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Modeling Approach to the Specific Tactical Activities

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***Abstract*—**The contribution deals with current or potential approaches to the modeling and optimization of tactical activities. This issue takes on importance in recent times, particularly with the increasing trend of digitized battlefield, the development of C4ISR systems and intention to streamline the command and control process at the lowest levels of command. From fundamental and philosophically point of view, this new approaches seek to significantly upgrade and enhance the decision-making process of the tactical commanders.

***Keywords*—**Computer decision support, C4ISTAR, ISR, DSS, OTU.

I. Introduction

ONE of the most important capabilities of the Armed forces is the ability to decision. Decision-making has to be supported by the processes and technologies. The military is important area of social theory and practice, were modeling and simulation have been used for centuries.

Computer support of military applications and processes is not exceptional by these days, however its domain still falls within the areas outside of the direct decision support of the commanders in combat operations. The first attempts to mathematically modelate the complex battle situations to support the decision-making processes of the commanders started in the 1960s. The original math models was based on a very general assumptions and tried to build the rationality of the behavior of the selected tactical element in the very approximate terms. These models were appropriate as doctrinal approaches, but for the implementation of individual tactical solution or as direct support to the tactical decision-making activities were not applicable.

Modeling and simulation performed important cognitive and practical function in military history. Its emergence and development form an integral part of military history and continuous development of all its important components. For a long time, the military modeling and simulation had a applied character, mainly in the commanders decision, prediction and planning in combat operations, it plays decisive role in immediate decision search in asymmetric warfare and war against terrorism.

Decision making is one of the most important activities, which a Manager or person generally do in their everyday life. Decision making can be understood as core of management. Decision-making is always a choice between two or more options. Decision process in military environment is similar to its civil equivalent, but with different inputs, outcomes and consequences. Same as in civil management, military commanders are forced to choose optimal solution based on proper weighting of multi-criteria requirements.

In a military decision-making practice it stands out in the foreground more than in the civil sector, mainly such factors as the time (speed of decision making), the issue of available material resources, unfamiliar environment (terrain, enemy, population), and particularly the factor of possible loss of life and technology.

The commander is often forced to make decisions quickly based on their experience with the mentioned conditions. We are talking about empirical-intuitive decision-making process. Under these assumptions, it seems logical to facilitate decision-making by a modeling support

II. The System Approach

The system concept of computer support of tactical decision, from fundamental point of view, is possible to split into two approaches, namely:

- Subjective - empirical and intuitive
- Objective – mathematical and algorithmic

For effective tactical decision making, it is necessary to keep the coexistence of these approaches in the balanced synergy conjunction and complementarity in such a proportion that fulfills the type of the decision-making problem. From the perspective of computer support and automation of decision-making activities, it is currently possible to provide a part of the decision-making process with the aid of machines and even though the trend of automation constantly growing, so far there is no indication that the human element should be fully excluded from the advanced decision-making processes in the near future. In any case, the impact of the automation to the effectiveness and to the time required for the key decision development is absolutely vital, as indicate the last experiences from the war in Afghanistan.

Until now, the decision-making process of the commander was usually conducted in terms of empirical experience and intuition and most likely it will remain identical in the near future. Already in the 60s in the last century, there appeared a tendency to model specific operational and tactical processes [1]. The initial math models have suffered from serious deficiencies relating to a complex data base of the battlefield. The models were unable to deal with a wide range of information cover, what is the key of the operational and

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tactical decision-making processes. Furthermore, in many cases, models were based on very approximate assumptions suffering from an information deficit and the solution could not lead to a rational result applicable in practice in any case.

Computer support within algorithmic approach is still a relatively new element which, though some initial attempts of its "start-up" done in the past, is still on the beginning and probably it takes some time to accommodate this approach in the decision-making process of the commanders on the tactical level.

Major upgrade of a new approach comparing a previous solutions consist in:

- comprehensive concept of the operational environment,
- detailed real-time virtualization,
- advanced extrapolation of its operational attributes (status) in a wide range of conditions,
- subsequent series of operational and tactical analyses, integrated into solutions that respect the multi-criteria priorities.

