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Critiquinq systems for the Estimate Process

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Critiquing systems for the Estimate Process

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Abstract

The Canadian Forces Operational Planning Process (CFOPP) is a methodical approach to analyzing a situation, bringing staff expertise to bear on the relevant factors, narrowing courses of action, obtaining the commander's approval, and developing the detailed annexes necessary to produce an executable plan. It is based on an Estimate Process that involves the elaboration of different Courses of Action (COAs) following situation analysis and the selection of the most appropriate one for its subsequent planning. The Estimate Process is often performed under high time pressure and stressful conditions. Under the influence of these factors, the human capacity of reasoning and judgment can be significantly reduced. In order to support the commander and his/her team in carrying out the CFOPP, Defence Research and Development Canada (DRDC) is conducting research and development activities to investigate different types of computer-based systems that can provide decision-support facilities. One of these activities is the investigation of computer-based critiquing facilities for the Estimate Process. The aim of this document is to document some of the work that has been executed at the initial phase of this project. It presents different critiquing systems that have been identified for the Estimate Process.

Résumé

Le Processus de planification opérationnelle des Forces canadiennes (PPOFC) est une approche méthodique pour analyser une situation, faire converger l'expertise du personnel sur les facteurs pertinents, restreindre les suites d'actions possibles, obtenir l'approbation du commandant et développer les annexes nécessaires à la production d'un plan exécutable. Il est basé sur un processus d'estimation qui implique l'analyse de la situation, l'élaboration des différentes suites d'actions ainsi que la sélection de la suite d'actions la plus appropriée à cette situation. Le processus d'estimation est souvent exécuté selon des contraintes temporelles et dans des conditions de stress. Sous l'influence de ces facteurs, les capacités humaines de raisonnement et de jugement peuvent être significativement réduites. Afin d'apporter une aide au commandant et à son équipe pour la réalisation du PPOFC, les centres de Recherche et développement pour la défense Canada (RDDC) poursuivent des activités de recherche et développement afin d'étudier les différents systèmes d'information pouvant fournir des fonctionnalités d'aide à la décision. Une de ces activités est l'étude des systèmes automatisés de formulation de critiques pour le processus d'estimation. Le but de ce document est de documenter une partie du travail réalisé lors de la première phase de ce projet. Il présente différents systèmes de formulation de critiques qui ont été identifiés pour le processus d'estimation.

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Executive summary

The Canadian Forces Operational Planning Process (CFOPP) is a methodical approach to analyzing a situation, bringing staff expertise to bear on the relevant factors, narrowing courses of action, obtaining the commander's approval, and developing the detailed annexes necessary to produce an executable plan. It is based on an Estimate Process that involves the elaboration of different Courses of Action (COAs) following situation analysis and the selection of the most appropriate one for its subsequent planning.

Military operations are evolving into a dynamic, complex and uncertain environment. Accordingly, the Estimate Process is often performed under high time pressure and stressful conditions. Under the influence of these factors, the human capacity of reasoning and judgment can be significantly reduced. In order to support the commander and his/her team in carrying out the CFOPP, Defence Research and Development Canada (DRDC) is conducting different research and development activities in order to investigate different types of computer-based systems that can provide decision-support facilities. One of these activities is a Technology Investment Fund (TIF) project called "COA Critiquing System for the Improvement of the Military Estimate Process". It proposes to investigate computer-based critiquing facilities to assist the commander and his/her team in the Estimate Process.

One of the first phases of this project is to identify different critiquing systems that may be useful for the military community executing the estimate process. Based on the identification of these systems, the most promising concepts are going to be identified, investigated and implemented. All this work will be performed in order to determine if critiquing systems are appropriate to support the Estimate Process.

The aim of this document is to present the critiquing systems that have been identified during the initial phase of the project.

Sommaire

Le Processus de planification opérationnelle des Forces canadiennes (PPOFC) est une approche systématique pour analyser une situation, faire converger l'expertise du personnel sur les facteurs pertinents, restreindre les suites d'actions possibles, obtenir l'approbation du commandant, et développer les annexes nécessaires à la production d'un plan exécutable. Il est basé sur un processus d'estimation qui implique l'analyse de la situation, l'élaboration des différentes suites d'actions ainsi que la sélection de la suite d'action la plus appropriée à cette situation.

Les opérations militaires ont habituellement lieu dans un environnement dynamique, complexe et incertain. Ainsi, le processus d'estimation est souvent exécuté selon des contraintes temporelles et dans des conditions de stress. Sous l'influence de ces facteurs, les capacités humaines de raisonnement et de jugement peuvent être significativement réduites. Afin d'apporter une aide au commandant et à son équipe dans la réalisation du PPOFC, les centres de Recherche et développement pour la défense Canada poursuivent des activités de recherche et développement afin d'étudier les différents systèmes d'information pouvant fournir des fonctionnalités d'aide à la décision. Une de ces activités est un projet du Fonds d'investissement technologique (FIT) appelé « Système de critique de suites d'actions pour l'amélioration du processus militaire d'estimation ». Ce projet propose d'étudier les systèmes automatisés de formulation de critiques pour aider le commandant et son équipe dans la réalisation du processus d'estimation.

Une des premières phases de ce projet est d'identifier les différents systèmes de formulation de critiques pouvant être utiles à la communauté militaire devant exécuter le processus d'estimation. En fonction des différents systèmes identifiés, les concepts les plus prometteurs seront identifiés, étudiés et implantés. Tout ce travail a été effectué afin de déterminer si les systèmes de formulation de critiques sont appropriés pour faciliter le processus d'estimation.

Le but de ce document est de présenter les systèmes de formulation de critiques qui ont été identifiés pour le processus d'estimation lors de la phase initiale de ce projet.

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1.   Introduction

The Canadian Forces Operational Planning Process (CFOPP) is a methodical approach to analyzing a situation, bringing staff expertise to bear on the relevant factors, narrowing courses of action, obtaining the commander's approval, and developing the detailed annexes necessary to produce an executable plan [1]. The CFOPP can be used at the strategic as well at the operational and tactical level. It is the process used to prepare plans and orders for CF operations, and accordingly, it focuses on establishing the areas of focus, the kinds of issues to be resolved, and the outputs that must be produced [2].

