REVIEW OF MODELS AND ANALYTIC INSTRUMENTS IN OPERATIONAL MILITARY DECISION MAKING PROCESS

Alexandru GĂLUŞCĂ*, Ionică CÎRCIU **, Mircea BOSCOIANU **

*Air Force Staff
** "Henri Coandă" Air Force Academy

Abstract: *In the era of IT, the high level military decision making process (MDMP) made a lot of progress. The focus is on building a framework capable to offer an effective tool for decisions in the field of force planning and operations planning.*

The complexity is influenced by the fact that high-level decision making occurs in uncertain environment that affects an extended set of factors (political, military, economic, social, information, infrastructure). The response based on different type of instruments (diplomatic, information, military, economic) should be supported by a new framework, capable to offer the power of selection is given by the limitation of resources. The use of modeling and simulation offer a better understanding of the concepts and solutions for commander's decision making.

The effective way to adopt a flexible, adaptive, and robust solution is totally different from the classic planning and is better focused on the exploitation of the strengths elements of the human creativity and knowledge. New analytical framework will offer also effective instruments in real time, capable to support the optimal decision making.

Keywords: *MDMP (military decision making process), DSS (decision support systems), CoA (course of action), modeling and simulation (M&S), the inspiration from economics*

1. AN INTRODUCTION IN THE ANALYSIS OF INNOVATIVE DSS FOR MILITARY APPLICATIONS

DSS (decision support systems) are represented by advanced rational/ analytic instruments capable to offer an integrated framework and a robust basis for commander decision making. All levels of commanders but especially high-level decision is influenced by the risk and uncertainty, and the impact on the real selection of a course of action (CoA) is significant. In the typical framework of a high-level DSS consistent with an uncertainty, sensitive, top-down approach is important to transform the vision about dealing with risk and uncertainty, and providing a dynamic recognized picture of the battlefield, the comparative potential of actors and their logistics, equipped with zoom capabilities.

In the literature (Davis, Kulick, Egner, 2005) are presented some aspects regarding DSS: risks and risk mitigation should be covered effectively, and provide multiple mechanisms capable to create dedicated FAR strategies; the focus is on the ways to mitigate the risks in the context of FAR strategies; it offers more intuition in the design of different solutions, but also hedging strategies; dealing with all relevant factors offers new opportunities for commanders.

In the modern military systems and processes the interest is to move toward a flexible, adaptive, and robust (FAR) strategy. There are different types of high-level MDMP from analytic to intuitive/ naturalistic to rational/analytic. DSS designers tend to favor rational-analytic methods, but real-world commanders often lean toward intuitive methods, arguing that models and simulations could not respond to the FAR (flexible, adaptive, robust) strategies.

But, in the modern literature, it is recognized that the top-down decision support should accommodate both types of thinking, attempting to exploit the strengths and mitigate the weaknesses of each and is based on the both lines: rational commanders are aware that the options presented to them may lack creativity, imagination; intuitive commanders are aware that risks exist in executing their strategies. A mix between the two types of thinking could be interesting. One candidate for this mixed framework is based on the portfolio-style method, inspired from economics, and capable to balance the risks, and the foresight exercises method, inspired from psychology, that addresses the need to include human factors in dealing with high risk and uncertainty.

The new framework to adopt FAR's style decisions, is different from planning for the best-estimate future and should include both innovative rational models like agent-based models, issues taken from control theory, game-theoretic simulation, the operations research, applied to military systems, but also human-intensive methods (war-gaming, foresight exercises, Red-teaming, assumption-based planning), based on creativity, expertise and intuition, but poorly structured. This new framework should offer a better understanding of the mechanisms of high-level military decision making, based on an innovative mixing of the emerging analytical methods and the instruments from the intuitive decision making style that capture the strengths of the components.

