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An Essay to Characterise Models of the Military Decision-Making Process

Topic: C2 Concepts and Organizations, Cognitive Domain Issues

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An Essay to Characterise Models the Military Decision-Making Processes

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ABSTRACT

Modeling the decision-making process has been an ongoing undertaking by the scientific, operational and business communities. Research communities have proposed different representations of decision making based on different perspectives like decision sciences, human factors, cognitive and psychological sciences, organisational behaviour, and social sciences. In the Command and Control context, the Observe–Orient–Decide–Act loop has been used since the 50s to describe the C2 process. For some, the military decision-making process might be seen as the full integration of both the Operations Planning Process and the Intelligence Preparation of the Battle space. It is our contention that each of the models has a valid contribution to make in advancing the understanding of the commander's decision-making process, but lack a common context. In order to better comprehend the seemingly disparate approaches, a unified decision-making framework is needed. This paper aims at depicting the fundamental elements of such a framework. This framework presents not only a unified vision of the decision-making process but also provides a setting to appreciate many contributions to the decision-making process modelling. It is developed around four domains of the decision-making activities: cognition, knowledge (information), organisation and observable effects. The framework could be mapped around four fundamental stages of the decision-making process: perception (observation), understanding (awareness), decision and action. We assume that many feed-back loops, control and tasking protocols govern this framework. This framework might help to comprehend the seemingly disparate approaches reported in the literature.

Keywords: military decision-making, models, command and control, human factors, organisation.

1. Introduction

Decision-making is an important duty of any military Commander. Decisions are the means by which the Commander translates his vision of the end state into orders and action (US Army, 1997). Decision-making is involved at all steps of the military business processes and is both *science* and *art*. For example, Commanders might apply a set of analytical or naturalistic problem solving approaches. He might be in a situation where a known solution pattern might apply to solve the problem. However, in many complex situations, understanding and framing the problem is the most important step in the problem solving approach. Einstein and Infeld (1938) stated that *"The formulation of a problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill"*.

Academia has long studied decision making from rational, cognitive, social and information perspectives. Fields like decision sciences, management sciences, administrative sciences, social choice, psychology or naturalistic decision making are a few examples of the growing interest in modelling and understanding the individual as well as organisational decision making. If one accepts that the decision making itself is said to be a psychological or cognitive construct, the question should be how to support or improve the process leading to developing that construct. In many instances, it is thought that decision making is always supported by a single process. Such a process could be formal and well defined similar to the military operational planning process, but it could also be informal or very subjective to each individual. In this paper, we define a decision-making process as a set of activities and tasks that directly or indirectly support the decision maker. The process and its activities could be well or poorly defined, rational or irrational, or based on explicit assumptions or tacit assumptions.

This paper proposes a unified decision-making framework that will explain why there are multiple decision-models presenting what appear to be conflicting views. The objective of such framework is not to argue for a unique and exclusive perspective to understand military decision-making, but is to argue for the importance of multiplicity of modelling perspectives given that decision-making is too complex a matter to be addressed from only one perspective. Moreover, this paper claims that decision-making models are important tools to understand the principles and dynamics of decision-making. Models are therefore seen as a means to achieve understanding. This understanding or conception of the decision-making technicalities influences the type of solution or aid that will be designed to support decision makers in making better decisions. Investments in Command and Control systems are good examples of a military effort to support Commanders making better decisions. Even if they are partial or incomplete, decision-making models should guide toward understanding some human limitations in making decisions. Thus, such understanding might lead some "bright people" to design solutions to overcome such deficiencies and hence define what really contributes to decision superiority. In our minds, the solution could be any combination of people, organization and technology.

This paper is organised as follows. Section 2 argues the importance of understanding the decision-making models. In section 3, we review some academic and military models reported in the literature. An essay to frame a unified modelling space is presented in section 4. Section 5 discusses our findings and claims presented in this paper. We finish this paper by presenting our conclusions and discussing the way ahead.

2. Importance of understanding the decision-making models

Decision-making models are abstract representations used by scientific, operational and academic communities to understand the Commander's decision-making process. Complex military decisions often involve multiple uncertainties, effects and outcomes. Commanders require information and often direct their supporting staff toward the most important issues at stake. Military Commanders do not hold a monopoly on decision-making. For example, managers in all organisations are making decisions that influence the behaviour and the well being of their organisations, employees and sometimes communities and countries. Politicians are involved in making decisions in behalf of their constituents that might affect the future of generations and doctors make medical decisions with sometimes life-changing outcomes. Structured decision-making is an important part of all science-based professions, where specialists apply their knowledge in a given area to make informed decisions.

Outcomes of a decision are not always observable as an action (March, 1994); decision outcomes might be an understanding or a requirement for better understanding. In this paper however, we are concerned with decisions leading to actions or effects. Commanders have to deal with several challenges such as information overload, technological complexity, ambiguity, uncertainty, and less predictability. The effects of their decisions cut across a wide range of societal, cultural, political, economical, diplomatic and physical domains. There is a closer scrutiny of decisions (e.g., media focus and accountability will increase), while decisions have to be made at a much higher rate and high tempo. Furthermore, Commanders have to deal with different values as they confront more global situations and sometimes address the asymmetric nature of the adversary. To support these leaders, military organizations are characterized by cross-functional decision and product teams often involving other government and non-government agencies. These organisations are developing a continuous learning posture as a key to keeping informed as the world gets more complex. Now more than ever, it is critical that military decision-makers are capable of making decisions more efficiently and more quickly in order to be able to take action before their adversaries thus achieving decision superiority.

For instance, the Joint Command Decision Support Technology Demonstration Project (JCDS 21 TDP) supports the military decision-maker in this new context and has as its aim to demonstrate a joint, net-enabled collaborative environment to achieve decision superiority. This will be accomplished through the development of components related to people, organization and technology in support of the decision-maker. It is through a complete understanding of the military commander's decision-making process that techniques and tools can be presented to make the commander's decision cycle more efficient and quicker.

Multiple models exist to represent the decision process, each approaching the unknown from a slightly different perspective, but each seeking to achieve a better understanding. Because the decision model chosen can influence the technical solution, it is important to look at the challenges facing the decision-maker from multiple perspectives (physical, information, social and cognitive). It is our position that understanding the decision process from only one perspective will lead to inefficiencies or ineffectiveness of any resulting solution. No single approach will meet all needs, rather each model needs to be carefully considered as proving an understanding of one portion of the Commander's decision cycle. It is only through studying and relating multiple models that a true appreciation of the complex environment can result in solutions in support of today's military commander.

3. Literature review

Modeling the decision-making process has been an ongoing undertaking by the scientific, operational and business communities. The research community has proposed different decision-making models based on decision sciences, human factors, cognitive sciences, organisational behaviour, social sciences, etc. Normative, descriptive, prescriptive or analytical, naturalistic or intuitive, behavioural, social, team and heuristics models are a few examples of such diversity of perspective used to represent and understand decision making. Military organizations have long understood the importance of developing "good" decision-making models based on lessons learned and best practices. These models are then transformed into doctrine, training, standard operating procedures or concepts of operations. The operational planning process is the military decision-making model according to some (US Army, 1997). In this section, we review a selected and non-exhaustive set of proposed decision-making models.

3.1. Academia Models

Several models and frameworks have been proposed to describe the decision-making process. These models could be categorised as being descriptive or prescriptive. Descriptive models are theories about how people normally think, and are most often expressed in terms of heuristics. Prescriptive models however "prescribe" or state how one ought to think. Normative models could be seen as sub-category of the prescriptive models and define standards or governing rules for achieving the decision maker's goals. As research has evolved, the distinction between descriptive and prescriptive theories has become fuzzy. One of the most well known descriptive decision-making models has been proposed by Simon (1960). Simon's model presents decision-making in three phases (see figure 1):

- *Intelligence activity*, in order to identify decision-making situations,
- *Design activity*, which consists of inventing, developing and analyzing possible alternatives, and
- *Choice activity*, which concerns the selection of a particular alternative among those envisaged.