CFOPP is comprised of five main stages (Figure 1) with specific outputs [1]:

- The *Initiation* stage results in the activation of the planning staff, and the commander's guidelines about the kind of planning process to achieve.

- The *Orientation* stage results in the development of the commander's planning guidance. In this 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.

- The *Course of Action (COA) Development* stage results in the production of the CONOPS that identifies the commander's line of action in order to accomplish his/her mission. It presents the COA that will be implemented. In previous version of the CFOPP there was a decision stage that has been integrated into this *COA development* one.
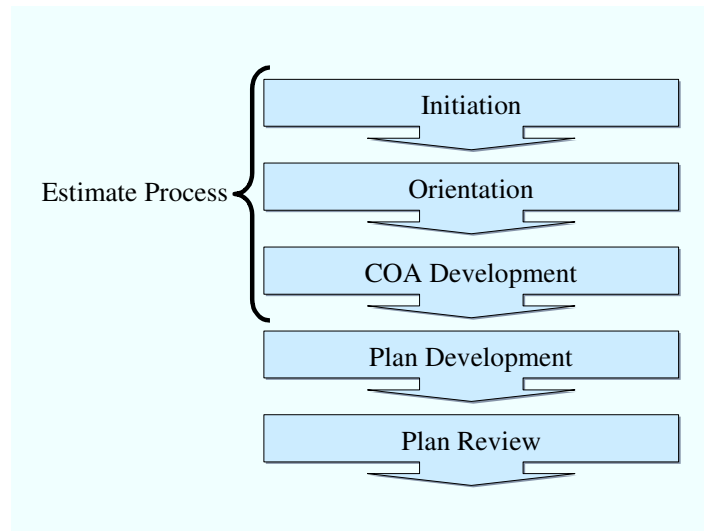
Figure 1. CFOPP

- The *Plan Development* stage results in a set of orders based on the commander's decision to provide subordinate and supporting units with all of the necessary information to initiate planning or execution of operations.

- The *Plan Review* stage results in a regular review of the plan to evaluate its viability. The period used to review the plan depends on the evolution of the situation, the type of operation and the environment.

The three first stages of the CFOPP constitute what is called the Estimate Process. It involves the elaboration of different courses of action (COAs) following situation analysis and the selection of the most appropriate one for its subsequent planning. The intent of the Estimate Process is to optimize logical, analytical steps of decision making in conditions of uncertainty and ambiguity while maximizing the commander's and staff's creative thinking and associated thought processes [1]. Besides, it needs to be tailored to units' and formations' specific needs as well as to standing operations procedures. It is assumed that the execution of the Estimate Process will maintain a minimum of quality in the planning results.

The Estimate Process is accomplished by a team with different expertise areas. Even if the different functions to be executed at the different stages are well identified, no formal procedures to execute them are defined [2]. Therefore, the planning staff employs intuitive strategies to execute these functions [2]. Based on their experience, background and capacity to retrieve relevant knowledge stored in their memory, they use the Estimate Process to guide them in order to provide their commander with a recommendation on the best COA to execute [2,3].

Most of the time, military operations are evolving into a dynamic, complex and uncertain environment. Accordingly, the Estimate Process is often performed under high time pressure and stressful conditions. Under the influence of these factors, the human capacity of reasoning and judgment can be significantly reduced. Different types of decision-support systems can be proposed to support the commander and his team in carrying out the Estimate Process [3]. Since critiquing systems are known to be well suited for situations where [4]:

- knowledge is incomplete and evolving,

- the problem requirements can be specified only partially, and

- necessary knowledge is distributed among many participants;

it has been decided to investigate their use for the Estimate Process.

Critiquing systems observe the inputs and decisions of the user and try to verify the decisions while drawing attention only in critical situations [5]. Vahidov and Elrod mentioned that the primary purpose of critiquing systems is to monitor the user's actions and indicate possible errors [6]. Then, the core task of critics is to recognize and communicate debatable issues concerning a product [4]. Critics point out problematic situations that might otherwise remain unnoticed. Accordingly, a critiquing system is a

tool that allows the decision-maker to be "fully" aware of the advantages and disadvantages of a solution. It can also provide some kind of guidance on how to improve the proposed solution [6]. In brief, critiquing systems do for experts what intelligent tutoring systems do for novices [7].

Critiquing systems are different from other types of advisory systems on these aspects:

- Type of input: The solution of the user is provided as an input to a critiquing system, while it is not the case to other types of systems;

- Type of output: A critiquing system provides a list of strengths and weaknesses of the user's solution instead of providing a solution;

- Type of interaction: A critiquing system determines the right information to be provided at the right time (which is the challenge according to Fisher [4]), while other systems will respond in real time to a user request or to a predetermined moment in a sequence. The level of autonomy of such a system is usually higher than other types of advisory systems since it tries to make the user aware of the critical issues and their impact when they are raised. Furthermore, justification and explanation facilities are common in such a system, even argumentation facility is expected.

Since critiquing systems help users in designing solutions themselves, as opposed to having a traditional expert system design solutions for them, it provides a more cooperative approach to problem solving [4]. Furthermore, it is expected that some of the benefits of the cognitive activity of critiquing will be effective for computer-based critiquing systems. These include the growth of knowledge, error elimination and the promotion of mutual understanding by all participants [4].

However, to be practically useful, critiquing systems must have these proprieties [5]:

- Critiquing systems should not ask for additional information too often, otherwise the system disturbs the user more than it helps;

- Critiquing systems should be able to help the user in situations where only partial information is available;

- Critiquing systems should be able to focus on critical situations.

Based on the author's understanding of the Estimate Process [3] and the critiquing systems [8, 9], this document presents different critiquing systems that could be developed for the different stages of the Estimate Process.