2. BASIC ASPECTS OF RISK, UNCERTAINTY AND SELECTION IN HIGH LEVEL MDMP

The classical concept of defense planning should be related to the need to identify areas in which the decision makers search for more risk (Henry, 2006), in order to identify gaps in capability areas and to find activities that can be supported by less funding in order to pay for the gap-filling. This is in fact a new way to implement the classic concept of the challenge of programming and budgeting (Hitch, McKean, 1965). The actions needed to balance budgets intelligently involve risks and the concept of balancing risk, inspired from the economic analysis express the ability to take more risks in some areas to pay for filling capability gaps in others.

In classic military organizations,

subordinates salute the plan too uncritically, rather than helping the commander to identify and avoid problems inherent in the plan. There are strong-willed commanders who resist suggestions, and are intuitively inclined to participate actively, but also commanders who are always saluting political level directions.

The battlefield and military systems are represented by enormous and deep uncertainties, and this implies risks but also signal potential opportunities. The concept of deep uncertainty (Knight, 1921) cannot be adequately treated by using simple random processes and cannot realistically be solved in near real time. Deep uncertainty should be acknowledged in the planning process by considering alternative courses of action (CoA) and by implementing a better understanding of the possible effects of operations.

High-level decision making is responsible for establishing and pursuing suitable visions and formulates the basic operational objectives. The focus is to obtain a framework capable to offer a proper design of operational objectives and actions. In addition is necessary to identify detailed and more-specific objectives expressed this time in the language of effects. Commanders analyze the documents offered by the analyst, focused on the relative ability of CoA to achieve all objectives and related effects, and extend the vision over the core subset offered initially.

In the new complex scenario-space typical in recent conflicts, characterized by deep uncertainty, are not understand the characteristics of the probability distribution. In the case of an imaginary strategy of a future adversary, the entire framework is hypothetical and unknowable. The deep uncertainty about the adversary's strategy is expressed by the lack of knowledge, in a similar way of the treatment in PMESII (political, military, economic, social, information, infrastructure) domains and attempts different DIME (diplomatic, information, military, economic) instruments.

The basic methods for analysis the future uncertainties (Davis, 1994, 2002; Davis, Gompert, Kugler, 1996) are focused on a better understanding of the concept of the capability to adapt the networked forces (Gompert, Lachow, Perkins, 2005; Tilson, 2005) in the context of mixing FAR strategies (flexibility- the ability to perform different missions; adaptiveness - the ability to adjust readily to diverse circumstances; robustness- the ability to withstand both foreseen and unforeseen shocks, such as surprise attacks or the loss of an important battle).

The treatment of deep uncertainty in the operational risk could be also proceed by using the Adaptive Planning (Bankston, Key, 2006; Hoffman, 2006), a concept oriented primarily toward normal periods, for the conception and the development of operations plans in terms of capability packages, in a proper manner that can enhance the adaptability. In analytic decision making, the treatment of uncertainty could be expressed by using alternative CoAs. Based on its intuition, the commander is then focused on improving the basic plan and providing staff evaluations of options (most-likely, best-case, worst-case). The commander reviews quickly the underlying analysis and try to be synchronized with the analyst's thinking and matched with his own character (conservator/ risk-avoiding vs. ambitious/ risk-taking.

In conclusion, military DSS should better address the quantitative elements of uncertainty, risk, and choice, hierarchically, at different levels of abstraction, in a more effective way, capable to encourage the development of FAR strategies. The mix framework to evaluate and improve CoA in an uncertain environment is realized by using analytic methods (war-gaming, human gaming, Red-teaming, assumption-based planning, agent-based models, exploratory analysis) and agent-based models, that should be more focused on human methods and should be better adapted for a simple use by commanders. DSS support should include the credibility of estimated confidence levels as a function of process. If the assessments are based only on in-group judgments the credibility is low, but if the judgments reflect Delphi or other techniques, the judgment is more credible.

3. REQUIREMENTS FOR A MILITARY DSS FRAMEWORK INSPIRED FROM ECONOMICS

Defense spending is characterized by cyclicality, and in crisis periods, like the period 2008-2010, budget crunches could put pressure on important programs, could exacerbate the under funding of other programs and could stop the recapitalization process of materiel used in recent operations.