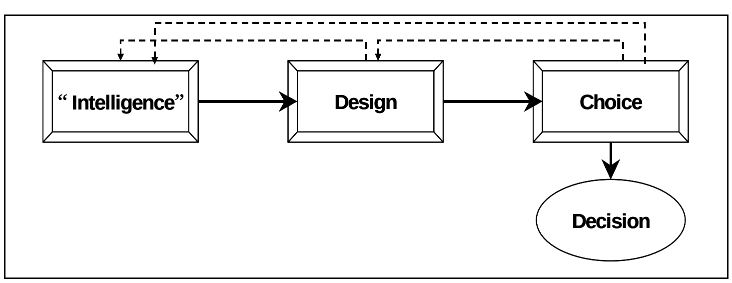

Figure 1. Decision-making Process (Simon, 1960)

This process isn't linear and every problem can be decomposed into sub-problems modeled by these three phases. Simon's model has the merit to introduce the concepts of human problem solving, limited rationality and the concept of "*satisfaction*". Simon's satisfaction approach to decision making reflects the fact that the assessment is not resource free and is applied when the individual has insufficient time or ability to evaluate all the alternatives.

Mintzberg et al. (1976) modeled the strategic decision process using the sequence Identification-Development-Selection (see figure 2):

- The *identification phase* consists of problem recognition and diagnosis. It begins with the problem recognition in which opportunities, threats and crises are recognised as indicators of decision activity. After the problem is identified, diagnosis is performed in order to clarify the nature of the problem. During diagnosis, management seeks to comprehend the evoking stimuli and determine cause-effect relationships for the decision situation.
- The *development phase* is the heart of the decision-making process. It consists of two activities: search and design. Search encompasses finding ready-made solutions. Design is used to develop custom-made solutions or to modify ready-made ones.
- The *selection phase* is a multistage, iterative process, involving the investigation of alternatives. It is described in terms of screen, evaluation/choice and authorization. Screening is used first to reduce a large number of ready-made alternatives to a few feasible ones. Evaluation/Choice is then used to investigate the feasible alternatives and to select a course of action. Finally, authorization is used to ratify the chosen course of action at a higher level in the organizational hierarchy.

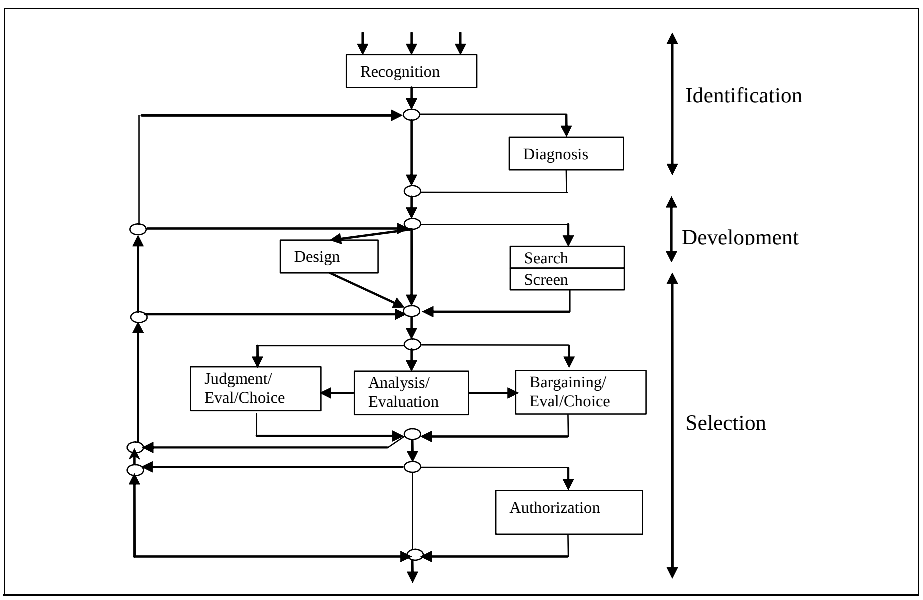

Figure 2. Decision-making Process (Mintzberg et al., 1976)

Merits of this model concerns could be seen in the set of supporting routines (decision control routines, decision communication routines, political routines) and identifying dynamic factors that influence the progress of the process (interrupts, scheduling delays, comprehension cycles, etc.). This model shows that the decision-making process is not a linear process. In addition, it explains the dynamic and linkages between all phases.

Recently, other models were developed within a framework of Naturalistic Decision-Making (NDM). This research field supposes that decision-making is affected by several characteristics of natural settings like uncertainty, dynamic environment, time pressure, high risks, shifting and competing goals, organizational goals and norms, multiple decision makers and ill-structured decision problems. The field of NDM has some of its roots in the military's need to better understand the human dimensions of C2. In fact, the characteristics of NDM settings are usually present in battle situations. Zsambok and Klein (1997) observed that military decision makers in difficult situations and under time stress did not use the classical approach to make decisions. Based on this observation and considering such behaviour as reasonable, Klein (1998) proposes a specific model of decision-making: the Recognition-Primed Decision (RPD) model (see figure 3).

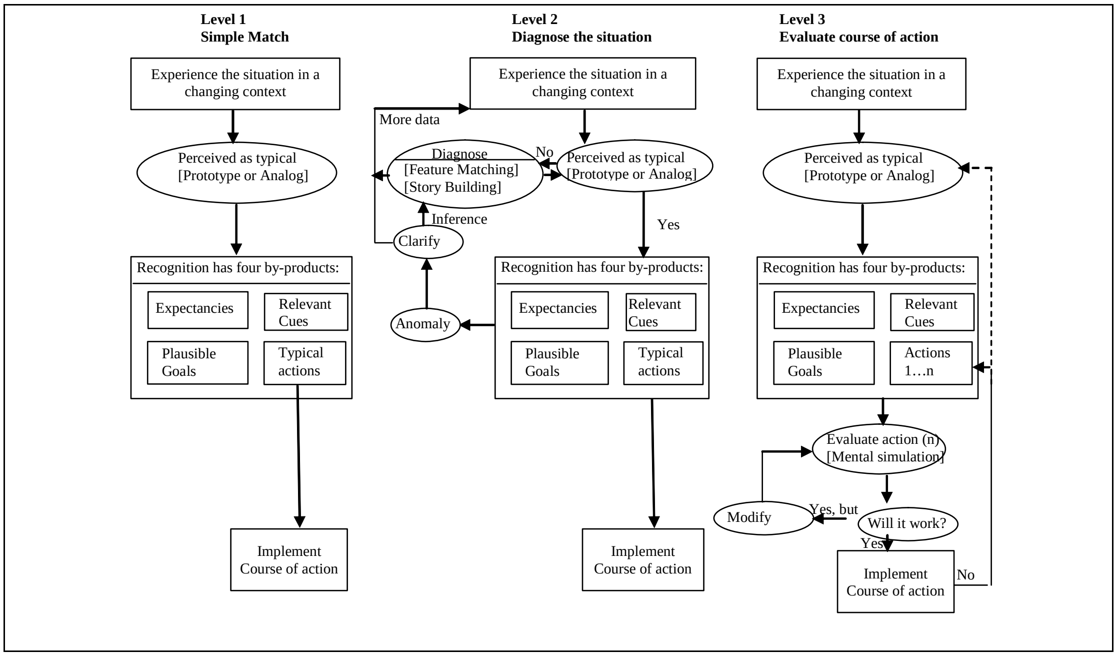

Figure 3. Klein's Recognition-Primed Decision model : RPD model (Klein, 1998)