2. Critiquing systems for the initiation stage

The *Initiation* stage can commence when initiating directive is received. This stage consists in activating the planning staff, gathering of planning tools (e.g. maps of the area of operations, own and higher headquarters' standing operating procedures (SOPs), appropriate documents), production of staff guideline related to how to apply the planning process as well as the time available to achieve it. Essentially, the commander must inform the team on how the process should be carried out.

Following are different critiquing facilities that have been identified for this stage.

2.1 Critiquing the composition of the team

Ideally, the team members' expertise areas of the planning staff should cover the expertise needed for the planning of operations. It would be possible to have a critiquing system able to provide the strengths and weaknesses of a proposed team based on the experience and training needed for the planning of a specific operation.

2.2 Critiquing the execution of a decision-making strategy

The initiation stage is the right place for setting parameters for the dynamics of the team. Usually, the chief of staff (COS) is the key player to set the decision-making strategy that will be used and have it followed by all members. A decision-making strategy is the process used by the group to reach any decision during the Estimate Process, such as the identification of the factors, the COAs, and the selection of the most appropriate one.

Methods of decision-making can be seen on a continuum with one person having full authority on one end to everyone sharing power and responsibility on the other [10]. The basic ways that team make decisions are [11]:

- Command Decision: An individual on the team can make the decision based on his/her own information.

- Consultative Decision: An individual on the team can make the decision based on input from other team members.

- Majority: The team can vote and base the decision on the majority.

- Consensus Decision: The whole team can work to decide on an option that everyone can support.

- Unanimous agreement: The team can have everyone agree on one option.
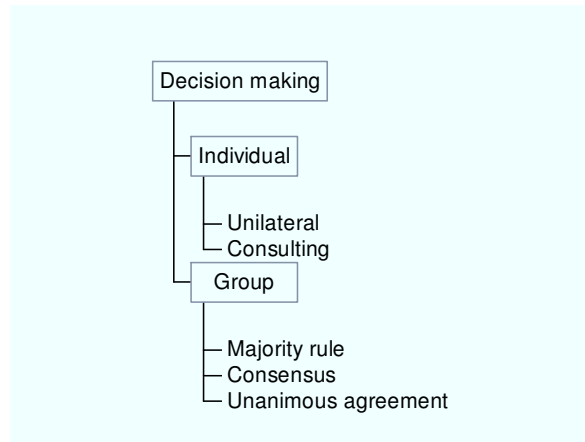
***Figure 2.*** *Decision making strategies [11]*

If group strategies such as majority and consensus are chosen (which is generally the case for military team executing the Estimate Process), a critiquing system can play the role of a monitor for the decision-making strategy selected. For example, different formal consensus processes have been proposed in the literature [10, 12, 13, 14]. All of them require a commitment to active cooperation, disciplined speaking and listening, and respect for the contributions of every member [10]. Generally, the team is taking possession of all proposals/ideas (the proposal is not the property of the presenter anymore). During a discussion, each proposal is challenged by raising any concerns the team members may have. Then, everyone in the team works to improve the proposal to make it the best decision for the group. A critiquing system could monitor the decision making process and advise the team on the weaknesses in achieving this process, such as notifying that some concerns have not been solved or that some proposals have not been studied, etc.

Having a critiquing system for the execution of a decision-making strategy involved that the system must be able to ear and understand the discussion and the body language exchanges of the team members (which is not the case right now, but could eventually happen), or that the team will use a computer-based infrastructure to exchange information (each team member uses a computer to communicate with the rest of the group). Accordingly, tools such as collaborative tools, computer-based discussion forums or brain-storming tools could be used as support tools for critiquing systems.

2.3   Critiquing the sources of knowledge

As part of the planning tools to be identified and gathered, there are the different sources of information and knowledge that can be needed to achieve the planning. These sources of knowledge may be automated or not. Automated planning tools or decision support tools will need to have access to different automated knowledge sources such as best practices Knowledge Base (KB), lessons learned KB, case base and doctrine KB, as well as expert KBs for specific areas of expertise (Figure 3).
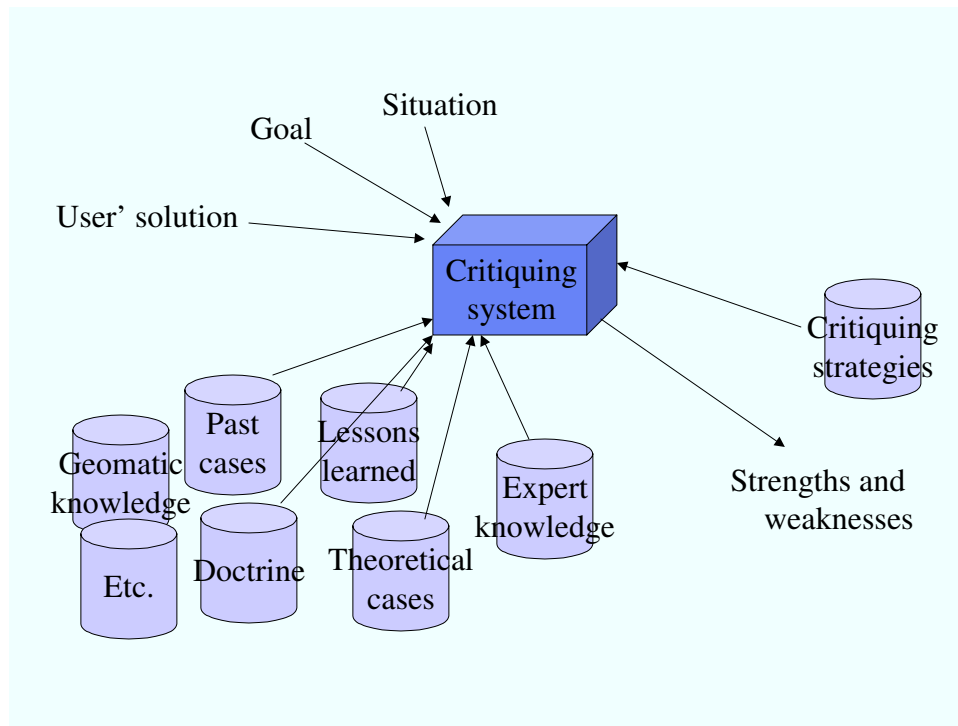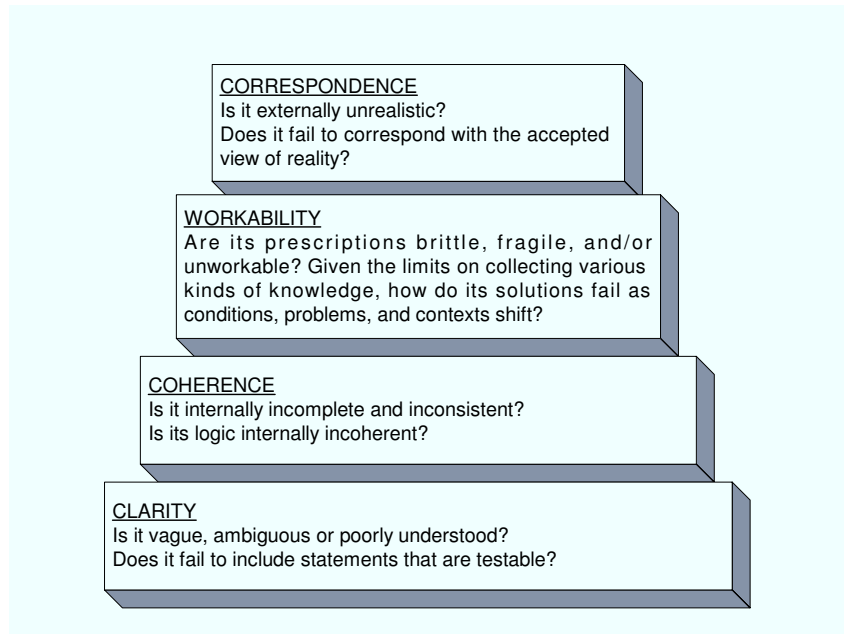
Figure 3. *Knowledge sources for critiquing system*

