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

DEFENCE R&D DÉFENSE

Concepts to support the operational planning process

A time-sensitive perspective

Micheline Bélanger
Normand Pageau
Adel Guitouni
(DRDC Valcartier)

Defence Research and Development Canada – Valcartier

Technical Report

DRDC Valcartier TR 2011-258

November 2011

Canada

Concepts to support the operational planning process

A time-sensitive perspective

Micheline Bélanger
Normand Pageau
Adel Guitouni
(DRDC Valcartier)

Defence Research and Development Canada – Valcartier

Technical Report
DRDC Valcartier TR 2011-258
November 2011

IMPORTANT INFORMATIVE STATEMENTS

Abstract

One facet of decision superiority is to shorten the time required to make good decisions. It is in this line of thought that OPP-ADS (Operations Planning Process Advanced Decision Support) has demonstrated an integrated suite of tools able to create/store/retrieve and rapidly adapt operational contingency plans to produce executable plans for specific situations. Complementary to these functionalities, a link management tool allows one to tightly couple tools that support the design of a campaign plan (for example, center of gravity analysis and decisive point analysis), the management of risk elements, the management of criteria with their associated after action report, as well as the management of decision-matrixes. This concept of linking key analysis elements provides the capability to rapidly identify pieces of analysis that can be customized according to the situation. This work has led to the identification of functional requirements related to decision-support tools for operational planning.

Résumé

Un des aspects de la supériorité décisionnelle est de réduire le temps requis pour prendre de bonnes décisions. C'est dans cet état d'esprit que OPP-ADS (Operations Planning Advanced Decision Support) a démontré une suite d'outils capable de créer/sauvegarder/récupérer et adapter rapidement les plans de contingence pour produire des plans exécutables adaptés à des situations particulières. En complément à ces fonctionnalités, un outil de gestion de liens permet d'associer des outils supportant la conception d'un plan de campagne (ex. analyse des centres de gravité et des points décisifs), la gestion des éléments de risque, la gestion des critères avec leur rapport d'analyse après-exécution ainsi que la gestion des matrices de décision. Le concept de lier des éléments clés permet d'identifier rapidement les éléments d'analyse qui devraient être révisés en fonction de l'évolution d'une situation. Ce travail a mené à l'identification de besoins fonctionnels d'aide à la décision pour la planification des opérations.

This page intentionally left blank.

Executive summary

Concepts to support the operational planning process: A time-sensitive perspective

Micheline Bélanger; Normand Pageau; Adel Guitouni; DRDC Valcartier TR 2011-258; Defence R&D Canada – Valcartier; November 2011.

The complexity of situations facing military decision makers makes it extremely difficult to obtain a comprehensive understanding of all dimensions of the decision making situation. It is also very difficult to foresee all possibilities of actions to influence the actual situation and make it change into the desired situation. For example, understanding all possible effects (desired or not) and their relationship is a tremendous undertaking.

The Canadian Forces Operational Planning Process (CFOPP) is the current structured way used by Canada Command (CANADA COM) to perform military planning and problem solving. A large portion of this process deals with brainstorming, holistic situation understanding and high level planning.

The investigation conducted at DRDC Valcartier to develop decision support tools for the CFOPP in a rapid response planning context led to the identification of seven (7) different tools:

- A Plan Management tool providing the flexibility to search and retrieve different types of contingency plans (CONPLAN) as well as to instantly upgrade them according to specific situations. It also provides functionalities to search for existing past plans based on operational category (e.g. domestic, international), force employment scenario (e.g. noncombat extraction, peace support) and the location of the operation. When existing plans have been identified, they can be viewed for reference or modified for use as an OP Plan. When a plan is completed, it is released for distribution;
- A Center of Gravity (COG) Analysis tool supporting planners in their brainstorming to identify the relationship between critical elements (capabilities, requirements, vulnerabilities) influencing friendly as well as adversary centers of gravities. It leads to the sketching of a first iteration of decisive points;
- A Decisive Point Analysis tool supporting the planners in their brainstorming to sequence decisive points into lines of operations and to identify operational phases with their associated objectives and tasks. It provides the grounds to initiate the thinking required to identify possible branch plans and/or sequel plans where transition conditions are desired;
- A Criteria Management tool providing management functions for COA evaluation criteria. This provides access to different repositories of COA evaluation criteria (e.g. different sets of evaluation criteria are associated with expeditionary operations or domestic operations) as well as to COA evaluation criteria used in previous, relevant operations and finally it copies them over for use in the current operation being planned;
- A Decision-Matrix Management tool supporting quantitative as well as descriptive analytical approaches;

- A Risk Management tool supporting the planners in the identification of risk elements (with their causes), their assessment and a mitigation strategy throughout the different stages of the CFOPP;
- A Dynamic Link Management tool providing the capacity to link key CFOPP elements (such as mission analysis elements, COA elements and plan elements) together. By visualizating these relationships, it enables the planners to easily identify the mission analysis and plans elements that could be affected by potential situational changes. It also allows linkage of strategic plan elements to operational plan elements and operational plan elements to tactical plan elements.

The existence of a baseline tool allowing the collaboration of a distributed team in the execution of a structured planning process is a prerequisite to operationalize such concepts. In the current investigation, we used COPlanS, which provides such appropriate network-enable planning environment.

The work described in this report is the result of a first implementation effort to demonstrate decision support tools for the design of campaign plans as well as the utilisation of contingency plans in order to reduce the time required to produce executable plans. The refinement of these concepts will require empirical validation and assessment as well as more R&D efforts. It is acknowledged that, this effort did not address all the concepts that could be integrated to support the CFOPP. For example, the integration of concepts such as the implications of second and third order effects will have to be considered in the future.

Sommaire

Concepts to support the operational planning process : A time-sensitive perspective

Micheline Bélanger ; Normand Pageau ; Adel Guitouni ; DRDC Valcartier TR 2011-258; R & D pour la défense Canada – Valcartier ; novembre 2011.

Les situations auxquelles les décideurs militaires font face sont tellement complexes qu'il est extrêmement difficile de développer une compréhension globale des implications associées à toutes les décisions possibles d'une situation de prise de décision. Il est également très difficile de prévoir toutes les actions possibles pouvant influencer la situation en cours et la faire évoluer vers la situation désirée. Par exemple, la compréhension de tous les effets possibles (désirés ou non) et leurs relations est une tâche non négligeable.

Le commandement Canada (COM CANADA) utilise le processus de planification opérationnel des Forces canadiennes pour planifier et résoudre les problèmes. Une grande partie de ce processus est associée au remue-méninges, à la compréhension globale de la situation et à la planification de haut niveau.

L'investigation exécutée par RDDC Valcartier pour développer des outils d'aide à la décision pour le processus de planification opérationnel des Forces canadiennes dans une situation de réponse rapide à permis l'identification de sept (7) outils différents :

- Un outil de gestion des plans permettant de chercher et récupérer différents types de plans de contingence et de les mettre à jour en fonction de la situation en cours. Il permet également de faire des recherches sur les plans passés en fonction de leur catégorie opérationnelle (ex. domestique ou internationale), des scénarios (ex. extraction de non-combattant, support à la paix) ainsi que de la localisation géographique des opérations. Lorsque des plans existants ont été identifiés, ils peuvent être consultés pour référence ou être mis à jour pour être utilisés comme plans d'opérations;
- Un outil d'analyse des centres de gravité assistant les planificateurs dans les sessions de remue-méninges permettant d'identifier les relations entre les éléments critiques d'analyse (capacités, besoins et vulnérabilités critiques) influençant les centres de gravité amis et adversaires. Cette analyse permet de faire des itérations pour identifier les esquisses des points de décision;
- Un outil de gestion des critères fournissant des fonctions de gestion aux critères d'évaluation de suites d'actions. Cet outil donne accès à différents répertoires de critères d'évaluation de suites d'actions (ex. différents ensembles de critères sont identifiés pour les opérations expéditionnaires ou domestiques) ainsi qu'à des critères d'évaluation des suites d'actions utilisés dans des opérations similaires précédentes afin de les copier pour les utiliser dans l'opération en cours de planification;
- Un outil de gestion des matrices de décision permettant de définir des matrices par des approches analytiques quantitatives aussi bien que descriptives;

- Un outil de gestion du risque pour l'identification des éléments de risque (avec leurs causes), de leur évaluation et des stratégies d'atténuation couvrant les différentes étapes du processus de planification opérationnelle des Forces canadiennes;
- Un outil de gestion dynamique des liens permettant de lier les éléments clés du processus de planification opérationnelle des Forces canadiennes (tels les éléments d'analyse de mission, les éléments de suites d'actions et les éléments du plan). La visualisation de ces relations permet d'identifier facilement les éléments de l'analyse de mission et du plan qui devront être modifiés par des changements potentiels de la situation. Il permet également de lier des éléments d'un plan stratégique à ceux d'un plan opérationnel et des éléments d'un plan opérationnel à ceux d'un plan tactique.

L'existence d'un outil de base permettant la collaboration d'une équipe distribuée pour l'exécution d'un processus de planification structuré est un préalable pour l'opérationnalisation de tels concepts. Dans l'investigation en cours, nous avons utilisé COPlanS qui fournit cet environnement réseau centrique pour la planification.

Le travail décrit dans ce rapport est le résultat d'un premier effort d'implémentation pour démontrer des outils d'aide à la conception de plans de campagne ainsi que pour l'utilisation de plans de contingence permettant de réduire le temps nécessaire au développement de plans exécutables. Le raffinement de ces concepts nécessitera des efforts de validation et d'évaluation empirique ainsi que davantage de recherche et développement. Il est reconnu que cet effort ne couvre pas tous les concepts pouvant être intégrés pour supporter le processus de planification des forces canadiennes. Par exemple, l'intégration de concepts, tels que les implications des effets du deuxième et du troisième ordre, devra être envisagée dans le futur.

Table of contents

List of figures

List of tables

This page intentionally left blank.

1 Introduction

Today's integrated command and control environment is extremely complex. The "Commanders" must accomplish multiple, varied, and frequently time-critical actions that may have life-or-death outcomes. A core enabler of modern C4ISR is the ability to perform military business within a network centric operations paradigm. The networking of all sensors, operational centers, organizations, and personnel of the Canadian Forces (CF) can provide a competitive advantage by enabling an operational tempo that will allow the force to accomplish its mission by shaping the situation or by reacting to changes faster than an opponent can react. This advantage will be possible by establishing organization and developing processes and technologies able to support decision makers in their decision making processes trough the transformation of the information superiority into knowledge and knowledge into decision leading to decision superiority. The concept of decision superiority [1] is being defined as the ability of the commander, based upon information superiority and situational understanding, to make effective decisions more rapidly than the adversary, thereby allowing one to dramatically increase the pace, coherence, and effectiveness of operations.

Figure 1: JCDS 21 Decision Loop

DRDC conducted a technology demonstration project to demonstrate a joint, network-enabled collaborative environment achieving decision superiority through the enhancement of agility in two broad domains: information (the way information is shared) and cognition (the way people in organisations perceive and think, share intent and make decisions). This project is called Joint Command Decision Support 21st Century Technology Demonstration Project (JCDS 21 TDP). In this project, process, organization, and technology are considered key elements of a net-enabled collaborative environment. In this project, the networking of people, organization and technologies to conduct collaborative work is considered key to achieving decision superiority. The complexity of the challenges facing the CF demands innovative means and technologies to support critical thinking, team building, course of action development, shared situation awareness,and execution management. Considering the provision of situational awareness as the prelude to informed analysis, adaptive planning, and effectual management of operations, JCDS

21 TDP demonstrated concepts, strategies and technologies to support situation analysis and knowledge management, visualization, planning and operations management (Figure 1).

A net-enabled environment supporting decision superiority should be inherently agile and flexible, rich in information, decision-centric and supports collaborative working. It should be available to all CF members and provide tools supporting their mission critical capabilities. Canada Command (CANADA COM) has identified one of them as being adaptive planning. This capability might be seen as the ability to conduct a timely and flexible planning process and to develop options for employing joint capabilities across the sea, air, land and cyber spectrums [2].

To support CANADA COM in the achievement of this dynamic planning capability specially time sensitive dynamic planning, JCDS 21 TDP has decided to include into its roadmap the demonstration of advanced concepts and technologies to support real-time course of action planning, decision analysis and execution management. Accordingly, JCDS 21 TDP concept of operations [3] states: "Joint Command Decision Support should effectively support time-critical as well as deliberative collaborative joint planning, distributed team problem solving and options analysis".

This report describes the CF planning process and the concepts that are being proposed to support the planners in the design of operational plans as well as in the utilization of contingency plans in order to reduce the time required to produce executable plans. These concepts address the needs to be able to create/store/retrieve and rapidly adapt operational contingency plans to produce executable plans for specific situations. An approach to support the design of a campaign plan (ex. center of gravity analysis and decisive point analysis), the management of risk elements, the management of criteria and the management of decision-matrixes is also discussed. The core functionality of linking key analysis elements together is presented as a capability enabling the rapid identification of pieces of analysis requiring revision according to modifications of the situation. Finally, the integration of a planning tool as an integrated piece of the overall operation management is described.

This report includes a description of how these concepts have been incorporated into OPP-ADS (Operations Planning Process Advanced Decision Support). OPP-ADS is a suite of advanced decision support tools added to COPlanS so as to support the planning of operations as part of joint, net-enabled collaborative environment to achieve decision superiority. Finally, the final experimentation of JCDS21 is briefly presented.

2 Planning in a military operational context

2.1 Operational planning process

The Canadian Forces Operational Planning Process (CFOPP) [4] is a coordinated and coherent process for determining the best method of accomplishing objectives or for planning for possible future tasks. This process is facilitating the logical, analytical and thorough consideration of the many factors that impact on a particular situation without stifling the commander's and his staff's freedom to apply their creativity to develop ideas and concepts to achieve success. The process can be used to develop operational plans, operations orders, contingency plans and the detailed planning of each campaign phase, branch and sequel. Essentially, the planning process is carried out by the staff in support of the commander's decision making process. Figure 2 provides the five steps of the CF OPP and their associated output products.

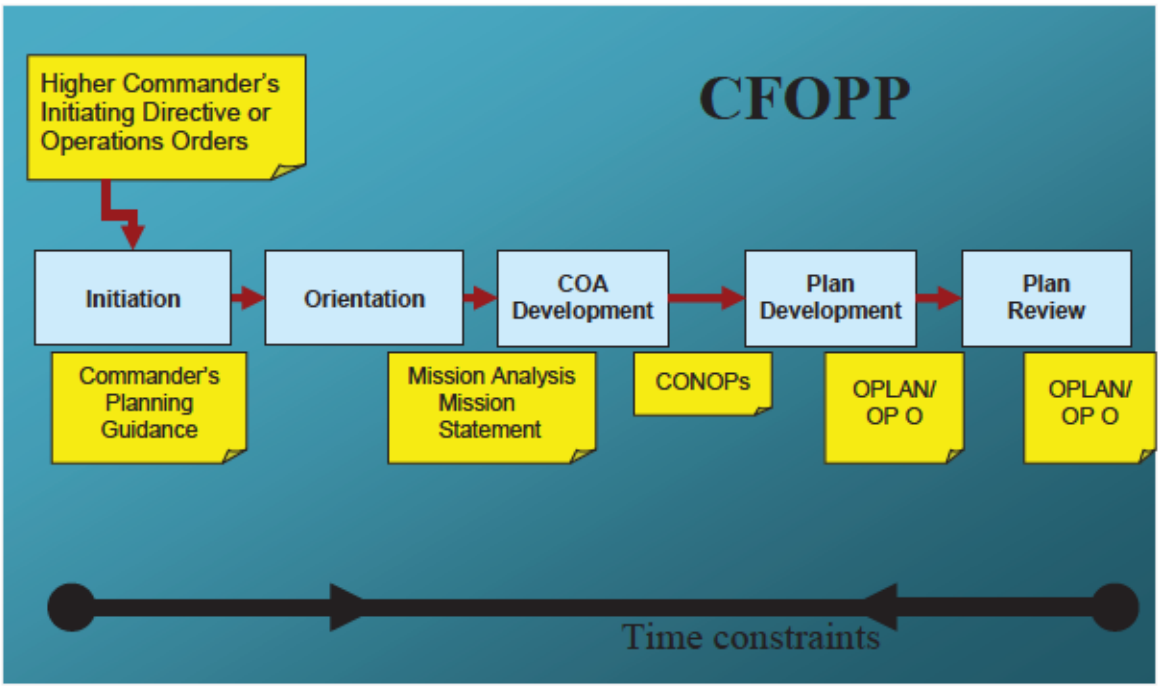

Figure 2 : Canadian Forces Operational Planning Process

The CFOPP can be employed for deliberate planning as well as for rapid response planning (or crisis action planning):

- Deliberate planning consists of initiating and developing plans in anticipation of a known or anticipated future events or circumstance. It is not subject to the immediate pressures of time or prevailing threats;
- Rapid response planning consists of initiating and developing plans in response to a current or developing crisis. It requires an expeditious co-ordination and approval.

Nowadays it is often very difficult to draw a firm distinction along classic staff lines between operations and plans. These are no longer (even if they once were) discrete processes. Operations in the 21st century have become analogous to continuous planning and planning and operations have grown into a single integrated process. In concert, the pace of environmental changes has also necessitated frequent reviews and updates of contingency plans, which have process, organization and technology implications [3].

Within Department of National Defence (DND), a meaningful distinction is now drawn between strategic/long-range and operational/nearer term planning. One benefit is that this arrangement aligns much more closely with non-military staffs (i.e., typically incident management operations staff focus on the next 24-48 hours and planning staff focus on 24 hours plus). There is no mature strategic/long range planning equivalent [3].

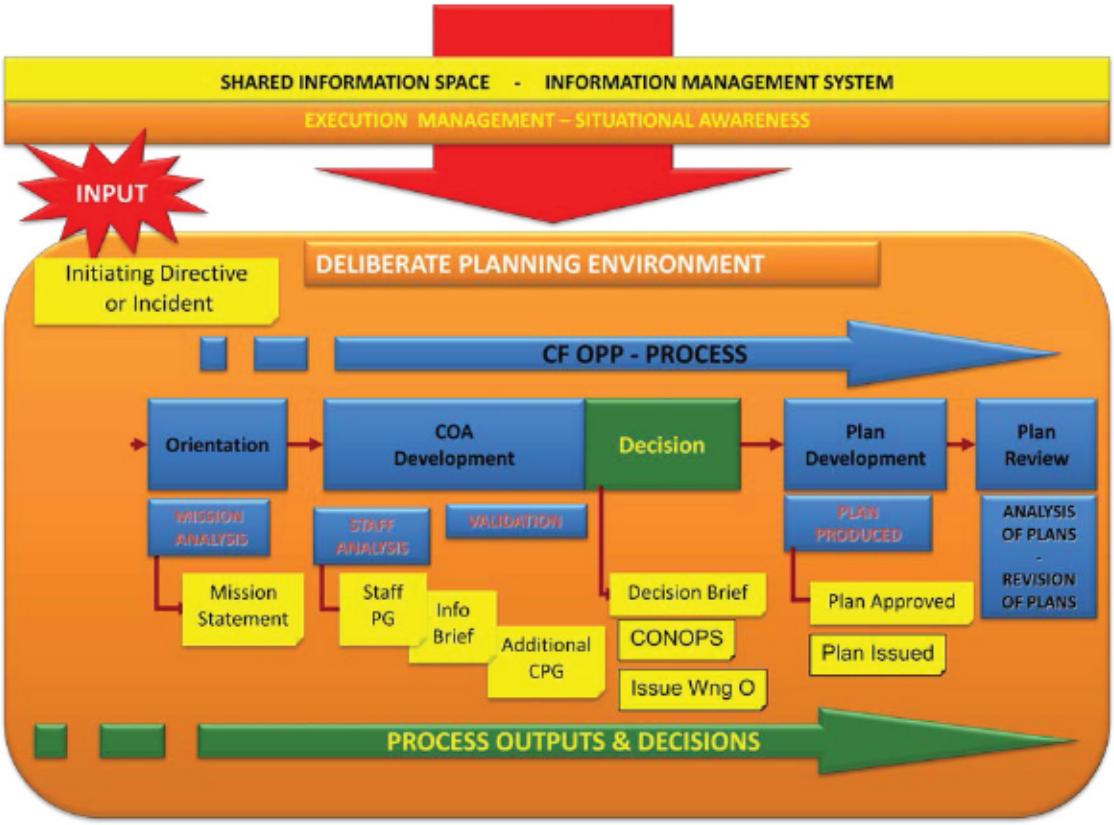

Figure 3 : Planning Process Information Flow & Requirements [5]

The CF OPP is fuelled by information that serves very specific purposes. The information required to allow the commander to remain engaged in this command support function falls in two basic areas. To do so, the commander must have unrestricted access to documents received from his superior headquarters to initiate and orient his own planning process. From this point on, the commander will be required to review and comment on key deliverables from the CF OPP and provide guidance and decisions to his staff. The final step would require the commander to review a plan, approve it and authorize its distribution. The yellow boxes in Figure 3 outline the type of information output to be exchanged between commanders and staff and higher commanders and his subordinate commanders.