The RPD model shows that people can make good decisions without having to perform extensive analysis. People use experience to recognize problems that they have previously encountered and for which they already know solutions. This strategy allows them to quickly make difficult decisions. Klein's model suggests that decision makers match the immediate problem situation to a condition in memory and retrieve a stored solution, which is then evaluated for adequacy. If it passes, it is adopted; otherwise, it is either modified or another solution is retrieved and evaluated. This model does not suppose generating alternatives and evaluating them one by one. The first alternative is usually workable or improved to a workable state. The RPD model presented in figure 3 contains three functions:

- The simple Match function represents a straightforward case (obvious goals, expectation about future state are formed, typical course of action is recognized) in which a decision-maker identifies a situation and reacts accordingly.
- The diagnostic function is initiated in response to uncertainty about the nature of the situation. Two diagnostic strategies are possible: Feature matching and Story building. Feature matching consists of identifying the relevant features of a situation in order to categorize it. Story building involves a type of a mental simulation in which a person attempts to synthesize the features of a situation into a causal explanation (Klein, 1998).
- The course of action evaluation function shows the case in which the course of action is deliberately assessed by conducting a mental simulation. The result is either to adopt the course of action or to consider a new course of action, etc.

The model of Noble (1989) is another model issued from NDM. It makes an assessment of the situation based on contextual and environmental information. This model does not include a process to deal with alternative selection. It supposes that alternative selection results from the interpretation of the situation. All models of NDM suppose considering the most intuitive alternative and adapting it to the situation. All these models are more concerned about situation awareness rather than the development of multiple alternatives for comparison. Situation awareness means that the decision maker interprets all tactical scenarios, makes assumptions about what is happening and projects the courses of action that are likely to happen (Endsley, 1997).

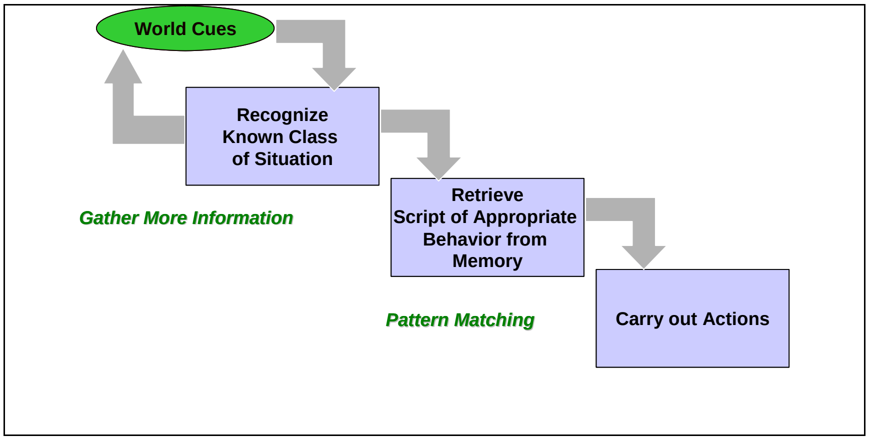

Figure 4. Endsley's Naturalistic Decision Model (Endsley, 1997)

"Classical theories of choice in organisations emphasize decision making as the making of rational choices on the basis of expectations about the consequences of action for prior objectives, and organisational forms as instruments for making those choices" (March and Olsen, 1986). Prescriptive or normative models have been developed for several years. This goes back to the voting system (Borda, 1781, Marquis de Condorcet, 1785). The "Utility Theory - in particular, the supposition of a cardinal utility function that decision-makers should maximize (von Neumann and Morgensten, 1944; Savage, 1954) – has served as the orienting point of decision science since the inception of the field" (Freeman, 1997). Prescriptive models are motivated by the principle of rational choice. The expected utility/value, optimization, statistical decision-making and economic models are examples of prescriptive or normative approaches. The basic steps of these models could be seen as comparable to the descriptive models. However, prescriptive decision-making models are all concerned with outcome, and assume the existence of a utility function to be maximised. The process itself that leads to the decision is seen as instrumental or sometimes completely neglected. The multicriteria decision aid proposed different decision models called constructive models (Roy, 1985). The focus is being on the process as well as the outcome. Social Theory Models like game theory are seen as prescriptive models. These models are based on the assumption of the existence of a social or collective welfare function. Game theory is developed around the principle of equilibrium based on each "player" utility function.

3.2. Military Models

Many researchers have tried to develop models of the military decision-making process. For instance, the OODA (Observe–Orient–Decide–Act) loop is widely used to describe the C2 process. The loop has the benefit of providing a simple description of phases included in the decision-making process (see figure 5):

- *The Observe component*: consists in gathering information and data from the situation.
- *The Orient component*: corresponds to situation assessment that includes data processing concerning the current situation.

- *The Decide component*: consists in the choice of a course of action to execute.
- *The Act component*: the implementation of the course of action that was previously chosen.

The processes of the loop are performed in a dynamic and complex environment and are influenced by factors such as uncertainty and time-stress. The OODA loop was originally developed as a model for tactical decision-making in air-to-air combat during the Korean Conflict in the 1950s. It has evolved into a general model for military C2 and is frequently discussed as a decision-making model in business. It is probably the best known and most frequently cited C2 process or decision-making model in current literature.

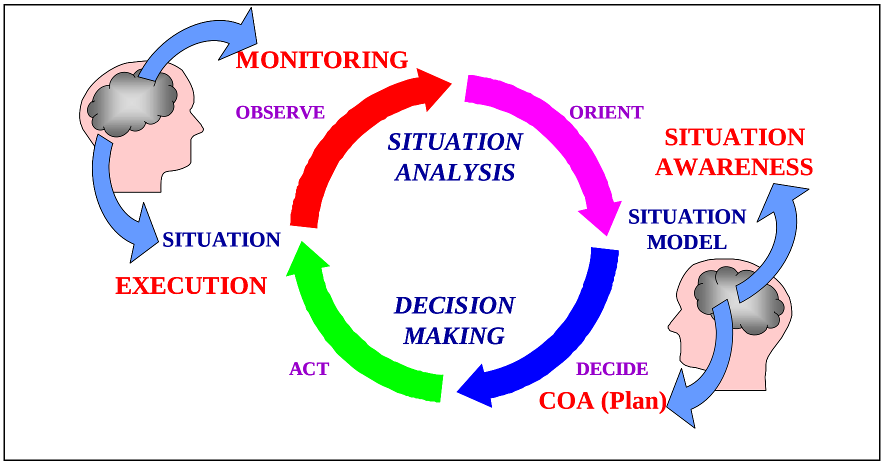

Figure 5. Military Decision-making Process: the OODA Loop Model

The shortfall of the OODA-loop model is that it infers that the process is discrete. By dividing the staff into functional areas, it creates stovepipe roles. In real situations, each member of the staff is performing the OODA-loop in a dynamic, real-time and continuous manner. Breton (2005) maintains that "despite many critics and proposed alternatives, the loop is still extensively used to represent the C2 decision cycle in military documents. The loop offers a simple and valid representation of own and enemy decision cycle while capturing the continuous aspect of C2. It also stresses the importance of two factors, uncertainty and time pressure that affect the decision performance." Breton (2005) extended the OODA-loop model by proposing other variations like the Modular OODA (M-OODA), Team OODA (T-OODA) and Cognitive OODA (C-OODA) (see respectively figures 6A, 6B, and 6C).

