METHODOLOGICAL ASPECTS OF AIR FORCE PARTICIPATION IN COMPUTER-ASSISTED EXERCISES USING JOINT THEATRE LEVEL SIMULATION

Abstract. The article presents the general features of the JTLS interactive simulation system, and more detailed features in the area of simulating air force operations in computer assisted exercises. The main phases of preparing, conducting and discussing computer assisted exercise are described. Against this background the author discusses selected methodical aspects of using JTLS in the simulation of air force operations.

Keywords: simulation, JTLS, computer assisted exercise, air force

1. INTRODUCTION

The establishment of Simulation and Computer War Games Centre (CSiKGW) in 2003, providing it with the Joint Theatre Level Simulation (JTLS) interactive system, which is a standard in NATO, has introduced a completely new quality into the training practice of the Polish Armed Forces. It consisted in the possibility of conducting various computer assisted exercises without the participation of real troops. The essence of such exercises consists in constructive simulation in real time or in accelerated manner in accordance with the will of the exercising commanders of opponent virtual troops that represent real not exercising troops with account taken of the model of their operating environment and assumed operational situation. Thanks to the virtues of the system it is possible, with regard to the real battlefield under the conditions of changing operational and strategic situation (every "action" entails a reaction, which generates a new situation), to simulate the rationale of commanders' decisions and to present the effects of the operations of the opposing parties. CSiKGW specialists were the first among JTLS users to develop methodology and to conduct crisis management exercise based thereon, that is non-military exercise. State institutions and universities have already participated in these exercises. Moreover, JTLS may be used to conduct research in various fields of (not only) military art, which demonstrates that the system has research and scientific functions.

Interactive JTLS system enables modelling the operations of all branches of armed forces and types of troops and non-military entities on an operational/strategic level, as the name implies. JTLS is not a trainer system, and on the tactical level the operations of the resources are conducted automatically beyond the control of the exercise players, but in accordance with the algorithm of operations at this level. The essence of simulation therein is the application of various partial models that determine the functionality and suitability of the model. The process of simulating combat is free of any doctrinal restrictions, the only limitation is the imagination of the exercising commanders. Therefore JTLS enables simulation of national, allied, coalition and opposing armed forces in various configurations.
and in all spheres of combat and, as required, simulation of non-military operations of government and non-government organisations and asymmetrical operations of informal armed units, etc. Operations of up to ten force sides can be modelled simultaneously, and the organisational structure of the armed forces, arms and equipment can be represented from the highest strategic level down to the tactical level, in specific situations (e.g. when conducting special, asymmetric operations) and lower level, e.g. diversionary groups, irregular operation units, etc. The duration of combat simulation process is equal to or close to the real time, it is possible, however, to speed up the process many times. The results of simulation are of stochastic nature.

In the area of aerial combat, JTLS enables constructive simulation of virtually the entire spectrum of tasks executed by air force on a strategic, theatre and tactical scale in real or accelerated time. Specifically, in the field of aerial combat, simulation of the following is possible:

1) functions of early detection and guidance systems;
2) conducting information warfare (electronic, psychological and network-centric);
3) aerial refuelling;
4) air cover by fighters of aerial combat formations in the air by escorting;
5) combating enemy air defence;
6) fighters tour of duty on an airfield and/or in a zone;
7) fighting ground (surface) objectives of known position – military units/ships, indicated objectives in unit groups, e.g. specific weapons, or even stationary objectives with indicated target point;
8) fighting ground (surface) objectives by searching and combating in indicated area;
9) direct support for army while on duty in short-term waiting zones and on airfields;
10) conducting air reconnaissance;
11) air transport of troops, arms and warfare agents and supplies;
12) creation of aerial combat formations to execute mass air and rocket impact;
13) mining/mining clearing of land and water body areas;
14) combating submarines;
15) retargeting aircraft on duty in air fulfilling the tasks of combating ground and air objectives;
16) functioning of the friend or foe identification system;
17) specifying the rules of using arms when executing air missions;
18) combat search and air rescue;
19) regaining combat readiness of aircraft with repair of combat damage;
20) distribution of representation of situation in airspace;
21) integrated air defence system;
22) data distribution under Link 16 protocol;
23) implementation/generation of order for air force operation.
It must be pointed out that the operations of aviation, in its broad meaning, must be controlled continuously, while the operations of rocket forces and radiotechnical air force troops are in most part carried out in an automatic manner. Simulation of these operations may be done both while interacting in the military sphere, as well as in the non-military sphere defined in the exercise. The organisational and functional structure of air force units, their armament and equipment can be reproduced from the level of a single aircraft up to the highest level of strategic air command.

