International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:8, No:12, 2014

Modelling of the Fire Pragmatism in the Area of Military Management and Its Experimental Verification

Ivana Mokrá

***Abstract*—**The article deals with modelling of the fire pragmatism in the area of military management and its experimental verification. Potential approaches are based on the synergy of mathematical and theoretical ideas, operational and tactical requirements and the military decision-making process. This issue has taken on importance in recent times, particularly with the increasing trend of digitized battlefield, the development of C4ISR systems and intention to streamline the command and control process at the lowest levels of command. From fundamental and philosophical point of view, these new approaches seek to significantly upgrade and enhance the decision-making process of the tactical commanders.

***Keywords*—**Military management, decision-making process, strike modeling, experimental evaluation, pragmatism, tactical strike modeling

I. Introduction

THE primary focus of the tactical activity modelling is usually to find a general evaluation method of input quantified conditions and characteristics according to set criteria, aimed at a final solution. The outcome of the model is usually considered to be a coefficient of pragmatism, probability or a risk degree of carrying out a given activity under given conditions which enter the model as variables. An appropriate model composition leads to a mathematical interpretation of approximated real life conditions for their pragmatic response in a virtual environment. A core of such a model can be usually interpreted in terms of a function of more variables in a limited defining field. The overall form of a mathematical model can acquire (and it usually does so) an algorithmic character, which depicts its essence better (chains of conditions).[1]

The pragmatism model is one of the key model components of the optimal strike, being based, in general, on multi-criterial evaluation of optimal conditions for opening and conducting fire on the enemy. Universal approach to a model solution of locating one or more fire positions has not been found so far, and it can be assumed that it can be carried out by more ways.

In this respect, there was defined a task of optimal location of a fire position in space defined by a commander (operator), so that meeting the following initially set up conditions is ensured:

- Maximal visibility coverage of the target area of maneuver of the enemy tactical entity
- Minimal distance from the area covered in vegetation – camouflage (optimally forest edges)
- Optimal distance from the enemy tactical entity in relation with counterfire execution

II. Constructing the Fire Pragmatism Model

Analogically, as it is mentioned in the previous part, it is possible, in solely theoretical terms, to perceive the fire pragmatism model as a mathematical interpretation of a pragmatic coefficient in relation with the input conditions present at the moment of opening fire. The pragmatic coefficient stands for a degree of significance or meaning of a certain (given) activity under the stated conditions. Then, in case of the fire model, the pragmatic coefficient interprets a virtual "price", which a shooter, when opening fire on the enemy target under given conditions, probably "receive" or "pay" in terms of a hit or potential injury. The pragmatism coefficient can generally occur at an interval of $(-\infty, \infty)$ but usually it acquires value at $\langle 0, 1\rangle$interval [1].

The model usually adopts quantified inputs of technical, meteorological, geographical, tactical and other character, for instance, distance, weather, terrain relief, range of fire and so on. The individual inputs usually variously affect the final size of the pragmatic coefficient.

One of the possible approaches to constructing the initial fire model, which was also selected by the author when processing the presented study, can be demonstrated by means of the following points:

- First, the foundation is in processing a one-dimensional fire model, and next other inputs (variables) are gradually added.
- It is necessary to consider the role of individual effects of an environment – key inputs which significantly influence the final calculation of the pragmatic coefficient and their level of approximation.
- The model construction shall respect the scientific approach, which means correlation of theoretical requirements with the real life state (the model respects the foundation from the statistical analysis of tactical experiments carried out in terms of verification). Carrying out this type of experiments is, in practice, demanding and costly in many respects, which is one of the main barriers of enhancement in this area.
- Although the way of constructing the model should be based on maximal correlation with real life conditions, it is currently impossible to avoid a certain approximation

Ivana Mokrá is with the University of Defence, Faculty of military leadership, Kounicova 65, 662 10 Czech Republic (e-mail: ivana.mokra@unob.cz).

[1]A solution to a given problem might have a whole range of applications and may serve as a foundation for solving different operational tactical tasks. In its consequences this refers to a multi-criterial problem, combining a range of factors of a geographical tactical character.

degree of the addressed model, because the character of the final calculation in the model is exact, and the random effects and influences, which are typical for operational environment, cannot be easily expressed.

Within the construction process of the fire model, which is composed in other models of tactical activities, it is necessary to proceed deductively, and initially it is appropriate to work on the minimum of the key parameters, for instance, from the functions derived from:

- probability of hitting (silencing) the enemy in terms of execution of fire
- probability of threat to one's own tactical entity posed by the enemy in relation with strike/fire execution.

