DECISION MAKING PROCESS AND THE ALGORITHM OF AIR COMBAT SIMULATION

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***Abstract**: Modern computer technology brings a new dimension into the decision making process. For optimal decision mathematical methods of the operational analysis and simulation of combat activities are used. The whole simulation process of the air combat is divided into several separate stages. The air combat simulation program for personal computers was processed on the basis of the mentioned algorithm. The model of decision making process was used for optimal using of Air Defence units.*

***Keywords**: Effects Based Operations, Decision Support System, Decision Making Process, Modeling & Simulation, Asymmetric Threat, Air Defence.*

1. INTRODUCTION

Major war, in the sense of formal and total conflict between industrialized states became considered generally unlikely. However, conflicts do still occur among minor states, and the use of force short of war inside some states is seen daily. The Global War on Terrorism shapes a transformation for new missions of militaries in many countries in the world. Adaptation for new missions and overall transformation of Armed Forces include intellectual, organizational, and material areas. Transformation of capabilities in intellectual area means a change of analytical tools, state-of-the art techniques, tactics and logistics in information age. Operations could be seen as a material-energetic and idea-information process, which goes through multi dimensional space and time. Environment and his parameters have always had a huge meaning to success of operation. Therefore, all relevant aspects (geometric, time, social, and natural) of environment of an operation area are to be involved and to be considered with models and simulation.

Although most (if not all) military and political decision makers must have considered the potential effects of their actions throughout time, Effects Based Approach (EBA), also known as the Effects Based Approach to Operations (EBAO), is an emerging and improved way of planning and conducting operational campaigns based on a holistic understanding of the operational environment taking all instruments of power of the political, military, civil and economic (PMCE) spectrum into account. NATO uses often the term PMCE (Political, Military, Civil and Economic) and sometimes the term DIME (Diplomatic, Information, Military and Economic) too. It is because as alliance of nations NATO is more acting on a political level than having own diplomatic resources.

Document NATO „Implementation of the Allied Command Transformation" sees new and broader alliance missions in:

- Conflict Prevention and Crisis Management,
- Peacekeeping - Humanitarian Operations - Disaster Relief,
- Stabilization and Support to Reconstruction,

which needs to harmonize efforts with other actors like International Organizations, National Governments, Non-Governmental Organizations and Industry [1]. Therefore the Allied Command Transformation is supporting experimentation and conceptual development which could lead to comprehensive changes in organization, processes, policy, doctrine,

strategy and training and education to enable EBAO for NATO.

2. EFFECTS BASED OPERATIONS (EBO)

The multinational concept of operations (CONOPS) developed for describes a way of planning and conducting Effects Based Operations (EBO). It introduces several new operational concepts and defines a process for organizations to carry out EBO [2]. The NATO Military Committee (MC) has expressed its position on the EBO and as a result the EBO Implementation Working Group in NATO is established who is tasked to develop a viable roadmap for NATO with respect to EBO. Modeling & Simulation Support to the Effects Based Operations is based on a holistic understanding of the operational environment looking at both physical and behavioral aspects of a system (a conflict state) to be changed taking all instruments of power of the PEMC spectrum into account (Fig. 1).

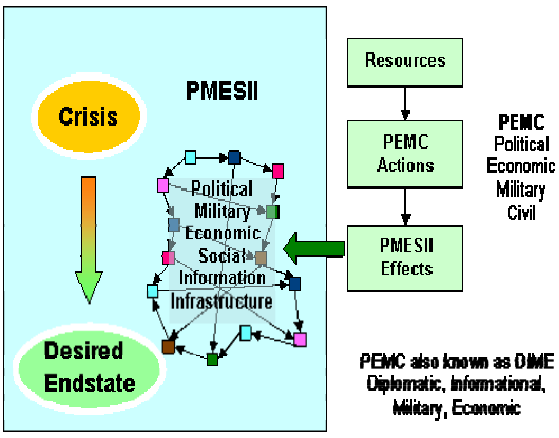

Fig. 1 Effects Based Operations

The conflict state is described by its associated PMESII (Political, Military, Economic, Social, Information and Infrastructure) elements in a system of systems approach. Elements with their links and relationships represent the system. The effects based approach comes into play in looking at the effects (required changes in the system state) that have to be achieved to reach the desired end state. In order to achieve effects, actions throughout the PMCE spectrum have to be carried out using all available and capable resources [3].

