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Computer simulation of two armed mobile platforms unexpected conflict

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Some of the results of the author's original research in the complex military systems computer simulation domain have been presented. The two armed mobile platforms (AMP) unexpected conflict has been defined, and the simulation model presented. The basic mechanisms developed as means for this class of complex military systems programme-simulators generation have been described: the space-to-time and time-to-space transforms, the firing action, the probability of hitting and the gradual destruction simulation, the reaction matrix and the transaction communication with rerouting. As an example of the model application, the computer simulation has been executed, in order to determine the main weapon (classic gun with the fast armour piercing rounds or the laser beam guided missile) impact on the unexpected conflict of two modern tanks.

Key words: **Military system, computer simulation, armed mobile platform, conflict, basic mechanisms, tank, main weapon.**

Reference:

BK – combat set (amount of ammunition associated with the weapon)
D – distance between armed mobile platforms in conflict
D_0 – initial distance between tanks in conflict
D_{ij} – AMP route section length between manoeuvres M_i and M_j
D_n – new distance between armed mobile platforms in conflict
D_{ON-i} – observation-sighting set range of tank $T-i$, $i \in \{1,2\}$
D_{OR-i} – main weapon range of tank $T-i$, $i \in \{1,2\}$
D_p – previous distance between armed mobile platforms in conflict
D_{S-i} – sensor range of armed mobile platform AMP-i, $i \in \{1,2\}$
E_k – k-th effect of the adversary main weapon hit in tank during conflict
GPSS – General Purpose System Simulatior
IP – exposed area
KTP – transaction communication with rerouting
M_i – i-th manoeuvre
nl – sighting line
AMP – armed mobile platform
ON-i – observation-sighting set of tank $T-i$, $i \in \{1,2\}$
OR-i – main weapon of armed mobile platform AMP-i, $i \in \{1,2\}$
$p_{1,3}$ – probability of smaller (front or rear) AMP area hit
$p_{2,4}$ – probability of lateral (left or right) AMP area hit
P_{OR-1} – one-shot AMP-2 hit probability of $OR-i$ weapon
p_{OR-2} – one-shot AMP-1 hit probability of $OR-2$ weapon
p_{T-il} – victory probability of tank $T-i$, $i \in \{1,2\}$
p_{ul} – immediate AMP destruction probability by hitting its front area
p_{u2} – immediate AMP destruction probability by hitting its lateral (left) area
p_{u3} – immediate AMP destruction probability by hitting its rear area
p_{u4} – immediate AMP destruction probability by hitting its lateral (right) area
REM – reaction matrix
REM-i – reaction matrix of armed mobile platform AMP-i, $i \in \{1,2\}$
R_k – k-th reaction
$S-i$ – sensor of armed mobile platform AMP-i, $i \in \{1,2\}$
$T-i$ – tank $T-i$, $i \in \{1,2\}$
T_{L-1} – projectile of OR-1 weapon flight to armed mobile platform AMP-2 duration
T_{OR-i} – time of preparation OR-i weapon for fire action, $i \in \{1,2\}$
T_{suk} – conflict duration
V_i – speed of armed mobile platform AMP-i, $i \in \{1,2\}$
VD – extraordinary event
V_{ij} – AMP speed on route section between manoeuvres M_i and M_j
V_{L-i} – projectile speed of weapon $OR-i$, $i \in \{1,2\}$
VTD – fire action

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α_1 – moving azimuth of armed mobile platform AMP-i, $i \in \{1,2\}$
β – angle between sighting line nl and the direction of North
β_2 – angle of AMP-2 moving direction and sighting line nl_1 of OR-i weapon
$\lambda(t)$ – time-to-distance transform
$\tau(d)$ – distance-to-time transform

Introduction

SOME of the results of the author's original research in the complex military systems computer simulation domain have been presented in the paper.

The armed mobile platform (AMP) concept has been introduced, as an abstraction suitable for research and development of complex military system class, which has the following common properties: autonomous propulsion, man crew, armament and significant need for logistic support. The AMP concept can be used in research and development of the complex military systems like: warships, armed helicopters, armed combat vehicle and many other. Even a person, infantry soldier, can be the subject of the research using that concept. Namely, a soldier has his own propulsion, he is his own crew, posesses armament and is component of the C^3I system, and during the combat action has a very significant need for the logistic support.

The armed mobile platform has an even wider application, for it can also be used outside the army domain, in research and development of complex systems which have autonomous propulsion, effectors, control systems and logistic support.

In the research results part presenterd in this paper, contemporary tank is considered as an armed mobile platform.

The goal of the research has been computer simulation of the sudden conflict of two tanks, which have been engaged in their own missions and have not been aware of each other until they met.

The basic scenario of two armed mobile platforms conflict has been set up in the paper, and then the developed simulation model has been presented, by means of graphical presentation of the armed mobile platforms in conflict moving, and appropriate space-in-time and time-in-space transforms. These transforms make possible the implementation of the simulation model as a discrete dynamic system, in which all of the activities are presented as pure time delays needed for their completion, and the main events in the system are designated by starting and ending instants of different conflict phases, based on the time-varying distance between platforms. The algorithmic description of an armed mobile platform activities in the sudden conflict simulation has also been given.

Special attention has been payed to description of the basic mechanisms developed during the research: already mentioned space-to-time and time-to-space transforms, fire action on the adversary AMP, simulations of the hit probability and graceful destruction of adversary AMP, the reaction matrix as a way of the expert rules introduction in the simulation model, and the transaction communication with rerouting. All of these mechanisms have been developed in order to create simulation models of this class of complex military systems in conflict and their implementations by means of the simulation programming language GPSS.

Finaly, as an application example, the most important results of the first experiments executed by means of the developed programme-simulator of two tanks sudden conflict have been given. The experiments have been conducted in order to determine the impact of the main weapon type (classic gun firing fast armour piercing rounds or the laser beam guided missile) to two tanks sudden conflict issue.

Armed mobile platform

The Armed Mobile platform concept (AMP) has been introduced as an abstraction suitable for complex military systems researech and development [1]. Many of these systems (see Fig.1), for example, warship, armoured combat vehicle, military aircraft or armed helicopter, have some coomon features, of which the most important are:

- autonomous propulsion
- man crew
- weapons and
- logistic support.

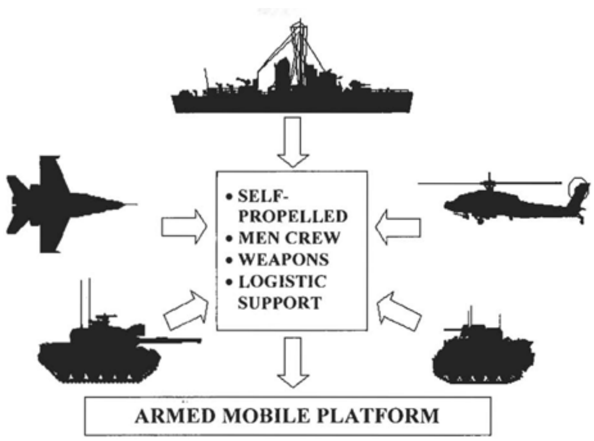

Figure 1. The Armed Mobile Platform concept

The AMP concept could be used for other similar complex systems (out side the army domain), which have autonomous propulsion, effectors, control systems and logistic support. The environment of the AMP, as a military system, represents the following: enemy, friendly forces and space (teritory or aquatory that the AMP is moving on, and the air above it).

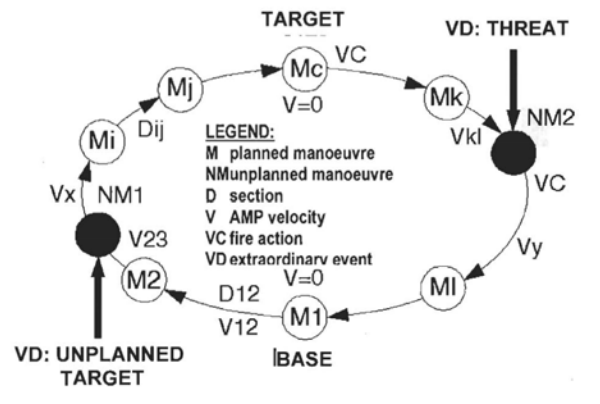

Figure 2. The armed mobile platform mission

The AMP mission is the route it is suppose to pass, from base to target and back to base. This route, which can be presented by means of a cyclic graph, consists of several sections D_{ij}, which are passed by AMP with constant velocity V_{ij} in this approach. Every section - graph arm - is bordered by two nodes, which are here referred to as manoeuvres (M_i and M_j). Manoeuvre M_i is an event on route, when the AMP velocity is changed. In order to simplify the model, it is assumed that the velocity changes are discrete, but during the manoeuvre when the AMP velocity is changed, it doesn't pass any distance.

The adversary impact to the AMP mission is represented by extraordinary events (VD) which in essence are appearances of different targets and/or threats (C/P). Target [2] is an adversary unit, system or device that can be destroyed or damaged by means of weapons at AMP disposal. The threat is an adversary unit, system or device that can destroy or damage the AMP. Most of threats can at the same time be targets, but the relative ratio of these two properties is different from one instance to another. Within the planned mission, the AMP ought to destroy one or several targets/threats, which means to open fire from some of the AMP weapons, and to expend some of the appropriate resources assigned to the mission, such as shells from the combat set (BK, amount ammunition with a weapon), or time spent by command information system.