The given functions of probability have to be consequently transformed into unified dimension, so that their unification becomes possible, that implies the pragmatism function of individual activities [1].

The exact course of given functions is not, from the perspective of the overall system concept of a complex solution, as much significant as, for example, for the use in realizing practical applications. The area of practical use of these models is in its beginnings for the time being, and in order to achieve it, many experiments have to be carried out. To demonstrate the approach to the initial fire model solution it is therefore possible to provisionally set up an algebraic expression of given functions by means of deduction and intuition.

The final course of given functions ought to be consequently adjusted in relation to a tactical entity type and other conditions (being trained, range of fire, type of weapon, level of protection, camouflage, capabilities to pass through terrain, maneuver and so on), but mainly according to the result of detailed statistical and regression analyses of the results of tactical experiments, which are not available at present [1].

The course of given functions, including their transformation into the unified pragmatism dimensionis demonstrated by (1) and (2) and Fig. 1.

$$F_1(x) = \frac{0{,}9}{\frac{x}{60}+1}; \quad (1)$$

$$F_2(x) = 0{,}9 - \frac{1}{\frac{x+15}{100}+1}; \quad (2)$$

These functions converted into the unified pragmatism dimension can be consequently unified by significance, either according to (3) or (4):

$$P(x) = \prod_{n=1}^{m} v_n F_n(x); \quad (3)$$

$$\text{or } P(x) = \sum_{n=1}^{m} v_n F_n(x); \quad (4)$$

hich means that after substitution according to (3) is ($v_1=2$, $v_2=3$):

$$P(x) = 6\left(0{,}9 - \frac{1}{\frac{x+15}{100}+1}\right)\left(\frac{0{,}9}{\frac{x}{60}+1}\right) \quad (5)$$

as it is demonstrated in Fig. 1.

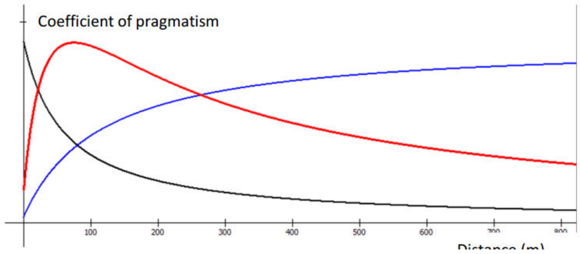

Fig. 1 Course of pragmatism strike model[2] [4]

The fire pragmatism model is, in its essence, a method of a multi-criterial integration of input effects under variance of conditions. Generally, any number of variables can enter the model, increasing, however, the so-called dimension of a model together with its complexity (complicatedness). Models that acquire higher dimensions than three cannot be easily visualized, and for the purposes of their visualization they must be transformed or represented only in their sectional views.

A variant proposal of an intuitively constructed fire model in terms of a function of three variables *f(x, y, w),* is illustrated in Fig. 2. This model is based on the relation (10), which aggregates the mentioned approaches, and processes three quantified input factors as follows:

- x - a distance to a target $(10-500)$
- y - a difference in altitude between the enemy tactical entity and the entity of one's own side (-150, 150)
- w - a distance from the nearest vegetation (0,50)

$$f(x,y,w) = \frac{0{,}51(5-w/10)}{2}\frac{(y+200)}{e^{\left(\frac{x-0{,}31y+40(5-w/10)}{90}-3\right)^2}+1} + \frac{(5-w/10)y}{100} \quad (6)$$

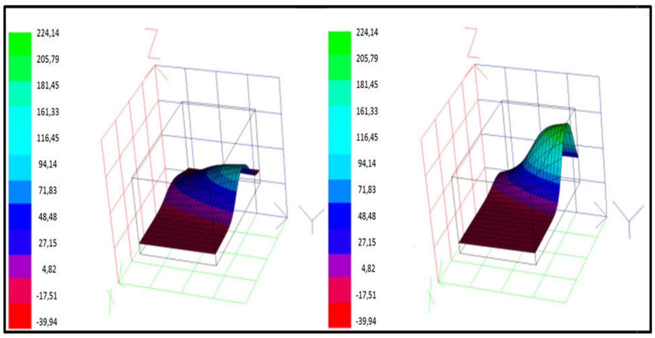

Fig. 2 3D sections of 4D model according to (6), parameter w is acquiring values 20,5 and 0 m

Fig. 2 illustrates a mathematical fire pragmatism model with consideration of 3 selected parameters. Axis x represents the distance to a target in a model span of 10-500 meters, axis y represents a target elevation (altitude differences between the entity of one's own side and the enemy), and axis z indicates the distance from the nearest vegetation. This input

[2]Where pragmatism strike model reflects - red, composed of a pragmatism function, related to probability of a target hit–black, and pragmatism function, related to probability of threat to one's own tactical entity – blue.

parameter considers the information whether the target is elevated or decreased towards the tactical entity of one's own side.

