are produced. Contingency Planning supports Crisis Action Planning by anticipating potential crises and operations and developing contingency plans that facilitate execution planning during crises. CAP activities are similar to Contingency Planning activities, but CAP is based on dynamic, real-world conditions vice assumptions. CAP procedures provide for the rapid and effective exchange of information and analysis, the timely preparation of military COAs

The Joint Operation Planning Process discussed here closely mirrors the Canadian Forces Operational Process (CF OPP). The JCF OPP has four functions consisting of seven steps and an assessment of the plan compared with the five phases of the CF OPP. The functions and steps of the JCF OPP are:

- Function I – Strategic Guidance consists of 2 steps; Planning Initiation and Mission Analysis.
- Function II – Concept Development consists of four steps; COA Development, COA Analysis and Wargaming, COA Comparison and COA Approval.
- Function III – Plane Development consists of Plan or Order Development.
- Function IV – Plane Assessment

These functions and steps are studied in depth.

Observations:

This essay is pertinent to the identification of decision support concepts as it presents a detailed analysis of Contingency and Crisis planning from a U.S. Forces perspective, our closest coalition partner. Although it is understood that a common planning process is not required it is important to at least be aware of the processes utilized by our allies.

The discussion of the JCF OPP is in great detail however, it is recommended that the reader browse chapters 9 to 19 to gain an appreciation for the JCF OPP and its resemblance to the CF OPP.

[34] Nilsson, M (2008). Characterising User Interaction to Inform Information- Fusion-Driven Decision Support, presented at the European Conference on Cognitive Ergonomics, Madeira, Portugal. Pages: 4.

Context:
This paper intends to extend current paradigms of user driven Information Fusion (IF) by further characterising the role of the user. The JDL Information Fusion approach serves as the primary starting point for this work. Concepts of Information Fusion are applied to a maritime surveillance control room and how they assist in decision support.

Content:
The author re-iterates previous work on Information Fusion by highlighting the limitation in technology driven information fusion and data collection without human interaction. The levels of refinement are reviewed in the context of the JDL model, with discussion on the merits of technology and how they do well in gathering information within complex environments. At some point however, human interaction is required to use this information in a meaningful manner as such, increase in information alone does not contribute to better decisions.

The authors state the problem of characterising the nature of user interaction within Information Fusion scenarios, and questions whether a common framework of such interaction can be established across all IF domains. Through this investigation, the concept of Distributed Cognition (DC) is introduced, where "systems are based on fused information from different resources such as sensors, humans, databases…both automatic and semi-automatics…consist[ing] of different transformations of representational states mediated by technology and humans". An example of automated transformation within the context of maritime surveillance would be the various radar readings from the automatic identification system. To the naked eye alone, the multitude of potential contacts would be difficult to sort through, but facilitated by the identification system through filtering and various display options (colour, filters, overlays, etc). To further enhance this information the user has at their disposal additional tools such as email, radio, fax which serve to assist in identification of vessels and consequent decisions via support from other sources (e.g., other surveillance vessels, known contacts database).

Observations:
The author offers a critique on both her and previous JDL models by proposing the requirement to characterise user interactions in Information Fusion models, as well as on-going need to thoroughly ground their studies in cognitive engineering. It is suggested that while her current research may help recognition of the importance of user interaction, this area of work requires formalisation and supplementation with follow on studies. In particular, these would involve investigations of more complex Information Fusion scenarios to identify a potential framework which may help guide future development of future IF systems.

[35] North American Treaty Organisation (NATO) (2006). Tool for the Operational Planning, Force Activation and Simulation (TOPFAS), Operations Research Division, NATO C3 Agency, The Hague, Netherlands. Pages: 15.

Context:
In the first 40 years after the formation of NATO the military operational planning process focused exclusively on a single overriding concern; – the potential need for the defense of NATO territory in Europe. With the end of the cold war and the emergence of the new European security environment and the expansion of the role of NATO to include force deployments and peace support operations outside NATO territories the need to establish NATO doctrine and planning procedures for such operations became a requirement. TOPFAS is being developed in response to this requirement.

TOPFAS is the data and planning support system for the operational planning and force activation in accordance with the NATO Operational Planning Process. It will provide a common database and tools for the planning process as well as a common repository of the operational plans and the audit trail for the Force Generation Process. TOPFAS supports the planning process with graphical tools to the greatest possible extent; i.e. graphical lay-out of the operational design, phases and tasks, geographical mapping tools for the specification of operational planning factors and environmental conditions; and for the disposition of the forces. Troop-to-task rules, combined with military expertise, are the basis for the identification of force requirements.

This paper is a summary of a symposium presentation of TOPFAS presented in 2006.

Content:
This document presents an overview of NATO's Operational Planning Process which is similar to national military doctrines including Canada's. However, certain key aspects of the planning process will be different for the obvious reasons that NATO is an alliance of 19 sovereign nations and that military forces only become available to the NATO commanders through the contributions from the nations in the force generation and activation process.

Operational planning in NATO can be conducted under a wide range of conditions, from routine exercises to immediate reaction to an attack on NATO territory. The main categories of planning situations are; 1) The response to an emerging crisis situation that NATO might become involved in, - typically a peace support operation where NATO become involved as the result of a UN resolution/mandate and request for intervention; and 2) Prudent military planning for potential future operations that are not linked to any expressed threat or an actual crisis situation, but which nevertheless require advance planning to ensure NATO's ability to respond should it be called upon to do so.

The user software associated with TOPFAS supports the activities and preparation of all planning products of the planning stages:

- **Initiation** based on the initiating directive and including the receipt of planning inputs and preparation of the database.
- **Orientation** with focus on the mission analysis, operational design and the identification of assigned and implied tasks and planning factors.

- **Concept Development** with identification of the preferred course of action (COA) to be developed into the concept of operations (CONOPS) including force requirements.
- Plan Development with the refinement of the CONOPS and detailed planning based on the actual forces and capabilities provided by the nations.
- **Plan Review** for further assessment, large-scale war-gaming and exercising, including the adaptation of the force requirements to the changing operational environment.

It should be emphasized that TOPFAS was still under development when this paper was produced in 2006. At that time it was too early to say what the final product would look like in terms of data, functionality and user interface. The early laboratory trials identified a number of challenges. Some of these spring from the fact that NATO planners come from diverse national backgrounds. Also, the operational planning process in itself is a highly creative process, including brainstorming techniques and the application of concepts that are not easily translated into bits and bytes. Other demands on the software functionality are driven by the quick response requirements in a real planning situation. The scope and aim of the TOPFAS development is to provide software and data support for all stages and activities of the CF OPP.

Observations:
TOPFAS is the data and planning support system for the operational planning and force activation in accordance with the NATO Operational Planning Process and as such gives us insight into to concepts to support rapid response planning that are being embraced by our allies. TOPFAS supports the planning process with graphical tools to the greatest possible extent; i.e. graphical lay-out of the operational design, phases and tasks, geographical mapping tools for the specification of operational planning factors and environmental conditions; and for the disposition of the forces.

One of the tenets being observed during the development of TOPFAS is that Operational Planning is not a full-time occupation of staff officers. So when the need arises the tool that he/she turns to has to be simple and intuitive. This is certainly the case of staff officers at all levels in the Canadian Forces.

The aim of TOPFAS is to harmonize all levels of planning from the strategic through the operational to the tactical level. It is recognized that planning activities at these various levels are not separate discrete activities but are a continuous balancing of interdependent considerations across all levels. The key function of the operational level is to act as a coordinating entity linking abstract strategic intent and direction to more pragmatic action plans that can be executed at the tactical level. Throughout the planning phases, which occur concurrently across all levels, the Operational level planners act as a clearing house of information clarifying and confirming strategic intent and direction to tactical level planners and informing strategic planners of the real status of all available capabilities.

Feedback received from operational planners indicated that the investment of time and effort to become proficient in a time-critical crisis response planning tool would not provide sufficient value if the same tool could not be used for the development of all planning products, under all conditions. This means the same tool must be appropriate for the planning of long-term routine operations, long lead time contingency operations as well as immediate contingency operations. This leads one to the conclusion that essentially the same process will be followed to the maximum extent possible implying a potentially less complete product using more assumptions with resulting higher risks as time constraints tighten. A key aspect then will be to identify and highlight the information gaps, assumptions and assumed risks of the plan to the Commander as critical factors included in the decision briefs.

TOPFAS is a NATO Network Enabled Capability that provides a distributed environment where planners from the strategic to the tactical levels can interact with each other. It also provides a common database management and manipulation tool as well as a creative planning support system that permits all levels to access the most up-to-date information available within the system. It must be noted that TOPFAS does not include many of the software suites for detailed planning of specialized tasks such as Intelligence Information Systems or Logistics Management Systems but rather ensures that it can directly interface and incorporate the outputs of those specialized systems into the aggregate planning at the appropriate level.

TOPFAS software suite provides a *"planning wizard"* that guides the planner through the operational planning process and associated software functionality. The wizard as shown below leads planners along the path of full consideration of all factors under all circumstances. This can be expanded as required to achieve the level of detail that the commander desires to make a sufficiently informed decision under the circumstances. Note that if the same tool is used by all levels of Command, lower levels will have the benefit of immediate transparency with respect to superior intent and higher levels will have immediate transparency on lower level constraints and restraints. In addition, if used across instruments of coalition or national influence, the most appropriate subject matter experts can provide the best information to all planners at all levels.