In the *orientation* stage, the commander orients his/her staff in the determination of the nature of the problem and the confirmation of the results to be achieved. Then, the commander begins the

analysis and definition of the mission, prepares the planning guidance and describes his intent and the desired end state of the operation. The orientation step includes the analysis of higher headquarters' orders; initial intelligence; assessment of specified, implied and essential tasks; review of the available assets; estimation of the constraints; identification of the critical facts and assumptions; risk assessment; commander's critical information requirements; initial reconnaissance; mission analysis briefing; development of initial commander's intent and issue of the commander's guidance. Commander's critical information requirements (CCIRs) are satisfied by the provision of information pertaining to friendly forces, the adversary and the physical environment. The intelligence preparation of the battlespace (IPB) process is critically dependent upon relevant information and in turn provides key inputs to the overall operational planning process (OPP).

All these analysis efforts conduct to the identification of a mission statement that will answer the following questions:

- Who (what types of forces) will execute the action?
- What type of action (for example attack, defend) is contemplated?
- When will the action begin?
- Where will the action occur (area of operations and objectives)?
- Why (for what purpose) will each force conduct its part of the operation?

The commander's planning guidance, which is the output of the orientation stage, will be used to develop the course of action (COA) (in the COA development stage) that will be further detailed in the plan development stage.

The *course of action development* stage results in the production of the concept of operations (CONOPS) that identifies the commander's line of action in order to accomplish his/her mission. This stage involves the entire staff. The commander's guidance and intent help the staff to focus on the development of comprehensive and flexible plans within the time available. These plans, called COAs, *"should answer the fundamental questions of when, who, what, where, why and how"*. Each COA should be suitable, feasible, acceptable, exclusive and complete[4]. A good COA positions the force for the future 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 COA development stage, staff members analyze the relative combat power of friendly and enemy forces, and generate comprehensive COAs. As part of the COA Development stage, the *Decision* follows and consists of a choice of the best COA according to the commander's beliefs and estimates. If the commander was to reject all of the proposed COAs, then the staff would be required to start the process over again. This step is based on the analysis and comparison of the proposed COAs, and the primary approach used in this analysis is war-gaming. The central framework used by the staff in the war-gaming is a discussion of the actions, reactions and counter-reactions. It relies heavily on doctrinal foundation, critical judgment and experience. During a war-gaming session, the staff takes a COA and determines its strengths and weaknesses by putting it against potential enemy's COAs. As a result of this analysis, the commander and his staff may make changes to an existing COA or develop an entirely new one. Prior to the war-gaming session, the commander will identify a list of evaluation criteria. These criteria represent the factors to measure the relative effectiveness and efficiency of each COA. The *COA comparison* step highlights the respective advantages and disadvantages of each COA. The most commonly used technique is the decision matrix, which used pre-defined evaluation criteria to assess the evaluation of each COA. Each staff officer is free to use his own matrix – with the commander's criteria – for comparison in his own field of expertise. Typically, these matrices do not provide a decision solution and, in practice, the Chief

of Staff (COS) determine each criterion relative importance. An ad hoc aggregation process leads to one or more recommendations and the COS then decides which one he will recommend to the commander during the commander's decision brief.

2.2 Commander's decision making process

In military terms, decision making is the process by which commanders make decisions. It corresponds to sufficiently reduce uncertainty and doubt about alternatives to allow a reasonable choice to be made. Commander's decision process is intimately linked to the staff planning process discussed earlier. The output of the planning process feeds information to the commander and enables him to make decisions.

Table 1 outlines the type of products the commander would need to access and how frequently he will access them to remain involved in the deliberate planning process and decision making associated with the CFOPP. Typically, the CFOPP at the operational level occurs over longer periods of time leading to the production of contingency plans or operational plans. Contrary to the planning and decision making process associated with an incident or on-going operation, these activities are not time sensitive. The commander would most likely have time to return to his headquarter to be involved in the planning.

Table 1: Planning Information Requirements Matrix [5]

Info Source	Information Product	Frequency	Commander's Interaction
Command View	Mission View	As required	Commander may have to access keystone documents such as plans, role of engagement (ROE), strategic guidance throughout the planning process
CF OPP: Higher Commander's orders, guidance Own SA	Initiation	Upon receipt of an initiating directive or warning order from CDS or SJS	Commander must read and react to the documents received from higher. Ability to extract key elements and import them into his commanders planning guidance
	Orientation	In accordance with the planning battle rhythm IAW the timeframe allocated by the higher HQ	Conduct mission analysis Develop own mission statement Fine tune CPG Access and participate in the mission analysis brief Issue guidance to the staff including concept of operation Develop and issue a warning order to subordinate commanders
	COA development	As required but most likely only once to receive the decision brief	Commander may be required to answer questions from the Staff via email, chat or voice Commander must have access to the decision brief produced by the staff Commander must have the capability to actively participate in the decision brief to provide guidance to staff Commander must be able to select COA, provide additional guidance and articulate an CONOPs
	Plan development	As required	Commander is generally not involved unless his staff needs to confirm elements of the plan with him commander may be required to consult his superior to discuss aspects of the plan or seek clarification
	Plan review	In accordance with the planning battle rhythm IAW the timeframe allocated by the higher HQ	Commander must be able to access the plan in order to: Review the plan Make changes to the plan Approve the plan and authorize its release as an order Commander may have to back brief higher or other government department (OGD) partners on his plan. This may include Providing guidance to staff to prepare a briefing Reviewing and approving the briefing Could include conducting the briefing from a remote location

The decision making process is all about the dynamic, which exists between a commander and his subordinates, the commander with his staff and the commander with his superior(s). Figure 4 outlines the decision making process by which commanders make decisions deliberately or under operational conditions often characterized by a compressed decision cycle. The diagram also identified the conditions and enablers required to support and enhance the decision making process.

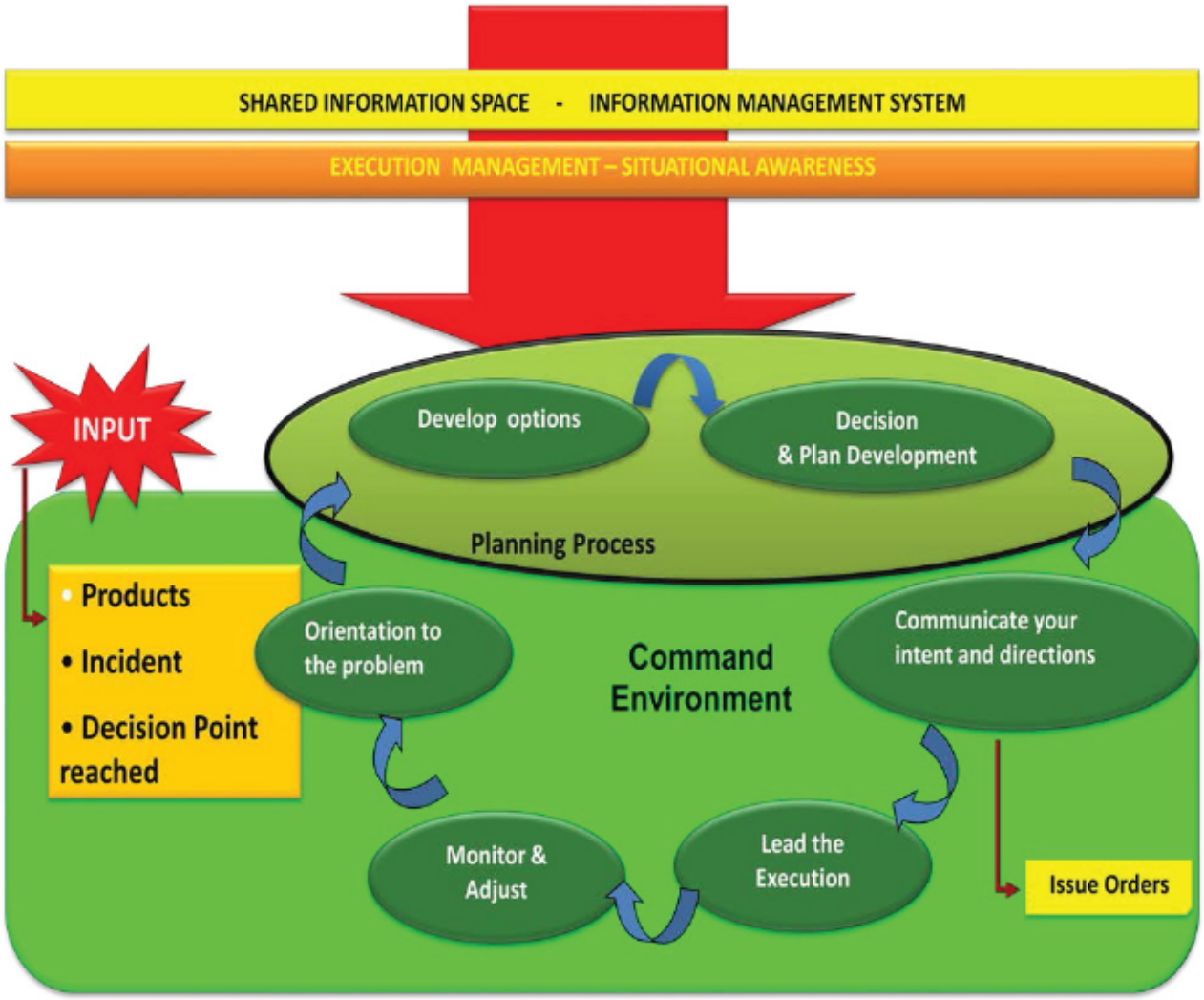

Figure 4 : Decision Making Process [5]

2.3 Key requirements

Requirements of the Joint Staff engaged in planning and decision making have been identified at the beginning of the JCDS21 project [6]. The analysis of observations of daily Global Situation Briefs (GSB), daily Joint Staff Action Team (JSAT) meetings, mission specific JSAT meetings and mission specific mini-JSAT meetings led to the identification of a list of gaps related to the planning of an operation. These gaps included:

- Difficulty identifying components in decision making process;
- Emphasis needs to be made on the quality of the decision, process of decision making and justification of decision;
- Lack sufficient resource visibility (people, materiel);
- Difficulty in identifying what are the critical information elements for decision-making;
- Difficulty in presenting the information in a way that helps identifying actions to be taken (action knowledge);

- Difficulty in developing and analyzing courses of action, including resource management, predictive analysis, risk analysis;
- Command and control structure needs to be coordinated for integrated operations – more holistic;
- Virtual collaboration environment to support distributed command is required – consideration that some technologies do not have dual use (i.e., knowledge walls (multiple screens with different views) that are associated with fixed command post, do not support vertical and horizontal neither multi-stakeholder environments;
- Delays in change detection or assessment (violation of assumptions in plans being followed, implications to plan not fully understood);
- Delays during re-planning/Inappropriate replanning (good options overlooked or implications of options not fully understood);
- Goal/priority mismatch between levels of command.

From this study, a list of general deductions and operational requirements has been extracted for the planning and decision support perspective. They are:

- Decisions will have to be made at a much higher rate and higher tempo;
- There will be closer scrutiny of decisions (e.g., public/media focus) and emphasis will continue to be placed on accountability;
- The stress level of the decision maker will increase;
- The "One solution fits all" approach will not be successful;
- Collaborative and analytic tools will be required to support decision makers to facilitate:
  - Synchronous and asynchronous communications and document editing;
  - Time and space planning/synchronization;
  - COA options analysis and risk mitigation;
  - Logistics feasibility; and
  - Process (e.g., IPB, OPP, RFI) management and tracking;
- Effects based planning involves many staffs, and the product is so detailed that a shared database is a prerequisite.

Subsequently, the Command Post Exercise (CPX) Ardent Sentry (1-12 May 2006), confirmed most of the shortfalls and challenges identified during the front end analysis [3]. In particular, there was potential for increased use of contingency plans.

This page intentionally left blank.

3 Concepts to support time-sensitive planning

Different perspectives were considered to support the different stages of the CFOPP that is being executed at the operational level. First, plan management is essential to better support the amendment of generic contingency plan to a specific situation, which should result into a time saving to produce executable plans. Then campaign design support would facilitate the development and the sharing of a common understanding of the commander's intent as being translated into line of operations, effects, decisive points, etc. Two related tools is proposed: a center of gravity analysis and a decisive point analysis. Criteria management as well as a decision-matrix management is proposed to provide more flexibility in the way the decision-makers want to document the COA analysis process. Risk management tool is designed to facilitate the integration of the risk management process into the execution of the CFOPP. Finally, additional mechanisms are proposed to allow the management of the links and dependencies between different elements of the CFOPP.

3.1 Plan management

An automated plan management approach should greatly reduce planning time by reusing common planning elements during the creation of new operation plans (OPLANs) and contingency plans (CONPLANs). As mentioned previously, the execution of the deliberate planning process leads to the development of an OPLAN that is a main executable plan. This type of plan usually addresses a complex defence mission to be executed within a specified time period [4]. An OPLAN includes information about specific forces, functional support and resources necessary to implement the plan. An OPLAN may be implemented at a prescribed time, on signal or through an implementation order (IMPL O) when the conditions of execution occur and an execution time is determined and then becomes an operation order (OP O).

A CONPLAN [4] is a plan prepared to address possible future security risks or in response to a current or developing crisis. A CONPLAN reflects potential response options but no specific time is set for the operation until higher authority approves the execution of the CONPLAN. It contains as much details as possible. A commander may implement a fully developed CONPLAN at a prescribed time, in accordance with prescribed measures through an IMPL O or on order. However, if more than minor changes or updates are required then an OP O must be developed. CONPLANs are developed to anticipate generic possible situations. CONPLANs are generally generic because they cannot predict exactly what will be the situation at a specific time and location. When a situation happens, the CONPLAN is used as the starting point for the OPLAN. Example: a terrorist attack on the Canadian territory. This kind of CONPLAN does not address a specific location. Thus, elements must be general like defining tasks to join local authorities, secure zone of danger, etc. Some CONPLANs can be more specific to address possible situations having a high level of risk. Example: An evacuation plan of Vancouver in the case of a Tsunami, or a terrorist attack during Olympic Games, etc. In both cases, a CONPLAN is used to create an OPLAN.

While an OPLAN as well as a CONPLAN are developed as details as possible, it is required to ensure that these plans stand valid to take advantage of any opportunity. Branch plans are contingency operations built into an OPLAN or CONPLAN and represents plan adjustment that can be executed during an ongoing operation.

While planning an OPLAN and CONPLAN, it is important to think about the approach to reduce the risks associated with transition leading to conflict termination and redeployment. Sequel

plans are these plans describing subsequent operations based upon the probable outcomes of current operations.

Finally, CFOPP can be conducted at strategic, operational and tactical levels. When initiated at the strategic level, the strategic plan developed leads to the development of the operational plan which leads to the development of the tactical plan.

As we can see, it is necessary to maintain a plan management approach that will support the development, storage, access and retrieve of these different types of plans while conducting a CFOPP. An important aspect that a plan management approach should support is the documentation of the execution of the process that has led to a plan. This means that all elements of the analysis conducted during the execution of the CFOPP need to be accessible when we need to work with a plan. Then, when we have to plan an operation for a situation that is similar to past situation, one may want to start with what has been done in this past situation, adjust the estimate according to the new situation and develop the new plan. Not starting from scratch every time may allows saving a lot of time. Furthermore, having access to the outcomes (including strengths and weaknesses of its execution) of a plan that was used for a similar situation in the past would be very efficient during a planning exercise. It is a direct exploitation of past experiences.

The instantiation of a CONPLAN to a specific situation is also in line with this approach since a CONPLAN can be perceived as a generic plan prepared in advanced that will be revised according to a specific situation.

The plan management approach needs to allow linking sub-plans into master plans. For example, constraints identified at the higher headquarter (HHQ) need to be considered in the current plan. Then, as Branch plans and sequel plans can be considered as part of an OPLAN or CONPLAN, we can also think about them as separate entity that could be reused for other situations. Again, all the analysis done for this plan need to be consider to avoid importing a solution outside an appropriate context.

Overall, it is expected that the possibility to manipulate intelligently existing plans to support development of new plans is a requirement that will lead to save time as well as improve plan quality.

3.2 Center of gravity (COG) analysis

Part of the orientation phase is the conduct of a mission analysis. It is an exercise where the review of the situation as well as the higher command level intents will lead to the designation of the centres of gravity, the end states and transition conditions. As described in [4] (Figure 5), these are core elements for the development of a campaign plan which will allow the clarification of concepts required for the conduct of operations, engagements and battles toward the achievement of strategic objectives.

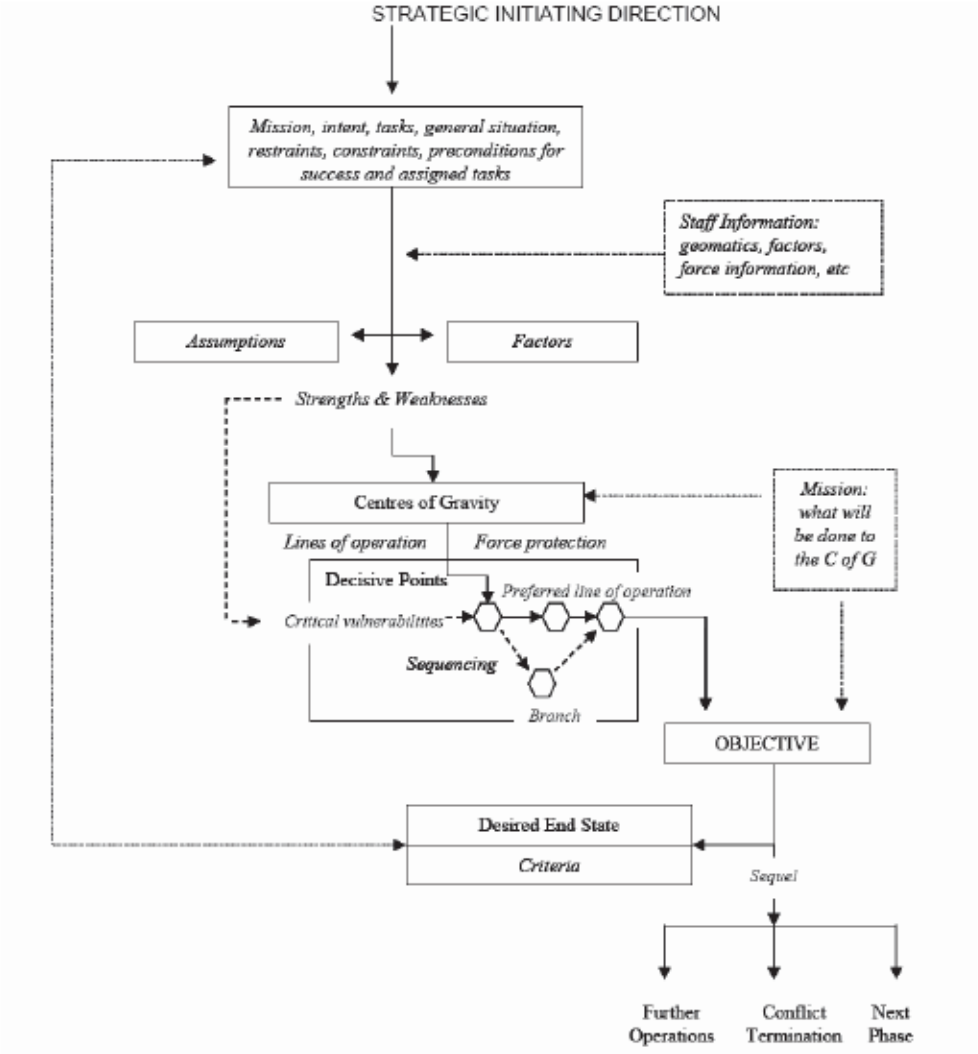

Figure 5: Campaign Planning Tools [4]

Even if not all missions will necessarily be aimed directly at the adversary's centre of gravity, it is expected that all missions must be analyzed in the context of their relationship to the center of gravity of the opposing forces. In fact, the usual expectation is to influence or attack the opposing force's centre of gravity while preserving our own.

Understanding and mapping the different links between the situation elements and center of gravity require a very intensive cognitive effort, which is function of the complexity of the situation. Dr Joe Strange and Colonel Richard Iron [7] have proposed a Center of Gravity Analysis model to facilitate the understanding and analysis of the relationships between centers of gravity and their critical vulnerabilities. Their model is based on four (4) concepts:

- Centers of Gravity (COG): physical, social or virtual (i.e., moral) entities that are the primary components of physical or moral strength, power and resistance;
- Critical Capability (CC): primary ability(ies) of a COG to destroy something, seize an objective or prevent from achieving a mission;
- Critical Requirements (CR): conditions, resources and means that are essential for a COG to achieve its critical capability;

- Critical Vulnerabilities (CV): critical requirements, or components thereof that are deficient, or vulnerable to neutralization of defeat in a way that will contribute to a COG failing to achieve its critical capability.