2. DATABASE PREPARATION

Database preparation for the exercise (research process) is lengthy and is done by the authors of the exercise in liaison with the experts of the Centre. This team of authors, guided by the objectives of the exercise, develops the details of the exercise scenario, presenting the air force combat formations of all parties of the exercise, organisational and functional structure of the individual units with their weapons and military equipment and logistic resources, their place and role in the exercise, as well as location within the chain of command and supply. The role of the experts from the Centre, to express it in simple words, is to help the team of authors in preparing the scenario for use in the JTLS system at the stage of exercise preparation, execution and recapitulation, and most importantly, the implementation of the scenario in the system. It should be pointed out that the standard database of the system includes various predefined combat means, such as: aircraft, along with their avionics, sensors, airborne munitions and sensors of various design and basing: radar stations, optoelectronic sensors, etc. Each of these combat means is described by several dozen parameters, among which some are real parameters, and some are virtual parameters, necessary to conduct simulation. Therefore the process of creating an exercise scenario in JTLS includes:

1) initial verification of standard database implemented in the system;
2) creating air force unit templates;
3) creating, based on templates, specific air force units and their interrelations in the command and supply chain;
4) building air force formations of the individual sides in the exercise;
5) verification of the formed database – exercise scenario;
6) scenario testing.

After passing the tests the scenario is "frozen", meaning that it is suitable for conducting the exercise. It should be pointed out that JTLS can operate with ICC (NATO-Wide Integrated Command & Control Software For Air Operations), which is a standard component of command posts of the Polish Air Force. Therefore the exercise scenario prepared for JTLS is transferred to ICC, and both systems are coupled. This way the air force commanders that participate in the exercises can, at the stage of exercise preparation and execution, use tools they are familiar with.

As mentioned earlier, every air force unit is created in JTLS using specific mathematical partial models included in the standard database of the system. Using these models as the building material, typical component models of future virtual air force units are created along with their operating environment – sphere of combat. An air force unit formed of such modules is a virtual model of the real squadron, air base, air defence missile battalion, radiotechnical company, reflecting their specific equipment, armament, materiel, command
systems, logistic support and typical objects, such as: runways, command posts, covers: shelters, warehouses, etc., Figs. 1-3.

Fig. 1. Fragmentary description of an aircraft in the standard database (Source: JTLS standard database)

Fig. 2. Fragmentary template of an air squadron with weapons, equipment and logistic resources (Source: JTLS standard database)
Methodological Aspects of Air Force Participation in Computer-Assisted Exercises...

After the exercise scenario is set up in JTLS, the input data are verified. Verification indicates the errors made, which are rectified in such manner as to arrive at such exercise scenario that enables its testing. Scenario testing consists in checking the functionality of adopted solutions, correctness of relations and effectiveness of the various interactions between units, forces and means. The exercise scenario that passed the verification and testing is presented to the superiors and the team of authors as a scenario ready to be used in the exercise.