We can divide the EBO model into few sections (Fig. 2). In the centre of this model there is the System State, which is represented in the Knowledge Base. The assessment of the system state in Effects Based Assessment (EBA) and Effects Based Planning (EBP) (situation awareness and understanding) starts the process. If the present system state is not acceptable the planning phase is started. The desired end state is defined and the effects to be achieved, including their sequencing, to reach the end state is assessed. The next step is to match actions and resources to gain the desired effects. EBP includes the synchronization of all actions and the development of an Effects Based Plan (EB Plan) with a Course of Action (COA).

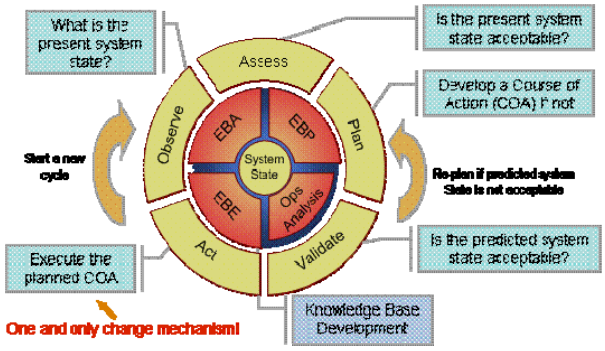

Fig. 2 Model of Effects Based Operations

Already during this process Operational Analysis (Ops Analysis or OA) with the use of respective tools helps to generate alternatives and to assess different courses of action. The chosen EB Plan is war-game and it is validated. This plan then forms the basis for operational execution (Effects Based Execution or EBE). Effects Based Assessment tries to capture all relevant data to assess the status of the plan achievements during the following execution. This is done using the measures defined during the planning phase: measures of performance (MOP – action related) and measures of effectiveness (MOE – effects related). Operational analysis can support this process with various tools and a forecast of the situation is based on the findings [4].

3. DECISION SUPPORT IN ASYMMETRIC OPERATIONS

Decision is one of the most significant activities, which are accomplished by organization managers, is sometimes comprehended as a specific core control. Some authors distinguish so-called consecutively managerial functions (planning, organization, selection and worker layout, people management and control), that are realized in a certain temporal sequence and continuous managerial functions (enterprise of the analysis, decision and communication), that are intersected with the consecutive managerial functions. Decision is a real integral element of the consecutive managerial function. The decision is applied during the planning, because the core of planning process is created by decision processes.

The meaning of the planning is applied in the quality and results of this process, primarily strategic decision process, take place on the highest levels of the command and control, influence basic way of operation effectiveness and future prosperity of the organization. Bad decision can be one of the important causes of failure. The core of decision process is the correct adoption of derived decision.

It is obvious, that decision making should be the most effective from the very beginning. Could it be reduced only to the conscious, rational? The Intuitive, even the routine practices are based on know-how decision terminal and on their inference. Their mechanism application is strongly individual, it is not possible to generalize, it is close to instinct activity and it could not be turned down as irrational. The conclusion is that not only know-how by itself is hidden in the intuition, but also generational know-how may be actually linked with genetic heredity. They are the assumption, starting point and sign of individuality and for this reason they are the foremost methodize for each commander. Nowadays, the science does not know the examination which methodizes our subconscious reaction. The science is focused on willful, programming and rational decision. Computing techniques development and primarily spread of personal computing leads to meaningful grow in utilizing these tools to support solution decision problem, also in warfare.

Decision making process essence is created by mutually dependent and connected activities, that are may be divided into certain elements, that are themselves indicated as stage (phase) of decision process. The Decision process is then gradual row of activities or phases, which accomplishment leads to effective problem solution (decision). These phases create structure of decision process in gradualness. Even with the use of decision making process support systems, the municipal model of decision process, which is supplemented by some additional stages, is preserved (Fig. 3).