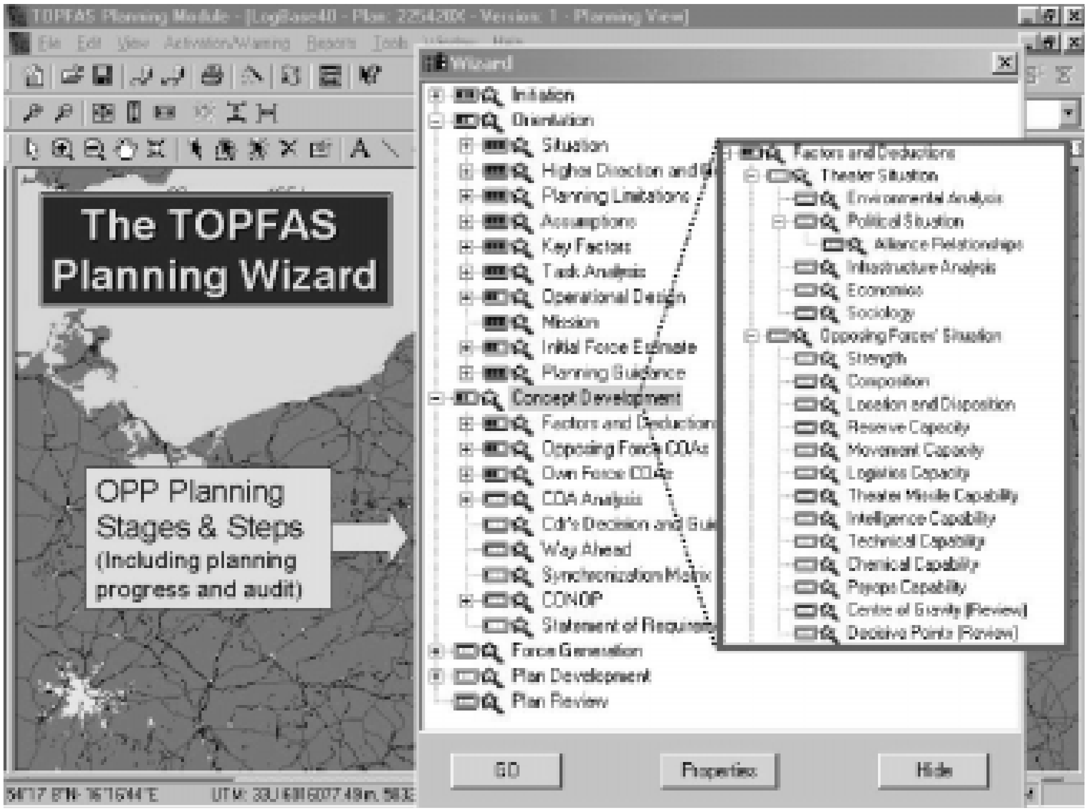

Figure 41. *TOPFAS Planning Wizard*

In the early phases of the planning process (initiation, orientation and concept development) the focus is on the more creative or abstract aspects of the planning process. As the completion of phases continue, the plan moves from the more abstract and general to the more tangible and detailed. An example of the more abstract conceptual view is provided by the TOPFAS Operational Design View shown below[13].

[13] Note that if the planning wizard were linked to the database of *"Standing Contingency Operations Plans"* those elements of the standing plans that have been pre-planned could be already completed within the wizard and require only planners to acknowledge and accept the appropriateness of the pre-programmed information.

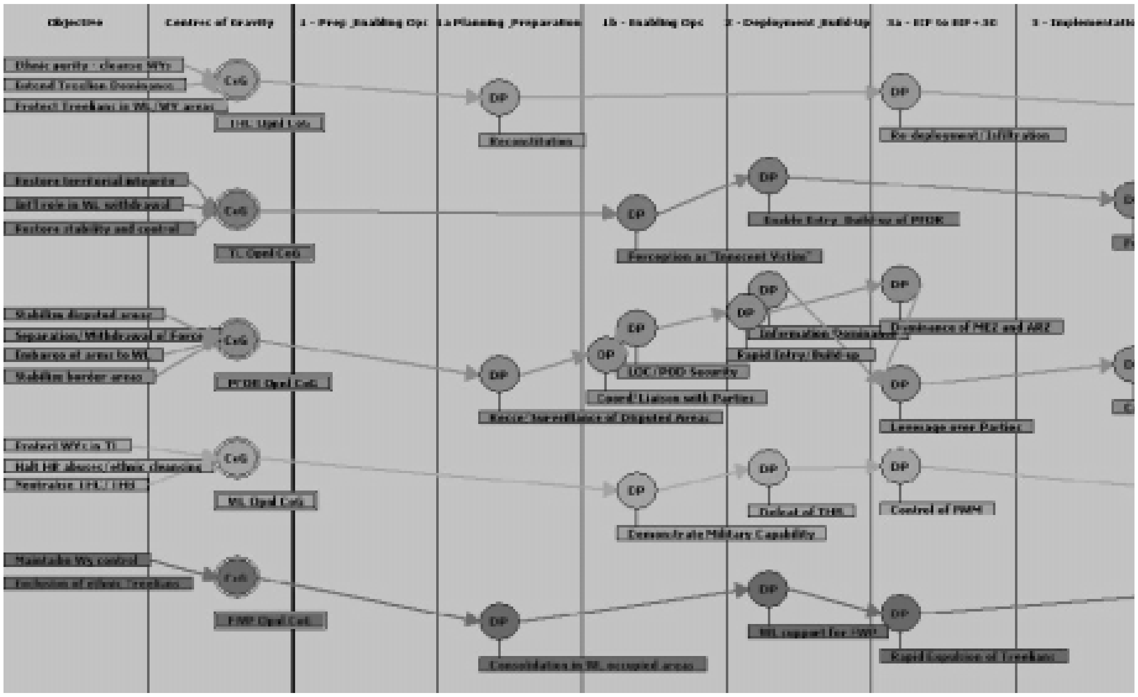

Figure 42. *TOPFAS Operational Design View*

TOPFAS also acknowledges that to be effective in today's planning environment the tool must be a "joint" tool equally effective for individual air, land or maritime planning as it is for joint planning. In Canada's case, not only is there a stated objective of the military becoming increasingly joint but government direction is to move toward a whole of government approach encompassing diplomatic, defence, development and trade (3D+T) instruments of influence in joint, interagency and multinational operations.

[36] Nten, C. A. (2004). Military Medical Decision Support for Homeland Defense During Emergency, North Carolina A&T State University, The Institute for Human-Machine Studies, Greensboro, NC. Page: 43.

<u>Context:</u>
After the deadly incident of September 11, 2001, the U.S. government determined never to be so unprepared during unexpected national or local disasters that may be orchestrated by terrorists or natural disasters. A critical shortcoming was the lack of an integrated, reliable system for sharing data and communication among all of the agencies involved. One of the responses to these shortcomings was the development of a software system known as the Medical Emergency Response using Military Asset in an Integrated Decision Support (MERMAIDS), designed to aid in the training of emergency response teams using heterogeneous resources under a unified command and control.

This report describes the application of cognitive engineering methods to the design and analysis of a decision support system for training of command and control (C2) functions in emergency response organizations with a focus on the development of human-computer interface as conducted by The Institute for Human-Machine Studies at North Carolina A&T State University.

The report includes as an annex a 10 page MERMAIDS user manual describing the main menu options.

Content:
The fundamental premise of this project report is that managing a single- or multiple- tier emergency planning with either heterogeneous or homogenous resources will require a decision support system (DSS) to support training and planning of command and control (C2) functions. The DSS should be designed to ensure that its multi-layered representation of individual and organizational procedures, practices, databases, computational aids, and other logistical resources are coordinated into an ad-hoc semi-automated decision support system, verified, and reconfigured to provide a continuous training and decision support for the responsible people involved. The DSS must also exhibit quality usability metric with the ability to process and manage heterogeneous information in real-time.

The scope of this report is limited to developing a prototype human-computer environment with embedded decision aids to support a heterogeneous team of medical emergency response agents. Specifically, this phase of research emphasizes computer modeling of emergency response team decision-making based on diverse organizational policies and standard operating procedures (SOPs).

This document provides the background of the problem addressed, presents an approach to designing a decision support for emergency C2 information management and contains the theory and methods of decision-centric user interface for emergency decision support software design.

The decision support components of the MERMAIDS are designed to take the advantage of the independent and diverse organizational standard operating policies (SOPs) existing within the civilian and military C2 emergency response elements. The MERMAIDS system is useful in presenting emergency planning scenarios at various levels of information complexity as manifested in emergency courses of action (COA) planning, analysis, and execution. The MERMAIDS system also supports a team of decision makers who are geographically collocated or dispersed to have access to plug and play emergency COA planning simulation scenarios, while performance is observed in real-time by the computer agent.

An important element in any effective rapid-response effort is the quick formation of C2 plans, coordinating the efforts among multiple agencies, and then guiding the responders by letting them improvise a plan constructed on-site based on the emergency situation and the prepared protocol (Mondschein, 1994). Two model examples in the MERMAIDS is the travel advisor which displays maps as well as instructions from location of resources to the incident site, and the Internet and Web information systems to support real-time distributive communication between emergency workers.

The MERMAIDS has established C2 at three interacting levels: (1) Local Incident Command representing the first-response personnel from one or more agencies, (2) Unified Interagency

Command for direction and synchronization of the interagency operations, and (3) Emergency Operations C2 center to support policy decisions.

Emergency situations, in general, often require distributed control because the agents involved are geographically dispersed. Some examples include the location of paramedics, police, fire stations, and so on. An operator monitoring a system for a potential terrorist attack or accident scene must have an accurate mental representation of the controlled system. Communication and information sharing in time and space are the basis for distributed decision-making by ERT staff. The MERMAIDS has been designed to contain decision-centric interface, which is not only useful for emergency information management, but has decision models to support response planning during emergency conditions.

Observations:
The decision support models in the MERMAIDS report present techniques and concepts applicable to numerous agencies including the military for the planning of immediate contingency operations. This report describes team performance using constructive simulation experiments of medical emergency planning conditions that require a heterogeneous team of military and civilian emergency personnel: Air Force Aeromedical units, Navy and Army medical units, Red Cross, Firefighters, Emergency Medical Response, Police, Federal Emergency Management Administration, etc.

MERMAIDS has been designed to contain a decision-centric interface, which is not Only useful for emergency information management, but has decision models to support response planning during emergency conditions (i.e. Immediate Contingencies Operations). Also of interest to this project is that this document contains decision aiding models designed to provide real-time support to the emergency personnel working in teams, as well as metrics for measuring human operator performance.

[37] Oak Ridge National Laboratory (date unknown). Virtual Information Processing Agent Research (VIPAR), Fact Sheet. Accessed January 2009 from http://computing.ornl.gov/cse_home/about/VIPAR_5-6-2003.pdf.

Context:
The artificial intelligence agents contained within theVirtual Information Processing Agent Research (VIPAR) technology has been developed to address challenges facing the military and intelligence community in quickly gathering and organizing massive amounts of information then distill that information into a form directly and explicitly amenable for use by an analyst. VIPAR has been successfully deployed for the US Pacific Command and the US Sixth Fleet. The original software was developed from a need for modeling on-demand manufacturing techniques

Content:
VIPAR collects, organizes and displays information from various electronic information sources. It can be used by the military, intelligence and business communities to provide timely, coherent information summaries of world news and intelligence from web-based sources. VIPAR differs from other software or search engines in that it interrogates each

source according to user-defined rules and clusters information according to content similarity.