While anyone of these elements can be identified anytime, the sequential approach can facilitate the analysis. So it is recommended to first identify the COGs (the friendly ones as well as the opponents ones), then for each COG, identify the related CC, for each CC, identify the related CR; and for each CR, identify the related CV. While conducting this analysis, any other element can added at any steps. This CG-CC-CR-CV model should be considered as a support approach to analyze existing and potential vulnerabilities of a center of gravity, leading to the determination of those that could be especially critical. Furthermore, one need to keep in mind that any strength that has already been identified can be considered as a CC or CR, and any weaknesses can be considered as a CV. However the opposite is not true, meaning that all CC, CR are strengths and all CV are weaknesses, but all strengths can not be considered as CC or CR and all weaknesses can not be considered as CV.

Once developed for friendly as well as opponent COG, some of the opponent CV can be considered as High Value Target (HVT). "HVTs are those targets, which the enemy commander is likely to need for the successful completion of his mission and are therefore, of high value to him" [8]. In other words, if attacked, these targets will yield greater benefits to the friendly by its defeat than the resources applied to defeat it.

The critical vulnerabilities identified need to be protected (if blue ones) or attack (if opponents' ones) considering the strengths and weaknesses of friendly, allied and opposition forces [4]. These critical vulnerabilities can be used to identify the critical events that would be able to pave the way to the end-state. These critical events can be called decisive points (DP) [9]. A decisive point is "a point from which a hostile or friendly centre of gravity can be threatened. The point may exist in time, space or in the information environment" [10]. In fact, a decisive point can be better described as an event, the successful outcome of which is a precondition to the defeat or neutralization of a centre of gravity. While COG, CC, CR, CV are associated to us or to an opponent, the DP should only be considered from our perspective, so these DP will be developed to protect our CV and attack opponent's one.

3.3 Decisive point (DP) analysis

Once the decisive points (those related to the protection of friendly critical vulnerability as well as those related to the attack of the opponent ones) have been identified in a COG Analysis, one has in hand most of the pieces to start thinking about possible solutions to achieve the expected results. DP Analysis can then be perceived as an initial step leading to the development of COAs.

Following the COG Analysis, one needs to logically arrange them in an order that is most likely to achieve the end-state. This is called the sequencing of DPs. The concept of Lines of operation allows the establishment of the relationships between decisive points as well as the production of a critical path in time and space along the path to the centre of gravity in order to ensure that events are tackled in a logical progression. They provide the conceptual orientation along series of decisive points that identify the connectivity between actions leading to the elimination of the opposing centre of gravity and the achievement of the strategic aim (desired end state). In a campaign design, the lines of operations can be used to synchronize joint effort and power of the components to integrate their multiple assets of firepower, deception, manoeuvre special operations, etc. to converge upon the opposition centre of gravity. Where possible, the commander should select a variable direction that offers multiple options or branches, thus providing flexibility and ambiguity to his actions [4].

To generate the lines of operations, a decisive point analysis composed of the following set of steps can be executed:

Step 1 – Identifying a Starting Point (Friendly COG) and an Ending Point (Opponent COG): The starting point represents the COG that should be protected and the ending point, the COG that should be taken;

Step 2 – Identifying the different lines of Operations (functional and environmental): These are two different perspectives to present the sequencing of the DP;

Step 3 – Ordering and synchronizing the Decisive Points in Lines of Operations (functional and environmental): For each line of operations, we need to identify which DP need to be achieved before or at the same time as the other ones [11]. If ordering the DP have be done with the functional view, then the environmental view could be provided automatically if the DP have been provided information about which environment would contribute to their achievements;

Step 4 – Identifying the Phases: Phasing is a way of organizing the extended and dispersed activities of the campaign or major operation into more manageable parts that allow for flexibility in execution [4]. Action verbs or templated phases could be used such as: protect, deter, defeat, consolidate, but there should always be the possibility to develop new ones for a specific situation;

Step 5 – Identifying the Objectives: Based on the DP associated to a specific phase, it should be possible to identify one or more objectives associated to this phase. An objective can be defined as "a clearly defined and attainable goal for a military operation, for example seizing a terrain feature, neutralizing an enemy's force or capability or achieving some other desired outcome that is essential to a commander's plan and towards which the operation is directed" [10];

Step 6 – Identifying the Tasks: Once objectives are clear and well understood, a list of tasks can be associated to each DP [12];

Step 7 – Identifying the Branches and Sequels: From the previous steps, we do have a pretty good idea of what is required to be done in order to attain the expected end-state. However, since a campaign plan needs to be adaptable to changing circumstances, resources and limiting factors, it is required to think about the possible opportunities to adjust the basic plan according to specific conditions that could be reflected into decision points. Called a branch plan, it may be represented by additional DP linked to some part of the basic plan. Furthermore in order to reduce the risk of transition between operations, it might also be appropriate to identify what would be the DP associated to a sequel plan.

The execution of these steps facilitates the identification of many elements of a campaign plan, i.e., the lines of operations, phases, objectives, tasks as well as branch and sequel plans. Even if the sequential execution of these steps is the usual way to initiate the execution of this DP analysis, the planners may always go back and forward to any step to modify/add/remove any analysis element.

It is also during this analysis that the identification of other analysis concepts such as desirable or non desirable effects can be developed. These concepts also need to be considered in relation with decisive points and associated objectives in order to develop an overall understanding of the operation.

3.4 Decision analysis criteria management

While going through the CFOPP, the planners have to consider two types of criteria: those criteria used to evaluate and compare the COAs as well as those criteria used to validate if a COA has been developed using a correct approach. These different types of criteria require different management approaches.

3.4.1 Evaluation criteria

Different courses of actions (COA) are usually developed based on the campaign design that has been produced with the Center of Analysis Tool and the Decisive Point Analysis Tool. Each COA should be analyzed and assessed according to a set of evaluation criteria. To identify possible criteria to consider in the evaluation, one can consider:

- Criteria extracted from doctrine documents can be identified for categories of operation (Domestic, Expeditionary) and types of operation (Disaster, low intensity, medium intensity and high intensity). This involves the capability to retrieve criteria from a list of criteria from the doctrine (See Table 2 and Table 3);
- Criteria that have been used in the planning of previous operations, which are similar to the one under planning;
- Criteria that have been categorized into different dimensions called factors. In a previous work [14], 5 factors divided into 14 criteria;
- Table 4) have been identified for problems of airspace control. While these have been developed for a specific type of problem, they can be used as a good basis for such generic list of criteria.

All these become food for thoughts to those that need to suggest evaluation criteria to be considered. The selection of these criteria will be done based on the experience of the planning staff and should represents the different aspects to be considered by the commander while considering the different COAs.

Table 2: Factors(criteria) used in COA Analysis for Expeditionary Operations [13]

Types of operation	**Disaster** Assistance Sp or Non-Combat Evacuation	**Low intensity** Humanitarian Assistance Sp (Permissive)	**Low Intensity** Peace Sp under NATO or UN (Ch VI) (Non-Permissive)	**Med Intensity** Peace Making under NATO or UN (Ch VII)	**High Intensity** War Fighting or Counter-Insurgency (NATO or other multi-lateral alliance)
Factors (Criteria)	C2 Cooperation Host Nation Sp Sustainment Time and Space	C2 Cooperation Host Nation Sp Sustainment Time and Space	C2 Freedom of Action Unity of Effort Interoperability Host Nation Sp ROE Sustainment Coercion Deterrence Time and Space	C2 Freedom of Action Unity of Effort Interoperability Host Nation Sp ROE Sustainment Coercion Deterrence Use of Force Time and Space	C2 Freedom of Action Unity of Effort Interoperability Lethality (Direct) Force Protection Sustainment Surprise Deception Synchronization Deterrence Concentration of Force Time and Space Transition to Peace Psychological Effect (Indirect)

Table 3: Factors (criteria) Used in COA Analysis for Domestic Operations [13]

Types of Operation	Disaster Assistance Sp or SAR	Humanitarian Assistance Sp	Aid to the Civil Power	Support to Law Enforcement	Martial Law under Emergency Measures Act
Factors (Criteria)	C2	C2	C2	C2	C2
	Cooperation	Cooperation	ROE	ROE	ROE
			Interoperability	Interoperability	Interoperability
	Public Support	Public Support	Public Support	Public Support	Force Protection
					Public Support

Table 4: Summary of factors and criteria [14]

Factor	Criteria	Optimization	Scale	Evaluation
Flexibility				
	C_1: Covering operational tasks	Maximize	Cardinal, [0,1]	Crisp, Deterministic, Continuous
	C_2: Covering mission locations	Maximize	Cardinal, [0,1]	Crisp, Probabilistic, Continuous
	C_3: Covering enemy COAs	Maximize	Cardinal, [0,1]	Crisp, Probabilistic, Continuous
Complexity				
	C_4: Operational complexity	Minimize	Ordinal, 5 echelons	Crisp, Deterministic, Discrete
	C_5: Logistical complexity	Minimize	Ordinal, 5 echelons	Crisp, Deterministic, Discrete
	C_6: Command and control complexity	Minimize	Ordinal, 5 echelons	Distribution, Discrete
Sustainability				
	C_7: Sustainability	Maximize	Cardinal, $\mathbf{R}^+$	Crisp, Deterministic, Continuous
Cost of resources				
	C_8: Cost of resources	Minimize	Cardinal, $\mathbf{R}^+$	Crisp, Deterministic, Continuous
Risk				
	C_9: Impact of sensor coverage gap	Minimize	Ordinal, 3 echelons	Distribution, Discrete
	C_{10}: Military personnel loss	Minimize	Ordinal, 7 echelons	Crisp, Probabilistic, Discrete
	C_{11}: Collateral damage	Minimize	Ordinal, 7 echelons	Crisp, Deterministic, Discrete
	C_{12}: Confrontation risk	Minimize	Ordinal, 7 echelons	Crisp, Probabilistic, Discrete
	C_{13}: Equipment reliability	Maximize	Cardinal, [0,1]	Crisp, Probabilistic, Continuous
	C_{14}: Personnel effectiveness	Maximize	Ordinal, 5 echelons	Fuzzy, Distribution, Discrete

3.4.2 Validation criteria

The validation criteria consists in aspects that need to be verified to make sure that elements of analysis have been developed "selon les règles de l'art". There could be such validation criteria developed for each type of analysis element. In the doctrine as well as in the literature, we usually limit such validation to 3 important aspects: the identification of COG, the identification of COA, the identification of evaluation criteria. For the COG validation, the CFC CJSOH proposes two criteria [16]:

- "Defeatability": Its destruction or neutralization will inevitably lead to the defeat of the adversary (or the nullification of the adversary's ability to prevent the joint force from attaining its objectives); and
- "Targetability": It is a system, target set or capability that can be successfully engaged, either directly or indirectly, with operational level military power.

For the identification of a COA, the doctrine CFOPP [4] proposed a set of viability requirements. To be viable, each COA must meet the following validation criteria:

- Suitability. Staffs must review and test every proposed COA to determine if it can accomplish the military mission and achieve the desired end state.
- Feasibility. Are there sufficient resources available and in-theatre to conduct and sustain the operation?
- Acceptability. Is the COA militarily prudent, that is, do the probable results justify the estimated costs in terms of potential losses in time, materiel and military personnel?
- Compliance. Does the COA comply with approved CF doctrine, applicable policy, regulations, legislation and guidelines?
- Exclusivity. Is the COA fundamentally different from the others that are being developed?
- Completeness. Does the COA, as presented, clearly identify the force requirements, timings, phasing, and objectives?

For the identification of a set of COA evaluation criteria, the field of multi-criteria decision-aid have identified that, to ensure the robustness of a decision, the family of criteria used should be [17]:

- Readable : The number of criteria used must be relatively low;
- Operational : The family of criteria must be accepted by the stakeholders and the decision makers);
- Coherent : The coherence property implies that the criteria used are exhaustive, non-redundant and cohesive. These proprieties being described as:
  - Exhaustivety: The set of criteria used is exhaustive in the sense that the addition of a new criterion would not affect the result of the decision process when comparing two options. In our case, it means that the addition of a new criterion would not affect the comparison of 2 COAs because this set already reflects adequately all the attributes and effects that a stakeholder (Officer, Commander, etc.) considered pertinent to the evaluation process [15];
  - Non-redundance: The criteria used must contribute to discriminate between different actions. Eliminating a criterion should have an impact on the result of the decision process and should render the criteria family non-exhaustive
  - Cohesivity: There must be consistency between the global and the local preference levels. For example, consider two options a and b which are indifferent on a global level. Suppose that a' and b' are 2 options obtained by degrading a with respect to a criterion i and improving b with respect to another criterion j. Then in a global sense, b' must dominate a';
- Independent: It is preferable but not absolutely necessary that the criteria used be independent.

While the COA evaluation criteria are identified by the military SME, the two first aspects are automatically granted. However, the other ones still need to be validated.

As we can see, the validation criteria, are aspects that are static (they do not change from an operation to another one) that need to be verify. According a standard checklist approach would be an acceptable approach to use if the appropriate checklist is brought automatically at the appropriate time during the execution of the CFOPP.

3.5 Decision-matrix management

Once COAs have been developed, COA analysis consists in challenging each one of these COAs to adversary COAs. Normally, the most probable and the worst case scenarios are developed as Enemy (or adversary) COAs. For each evaluation criteria, each COA is evaluated in perspective of adversary COAs. The next step consists in considering this information to identify the best COA to perform the mission. The Decision Matrixes is one approach to support the decision-maker in this cognitive activity. Those grids allow identification of strengths and weaknesses of each COA. Then, the identified weaknesses can help planners to correct their COAs.

To support the planning staff in the comparison of COAs, two different decision-matrix approaches were identified to provide flexibility according to the preference that the user may have: a qualitative analysis decision-matrix (descriptive comparison) as well as a quantitative analysis decision-matrix (numerical and ordinal comparison). In the qualitative analysis grid, the planner is given the opportunity to document any advantage or disadvantages that are identified for each COA according to each criterion and present them in a grid. In the quantitative analysis, the planner will have to determine the evaluation of each COA according to each criterion. The scale of the evaluation can be cardinal or ordinal, according to the definition of the criteria. With the quantitative approach, the COA can be compared using a MultiCriterion Decision Aid (MCDA) approach to produce a ranking of the COAs with the associated explanations [18].

The qualitative approach can be used alone, or can be used conjointly with the quantitative approach. Effectively, the information provided in the qualitative approach becomes the justification of the results of the evaluation identified in the quantitative approaches. Anyway, in both cases, the decision-maker will have to identify the importance of each criterion. This is called the weight of the criteria. If the decision-maker have consulted past cases, then, he can also have access to the weights that were identified at the time, and the after action report that may provide indication about the appropriateness of the weights used at that time. Accordingly, we can see that the criteria management approach will also have to support the manipulation of weights and some after action report information.

3.6 Risk management

Due to the nature of military operations, the identification and mitigation of risks need to be performed often and across all the processes. In military operations, the failure to manage risk can lead to the loss of resources, lives and ultimately catastrophic mission failure. Accordingly, the Canadian Forces have developed a risk management methodology (Figure 6, Figure 7) that needs to be conducted during all operation life cycle [19]. Risk management consists of risk assessment (threat identification and assessment) and risk mitigation (develop controls, make decisions, implement controls, and supervise and review).

Risk management is also an essential part of the CF OPP. The commander will use his judgment to balance the requirement for mission success with the inherent risks of military operations. The risk management process is a tool that can assist the decision-makers in identifying the most appropriate course of action (COA) and ensures that the implications of residual risks are understood and communicated. Risk management, a commander's responsibility, must be fully integrated into the planning, preparation, and execution of operations.

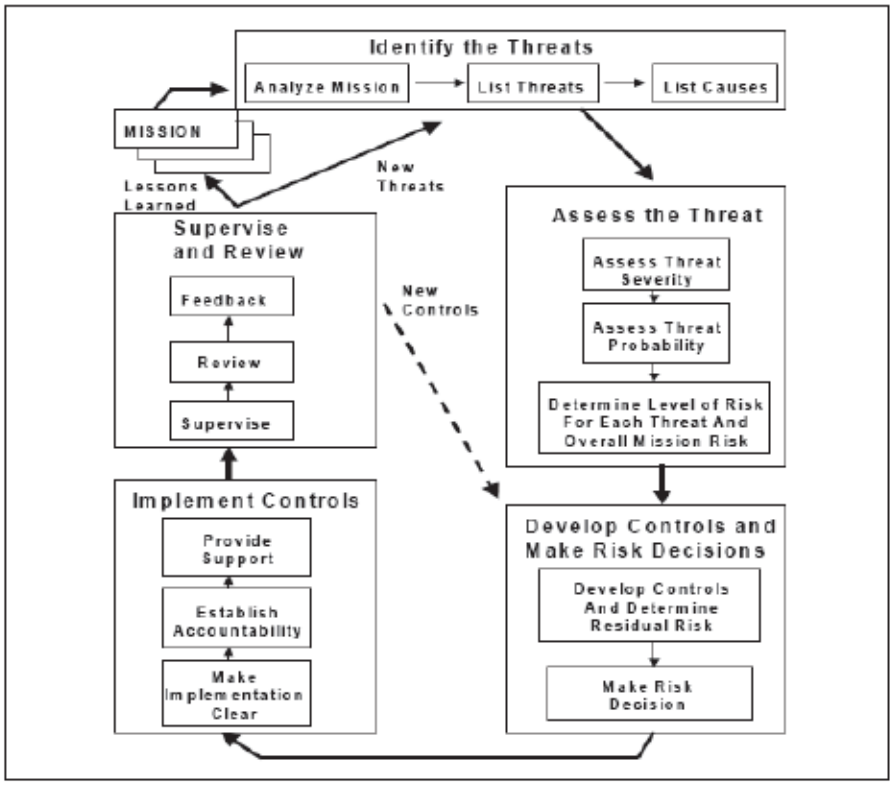

Figure 6: Risk Management Process

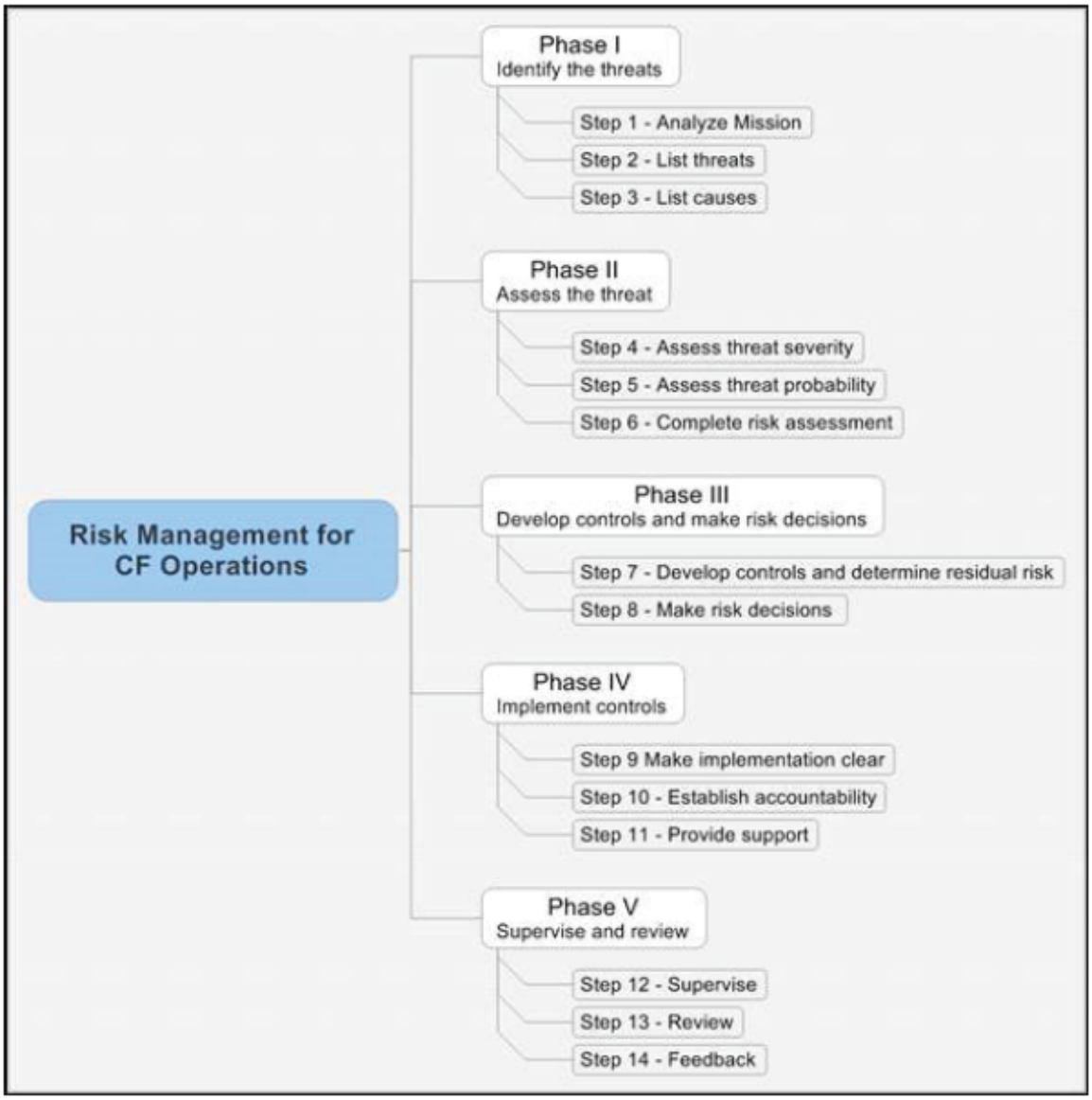

Figure 7: Risk Management Phases

It becomes mandatory to any decision support tool for the CFOPP to support the risk management process for:

- Identification of the threats;
- Assessment of the threats;
- Identification of threat reduction strategies.