When a human, a semi-automated or an automated system (critiquing or any type of advisory systems) needs to use the information contained in these knowledge bases, they must be aware of the quality of its information.

Focussing on critiquing the credibility of the knowledge, Sylverman [7] has identify four tests (clarity, coherence, workability, correspondence) that indicate if observers will reject the credibility of a body of knowledge (Figure 4). Based on this approach, a critiquing system could be used to verify the credibility of the knowledge in each KB.

Furthermore, since a critiquing systems will probably consult more than one knowledge base and that different knowledge bases may provide different perspectives to consider when identifying the strengths and weaknesses of a solution, it may happen that conflicted knowledge be produced. A "meta-critiquing system" should be able to detect conflicted as well as concordant evidence between the list of strengths and weaknesses produced by the use of different sources of knowledge.

On another side, a critiquing system can also produce a list of strengths and weaknesses related to the identification of aspects that are not very well covered by the KBs used.

Figure 4. *Framework for critiquing a body of knowledge (from Sylverman)*

3. Critiquing systems for the orientation stage

In the *Orientation* stage, the "Commander must orient the staff towards the requirements of the new operation" [1]. To orient the planning, a mission analysis will be conducted. It is an exercise between the commander and key staff to designate the centre of gravity, the end state and criteria for success for the staff. This is a key activity in the CFOPP, which has two objectives: determine the nature of the problem and confirm the results to be achieved. These results will be in the form of a draft mission statement that answers the following questions [1]:

    a. Who (what types of forces) will execute the action?

    b. What type of action (for example attack, defend) is contemplated?

    c. When will the action begin?

    d. Where will the action occur (area of operations and objectives)? And

    e. Why (for what purpose) will each force conduct its part of the operation?

The output of the orientation stage is the commander's planning guidance.

Following are different critiquing facilities that have been identified for this stage.

3.1 Critiquing the commander's guidance elements

The commander's guidance [1] includes the description of higher command level intent as well as the description of the situation based on planning staff factors.

The higher command level intent is described by [1]:

- Assumptions

- Constraints/restraints

- Centre of gravity (own/enemy)

- Objectives

- Endstate

- Criteria for success

- Tasks

and the description of the situation is made by the development of these planning staff factors [1]:

- Critical facts and assumptions

- Constraints/restraints

- Key strengths and weaknesses (own and enemy)

- Centre of gravity (own and enemy)

- Tasks (assigned/implied)

- Objectives

- Endstate

- Criteria for success

- Force capabilities and groupings required

- Command and control structures

- Assess risk

- Propose timelines

- Battlespace effects

- Etc.

The commander and key team's evaluation of each one of these elements, which are described in the commander's guidance, can be used by a critiquing system as a user's solution. Critiquing systems could provide the list of strengths and weaknesses for each one of these evaluations. Such tool will then allow a verification of the accuracy of these evaluations.

4. Critiquing systems for the COA development stage

The *Course of Action (COA) Development* stage (Figure 5) starts with a review of commander's guidance to ensure that all staff develops a common understanding of the commander's intent, and that this understanding is consistent with the intent of the commander. Then a staff analysis is executed to identify the factors and the derived deductions that are relevant to the operation being planned as well as to determine whether the mission is achievable based on limitations imposed by higher authorities. Following this step, realistic enemy COAs are developed and effects associated with them are analysed. Own forces COAs are also developed and analysed to determine 1) their viability; 2) how they counter the expected enemy COAs and; 3) how they respect the principles of war or tenets of joint warfare. Own COAs are then validated with the commander and adjusted according to his comments/preoccupations. Validated COAs are compared among them and the result of the comparison is presented to the commander, so he can select the COA that is the most appropriate to the situation according to his point of view. The output of the COA development stage, which is also the output of the Estimate Process, is the CONOPS.