AMP mission simulation is a computer presentation of a dynamic scenario in which, from its beginning to the end (from departure to return to base), manoeuvres and section passing are following each other, as well as extraordinary events and appropriate AMP reactions (actions), in which the mission assigned resources are gradually expended [1,3]. Mission efficiency is evaluated by means of performance measures, such as the duration, number of used shells per destroyed target, efficiency on route, percentage of favourable accomplished missions and the like.

The mission simulation goal [1,3] is to obtain, , the indicators of efficiency of the techical solutions, applied during development of the AMP, its subsystems and components by means of evaluating performance measures under various conditions. Another, but not less important goal, are the AMP mission simulator applications in the research of correct decision making, regarding the possibilities of usaging the AMP in combat actions, which is the domain of commandment, and/or logistic support, and can be applied in technical maintenance and procurement domain of such complex military systems.

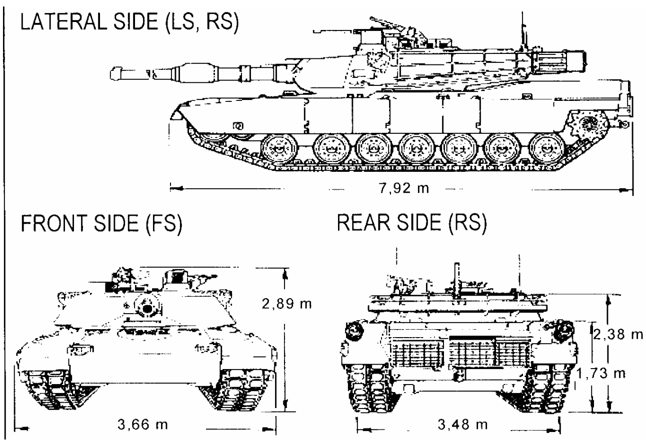

Figure 3. Tank as AMP: basic dimensions

During this research, tank has been considered an armed mobile platform (see Fig.3). The computer simulation goal has been the research of sudden tank coflict [3,4,5,6,7,8], i.e. an extraordinary event when two adversary tanks meet, while pursuing their own independent missions, and not beeing aware of each other until thy meet. Tank [6] is an offensive armoured combat vehicle, which means that its front side has the best, lateral sides somewhat less, and the rear side the least protection.

The crew of the tank considered in this research [7] consists of commander, gunner, loader and driver. The first three members of the crew are mutually replaceable, so in the event of loss of some of them, tank continues to operate as a system, though with degraded performances. Due to his specific placement in the tank, driver is inaccessible and irreplaceable, which means that such hit is critical. Commander and gunner are in the turet, on the left side, related to the tank driving direction, loader is on the left side, and driver is in the middle of the front part of the tank.

The basic drive subsystem (engine, transmission) is in the rear part of the tank [7]. Therfore it is most exposed from the rear, less from the lateral, and least from the front side of the tank. The propulsion subsystem (tracks, drive wheels) is least exposed from the front, more from the rear, and most from the lateral sides of the tank. The turret drive mechanism is mostly exposed at the turret and tank corps joint.

Commander's and gunner's surveilling-sighing systems are mutually replaceable in their basic functions. In addition, if their primary users are not lost, each of those can, to certain measure, replace destroyed driver's surveilling system.

The destruction of the main weapon is one of the critical effects of the tank hit. The main weapon is least exposed from the rear, more from the front, and most from the lateral sides of the tank.

Two armed mobile platforms sudden conflict

The phases of two armed mobile platforms conflict [3] are shown in Fig.4.

The armed mobile platforms, AMP-1 and AMP-2, are symbolically represented by points - their positions in space in which they are moving, zones of detection by means of their surveillance and fire directing sensors (wider circles) and zones of the main weapons possible fire actions (narrower, shaded circles).

Part (a) of Fig.4 represents the pre-conflict phase, in which the conflict has not yet occurred, and the NPP-1 and AMP-2 are not aware of the adversary's presence, for they are both out of S-1 and S-2 surveillance and sighting sensors' range, i.e. out of their zones of detection.

The conflict begins in the phase which is presented in the part (b) of Fig.4. The necessary condition is that at least one of the platforms enters in the adversary's sensor zone of detection. Then the armed mobile platform, whose sensor detected the adversary, takes fire directing elements and prepares its weapon for action.

Fire action begins in the conflict phase shown in the part (c) od the Fig.4. The necessary condition is that at least one of the platforms enters in its adversary's main weapon fire action zone, and that the adversary, in turn, has its weapon available and ready. In this phase, which is the very essence of the conflict, the armed mobile platforms AMP-1 and AMP-2 exchange fire, thus trying to destroy each other. They continue to do that, until one of the following events occures:

- the adversary has been destroyed by means of AMP's main weapon;
- further firing action has been disabled, due to weapon failure, lack of ammunition, or some new course of action;
- due to continued moving of armed mobile platforms AMP-1 and AMP-2, the distance between them has become greater than their weapons' ranges.

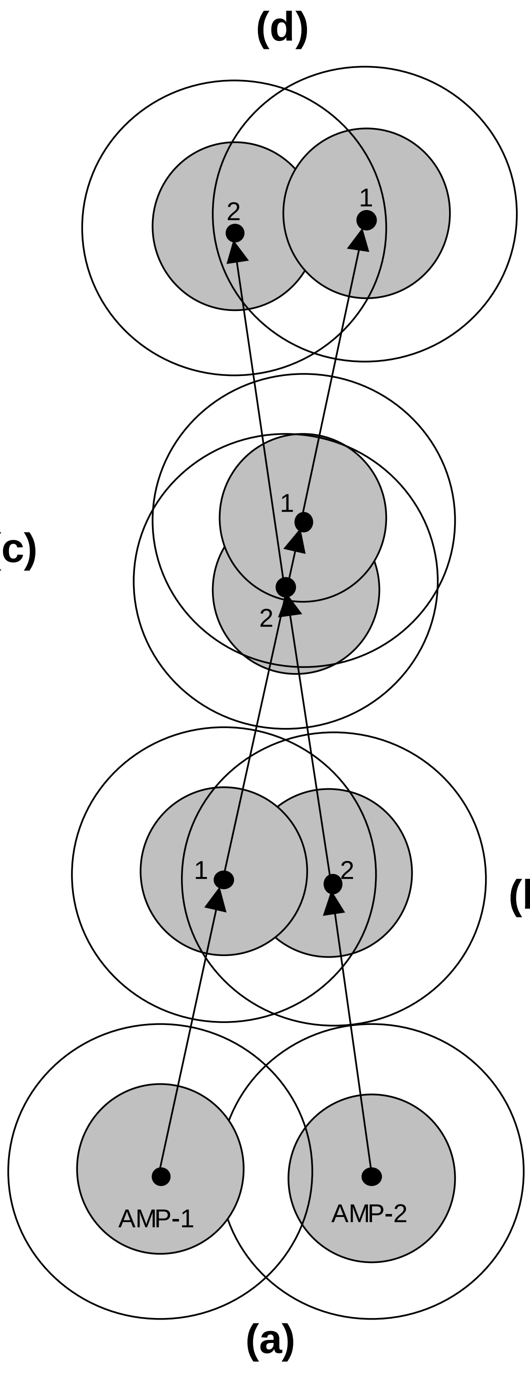

Figure 4. Phases of AMP-1 and AMP-2 conflict

If one of armed mobile platforms has been destroyed by firing action of another AMP, the coflict for it ends in fatal conseguences. This outcome is also possible for both armed mobile platforms (AMP-1 and AMP-2).

If weapon failure occurs, the armed mobile platform still takes part in the conflict, but without active combat engagement and with significantly diminshed prospects for survival.

If, due to further moving, armed mobile platforms exit their weapons' firing action zones, the conflict enters the next phase, which is presented in the part (d) of Fig.4. That is the last, post-conflict phase, when the firing action is suspended, but the armed mobile platforms are still in their sensors' detection zones. They observe each other until they exit the surveillance zones, in which case the conflict ends by survival of both armed mobile platforms.

The simulation model

Basic assumptions for developing the simulation model of two armed mobile platforms (AMP-1 and AMP-2) sudden conflict are the following:

a) AMP-1 and AMP-2 are moving by azimuths α_1 and α_2, and velocities V_1 i V_2. Until the sudden conflict, they are not aware of each other presence, and are pursuing mutually independent missions.

b) AMP-1 is in possession of S-1 a sensor, and AMP-2 is in possession of S-2 ansensor, which are intended for surveillance and fire directing. Sensors are defined by their maximum ranges, DS-1 i DS-2.

c) The AMP-1 platform is in a possesion of the OR-1 weapon, which can hit AMP-2 with probability $p_{\text{OR-1}}$, and AMP-2 is in a possesion of the OR-2 weapon, which can hit AMP-1 with probability $p_{\text{OR-2}}$. The hit probabilities $p_{\text{OR-2}}$ and $p_{\text{OR-2}}$ depend on the distance D between AMP-1 and AMP-2. The weapons are defined by their average action preparation times $T_{\text{OR-2}}$ and $T_{\text{OR-2}}$, maximal ranges DOR-1 and DOR-2, velocities of projectile flights to targets V_{L-1} and V_{L-2} and sizes of combat sets BK_1 and BK_2 associated with OR-1 and OR-2 weapons.

d) The conflict between AMP-1 and AMP-2 occurs when at least one of them detect the adversary by means of its sensor and if, due to further moving, their distance D decreases reaching the range limit of at least one of the weapons, OR-1 and/or OR-2. The conflict stops when one of the AMPs is destroyed by the adversary's fire or when, due to further moving, their distance D increases and puts them out of range limits of weapons and sensors.