Two other C2 process models that are often cited are the Lawson model and the Headquarters Effectiveness Assessment Tool (HEAT). The former is a model that describes decision making as a five step process; Sense, Process, Compare, Decide, and Act (Lawson, 1981). The model assumes a Commander will 'Sense' the environment and 'Compare' to drive solutions toward a desired state. As such it provides a model for C2 from a control system perspective. The HEAT model is a model of decision-making that has also been described as a command function model that treats C2 as an information management system (Rand, 1999). The HEAT model was developed in the 1980s as a generalization of the original OODA loop to the activities in a headquarters (Noble and Kirzl, 2003). It was, however, developed to be a tool for the evaluation of headquarters effectiveness and has been used in over 200 exercises and experiments (Hayes and Wheatley, 2001). An overview of the HEAT model may be found in the recently published "Understanding Command and Control" (Alberts and Hayes, 2006). This model is based upon a five-step loop; Monitor, Understand, Plan Preparation (involving the development of alternatives and the prediction of their feasibility), Decide, and Direct. Similarly to the Lawson model, the C2 process is characterized as a control system with the Commander reacting to inputs to move the system toward a desired state.

Bryant (2003) proposed the Critique, Evaluate, Compare and Adapt (CECA) model to represent the cognitive decision-making process (see figure 7). This model identifies a set of cognitive controls that orient the decision-making. Bryant (2003) argues "that the Observe-Orient-Decide-Act (OODA) Loop is outdated as a model of human cognition and proposes a new model based on theoretical advances in the psychological and behavioural sciences since the 1950s". The (CECA) Model is based on the goal-oriented mental models. The CECA model has the merit to expose the dynamic of the decision-making model, but excludes the creative part that is supposed to be an input: Plan.

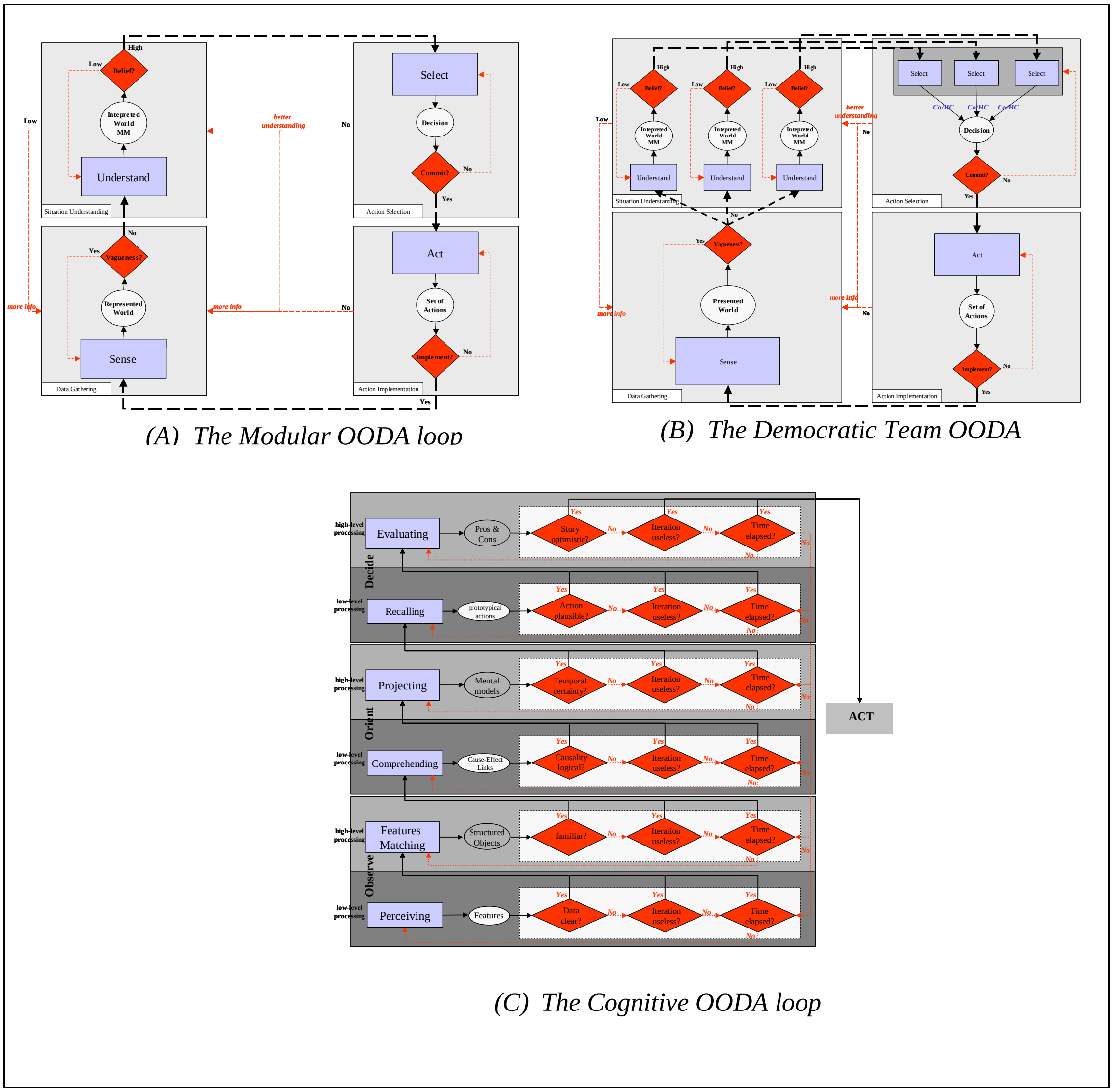

Figure 6. Breton's OODA Loop Models (Breton, 2005)

The Canadian Forces (CF) Command Decision Support Capability Document (DGJFD, 2003) defines the overall CF C4ISR vision and goals in support of the Command decision cycle. The document supposes that the Command cycle is represented by the model shown by figure 8. This model has the advantage of combining the intelligence and the OODA-loop processes. Moreover, the proposed model refers to capabilities and targeted solutions needed to support the Command decision cycle. All of the subsequent CF C4ISR Campaign Plans have been developed using the proposed Command Cycle (Decision-Making Model) as a cornerstone to engineer and prioritize the CF C4ISR capabilities. This is a good example where our conception or understanding of the decision-making model constitutes the basis for solution concepts. "It [*Command Decision Support Capability Document*] will serve as the mechanism to understand and review C4ISR issues by providing a single and consistent context for C4ISR capability development – thereby ensuring an integrated approach that promotes maximum effectiveness, efficiency and economy" (DGJFD, 2003).

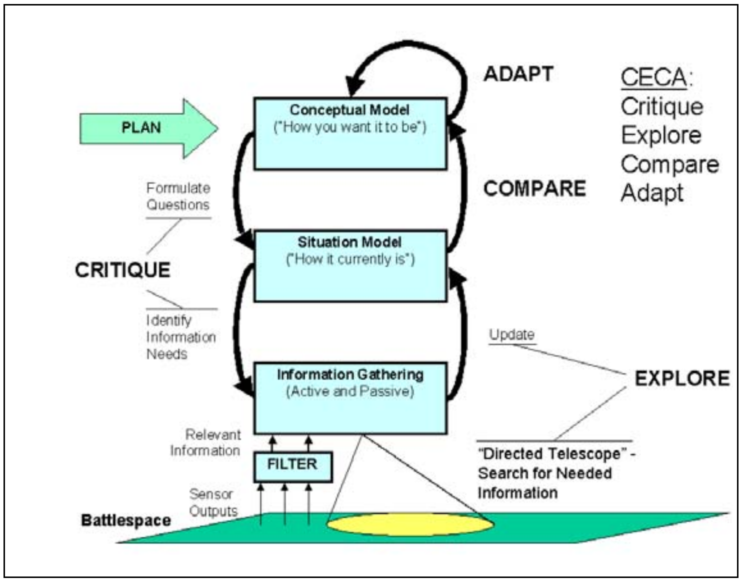

Figure 7. CECA Model (Bryant, 2004)