3. AIR FORCE OPERATIONS IN THE EXERCISE – THE "DYNAMICS" OF OPERATIONS

A computer assisted exercise is completed within a few days in a single- or two-shift system. During this time the exercise players are forced by the system to make an intense intellectual effort under stressful circumstances and conditions of pressure of time. In the exercise the air force commander operates at his/her command post fulfilling the commanding functions, developing decisions on the use of the resources at disposal, tasking his/her subordinates and carrying on ongoing activities. The decisions of the air force commander are passed on in the command system, as in real world situations, to real executioners (command posts) and virtual air force units in the JTLS system. For this reasons CSiKGW has at its disposal components of the exercising commands – operational groups and JTLS system operators trained for the purposes of the exercise. The role of the operational groups is, on the one hand, to deliver to the JTLS system operators tasks to be performed by virtual units, on the other it is the transfer of reports and messages generated in the system by the virtual units to their command posts, in accordance with applicable Air Force reporting scheme. The task of the operators is the transfer of the decisions of the air force commander into system orders and inputting them into the system - Fig. 4, supporting the operational group in interpreting: the representation of the airspace situation and reports and messages generated by the virtual units during preparation, execution and recapitulation of operations. The air force order forms are usually arranged traditionally and therefore they can be filled in in a similar and intuitive manner. There are fields in the form that are obligatory, and some of the fields are optional. By filling in all the fields, the virtual units are given precise tasks to execute. If some optional fields are left unfilled, the effect is that (as it also happens in the real world) the virtual units,
based on the current "system knowledge" about the opponent possessed by the given side, on own abilities and conditions of performing actions, undertake the task in a manner the details of which they have to work out on their own, not necessarily in line with the superior's will and intention, which obviously brings about definite consequences. It is, however, possible to modify the parameters of aerial missions in real time and to generate information about the current status of these missions and aviation units.

In JTLS the simulation of air to air and ground to air operations is aggregated to the level of individual partial target, with probability of hit and probability of kill factors used for each element. The results of air to air, ground to air and air to ground combat with the use of precision-guided munitions is of stochastic nature. Air to ground operations with the use of area weapons are of deterministic nature.

During the exercise the players have access to information on scenario input data only in relation to their own side, and to current information on the course of operations and status of the virtual units in the exercise. The tools that enable communication between the virtual units and the operator and the players include: order panels for generating required reports, message browser, situation report window and information browser. These tools enable the players to obtain information about the current status of air force units and on the course and effects of their operations. Communication is in English language. The information obtained enables the operators/players to continuously track the developments and to respond to the changes occurring.

The operator receives all information in the flow of order documents and reports in the message browser. After a combat order is entered into the system, it is transmitted to the virtual executor, which acknowledges its receipt and initiation of its execution (Fig. 5), or indicates and specifies reasons of the inability to execute or of a delay in execution, e.g. changes in weather conditions, lack of specific munitions or materiel. The operator observes task accomplishment on his/her workstation (Fig. 6), the exercising commander observes it in the ICC system. During task execution, the unit, in the case of obstacles, such as
counteraction of aerial opponent or of air defence, change in weather conditions, etc., reports to the operator. Upon task completion, the unit sends in a report (Fig. 7). It must be pointed out that task completion reports submitted by virtual units are of specific subjective nature that does not reflect the real effects. This is a deliberate effect produced by the system creators, which reflects the situation often encountered in the real world. Such subjective and unverifiable effects of air force operations force the commands to make in-depth appraisal of the situation and to make further risk-bearing decisions based on uncertain data.

**Fig. 5.** Report on the initiation of combat task execution

**Fig. 6.** One of the possible variants of presenting aerial task execution on the operator’s workstation
The dynamic of the operations of the virtual units in the exercise force the exercising commanders to react promptly to the developments and threats. Therefore any mistake, improper action, failure to act or wrong appraisal of the situation by the exercising commander brings about adverse effects and may eventually result in a loss of control by the exercise director over the course of the exercise and may preclude the attainment of intended results. In order to prevent such situation from occurring, there is an exercise controller that monitors the course of the exercise. This way the exercise director can respond to threats that appear by adjusting some of the parameters of the units, by imposing tactical penalties, etc. Moreover, by using the feature that enables simulation acceleration, the exercise director can "look into the future" and learn the results of decisions made in advance and respond adequately. In this context an observation and a suggestion arises that the coupling of JTLS with ICC in the everyday practice of air force commands would enable optimising the decision process regarding the use of available resources.

4. EXERCISE SUMMARY STAGE

Summary exercise is the exercise's last stage, consisting of initial and final discussion and drawing up of a report with the main conclusions and recommendations arising from the whole process of preparing and conducting the exercise, performance of the players, and an indication of innovative solutions (if any), together with the manner of their implementation (dissemination) in the process of commands and troops training.