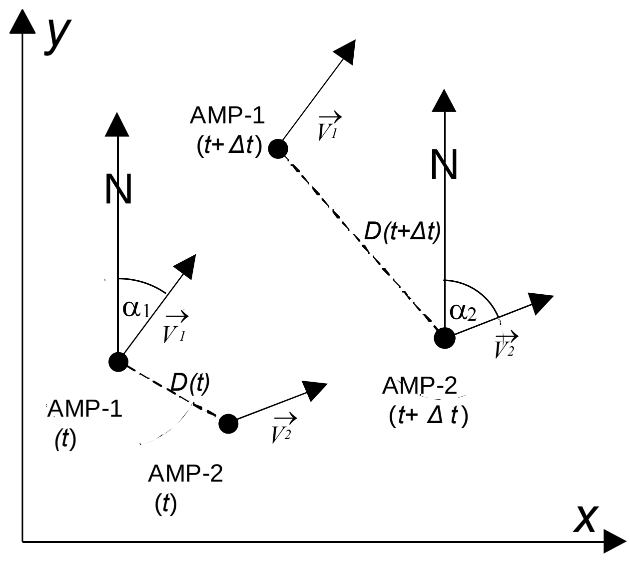

Figure 5. The simulation model: moving of AMP-1 nad AMP-2

In the simulation model, armed mobile platforms AMP-1 and AMP-2 are moving in two-dimensional space (Fig.5), which is represented by Cartesian coordinate system (x,y), in which the y axe is oriented towards North [3,4].

During th conflict, the azimuths (α_1 i α_2) of the AMP-1 and AMP-2 directions of moving, as well as their velocities, do not vary. This is assumed, because the armed mobile platforms sudden conflict is rather a random than a planned event, while the intention of every AMP is to continue pursuing its missio. On the other hand, the duration of the conflict itself and the weapon characteristicts nearly exclude the posibility of manoeuvring during the conflict. Current positions of the armed mobile platforms are presented by points AMP-1 (x_1,y_1) and AMP-2 (x_2,y_2), and the trajectories of their movements by equations of straight lines.

The simulation model of the AMP-1 and AMP-2 conflict is a discrete and dynamic one, oriented to events. Activities in the system are represented by pure time delays. Phases of the conflict begin and end depending on the distance between platforms D. The distance D depends on current coordinates of AMP-1 and AMP-2, and is varying in time. On the other hand, the duration of on activity in the system, in a time interval Δt, will result in, among other things, the change of distance between the platforms $D(t+\Delta t)$. Therefore, two types of transforms have been introduced in to the model:

- λ(t): time interval to space dimension transform and
- τ(d): space dimension to time interval transform.

The distance between the AMPs is $\lambda(\Delta t)$, and it is given by the expression:

$$D(t+\Delta t) = \sqrt{A\cdot(\Delta t)^2 + B\cdot\Delta t + C} \qquad (1)$$

where A, B and C are:

$$A = V_2^2 - V_1^2 - 2V_2V_1\cos(\alpha_2-\alpha_1) \qquad (2)$$

$$B = 2\{[x_2(t)-x_1(t)](V_2\sin\alpha_2 - V_1\sin\alpha_1) + [y_2(t)-y_1(t)](V_2\cos\alpha_2 - V_1\cos\alpha_1)\} \qquad (3)$$

$$C = [x_2(t)-x_1(t)]^2 + [y_2(t)-y_1(t)]^2 \qquad (4)$$

On the other hand, the transform of distance D to the corresponding time interval which elapses until the given distance D is reached is also necessary in the model. The time interval Δt is the function $\tau(D)$, and it represents a real positive solution of the following quadratic equation:

$$A\cdot(\Delta t)^2 + B\cdot\Delta t + C - D = 0 \qquad (5)$$

i.e.

$$\Delta t_{1,2} = \frac{-B \pm \sqrt{B^2 - 4A(C-D)}}{2A} \qquad (6)$$

If two real positive solutions exist, then the smaller of the two is chosen in the model, i.e. that time interval Δt after which the distance D between AMP-1 and AMP-2 will reach the given value for the first time. If the positive solution does not exist, it means that, under given conditions of current positions and further movings, AMP-1 and AMP-2 will never reach the given value of distance D between them, so no event will occur due to that distance.

The algorithmic description of the two AMPs in coflict simulation model consists of the following four modules:

- module for genereting coflicts of AMP-1 and AMP-2;
- module for simulation of AMP-1 activities;
- module for simulation between AMP-2 activities;
- module for terminating conflicts of AMP-1 and AMP-2.

The algorithm of the module for simulation of AMP-1 activities, which is structuraly identical to the corresponding module for AMP-2, has been depicted in the Fig.6. The mutual distance of the AMP-1 and AMP-2 platforms in the simulator has been defined by means of two programme variables: previous distance (D_p) and next distance (D_n). Any event in the system is determined in time related to the moment when the platforms' mutual distance becomes D_n, and the distance value D_n up to that momoment proceeds to be the variable D_p.

The armed mobile platform AMP-1 constantly checks wether its sensor's range (D_{S-1}) has become greater or equal to D_n. If it has, the coflict for AMP-1 begins. If not, the time interval Δt, necessary to elapse until the platforms AMP-1 and AMP-2 in further moving reach the positions such that their mutual distance is such that AMP-2 enter in the senor's S-1 range (D_{S-1}), i.e. AMP-1 detects the adversary is determined. The time interval Δt represents distance-to-time transform, $\Delta t=\tau(Dn - D_{S-1})$, which is calculated as the solution of a quadratic equation (5). If the real solution does not exist, it means that the positions, moving directions and velocities of the platforms AMP-1 and AMP-2 are such that the conflict between them will never occur, the simulation ends s (ISSUE-1). If the real solution exists, then the simulated time is advanced by Δt, appropriate changes in variables D_n and D_p are applied and the sudden conflict simulation continues.

When the distance between the platforms becomes equal or less than the sensor's range D_{S-1}, the conflict begins for AMP-1. The crew of AMP-1 needs time T_{OR-1} to prepare the OR-1 weapon for firing, which means that the next event in the AMP-1 system will occur when the simulated time increases by T_{OR-1}. The new distance between platforms, D_n, is distance-to-time transform, $D_n=\lambda(t + \Delta t)$, which is calculated as the solution of the quadratic equation (1). If the new distance is greater than the maximal AMP-1 and AMP-2 sensors' range, it means their positions, moving directions and velocities are such that they exit out of sensors' ranges, so the conflict ends by survival of both platforms (ISSUE-2). If it is not, the simulation of the conflict continues.

When the crew of AMP-1 has prepared the $OR-1$ weapon for firing, it is checked wether the distance between the platforms is less or equal to the weapon's range (D_{OR-1}). If it is not, the time interval Δt needed to elapse until the platforms, by further moving, reach the positions, such that APM-2 enters in the OR-1q weapon's range is determined. The time interval Δt is distance-to time transform $\Delta t=\tau(D_n - D_{OR-1})$, which is calculated as the solution of the quadratic equation (5). If the real solution does not exist, it means that the positions, moving directions and velocities of the platforms AMP-1 and AMP-2 are such that AMP-1 will do longer be in the situation to fire its weapon at AMP-2, so it is checked wether the distance between platforms has become such that the conflict ends by both platforms survival (ISSUE-2), or AMP-1 will take part in the further conlict only as the target of the OR-2 weapon's firing action. If the real solution exists, then the simulated time