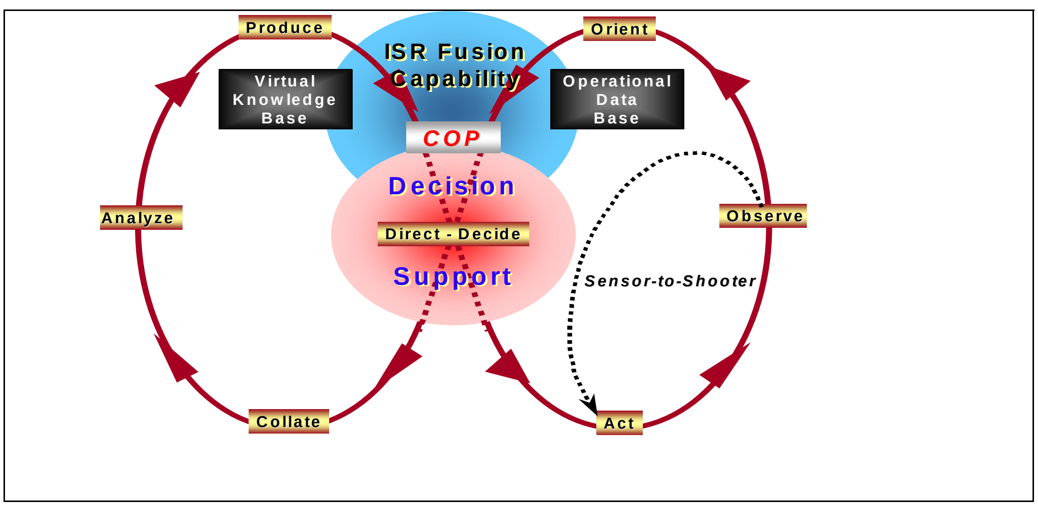

Figure 8. Canadian Forces C4ISR Support to Command Cycle (DGJFD, 2003)

Military Headquarters staffs are trained and formed in order to be able to perform tasks supporting Commanders decision cycles. The Operations Planning Process (OPP) and the Intelligence Preparation of the Battlespace (IPB) process are well-known processes that are designed to support Commanders decision-making. Guitouni and Wheaton (2005) suggested that the "classical" military decision-making process (MDMP) is composed of the full integration of both the OPP and the IPB (see figure 9). This model could be seen as an extended representation of the CF Command Decision cycle. It is a mixture of activities, information products and organizational flow. The IPB is the process used by intelligence organizations to prepare assessments, estimates and other products for the Commander's decision-making process. "The purpose of the IPB is to support the commander's decision-making process by providing him with the basis for achieving situational awareness." (CF Joint Doctrine, 2003) The IPB process consists of four steps; define the battlespace environment, describe the battlespace effects, evaluate the adversary, and determine adversary courses of action. The IPB helps the Commander determine his information requirements and provides the basis for wargaming, which supports the planning process. The IPB is a graphical analytical methodology that produces cues for intelligence collection, guidance on the placement of forces and targets, and most importantly for the MDMP model the decision points where the Commander should act to influence the operation.

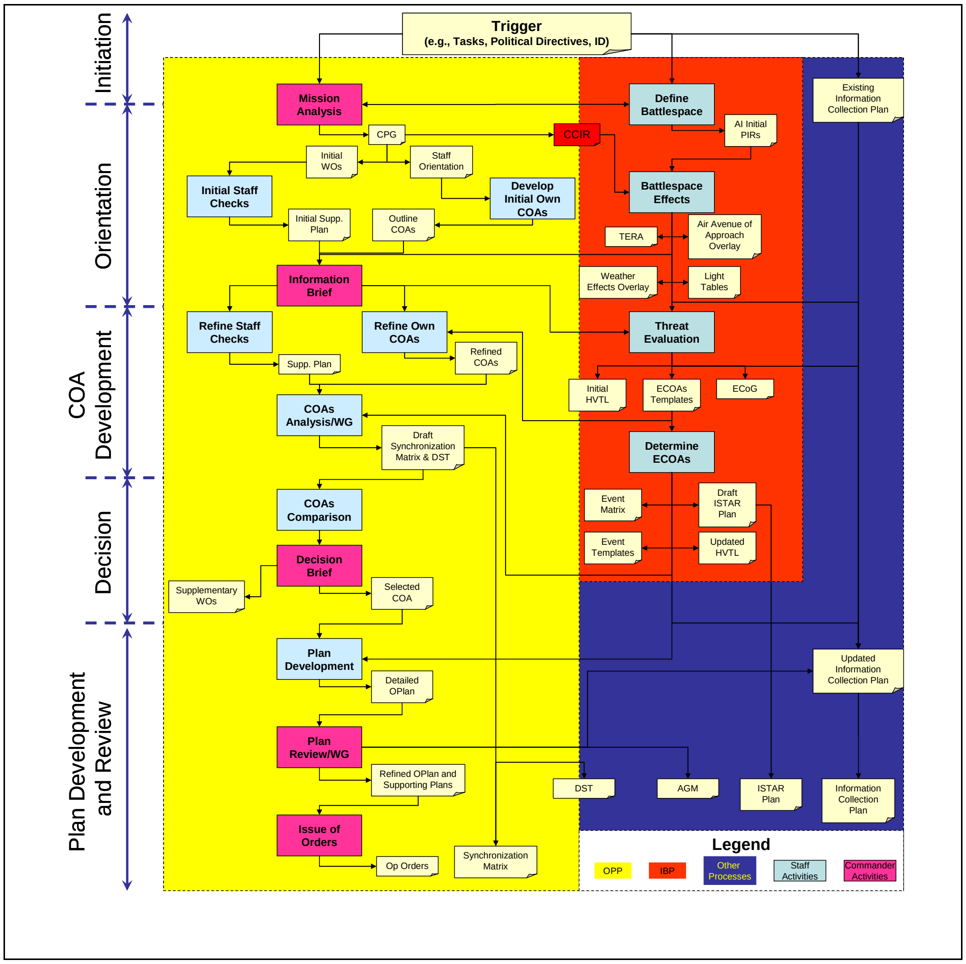

Figure 9. CF Decision- Making Process (Guitouni and Wheaton, 2005)

The Canadian Forces (CF) OPP (CF Joint Doctrine, 2002) is similar to the doctrine of other nations and is composed of five steps: Initiation, Orientation, Course of Action (COA) development, Plan development and Plan review. The Initiation step starts with the receipt of a mission statement or simply in anticipation of a new mission. The analysis and definition of the mission begins in the Orientation step where the Commander's critical information requirements are defined, the initial Commander's intent is prepared, the Commander's guidance is issued, and the desired end-state of the operation is described. The staff develop comprehensive and flexible plans in the COA development step. The Commander makes a decision on a COA for the mission based upon the analysis and comparison of the proposed COAs. (This analysis is typically accomplished through war-gaming which is linked to the IPB.) Based upon this COA, the staff prepare the Commander's CONOPS which is used in the Plan Development step to prepare the Operation Order which completes the planning process for a mission. The fifth step is Plan Review, mission plans will be reviewed periodically and if major changes are required the entire process may be repeated from the initial step.

Effects Based Operations (EBO) is a new concept for planning missions and therefore another model for military decision-making. The Effects Based Approach (EBA) promotes an outcome-focused approach to the management of changes within the Strategic Environment. It requires an in-depth understanding of the Strategic Environment which can only be obtained by taking an all-embracing view of the dimensions of this environment and the stakeholders within it. A comprehensive view of the interactions and influences between the different dimensions and the different stakeholders is critical and can only be achieved through collaboration, which should be across government and if possible encompass other nations' governments and the widest range of non-government organisations. Using effects as the means for translating strategic aims into activities has some significant advantages. An EBA exposes the complexity of issues thereby improving understanding of the causal links between actions and effects (both desired and undesired). It also helps senior decision-makers to concentrate on the key areas and better avoid potential distractions and dilution of effort. The EBO process starts with knowledge base development and then Effects Based Planning (EBP). The EBP function supports the development of a plan that matches end-state(s) with effects and the actions and resources required to create the effects. Following the development of the Effects Based Plan is execution and assessment. An effects based assessment provides the Commander the means to ascertain campaign success from the start to finish of an EBO and provides feedback to the other components of the EBO process.