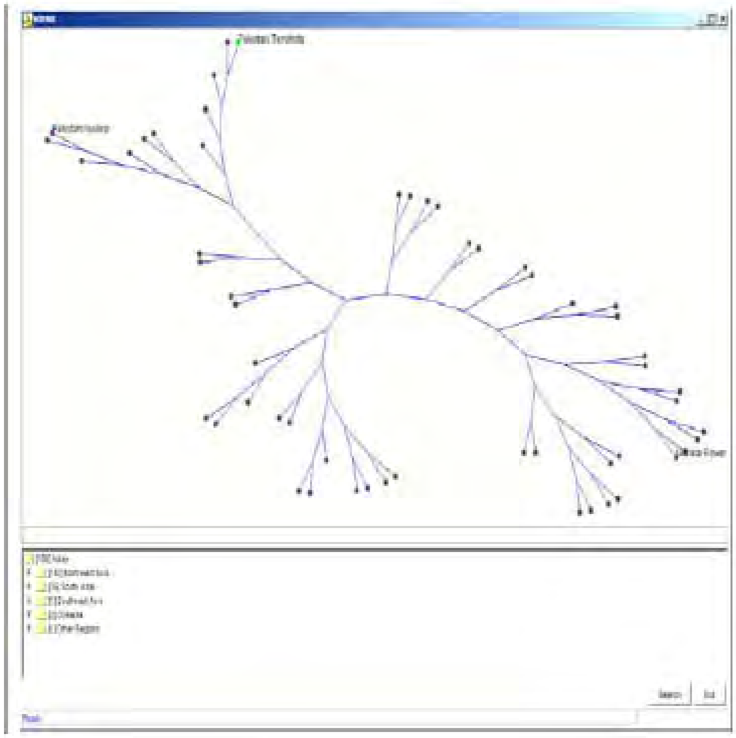

Figure 43. *VIPAR clustering technique*

<u>Observations:</u>
The VIPAR technology would be useful to rapid response planners for evaluating COA and SA information. The system leverages an analyst’s expertise to process and distill information orders of magnitude faster and more thoroughly than could be done by the analysts themselves.

[38] Raskob, W. and Ehrhardt, J. (2000). The RODOS System: Decision Support For Nuclear Off-Site Emergency Management In Europe, International Radiation Protection Association 2000. Pages: 10.
Additional information was provided by The RODOS System Brochure, 2005 Pages:39 (http://www.rodos.fzk.de/rodos.html).

<u>Context:</u>
A number of requirements have emerged from public and political discussions of the Chernobyl accident on 26 April 1986, the attacks on the World Trade Centre in 2001 and the threat of attacks with radiological dispersal devices (RDD), which spread radioactive material by aerosolising or dissolution in water reservoirs; they include

• the need for a more coherent and harmonized response in Europe and in the different stages of an accident (in particular, to limit the loss of public confidence in the measures taken by the authorities for their protection);

• exchange of information and data in an emergency to enable neighbouring countries to take more timely and effective actions; and

• the necessity to make better use of limited technical resources and avoid duplication.

Under the auspices of its RTD (Research and Technological Development) Framework Programmes, the European Commission has supported the development of the RODOS (Real-time On-line DecisiOn Support) system for off-site emergency management to address these requirements.

The main objectives of the RODOS project were: to develop a comprehensive and integrated decision support system that is generally applicable across Europe, to provide a common framework for incorporating the best features of existing decision support systems and future developments, to provide greater transparency in the decision process as one input to improving public understanding and acceptance of off-site emergency measures, to facilitate improved communication between countries of monitoring data, predictions of consequences, etc., in the event of any future accident, and, the overriding consideration, to promote, through the development and use of the system, a more coherent, consistent and harmonised response to any future accident that may affect Europe.

The paper summarizes the status of the RODOS project and system at the beginning of the year 2000; the current version of RODOS is version 6.0 (released May 2004).

<u>Content:</u>
Main users of the system are those responsible at local, regional, national and supra-national levels for off-site emergency management. The RODOS system is designed for enabling a seamless transition between local/regional/national/European scales; early and later phases of an accident; and all types of emergency actions and countermeasures. To that purpose, models and data bases can be customized to different site and plant characteristics and to the geographical, climatic and environmental variations in Europe. Its operational application requires on-line coupling to radiological and meteorological real-time measurements and meteorological forecasts from national weather services.

The RODOS system can provide decision support at four distinct levels:

• Level 0: acquisition and checking of radiological data and their presentation, directly or with minimal analysis, to decision makers, along with geographical and demographic information.

• Level 1: analysis and prediction of the current and future radiological situation (i.e., the distribution over space and time in the absence of countermeasures) based upon information on the source term, monitoring data, meteorological data and models.

• Level 2: simulation of potential countermeasures (e.g., sheltering, evacuation, issue of iodine tablets, relocation, decontamination and food-bans), in particular, determination of their feasibility and quantification of their benefits and disadvantages.

• Level 3: evaluation and ranking of alternative countermeasure strategies by balancing their respective benefits and disadvantages (e.g., costs, averted dose, stress reduction, social and political acceptability) taking account of societal preferences as perceived by decision makers.

Most decision support systems that have been developed to an operational state are limited to levels 0 or 1. A few extend to level 2 or even level 3 but, in general, are limited in the range of countermeasures they address or in the completeness of benefits and disadvantages that are considered. RODOS is unique in providing support to level 3 for all practicable countermeasures.

The conceptual RODOS architecture is split into three distinct subsystems, which are denoted by Analyzing Subsystem (ASY), Countermeasure Subsystem (CSY) and Evaluating Subsystem (ESY). The interconnection of all program modules, the input, transfer and exchange of data, the display of results, and the interactive and automatic modes of operation are all controlled by the specially designed UNIX based operating system OSY. The main duties of OSY are the correct control of system operation, data management, and the exchange of information among various modules as well as the interaction with users in distributed computer systems. The flexibility of the whole system is defined by OSY and is independent of the development of program modules.

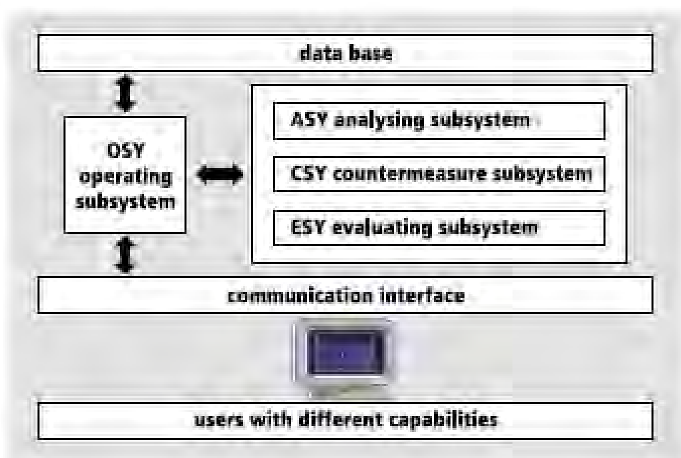

Figure 44. *RODOOS System Conceptual Structure*

Each of the subsystems consists of a variety of modules developed for processing data and calculating endpoints belonging to the corresponding level of information processing. The modules are fed with data stored in a distributed database allowing for a decentralized data management and the parallel execution of multiple task operations. The distributed database comprises: real-time data with information coming from regional or national radiological and meteorological data networks; geographical data defining the environmental conditions; program data with results obtained and processed within the system; and facts and rules reflect feasibility aspects and subjective arguments. A database manager gives the programs of the RODOS system access to the data stored in these databases with a unique interface format. It converts the requests from the programs into a request to the appropriate database and enables multiple clients to access multiple database servers.

The content of the subsystems and the databases will vary depending on the specific application of the system, i.e., the nature and characteristics of a potential accident. At different points in time various modules will have to be linked (with at least one each from ASY, CSY and ESY) in order to produce the required output. For example, after the passage of the plume, meteorological forecasts are no longer necessary for the region considered or, after evacuation, models for simulating sheltering or relocation in the same area are no longer needed.

The dialogue between RODOS and a user is organized in two different modes. In the so-called "automatic mode" the system automatically presents all information which is relevant to decision making and quantifiable in accordance with the current state of knowledge in the real cycle time (e.g., 10 minutes in the early phase of emergency protection). For this purpose, all the data entered into the system in the preceding cycle (either on-line or entered by the user) are taken into account in the current cycle. Interaction with the system is limited to a minimum amount of user input necessary to characterize the current situation and adapt models and data.

Either in parallel to the automatic mode or alone, RODOS can be operated in the "interactive mode". In this dialogue mode, the user of the system and RODOS communicate via a menu interface. Editors specially developed for this purpose allow specific modules to be called, different sequences of modules to be executed, input data and parameter values to be changed, and the output and representation of results to be varied.

The dialogue between RODOS and a user is performed via various user-interfaces tailored to the needs and qualification of the user. The access rights of different user groups determine the type of user-interface, which allows increasing access to models, data and system parameters in a hierarchical structure. At the lowest level of access, there is an easily understood but very limited interface for training courses on emergency management; at the highest, the full spectrum of interface tools is available for system developers familiar with the system content and structure.

<u>Observations:</u>

The RODOS system development process has brought together a number of people from various backgrounds and stakeholder groups across Europe and has addressed the need to be applicable to a number of users. The involvement of the stakeholders is critical in the process of bringing users from a non-computerized to fully computerized EDM.

As stated above, RODOS is unique in providing support to level 3 response activities, encompassing the development of countermeasures or courses of action (COA), enabling interface to a number of information sources and providing data assimilation that combines measured data with results of model predictions for improving the diagnostic and prognostic results. The RODOS system, in a coherent and comprehensive approach, simulates and estimates the timing and the extent and duration of all countermeasures which might be implemented. Intervention strategies adopted in various European countries (i.e. in various areas of operation) can also be considered through its modular format. Benefits of this application to Air Force rapid response planning include (1) the analysis of countermeasures/COAs and (2) its modular format to incorporate information for countermeasures from various AOOs. The elements that are brought together in the countermeasures analysis include aspects that consider public opinion. Public affairs, similar to legal and policy domains, are an important aspect for COA development, and inclusion here is key.