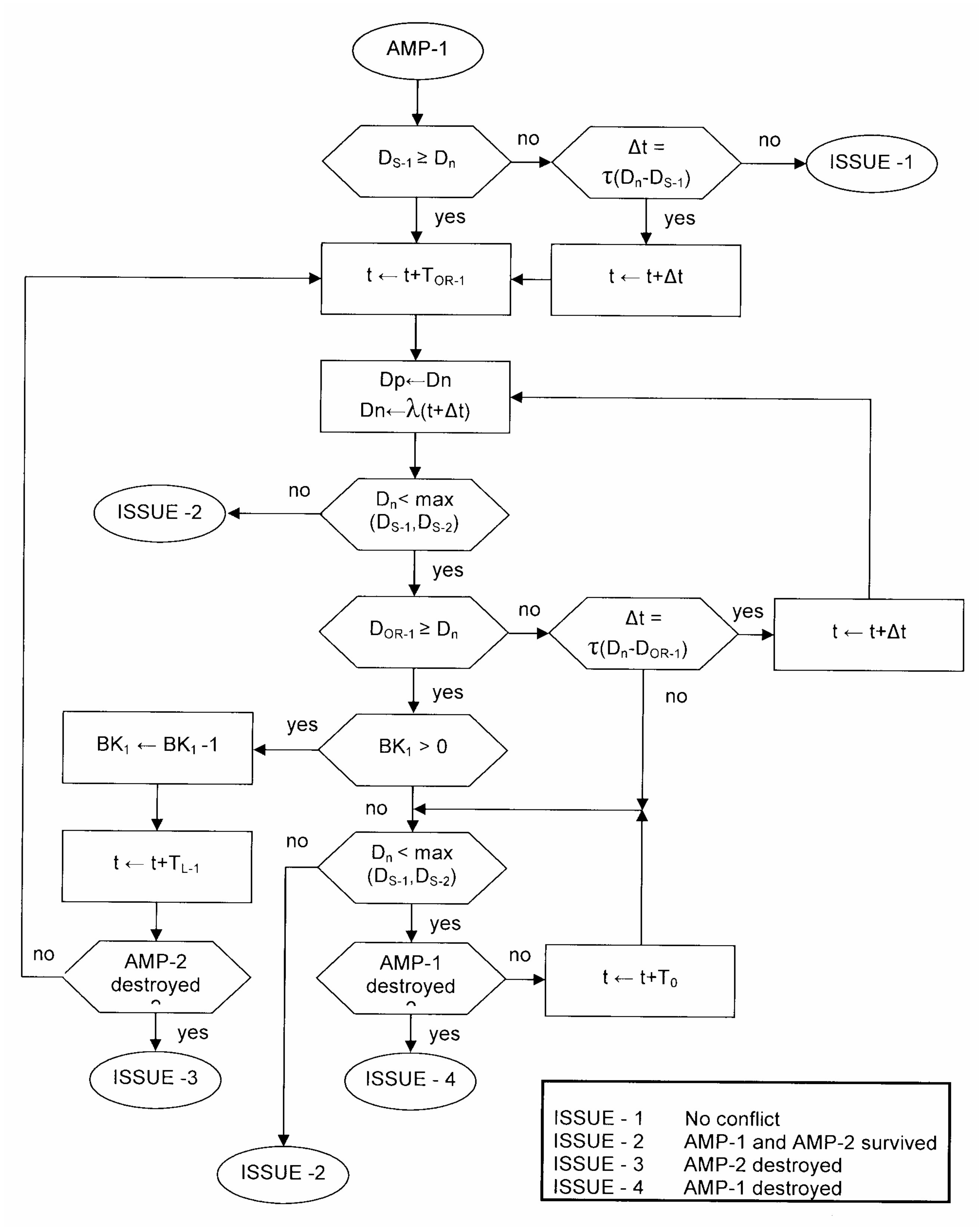

Figure 6. Algorithmic description of module for simuolation AMP-1 in coflic in voflict with AMP-1

advances for Δt, the appropriate changes are applied to D_n and D_p, and the sudden conflict simulation continues.

When the distance between the platforms becomes equal or less than the OR-1 wepon's range, the AMP-1 has an apportunity to open fire at AMP-2. This is possible, if the combat set of ammunition at the OR-1 weapon (BK-1) is not equal zero (the whole amount of ammunition has not been expended yet). In case it has, the AMP-1 platform is no longer capable of firing, so it is checked wether the distance has become such that the conflict ends by both platforms' survival (ISSUE-2), or AMP-1 will take part in the further conflict only as the OR-2 wepon's f target.

The OR-1 weapon firing is simulated, first by decreasing the combat set BK-1 by 1 (firing one projectile), and then by time delay T_{L-1}, time needed for the projectile fired from the OR-1 weapon to reach the target. When this happens, a random number is generated, the corresponding functions of distributions are sampled, other mechanisms, by means of which the possibility of AMP-2 destruction is simulated are activated, and it is checked whether this has occured. If AMP-2 has been destroyed, the simulated conflict ends (ISSUE-3). If AMP-2 has not been destroyed, the AMP-1 platform's crew needs time T_{OR-1} to prepare the OR-1 weapon for repeated action, and the the conflict simulation continues, as described.

Finaly, if AMP-1 is left without ammunition, or its position is such that the adversary is out of its weapon's range and the conflict continues, it is checked wheter it has been destroyed by means of the OR-2 weapon's fire. If this is the case, the conflict ends (ISSUE-4). If not, the conflict simulation continues, until t of some of these conditions are reached.

Basic mechanisms for two AMPs sudden conflict simulation

The AMP-1 and AMP-2 sonflict simulation model is a discrete and dynamic one, oriented to events. The armed mobile platforms AMP-1 and AMP-2 are presented by means of the GPSS transactions [9], which carry all relevant information in their parametres (current position coordinates, velocities, etc.). System activities are represented by pure time delays in the model.

The basic mechanisms [5] which are to be realized in such programme-simulators building are the following:

- λ(t): time-to-distance transform;
- τ(d): distance-to-time transform;
- VTD: fire action to adversary AMP
- mechanism for adversary AMP hit probability simulation;
- mechanism for adversary AMP graceful degradation simulation;
- reaction matrix;
- transaction communication with rerouting.

Now we will briefly review each of these mechanisms.

Time-to-distance transform

Duration of an activity in the system, in time interval Δt will, among other, thing, result in the changed distance $D(t+\Delta t)$ between platforms upon its completion. In order to determine that new distance, it is necessary to perform the transform of given time interval to the changed distance. In the case shown in Fig.5, the new mutual distance od platforms $D(t+\Delta t)$ in function of elapsed time interval Δt is given by the following expression:

$$D(t+\Delta t) = \sqrt{A\cdot(\Delta t)^2 + B\cdot\Delta t + C} \quad (1)$$

where A, B and C are:

$$A = V_2^2 + V_1^2 - 2V_2V_1\cos(\alpha_2 - \alpha_1) \quad (2)$$

$$B = 2\{[x_2(t) - x_1(t)](V_2\sin\alpha_2 - V_1\sin\alpha_1) + [y_2(t) - y_1(t)](V_2\cos\alpha_2 - V_1\cos\alpha_1)\} \quad (3)$$

$$C = [x_2(t) - x_1(t)]^2 + [y_2(t) - y_1(t)]^2 \quad (4)$$

Distance-to-time transform

In the figures 4 and 5, one can see that occurrence of the main events in the system, which designate beginning and termination of some phases of the conflict or samo other activities, depends on the mutual distance D between the platforms AMP-1 and AMP-2. That distance is determined by current coordinates of AMP-1 and AMP-2, and the changes dynamically in time. Therefore, the transform of given distance D in the appropriate time interval Δt, which elapses until the given distance is reached, i.e. until the condition for the corresponding event in the simulated system is met, is necessary in the model. The time interval Δt, in case of the model depicted in the Fig.5, represents the real positive solutionof the following quadratic equation:

$$A\cdot(\Delta t)^2 + B\cdot\Delta t + C - D = 0 \quad (5)$$

i.e.

$$\Delta t_{1,2} = \frac{-B \pm \sqrt{B^2 - 4A(C-D)}}{2A} \quad (6)$$

where A, B and C are also given by expressions (2), (3) and (4), respectively.

If two real positive solutions exist, then the smaller one is chosen in the model, i.e. that time interval Δt after which the distance D between AMP-1 and AMP-2 will reach the given value for the first time. If the positive solution does not exist, it means that the event considered, under given conditions, will never occur, which gives appropriate results in the simulation.

Fire action to adversary AMP

The flow diagram of the mechanism for simulation of the fire action of AMP-1 to adversary AMP-2 is shown in Fig.7.

Fire action to adversary AMP includes:

- preparation(decision making, determining of firing elements and weapon adjusting),
- weapon action (firing one of the projectiles of BK, projectile flight to adversary AMP),
- firing effect evaluation (hit and/or destruction),
- firing elements correction and
- repeated firing at the target.

Mechanism for simulatig the AMP-1 weapon's firing in Fig.7 is included in the flow diagram of the simulation model algorithm between points A and B.

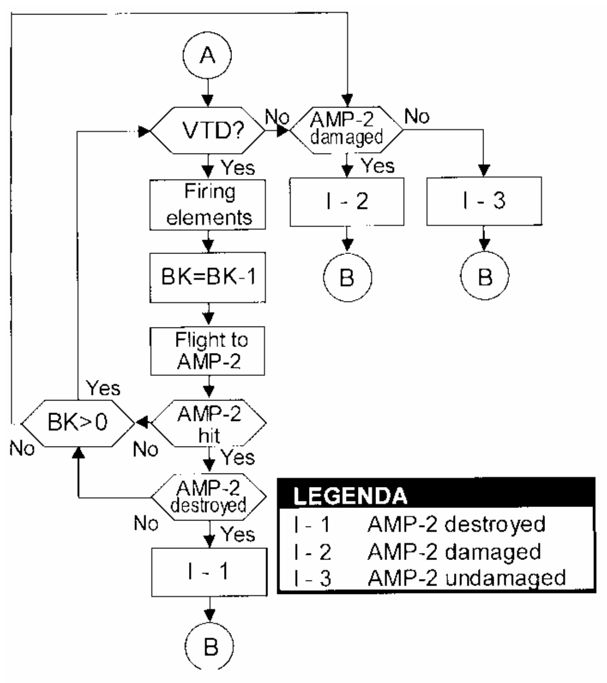

Figure7: Mechanism for simulating the fire action of AMP-1

Deciding weather to under take a firing action (block "VTD?") depends on many factors, specific to simulations of various AMPs conflicts (the main task of an AMP, whether it has already fired at the same target, whether the matching combination weapon-target exists, what the state of AMP resourcesis, etc.). If it has been decided to undertake a fire action determining elements for firing is simulated, and the a projectile, which resullts in combat set BK decreasing by 1. All of these activities, besides time delays, also request reviewing and updating the contens of the reaction matrix REM-1[2], which belongs to AMP-1 in the model.