According to the US Joint Experimentation Analysis Division (2003) and the US Joint Force Command (2005), the core Effects Based Planning (EBP) process model consists of six major activities, as follows: End State Analysis, Effects Development, Action Development and Resource Matching, Effects Based Assessment Planning and Synchronization and Plan Refinement (figure 10). The purpose of the End-state Analysis (ESA) is to examine the input from higher level guidance, determine the nature and scope of the problem, and to identify goals for the operation in the context of higher and subordinate commands. The goal of the Effects Development activity is to identify the changes required in the operational environment to progress from the current situation to the desired end-state. Action Development and Resource Matching examines causality and other relevant factors in order to first develop COAs to achieve the desired effects and reach the desired end-state and then determine the best option to achieve the end-state. This is typically based on war gaming. The resource matching determines the best combination of resources to execute the chosen option. The Effects Based Assessment Planning (EBAP) activity is the preparation for the mission effects based assessment and its primary purpose is to develop EBA criteria and other associated EBA knowledge elements.

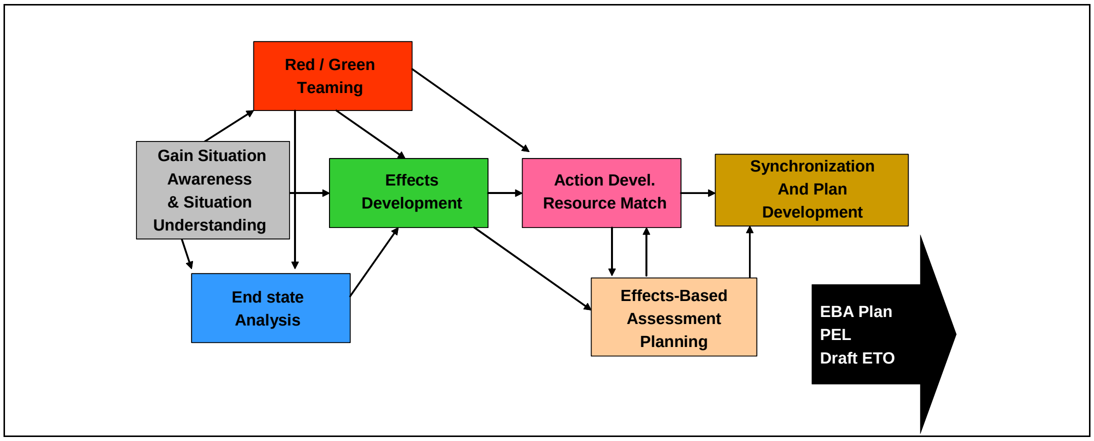

Figure 10. Effect Based Planning Process according to MNE 4 CONOPs Ver 0.65

3.3. Literature Review Summary

The gap between descriptive (what we are observed to do) and normative (what we should do) decision-making models is extensive and in fact has widened over recent years. As decision-making becomes an increasingly popular field, the distinction between descriptive and normative models has become fuzzy. Normative models have been refined so that they better "describe" decision making, while descriptive models in nature have sought to introduce normative axioms. Early researchers were consumed with producing descriptive theories for which all observed decision-making could be described. More recently, it is increasingly acknowledged that the vast array of decision-making styles and environments makes developing such a theory unachievable. Authors such as Shafir et al. (1993) and Kahneman and Tversky (1979) recognised that accurate descriptive models were possible, but only in describing isolated types of decisions such as choices between monetary lotteries. In addition these theories were purported only to be able to predict the chosen alternative rather than describe the process. The results of this study emphasize the role Bounded Rationality plays in individual decision-making.

The value of work such as this lies in the development of better decision techniques and aids for the less than rational decision maker. An understanding of the decision maker's behaviour, and more specifically, the reasons for such behaviour, is useful in the advancement of managerial decision-making. There is likely to be certain types of decision behaviour that are always going to be present in unaided decision making. Rather than trying to remove some of these apparent inhibitors to "good" decision-making, we need to use them to help in the development of more appropriate prescriptive decision-making methods.

The review of military decision making models could go on and on and on. Each country and each alliance has its own doctrine, C2 structures, SOPs and CONOPs. However, the exercise of Command is always closely linked to decision-making and orders. Therefore, models are being adopted and developed in order to better communicate decision-making process model and governance structures. Commanders are trained in order to become "better" decision makers. Sometimes, it is very difficult to really understand what "better" really means.

Based on this review, the question now is to make sense of it all. Is a single model needed, or multiple models? Is there a better way to represent the decision making process? Do we need models to understand and other models for the application? What relationship exists between understanding and application? There are many questions and we do not have the intent to address them all. Our goal is more modest. We would like to discuss a common framework to help understand differences between all decision-making models. By doing so, we hope that the framework will become a basis for discussion and cross-fertilization between modelling perspectives rather than competing for the right to the truth.

4. Unified Decision-making Framework

The decision maker, generally speaking, considers available information before making a decision. In organisations, this information is produced or gathered by social (employees, subordinate…) or artificial (computers, machines, alarm systems…) agents. The information could have its roots in the environment of the organisation (society, stock market, adversary, weather…). The consequences of a decision are also entities that evolve into an organisation, and influence an environment. The framework, we suggest, presents not only a global vision of decision aid process but also a detailed one. It's developed around four layered domains of decision-making. A high level representation of the proposed framework is given by figure 11:

- *Cognitive or psychological domain*: as argued in this paper, we assume that the decision is a cognitive or psychological construct guided by a will and influenced by circumstances. Therefore, we think that it is justifiable to consider this domain central to the proposed framework. Most models of this category describe the cognitive process leading a human-being to make decision. Therefore, most of these models are more descriptive models. Therefore, it is logical to accept that many decision models have been developed to understand or prescribe how human cognition deals with decision making

- *Knowledge domain*: without getting into the debate what is information and what is knowledge, we assume that decision-making is nourished by knowledge (information) and articulated as knowledge (information). In the case of a military order, information could be in any form perceptual, textual, etc. It is rare to find a specific model describing the information flow model of a decision making, however, most of the existing models refer to information entities that are handled and exchanged during a decision making process.
- *Organisational domain*: we assume, without loss of generality, that decision makers – Commanders for example – are social characters. Moreover, most of military decision-making is based, justified, supported and legitimized by the military organizations or in a larger extent by the government or an international political body. It is therefore logical to assume that the information flows within organisations in order to support decision makers. The decision maker communicates and exercises his Command authority through the organization. Many models describe the staff process or employee roles and responsibilities needed to support the senior decision maker. Admitting that the decision maker is a social being, many decision-making models have proposed descriptive, normative or prescriptive ways to support decision-making.
- *Observable effects domain*: March (1994) claims that there exists a typology of decisions. For example, some decisions might have no actionable outcomes. We are concentrating our attention on actionable decisions - those decisions leading to observable outcomes. Therefore, we propose to consider the outer layer as a melting pot representing the domain where action might be observable (e.g., physical domain, political). Many organisational decision making models are designed to describe the decision making process in term of interaction of complex intelligent entities. Moreover, models like participative decision-making and democracy propose methods to integrate the environment of the decision maker into his decision-making. EBO is a good example of a holistic approach