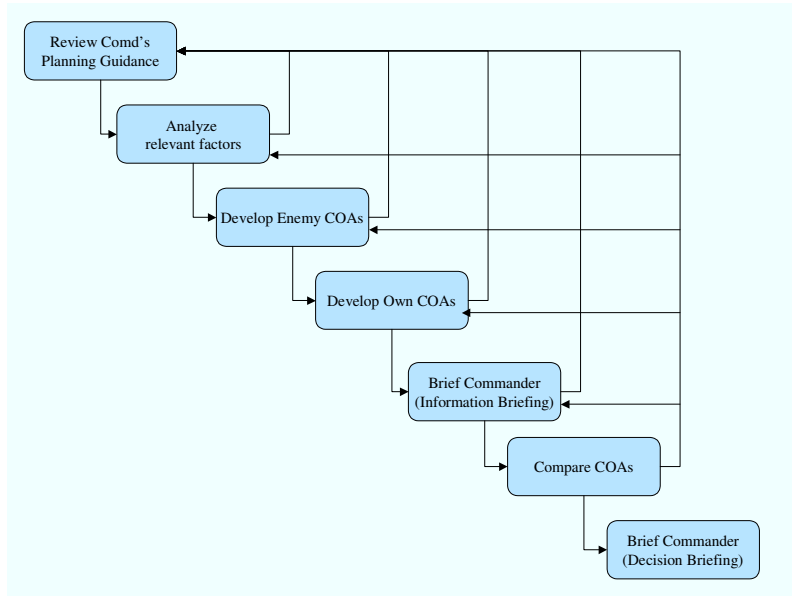Following are different critiquing facilities that have been identified for this stage.

Figure 5. *COA development*

4.1 Critiquing the COA development process

The intent of the COA development process is that some functions need to be addressed in a certain sequence; for example, the COA should not be developed before the situation is

understood. To do so, the pertinent factors must have been identified and understood, and the team must focus on the critical factors to the mission, avoiding spending too much time on details that are not so important. Then, an acceptable set of options should be defined before the decision is made [3]. If new information is received or an hypothesis modified, the team can always go back in the process to review/modify previous deductions, COAs.

By simplifying the COA Development as in Figure 6, we can imagine a critiquing system capable of detecting any omission of any of these steps and advise the team of the possible impact of this fact. Such critiquing system will need that the team use a computer-based infrastructure to exchange information.
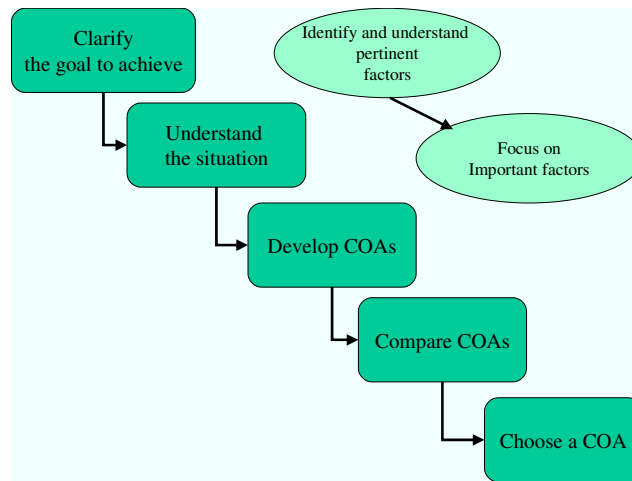
Figure 6. *COA development view*

4.2 Critiquing different perceptions of the goal to achieve

The intent of the commander is described in the commander's guidance. By reading it, each member of the team develop an understanding of the commander's intent, and by discussion among the team, a shared understanding will be developed.

Previous work on team decision making have identified the importance of a shared mental model. For example, Cohen mentioned that:

- "Effective team coordination in turn is enhanced when team members share mental models (Paris, Salas, & Cannon-Bowers, 2000). Communication among team members, through validation and elaboration of shared mental models, leads to improved decision making and problem solving." [15]

- "Team decision making depends on shared mental models of the task, the situation, and the communicative processes within the team that create and maintain such shared knowledge." [15]

Then, it is possible to consider the team common understanding of the commander's intent that has been developed through exchanges among the team members as a common mental model. This common mental model can be seen as a subset of each team member's mental model.

Based on his work on critical thinking, Cohen [16] identified three types of problems in mental models (Figure 7): gaps, conflict and unreliable assumptions. Freeman [17] also mentioned that critiquing "ferrets out specific sources of uncertainty, such as gaps in knowledge, untested assumptions, and the existence of conflicting interpretations of events". It is then possible to think of a critiquing system trying to identify these problems in the mental models of the different team members.

Based on this approach, a critiquing system could monitor the discussions of the team members in order to detect and identify any conflicts or gaps between the commander's intent and the team's understanding of the commander's intent or between the individual understandings of the commander's intent and the team's understanding (Figure 8). Furthermore, it could detect unreliable assumptions in the team's understanding of commander's intent.