The flight of projectile from the weapon to the adversary AMP is calculated from its velocity and the distance between AMP-1 and AMP-2 basis. In the model, it is represented by pure time delay.

When the projectile has reached the target, the distribution function of the hit probability is sampled, in order to determine wether the AMP-2 platform has been hit. If AMP-2 has not been hit, and there are still projectiles in the combat set (BK>0), the simulation programme returns to the block where it is decided weather to continue fire. If the whole combat set has been expended, the programme goes to the block in which it determines wether the AMP-2 platform has been damaged (issue "I-2") or undamaged (issue "I-3") in the conflict. If AMP-2 has been destroyed, the conflict ends by issue "I-1". If not, the effect (degree of damage) of the OR-1 weapon's projectile on AMP-2 is first entered in the REM-2 reaction matrix. Then, it is determined wether the whole combat set BK is expended, and the simulationm continues, as described.

Mechanism for adversary AMP hit probability simulation

The adversary AMP hit probability (p_p) by means of a sole projectile is among the most important functional mechanisms in the considered class of simulation models. General appearance of the family of curves p_p in function of distance *d*, for several exposed areas of target (*IP*), is depicted in Fig.8. Different additional factors afect p_p, depending on the type of main weapon and projectile, i.e. their technical and balistic characteristics, which is beyond the scope of this paper, due to particularities of various cases.

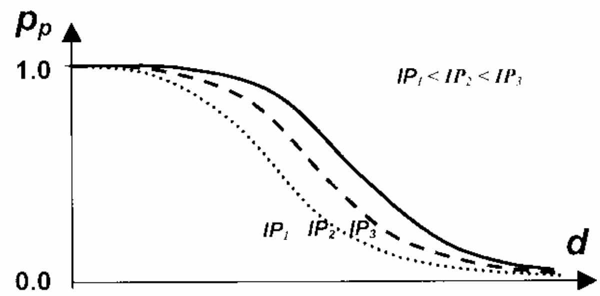

Figure 8: General appearance of thefamily of curves $p_p(d)$

The common place in every case is that the OR-1 weapon, at a distance *d*, has to hit the whole exposed area (*IP*) of the AMP-2 platform, which depends on its direction of moving and the position related to the AMP-1 platform (see Fig.9).

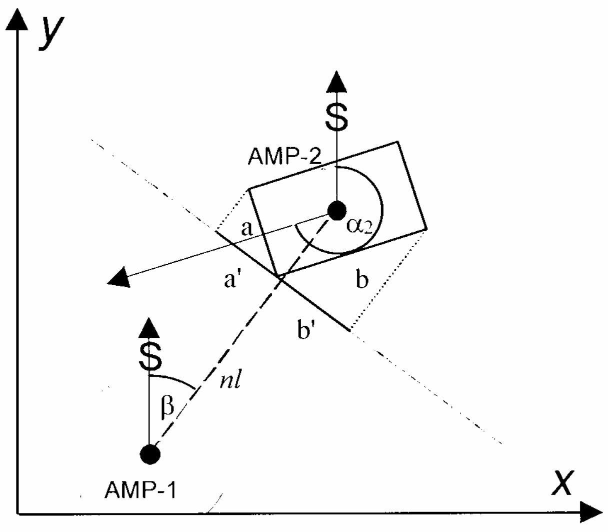

Figure 9: Exposed area of AMP-2

Let us suppose that the AMP-2 platform shape can be simplified and presented by means of a parallelpiped with dimensions *a* (width), *b* (length) and *c* (height). The total exposed area is the parallelepied projection to the plane perpendicular to the sighting line (*nl*) which connects the OR-1 weapon with the APM-2 platform. The minimun and the maximum AMP-2 platform's exposed areas are $IP_{min}=ac$ and $IP_{max}=c\sqrt{a^2+b^2}$.

In some arbitrary AMP-2 position and direction of moving, its total area exposed to the OR-1 weapon fire action is $IP= c(a'+b')$.

That the total area, exposed in some arbitrary position of the AMP-2 platform can be seen in the Fig.9, and it is defined by the expression:

$$IP=\frac{c}{\sqrt{1+tg^2\beta}}\left(a\frac{1+tg\alpha_2 tg\beta}{\sqrt{1+tg^2\alpha_2}}+b\frac{1-ctg\alpha_2 tg\beta}{\sqrt{1+ctg^2\alpha_2}}\right) \qquad (7)$$

where: a, b and c are dimensions of AMP-2, α_2 is the azimuth of the AMP-2 moving, β is the angl between the sighting line nl and the direction of North.

The mechanism is used so that IP is determind first, and ofter that the corresponding curve from the $p_p(IP,d)$ family, is chosen by means of IP; finally, the appropriate hit probability p_p is read from that curve for the given distance d.

Mechanism for the hit AMP graceful degradation simulation

Hitting the AMP-2 does not always mean its destruction. Reality is that in most cases, a hit causes only a certain degree of damageon the AMP-2 platform's The instantaneous destruction occurs if an extremely sensitive part of AMP-2 has been hit, or if, due to previous hits, it has been damaged to such degree, that the effect of the current hit is enough to permanently disable it for further combat actions. The destruction simulation mechanism ought to enable:

determination of instantaneous destruction by single hit probability, and

"memory" feature of the AMP-2 platform hitting (cumulative effect of destruction - gradual destruction due to several successive hits of the platform).

In the case Fig.9, at least one (entire: front, rear, or lateral), and two (decreased, contiguous: front or rear, and lateral) areas of the AMP-2 platform at the most can be exposed to the OR-1 fire. The areas affected will depend on the positions of the AMP-1, which is in possession of the OR-1 weapon, and that of the AMP-2 platform, which represents the target. The probability of AMP destruction, provided that some of its areas have been hit, is a complex problem, varying between AMPs. It also depends on some other factors (target-weapon combination, distance, parametres of movement, state of resources, and the like).

Every exposed area of AMP-2 has different value of a hit destruction probability. If AMP-2 is, for example, a tank - it will have, being a typical offensive armed mobile platform, the best protection, and by itself the least probability of instantaneous destruction (p_{u1}), in its front area, somewhat greater (and mutually different) probabilities p_{u2} and p_{u4} in lateral areas, and the greatest probability p_{u3} in the rear area. Thus, the total probability of instantaneous destruction of AMP-2 by one sole hit is defined by the expression:

$$p_u = \frac{c}{\sqrt{1+tg^2\beta}}\left(a\frac{1+tg\alpha_2 tg\beta}{\sqrt{1+tg^2\alpha_2}}p_{ui} + b\frac{1-ctg\alpha_2 tg\beta}{\sqrt{1+ctg^2\alpha_2}}p_{uj}\right) \quad (8)$$

where: p_{ui} and p_{uj} are the instantaneous destruction probabilities of AMP-2 by hit in its areas i and j, which are exposed to the OR-1 weapon fire action.

In order to explain the mechanism for gradual destructionof an armed mobile platform, due to multiple hits by projectiles fired from the adversary's weapon, let us use Fig.10, which depicts the relation between AMP-1, which is in possession of the OR-1 weapon, and AMP-2, which represents the target, just like in the Fig.9. Exception is that in the later case we consider only the angle gradual destruction between the sighting line nl and the moving direction of the AMP-2 platform. Again, the shape of the armed mobile platform (AMP-2) can be simplified and presented by means of a parallelpiped whith dimensions a (width), b (length) and c (hight). Fug,10 shows, that the total exposed area in some arbitrary position of AMP-2 is defined by the expression:

$$IP = c\left(a|\cos\beta_2| + b|\sin\beta_2|\right) \quad (9)$$

where: a, b and c are the AMP-2 platform dimensions, and β_2 - the angle between the direction of movement of AMP-2 and sighting line nl_1 of the AMP-1 platform's OR-1 weapon.

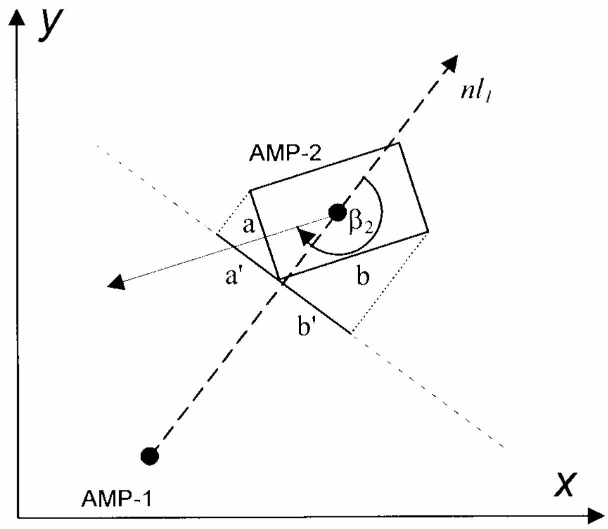

Figure 10. Exposed area of AMP-2

In the case of Fig.10, at least one (entire), and two (decreased) areas of AMP-2 at the most can be exposed to the OR-1 weapon's fire action. The areas affected will, depend on the position of AMP-1, the platform which is in possession of the OR-1 weapon, and the position and moving direction of the AMP-2 platform, which represents the target. Generally speating, when AMP-2 has been hit, the hit probability of its less (front or rear) area is given by the expression:

$$p_{1,3} = \frac{a|\cos\beta_2|}{a|\cos\beta_2| + b|\sin\beta_2|} \quad (10)$$

and the probability that one of its kateral areas has been hit, by the expression:

$$p_{2,4} = \frac{b|\sin\beta_2|}{a|\cos\beta_2| + b|\sin\beta_2|} \quad (11)$$

A random number is generated in the simulator and, according to probabilities given by expressions (4) i (5), as well as the position and moving of AMP-2 related to AMP-1, the area hit is determined.