III. Experimental Verification

For the purpose of verification of the theoretical approaches and the abovementioned semi-processed solution it is necessary to carry out a set of experiments, whose aim is, in an iteration cycle, to either support or disprove the theoretical model. The tactical experiments need to be carried out not only in order to verify the course of the mathematical model, but also in order to ensure its parameters to be set up properly, since they affect the final pragmatic coefficient.

In case the model is not verified by an experiment, it is necessary to seek the reason that causes its failure, and try to find a solution. It seems most likely that for a majority of tactical activities mathematical models can be theoretically constructed. However, in many cases this involves a rather complicated problem, whose solution, being contemporarily in its beginnings, demands many years of research and experiments. Therefore also in case of the fire model there is an initial intention to carry out a time-manageable experimental phase, whose aim is to verify the basic part of the fire model, in particular the two-dimensional pragmatic level of the attack by the entity of one's own side versus the enemy counter reaction. In the following part, the fundamental characteristics of a classical experiment, carried out for the purposes of the presented study, are outlined.

Experimental research within this study is carried out in the form of a classical experiment, specified by a causal relation of a dependent and independent variable. As the dependent variable a combination of fire by the entity of one's own side versus the enemy counter reaction (fire by the enemy tactical entity). The independent variable is represented by the distance to a target.

A. The Process of Carrying out a Classical Experiment

The classical experiment carried out here can be described by means of the following attributes.

Research sample selection (candidates selection) – while carrying out the selection of the appropriate research sample, it is necessary, according to **Error! Reference source not found.**, to consider three basic aspects – what candidates to select (research sample specification), how to select the research sample (selection technique) and the size of the research sample (the number of candidates necessary for the experiment to be carried out).

1. **Research sample specification** –the students of the University of Defence (members of a tactical team Commandos) were selected. This selection was determined by their characteristics (professional soldier, tactical knowledge, weapons handling etc.) and their willingness to carry out the experiment. The selection of the candidates was also determined by their sufficient trained level. The research sample formed an experimental group[3].
2. Technique of research sample selection – in order to select the research sample (experimental group) a technique of deliberate (purposive) selection[4] was chosen, representing one of the kinds of non-probability sampling [1].
3. Research sample size – 6 students participated in the experiment. In this respect, the author is aware of the fact that this involves an initial stage of a long-term research. The findings of the research shall provide primary conclusions, which should be verified on a larger (representative) sample in the future.

B. Scenario Proposal

The experiment scenario is based on the conditions and possibilities of the author, regarding the practicability of a given activity, and also the requirements for the information type that is to be identified or measured in terms of the experiment. The core of the experiment was a cyclical execution and evaluation of one's own tactical entity's fire activity on the maneuvering enemy tactical entity and its counterfire reaction. To ensure the experiment, stationary and moving target systems were assembled, on which fire was conducted so that the soldiers were not excessively exposed to direct fire, and probability of injury was decreased. In order to meet safety measures and due to disposition possibilities, airsoft firearms were chosen for the purpose of fire, being able to hit targets of a size of $0.25m^2$ with a distance up to 100m.

The experiment took place in the following phases:

1. First, the target system was assembled and target distance markers arranged, the target system was geodetically localized.
2. Then, instructions were issued for the experimental sample (group) regarding the target maneuver of reactions to signals.
3. After that, the experimental group took its position – four targets and one moving target (consisting of two students).
4. The execution of maneuver of the moving enemy tactical entity (moving target) and fire conducting by the entities of one's own side (stationary targets). After execution of fire by a random stationary target, fire was evaluated (hit or missed), and the moving target stopped and executed reciprocal fire on a given stationary target, which was again evaluated. At the moment of opening fire by the stationary target (entity of one's own side) the position of the moving target was recorded for an exact distance calculation of individual entities.

[3]An experimental group represents a group that is exposed to an experimental variable. In some cases, also a control group is formed in terms of experimental research, providing that it is meaningful and logical in terms of the course of the experiment. Based on the character of the experiment carried out here no control group was necessary.

[4]In terms of deliberate selection a researcher concludes that a given candidate is suitable, based on achieving the established criteria as well as willingness of a candidate to participate in the research [2].