However, to be able to do so, a critiquing system must be able to define and keep in record a profile of each team members (user's models), including the commander's profile, as well as a profile for the team (Figure 9). Furthermore, such a critiquing system will need that the team use a computer-based infrastructure to exchange information.
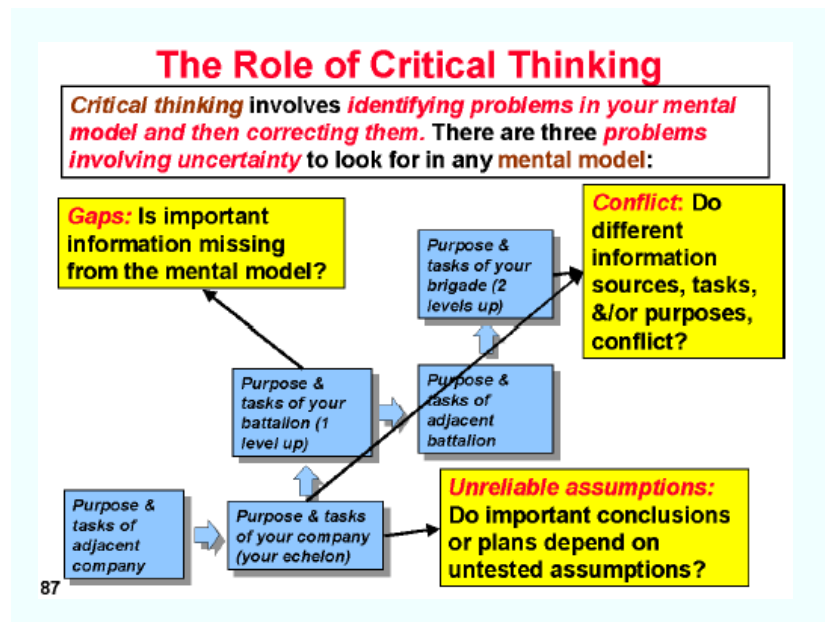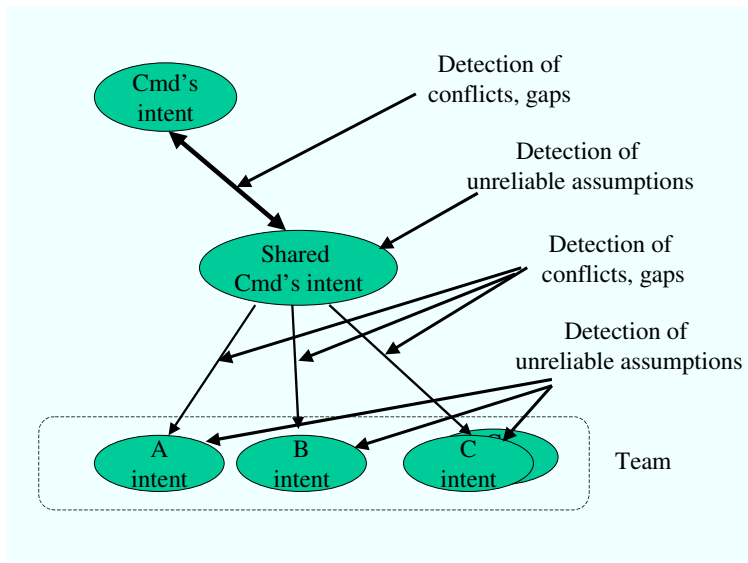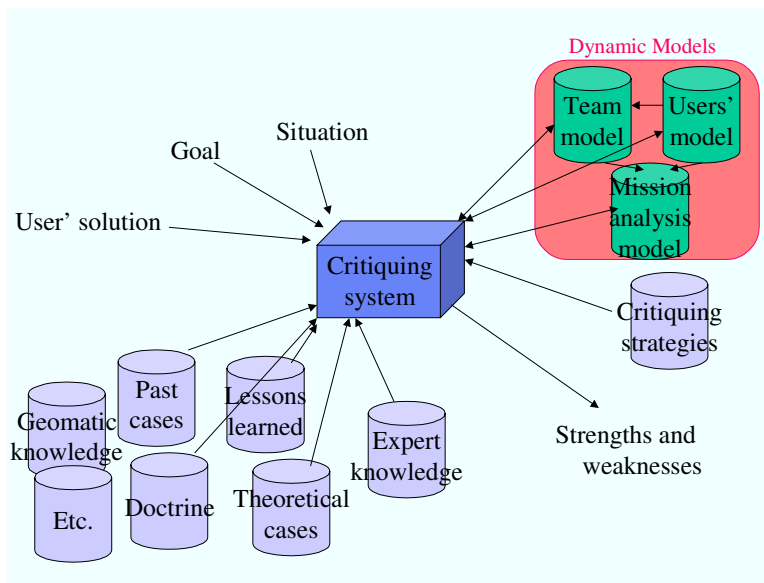

Figure 7. Three different kinds of uncertainty in mental models [16]

Figure 8. *Role of a critiquing system for understanding of commander's Intent*

Figure 9. *Dynamic models for critiquing system*

4.3   Critiquing the assessment of the situation

The staff analysis is performed at the COA development stage in order to have a better assessment of the situation by improving the understanding of the team' members about what is going on in the situation. It allows a refinement of the understanding of the situation that have been developed during the mission analysis of the orientation stage.

Since one of the most frequent problem of novices as well as more experimented planners is the fact that they have a tendency to develop solutions before completing their understanding of the complete situation [3], it is possible to think about developing a computer-based critiquing system that could help reducing this natural tendency. Such systems could improve the result of the Estimate Process since it has been observed that "groups were more successful in solving problems if they had analyzed problems instead of focusing on solutions." (Orasanu and Salas (1993) [15]) .

The following subsections introduce some of the aspects that can be used to provide critiques about the user's understanding of the situation.

4.3.1   Based on staff analysis factors

The factors that may have an impact on the operations cover, but are not limited to this list [1]:

- Area of Operations (AOO)

- Opposing forces capabilities

- Political considerations

- Own forces capabilities

- Time and space

- Command and control

- Logistics and movement

- Rules of engagement

- Conflict of termination

- Risk

- Assigned/implied tasks

- Etc.

These factors and their assessment (the gist of their impact) are documented in the staff analysis. The assessment of each one of these aspects could be used by a critiquing system as an input to be critiqued. The critiquing system could verify if the assessments of these factors are correct according to the doctrine, expert knowledge, lessons learned, etc.

4.3.2 Based on different user's perceptions of the situation

At the beginning of the COA development stage, each team member will develop a comprehension of the situation. During discussion, the team will develop a common understanding of the situation. Then it is possible to consider the team common understanding of the situation that has been developed through exchanges among the team members as a common mental model. This common mental model can be seen as a subset of each team member's mental model.