The AMP destruction probability, provided that some of its areas have been hit, is a complex problem, specific to every AMP individual. The common place is that for every type of AMP, as well as every type of projectile that gits it, exists a finite, enumerable set if effectsof such hits (see Fig.11). They can have different influence on to the AMP gradual destruction:

- some of them are critical (hits in the vital parts), because they destroy the AMP instantaneously;
- others cause certain degree of destruction, the effect cumulates, and in combination with the effect of some other hits eventually causes the AMP's complete destruction;

– finally, some hits cause several different (combined) effects simultaneously.

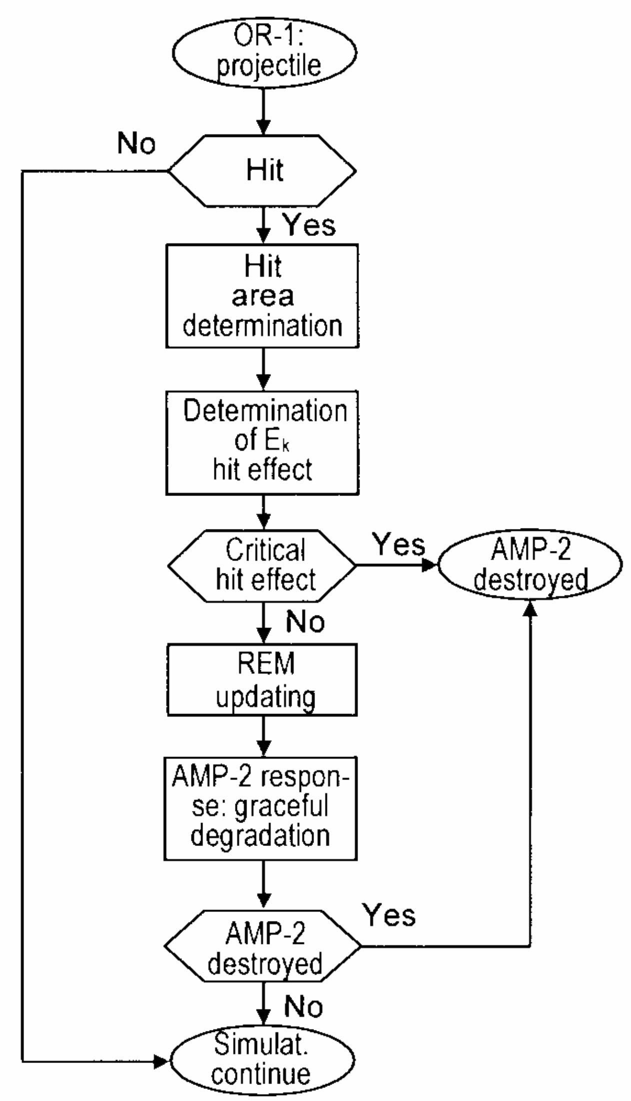

Figure 11. Gradual destruction of AMP-2

Possible effects of the successful hits in the of exposed AMP-2 platform areas have different value of probability. The total realisation probability of a hit in the AMP-2 platform effect (E_k) is determined by the expression:

$$p_{E_k} = \frac{a|\cos\beta_2|\,p_{ki} + b|\sin\beta_2|\,p_{kj}}{a|\cos\beta_2| + b|\sin\beta_2|} \qquad (12)$$

where: p_{ki} and p_{kj} are the *k-th* effect to AMP-2 by hit in its areas *i* and *j* which are exposed to the OR-1 weapon's action.

The memory feature of the AMP-2 platform damage by hits of the OR-1 weapon is realised in combination with the following mechanism - the reaction matrix REM-2 [2]. In the later, the record of every hit is registered during the simulation (for example, for all of the four areas of AMP-2 in Fig.10), along with the effect of each on the important subsystems and parts of AMP-2.

The cumulative feature is realised by gradual increase of individual and total probability of destruction, depending on the achieved hits to AMP-2 by means of the OR-1 weapon.

Reaction matrix

The reaction matrix (REM), described in greater detail in [2], with logical organization as shown in Fig.12, makes possible the introduction on the conflict simulation:

- Characteristics of threat/target which are important for the conflict simulation, reactions and combat activities of AMP.
- Characteristics and state of the essential subsistems of the AMP-1 and AMP-2 platfoms their parts and other resources.
- Expert rules of AMP command decision making, which are applied in order to determine the AMP platform reaction in the conflict situation.
- Combined hit effects of the adversary's weapon to the caharacteristics and state of essential subsistems, parts and other resources of the AMP.
- Response, i.e. gradual degradation of performances, till the eventual destruction of the AMP.

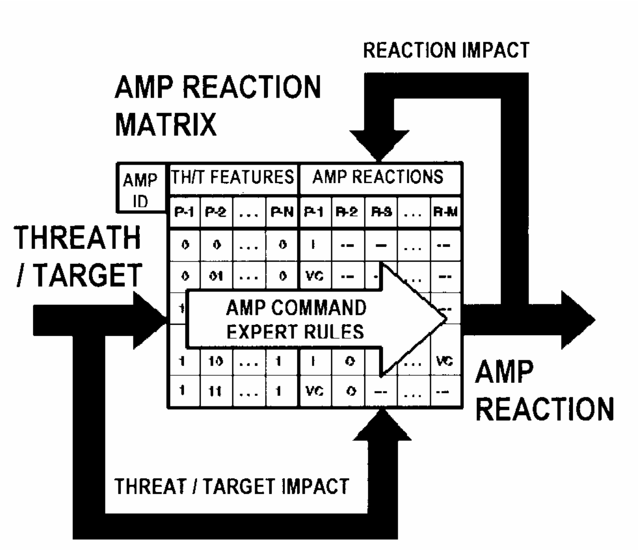

Figure 12. Reaction matrix (REM)

There is one corresponding reaction matrix per AMP in the conlict, REM-1 and REM-2.

The characteristics of threats and/or targets are the adversary AMP significance the destruction probabilities (of the adversary AMP, as well as of the own AMP by the adversary), and the like.

Possible reactions of the AMP-1 and AMP-2 to various phases in the conflict are the subset of all AMP's reactions, mapped to an azrranged set of the corresponding fields in the matrix $\{R_1, R_2, \ldots, R_K\}$. For example, AMP-1 reacts to the sole appearance of AMP-2 by activities which are registered in the corresponding reaction fileds in the REM-1 matrix.

The AMP's reactions to various caharacteristics of threats and/or targets, as well as the introduction of the expert rules for commanding the AMP, have been described in [2]. The AMP-2 platform response to the OR-1 weapon's hits, i.e. its gradual destruction, represents specific reaction of AMP-2, its subsystems and essential parts to projectiles hits fired from the adversary's weapon. This is reflected in degradation of the performances, i.e. updating the state of own resources and, on the other hand, changing the sensitiveness to successive hits. This phenomenon can be expressed by the following relation:

$$\{E_1, E_2, ..., E_K\} \xrightarrow[\text{soma essential part}]{\substack{\text{reache state of} \\ \text{AMP, subsystem, or}}} \{R_1, R_2, ..., R_L\} \quad (13)$$

where: M is the total number of possible effects of the hits to the AMP, N is the total number of possible AMP's reactions to hits and other events in the conflict system, where

$$\{E_1, E_2, ..., E_K\} \subseteq \{E_1, E_2, ..., E_M\} \quad (14)$$

and

$$\{R_1, R_2, ..., R_L\} \subseteq \{R_1, R_2, ..., R_N\}. \quad (15)$$

The full importance of the memory feature becomes obviouse with the cumulative effect of several successive hits. Disabling some of the AMP's resources which is redundant to a degree in some other resource (for e.g., AMP with two propelling engines, or two members of the crew, who can replace each other), is not critiacal for AMP, but rests in the memory of the simulator, by means of updating the REM. If, in case of some successive hit, the remaining resource is destroyed, that becomes a critical event which causes the AMP destruction.

Transaction communication with rerouting

The mechanism for transaction communication with re-routing (KTP) is necessary in the model, in order to simulate the impact of one AMP to the other.

For e.g., if weapon OR-1of AMP-1 has succeeded to hit AMP-2 and destroyed the OR-2 weapon, which was in that very moment in the phase of preparation for fire action, the AMP-2 platform will have to stop that activity, which has become unfeasible. The transaction representing AMP-2 will suspend its current activity, and will be directed to wards anew activity - AMP's reaction corresponding such development of the simulation conflict.

One of possible KTP implementations has been described in the paper [1]. This is in fact the use of separate entities, one per every activity which AMP can undertake in the simulator: manoeuvring, passing a section in the mission or fire action at the adversary (see Fig.13). When one of the AMPs in conflict wants to make an impacton the other, it preempts all these entities, rerouting the other transaction to the part of the program, where the forced activity is simulated. Beaving in mind that the other transaction can not seize more than one of these entities at a time, it will undertake just activity appropriate at that moment, while the preemption of other entities, representing the other activities in the model, will be of no consequence.