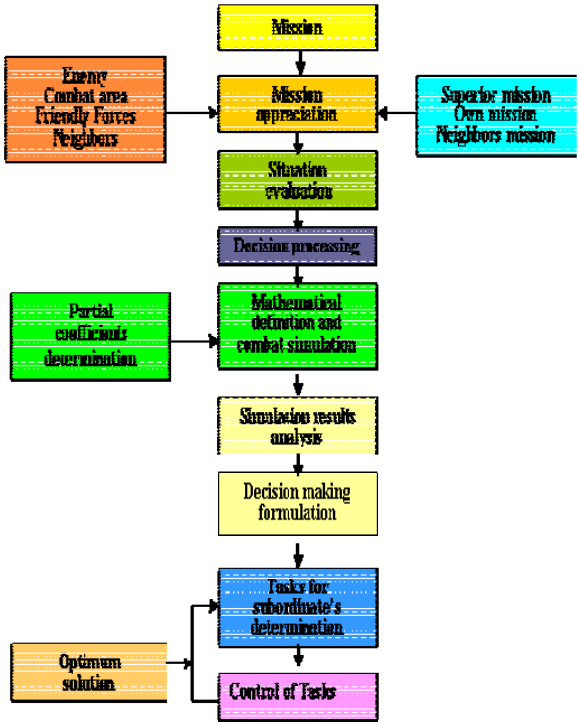

Fig. 3 Algorithm of decision making process

In a long term at the Military Academy of General M. R. Stefanik while dealing with the problems connected with the problems connected with the military sphere, our attention is focused on the application of decision making process. The systems, which support a decision making process, show how interaction character of computing systems consisting by model, programmatic and information security is applied. These systems

help managers to find the way of problem solutions and decision accomplishment activities.

Technical base of support decision system are generally personal computers connected to computer networks. Support decision systems are appropriate in the cases, when solution decision problems can be effectively supported by mathematical model application, sometimes relatively complicated, or when it concerns processing extensive files with exploitation model techniques. The shock effect near their creation is characteristics for asymmetric operations even in case we are followed by growing danger factor. This reality is further highlighting that generally we do not have enough detailed information, where from and when the crises situation could come. There is also a factor of further giant grow activity rate and their big heterogeneity, threat of the important interests of society expressed directly or vicariously, activities under stress and in the press of time, violation exerted operation processes and decision processes and their compulsory special treatment activities, decision without decision detailed analyses and other circumstances.

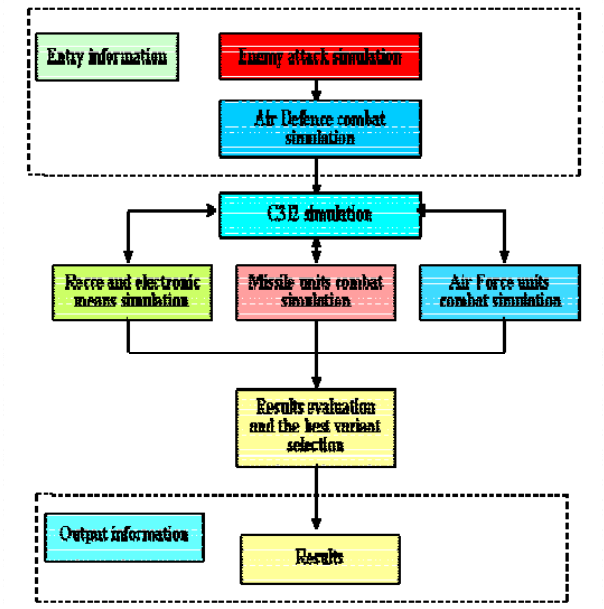

Fig. 4 Air Combat process scheme

At present effective command and control in asymmetry battlefield considers being the one of critical factor, which is able to help to fulfill the aim and task of commander. The aim must be achieved by superiority in decision, condition information superiority, when it is susceptible for faster planning, superior decision and decisive effects operation.

Conditions achievement superiority in decision is development and implementation of conception operation nourishment, computing technology and informative network. These conception allow to accomplish the operations through complex, common and purposeful using of Command, Communication, Computer, Information and Intelligence system-C4I2 by digitizing form and cross-linked disposition forces on maximize effects in the real time operation up to the weapons and soldier level.

4. THE ALGORITHM OF AIR COMBAT SIMULATION

We can analyze combat possibilities by using of mathematical models and also by preparation of military staff and commanders for a real battle.

Decision making process usually starts with the clarification of assigned mission and evaluation of situation (Fig. 3). On the basis of clarification mission and results from the evaluation of situation the mission is defined. The goal is analyzed and clarified, the possibility of its accomplishment is determined. The stated and clarified goal creates the basis for the next decision. It is continued with the admission of the decision and its delivery to the subordinates.

Modern computer technology brings a new dimension into the decision making process. Nowadays the commandant and his staff dispose of sufficient theoretical knowledge, practical experience, creativity and initiative, they suffice for the admission of optimal decisions. The mathematical methods of the operational analysis, combat activities simulations with using of efficient computer technology are used for optimal using of Air Defence units (Fig. 4).