Fig. 7. Fragment of a report on the execution of a find and kill task in an indicated area
In computer assisted exercise the process of collecting data required for the discussion starts from the setting up of an exercise analysis, evaluation and review team. At CSiKGW there is a permanent system analysis team that has at its disposal tools that enable selection, organisation, collection and representation of data. These tools form a specific "black box" that enables:

- reproducing events in time and space;
- analysis of the state of combat systems;
- monitoring of force ratios;
- analysis of orders issued in the system;
- monitoring of operations in the system;
- monitoring of simulated events.

These two teams, as early as at the exercise preparation stage, establish the principles of collaboration, specify the mutual needs with regard to data needed for discussion. There is a great plenitude of these data collected during the exercise as, depending on the scale and extent of the JTLS exercise, several thousand to several hundred thousand events of various importance are recorded. During the exercise these two teams collaborate closely and select, collect and process the most important data. The processed data are used by the exercise director (during the exercise), who presents correct/wrong actions of the players, motivates them to act more effectively, adjusts the course of the exercise to successfully achieve exercise objectives. The data collected and processed during the exercise forms a collective data set. The evaluation of the exercising commander issued on the basis of the analysis of data contained in the data set is objective. The analysis of data contained in this data set enables the exercise director to draw conclusions, make recommendations for the training of subordinate commands and troops.

5. SUMMARY

The interactive JTLS system is designed primarily for modelling and presenting the outcomes of combat on an operational/strategic scale. The idea of constructive simulation effected therein is based on simulation models that represent the processes of fire interactions and internal processes: command, combat and logistic support, and in addition the processes of battlefield dynamic in the virtual environment of air force operations in the function of time and space. Simulation models generate events, new situations and behaviours of troops in accordance with the exercise players' decisions. They represent the effects of decisions made by the exercising staffs, creating thereby new challenges. The results of simulation are objective. Therefore, the JTLS system creates a "virtual battlefield" with all its attributes, where exercising commands can control subordinate virtual troops, improving thereby their commanding skills, and can create new solutions in the field of military art. The capabilities of JTLS reflect virtually the whole array of tasks executed by the air forces.

According to normative documents, the main form of exercise where JTLS is applied is the computer assisted command post exercise. However, the capabilities of the system enable its application in other forms of command and troops training, in non-military exercises and in research. Preparation of a computer assisted exercise is a long-term process, formalised to a large extent, requiring close and timely cooperation of specialists of various branches of armed forces and types of troops. At this stage the initial situation for the exercise is developed in great detail, and afterwards it is implemented in the system, precisely verified and tested comprehensively. The situation implemented in the system resembles a freeze
frame, extremely dynamic and complex in terms of battle specifics. The stage of exercise conduct is, as opposed to the previous one, short in duration, although very intense. Just at the beginning of this stage, the specific freeze frame is activated and the exercising commanders are immediately forced to take actions in the deficit of time, against the background of rapidly changing operational and strategic situations. Each of the commander's action/failure to act results in the opponent's reaction, and in the consequence of simulation new conditions of performing operations are generated. Under such circumstances, the operational condition of the exercising commanders is checked, effects of their decisions are demonstrated, their operational and strategic imagination is shaped. All of the exercising commanders' actions are monitored and recorded, and the objectivity of supervision is warranted by the capabilities of the JTLS system. The last stage of the exercise is its discussion, during which (on the basis of the collective data set, for instance) in-depth analyses can be performed, conclusions can be drawn and recommendations may be made based on the conclusions.

The advantages of such exercises include: their effectiveness and attractiveness of conducting them, as compared to traditional exercises with maps, the manner of acting on the operational imagination of commanders, the intensity of the forms and methods of operational and strategic training, effectiveness and reliability of the simulation of modern and predicted battlefield, objective evaluation, cost effectiveness of the means applied as compared to exercises with troops. Apart from unquestionable advantages, computer assisted exercises also have their drawbacks, among which the most prominent include the lengthy and complex process of preparing them.

6. REFERENCES


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