Leading position on that field still keeps the US military. US introduced the revolutionary operational and tactical approach called the Deep Green concept in 2008 [2]. Deep Green concept is inspired by a Deep Blue supercomputer (1997) and is focused on advanced operational and tactical tasks dedicated to the ground forces of 21st century. This concept is solved through the DARPA Agency (Defence Advanced Research Project Agency) and its philosophical and componentary scheme is shown on the following Fig. 1.

Computer support of this approach is splited in two ways:

Algorithmic - having an impact on the development of theoretical algorithmic solutions and also affecting the software for particular computing platforms. This approach includes the fundamental math solution and its adaptation and optimization for machine processing

Technological - focused on the development of a computer systems-technological performance and aspects, including the architectural upgrade, cluster integration, distributed calculations, assembly techniques development and so on.

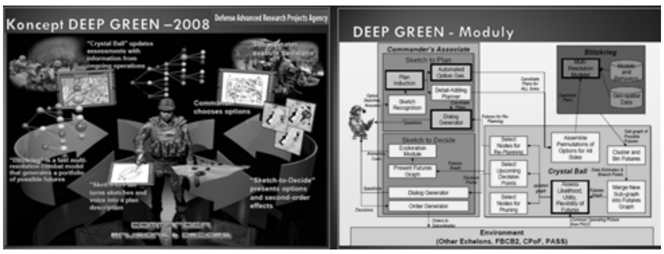

Fig. 1 The DEEP GREEN concept referred by DARPA

III. Operational and Tactical Tasks

On many fields, particularly in technical and technological base is already usual the state, that the large spectrum of processes can be not only virtually modeled but also solved in inverse manner with specified requirements. In many cases it is possible to achieve such precision that correspond with the real tests for more than 90 percent (statics, aerodynamics, hydrodynamics, and so on). This is caused by a small degree of uncertainty of the model, which unfortunately appears in a high degree in the socio-economic area particularly in the operational and tactical environment. Therefore it is extremely difficult to model the combat activities progress with an accuracy of technological processes, however, it is possible to model the conditions of certain tactical scenario and through the optimization of these conditions to use the results as an issue for the selection of particular option or activities.

There are two approaches of the operational tactical tasks solution, in particular those, which fulfill the criteria of the so-called inverse task:

- **Analytical** – it allows formulating the solution of inverse task by mathematical expression (for example by polynomial). In the area of operational and tactical tasks it is usually very difficult to find such a solution, and the way-out is the evolutionary solution.
- **Evolutionary** - it is approach (using brute force), where the solution is based on the search through a broad spectrum of possible iteration assessment or all possible input sets. As a model example on that field can serve for example the square root calculation, where the accurate solution is based on iterative algorithm.

As already indicated above, usually in the area of complex operational tactical tasks dominate the evolutionary approaches, since finding a direct analytical solution is either very difficult or does not exist. Furthermore, it should be noted that, in the case of operational and tactical solutions, it is usually a multi-criteria problem, where just the settings of the entry criteria can be quite a complex task by itself. There plays the key role the individual approach (opinion) linked with the pragmatic (tactical) aspect of the solutions. Like the classic examples of operational-tactical tasks, may serve the search for the optimal location of shooting position.

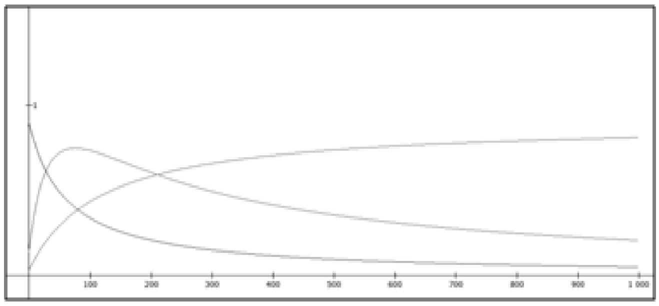

Fig. 2 2D Strike model (reciprocal hyperbolic), constructed with the probability target hit function (hyperbolic) and probability function of the friendly element endanger (logarithmic)

In the construction of the model, it is possible to implement deductive approach and is it possible to issue from the assumption of the likelihood compromise of intervention of the target and acceptable risk of friendly element in the context of the implementation of the attack. It is demonstrated in the Fig. 2, where the function of 2tactical pragmatism of the fire depends just on the distance to the target.