Specific application details that are relevant to Air Force rapid response planning include:

(1) The MAV/UT-based software package, WebHIPRE, has been integrated in RODOS to enable users to compare and evaluate the benefits and drawbacks of different countermeasure strategies (e. g., risks, costs, feasibility, public acceptance, perceptions, social, psychological and political implications, and preferences or value concepts of decision-makers, etc.). Rules, weights, and preference functions are encoded and applied to a list of alternative countermeasures providing a ranked shortlist to decision makers together with the rules and preferences which determined the order of the list. Intuitive justification of choices and underlying uncertainties inherent in the predictions are also provided. The evaluation software assists users in modifying rules, weights, and preferences and other model parameters as well as exploring the consequences of each change. The importance of this exploration cannot be emphasized too strongly. Any decision support systems helps decision makers not by making the decision itself, but by enhancing the decision makers' understanding of the problem, the issues before them, and their value judgments. Because of this improved understanding, they are then in a better position to make sensible decisions

(2) RODOS is a modular structured UNIX based system and has a client-server architecture that allows it to be distributed across a network of computers. Three categories of users can access the system: (1) via an X-Windows user interface (full functionality), (2) on PCs with standard browser via a simplified Web based user interface, (3) as passive users with access to results generated by Category A or B users. Furthermore, software tools exist for directly exchanging raw and processed data between decision support systems of neighbouring countries.

[39] Ross, Karol G., Gary A. Klein, Peter Thunholm, John Schmitt, and Holly C. Baxter (2004). "The Recognition-Primed Decision Model", Military Review, July – August 2004.

<u>Context:</u>
In 2003, the US Battle Command Laboratory conducted a 2-week experiment to assess the RPM. The experiment and findings were reported by Karol Ross, Gary Kleign, Peter Tunholm, John Schmitt, and Holly Baxter in the July-Aug 2004 Military Review.

<u>Content:</u>
Most participants favoured the RPM from the beginning, estimating the RPM took at least 30 percent less time than did the MDMP. But participants did express some concerns, such as the tendency to rush through the mission analysis to get into the COA development. It was also suggested that mission analysis can benefit from knowing the COA early and that the two processes can be iterated as required.

Several instances were recalled where planners suffered with inadequate plans initiated by inexperienced staff members. The RPM allows the commander to drive the process, using the staff to detail the plan and identify flaws and improvements. Even if the commander were under pressure, it seemed better to spend more time at the beginning identifying the base COA than to later spend several hours fixing inadequate plans. The entire planning process benefits from the commander's participation in the initial COA definition. The RPM was enhanced with the "commander's interview" to encourage the commander to clearly state the rationale and intent behind the preferred COA and to allow planning staff to question the commander's thinking behind the COA.

Participants also recommended that some means to rapidly sketch and disseminate the base COA was imperative. Using the collaborative tools available at the time was time-consuming and frustrating. Until they could prepare a more detailed electronic map, all they needed was a hand-drawn sketch, which the commander could disseminate quickly. This recommendation is consistent with observations of experienced decision-makers who tend to concentrate on understanding the situation as fully as possible. When the situation is well understood, the best COA often suggests itself to the decision-maker.

The conclusion from their work is that the tools that make visualization of the battlespace easier are more helpful than COA generation and evaluation tools.

Observations
The authors suggest the RPM requires a different set of planning tools than those the traditional CF OPP needs. Instead of needing tools for generating and comparing COAs, the RPM needs tools for sizing up situations and facilitating replanning as part of the cycle of continuously improving and adjusting the COA.

The essence of RPM is to recognize a base COA from experience and to adapt it quickly to the situation at hand. The essential ingredient is to establish a shared understanding of the situation and the commander's intent as soon as possible and to use the base COA, or candidate COP to refine on a continuing basis as the situation evolves through actions taken and new situational information arrives.

[40] Rovira, E., McGarry, K., & Parasuraman, R. (2007). Effects of Imperfect Automation on Decision Making in a Simulated Command and Control Task. Human Factors, 49 (1), 76-87.

Context
This paper concerns automation complacency, focusing more precisely on obliviousness towards automation unreliability, by investigating the effect of various levels of unreliability in decision support system automation, on human performance in a STS (sensor-to-shooter) targeting C2 task. By reduced performance, the authors are talking about both decision accuracy and latency.

Content
The effectiveness of automated decision aids used by human operators in command and control systems may depend not only on automation reliability, but also on the type (stage) and level the automated support provides. Automation can be applied to information acquisition, information integration and analysis, decision choice selection, or action implementation. The present study examined the effects of variations in the stage of automation support on performance in a "Sensor to Shooter" targeting simulation of command and control. Independent variables included the type and level of automation support (complete listing, priority listing, top choices, and recommendation of decision choice) and the reliability of the automation (60% and 80%). Dependent variables included accuracy and reaction time of target engagement decisions. Compared to manual performance, reliable

automation did not affect the accuracy of target engagement decisions but did significantly reduce decision times. When the automation was unreliable, under the higher reliability condition (80%) there was a greater cost in accuracy performance for higher levels of automation aiding (priority listing, top choice, and recommendation) than at a lower level (complete listing). The results support the view that automation unreliability has a greater performance cost for decision automation than for information automation. This performance cost generalizes across a number of different forms of decision-aiding.

Observations

The authors comment that completely reliable decision support systems automation cannot be guaranteed, and as such, systems design should include the means for end-users to inspect and analyze the information being processed, such as raw data and decision heuristics characteristics. This suggests that a better system design would include a "trace" of the information automation, or of decision automation details, made available to the end-user, so as to avoid potential mistakes caused by faulty system design, wherever such faults may be originating from (i.e., sensors, algorithms, UI design flaws or performance glitches, faulty database updates or entries, etc.).

Of particular interest are the following comments by Rovira et al. in their discussion section: "*… the differential cost of automation unreliability for the three forms of decision automation, as compared with information automation, confirmed our hypothesis regarding the effects of automation unreliability. However, these effects were found only for 80% overall automation reliability. At 60% overall automation reliability, both information and decision automation reduced performance on unreliable trials. This finding suggests that below a certain threshold level of reliability, automation imperfection leads to poorer performance irrespective of the type of automation.* [Other researchers] *suggested that human performance is sensitive to the level of automation imperfection* […] *Information automation can give the operator status information, can integrate different sources of data, and may recommend possible courses of action. However, this form of automation typically does not give values to the possible courses of action, whereas decision automation does. Therefore, it is possible that when the automation is highly reliable yet imperfect, performance is better with an information support tool because the user continues to generate the values for the different courses of action and, hence, is not as detrimentally influenced by inaccurate information. Additionally, a user of decision automation may no longer create or explore novel alternatives apart from those provided by the automation, thus leading to a greater performance cost when the automation is unreliable* […] [Research] *indicates that participants rely to a greater extent on automation when it is more reliable, even though it is imperfect* […] *when the automation was performing reliably, complacency increased, leading to poorer operator detection rates when it failed. The results of the present study parallel this finding, and both are examples of one of the paradoxes of automation. The more reliable the automation, the greater its detrimental effect when it fails.*"

Further: "*Such conditions* [uncertainty, high workload, stress, limited time to make decisions, etc.] *may have encouraged reliance on the decision choice suggested by the automation, particularly if there was insufficient time for the user to check the information sources to verify the automated advice. When the conditions permit such verification, however, the costs of imperfection in decision automation may be reduced. Lorenz et al. (2002) found that a high level of decision automation did not lead to poorer decision-making performance (as* *compared with a lower or moderate level of automation) when an automated fault management system failed.* ***They attributed this lack of a cost of imperfection in high-level decision automation to the ability of the users to query the system, inspect the raw information sources, and verify or negate the automated advice****.*" (our emphasis).

Finally, in line with Cummings' (2004) comments on automation biases, the authors suggest that automation tools are oft designed with much of the raw data removed from the end-user's toolset, with the adverse effect of limiting the user's understanding and/or awareness of the details. This distances the decision-making process itself from the support system's user, and when decision automation is unreliable, overall performance degrades significantly precisely because of this information opacity. In the authors' words: "Therefore, if reliable decision automation cannot be guaranteed, it is recommended that information automation be provided to support the user, or at least a low level of decision automation versus a highly autonomous decision support tool."

[41] Roy, Marcel (2005). Air Force Command and Control Information System, 32938-313-0013 User Guide v1_1. Document #32398-313-0013, Pages: 47.

<u>Context:</u>
This user guide was issued in September 2005 then reissued again in November of that year to include an RELCAN Firewall Email functionality update. The purpose of this document is to describe the AFCCIS from the perspective of the user. It includes a high-level description of the capabilities provided by AFCCIS.

The intent is to provide the AFCCIS user community with a high-level understanding of the AFCCIS functionality and how it can be used to support their daily activities.

<u>Content:</u>
AFCCIS is an Air Force wide, Canadian / United States (CANUS) Secret computer network and is the principal information system to support Air Force operations. It provides users at all levels with a very comprehensive set of capabilities, including communications networks and planning tools, to support the conduct of their daily operations. This document provides a description of the elements that make up the AFCCIS.

Where practical, step-by-step procedures have been extracted and placed in annexes at the end of this document. Given that this document is intended for users, every attempt has been made to minimize the amount of technical information provided.

An important aspect of this guide is the description of the various planning tools and applications that are available to users at all levels. These tools and applications include:

- The **Theater Air Planning (TAP)** application which is a joint standard application for the development of an Air Battle Plan for offensive and defensive operations, and for production of an Air Tasking Order (ATO) message for dissemination to execution units and other affected agencies.

- The **Remote Access Mission Planning (RAMP)** application which provides for remote and local submittal of "mission shell requests" via a web browser to the TAP database for subsequent review and import processing by a TAP operator. RAMP supports submittal of both air and surface-to-surface mission requests that can include much of the data required for planning a mission within TAP.

- The **Execution Management - Replanner (EMR)** application is a joint standard application for modification or replanning of an Air Battle Plans. EMR supports the same functional capabilities as the Theater Air Planner (TAP) for planning of offensive and defensive operations and is used for production of Air Tasking Order (ATO) changes. The replanner can perform Air Battle Plan (ABP) management functions, setup Air Operations Database (AODB) functions, perform mission planning functions, review and analyze ABPs, plus set-up system alerts.