For all styles of defense planners, DSS should facilitate the economic selection, but for commanders, the resource issue is less focused on budgets, but more focused on the survivability of people and materiel.

The portfolio management is an approach inspired from economics, is an effective instrument for the treatment of risk, based on a top-down mechanism evaluation equipped with cost-effectiveness analysis and the mathematics of aggregation. In strategic decision-making, the use of orthogonal strategies is limited by the scenario space of the possible strategies, but the optimal output should be filtered and mixed, because of the multiple objectives and the use of FAR strategy. The use of orthogonal options in an analytic process should be based on a flexible selection mixed with dynamic adjustments, but in this complex task, the portfolio perspective, becomes more intuitive and effective. In the classic portfolio-management approach, investments are operated in different types to realize a balance among conflicting objectives.

In defense planning, objectives are more complex and is difficult to asses the likelihood of subsystems/elements but a portfolio might involve activities capable to support the general objectives, to maintain the military capability, and to avoid different types of risks. In this approach setting priorities and adjusting the weights of effort within the portfolio is important in the context of limited resources.

In the literature on defense planning (Davis, Gompert, Kugler, 1996; Davis, 2002; Hillestad, Davis, 1998; Dreyer, Davis, 2005) are also presented the key aspects of a portfolio- management framework, that responds to military FAR restrictions: the routine to use portfolio management tools; it responds to assessment of critical-component capabilities, costs, and benefit-cost ratios (near, mid, long term, anticipation of strategic adaptations); portfolio adjustment fill gaps, balance risks and opportunities, prioritize by packages, and conduct marginal or chunky marginal analysis; it offers more levels of zoom where needed in a clear assessment; it offers parametric capability models for comprehensive analysis; it permits the development of families of models, games, experiments.

This framework should support the commander's decision regarding the adjustment/ tuning of the portfolio so as to fill the gaps, balance risks/ opportunities, prioritize by groups rather than by discrete activities, and even to conduct investment analysis, such as marginal or chunky marginal analysis. Commanders are focused on the dynamics of the adjustment, the flexibility of levels of zoom or drill-down. The treatment and the representation of the risk within a portfolio-management DSS is based on the following risks: acquisition risks (feasibility, cost), at-the time strategic risks (warning and decision time, allied permission to use bases), operational (effectiveness in achieving the principal effect sought, control of collateral damage, perceptions, behaviors), subsequent strategic-effect risks (the risk that a coalition will disintegrate, the fragility of domestic support). The set of risks includes risks involved in acquiring the capabilities in the first place, risks associated with their usability when needed in crisis or conflict, operational risks when actually employed, and risks associated with negative strategic effects (e.g., international perceptions) even if the operation itself is successful and achieves the desired operational-level effects. The representation of different types of risks in a portfolio-oriented DSS is difficult to be realized in a top-down architecture that needs to achieve comprehensibility. Some authors (Davis, Shaver, 2008) propose the following principles in the treatment of risks: the use of measures of effectiveness for both normal and extreme risk cases; the use of composite risk indicators.

The interpretation of the analytical results from detailed technical calculations (the so called zooms) should be easy understandable by using intuitive charts and simple logic tables, and tuned by a combination of intuitively variables, charts allowing interactive response to questions, and simple logic tables.

Portfolio-management instruments are well adapted for the top-down perspective, but not for going into much depth. A candidate ingredient is the exploratory analysis, in which all of the key parameters are varied simultaneously so that one can understand results as a function of those parameters in the complex n-dimensional space. In the cost benefit analysis (CBA) the most important issues are the following: a mechanism for exploring the consequences of different perspectives about the relative importance of different missions and constraints and the relative probabilities of various risks; there is a need for marginal analysis (where to spend/ cut) and a more chunky type of analysis that uses larger increments of spending/ cuts; the use of cost-benefit strategic comparisons on large composite options.