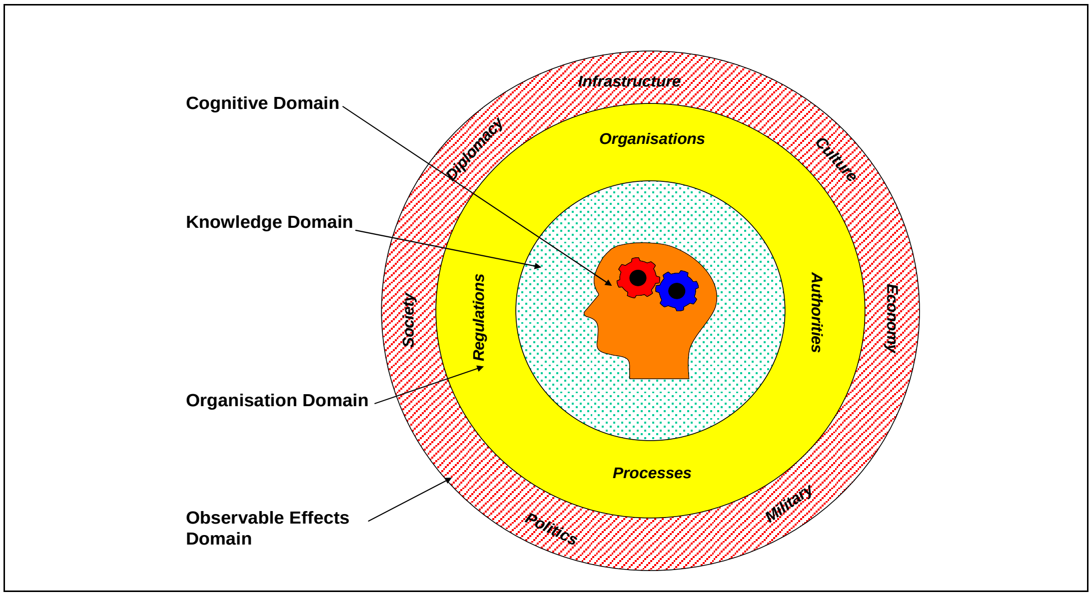

Figure 11. Unified Decision-Making Framework

Our framework considers also the four fundamental stages of the decision-making process: *observe, understand (orient), decide and act*. This framework has the potential to discriminate between most of the proposed decision making processes and loops. We support our argumentation with illustrative examples. In section five, we present a discussion and final conclusions.

Let us consider the CF operational planning process (OPP). This process is generally decomposed into five stages: Initiation, Orientation, COA Development, Plan Development and Plan Review. Other doctrine might have a different representation or different number of stages. The OPP is recognized and respected throughout most of the NATO staff colleges. Many doctrinal publications are devoted to describing exactly what should be done and how at each stage. Moreover, staff duties and outputs are described and sometimes clearly templated. In some military organisations, the OPP has become the goal rather than a problem solving process.

The OPP is a good example of a model crossing all domains. First, OPP manuals and training prescribe how Commanders should make decisions. It provides them with a decision-making framework and indicates important aspects to be considered. The OPP could be seen as a prescriptive decision making model. Secondly, the OPP provides an information exchange model where formal and informal information outputs are described – and sometimes templated. Thirdly, the OPP provides the organization supporting the Commander with a list of duties and activities. These activities, even if non-linear, are sequenced and arranged as a workflow process leading to a culminating activity involving the Commander. Thus, the OPP could be seen also as an organizational process model. Finally, the OPP targets military actions to affect the surrounding environment (e.g., military operations, peace keeping, support to law enforcement agencies). Figure 12 describes schematically how sensing an environment is manipulated through a staff involved in the OPP stage III to produce a decision brief. The decision brief provides necessary information to the Commander to make decision. That decision, a cognitive construct, is translated into the information domain as orders or directives. These directives are used by the staff to perform the work of stage IV and actions are observable in the environment.

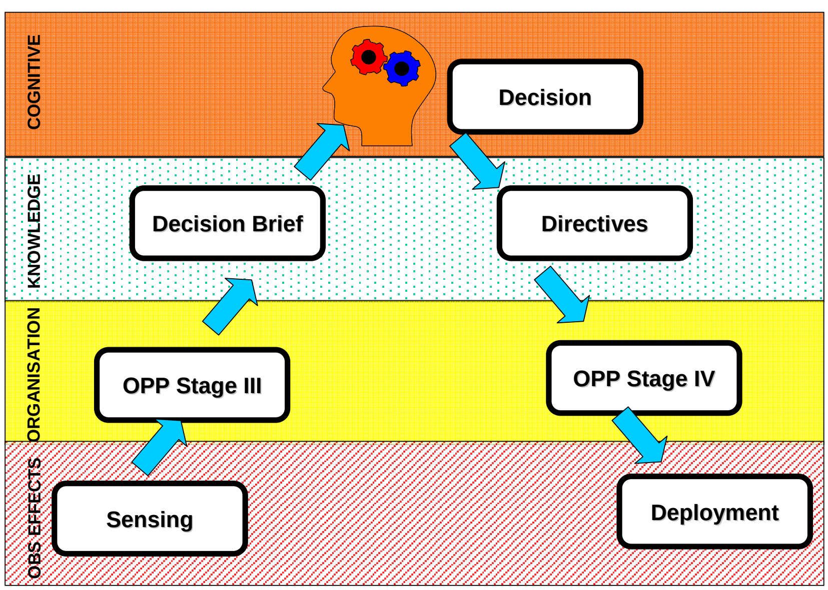

Figure 12. Dynamics of the proposed Framework: Example of OPP Stage III and IV Mapping

Figure 13 maps a more complex process showing the dynamics between the different layers of the proposed framework. Even if the proposed framework might be seen to be simplistic, it can be used to depict and understand complex and dynamic processes.