- The **Joint Defensive Planner (JDP)** is a US TBMCS tool that is available in AFCCIS but sufficient evaluation has not been completed to determine if it would be useful. The Joint Defensive Planner (JDP) assists Theater Air and Missile Defense (TAMD) staffs of the Joint Force Commander (JFC), Area Air Defense Commander (AADC), Regional Air Defense Commander(s) (RADC), and Component Commanders in the development of operational level joint TAMD plans to counter air and missile threats. The design of JDP features a Graphical User Interface (GUI) that allows operators to set up or edit cases of interest.

- The **Mission Management Application (MMA)** is a legacy application that has been developed by the Aerospace and Telecommunications Engineering Support Squadron (ATESS) to streamline the various mission tracking functions and processes currently in place within the Air Force. It provides a "single data entry point" for aircrew and wing/squadron support personnel. MMA was designed as a tool to access a variety of mission tracking options in a "user friendly" interface, with easy to follow screens, point and click features, minimal typing and easily recognizable icons.

- The **Portable Flight Planning Software (PFPS)** is a comprehensive mission planner at the tactical level. The system consists of PC-based tools to help planners conduct effective and timely planning and updates as well as providing materials required for flight/ground/maritime operations including post-mission debriefing. These tools are used to support a broad range of mission needs and operational environments. PFPS is a continually expanding suite of applications designed to integrate together to provide a robust mission planning capability. The core components of PFPS consist of Combat Flight Planning Software (CFPS), FalconView, Combat Airdrop Planning Software (CAPS), and Combat Weapon Delivery Software (CWDS).

Observations:
Within the context of immediate contingency planning of air operations it is imperative that we have a clear understanding of the systems/networks, planning tools, and applications that are available to users at all levels today. This document provides the JCDS team with a description of the components of the AFCCIS that are currently being utilized in the planning of air operations. Albeit some of the applications have being refined and improved upon since 2005 this document does provide a start point for us to gain an understanding of what the users have available to them today.

[42] Schoenharl, T. et al. (2006). WIPER: A Multi-Agent System for Emergency Response, Proceedings of the 3rd International ISCRAM Conference, Newark, NJ (USA), May 2006. Pages: 7.

Context:
Numerous software tools have been developed to aid emergency responders by providing methods of gathering information on the current status of crisis situations. They provide emergency response planners with detailed, high-quality information, but with a high cost in terms of personnel and deployment. (PDAs and wireless infrastructure must be purchased, personnel trained and both need to be sent to crisis sites.) WIPER would act as a low-cost, highly available monitoring system. Its deployment would be automatic, as anyone with a cell phone in the area is a participant.

The WIPER system is designed as a distributed, multi-agent system built on open standards to address events in the real world of emergency response. WIPER brings cutting edge social network modeling algorithms, anomaly detection, sophisticated GIS-enable Agent-Based simulation and web-based interaction and visualization tools together in one package to enhance the decision making process of Emergency Management professionals.

Content:
This paper presents a high-level overview of the proposed architecture for the WIPER system. WIPER serves as a test bed to research open DDDAS design issues, including dynamic validation of simulations, algorithms to interpret high volume data streams, ensembles of simulations, runtime execution, middleware services, and experimentation frameworks:

A Dynamic Data Driven Application System (DDDAS) is an application software system capable of accepting and effectively utilizing remote data in real time (i.e., during the execution of the application software). Many software systems currently utilize static input data, i.e., input data which is specified a priori. The key concept of DDDAS is the generalization of application software systems to dynamically utilize real-time data arising from remote experiment and simulation, and to control such remote experiment and simulation to improve the performance of the application software system.

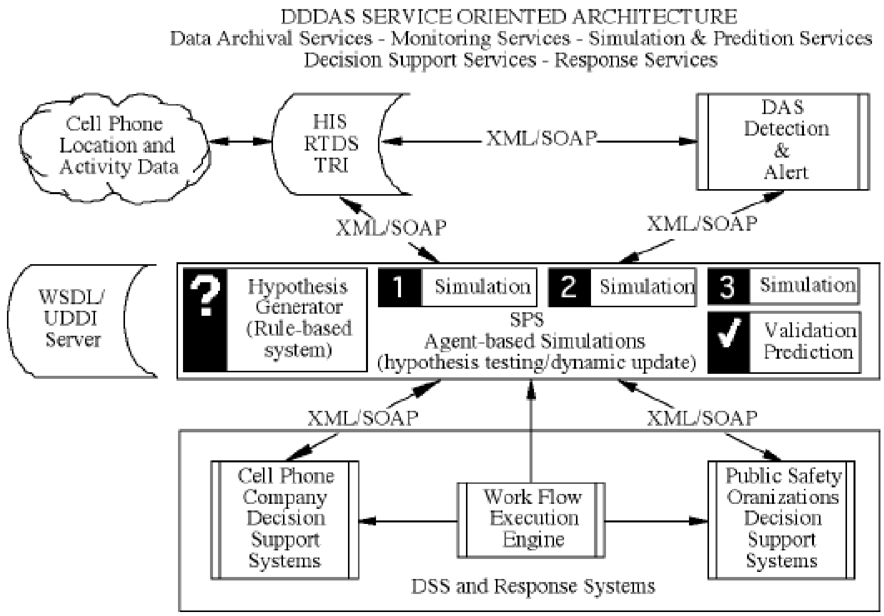

Figure 45. *DDDAS SOA*

Observations:

Relevant elements of the tool worthy of highlighting include:

- The stream of incoming data monitored by an anomaly detection algorithm, flagging potential crisis events for further automated investigation.
- Agent-Based simulations to predict the course of events and suggest potential mitigation plans. The system is designed to display output at every level to human planners so that they can monitor the current situation, oversee the software process and make decisions.
- When completed, the WIPER system is designed to integrate into a crisis response workflow.

The WIPER system is being designed as a distributed system combining traditional methods of composition (RMI) with newer, more robust methods (Service Oriented Architecture, Web Services, Intelligent and Mobile Agents) in three layers:

- Data Source and Measurement (DSM) – through the applications three modules, information is fused into a unified data stream and redirected into components in the DSP layer.
- Detection, Simulation and Prediction (DSP) - handles the monitoring on the streaming data and uses automatically generated computer simulations to determine whether perceived anomalies represent potential crisis events and what actions can be taken to mitigate these events.

- Decision Support (DSS) - acts as a front end for the WIPER system. The DSS will aggregate information from the SPS and present the real time system status and any predicted anomaly information in a web based interface. There will be options for crisis planners to specify and evaluate mitigation plans through the web interface. These plans will be evaluated with Agent-Based simulations and the results will be accessible from the web based interface.

The use of agent-based simulation for course of action analysis should be considered for use in the development of an Air Force rapid response planning decision support system. The ability to operate through a SOA platform is also valuable, allowing a greater degree of modularity and interoperability. Planning staff require the ability to push and pull data, and a SOA backbone can provide the foundation for such interactions.

The WIPER concept is very good instantiation of a modularizable architecture leveraging a combination of techniques, such as web services and multiple-agent systems, to provide a tool that any participant can plug in a bridge to be part of the EDM. The idea of using cell phones as sensors is probably an ideal for the future. The described baseline concept architecture is solid for information retrieval and EDM.

[43] Sheremetov, L.B., Contreras, M, and Valencia, C. (2004). Intelligent multi-agent support for the contingency management system, Expert Systems with Applications, 26 (2004) 57–71 Pages: 15.

<u>Context:</u>
The paper describes the agent-based intelligent infrastructure of contingency management system (CMS) developed with experience obtained with EVACUSONDA 3.0, a simulator of contingency situations in the marine zone of the gulf of Campeche. This infrastructure supports information collection from distributed heterogeneous databases, integration with enterprise legacy software systems, logistics planning, and monitoring of contingency situation in open, dynamic agent environment.

<u>Content:</u>
Information management is a huge challenge for emergency management. The CMS referred to attempts to deal with real issues concerning data such as incomplete and uncertain data, different data structures, missing values, large amounts of data, the unknown causal or dependence relations among relevant variables and the requirement for approximated data retrieved within a limited time and processed with limited recourses. The research applies the principals of three level architecture of Environmental Decision Support Systems proposed by Corte´s, Sa`nchez Marre`, Comas, R-Roda, and Poch (2000): data gathering and interpretation, diagnosis or prediction, and decision support. Decision execution and monitoring level is added to the above scheme. Each level is implemented as a multi-agent system (MAS) seen as a set of cooperating agents operating over a collection of distributed knowledge sources and having a specific set of conditions and associated goals, which indicate the events they should respond to.

A generic architecture of a CMS is proposed using knowledge source concept and agent technology as an agglutinating center of the system. Decomposition of the large system into smaller knowledge-based units associated with knowledge sources reduces the system's control complexity and results in a lower degree of coupling between components.

The CMS architecture outlines the three main components:

1. Prediction system:
Multi-agent architecture of the prediction system consists of three kinds of agents: (1) agents associated with the data sources, (2) agents supporting the implementation of conventional (such as K-means or a nearest neighbor algorithms) and fuzzy classifiers working with particular data sources, and (3) a metalevel component, which is responsible for coordination of local source-based classifiers (meta-classifier Agent).

2. Evacuation logistic planning (ELP) system:
The ELP receives information from the Prediction System to generate contingency plans based on evacuation rules. The plans are generated by means of a mechanism of distributed planning implemented by MAS that considers multiple parameters (such as time required to carry out the plan, cost, risk possibility) to generate the best solution of the problem.

The ELP system is described in more detail to illustrate the approach of the CMS using the formation of coalitions for logistics planning in a multi-agent environment. The logistics problem is solved by colluding- coordinating actions between agents by solving a joint optimization problem. Two models are implemented in the ELP. The first one uses distributed coalition formation algorithm with fuzzy rules. The second approach uses cooperative game theory with fuzzy coalitions. In both algorithms, agents use fuzzy rules of Mamdani type for decision making and leverage previous work by the authors for Supply Chain Networks.

3. Control and monitoring system:
Implemented as a MAS, with a purpose to monitor the situation and to transmit orders to personnel's units involved in the handling of the contingency, the control and monitoring system connects the ELP and prediction systems directly with the real units that participate in the evacuation. This system allows data collection from both fixed infrastructure (platforms, ducts, warehouses, housings, etc.) and mobile infrastructure (terrestrial, marine and air rescue vehicles, specialized units, etc.) and provides this information to the planning system. Another important function (to be implemented in future releases) of this system is the real time tracing of the current state of the system (personnel at the platforms, location of a ship or a helicopter, how many people it carries on board, etc.). Finally, this system facilitates op order transmission to the units to carry out the contingency plans.