Based on the work of Cohen [16], it is possible to think about a critiquing system that could monitor the exchange of information between team members, used them to represent a mental model of each individual and detect inconsistencies between individual mental models and team mental model (Figure 10). Such a critiquing system will need that the team use a computer-based infrastructure to exchange information.
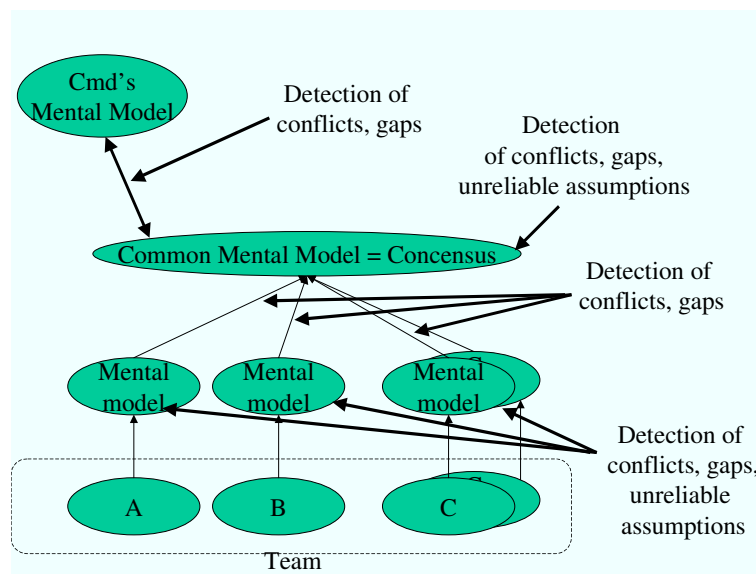
Figure 10. Critiques for common mental model

4.4 Critiquing the COAs

The COAs are at the core of the COA development stage. Critiquing systems could provide the team with support by providing the strengths and weaknesses of the different COAs according to the situation. The critiquing systems would use as an input a complete or a partial COA. The following subsections introduce some of the aspects that can be used to provide critiques for a COA.

4.4.1 Based on conception analysis

A COA is composed of a set of phases that will ultimately allow reaching the commander's goal. A COA can then be seen as a user's solution composed of a complex structure of tasks.

It is possible to think about a critiquing system able to detect any ambiguity (clarity), conflict (temporal or logical), incoherence (temporal or logical incompleteness and inconsistency) or reality mismatch in the structure of tasks within each phase of a COA as well as in the amalgamation of the different phases when considering them as a whole COA. Such a critiquing system would detect conception problem within the plan itself.

4.4.2 Based on staff analysis factors

A COA can also be critiqued on the basis of how it deals with the different issues that have been identified during the staff analysis. These issues are usually documented in the "So what" part of the different factors, which are [1]:

- Area of Operations (AOO)

- Opposing forces capabilities

- Political considerations

- Own forces capabilities

- Time and space

- Command and control

- Logistics and movement

- Rules of engagement

- Conflict termination

- Risk

- Assigned/implied tasks

- Lessons learned

- Etc.

4.4.3 Based on the viability analysis

A COA can be critiqued on the basis of its viability. The viability of a COA can be tested by considering these aspects [1]:

- Suitability: Does it achieve the mission, satisfy the commander's intent and accomplish the tasks? Does it counter enemy COAs?;

- Feasibility: Do force structure and resources exist to mount and sustain?;

- Acceptability: Does it account for limitations placed on the operation, is it worth the risk?;

- Compliance: Does it conform to approved CF doctrine and applicable policy, regulations, legislation and/or guidelines?

4.4.4 Based on enemy COAs analysis

A COA can be critiqued on the basis of how it counter the different Enemy COAs identified.

4.4.5 Based on criteria analysis

A COA can be critiqued on the basis of the criteria used for comparing the different COAs. For example, in a situation of counter-drug, the following factors/criteria have been identified [18,19]:

Table 1. Evaluation criteria

Factor	Criterion	Concerned with
Flexibility		
	C1: Covering Operational Tasks	the ability of a COA to adapt to possible changes in operational task which may occur during its implementation
	C2: Covering Mission's Possible Locations	the ability of a COA to adapt to possible changes in the predicted mission's locations which may occur during the implementation of a COA
	C3: Covering Enemy's COA	the ability of a COA to adapt in time to possible changes in the enemy's COA that may occur during the implementation
Complexity		
	C4: Operations Complexity	the COA implementation difficulties caused by its operational requirements
	C5: Logistics Complexity	the COA implementation difficulties caused by its logistics requirements
	C6: Command and Control Complexity	the COA implementation difficulties caused by command and control relationships and co-ordination requirements in operation
Sustainability		
	C7: Sustainability	the ability to continue (stay in) the operation as a function of the on-station time associated with the COA
Optimum use of resources		
	C8: Cost of Resources	the cost of the resources being used
Risk		
	C9: Impact of the Sensors Coverage Gap	the possibility of mission failure caused by the existence of radar and/or radio gaps
	C10: Military Personnel Loss	the likelihood of military personnel loss during the mission
	C11: Collateral Damage	the possibility of collateral damage (anything but the target) during the mission
	C12: Confrontation Risk	the possibility of mission failure due to confrontation
	C13: COA Equipment Reliability	the equipment reliability and the robustness of the COA
	C14: COA Personnel Effectiveness	the effectiveness of the personnel which may be jeopardized by fatigue, stress, etc. at any moment during the mission

4.4.6 Based on the analysis of direct and indirect effects

A COA can be critiqued on the basis of different effects, direct as well as indirect (physical or psychological), caused by the execution of this COA. This notion of direct and indirect effects is at the core of the notion of effects based operations (Figure 11). Effects based operations are coordinated sets of actions directed at shaping the behavior of friends, foes, and neutrals in peace, crisis and war [20].
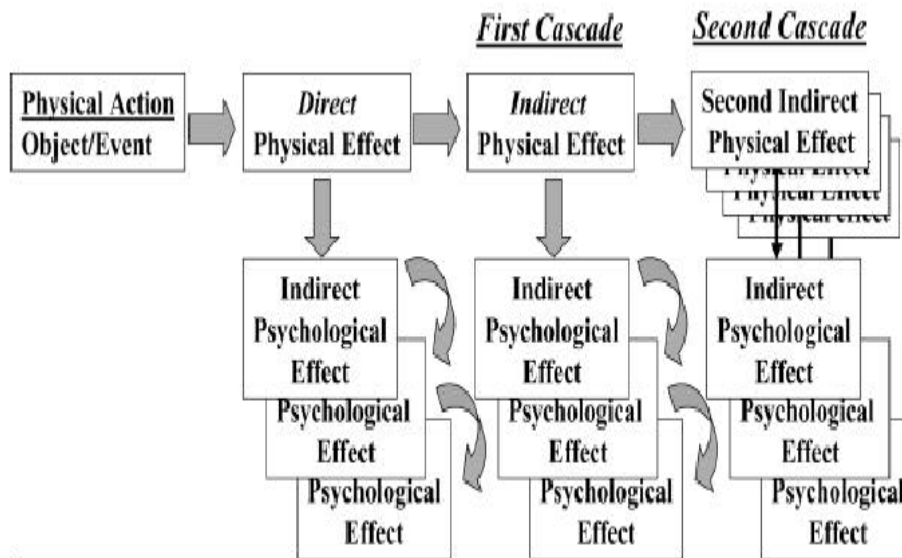