This can be done by providing a collaborative authoring tool for the identification of risk elements (with their causes), their assessment and a mitigation strategy throughout the different stages of the Canadian Forces Operational Planning Process (CFOPP). The existing risk management tool that is developed in the doctrine should be integrated into such tool (Figure 8). A risk element will be assessed considering its level of severity and its level of probability (Figure 9), where the level of the risk severity is defined according to Table 5. The resulted risk assessment should be interpreted as follow:

E - Extremely High Risk: If these threats occur during the mission, it will most likely fail with severe consequences to personnel and equipment or operational objective(s). The ability to accomplish the mission will be lost;

H – High Risk: If these threats occur during the mission, a significant degradation of capability in terms of achieving the required operational objective(s), the inability to accomplish all parts of the mission, or the inability to complete the mission to standard; will occur;

M – Moderate Risk: If these threats occur during mission, the expected degradation of mission capability, in terms of achieving the required operational objective(s), accomplishing all parts of the mission, or completing the mission to standard; will occur. An unlikely probability of catastrophic loss exists; and

L – Low Risk: Expected losses or effects have little or no impact on accomplishing the mission.

A risk matrix can be used to present a view of the global risk assessment before and after mitigation strategies have been developed (Table 6).

Risk Management in CF Operational Planning						
		Identify Threats	Assess Threats	Develop Controls Make Risk Decisions	Implement Controls	Supervise And Review
CFOPP	Stage I Initiation	X				
	Stage II Orientation	X	X			
	Stage III COA Development	X	X	X		
	Stage IV Plan Development			X	X	
	Stage V Plan Review					X
Rehearsals					X	X
Employment and Assessment					X	X

Figure 8: Risk Management Process and CFOPP

Risk Assessment Matrix						
		Probability				
Severity		Frequent A	Likely B	Occasional C	Seldom D	Unlikely E
Catastrophic	I	E	E	H	H	M
Critical	II	E	H	H	M	L
Marginal	III	H	M	M	L	L
Negligible	IV	M	L	L	L	L

Figure 9: Risk Assessment Matrix

Table 5: Risk Severity Categories

Risk Severity Categories	
Category	**Definition**
CATASTROPHIC (I)	Loss of ability to accomplish the mission or mission failure. Death or permanent disability. Loss of political support or coalition effectiveness. Loss of major or mission-critical system or equipment. Major property (facility) damage. Severe environmental damage. Mission-critical security failure. Unacceptable collateral damage.
CRITICAL (II)	Significantly degraded mission capability, unit readiness, or personal disability. Damage to political support or coalition effectiveness. Extensive damage to equipment or systems. Significant damage to property or the environment. Security failure. Significant collateral damage.
MARGINAL (III)	Degraded mission capability or unit readiness. Minor impact on political support of coalition effectiveness. Minor damage to equipment or systems, property, or the environment. Injury or illness of personnel.
NEGLIGIBLE (IV)	Little or no adverse impact on mission capability. No adverse affect on political support or coalition effectiveness. First aid or minor medical treatment. Slight equipment or system damage, but fully functional and serviceable. Little or no property or environmental damage.

Table 6: Risk Probability Categories

Element Exposed	Definition
FREQUENT (A) Occurs very often, continuously experienced	
Single item	Occurs very often in service life. Expected to occur several times over duration of a specific mission or operation.
Fleet or inventory of items	Occurs continuously during a specific mission or operation, or over a service life.
Individual	Occurs very often. Expected to occur several times during mission or operation.
All personnel exposed	Occurs continuously during a specific mission or operation.
LIKELY (B) Occurs several times	
Single item	Occurs several times in service life. Expected to occur during a specific mission or operation.
Fleet or inventory of items	Occurs at a high rate, but experienced intermittently (regular intervals, generally often).
Individual	Occurs several times. Expected to occur during a specific mission or operation.
All personnel exposed	Occurs at a high rate, but experienced intermittently.
OCCASIONAL (C) Occurs sporadically	
Single item	Occurs sometime in service life. May occur about as often as not during a specific mission or operation.
Fleet or inventory of items	Occurs several times in service life.
Individual	Occurs over a period of time. May occur during a specific mission or operation, but not often.
All personnel exposed	Occurs sporadically (irregularly, sparsely, or sometimes).
SELDOM (D) Remotely possible; could occur at some time	
Single item	Occurs in service life, but only remotely possible. Not expected to occur during a specific mission or operation.
Fleet or inventory of items	Occurs as isolated incidents. Possible to occur sometime in service life, but rarely. Usually does not occur.
Individual	Occurs as isolated incident. Remotely possible, but not expected to occur during a specific mission or operation.
All personnel exposed	Occurs rarely within exposed population as isolated incidents.
UNLIKELY (E) Can assume will not occur, but not impossible	
Single item	Occurrence not impossible, but can assume will almost never occur in service life. Can assume will not occur during a specific mission or operation.
Fleet or inventory of items	Occurs very rarely (almost never or improbable). Incidents may occur over service life.
Individual	Occurrence not impossible, but may assume will not occur during a specific mission or operation.
All personnel exposed	Occurs very rarely, but not impossible.

Table 7: Risk Matrixes

B-GJ-005-502/FP-000

EXAMPLE

Preliminary Risk Score Matrix						
COA # 2		Probability				
Severity		Frequent A	Likely B	Occasional C	Seldom D	Unlikely E
Catastrophic	I	1	2	3		
Critical	II	1		2		
Marginal	III	3	4	1		
Negligible	IV	4				

Residual Risk Score Matrix						
COA # 2		Probability				
Severity		Frequent A	Likely B	Occasional C	Seldom D	Unlikely E
Catastrophic	I					
Critical	II	1	1			
Marginal	III	2	1	3		
Negligible	IV	4	2	4		

In the preliminary risk score matrix the scoring indicates that there are "3" threats in quadrant IIIA, "2" rated in IB and so on. Controls are imposed to eliminate the priority risks: those most likely to occur and with the most severe consequences. Once the controls are imposed the risk is re-evaluated to determine its new level. The goal is to have residual risk at the minimum level possible.

3.7 Dynamic linkages of CFOPP elements

The CFOPP is a structured problem solving process accomplished by a team of people from different military environments (joint, air, maritime, land) and having different areas of expertise. The execution of this process leads to the identification of information elements essential to understand the different aspects of a complex situation and produce genuine operational plans. By analysing the different elements (e.g., the facts, assumptions, constraints, restraints, centers of gravity, effects) and their potential relationships and dependencies, the planning staff will be in a better position to understand the problem structure and how to propose good COAs for the Commander to achieve his desired effects.

While the situation evolves, some of the conclusions obtained during the mission analysis may be invalidated. As the planning process is executed by a team of many people, it is possible that the

details of the analysis (which have mostly been developed in the head of some individuals) have not been shared amongst all the team members even if the end result of the analysis has been shared. In this case, it could be difficult for the different team members to identify what elements of the analysis need to be revised.

Furthermore, since there may be a time gap between the development of a plan and its actual execution, the situation needs to be continuously monitored to detect, as soon as possible, any change that may have an impact on the plan. The plan modifications will directly depend on the situation changes. For example, change detection about the availability of resources under our responsibility may require to adjust the plan and if not possible, to develop a new COA. Moreover, if the situation evolves quite differently from the expectations and there is time available, the planning process may have to be restarted from the beginning. It is important to notice that the people monitoring the situation to identify if the plan needs to be revised may not be the ones involved in the planning process. This involves that the monitoring team would not necessarily be aware of the details of the analysis. Accordingly, it could be difficult for them to identify what elements of the situation may have an impact on the operation that has been planned.

At this point, one can ask if a more structured way to document the analysis done during the mission analysis (Orientation stage) would be appropriate. It could facilitate the identification of the situation aspects/elements that would require to be closely monitored. Since the CFOPP is executed in a context where different people may be involved, it is believed that such documentation would be helpful.

In a previous work [13], we have identified links between CFOPP elements of a same plan, links between CFOPP elements of different plans (ex. between strategic plan and operational plan), as well as the different types of links that represent different types of relationships between these elements. In fact, four types of links have been identified:

- Links supporting or refuting the existence of an element of analysis;
- Links indicating an influence between elements of analysis, for example for inheritance of info (e.g. from strategic to operational; , to supports Risk Management);
- Links indicating time (e.g., sequencing, concurrence) and space synchronization (i.e. Supports DP Analysis) relationships ;
- Links representing a refinement of an object (ex. Decomposition).

Accordingly, we think that the CFOPP elements require a link enforcement concept to keep integrity between elements. The establishment of these links will allow to rapidly track the impact a planning element may have on other elements. Link management approach should provide the ability to dynamically link different essential CFOPP elements of a same plan (e.g. mission analysis elements, COA elements and plan elements) or of different plans (e.g. between strategic plan and operational plan). By allowing the visualization of these relationships, it enables the planners to easily identify the mission analysis and plans elements that would be affected by potential changes in the situation. It also allows the linkages of strategic plan elements to operational plan elements and operational plan elements to tactical plans elements.

3.8 Interactions with operation management activities

As the current situation evolves over time, the conduct of the operation may not be conformed to what has been initially planned. In monitoring the execution of the operation guided by the operational order, the operations cell will identify and react to discrepancies. Depending on the

scope of change between the plan and evolving operational situation, a decision to re-plan the operation may have to be made by the JTFC upon recommendation of the joint operation cell. In this case, the joint planning cell is notified to redo the plan partially or entirely. An issued order will not normally be modified. To amend an order, another order must be issued. The Fragmentary Order (FragO) is used to amend an order. A new Operational Order (OpO) could also be issued to completely replace an existing order. The new order/amendment is executed and monitored and may require another re-planning if the situation changes again. This is done until the operation is executed completely.

As we can see, in the current context, to be fully beneficial, a planning tool needs to be able to interact with tools used for operation management activities. A planning tool has to be able to get real-time information about the availability of the resources. Then in the development of the plan details, the lack of resources could be handled directly. Also it is mandatory for a planning tool be able to send plans (for example, OpO) to an execution management tool for execution and monitoring purpose. Then this execution management tool also needs to send information to the planning tool related replanning need and the purpose of the need.

4 Prototype

A computer-based system called Collaborative Operations Planning System (COPlanS) has been developed at DRDC Valcartier to support the different stages of the Canadian Forces Operational Planning Process (CFOPP). COPlanS is an integrated flexible suite of planning, decision-aid and workflow management tools aimed at supporting a distributed team involved in the planning of military operations. While this tool has been mainly developed to support the deliberative planning, it was felt that it could also support the rapid response planning. Therefore, the Operations Planning Process Advanced Decision Support (OPP-ADS) tools have been designed as an extension of COPlanS to support time sensitive planning.

This section gives an overview of the different tools that have been implemented as OPP-ADS into COPlanS. For more details, [20] and [13] can be consulted.

4.1 COPlanS

COPlanS (Collaborative Operations Planning System) is an integrated flexible suite of planning, decision aid and workflow management tools design to support a distributed team involved in the Military Operations Planning Process (e.g., CFOPP). COPlanS provides the ability to plan an operation in a net-centric environment with integrated collaborative tools. The system offers functions to design and manage multiple concurrent distributed battle rhythms at different planning levels. It helps synchronize workflows, document processes and replaying the decision-making path. The planning tools allow to sketch of COAs on maps, to perform time and space synchronization, to manage resources and ORBAT, and to perform limited logistics analyses. The decision aid tools rationalize the process, improve COA evaluation and comparison and rapidly produce documents to support the Commander's decisions.

Being a client-server as well as a web-based application, COPlanS offers functions to design, manage and synchronize multiple concurrent battle rhythms at the strategic and, operational levels and to a limited extent at the tactical level. It helps synchronize the staff workflow, documents automatically the decision-making process and allows the replaying of the decision-path. The planning tools help the staff to sketch COAs on maps, to perform time and space synchronization, to manage resources and capabilities, to manage ORBAT and to perform logistics analyses. The decision-aid tools help the staff to rationalize the process, to improve the COAs evaluation and comparison, and to rapidly produce documents to support the Commander's decisions. COPlanS offers multi-level collaborative tools including Chat, White Board and On Map Planner. A context sensitive search engine is available to browse past similar operations and recall plans and lessons learned from the database.

COPlanS offers some generic capabilities to capitalize on net-enabling environment. This covers process management, distributed collaboration, distributed document management and automated WEB Master. The process management facilities allow to graphically design and implement different process templates (e.g. the deliberate OPP, the crisis action planning, etc.), conduct staff check, manage staff, roles, activities, workflows and approval process. It allows to design and manage multiple concurrent distributed battle rhythms at different planning levels. The distributed collaboration facilities provide a distributed collaborative workspace for sharing data and tools across workgroups/agencies, as well as direct conduit to existing CF tools such as Microsoft Outlook and Exchange Server; Chat tool is also available. The distributed document management facilities allow to automatically manage documents. It supports distributed document editing (check in/check out), version control and is able to handle different formats of

documents (doc, ppt, avi, etc.). The automated WEB Master allows to automatically maintain a WEB consultation center for real-time information access.

COPlanS also offers different enhanced collaborative OPP capabilities to support the execution of the CF OPP in a net-enabled environment. The initiation tool allows to:

- Create the operation;
- Describe the area of operation by locating the area of interest;
- Describe the direction provided by higher level of command, which includes any time constraints;
- Set the scene by assigning people to the planning team anddetermining the tools to be used for the planning;
- Start the process of planning the operation.

The orientation tool allows to collaboratively perform the mission analysis. The COA development tool allows the sketching of COAs on maps or Gantt chart, to perform time and space synchronization, to manage resources and ORBAT, and to perform logistics analyses. The decision-aid tools rationalize the process, improve the COAs evaluation and comparison, and rapidly produce documents to support the Commander's decisions.

The plan development and plan review tools, that are not implemented yet, will provide facilities to complete, and review if needed, the different annexes that need to be produced for these steps.

4.2 Plan management tool

The plan management tool supports the planning staff in the planning of operations by facilitating the access and the exploitation of existing plans that have been developed using COPlanS. On top of accessing the final results of previous planning efforts (i.e. the deliverables being the plan itself, the briefings, etc.), planning staff have access to information and analysis that have been developed while going through the planning process. The computer-based tool provides plan searching and retrieving functionalities within COPlanS databases. It is possible to develop and save contingency plans (CONPLAN) with generic proprieties such as relative critical timings (Figure 10), fictitious area of operations and generic ORBAT. These contingency plans can be loaded when needed and instantiated according to a specific situation (Figure 11). Then the planning staff will have to review the different analysis elements that were produced at the time of the creation of the CONPLAN and modify them according to the new situation.

Search and retrieving functionalities for existing or past similar plans might be used when no CONPLAN has been developed previously. The search can be based on operation category (i.e., domestic, multinational, coalition, UN), force employment scenario (i.e., non-combat extraction, peace support) and the location of the operation. When existing plans have been identified, they can be viewed for reference or duplicated and then modified for use as an OPlan. When a plan is completed, it could be released for distribution.

When generating a new plan, it may also be required to link this new plan with a higher level plan. Then, appropriate planning information will automatically cascade from higher plan to subordinate plan (Figure 12). Keeping a link between these two plans become very important when some of these elements need to be modified because, in that case, the other plan needs to be notified that some elements require to be revisited. Sometimes we want to copy an element from

the Higher HeadQuarter (HHQ) analysis and keep a link with the HHQ, sometimes we want to link an element of the current plan to an element of the HHQ analysis.

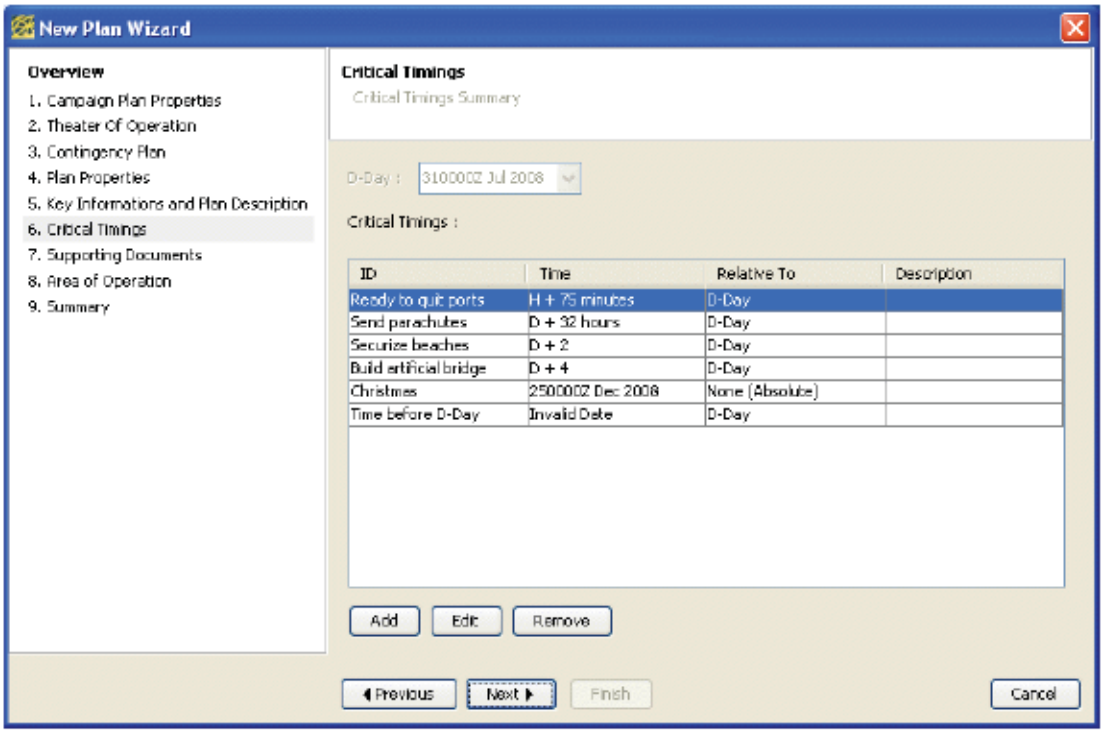

Figure 10: Generic Critical Timings

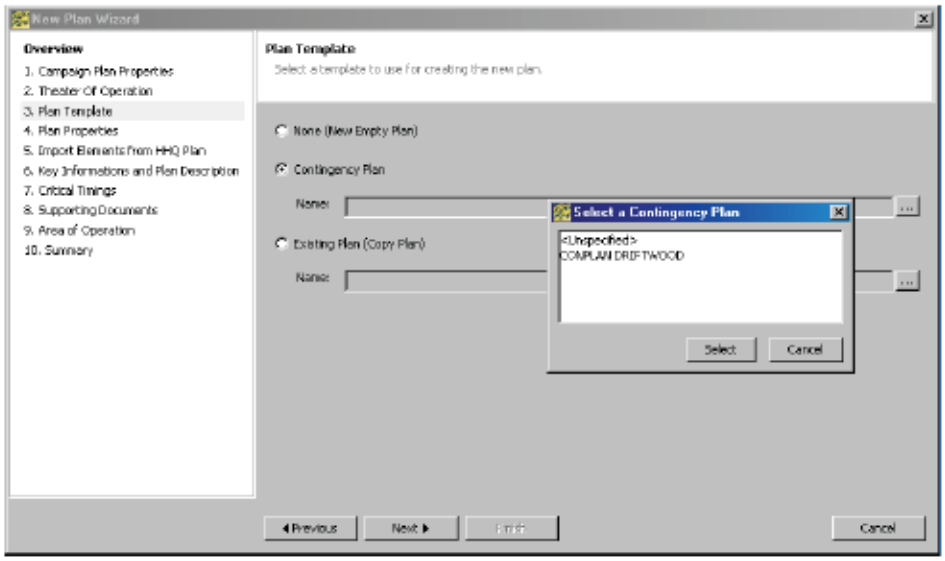

Figure 11: Contingency Plan Creation

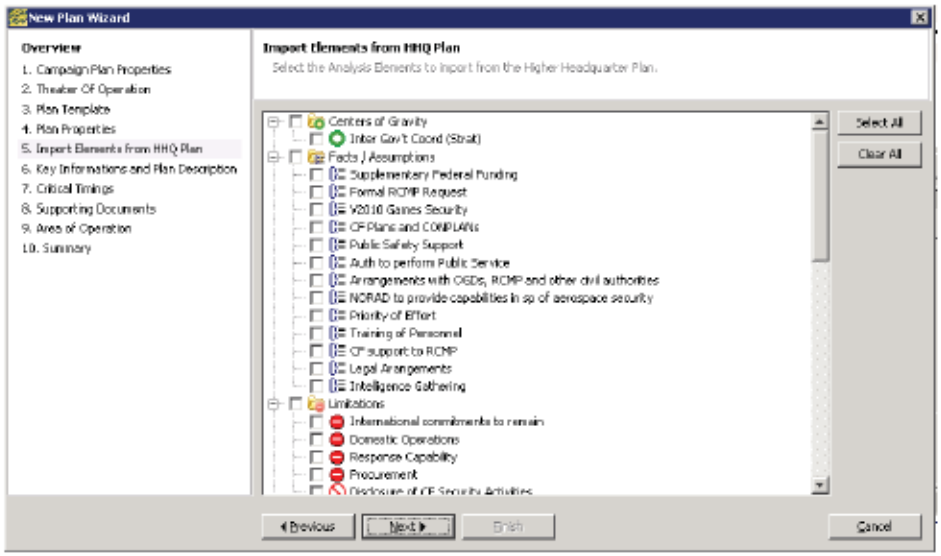

Figure 12: Importation Functionalities

4.3 COG analysis tool

The COG analysis tool support the brainstorming of different people working together to identify the concepts of COG, critical capability (CC), critical requirement (CR), critical vulnerabilitiy (CV) and decision point (DP) as well as the relationship between them. A whiteboard approach allows different people geographically distributed to contribute to the creation, modification, deletion of any of these elements and the relationships amongst them. While anyone can create a new element anytime, the approach proposed is in line with the CG-CC-CR-CV model, i.e.:

1. Identify the COG (friendly' ones as well as opponents' ones);
2. For each COG, identify the related CC;
3. For each CC, identify the related CR;
4. For each CR, identify the related CV;
5. Based on the existing CV and possibly the existing CR, identify the DP.