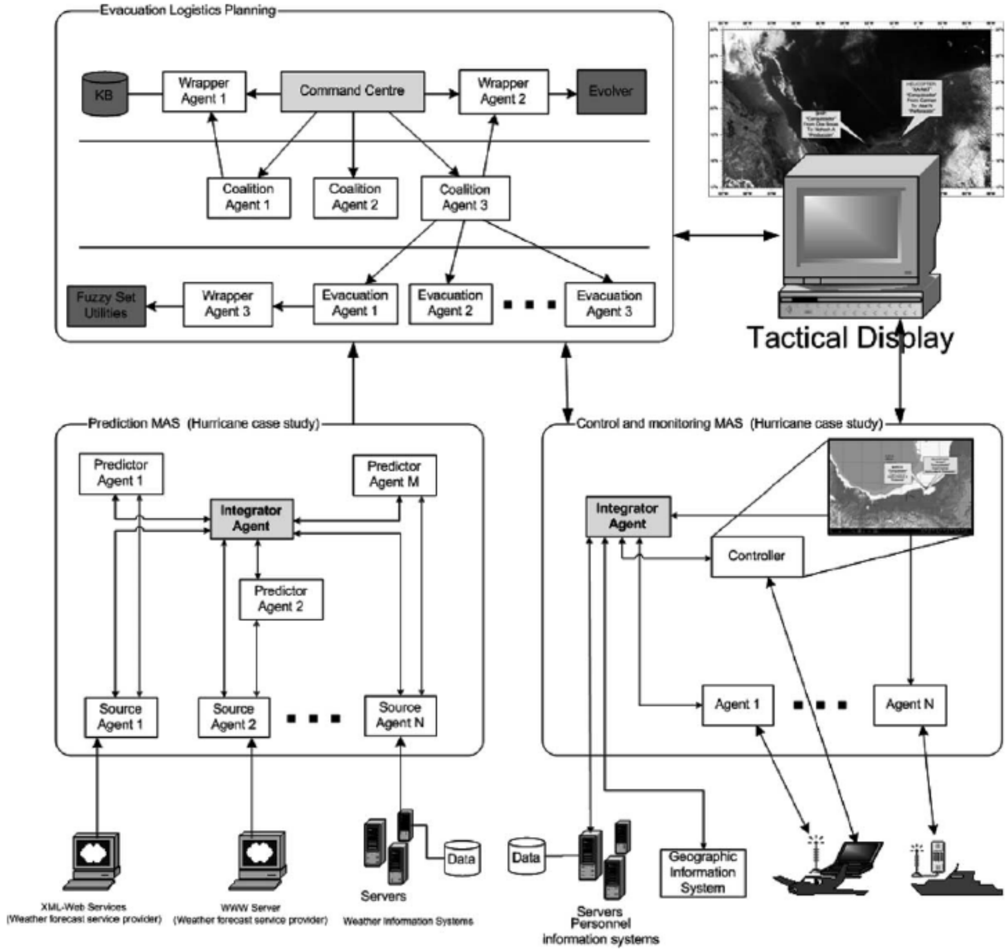

Figure 46. *CMS generic architecture*

<u>Observations:</u>
Very comprehensive description of a CMS that uses an agent-based system that could operate as a stand alone or be integrated into a larger DSS. The development of coalition formation techniques with fuzzy knowledge acquisition for environments where the agents are self-interested, and there is an underlying intractable combinatorial problem that limits the agents' rationality because the problem cannot be solved optimally in practice is applicable to Air Force rapid response planning. In addition, the communication infrastructure between the involved units and the control centers enables the data acquisition that allows the CMS to re-plan the contingency plan in case the current plan cannot be carried out.

[44] Tryan, Jana Lee (2008). CAE Deploy: Revolutionizing first responder deployment, White Paper published by CAE Professional Services (Canada) Inc., Ottawa, ON.

<u>Context:</u>

Much of the decision support tool requirements for air force immediate contingency operations mirror those requirements of emergency management planners. The planning process is often conducted after a critical event has occurred, requiring immediate response time. An understanding of the resources available, identifying an optimal course of action and issuing the order to execute through appropriate channels is all a part of this process. One available tool is CAE Deploy One available tool is CAE Deploy which is currently implemented to support the Ottawa Paramedics Services. [14]:

Content:

> "CAE Deploy is a revolutionary decision support tool to facilitate Communications Officers (emergency response dispatchers) in making challenging real-time deployment decisions. Integrated with the Service's computer-aided dispatch (CAD) system, CAE Deploy provides the Communications Officer with real-time deployment recommendations to ensure the organizational business rules are met for the immediately call while concurrently optimizing the probability that the business rules will continue to be met if a subsequent response is required before the assigned resources are released form the current tasks. At all times the Communications Officers are prompted to adhere to the organization's predetermined deployment strategy and consider the human factors requirements of the Paramedics".

The CAE Deploy system functions of this emergency management DSS provide a departure point for the development of a DSS for air force immediate contingency operations in the areas of SA, human factors, coverage area modelling, COA development and GUI.

Observations:
A civilian emergency response system used for crisis action planning is an applicable comparison for research of Air Force rapid response planning and it serves as a useful comparison to military planning tools. The following outlines the information for each area investigated as they pertain to the Air Force.

1. Situational Awareness:

CAE Deploy provides a task tailored operational picture through the graphical user interface (GUI) of the DSS. The recommendations of the DSS are included as an overlay of this interface. The display has a simple, one-stop representation of resource status and availability, updated in real-time through automatic vehicle locator (AVL) feeds.

For air force immediate contingency operations, this should be one of the primary interface for planners. The nature of most immediate contingency operations requires a persistent understanding of the current situation as it evolves.

CAE Deploy's GUI also provides an alerting system to indicate a change in the situation that requires a decision from the Communication Officer, along with a recommended COA. This change in situation could be a new incident that requires

[14] There are a wide variety of emergency resource management tools that are available for first responders. This tool was chosen as a representative sample. CAE's familiarity of its design enabled an in-depth discussion.

the deployment of an available unit, or the release of previously tasked units now available for new tasks. Within the context of air force immediate contingency operations, an alerting system would provide for dynamic COA generation based on changes in readiness.

2. Human Factors:

Within the realm of Paramedic deployment, many human factors considerations are often omitted on the grounds that planning time is severely constrained. As a result, little attention has been paid to addressing the habitual issues plaguing Paramedics, such as not receiving adequate eating or break periods, spending countless hours mobile in the unit, working unscheduled overtime, and inequitable distribution of the workload [CAE Deploy White Paper]. As a result, the recommended COA for deployment utilizing CAE Deploy includes considerations of preset priorities related to business rules related to Paramedic human factors.

Applied to the context of air force immediate contingency operations, a similar underlying rule-based algorithm would provide a means for incorporating considerations that would otherwise be either overlooked or removed from consideration due to time constraints.

3. Coverage Area Modelling

CAE Deploy provides a response coverage model that represents area of responsibility as well as probabilistic considerations of next available deployment in providing an up-to-date understanding of real-time response capability. The coverage area considers factors related to the next call for service as well as the ability for available resources to respond.

For air force immediate contingency planning, the coverage area model could provide a filter for graphically representing operational capability, including the capability to respond to a range of potential contingencies as defined within existing CONPLANs.

4. Course of Action (COA) Development

The main purpose of CAE Deploy is to offer the optimal deployment option to Communication Officers, taking into account those predetermined human factors, road algorithms and resource availability. The same process is desirable for a DSS for air force immediate contingency planning. Evaluating a feed of required operational information (i.e. own air resource readiness) against a set of defined rules allows for the assisted generation of real-time COAs for a time-constrained deployment of resources for a mission.

Some key differences exist. CAE Deploy is designed to run off of a predetermined, policy-driven set of human factors business rules. To have a functioning COA development system that supports immediate contingency operations and the CF OPP, there needs to be the ability to modify these rules based on a specific mission's end-state. A template set of rules based on CONPLANs and standing national and CF objectives. Nonetheless, these rules need to be both explicit and modifiable.

The nature of paramedic deployment requires the DSS to provide a single, optimized COA for responding to a change in the situation. However, the CF OPP calls for the development and comparison of multiple COAs. By modifying the transitive nature of the business rules, separate COAs can provide alternatives that meet multiple objectives within a constrained time period.

The development of COAs would need to advance beyond a single functional resource. CAE Deploy specifically addresses the deployment of paramedic units. The DSS would require the capability to include or interface with joint and other agency DSS. Further, air force operations often require complex operational activities, requiring more robust event sequencing and deployment options.

5. Graphical User Interface

The success of Deploy is partially due to the effort put into the user interface design. The UI was designed in collaboration with the users to allow optimal display of information at critically-relevant times. Because the end-users were involved in the process from conception, they have an emotional investment into it.

Any tool developed for the Air Force should have end user involvement in the interface design to ensure not only ease of use but willingness to use.

[45] United Nations (2006). Integrated Missions Planning Process (IMPP), New York, USA: United Nations. Pages: 21.

Context:

The Integrated Mission Planning Process (IMPP) is the authoritative basis for the planning of all new integrated missions, as well as the revision of existing integrated mission plans, for all UN agencies (departments, offices, agencies, funds and programs). The process will follow three stages, each requiring specific inputs, outputs and decision points:

- Stage 1: Advance Planning, comprising two ‘levels’ – Level 1 being the Advance Planning to develop strategic options for expanded UN engagement, and Level 2 which provides the Foundation Planning as the basis for development for a concept of operations (COP).
- Stage 2: Operational Planning, again comprising two ‘levels’ - Level 3 which operationalizes the draft mission plan and Level 4 which covers transition of responsibility to the field.
- Stage 3: Review and Transition Planning, the final two ‘levels’ – Level 5 which focuses on continuous review and updating of the mission plan where necessary and Level 6 which deals with draw-down of peacekeeping and transition.

Content:

The IMPP is intended to be implemented in a flexible manner, taking into account varying circumstances and timeframes, while ensuring that adequate planning standards, outputs and the key decision points are respected. Below are key elements of the IMPP:

- The IMPP proposes timeframes for each level;
- Both the process and mission structures must be properly established so as to avoid the ad hoc approach of the past and ensure that system wide strategic objectives are clearly established and supported by the functional planning of the respective mission and UN Country Team (UNCT) components;
- Integrated mission form (mission structure) should follow function and be tailored to the specific characteristics of each country setting;

- It aims to ensure that the right people are at the table, that the right issues are being considered, and that the appropriate authorities and accountabilities are in place to motivate flexible, creative, and integrated strategic and operational thinking and planning;
- Integration is the guiding principle - The IMPP will be consistent with and mutually supportive of other relevant planning processes with emphasis placed on achieving proper sequencing of planning activities, coherence in identifying needs, objectives and results, and identifying CF OPPortunities for linking planning activities.