Application of the model: simulation of the weapon impact to the conflict of two armed mobile platforms

In this application of developed simulation model and programme-simulator, implemented by means of the GPSS World simulation language [9], the impact of the weapons' (OR-1 i OR-2) characteristics to two in conflict tanks has been researched.

The initial assumptions are given. Based on them the simulation model and the conflict of the two tanks has been defined: what are the conditions under which it begins, how is it developping and when does it stop. Then, the summary of the comparative features of the tanks, senzors and weapons, for whose impact the components of the conflict have been given follows. Finally, the rezults of the experiments executed have been analyzed. The goal of this simulation is to investigate the impact of the main weapons characteristics in a sudden conflict. Therefore, the experiments have been conducted, so that the conflict is provoked, that there is no pausing, and the conditions under which the conflict develops are the most difficult ones: the T-1 and T-2 tanks rush one towards other, by their maximum velocities, and expose to adversary weapons their minimal and best protected areas.

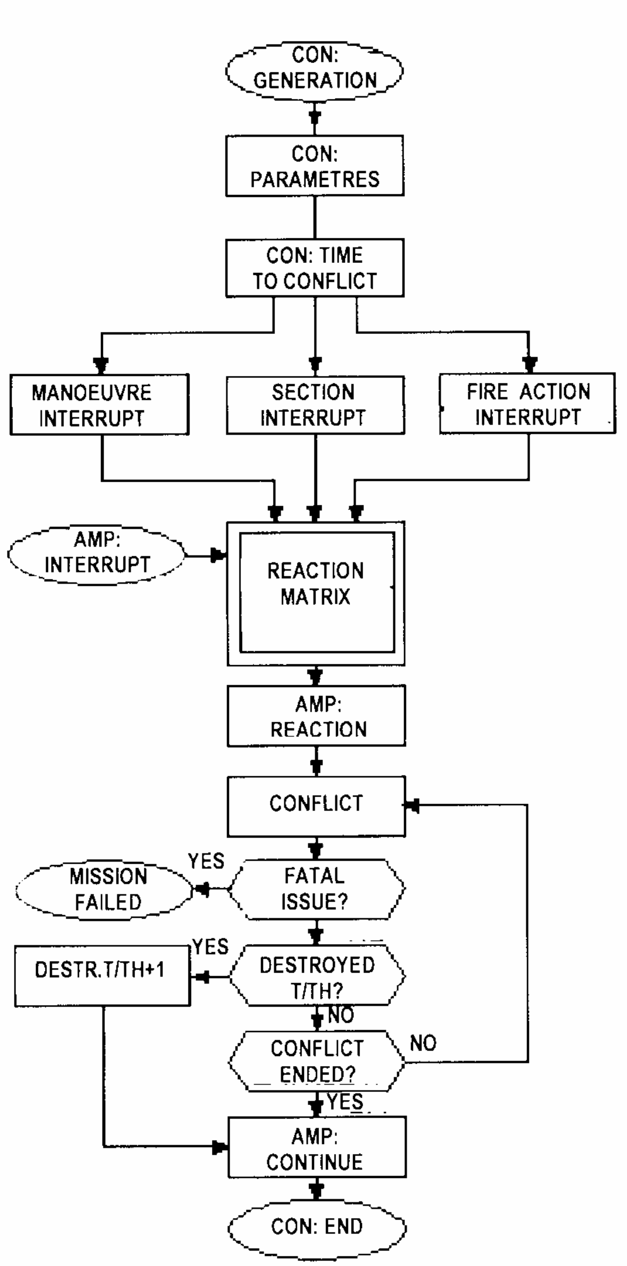

Figure 13. KTP application (transaction communication with rerouting)

The initial assumptions for the sudden conflict of the T-1 and T-2 tanks simulation model developping are the same as the general initial assumptions, defined in section 4, in which the simulation model of the two armed mobile platforms conflict has been discussed, with the following exceptions:

a) The T-1 and T-2 tanks are moving towards each other, under azimuths α_1 and $\alpha_2=\alpha_1+180^0$.
b) As sensors, the T-1 and T-2 tanks are in possession of observation-sighting sets (ON-1 and ON-2), which are intended for surveillance and fire directing. The observation-sighting sets are defined by their maximal ranges D_{ON-1} and D_{ON-2}.
c) Tanks are armed with main weapons OR-1 (anti-armour laser beam guided missile) and OR-2 (classical gun with armour-piercing disposing sabot shells), which can hit the adversary with probabilities p_{OR-1} and p_{OR-2}. The average weapon preparation times for action are T_{OR-1} and T_{OR-2}, ranges are D_{OR-1} and D_{OR-2}, flight to target velocities are V_{L-1} and V_{L-2} and the sizes of combat sets of ammunition with weapons are BK_1 and BK_2.
d) The sudden conflict between the T-1 and T-2 tanks begins when at least one of them detects the adversary by means of its observation-sighting set. Once it has begun, the coflict cannot be renounced, until its termination.
e) The conflict stops when one of the tanks hits the adversary, or when, due to complete consumption of combat sets BK_1 and BK_2 and the OR-1 and OR-2 lack of ammunition.

Table 1: Comparative characteristics of tanks T-1 and T-2

Characteristic	Tank T-1	Tank T-2
Maximal velocity V_i [km/h]	65	72
Azimuth α_i [^{0}]	0	180
Sensor range $D_{ON\text{-}i}$ [m]	5000	5000
Main weapon range D_{OR-i} [m]	5000	2000 or 3200
Probability of destruction p_{OR-i} [%]	80	70
Weapon preparation time $\boldsymbol{T_{OR-i}}$ [s]	10 ± 4	8 ± 2
Projectile flight velocity $\boldsymbol{V_{L-i}}$ [m/s]	300	1800
Combat set size BK_i	4	45

The simulation model of the T-1 and T-2 tanks conflict is a discrete and a dynamic one, and event oriented. The programme-simulator has been implemented by means of the GPSS World simulation language [9]. The tanks are represented by means of the GPSS transactions [9], which in their parametres carry all relevant information (current positions coordinates, velocities, and the like). Activities in the system are represented in the model by pure time delays. During the programme-simulator development, the following basic mechanisms have been applied:

- λ(t): given time-to-distance transform;
- τ(d): given distance-to-time transform;
- VTD: fire action to adversary tank;
- KTP: transaction communication with rerouting.
- In this application, the following performance measures have been considered:
- TIME OF CONFLICT DURATION T_{suk}, defined as time interval that elapses from the moment of the T-1 and T-2 mutual perception, till the moment when one of them succeeds to hit the other one with the projectile fired from its main weapon.
- TANK T-1 VICTORY PROBABILITY pT-1:

$$p_{T-1} = \frac{N_{T-1}}{N} \tag{16}$$

where: N_{T-1} is the number of simulated conflicts in which T-1 have hit T-2 first, and N is the total number of simulated conflicts (simulation passes) in the experiment.

- TANK T-2 VICTORY PROBABILITY p_{T-1}:

$$p_{T-2} = \frac{N_{T-2}}{N} \tag{17}$$

where: N_{T-2} is the number of simulated conflicts in which T-2 have hit T-1 first.

A total of 20 experiments has been executed, each consisting of N = 10000 simullated conflicts. The values have been changed in the following factors:

- Initial distance of the tanks, D0 ∈ {500, 1000, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000} [m];
- Range of the OR-2 weapon, DOR-2 ∈ {2000, 3200} [m].

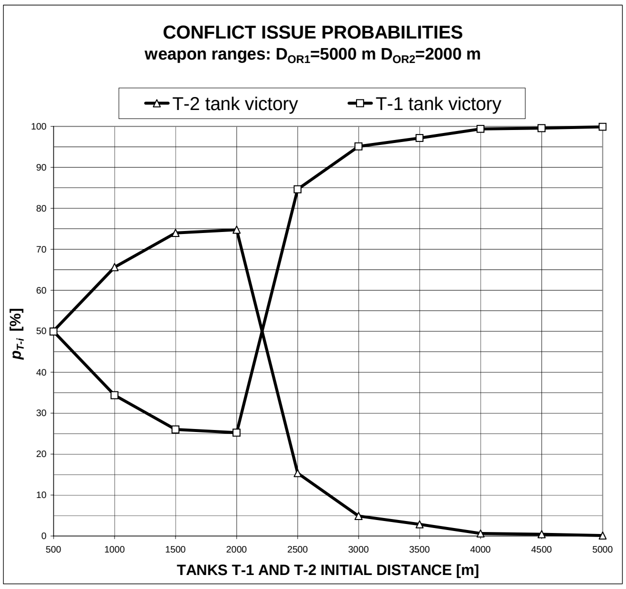

Figure 14. Mean time of conflict duration in function of tanks' initial mutual distance