Even if the COG analysis is usually executed in a sequential way, it also supports the execution of this analysis in any order and sequence pursued by the planners and/or the possibility to go backward or forward to any step in order to modify/add/delete any analysis element. Any CV considered as a HVT can be identified by clicking on the High Value Target box in the description window for this DP (Figure 13).

A structured graphical view is proposed to facilitate the analysis of each identified friendly and opposing COG (Figure 14). A tool bar at the top of the screen allows the creation of new elements of analysis. All elements of analysis that have already been created previously can be added to the graphical view using a drag and drop from an explorer window (Figure 15). Considering that the full name of these elements could be pretty long, it was decided to display the associated acronym. Full name might be displayed by clicking the "show names" box or by moving the mouse over the symbol. Usual editing functionalities (creation, edition, modification, deletion) are available. The implementation of an algorithm automating the disposition of these elements in the appropriate column was also considered as appropriate.

Figure 13: Decisive Point Description

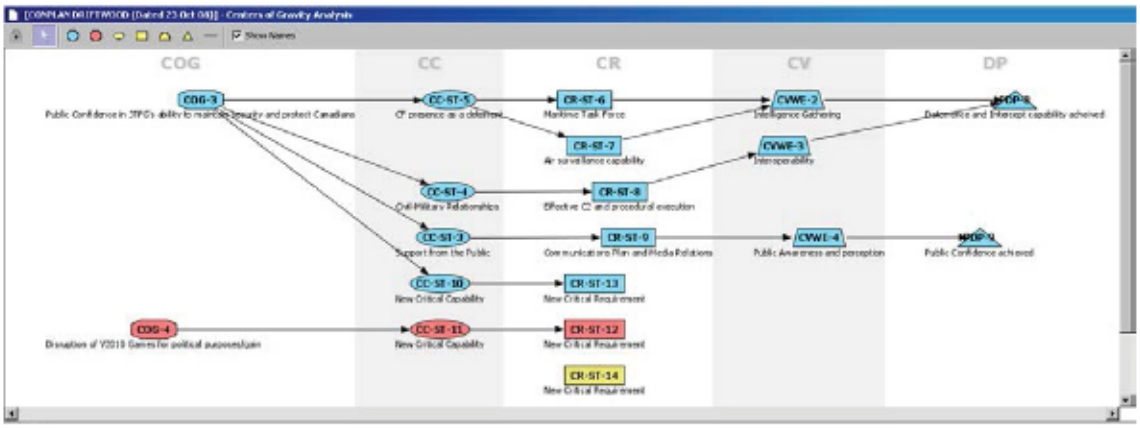

Figure 14: Center of Gravity Analysis Whiteboard

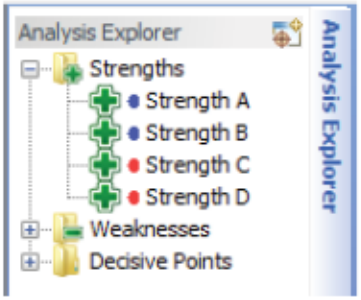

Figure 15: Analysis Explorer for Existing Elements of Analysis

4.4 DP analysis

The Decisive Point Analysis tool supports the planners in their brainstorming to sequence decisive points into lines of operations and to identify the phases of the operation with their associated objectives and tasks (Figure 16). Using a whiteboard approach, it allows different people being geographically distributed to contribute to the creation, modification, deletion of any of these elements and the relationships amongst them. Here again, a structured graphical view is proposed to facilitate the construct of each line of operation. All decisive points that have already been created in the COG analysis tool can be added to the graphical view using a drag and drop from an explorer window. As in the COG analysis tool, a tool bar at the top of the screen allows the creation of new elements of analysis and the full name of a symbol can be obtained by moving the mouse over the symbol or the full name of all symbols can be obtained by clicking the "show names" box. The tool provides the flexibility to initiate multiple DP analyses from a single COG analysis.

Different courses of actions (COA) can be developed based on the campaign design that has been produced with the Center of Analysis Tool and the Decisive Point Analysis Tool.

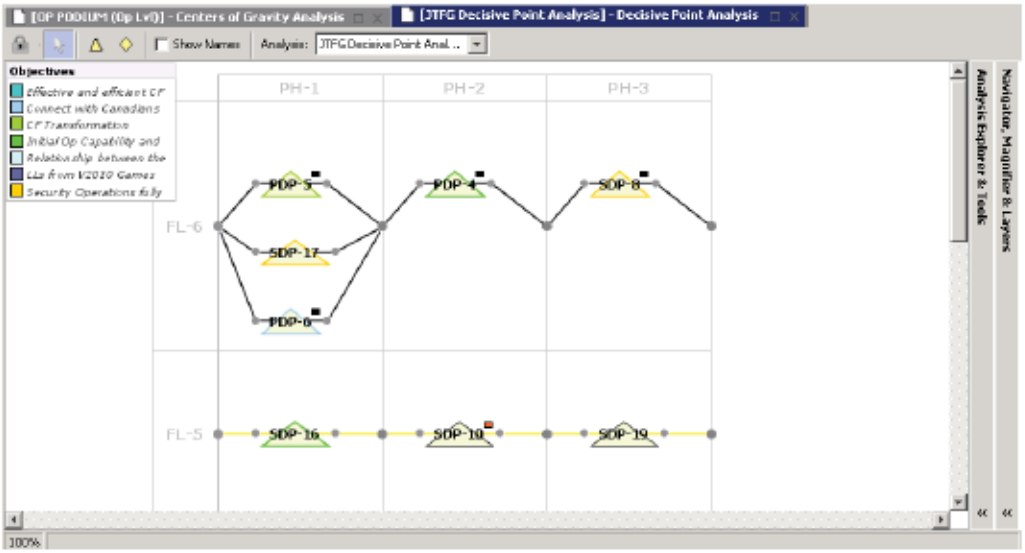

Figure 16: Decisive Point Analysis Whiteboard

4.5 Criteria management

The Criteria Management tool facilitates the criteria retrieval process. First, it allows to consult and select criteria identified in doctrine. A search functionality (Figure 17) allows the retrieval of similar operations based on operation category (Domestic, Expedition), operation type (eg. disaster assistance.) and/or operation location (e.g., Afghanistan). Having access to these past similar operations will allow to consult their after action reports, which may help to determine the criteria to consider and their importance.

Globally, the criteria management tool provides the following capabilities:

- Criteria creation / criteria parameter settings;
- Criteria saving

- Criteria consultation and/or retrieval :
  - From operation types;
  - From type of criteria (factors);
  - From past similar operations;
    - From similar operation type;
    - From similar locations;
- Criteria post-analysis capture and exploitation:
  - Lessons identified related to the criteria itself;
  - Lessons identified related to the weight associated to each criteria.

These functionalities help the planning staff to identify the criteria that should be used for the assessment of the COAs according to a specific situation. Then, the team members have to determine which aspects are more important to consider than others. The assignation of priority to the different criteria may be challenged considering past experiences. The criteria selected by the staff and their level of priority are then being adjusted according to the direction that the commander may provide.

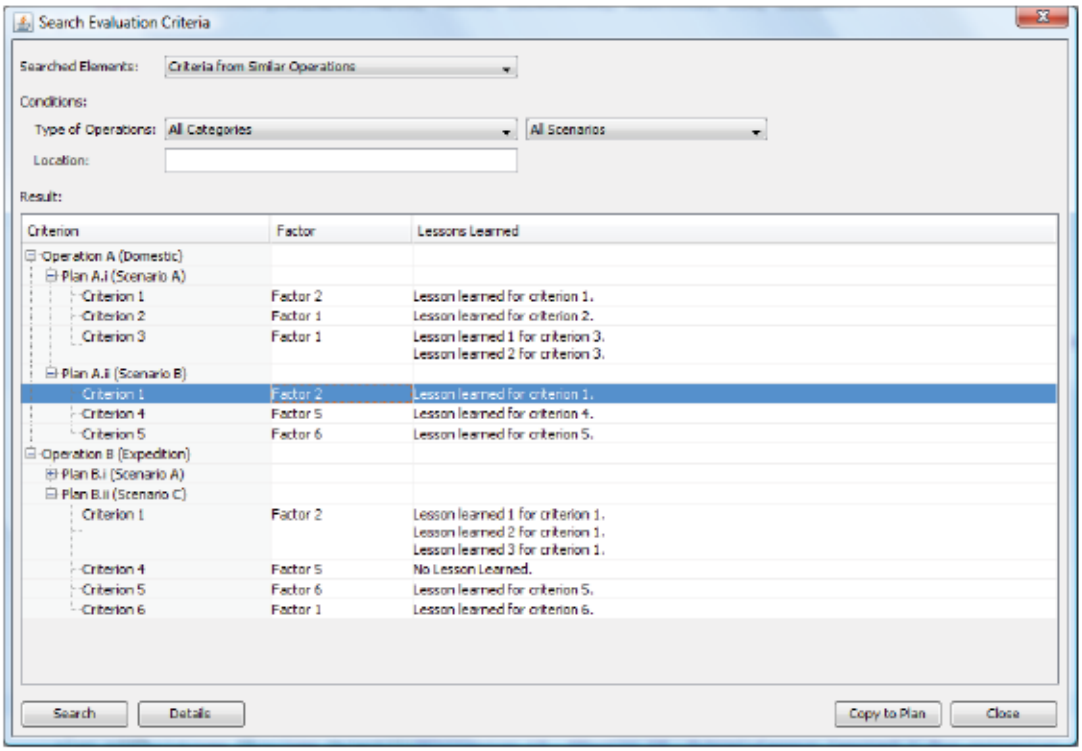

Figure 17: Criteria Management– Search Functionality

4.6 Decision-matrix management

The decision-matrix management tool supports the planning staff in the comparison of different COAs, considering the evaluation of each COA based on each criterion (selected from the Criteria Management tool) has been selected in the evaluation criteria management tool. To support the planning staff in the comparison of COAs, two different approaches were implemented to provide flexibility according to the preference that the user may have: the possibility to work with a qualitative analysis (descriptive comparison) as well as a quantitative analysis (numerical and ordinal comparison).

In the qualitative analysis grid (Figure 18), the planner is given the opportunity to document any advantages or disadvantages that are identified for each COA according to each criterion and present them in a grid. A text field is provided for the edition of the advantages and another one for the disadvantages. These two types of information are then globally presented for each COA in a grid using color coding (green for an advantage and red for a disadvantage). In the quantitative analysis (Figure 19), the planner will have to determine the evaluation of each COA according to each criterion. The scale of the evaluation can be cardinal or ordinal, according to the definition of the criteria. The COA will then be compared using a MultiCriterion Decision Aid (MCDA) approach to produce a ranking of the COAs with the associated explanations (Figure 20).

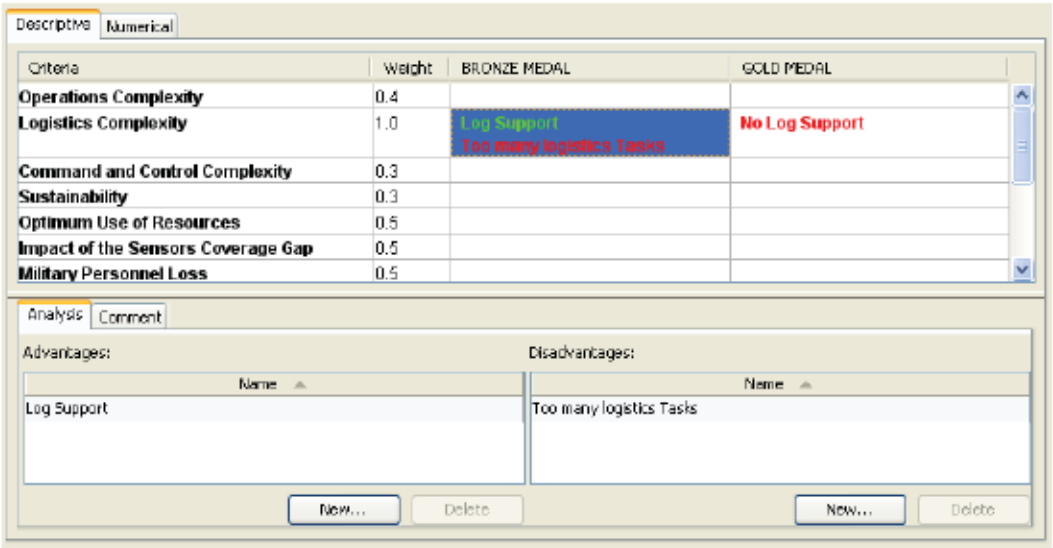

Figure 18: Qualitative Analysis Grid

Descriptive | Numerical

Criteria	Weight	Optimization Direction	BRONZE MEDAL	GOLD MEDAL
Operations Complexity	0.4	Maximize	Very High	Missing Evaluation
Logistics Complexity	1.0	Maximize	Very High	Missing Evaluation
Command and Control Complexity	0.3	Maximize	Very High	Very Low
Sustainability	0.3	Maximize	2	Missing Evaluation
Optimum Use of Resources	0.5	Maximize	2	Missing Evaluation
Impact of the Sensors Coverage Gap	0.5	Maximize	Medium	Low
Military Personnel Loss	0.5	Maximize	Medium	Missing Evaluation
Collateral Damage	0.5	Maximize	Extremely High	Missing Evaluation
Confrontation Risk	0.5	Maximize	Very Low	Missing Evaluation
COA Reliability	0.5	Maximize	2	1
Human Reliability	0.3	Maximize	Very Low	Missing Evaluation
Covering Enemy's Courses of Actions	0.5	Maximize	2	Missing Evaluation
Covering Mission's Possible Locations	1.0	Maximize	Missing Evaluation	Missing Evaluation
Covering Operational Tasks	0.5	Maximize	1	Missing Evaluation

Relevance: Missing But Not Relevant

Evaluation:

Figure 19: Quantitative Analysis Grid

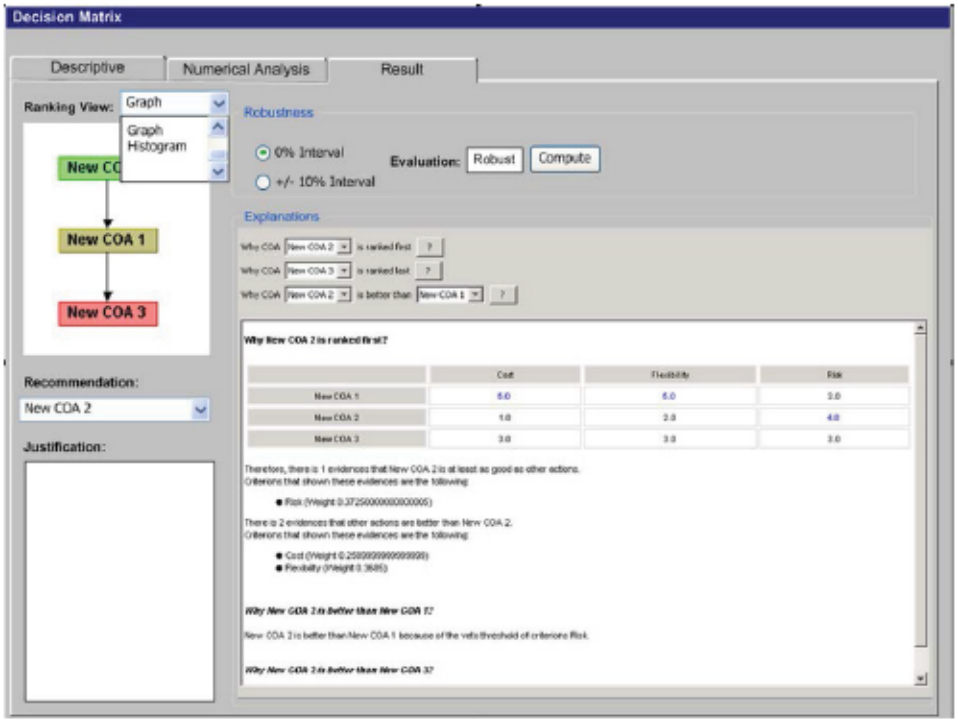

Figure 20: Ranking Results

4.7 Risk management

A Risk management tool has been developed to support the risk identification and mitigation strategies in the planning process. The risk concepts implemented should be an expression of a

possible loss or negative mission impact stated in terms of probability and severity (Figure 22). For each element of risk identified, a qualitative assessment can initially be provided for the military functional aspects (command and control (C&C), sense, act, shield, sustainability) (Figure 22). Based on these different perspectives, a planner can then determine what the global estimation for this element of risk is. Then for each COA developed, a mitigation strategy can be described as a set of control processes, and a revaluation of the risk for this COA can be done (Figure 23).