Observations:
The model is decision centric. Each stage has associated levels, with each level is tied to a decision point – the outcomes of the decision triggers movement to the next level. Each level has defined objectives, responsibilities, key outputs, phase and timeframe.

The HQ planning team (operational) works closely with the in country team (tactical) and may provide representatives from one to work with the other (co-located liaison officers).

Flexibility acknowledges that throughout the lifespan of the Integrated Mission Task Force (IMTF), its membership and level of participation may change as required depending upon the Mission's objectives. Once the Integrated Mission is fully operational, the objectives, membership and functions of the IMTF should be reviewed and revised accordingly. The importance of flexibility from the goal and objectives portion down to the assignment of tasks to the tactical level all need to be flexible within this type of coalition environment. When Canada and other nations contribute to UN actions, the schedule and activities involved in their planning process need to be complimentary. This is enabled by the sharing of data at various stages is critical in maintaining this flexibility.

This article points towards the importance of a tool that could support an integrated process by enabling the sharing of data and, as such, providing an interface between multiple partners. However, the reality of an integrated tool is difficult considering the complexity of elements in multiple stakeholder planning processes. It is more worthwhile to focus on the concept of interfacing and thus enabling sharing information, to, for instance, support partners to align their planning process rather than integrate them.

[46] United States Army (2006). The Operations Process, FMI 5-0.1, US Army Training and Doctrine Command, United States.

Context:
As mentioned in the document, the manual "provides doctrine for the exercise of command and control throughout the conduct (planning, preparing, execution, and assessment) of full spectrum operations." It is the US equivalent of the Canadian doctrine, "CF Operations". As a result, it is written for a broad audience as a standalone document within an army context. It was updated in 2006, and is thus the most recent doctrinal publication available. It has a specific section on military decision making, which is of greatest relevance to the project and is covered below. Also of interest is the specific coverage of stability and reconstruction operations to increase relevance for commanders in theatres such as Iraq and Afghanistan.

Content:

The majority of the manual is focused on specific army-related definitions, functions and guidance. The generic information of relevance relates to overall operations cycles and decision support cycles.

Of use are the definitions provided for the different types of operations. The different types are included in the diagram below:

Figure 47. *Full Spectrum Operations*

Of relevance is the definition of stability and reconstruction operations:

Stability and reconstruction operations sustain and or establish civil security and control over areas, populations, and resources. They employ military capabilities to reconstruct or restore essential services and governance, and provide support to civilian agencies. Stability and reconstruction operations involve both coercive and cooperative actions. They may occur before, during, and after offensive and defensive operations; however, they also occur separately, usually at the low end of the spectrum of conflict. Stability and reconstruction operations lead to an environment in which, in cooperation with a legitimate government, the other instruments of national power can predominate.

As one of the most common type of current operations, this definition provides useful guidance in understanding the general scope for providing decision support. Additional value is the US Army's understanding of the difference between objectives, effects and tasks:

Objectives *prescribe* friendly goals;
Effects *describe* behaviour in the operational environment; and
Tasks *direct* friendly action.

The section on military decision making is of greatest relevance to this project. The manual differentiates between intuitive decision making ("the act of reaching a conclusion that emphasizes pattern recognition based on knowledge, judgment, experience, education, intelligence, boldness, perception, and character"), Analytic decision making (to "analyze a problem, generate several possible solutions, analyze and compare them to a set of criteria, and select a solution"), and the hybrid of military decision making. It mentions the importance of intuitive decision making when time is compressed, allowing for the most effective execution of key command functions: recognizing the key elements and implications of a particular problem or situation; rejecting impractical COAs; and selecting an adequate (rather than the optimal) COA.

The operations process laid out in the manual is very comparable to the CF process. It includes four major steps:

1. Planning;
2. Preparation;
3. Execution; and
4. Assessment.

The planning functions carry the same principles of developing an appropriate COA to meet a desired end state, and engaging in continuous review through the operation. Of relevance is the importance placed on command visualization, the first stage of the planning process: "the mental process of developing situational understanding, determining a desired end state, and envisioning how the force will achieve that that end state". This process is further illustrated in the figure below within the overall context of command and control:

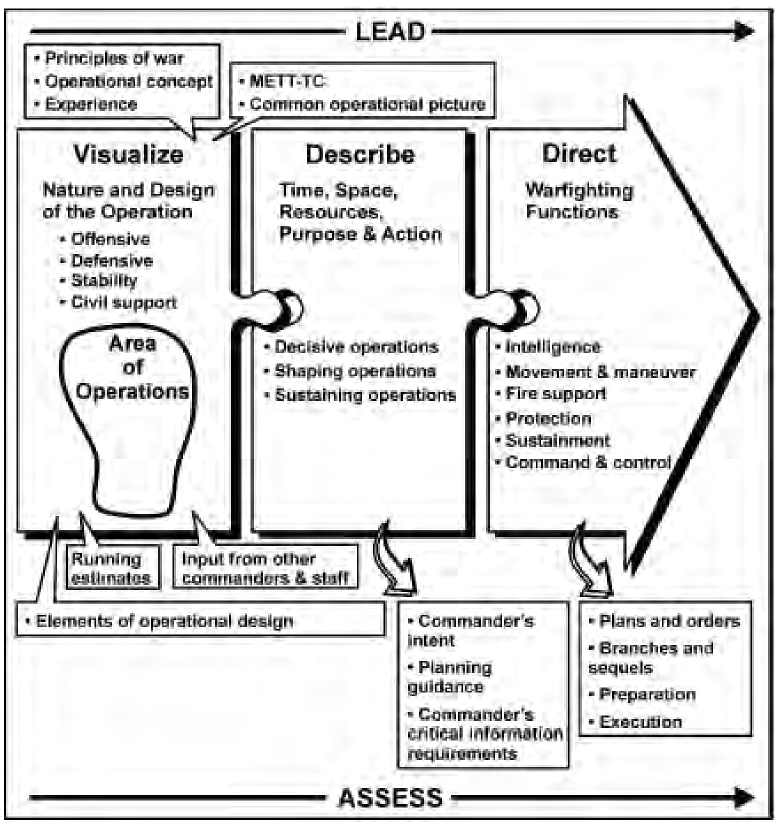

Figure 48. *Commander's role in Command and Control*

<u>Observations:</u>

The doctrine in the manual is of interest from a command decsioin making perspective, but there is little specific data on air force. The data on command visualization, definitions of decision making and the overall operational process is informative for framing, and can be referenced in the high level requirements of the system development. Since the Canadian and US operational doctrines are so similar, there is little additional knowledge that can be gained out of the documentation that is not already raised from *CF Operations.*

[47] Valentine, Nick et al. (2007). Resource utililisation and situational awareness in a computer simulated decision task: A pilot study. Funded by US Air Force contract AOARD-05-4018 titled Metacognition and Situation Awareness in Dynamic Decision Making.

Context:

Achieving control of dynamic and complex situations is always challenging involving as it does the management of cognitive resources. It has been proposed that one of the leading causes of error in such dynamic environments is a generalised tendency to attempt to use more task resources than one's cognitive capacity can sustain, termed the overutilisation of resources bias.

Content:

The aim of the study was to explicitly take into account individual differences in cognitive capacity in an investigation of this human tendency to overuse resources, and its proposed effect on decision-making efficiency. By forcing a measurable overload of data to manage on users, traditional cognitive processing limitations were expected to be observed, but it was found that individuals can cope with excessive workloads by strategic allocation of resources usage, a capability referred to as *metacognitive* control. This research was originally meant to detail the overutilization bias in resources management, involved in dynamic decision-making. Three dependent variables were measured to assess the impact of excessive resources to be managed, with the hope of observing the impact of the overutilization bias on dynamic decision-making tasks: (i) decision-making performance, (ii) mental workload, and (iii) situational awareness.

It was concluded that individual flexibility in the quality of strategic thought allocated to resource usage, or in other words, the degree metacognitive control, may well be a major predictor of decision-making efficiency in dynamic environments.

Observations:

Somewhat surprisingly, the impact of excessive additional resources to manage in the simulation exhibited no significant impacts on decision-making performance, mental workload, and situational awareness. There were subtle, indicative differences in measurement interactions, such as the following:

> "*Participants who performed relatively better in the MANAGEABLE condition allocated more strategic thought to appliance usage in the EXCESS condition than participants who performed relatively better in EXCESS. Therefore, participants relatively better in MANAGEABLE appeared to be trying to utilize the overabundance of appliances in a more strategic manner, which led to their working memory and attention capacities being exceeded. In support of this, participants relatively better in MANAGEABLE had a higher mental workload and had more*

difficulty managing their mental workload in the EXCESS condition than participants relatively better in EXCESS, a finding that will be discussed in further detail later", and "*… the general finding that participants sacrificed strategic thought more in the EXCESS condition provides some evidence that the participants were perhaps compelled to use the over-abundance of appliances. Important to note however, the finding of no-difference in self-perceived performance between the conditions is contrary to the proposal that all people believe "more is better" with regard to information and other decision resources. Rather, only some individuals might hold this belief. Also important to note, perceptions of performance generally correlated with actual performance and therefore, the low correlation in such perceptions across conditions suggest participant insensitivity to the effect of the resource availability manipulation on their performance.*"

Such comments may suggest that different cognitive "styles" are involved in resource management and dynamic decision-making. It may be worthwhile to assess the fit between users and system design with regards to resource management capabilities as well as looking into the cognitive ergonomics relating to cognitive and learning styles, to see whether individual differences may provide specific recommendations for system use, training, and development.

[48] Wang, X., X.Z. Gao and S. J. Ovaska. A. (2007). Hybrid Optimization Algorithm Based on Ant Colony and Immune Principles. International Journal of Computer Science & Applications 2007 Technomathematics Research Foundation, Vol. 4 Issue 3, pp 30-44.