Figure 56. Effects Cascades: Derivative Cascades of Indirect Psychological Effects

Figure 11. *Effects based operations [20]*

4.4.7 Based on different user's perception of COA assessment

During discussions, the team develop and assess the COAs. The team will develop an agreement on a common assessment. Here again, a common understanding of the assessment of these COA phases is essential and can correspond to a common mental model of the assessment of a COA. As mentioned in subsection 4.3.2, critiquing system could monitor the exchange of information between team members, use them to represent a mental model of each individual and detect inconsistencies between individual mental models and team mental model. Such a critiquing system will need that the team use a computer-based infrastructure to exchange information.

4.5   Critiquing the diversity of a set of COAs

When developing a set of COAs, the team must make sure that this set covers well the different possibilities, that there is a good diversity of options among the different COAs. Accordingly, a critiquing system can identify the strengths and weaknesses of a set of COAs based on how this set covers all possible alternatives. This critiquing aspect can also be used for the set of enemy COAs.

4.6   Critiquing the comparison of COAs

When comparing many COAs, different factors can be considered (as presented in subsection 4.4.5). The team determines them, and the commander may give direction on specific factors (additional or not) that he may want to cover. The team members will have to determine which aspects are more important to consider than others. A critiquing system can identify the strengths and weaknesses of the aspects proposed by the team and identify any problem based on focussing on less important aspects.

5.   Conclusion

The CFOPP can be seen as a coordinated process to determine the best method for preparing plans and orders for CF operations. The Estimate Process, which consists of the three first stages of the CFOPP, involves the elaboration of different Courses of Action (COAs) following situation analysis and the selection of the most appropriate one for its subsequent planning. Among the different computer-based approaches that can be used to provide support in carrying out the Estimate Process, this work is dedicated to the investigation of critiquing systems.

In this document, different critiquing systems are presented for each stage of the Estimate Process. It would be easy to image a system able to integrate more than one critiquing aspects presented here. Nonetheless, based on this work, it is possible to identify three categories of critiquing systems that could be developed for the Estimate Process. First, there are those critiquing intermediate results such as the commander's guidance elements, the evaluation of the situation, the COAs, the assessment of the COAs, the comparison with the COAs, the composition of the team, the different sources of knowledge. Second, there are those critiquing the process executed by the team members to accomplish the planning. Third, there are those critiquing the perceived mental models of the different team members to make sure that the team has a common understanding of the subjects discussed.

From this work, it was identified that critiquing systems for the Estimate Process will need to have access to different domain knowledge bases (such as best practices Knowledge Base (KB), lessons learned KB, case base and doctrine KB and expert KBs) as well as being able to build and maintain dynamic individual as well as common user's models (Figure 9). Furthermore, some of the critiquing systems identified would need that the team use a computer-based infrastructure to exchange information, while only one member of the team could use others.

The next step of this project is to determine a set of concepts related to the critiquing systems that will be further investigated in order to verify their utility. That is why measure of efficiency for critiquing systems need to be developed in order to be able to identify what is good and what is wrong. Experimentation must be designed in order to be able to quantify or qualify them.

While carrying out this work, many questions have been raised. These questions are sometimes specific to critiquing systems for the Estimate Process, sometimes applicable to any critiquing systems or decision support systems. It is important to keep this list opened and recorded since they may eventually be used in other research projects. These questions are:

- What types of critique would be more appropriate to the Estimate Process?

- Where should be provided critiques into the Estimate Process?

- How should be introduced critiquing systems into the Estimate Process?

- By providing a list of weaknesses, would a critiquing system be perceived by the users as too negative?

- Will the user trust the result of a critiquing system?

- Will the user trust too much such a system?

- Will the integration of a critiquing system into a team dynamic be disruptive?

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List of symbols/abbreviations/acronyms/initialisms

CF OPP   Canadian Forces Operational Planning Process

COA   Course of Action

COS   Chief of Staff

DND   Department of National Defence

DRDC   Defence Research and Development Canada

DRDC   Defence Research and Development Canada

FIT   Fonds d'investissement technologique

KB   Knowledge Base

PPOFC   Processus de planification opérationnelle des Forces canadiennes

RDDC   Recherche et développement pour la défense Canada

SOPs   Standing operating procedures

TIF   Technology Investment Fund

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The Canadian Forces Operational Planning Process (CFOPP) is a methodical approach to analyzing a situation, bringing staff expertise to bear on the relevant factors, narrowing courses of action, obtaining the commander's approval, and developing the detailed annexes necessary to produce an executable plan. It is based on an Estimate Process that involves the elaboration of different Courses of Action (COAs) following situation analysis and the selection of the most appropriate one for its subsequent planning. The Estimate Process is often performed under high time pressure and stressful conditions. Under the influence of these factors, the human capacity of reasoning and judgment can be significantly reduced. In order to support the commander and his/her team in carrying out the CFOPP, Defence Research and Development Canada (DRDC) is conducting research and development activities to investigate different types of computer-based systems that can provide decision-support facilities. One of these activities is the investigation of computer-based critiquing facilities for the Estimate Process. The aim of this document is to document some of the work that has been executed at the initial phase of this project. It presents different critiquing systems that have been identified for the Estimate Process.

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