A global view (Figure 24) presents the number of risk elements that have been initially associated to each risk assessment couple (severity, probability) followed by the risk assessment associated for each COA

Risk Evaluation Matrix					
	Probability				
Severity	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	E	E	H	H	M
Critical	E	H	H	M	L
Marginal	H	M	M	L	L
Negligible	M	L	L	L	L

Not Applicable | Unspecified | Ok

Figure 21: Global Risk Assessment Grid

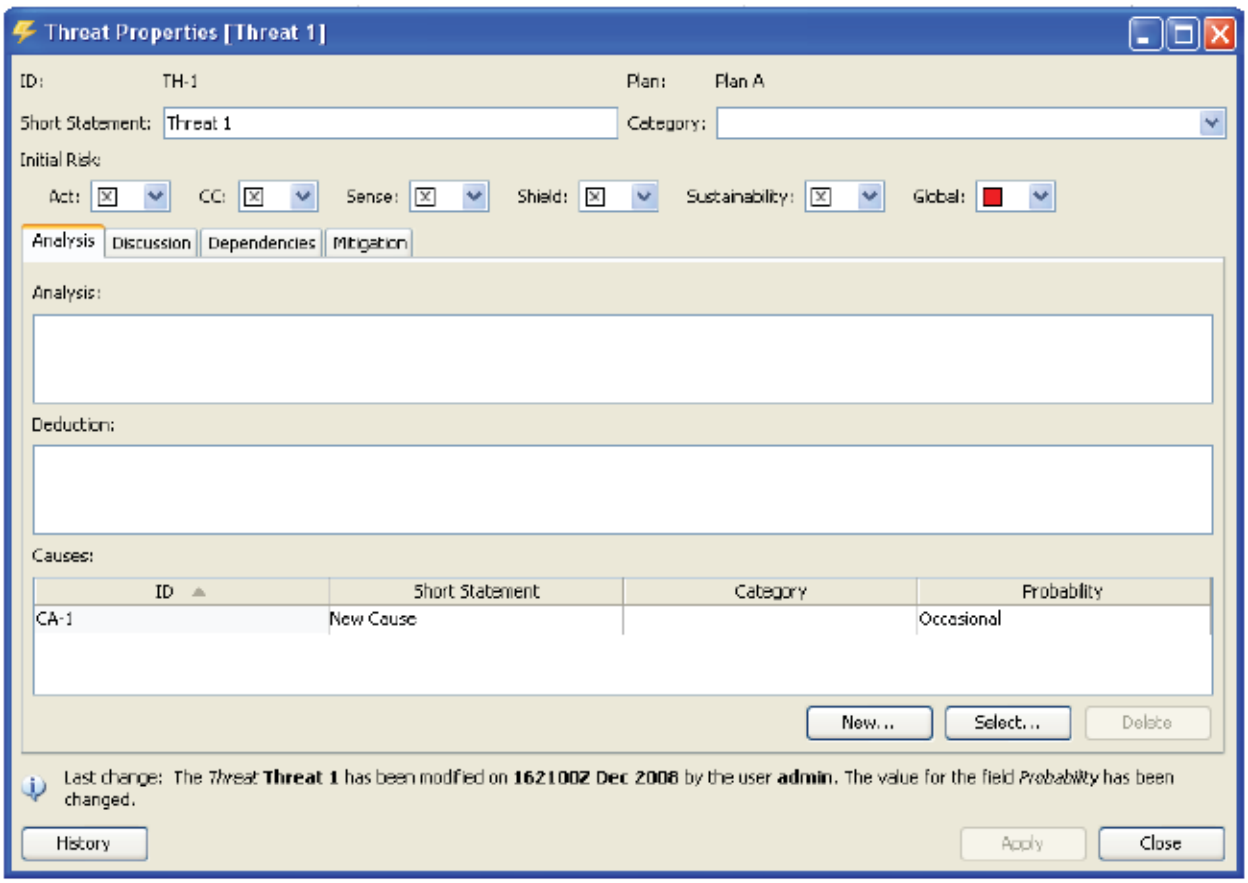

Figure 22: Threat Analysis

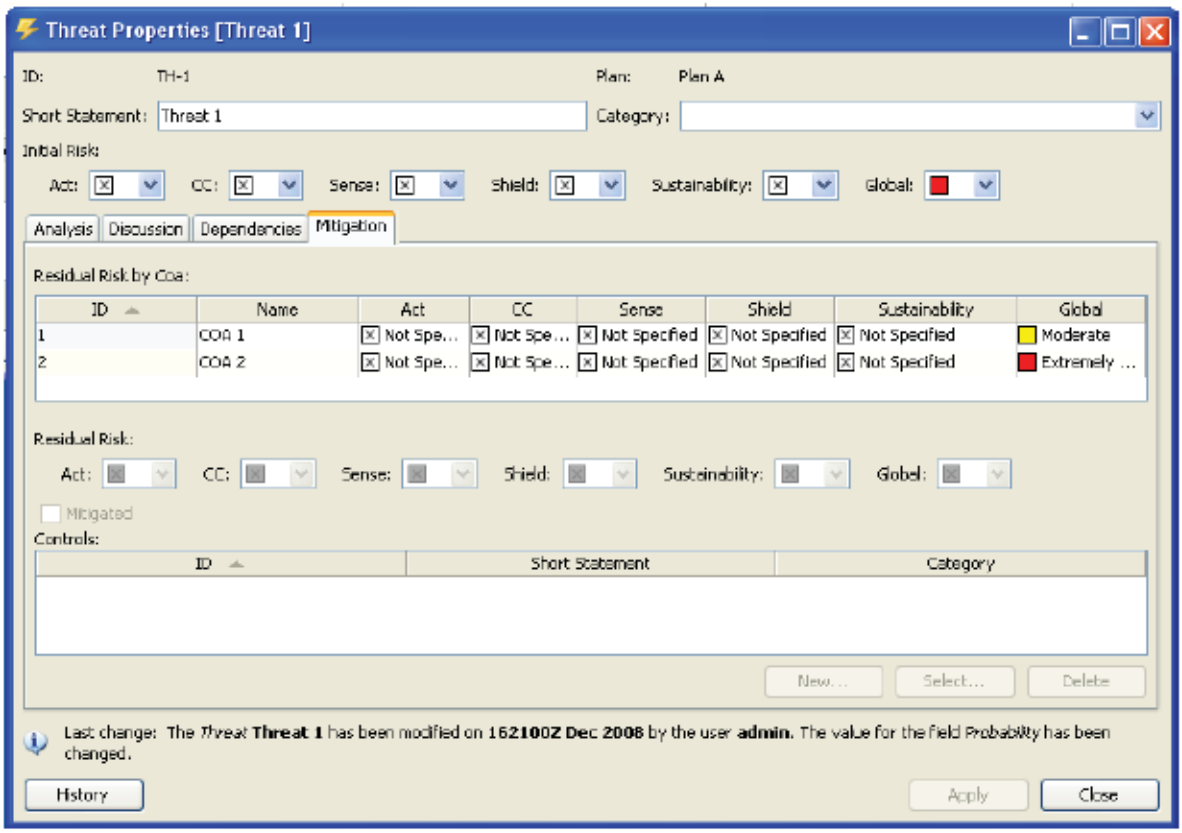

Figure 23: Assessment of Mitigation Strategies

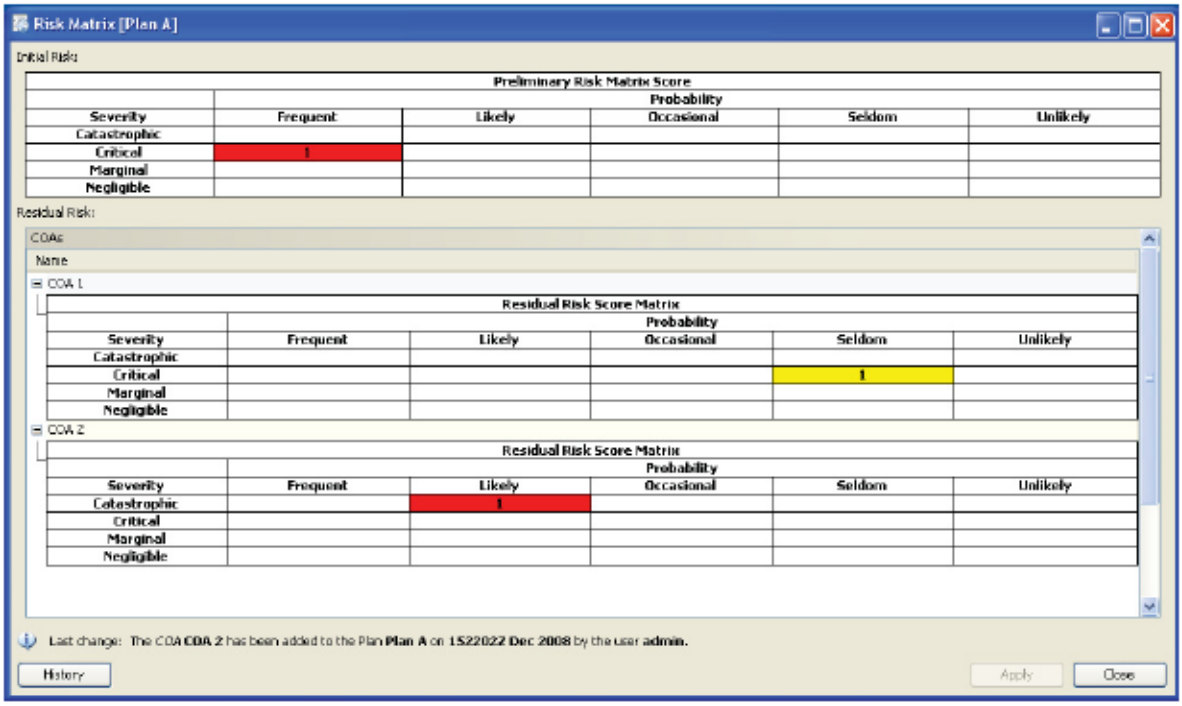

Figure 24: Global Risk Assessment Grid

4.8 Dynamic linkages of CFOPP elements

The implementation of link management approach considers links as entity that can be created, documented, manipulated and deleted. Each link has a type, an element source and an element target, a type as well as the status of the link (Figure 25). The type allows considering the different types of links that have been identified previously, i.e.

- Links supporting or refuting the validity of an element;
- Links indicating an influence between elements, for example for inheritance of info (e.g., strategic to operational);
- Links indicating time and space synchronization relationships (e.g., sequencing, concurrence);
- Links representing a refinement of an object (ex. Decomposition).

The status indicates if the link is valid (Figure 26) or if modifications of the elements of the CFOPP have invalidated that link (Figure 27). In that case, it would indicate that the link's target element would benefit to be reviewed by someone in the planning staff. Eventually, a graphical view of the elements of the CFOPP that are linked together should be provided to facilitate a good appreciation of the relationships of the elements. By allowing the visualization of these relationships, it enables the planners to easily identify the mission analysis and plans elements that would be affected by potential changes in the situation. It also allows the linkages of strategic plan elements to operational plan elements and operational plan elements to tactical plans elements.

Furthermore, such approach provides the ability to dynamically create links between different essential CFOPP elements of a same plan (such as mission analysis elements, COA elements and plan elements) or of different plans (ex. between strategic plan and operational plan).

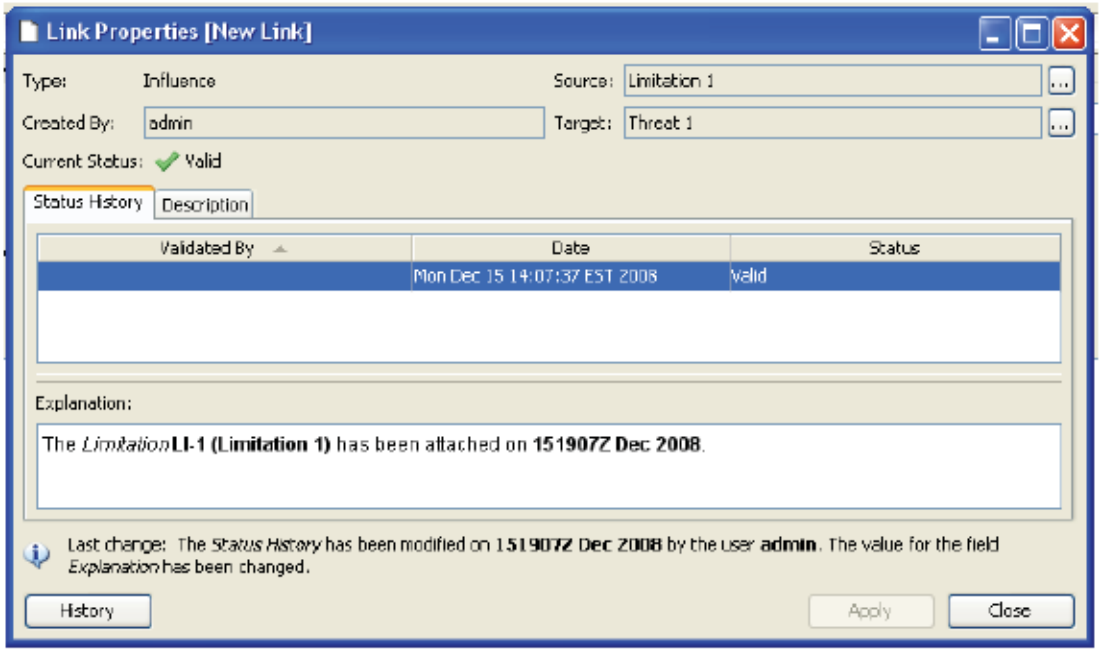

Figure 25: Link Properties.

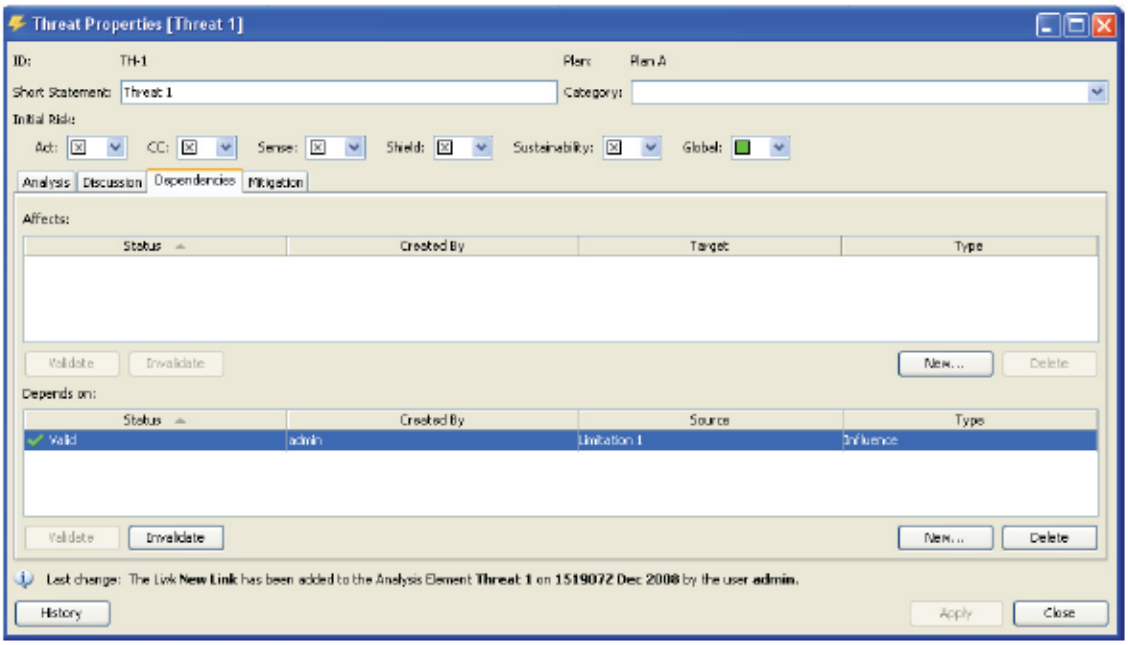

Figure 26: Link Status

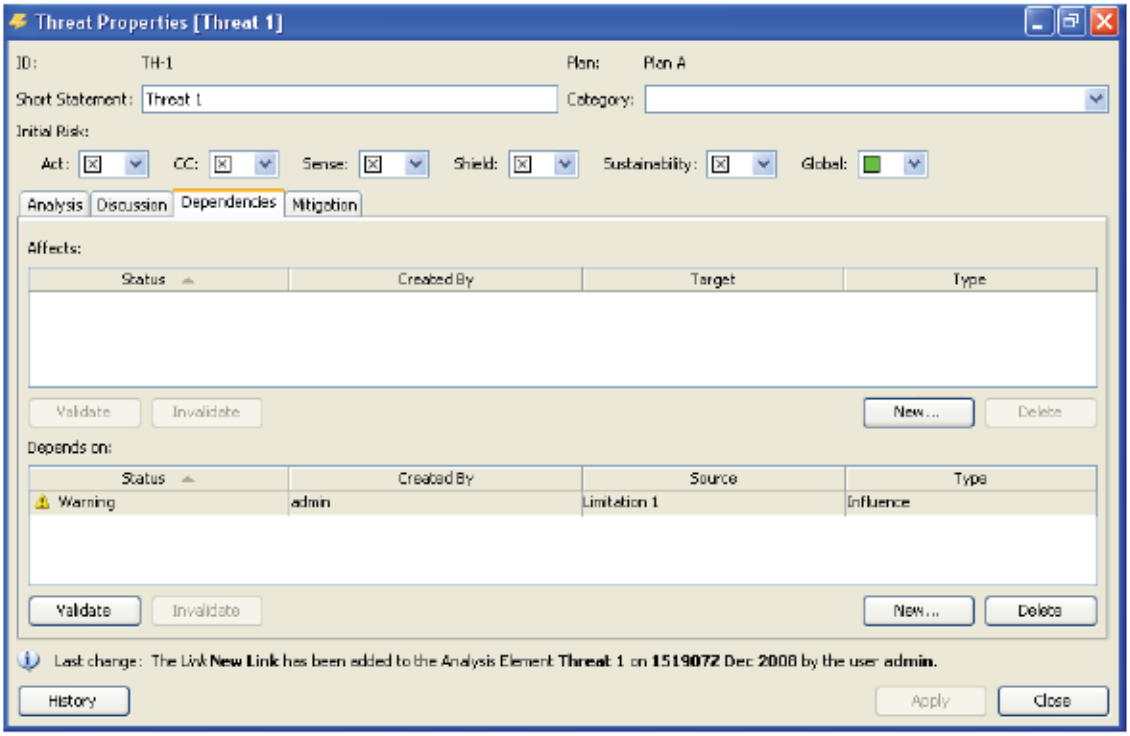

Figure 27: Analysis Warning Link Status

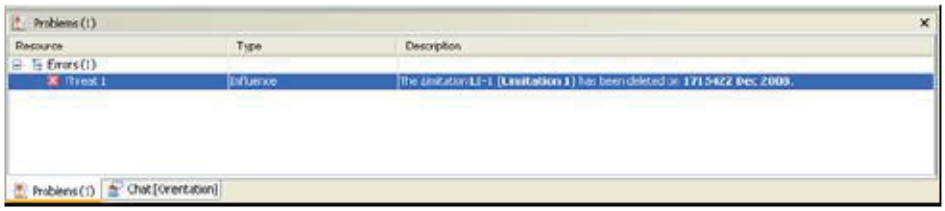

Figure 28: Warning Description

This page intentionally left blank.

5 Design of decision aids

5.1 COPlanS architecture

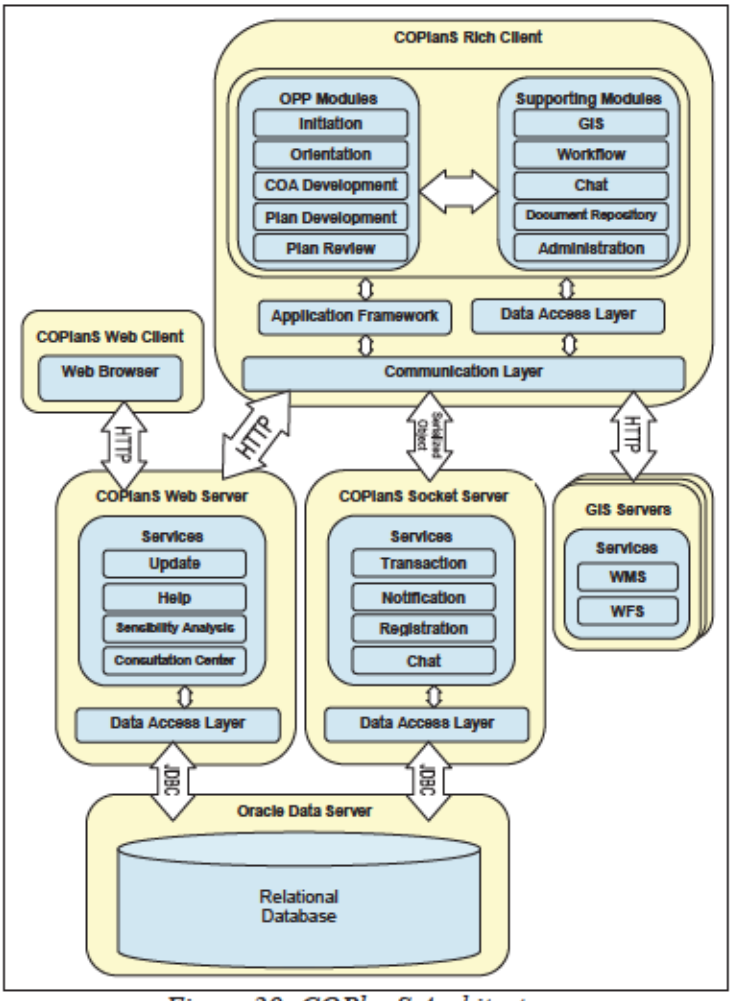

Figure 29: COPlanS Architecture

COPlanS architecture is based on a client-sever approach and a publish-subscriber model to enable real-time information update on the client (Figure 29). The client is a rich Java application divided in a number of independent and interoperable modules that correspond to the main functional part of COPlanS. Those modules are subdivided into feature components that address directly or indirectly specific activities of the CFOPP. The feature components are plug-in components into COPlanS and can be activated or deactivated and reuse by any modules. Each feature is separated into presentation, business logic and data access layers where the common functional requirements are supported by the application framework. That framework also manages and provides advanced graphical user interface (GUI) components, the persistence of user preferences, the exception handling and recovery, the update mechanism and the contextual help. The presentation layer of the features is based on the Model-View-Controller (MVC) pattern to manage user graphical interface and interaction. The data access layer keeps the data integrity and encapsulates data changes in a transaction to be transmitted to the communication layer. The communication layer is responsible to establish the connection with the servers, send

the transactions to the server and process the response. The data and communication layers can be used independently from COPlanS to build 3rd party application able to use and manipulate COPlanS data.