4. THE HUMAN GAMING INGREDIENT IN MDMP

The foresight approach seeks the potential drivers of change relative to a simple extrapolation. In uncertainty, planning based on extrapolation is difficult, and the drivers of change are rarely fully controllable. Although the development of foresight methods first occurred in nonmilitary applications, the central ideas are part of an ongoing interaction between military and nonmilitary thinking.

Indeed, the use of human gaming ingredient in the form of foresight exercises could offer a good support for commander in creating and evaluating optimal CoAs. In military, the foresight approach is focused on building potential CoA in an attempt to obtain the desirable output.

In the absence of an efficient vision of the future potential of forces, commanders build different visions (scenarios) capable to offer a logical and consistent picture of the future, and then, elaborate the plan. In real world, the interest is to select scenarios that are intrinsically interesting or to decide which of the interesting scenarios could be used in planning. The challenge is to define a set of scenarios that, if used to challenge our planning in different ways, will provide adequate insight into the larger scenario space of interest. The creation of scenarios can be described as a set of tasks: expanding, structuring, focusing, assessing, and constructing.

The first step is to expand the evidence base, and to include all the elements (L factors) or relationships (R factors) is included. Then, the analyst put form onto the information that has been collected. Expanding and structuring of tasks is not linear in time but is interactive and build the relational database in the collective mind of experts. To maintain coherence and comprehension, the foresight exercise should have a focus, based on objectives. The assessment tasks match the uncertainty of the scenarios with the aspects of the future taken as certain and the CoA, and identify the number and nature of the scenarios to be taken into account. Finally, the scenarios are build in a concrete, logical, meaningful, and thought-provoking manner, in anticipation of requests for more information.

5. THE USE OF THE CONCEPT OF FAMILY OF MODELS IN MDMP

Operation planning should be matched with the strategy of multiple goals, capable to improve the probability of success. This is not a pure strategy and it should includes heavy preparation of the battle space (air power, ground maneuver forces, information operations) and is design so as to avoid unnecessary collateral damage. An efficient use of alternative ways to achieve FAR strategies should be also considering portfolio-management techniques.

The key functional needs for analysis and supporting modeling and simulation include: routine and perceptive treatment of uncertainty, emphasis on FAR strategies, adaptive models and reinserting human capital in modeling and simulation and the use of the concept of family of models could offer a better functionality. The particularities of the concept of family of instruments to support analysis would include: a diversity of models with different levels of resolution, perspective, and character and different degrees of interactivity; human games and other exercises structured to increase the analytical aspects; experiments for integration and representing phenomenology, other empirical work and consultation with experts. Strategic simulations for (multi)theater strategic and operational levels can have good capability for analytical functions, decision support, and integration, but the models are not adaptive.

Agent-based models in bottom-up architecture have modest ability to explore phenomenology and human action. Detailed models are important at low and intermediary levels, but are poorly suited to higher-level analysis or DSS, due to uncertainty. War-gaming offers agility and high speed to deal with previously unstudied issues. Multiple scenarios, can improve war- gaming offering a good focus on real factors, including human perceptions and behaviors. Field experiments offer an integrated picture that includes human issues.

The human factor should be used more effectively in modeling and simulation, and DSS (human gaming, use of experts). Human games are idiosyncratic to players, focused on the playing through of a single scenario, undocumented, and relatively unstructured. In this case, games can be used for the following analytical purposes: discovery, sensitization, concept development, knowledge elicitation, identification of assumptions, and testing of hypotheses. In the literature is presented how to make human war-gaming more effective (Davis, 2004): the use of a design focused on vignettes with relatively well-described situations; the use of competing teams with different backgrounds to see/ test diverse tactics and assumptions, and to encourage teaming and team protection; to implement record planning factors and reasoning used during team play; a more effective use of Red teams, both to better appreciate different ways of assessing the situation and defining objectives.