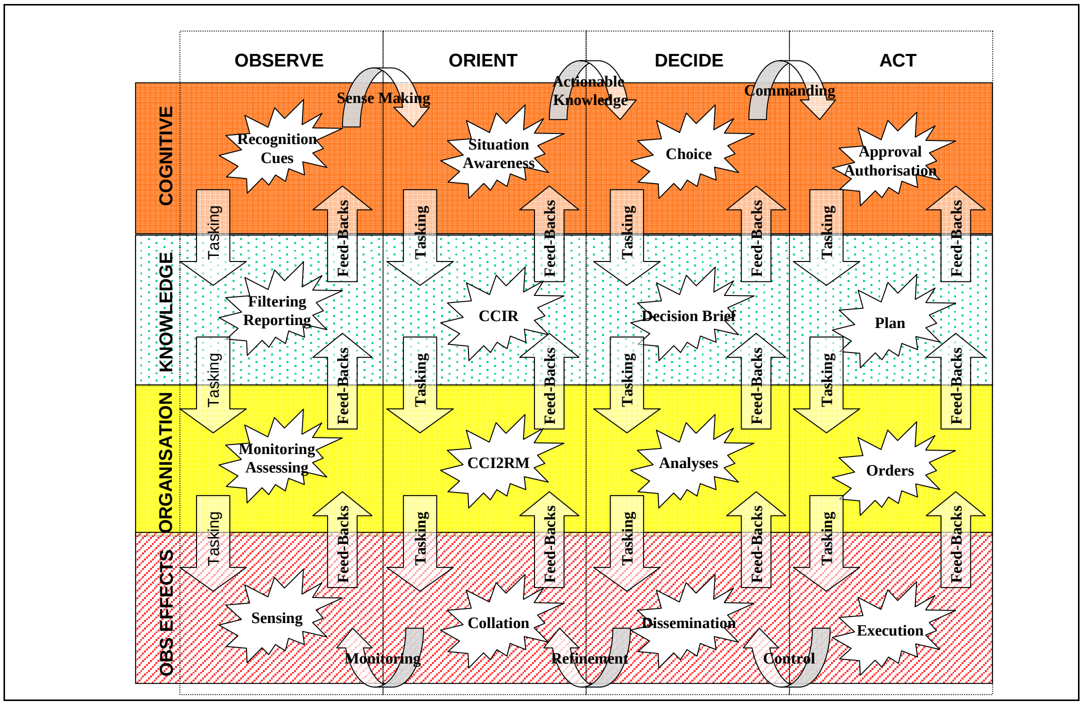

Figure 13. Dynamics of the proposed Framework: Example of OODA-Loop Mapping

5. Discussion of Implications of the proposed framework

Decision-making models are constructs designed either to help understand how decision makers make decisions or to prescribe ways for these decision makers to achieve better decisions. The models discussed in this paper are tentatively categorised in Table 1 in accordance with the framework and the perspectives outlined earlier - descriptive, prescriptive or analytical, normative, naturalistic or intuitive, behavioural, social, team and heuristic. This categorisation should be refined to better reflect each model contribution. A quick analysis of Table 1 shows that the majority of the models reviewed in this paper are either descriptive or prescriptive. Within the framework, the models are primarily in the Cognitive and Knowledge domains. Several of these are categorised as addressing the Organization domain secondarily, and only one is primarily in the Observable Effects domain – EBO.

Why does this matter? From a theoretical view, we think that the proposed framework might give an opportunity to understand decision-making challenges by considering multiple models. For example, JCDS 21 TD should consider models with a "**P**" in each one of the framework domains in order to design Commander's Decision Support solutions. The research community should also consider working toward developing more comprehensive decision-making models that cross multiple domains. The goal would be to bring together communities from different academic and operational backgrounds to address a problem from different perspectives.

From a Command and Control perspective, the importance of decision-making models can be examined in terms of the people that function as a part of a C2 system, the organization that comprises a C2 system and the technology that supports a C2 system. People are, of course, the key elements of any C2 system. Understanding the role they play in the system requires the application of human factors as a discipline. It has only been recognized in the last 10 years that human factors is a critical discipline for the analysis of C2 exercises and experiments. For example, after trying human factors in the analysis of the Multinational Limited Objective Experiment 1 (Salamacha et al., 2002), this discipline was instituted as a key element of all future Multinational Experiments. So, to understand the importance and effect of issues like Situational Awareness and Commander's Intent on C2 effectiveness in a headquarters or in an operation, it is important to employ models that reflect the decision-making process from the Cognitive domain.

MODEL	DESCRIPTIVE	PRESCRIPTIVE	OTHER	FRAMEWORK			
				COGNITIVE	KNOWLEDGE	ORGANISATION	OBSERVABLE EFFECTS
ACADEMIC MODELS							
Simon's Model (1960)	X			**P**	S		
Mintzberg et al.'s Model (1976)	X			**P**	S		
Klein's Model (1997)	X			**P**	S		
Noble's Model (1989)	X			**P**	S		
Endsley's Model (1995)	X			**P**	S		
Classical Decision Theories Models		X			**P**	S	
Multicriteria Decision Aid Models			X		**P**	S	S
Optimization Models		X			**P**	S	
Social Choice Theories Models		X			**P**	S	S
Participative Models			X		S	**P**	S
MILITARY MODELS							
OODA-Loop	X			**P**	S		
Lawson's Model (1981)	X			**P**	S		
HEAT Model (1980s)	X			**P**	S	S	
Breton's Models (2005)	X			**P**	S		
CECA Model (Bryant, 2003)	X			**P**	S		
CF DGJFD Model (2003)			X	S	**P**	S	
Classical Military Decision-making Model: OPP-IPB		X			S	**P**	S
Effect Based Operations		X			S	S	**P**

(**P –** Primary, S – Secondary)

Table 1. Classifying Decision-making Models

Better C2 will only be realized through better designs for headquarters and the technologies and processes that support them. It must start with understanding the behaviours of the people that work in these headquarters. To meet the agile threats of the 21st Century, Commanders will need headquarters designed to optimize the decision-making process. The development of better organizations will be served in part by decision-making models oriented to the Organization domain. In order to achieve an effective C2 system, the organizations and processes in a headquarters will have to be integrated such that future versions of the MDMP (OPP-IPB or EBP) reflect the internal structure and battle rhythm of the headquarters and its tasks. The research and experimentation required to optimize the organization of such headquarters will depend upon process models that will certainly include models of the decision-making process. Hutchins et al. (2005) is an example of such a study, where a simulation was developed of the Standing Joint Force Headquarters (SJFHQ). The EBO process as it is employed in the SJFHQ is designed for that organization. This simulation models the EBO processes, including the intelligence activities, within that organization down to the individual level and addresses how workload and personnel issues affect the planning process of the headquarters.

In the last 15 to 20 years there has been tremendous development in IT solutions to support C2. Large investments have been made in COP systems and information management systems as well as the installation of infrastructure to support high bandwidth networks. While these changes have benefited the operational community in many ways, it is now acknowledged by many that Commanders experience information overload. In moving to a net-centric environment where the requirement to manage information to support C2 will only increase, it will be very important to employ models for decision making in order to develop effective solutions. Models from the Knowledge domain should be employed in the design of information portals, or Collaborative Information Environments. Models from the Cognitive domain should be used in the design of the interfaces to C2 systems such as COP systems, automated planning tools or information visualization tools (i.e. Readiness, Logistics). The staff in the headquarters of tomorrow, literally, must be able to identify the key pieces of information for their analysis and planning tasks quickly and accurately for the headquarters to plan missions or react to changing situations.

The unified decision-making framework proposed in this paper does not argue for a unique representation of decision-making models. Different models are required to help understand different aspects of the decision-making process. Moreover, models are motivated by their author's primary perspective, and thus are not neutral. Therefore, we think that the proposed framework provides a perspective on the model options to understand the decision-making challenges. It is intended to serve as a way to distinguish between different decision-making models. Moreover, this framework might serve as a guide to readers to assist in the selection of a model that best fits their purpose. From this brief discussion, it should be clear that different models should be used to help understand different aspects of the decision-making process. Designing a C2 system that provides effective support to the decision maker is a complex and challenging task. A unified framework aids in selecting an appropriate model(s) for the task at hand. Decision support should be implemented with clear goals and a view of all aspects of the C2 process.

6. Conclusion

This paper is concerned with decision-making models. The review of the literature has revealed the existance of several and seemingly disparate models. The motivation of this work is justified by the following assumptions:

1. Understanding of decision-making process is a prerequisite to any design of a decision support solution;
2. Understanding the decision-making process is a multi-faceted undertaking and requires multiple perspectives to handle all its nuances and complexity;
3. There is no universal decision-making model that might fully represent the complexity of decision-making process (specificly the military decision-making process).

Therefore, we uphold the idea that a succesful approach to military decision support should be holistic from the beginning. Understanding all the dynamics, motivations and technicalities of military decision making is necessary to avoid errors and useless solutions. It is very easy to focus on developing a unique IT system, but it is harder to demonstrate that it really supports achieving decision superiority.

We have reviewed a limited set of decision-making models reported in literature. Such a review shows the diversity of these models and their motivation. Our findings led us to propose a unified framework based on four distinct but layered domains: cognitive, knowledge, organisation and observable effects (e.g., environment). The framework does not promote a single view of decision making, but it should encourage cross-fertization between modeling perspectives and decision focused theories. Moreover, the analysis of the reviewed decision-making models reveals that no model fits all the domains. There is more to gain by starting a constructive discussion among the models rather to put them one against another in competition for the right to the "truth". Finally, we argue for a multi-disciplinary and open approach to study military decision making. We think that this is a necessary, but not sufficient, condition to design genuine decision support solutions for Commanders in order to achieve "decision superiority".

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