The server side of the architecture is divided in three distinct services providers and one data server. The socket server is the main COPlanS server that provides core services needed by a distributed collaborative environment. More precisely, it ensures the consistency of the data model by managing all the transactions and it updates all clients information by sending notifications of any changes to the client that are registered trough the registration service. One of the most important services of the socket server is to provide chat session management used by the client chat module. The web server is in charge of the update mechanism that keeps the client software version always up-to-date, the help service that maintains the different contextual help content needed by the sub components and gives access to COPlanS plans consultation via a web browser.

The geo-referenced information system (GIS) servers provides all the data support needed by the map planning features. The GIS servers can be any map providers that are Open Geospatial Consortium (OGC) compliant, for instance Web Map Service (WMS) and Web Feature Service (WFS).

The COPlanS architecture benefits from the application framework common services to develop more rapidly a new feature component and easily integrate it into the COPlanS application. Using that approach, the concepts related to OPP-ADS have been integrated as new feature components of COPlanS rich client.

5.2 JCDS21 architecture

JCDS 21 TDP has developed a set of technologies and tools based on the human and organisational teaching to support the joint command decision support processes. In particular, JCDS 21 TD has innovated by proposing a new way for information and knowledge discovery, exploitation and management, for situation awareness support and collaboration (Figure 30) among distributed team members:

- *Advanced Command Portal* provides the foundations for a Command and Control Collaborative Environment (on top of Command View) supporting shared situation awareness, information management, systems integration and collaborative working;
- *Knowledge Mapper (KMapper)* supports organizational management of knowledge assets and provides advanced link displays and reporting tools;
- *LiveSpace/LiveFrame* is an exploitation of the Australian LiveSpace technology to provide a smart meeting space supported by a smart room operating environment where hardware and software are integrated.

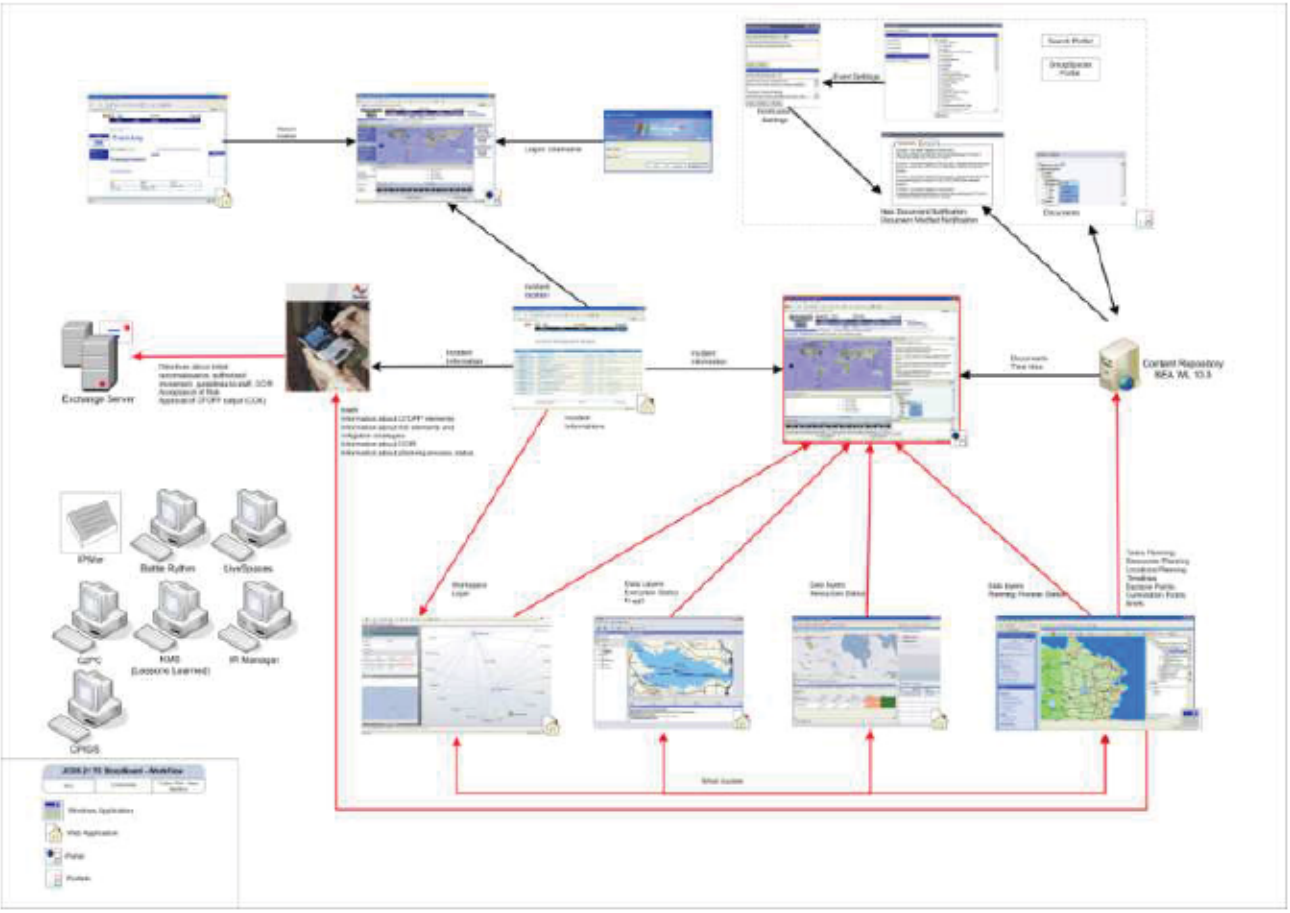

Figure 30: JCDS 21 - Interactions

JCDS 21 TDP has developed advanced decision aids to support the planning, options analysis and execution management processes. These decision aids include:

- *Advanced COPlanS Decision Aids* are automated and distributed OPP tools including the latest decision support enhancements; time-sensitive planning, planning dependencies and implications management, analysis, risk management and reporting tools (including OPLAN, CONPLAN, branch plan and sequel plans management tool);
- *Commander's HandHeld Support System (CHESS)* provides Commanders and senior staff officers on the move or with limited connectivity with real-time (or near real-time) access to / interaction with information from Command View and COPlanS in a secure manner;
- *Total Resource Visibility (TRV)* is a decision support system for near real-time resource visibility providing asset information: identity, location, status, and condition of assets in the logistics chain;
- *The Execution Management and Plan Adaptation (EMPA)* supports time-sensitive as well deliberative operations execution through continual automated monitoring of the situation inputs and execution reports.

(see Figure 31) depicts a system of systems integration based on a service oriented architecture (an enterprise service bus (ESB), standards and data exchange services).

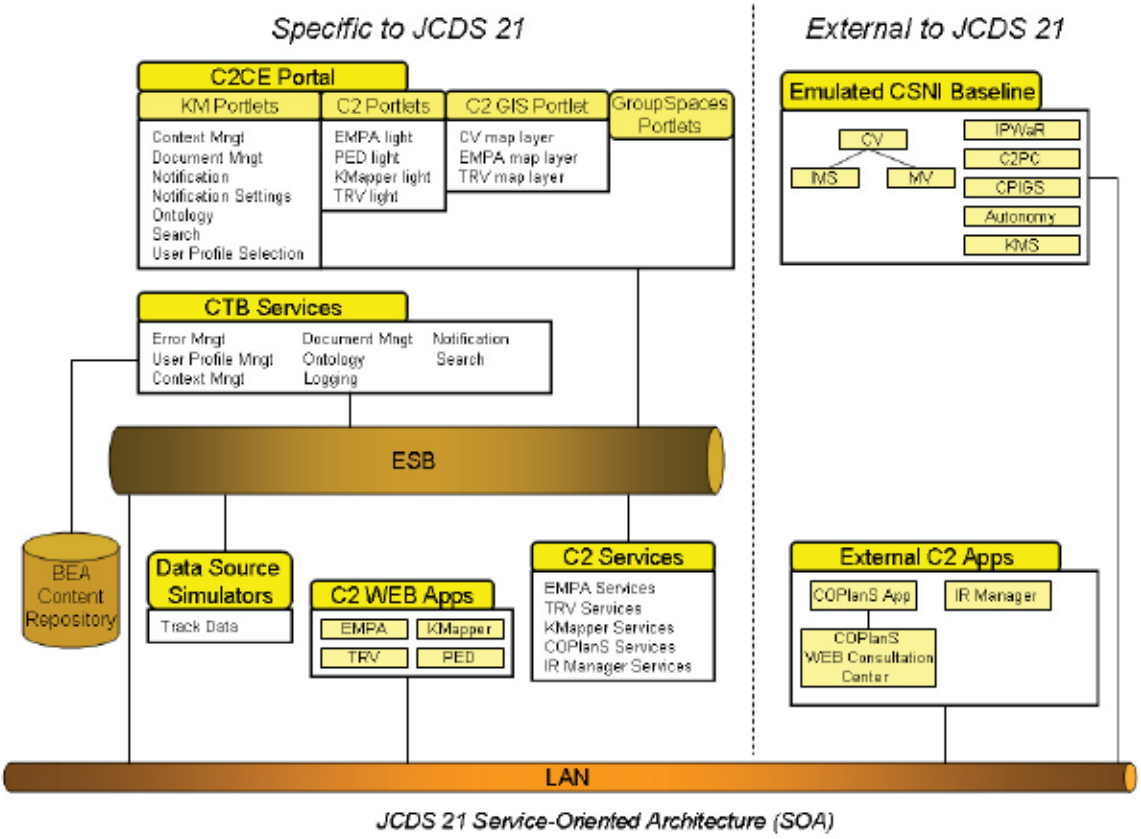

Figure 31: JCDS21 Architecture

5.3 Integration with other tools of JCDS21

Using COPlanS, the joint operational planning cell develops plans to deal with specific operational situations. When the operational plan is approved by the commander, it is disseminated as an operational order (OpO). COPlanS produces several documents related to planned operations (for example, Warning Order, information brief, decision brief, CONOPS, OpO). The JCDS environment provides the capability to share documents with other applications. In re-using this JCDS document management capability, COPlanS can send its documents to the JCDS repository. Furthermore, anyone having a handheld device can have access to CHESS (Commander's Handheld Support System) through their internet explorer. CHESS provides real-time information about the planning process, mission analysis, and courses of actions, as well as the briefs and the Orders. The commander can then be briefed and he can select the desired course of action while being outside of the command post.

Once the COA has been selected, and the Op order disseminated, the OpO is executed by the operational forces under command of the Joint Task Force Commander (JTFC) and monitored by the joint operations centre through the EMPA (Figure 32).

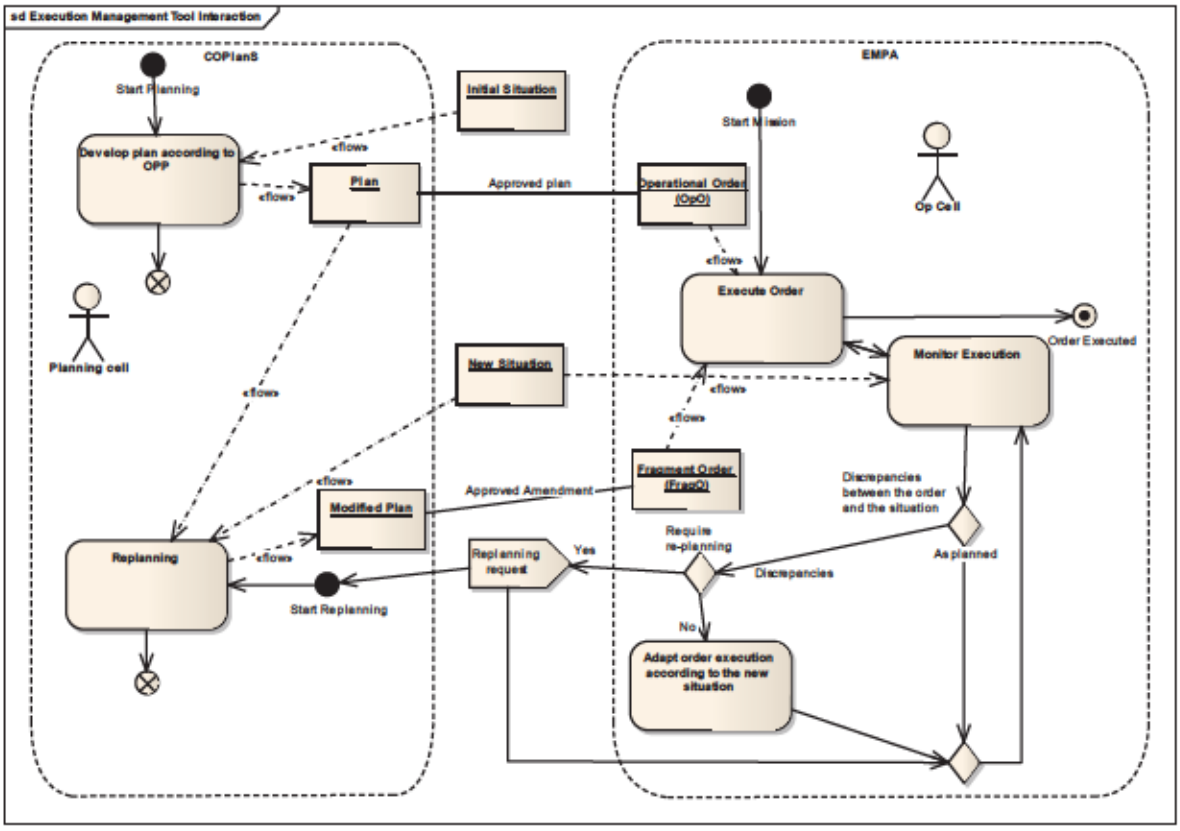

Figure 32: Interactions with Execution Management- Activity Diagram

This page intentionally left blank.

6 Demonstration and validation

As mentioned previously, the aim of the JCDS 21 TD project is to demonstrate a joint, net-enabled collaborative environment to achieve decision superiority. An experiment was conducted at the end of the project to demonstrate how these tools can significantly influence the Canadian Forces' (CF) ability to respond to complex situations such as those resulting from terrorist attacks and other asymmetric threats.

Due to the load of work associated to the conduct of an experiment, it was decided to conduct a unique experiment which will include all the concepts developed during JCDS21. First consideration was that a Joint Task force would have access to his usual tools, being:

- CommandView;
- Information Management System (IMS);
- Mission View;
- IPWar;
- C2PC.

Though the JCDS 21 testbed architecture, JTF would also have access to the following JCDS 21 tools [21]:

- Advanced Command Portal;
- Knowledge Mapper (KMapper);
- LiveSpace/LiveFrame;
- Advanced COPlanS Decision Aids;
- Commander's HandHeld Support System (CHESS);
- Total Resource Visibility (TRV);
- The Execution Management and Plan Adaptation (EMPA).

The approach was then to obtain global assessment instead of specific assessments for any of these tools. The primary experimental objectives were then:

1. Determine whether the Integrated Command and Control Collaborative Environment (IC2CE) supports and influences CF time-sensitive decision-making processes;

2. Determine if the IC2CE improves shared situation awareness within the Command Post;

3. Determine if the IC2CE improves collaboration within the Command Post and with external agents.

6.1 Vignette

The scenario used for demonstration is based on fictitious Olympic Games happening in Vancouver beginning on 17 Oct and ending on 5 Nov [21]. Opening Ceremony and the Closing Ceremony are taking place at BC Place Stadium, skiing and sledding event in Whistler and Cypress Bowl and others, such as speed and figure skating and hockey, are underway at

Vancouver venues. Victory Ceremonies are holding every night at BC Place and at a celebration site in Whistler Village.

The security forces of the Integrated Security Unit (ISU), including the military component of a Joint Task Force (JTF), are deployed into Whistler and Vancouver Commands and the coordination with public safety and emergency management agencies after several work-up exercises is working well. The Integrated Coordination Center (ICC) is maintaining good cooperation with VANOC and SA on all Olympic venues and events.

The scenario is conducted from the 17th of October to the 22nd of October 2008. During this time, different events happens going from protesters, earthquake, destruction of coaches by home-made fire bombs, bomb threats to BC ferries, creeping of globs of crude oils toward the coast, vessels of interest to monitor, computer worm attacks, etc. The Joint Task Force (JTF) composed of a maritime component, a land component, an air component, special operations and supports elements, are involved in support of the government of BC and Canada. The intent of the scenario is to assess how, in the burden of all these events, the JTF will used a CONPLAN developed for supporting Law enforcement authorities in the Province of British Columbia (BC) and at the Federal Level in response to Vessel of Interest (VOI) who may present a threat to the security of the Vancouver 2010 Olympic Games.

This scenario is an unclassified event. All information used in developing the scenario and incidents was taken from unclassified sources. However, because some incidents represent possible operational scenarios some of the storylines are considered sensitive, and that portion of the information requires appropriate classification.

6.2 Conduct of experimentation

The JCDS21 experimentation has been conducted at Ottawa 22-23 October 2008 in order to assess the situation awareness of a Joint Task Force involved in the planning and execution of a complex operation [22]. JTF team was composed of the following player roles: Commander, COS, J2,J2 Ops, J3, J3 Ops, J3 Ops 2, J3 Plans, J3 IM, Battle Watch, Ops NCO, J4, J5, J6, MCC.

The mornings of experimentation days involved participants exercising a scenario using the JCDS 21 tools. Detailed data were collected about tool effectiveness, usability, situation awareness, etc during these sessions (more details on the data collection plan can be found in [22]). No outside visitors were allowed in during this time in order to ensure the most reliable and accurate data can be collected for further analysis.

The afternoon of experimentation days were intended to be demonstration sessions for representatives from Canada Command, CEFCOM, CANOSCOM, CANSOFCOM, Strategic Joint Staff personnel, as well as DND procurement planners will visit the demonstration to learn about the functionality of the systems. However, in practice, the morning experimentation continued during the beginning of the afternoon.

Each experimentation day was distinct, with a focus on different aspects of C2 (Figure 33, Figure 34). The first day focused on situation awareness, information sharing and planning within a JTFG Operations Planning (OPP) cycle; whereas Day 2 focuses more on collaboration, decision-making and execution management. An extensive amount of pre-filled in preparation information has been placed in the tools (maps, SOPs, etc) [21].