It is possible to divide the whole process of air combat simulation into several separate stages, which characterize the simulation of partial activities:

- assumed air enemy activity;
- targets detection by reconnaissance means;
- decision making process in the C3I2 system;
- Air Force combat;
- missile units combat;
- coordination between missile units and Air Forces;
- air combat results evaluation and the best variant selection.

The air combat model is the model of competition of two sides, where one side is presented by the Enemy Forces and the other one by Air Defence (Fig. 5).

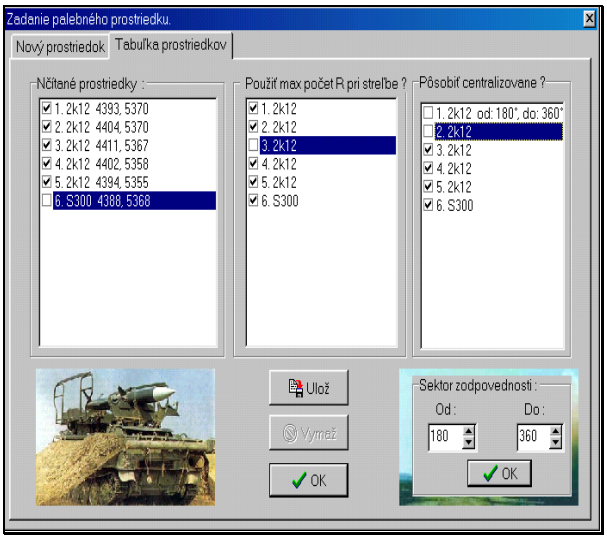

Fig. 5 Entry information Air Defence Missile System

The theory of probability, theory of statistic experiments, theory of bulk service, the rules of simulation and system access were used in the model assembling, and other methods enabling to arrange the model, which reflects the main principles and the logic of air combat.

It is possible to prepare the model of Enemy Forces attack in several alternatives, which characterize the basic assumed alternatives of the attack at the defended areas and places. For simulation of air attack it is necessary to put in entry data the assumed number and density of air targets performing from individual lines, assumed perceptual air targets divided into the vertical level and assumed way of reprisal activity to our Air Defence.

Air Defense entry data are prepared in a similar way. There are coordinates of position of reconnaissance units and the type of its equipment coordinates of position of missile units, the type of its equipment, the missile supply and also the Air Force.

In the first stage air situation is simulated with regard to the possibilities of air targets identification from individual positions with respect of the particular terrain, man oeuvre possibilities and jamming by Enemy Forces.

5. THE MATHEMATICAL MODEL OF AIR COMBAT SIMULATION

The quality of the air situation information is evaluated by the probability of the right task fulfillment supported by the reconnaissance system.

In the case of the evaluation of the individual subsystems (missile units, Air Force) portion on the effectiveness of the whole air defence system, it is suitable to choose the coefficient of system effectiveness that way as it would be possible to tie simply also with the coefficients of effectiveness of the individual subsystems. This is possible to accomplish through the mathematical chance of number of destroyed air targets. On the basis of the above mentioned, the coefficient of effectiveness of air defence system was selected as the basic coefficient [5]:

$$E_{AD} = \frac{M_C}{N_C} \qquad (01)$$

Where: Mc - mathematical chance of number of destroyed air targets; Nc - number of air targets in the strike.

Mathematical chance of number of the destroyed targets is determined in dependence on the quality of the reconnaissance system, affectivity of C3I2 system, on the possibility of the enemy to destroy the missile units and Air Forces. The mathematical chance of the number of destroyed air targets by the missile units and Air Forces can be simply expressed as [5]:

$$M_{CMU} = \sum_{j=1}^{N} \left[1 - \prod_{i=1}^{I} \left(1 - P_{MU} \right) .P_F .P_D \right] i \, j \qquad (02)$$

$$M_{CAF} = \sum_{j=1}^{N}\left[1-\prod_{i=1}^{I}\left(1-P_{AF}.P_F.P_D\right)i\right]j \qquad (03)$$

Where: P_{MU} is the probability of the correct information for missile units; P_{AF} - probability of the correct information for Air Forces, P_F - probability of fire realization by missile units and Air Forces; P_D - probability of target destroying by one fire; I - number of fire to the target; J - number of lines in the enemy strike.