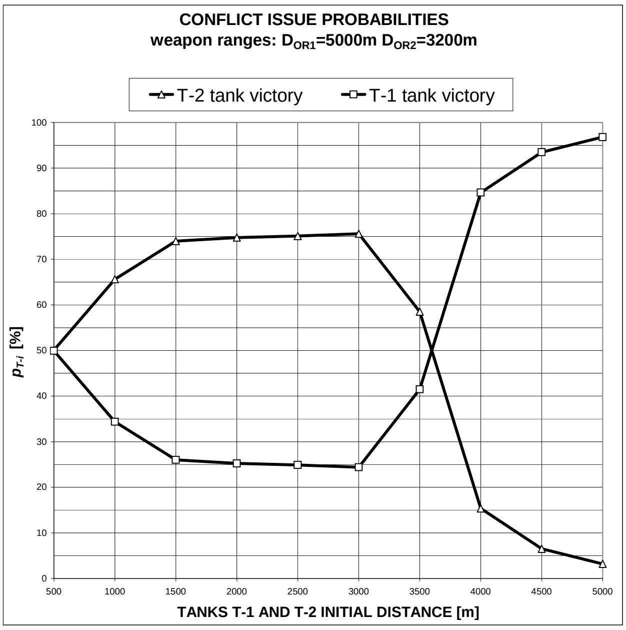

Figure 15. Actual state: maximal ranges D_{OR-1} = 5000 m and D_{OR-2} = 2000m

The experimental results are presented by means of diagrams in figures 14, 15 and 16. The first 10 experiments have been executed in order to determine the impact of the main weapons characteristics to the duration and issue of the sudden conflict in the given state, in which the T-1 tank is in possesion of the OR-2 weapon with maximal range of 2000 m. The goal of the other 10 experiments has been to determine the effects of the OR-2 weapon improvement, with its increased maximuml range up to D_{OR-2} = 3200 m. When D_{OR-2} = 2000 m, the average conflict duration time T_{suk}, the initial distance range up to 2000 m, it has a slow linear increase from od 10.542 s to 12.754 s (see Fig.14). In this range, the impact of fast armour-piercing disposing sabot shells from the OR-2 weapon is dominant. At greater initial distances, T_{suk} increases faster, due to prevailing impact of 6 times slower guided missiles launched from the OR-1, weapon, until it reaches the value of T_{suk} = 30.858 s at the maximal range of 5000 m.

If, by means of the OR-2 weapon improvement, its maximum range increased to D_{OR-2} = 3200 m, the situation would not change in the initial distance range from 500 to 2000 m, because the curves in the diagrams overlap, while this trend of T_{suk} increase will extend to 3000 m, due to the prevailing impact of the fast armour-piercing disposing sabot shells from the OR-2 weapon. At greater initial distances, slower missiles launched from the OR-1 weapon have increasingly greater impact, and at the maximum range of 5000 m, the conflict duration time is once again T_{suk} = 30.858 s.

Fig.15 shows that, in the existing state, at minimum initial distance of 500 m, the probabilities of victories of the T-1 and T-2 tanks are aproximatelly equal. From 500 m to 2000 m, the probability of the T-2 tank victory increases and reaches the value of 75%. The initial distances range from 2000 m to 2500 m is the zone of change, where the probabilities of tanks' victories at first becomes equal, and then the T-2 tank victory probability increases, to reach its maximum value of 99. 88 %.

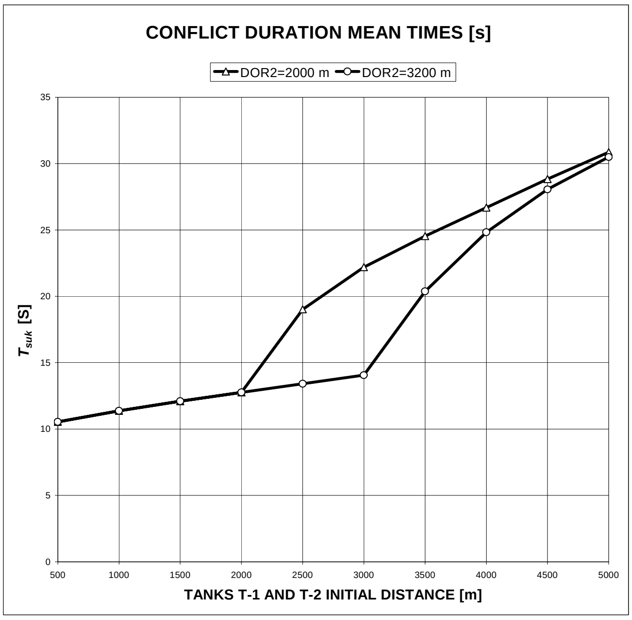

Figure 16. OR-2 weapon improvement: range extended to 3200 m

It the OR-2 weapon's maximum rangeis increased to D_{OR-2} = 3200 m, it is obvious (Fig.16) that the situation does not change at minimum initial distance of 500 m, and in the initial distance range from 500 m to 2000 m. However, the zone of aproximatelly constant T-2 tank victory probability of 75 % now extends in the initial distance range from 1500 m do 3000 m. The zone of change is from 3000 m to 4000 m, and then the T-1 tank victory probability increases, to reach its maximum value of 96. 81 %.

The results of the experiments executed indicate that the weapon have significant influcence characteristics in the sudden conflict of two tanks.

In the existing state, at distances up to 2000 m, the T-2 tank, armed with the OR-2 weapon (classical gun) which fires faste armour-piercing disposing sabot shells has an advantage. At distances from 2500 m to 5000 m, the T-1 tank, armed with the OR-1 weapon (anti-armour laser beam guided missile) has an adantage.

By means of the OR-2 weapon range increase to 3200 m, the performance of the T-2 tank at distances up to 3000 m can be improved. At distances from 4000 m to 5000 m, the T-1 tank, armed with the OR-1 weapo is in better position.

Conclusions

The following results of the research in the area of computer simulation of complex military systems in conflict have been presented in this paper:

- New armed mobile platform (AMP) concept has been introduced, as an abstraction suitable for the research and development of the class of complex military systems, which have the following common properties: autonomous propulsion, man crew, armament and significant need for logistic support.
- The basic scenario of two armed mobile platforms sudden conflict has been set up.
- The developed simulatiom model of moving armed mobile platforms in conflict has been presented of graphically along with the appropriate space-in-time and time-in-space transforms. These transforms make possible the implementation of the simulation model as a discrete dynamic system, in which all the activities are presented as pure time delays needed for completing them, and the main events in the system are designated by starting and ending instants of different conflict phases, based on the time-varying distance between platforms.
- The algorithmic description of an armed mobile platform activities in the sudden conflict simulation has been given.
- The following basic mechanisms have been developed during the research: space-to-time and time-to-space transforms, fire action to adversary AMP, simulations of the hit probability and graceful destruction of adversary AMP, the reaction matrix as a way of introducing expert rules in to the simulation model, and the transaction communication with rerouting. All of these mechanisms ensure the development of computer simulation models of this class of complex military systems in conflict and their implementations by means of the simulation programming language GPSS.
- As an example of the application, the most important results of the first experiments executed by means of the developed programme-simulator of two tanks sudden conflict has been given. The experiments have been conducted in order to determine the impact of the main weapon type (classic gun firing fast armour piercing rounds or the laser beam guided missile) to two tanks sudden conflict issue. The results obtained can be used in the phase of decision-makings about the modernisation of the existing tanks and the development of new tanks and equipment, for the Army purposes and/or export businesses.

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Računarska simulacija iznenadnog sukoba dve naoružane mobilne platforme

Prikazuju se neki od rezultata sopstvenih originalnih istraživanja u oblasti računarske simulacije složenih vojnih sistema. Definisan je iznenadni sukob dve naoružane mobilne platforme (NMP) i predstavljen simulacioni model. Opisani su osnovni mehanizmi razvijeni u cilju stvaranja programa simulatora ove klase složenih vojnih sistema: transformacija prostora u vreme i vremena u prostor, vatreno dejstvo, simulacije verovatnoće pogotka i postepenog uništenja protivničke NMP, reakciona matrica i komunikacija transakacija sa preusmeravnjem. kao primer primene modela, izvršena je računarska simulacija radi određivanja uticaja vrste glavnog oruđa (klasičan top sa brzim potkalibarnim probojnim projektilima i protivoklopna raketa vođenja po laserskom snopu) na ishod iznenadnog sukoba dva savremena tenka.

Ključne reči: **vojni sistem, računarska simulacija, naoružana mobilna platforma, sukob, osnovni mehanizmi, tenk, glavno oruđe.**

Моделирование на вычислительных машинах неожиданной конфликтной ситуации двух подготовленных подвижных платформ

Здесь показаны некоторые из результатов собственных оригинальных исследований в области моделирования на вычислительных машинах сложных военных систем. Определена неожиданная конфликтная ситуация двух подготовленных подвижных платформ (ППП) и представлена моделирующая модель. Здесь описаны базовые механизмы разработаны с целью формирования программы моделирующего устройства этого класса сложных военных систем: преобразование пространства во время и времени в пространство; стрельба; имитации вероятности попадания и постепенного разрушения неприятельской подготовленной подвижной платформы; реактивная матрица и коммуникация групповой операции со повторной маршрутизацией.В роли примера применения модели сделано моделирование на вычислительных машинах ради определение влияния категории главного оружия (классическая пушка со быстрыми подкалибровыми пробивными снарядами и противобронированная ракета управляемая по лазерному лучу) на завершение неожиданной конфликтной ситуации двух современных танков.

Ключевые слова: военная система, моделирование на вычислительных машинах, подготовленная подвижная платформа, конфликтная ситуация, базовый механизм, танк, главное оружие.