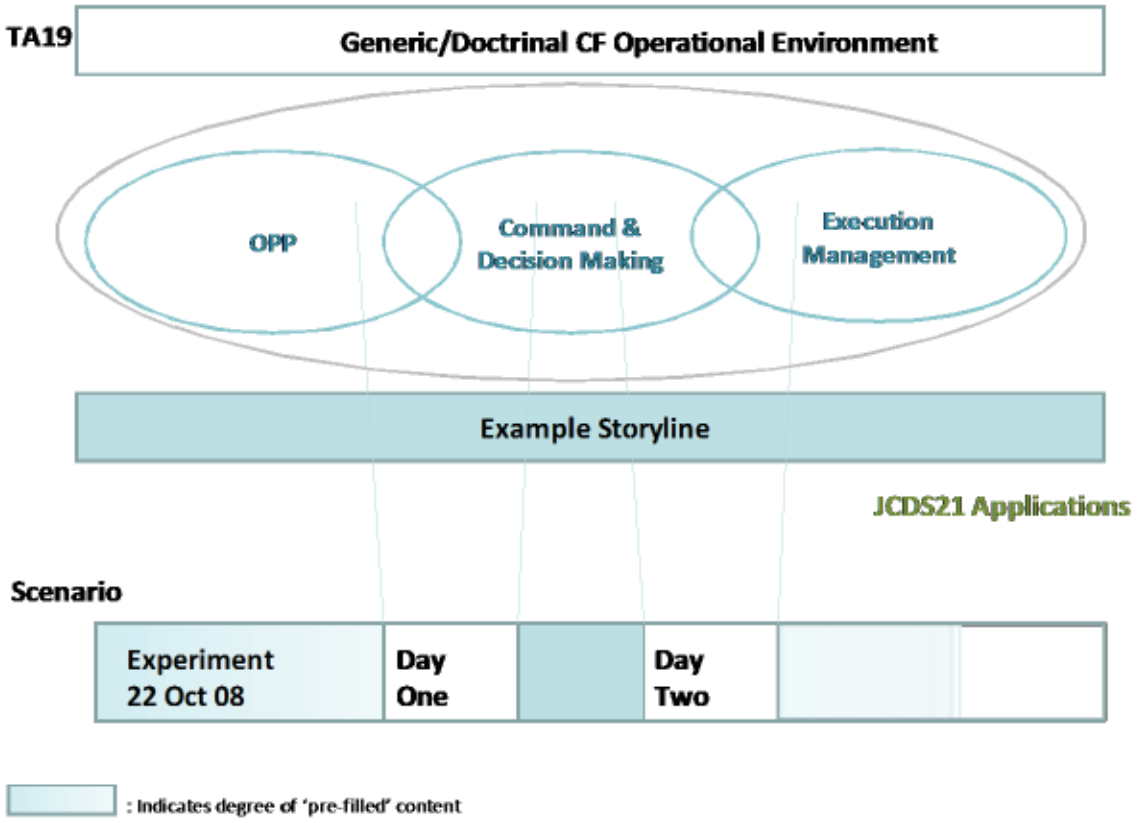

Figure 33: Assessment of Functional Areas associated to Experimentation

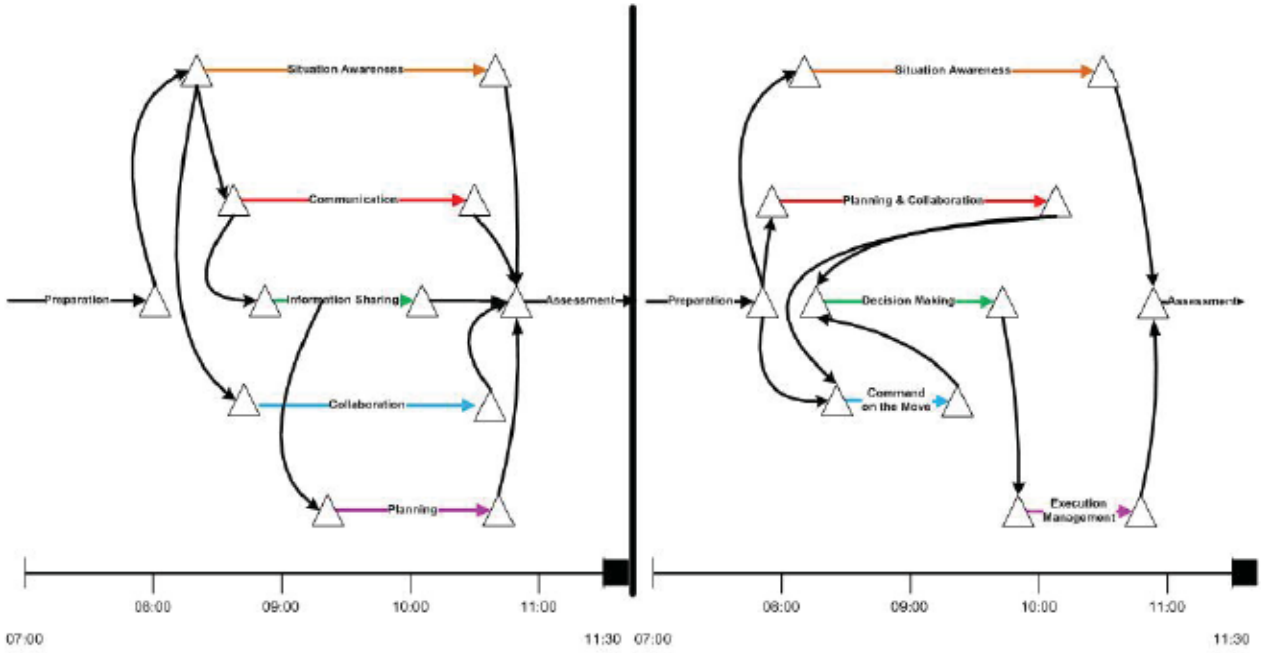

Figure 34: JCDS21 Scenario (document July 2008)

6.3 Experimentation results

A mandate for the data collection team was to assess the quality of participants' SA and their understanding of the situation [22]. Part of the data collection was specific to COPlanS, including OPP-ADS, the planning tool provided to the planning team. It was used to initiate the planning process and execute the CFOPP using an existing CONPLAN. Questionnaires provided to the planning staff indicate that COPlanS obtain a global evaluation of 3.46 on Day 1 and 3.6 on Day 2 (based on a 5 levels scale 1 being vary bad and 5 very good). This score considers the clarity of the information, the timeliness of the information, the correctness of the information as well as the completeness of the information (Figure 35). Considering that COPlanS offer a lot of possibility and that only 1.5 hours of training was provided to the team, these can be considered relatively positive results.

During Day1, which was the main day for planning activities, it is interesting to notice that COPlanS ranked higher than all other C2 tools, including Command View, Mission View, Incident Management System (IMS). This confirms the benefit to have a specific tool for the planning of operations.

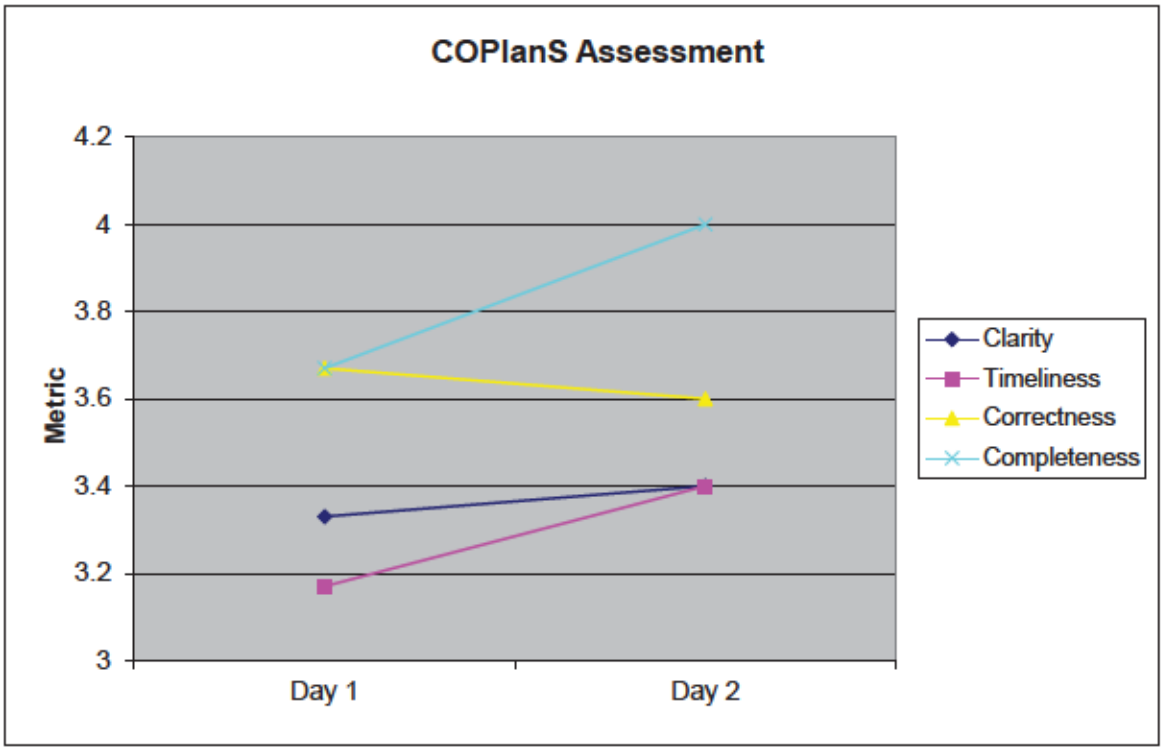

Figure 35: COPlanS Assessment

This page intentionally left blank.

7 Conclusion

This report describes the concepts that have been developed during JCDS21 TDP to support the planners in the design of campaign plans as well as in the utilization of contingency plans in order to reduce the time required to produce executable plans. These concepts are specifically addressing the different stages of the CFOPP in a global Joint Decision Making Process.

COPlanS, a collaborative tool to support the planning of operations as part of Joint, Net-Enabled Collaborative Environment already provided the basic functionalities to execute the five main stages of the CFOPP (initiation, orientation, course of action development, plan development, plan review) with their specific outputs.

The implementation of the concepts developed during JCDS21 into OPP-ADS (Operations Planning Process Advanced Decision Support) provides an additional suite of advanced decision support tools to COPlanS facilitating rapid response planning to achieve Decision Superiority. These tools are:

- Plan Management: This computer-based tool provides the flexibility to search and retrieve different types of contingency plans (CONPLAN) and to instantiate them according to a specific situation. It also provides the functionalities to search for existing or past plans based on an operation category (domestic, international), force employment scenario (non-combat extraction, peace support) and the location of the operation. When existing plans have been identified, they can be viewed for reference or instantiated and modified for use as an OP Plan duplicated for modification. When a plan is completed, it is released for distribution;
- Center of Gravity Analysis Analysis: This computer-based tool support the planners in their brainstorming to identify the relationship between the critical elements (critical capabilities, critical requirements, critical vulnerabilities) influencing the friendly as well as the adversary center of gravities (COGs). It leads to the sketching of a first iteration of decisive points;
- Decisive Points Analysis: This computer-based tool supports the planners in their brainstorming to sequence decisive points into lines of operations and to identify the phases of the operation with their associated objectives and tasks. It provides the grounds to initiate the thinking required to identify possible branch plans and/or sequel plans where transition conditions are desired;
- Criteria Management: This computer-based tool provides management functions for different types of criteria related to the CFOPP. First, criteria used to validate the proposed COG as well as to assess the viability of a COA have been translated into checklists; these are brought to the planners at appropriate time within the CFOPP Stages. It gives access to different repositories of COA evaluation criteria (e.g. different sets of evaluation criteria are associated to Expeditionary Operations or Domestic Operations respectively) as well as to COA evaluation criteria used in previous operations that are relevant and copies them over for use in the current operation being planned;
- Decision Matrix Management: This computer-based tool supports decision-matrixes with the flexibility to use numerical as well as descriptive analysis approaches;
- Risk Management: This computer-based tool supports the planners in the identification of the risk elements (with their causes), their assessment and the mitigation strategy throughout the different stages of the CFOPP;

- Dynamic Link Management: This computer-based tool provides the capacity to link key CFOPP elements (such as mission analysis elements, COA elements and plan elements) together. By allowing the visualization of these relationships, it enables the planners to easily identify the mission analysis and plans elements that would be affected by potential changes in the situation. It also allows the linkages of strategic plan elements to operational plan elements and operational plan elements to tactical plans elements.

As part of the JCDS suite of applications, COPlanS/OPP-ADS have demonstrated the need to automatically interact with a system used to monitor and manage orders at an operational level. When plans are developed and produced with COPlanS, their execution can be managed by EMPA. JCDS provides an environment to exchange information between these systems. Using the JCDS communication facility, COPlanS' plans and EMPA's orders can be synchronized. In the same way, COPlanS produces supporting documents related to developed plans where they can be shared and retrieved from the JCDS document repository. The seamless integration of these applications supports the concept of time-sensitive planning and execution.

OPP-ADS has been demonstrated during JCDS21 experimentation conducted in Ottawa in October 2008 for a Joint Task Force involved in the planning and execution of an operation complex. The conclusion supports the requirement to have a specific tool for the planning of operations.

This work has allowed identifying all the building blocks that would be required to support the planning of time-sensitive operations. It has opened the door to many advanced concepts that would require further investigation such as:

- The investigation of argumentation models to automate establishment of relationships between analysis elements of the CFOPP. Argumentation models could provide a structure to document the analysis activity and be used to identify and explain why some elements/aspects of the situation would have an impact on the operation, and therefore affect the analysis that has been done. It is expected that using argumentation models to document elements of the situation that may have an impact on the operation will help to determine if the mission analysis has to be revised;
- Decision aids for campaign design elements;
- Intelligent mission analysis tools;
- Advanced COA design tools;
- Intelligent COA analysis tools;
- Advanced decision support for COA comparison;
- Adaptive interface to different users' roles and preferences.

References

[1] US Joint Forces Command Glossary (online), US Joint Forces Command, www.jfcom.mil/about/glossary.htm, (Access date: 8 Jan 09).

[2] CANADA COMMAND (2006), CANADA COM Concept of Operations version 3, Unclassified, Draft Effective 3 April 2006.

[3] Hales, D. and Scipione, A. (2008), Joint Command Decision Support for the 21st Century (JCDS21) Technology Demonstration Project – Concept of Operations (CONOPs), DRDC. CRDC-CR-2008-02.

[4] Strategic Joint Staff (SJS) (2008), The Canadian Forces Operational Planning Process (OPP), Department of National Defence, Government of Canada. B-GJ-005-500/FP-000.

[5] Fujitsu (2009), Joint Command Decision Support for the 21st Technology Development Environment (JCDS21 TDE) Concept of Use Document, DRDC Valcartier, W7701-5-3182.

[6] Greenley, A., Baker, K. and Cochran, L. (2006). JSTAFF Front End Analysis (FSSE Task 147), Technical Report Ottawa, Canada.

[7] Strange, J. and Iron, R. (online), Understanding centers of gravity and critical vulnerabilities Part 2. http://www.maxwell.af.mil/AU/AWC/awcgate/usmc/cog2.pdf. (Access date: 8 Jan 09).

[8] Defence Terminology and Forms Management (DTFM) (online). Defence Terminology Bank. Department of National Defence. Government of Canada, (Access date: 8 Jan 09).

[9] Dickson K. D. (2007). Operational Design: A Methodology for Planners. Journal of the Department of Operational Art and Campaigning, Joint Advanced Warfighting School (JAWS), Spring 2007, pp 23-38. (http://www.jfsc.ndu.edu/schools_programs/jcws/Publications/Campaigning_Journal_Spring_2007.pdf).

[10] NATO Standardization Agency (NSA) (2008). NATO glossary of terms and definition (English and French), AAP-6. http://www.nato.int/docu/stanag/aap006/aap-6-2008.pdf

[11] Zhang, L., Falzon, L., Davies, M. and Fuss, I. (2000), On Relationships between Key Concepts of Operational Level Planning, 5th ICCRTS, Track 2: Modeling and Simulation, Canberra, Australia.

[12] Springman, Jeffrey A. (1998), The relationship among tasks, centers of gravity, and decisive points. School of Advanced Military Studies. Command and General Staff College, Fort Leavenworth, Kansas 66027, DTIC ADA356944.

[13] Porter, L., Tardif, M. and Audet, M. (2009). Operational Decision Making Support – Operational Concept Description. DRDC Valcartier CR 2009-125.

[14] Abi-Zeid, I., Bélanger, M., Guitouni, A. and Martel, J.-M. (1998), The reformulation of the family of criteria in commander's expert system advisor (CESA), UNCLASSIFIED, CRDV TM-9739.

[15] Abi-Zeid, I., Bélanger, M., Guitouni, A. and Martel, J.-M. (1998), The criteria for an advisor tool in Canadian airspace violations situations, 1998 Command and Control Research and Technology Symposium, Naval Postgraduate School, Monterey, California, 29 June -1 July 1998, pp. 731-739.

[16] Canadian Forces College (2005). Combined and Joint Staff Officer's Handbook. Government of Canada. CFC CJSOH.

[17] Roy, B. (1985), Méthodologie multicritère d'aide à la décision, Economica, Paris.

[18] Guitouni, A., Martel, J.-M., Bélanger, M. and Hunter, C. (2008), Multiple Criteria of Action Selection, Unclassified, Military Operations Research Journal, Vol. 13, No 1, 2008, pp.35-50.

[19] Joint Doctrine Branch (2007), Risk Management for CF Operations, Department of National Defence. Government of Canada. B-GJ-005-502/FP-000.

[20] Tardif, M., Pelletier, G., Gosselin, G., Côté, D. and Savard, M. (2009), Operational Decision Making Support – JCDS- Architecture. DRDC Valcartier CR 2009-118.

[21] Rehak, L. (2008). Demonstration and Experimentation Plan for JCDS. Contractor report.

[22] Breton, R. and Guitouni, A. (2008). Joint Command Decision Support Experiment 1 – Data Collection Plan, DRDC Valcartier TM 2008-168.

List of symbols/abbreviations/acronyms/initialisms

BC	British Columbia
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
C&C	Command and Control
CC	Critical Capability
CCIRs	Commander's Critical Information Requirements
CF	Canadian Forces
CFOPP	Canadian Forces Operational Planning Process
CHESS	Commander's HandHeld Support System
CR	Critical Requirements
CV	Critical Vulnerabilities
COA	Course of Action
COG	Center of Gravity
COPlanS	Collaborative Operations Planning System
CONOPS	Concept of Operations
CONPLAN	Contingency Plan
COS	Chief of Staff
CPG	Commander's Planning Guidance
CPX	Command Post Exercise
DND	Department of National Defence
DP	Decisive point
DRDC	Defence Research & Development Canada
DRDKIM	Director Research and Development Knowledge and Information Management
EMPA	Execution Management and Plan Adaptation
ESB	Enterprise Service Bus
GIS	Geo-referenced Information System
GUI	Graphical User Interfac
GSB	Global Situation Briefs
HHQ	Higher Headquarter
HQ	Headquarter
HVT	High Value Target
IC2CE	Integrated Command and Control Collaborative Environment
IMS	Information Management System

IPB	Intelligence Preparation of the Battlespace
IMS	Incident Management System
ISU	Integrated Security Unit
JCDS 21 TDP	Joint Command Decision Support 21st Century Technology Demonstration Project
JIMP	Joint, Interagency, Multinational, Public
JSAT	Joint Staff Action Team
JTF	Joint Task Force
JTFC	Joint Task Force Commander
KMapper	Knowledge Mapper
MCDA	MultiCriterion Decision Aid
MVC	Model-View-Controller
NATO	North Atlantic Threaty Organization
OGC	Open Geospatial Consortium
OGD	Other Government Department
OPLAN	Operation Plan
OpO	Operational Order
OPP	Operational Planning Process
OPP-ADS	Operations Planning Process Advanced Decision Support
R&D	Research & Development
RFI	Request for Information
ROE	Rules of Engagement
SA	Situation Awareness
SOA	Service Oriented Architecture
SJS	Strategic Joint Staff
TRV	Total Resource Visibility
UDDI	Universal Description, Discovery and Integration
UN	United Nations
VOI	Vessel of Interest
WFS	Web Feature Service
WMS	Web Map Service

DOCUMENT CONTROL DATA

(Security markings for the title, abstract and indexing annotation must be entered when the document is Classified or Designated)

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

Defence Research and Development Canada – Valcartier
2459 Pie-XI Blvd North
Quebec (Quebec)
G3J 1X5 Canada

2a. SECURITY MARKING (Overall security marking of the document including special supplemental markings if applicable.)

UNCLASSIFIED

2b. CONTROLLED GOODS

(NON-CONTROLLED GOODS)
DMC A
REVIEW: GCEC JUNE 2010

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

Concepts to support the operational planning process : A time-sensitive perspective

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

Bélanger, M., Pageau, N., Guitouni, A.

5. DATE OF PUBLICATION (Month and year of publication of document.)

November 2011

6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)

82

6b. NO. OF REFS (Total cited in document.)

22

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

Technical Report

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

Defence Research and Development Canada – Valcartier
2459 Pie-XI Blvd North
Quebec (Quebec)
G3J 1X5 Canada

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

15at

9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)

10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.)

DRDC Valcartier TR 2011-258

10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

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

Unlimited

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

Unlimited

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

One facet of decision superiority is to shorten the time required to make good decisions. It is in this line of thought that OPP-ADS (Operations Planning Process Advanced Decision Support) has demonstrated an integrated suite of tools able to create/store/retrieve and rapidly adapt operational contingency plans to produce executable plans for specific situations. Complementary to these functionalities, a link management tool allows one to tightly couple tools that support the design of a campaign plan (for example, center of gravity analysis and decisive point analysis), the management of risk elements, the management of criteria with their associated after action report, as well as the management of decision-matrixes. This concept of linking key analysis elements provides the capability to rapidly identify pieces of analysis that can be customized according to the situation. This work has led to the identification of functional requirements related to decision-support tools for operational planning.

Un des aspects de la supériorité décisionnelle est de réduire le temps requis pour prendre de bonnes décisions. C'est dans cet état d'esprit que OPP-ADS (Operations Planning Advanced Decision Support) a démontré une suite d'outils capable de créer/sauvegarder/récupérer et adapter rapidement les plans de contingence pour produire des plans exécutables adaptés à des situations particulières. En complément à ces fonctionnalités, un outil de gestion de liens permet d'associer des outils supportant la conception d'un plan de campagne (ex. analyse des centres de gravité et des points décisifs), la gestion des éléments de risque, la gestion des critères avec leur rapport d'analyse après-exécution ainsi que la gestion des matrices de décision. Le concept de lier des éléments clés permet d'identifier rapidement les éléments d'analyse qui devraient être révisés en fonction de l'évolution d'une situation. Ce travail a mené à l'identification de besoins fonctionnels d'aide à la décision pour la planification des opérations.

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

planning; operational planning process; decision support; plan management; centre of gravity analysis; decisive point analysis; campaign design; criteria management; risk management

Defence R&D Canada

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

R & D pour la défense Canada

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

DEFENCE DÉFENSE

www.drdc-rddc.gc.ca