However, the model in real conditions is linked to additional criteria and inputs, such as the enemy and friendly element altitude difference, distance from the nearest vegetation, position of the Sun, type of the weapons, level of the training and so on. In the case that we assume the second parameter as the angle between the source and the target element, then the construction of the model can look like follows formula (1):

$$f(x,y) = \left(\frac{2}{3}\tan^{-1}\left(\frac{0,5*y-30}{x+1}\right)+1\right)\left(\frac{810}{\frac{x}{60}+1}\right)\left(0,9-\frac{1}{\frac{(x+15)}{100}+1}\right) \quad (1)$$

x – the distance to target (0,1500)

y –the horizontal angle between the friendly and enemy element (-80,80)

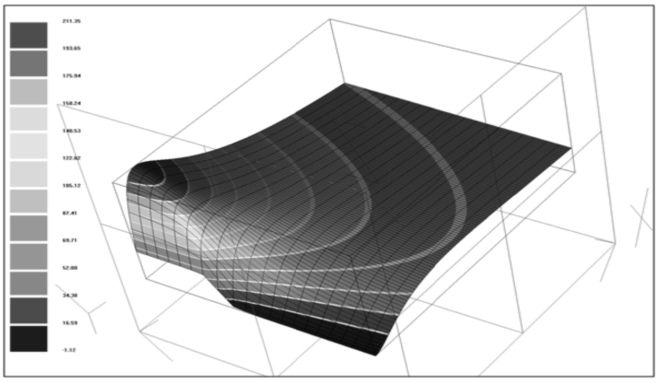

Fig. 3 Model of the shooter location pragmatic function

In general, it is relatively complex task, where each additional input increase the dimension of the model, so another approximate model represents the formula (2) and Fig. 3, there are considered 3 inputs (n1,n2,n3) in this case, where this calculation must be applied to any combination of the deployment configuration of individual elements (the shooter and target) on a digital model of the battlefield to find the optimal solution.

$$f_{(n1,n2,n3)} = \frac{(1-0,002n_3)\left(0,7e^{-\left(\frac{n_3-200}{100}\right)^2}\right)+\frac{(1-0,002n_3)}{\frac{n_3}{1000}+20}}{n_1+1} \times \frac{\tan^{-}\frac{n_2}{n_3}}{2} \quad (2)$$

n1 – the distance from the nearest vegetation

n2 –the difference of the excess of friendly and enemy element

n3 – the distance to target

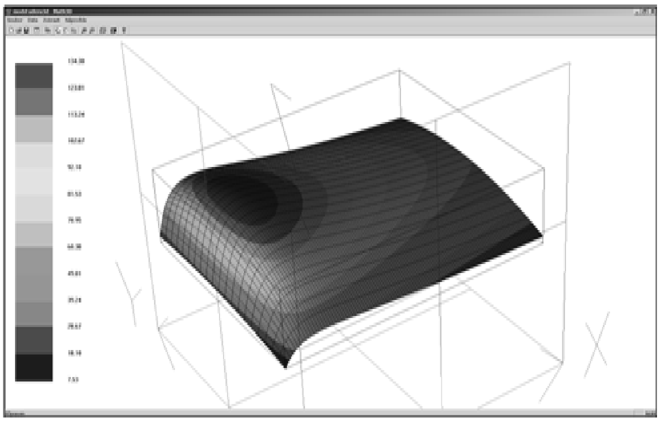

Fig. 4 3D cut of the model of the shooter location pragmatic aspect function

IV. Modeling and Digitizing of the Battlefield

The relevant results achievement in the framework of the battlefield modeling lay in the deployment of high level complexity and relations, which previous models did not implement. This condition could be achieved by implementation of the same or higher information view (scope) of the commander addressing the tactical problem. This circumstance is currently simply achievable by C4ISR utilization.