A different approach (Davis, 2002) for using humans and gaming to help inform and tune adversary models is based on the following aspects: it is necessary to develop a theory and structure for understanding possible high-level adversary decisions and behaviors; the use of war-gaming to check on the adequacy of the factors and structure and to test the theory in extreme, difficult or ambiguous situations; the generation of alternative adversary models, each of which, parameterized to reflect inherent uncertainties; the integration of the exploratory analysis to develop candidate FARs. Another version (Santos, Zhao, 2006) address how adversary modeling can be accomplished focuses on inferring the intent and developing the consequences of that intent for subsequent actions in a dynamic environment. In the case of optionally interactive simulation, where humans may be used to make C2 decisions, such as shifts in strategy or commitment of reserves, the simulation should take into account the following: a better representation of the plans in the simulation; the possibility to do the simulation with interruption points at which humans review the situation and, as necessary, make adjustments in the strategy; the introduction of new action sets and rules.

The additional requirements refer to a more intuitive capability to build strategies and a more simple way to build easily accessed libraries of building-block actions.

Another strategy is based on making better and more systematic use of experts. The focus is on the following methods: Delphi (Helmer-Hirschberg, 1967; Linstone, Turoff, 2002), Analytic Hierarchy Process- AHP (Saaty, 1999), Value-Focused Thinking- VFT (Parnell, 2004), Subjective Transfer Function Techniques- STFT (Veit, Callero, and Rose, 1984), Scenario-Based Planning- SBP (Schwartz, 1995), Day After Games- DAG (Mussington, 2003), Uncertainty-Sensitive Planning – USP (Davis, 2003), Assumption-Based Planning-ABP(Dewar, 2003). In the literature (Davis, Henninger, 2007) are also presented the main difficulties related to these models: the real capability to find/ and select the experts; the problem related to the group dynamics, such as effects of hierarchy and social context, and the well-known group-think phenomenon; the effective cross-disciplinary discussions when experts from diverse disciplines often have different languages, assumptions, and tacit knowledge; the tendency in the expert discussion/ group of experts, to move toward a best estimate or consensus, rather than exploit the opportunity to see distributions of possibilities.

6. CONCLUSIONS

There is a clear interest for the building of a framework capable to offer high-level decision support, in high uncertainty, in operations, or planning. Modeling and simulation should be more oriented toward FAR (flexible, adaptive, robust). The adaptiveness may be achieved by having submodels that adjust simulated strategy and tactics depending on objectives, situation, and projections or submodels representing the behavior of individuals (adversary leaders), groups, or countries. The elements to improve adaptiveness include using agent- based models, control theory, game-theoretic methods, innovative model-related operations-research algorithms, in different styles, deterministic, stochastic, hybrids.

The principles for building a military DSS capable to serve high-level commanders are analyzed and it is also presented the possibilities to use and adapt the inspiration from classic portfolio-management methods mixed with human gaming. This strategy of mixing leads to an effective implementation of FAR strategies, based on a better exploitation of the human innovation in adaptive models

The future design of DSSs should be focused toward the use not only on the classic modeling and simulation, but also on human-intensive methods such as war-gaming, foresight exercises, Red-teaming, assumption-based planning, and various methods for using experts.

REFERENCES

[1] Burdick, Chuck, *Plan Building in JWARS*, in Proceedings of 11th Conference on Computer Generated Forces and Behavioral Representation, 2002, pp. 421-430;
[2] Clark, Wesley, Waging Modern War, Cambridge, Mass.: *Public Affairs*, Perseus Books, 2001;
[3] Prelipcean, G., Moisescu, F., Boşcoianu, M., Ciufudean , C., *A hibrid trading system for defense procurement application, simulation, Modeling and Optimization (SMO 09)*, Budapest, Hungary, 2009, pp.173-178;
[4] Prelipcean, G., Moisescu, F., Boşcoianu, M.,*New ideas on the artificial intelligence support in military applications*, Knowledge Engineering and Data Bases, AIKED'10.