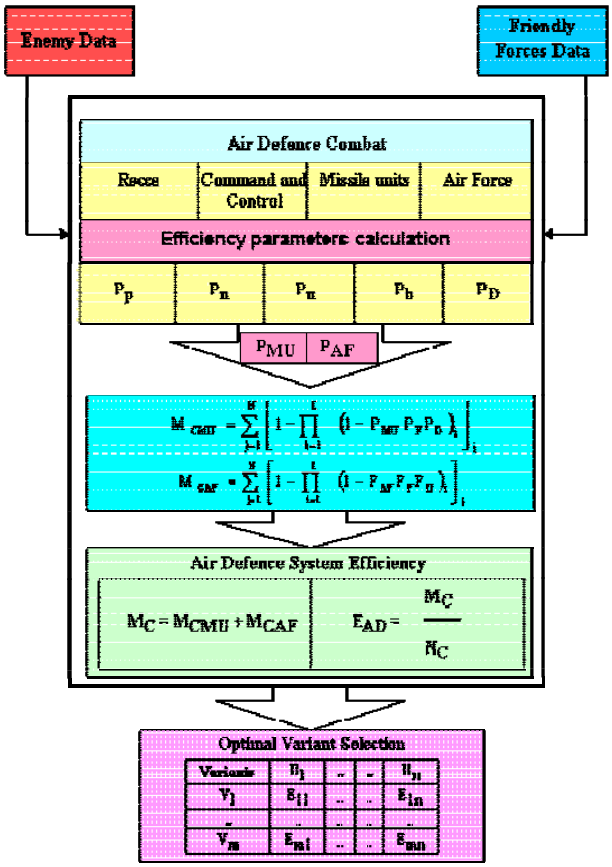

Fig. 6 Model of air Combat Conduct

The air combat is simulated in the concrete situation. In simulation we used the quality reconnaissance information, the engagement zone, the number of serviceable missiles in the missile unit positions, the arrival time of air targets to the engagement zone, the parameters of air targets act.

On the basis of the entry data we can determine the arrival time of the air targets to the engagement zone and to synchronize the lines according to the arrival time.

The Air Force combat is simulated analogically, considering the time and space factors.

It is assumed that the Air Force will be used out of the missile unit's engagement zone. We also have to take into the air combat simulation the action of the enemy against Air Defence.

Those means that are destroyed will not participate in the next air combat circle. This reality shows the probability of targets destroying and then subsequently, in the mathematical chance of the number of destroyed air targets.

The simulation results can be displayed for single Recce and Electronic systems, Air Defence Missile Systems (Fig. 7) and Air Force Fighters or to all fire systems too. For example for each target, on which Air Defence Rocket system operates, the distance of missile's blastoff (green color) and the distance at which it was destroyed by fire (red color) will be displayed. If the target wasn't destroyed, that fact will be displayed, too (blue color).

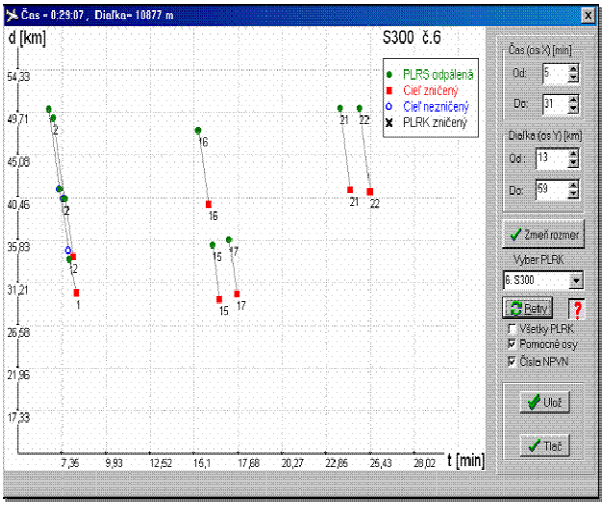

Fig. 7 Output information for Air Defence Missile System

6. CONCLUSIONS

The coefficient of the effectiveness of the air defence system is determined for every variant of air defence system and variant of enemy's attack. The effectiveness coefficients are registered in the matrix.

We obtain the optimum variant of organization of the air defence system by the analysis of the matrix of effectiveness coefficients; where the selection of the optimal

variant is executed with the use of mathematical methods of game theory.

The air combat simulation program for personal computers was processed on the basis of the mentioned algorithm. It is possible to use the model for optimization of decision making process on the air defence reconstruction.

The main responsibility for the particular decision is always up to the commander, who can't be replaced even by the best algorithm, program or computer.

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