To resolve this issue it is necessary to realize the goal of the entire tactical modeling process and the context of the command and control. If we come from the fundamental nature of the army and its dedication to the martial activity, then the decision of commanders usually follow the search for an optimal tactical activity, or the sequence of activities leading to assigned tasks competition in the shortest (possibly fixed) time and with a minimum released effort or resources. So in other words, the main aim is such a sequence of tactical elements (maneuver, fire and strike) subordinated units/troops which will lead to the most effective task fulfillment.

To resolve this issue, it is possible to partially take inspiration from the game of chess as well as the military leaders did in the past. Mainly from the basic model of the playing field and the rules for the individual elements, it can serve as an approximate raster scenario for the tactical battleground modeling, where the model adapted to the current conditions will be incomparably greater complexity and must take into account all relevant factors affecting the combat activities. Despite the fact that the current modeling of the combat is from the philosophical perspective relatively highly theoretical matter, it is intuitively clear that the chances of a successful application of these models can be in case of fulfilling the appropriate complexity, very high.

Solutions to the particular problems are based on a set of individual approaches and could not be unified. The overall concept should be understood as a comprehensive issue, rather than an isolated problem. Currently, there is no universal solution capable of addressing more various tactical tasks, and it is necessary to find adequate (separate) solutions to each problem. The way of individual problem solution usually comes from the weighted integration of tactical analysis linked to the quantification and multi criteria decision making. A general approach to the battlefield modeling can be compared with the large 3D matrix (set) of particular math and tactical models. As an example solution may serve the ambush area optimization, illustrated on Fig. 6, where the red circles represent the extrapolated positions of the opponent and the pink circles indicates the position of friendly elements.

Increasing diameter of the pink circles indicates the position relating to the particular position of the opponent indexed in this case, from top to bottom. So, the center of the red circle on the top position is related to the center of the pink circle with the smallest diameter and the center of the red circle on the lowest position correspond with the center of the pink circle with the largest diameter. The optimal maneuver of each element is depicted from the default position for optimal action (the route is shown in red).

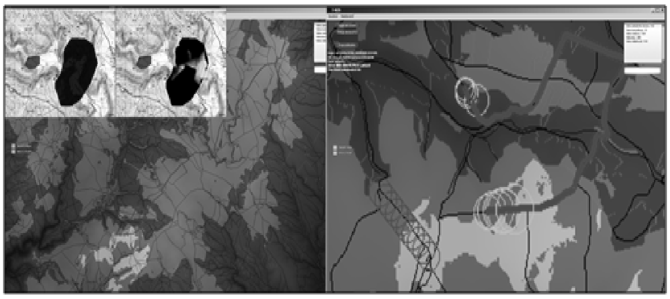

Fig. 5 Ambush area optimization (SW University of defence)

V. Conclusion

The latest military trends are setting the demanding requirements to the contemporary operations. The focus is laid on the quality and proper integration of underlay analyses, necessary for the effective decision process execution. These trends are apparent since the year 2002 and escalating in the context of building the new approach to the decision making activities of the commanders.

In context of information technology development and increasing demands on combat information systems as for instance C4ISTAR, what slowly reach its technological edge, the next way of tactical and technological future of 21-st century battlefield are turning to model based tactical decision support. This problematic consist of wide set of operational and tactical problems, generally reaching side of multi-criteria decision tasks and in most cases converge to tactical battle and non-battle process optimization.

The construction of models of decision-making processes and their solution is motivated by intentions to limit the intuitive decision-making and eliminate the negative consequences of subjective problem-solving procedure.

Optimization of operational and tactical activities, though this is not apparent at the first glance, is linked to the pragmatic aspects and algorithmic scheme, enabling their advanced automation. The solutions are not usually the trivial and the results are necessary to analyze in terms of its stability and assess its pragmatic level. However, this innovative approach has pushed a previous static concept of information distribution to a new dimension and provides a powerful tool in the planning and combat operation management process. This concept also creates the key conditions for the effective integration of automated and robotized systems into the combat operations.

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