Content

During recent years, biology-inspired soft computing methods have been widely used in different optimization problem solving cases. For example, the Clonal Selection Algorithm (CSA), an important branch of the Artificial Immune Systems (AIS), takes its inspiration from the clonal selection mechanism that describes the basic natural immune response to the stimulation of non-self cells, namely antigens. The Ant Colony Optimization (ACO) algorithm is another emerging approach mimicking the foraging behavior of the ant species. However, these powerful optimization methods have their inherent shortcomings and limitations. As we know, fusion of the computational intelligence methodologies can usually provide superior performances over employing them individually. Therefore, this paper proposes a hybrid algorithm based on the CSA and ACO is proposed to cope with complex optimization problems under both static and dynamic environments.

Context

The pheromone-based meta-heuristic elitism and hieratical search strategy of the ACO together with the outstanding local search ability and solution diversity characteristics of the CSA are fully utilized and combined in the new optimization algorithm. Simulation results demonstrate the remarkable advantages of the approach in diverse optimal solutions, closely tracking varying optimum, as well as improved convergence speed, achieving an improved performance over both the CSA and ACO. Compared with these two methods, it is capable of providing more diverse and flexible solutions as well as closely tracking the optimum under dynamic environments. However, the hybrid optimization approach suffers from a moderately high computational complexity, which may lead to certain engineering implementation difficulty, and thus hinder its employment in the real-time cases. The future research work will focus on applying this novel optimization scheme for solving practical problems.

Observation

Bio-philosophy is increasing being used to understand structures of behaviour and define realms that contain a number of contextual relationships of activities. The theory of emergence and the analysis of swarm behavior and ant systems are examples. This perspective can provide solutions for optimization which are more ‘bottom up’ rather than ‘top down’. In crisis environments, the situation evolves from the bottom up, and as such, these perspectives warrant investigation for rapid response planning.

List of symbols/abbreviations/acronyms/initialisms

1 CAN AIR DIV	1 Canadian Air Division
3-D	3-D Policy: Defence, Development and Diplomacy
ACC	Air Combat Command
ADANS	Airlift (or AMC) Deployment Analysis System
ADL	Action Description Language
AFCCIS	Air Force Command and Control Information System
AFMSS	Air Force Mission Support System
AI	Artificial Intelligence
AIMS	Australian Incident Management System
AMC	Air Mobility Command
AOD	Air Operations Directive
AOR	Area of Responsibility
AOO	Areas of Operation
APSS	Anticipatory Planning Support System
ARP	Advanced Research Project
ARRC	NATO Rapid Reaction Corps
ATD	Analyse Taskind/Direction (module)
ATO	Air Tasking Order
AW	Action Workflow
BC	British Columbia
BCKS	Battle Command Knowledge System (US Army)
BCRC	BC Response Centre
C2	Command and Control
DCR	Deputy Commander Canadian NORAD Region
DP	Directorate of Personnel
C4I	Command, Control, Communications, Computers, Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance
CADTTAP)	Concepts, Approaches, Doctrine, Tools, Techniques, Algorithms and Processes
CAMAS	Crisis Assessment, Mitigation, and Analysis System
CAMPS	Consolidated Air Mobility Planning System
CanadaCOM	Canada Command
CANOSCOM	Canadian Operational Support Command
CANR	Canadian North American Aerospace Defence Command (NORAD) Region
CAOC	Combined Air Op Centre
CAOS	Combat Air Operations System
CAP	Crisis Action Planning

CAS	Complex Adaptive Systems
CBR	Case Based Reasoning
CBRNE	Chemical, Biological, Radiological, Nuclear, Explosive
CEFCOM	Canadian Expeditionary Force Command
CF	Canadian Forces
CF OPP	Operational Planning Process
CFACC	Combined Forces Air Component Command
CFB	Canadian Forces Base
CFD	Chief of Force Development
CJTL	Canadian Joint Task List
CLOIS	Complex, Large-scale, Integrated, Open System
CMSS	Crisis Management Support System
COA	Courses of Action
COMPES	Contingency Operations/Mobility Planning and Execution System
CONPLAN	Contingency plans
COPlanS	Collaborative Operational Planning System
COPS	Collaborative Operational Planning System
COS	Chief of Staff
CPMT	Collaborative Project Management Tools
CTAPS	Contingency Theater Automated Planning System
DART	Disaster Assistance Response Team
DC	Distributed Cognition
DCAPES	Deliberate and Crisis Action Planning and Execution Segments
DCAPES	Deliberate Crisis Action Planning and Execution Segment
DDM	Dynamic Decision Making
DFO	Department of Fisheries and Oceans
DI	Distribute Information (module)
DND	Department of National Defence
DNDAF	Department of National Defence Architecture Framework
DoDAF	Department of Defense Architecture Framework
DRDC	Defence Research and Development Canada
DSS	Decision Support System
EDM	Emergency Decision Making
EMAT	Emergency Management Active Tool-Kit
EMR	Execution Management - Replanner
FEMA	Federal Emergency Management Agency
FM	Force Module
ForMAT	Force Management and Analysis Tool
FP	Finalize Planning (module)
FPS	Force Planning Scenarios
FSET	Fighter Standards and Evaluation Team

GA	Generic Algorithms
GCCS-AF	Global Command and Control System–Air Force
GEMINI	Global Emergency Management Information Network Initiative
GIS	Geographic Information Systems
GPS	Global Positioning System
GVRD	Greater Vancouver Regional District
GWWS	Groupware Windowing Systems
HHQ	Higher Headquarters
HLSCOM	Homeland Security Command
HQ	Headquarters
HQDP	Headquarters Defence Plan
I/O	Input and Output
IAP	Incident Action Plan
IBLT	Instance-based learning theory
ICS	Incident Command System
IDSS	Intelligent Decision Support System
IF	Information Fusion
IFP	In-Flight Planner
IMPP	Integrated Mission Planning Process
IO	International Organizations
IRF(L)	Immediate Reaction Force (Land)
IS	Information Systems
ISAF	International Security Assistance Force
JADE	Joint Assistant for Development and Execution
JCF OPP	Joint Operation Planning Process
JDL	Joint Director of Labs
JDL	Joint Director of Labs
JDP	Joint Defensive Planner
JFHQ	Joint Force Headquarters
JIMP	Joint, Inter-agency, Multinational and Public
JOPES	Joint Operations Planning and Execution System
JSTAFF	Joint Staff
JTF	Joint Task Force
KARMA	Knowledge-based Adaptive Resource Management Agent
KM	Knowledge Management
MERL	Mitsubishi Electric Research Laboratories
MERMAIDS	Medical Emergency Response using Military Asset in an Integrated Decision Support
MHSET	Maritime Helicopter Standardisation and Evaluation Team
MILR	Mobile Incidence Level Response
MMA	Mission Management Application

MOAD	Monthly Air Operations Directive
MOGA	Multi-objective genetic algorithms
MOU	Memorandum of Understanding
MPS	Mission Planning System
MPSET	Maritime Patrol Standardisation and Evaluation Team
MRCPS	Multiple Mode Resource-Constrained Project-Scheduling problem
MSS/CAMPAL	Mission Support System -Computer Aided Mission Planning at Air Base Level
NAPP	National Air Planning Process
NATO	North Atlantic Treaty Organisation
NGO	Non-governmental Organizations
NIMS	National Incident Management System
NOC	National Operations Centre
NORAD	North American Aerospace Defence Command
N-PFPS	Portable Flight Planning System
OA	Options Analysis (module)
OGDs	other government departments
OMB	Office of Management and Budget
Op O	Operation Order
Op Plan	Operations Plan
OSCE	Organization for Security and Cooperation in Europe
OV	Operational View (see DoDAF)
PDA	Personal Digital Assistant
PDDL	Planning Domain Definition Language
PDH	Personal Digital Historian
PFPS	Portable Flight Planning Software
PSEPC	Public Safety and Emergency Preparedness Canada (now Public Safety Canada)
RAMP	Remote Access Mission Planning
RBR	Rule Based Reasoning
RCMP	Royal Canadian Mounted Police
RFA	Requests for Assistance
RFI	Request for Information
RHLSCOM	Regional Homeland Security Commands
RI	Receive Information (module)
RRF(A)	Rapid Reaction Force (Air)
RTEST	Real-Time Expert System
S&T	Science and technology
SA	Scientific Authority
SAIC//MPS	SAIC Mission Planning System
SAR	Search and Rescue
SDG	Single Display Groupware
SDLC	Systems Development Life Cycles

SE	Software Engineering
SOA	Service oriented architecture
SOCAP	System for Operations Crisis Action Planning
SOP	Standard Operating Procedure
SSE	Strategic Server Enclave
STRIPS	Stanford Research Institute Problem Solver
TA	Time Appreciation (module)
TAMPS	Tactical Automated Mission Planning System
TAP	Theatre Air Planning
TF	Task Force
TFC	Task Force Commander
TOC	Tactical Operations Centre
TOPFAS	Tool for Operational Planning, Force Activation and Simulation
TPFDD	Time-Phased Force and Deployment Data
TPFDD	Time Phased Force Deployment Data
TRIPS	The Rochester Interactive Planner System
TRSET	Transport, Rescue Standards Evaluation Team
TRUE	Traffic Rerouting for Unplanned Events
UC	Unified Command
UK	United Kingdom
UN	United Nations
US	United States
USAFE	United States Air Forces in Europe
UTC	Coordinated Universal Time
UTC	Unit Type Codes
WAOD	Weekly Air Operations Directive
WKB	Warrior Knowledge Base (US Army)
WNG O	Warning Order
YAOD	Yearly Air Operations Directive

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This project was conducted to provide research support to the Command and Control (C2) Decision Support Systems Section of Defence Research and Development Canada (DRDC) – Valcartier in the area of Air Force rapid response planning for immediate contingency operations. To enhance the ability to effectively plan and conduct immediate contingency operations, there is a requirement to understand both where the planning cycle can be optimised, and in what way new concepts, approaches, doctrine, tools, techniques, algorithms and processes (CADTTAP) can support this. This study identifies operational, theoretical and technical requirements for Air Force operational level rapid response planning for immediate contingency operations and applied applicable CADTTAP to design a conceptual roadmap for decision support system development. Use standing CONPLANs as a key element, the proposed roadmap facilitates the generation of planning documents including identifying the optimal course of action while leveraging a single point data entry of information elements and a flexible template system. The envisioned DSS is based on a Service Orientated Architecture (SOA) that will enable flexibility for system integration and web-based to facilitate the distributed collaboration in a Joint, International, Multi-agency and Public (JIMP) context that is becoming the norm in military operations, especial rapid response

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Air Force, decision support, rapid response, operational planning, immediate contingency operations.

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