5. The track of the moving target was approx 70m long, in the course of covering the track distance, multiple fire was conducted on the moving target by randomly chosen stationary targets, and after having covered the track, the individual targets at all positions were relieved/changed in order to ensure the representativeness of the testing sample.
6. Audiovisual recording was used for the experiment. The moving target's track was covered 21 times in total, and fire by one's own or the enemy tactical entity was executed 564 times.

C. Specification of Limiting and Intervening Experimental Conditions

Limiting Conditions[5]

In the course of the experiment the conditions and environment were set up, reflecting the disposition possibilities for carrying out the given experiment, and diverging from the conditions prevailing in operational environment. Nevertheless, for the purpose of verifying the approach to mathematical models of tactical activities the conditions of the initial experiment should not disturb the goal in this perspective. The limiting conditions and factors were as follows:

- In order to meet safety measures, the soldiers were equipped only with airsoft firearms, which differ in parameters from the firearms used in combat operations.
- The experiment was bound to a level of shooting practice of the students of the University of Defence, who are members of the interest group Commandos.
- Due to limited time schedule of the University of Defence students, logistic, climatic and other conditions, the experiment could be carried out only once with more than five hundred fire attempts.

Intervening Conditions[6]

The author is also aware of a great number of intervening conditions, influencing the experiment carried out here, which are beyond the scope of this study to be addressed substantially. Among the significant ones, let us mention the following.

- Shooting capability of the experimental group (experimental sample) showed, in terms of its defined (evaluated) zone, slight divergences, including one extreme, but this intervening condition was of little significance in the research carried out here.
- Personal characteristics of an individual – intrinsic motivation. Although the participants had equal input conditions, it can be estimated that the intervening condition was fixed to a certain degree, but on the other hand, the intrinsic motivation is affected also by student's personality, which the author could neither fix nor restrict.
- Climatic conditions – this represents an intervening condition that could not be fixed or restricted by the author.

D. Data Collection Method

Creating the Checklist

In order to achieve the classical experiment's goal it was necessary to collect values of several variables. The attention was focused on a distance in meters between the entities (targets), a number of hits on the stationary targets (targets) and also a number of hits on the moving target (entity). Hitting a target was audible. The data was recorded by means of the checklist, comprising four columns:

- The first column distance in meters represents an independent variable, which in a closed interval acquires values 0-50 (measured every 2 meters).
- The second column, called stationary target, also represents a nominal variable, providing the information on a given static target's fire. This variable acquires, with a particular stationary target, values 1, 2, 3 or 4. In order to carry out the experiment, four targets were used, arranged as shown in Fig. 4.
- The third column, called Hit yes/no, presents a binary variable, acquiring values hit/missed (indicated in a table as Yes/No).
- The last column, recording the moving target's fire, is called Element in motion. It also presents a binary variable, acquiring values hit/missed (indicated in a table as Yes/No).

The Course of Data Collecting (Experiment)

With respect to relevancy of the acquired data, the size of the research sample of the presented experiment was determined by 21 measurements. First of all, the four stationary targets' positions were determined (the target system was assembled), provided that one target = one participant (student) at all times. Their positions were properly geodetically localized. Next, the target distance markers were arranged every two meters.

Prior to the experiment itself, the experimental group was thoroughly informed about the experiment's goal and its course, so that the experimental group was familiar with specific tasks of every individual member (on a selected position), and specify the partial participation.

The experimental group (participants) took the determined position. The allocation of the students to the positions was random[7] with subsequent rotation for every individual measurement. The abovementioned is related with ensuring the representativeness of the tested sample and with increasing transparency of the results in terms of elimination of possible

[5]In their nature, they limit the result applicability of the experimental research, in other words, determining to which conditions the results of the experimental research can be generalized.

[6]It is necessary to understand the approximation level of the math modeling, because lot of factors and variables, that the researcher does not consider or include in the modeling, may have an impact on studied behavior, which affects the dependent variable.

[7]Random allocation helps a researcher to give participants of the research sample an equal chance to be placed on any of the selected positions in terms of the experimental research, which helps to increase objectivity of the course of the experiment.

extremes (such as a very good shooter, adjusted firearm and so on).

In addition to the stationary targets, representing the entity of one's own side, one moving target was chosen into the area of operation, determined by two students (one with a firearm, the other with a shield – ensuring safety for the students), representing the enemy tactical entity.

The position determination of the stationary targets (target system), their geodetic localization and arranging the distance target markers are illustrated in Fig. 3. The course of the experiment is shown in Fig. 4.

Fig. 3 (Course of experiment)

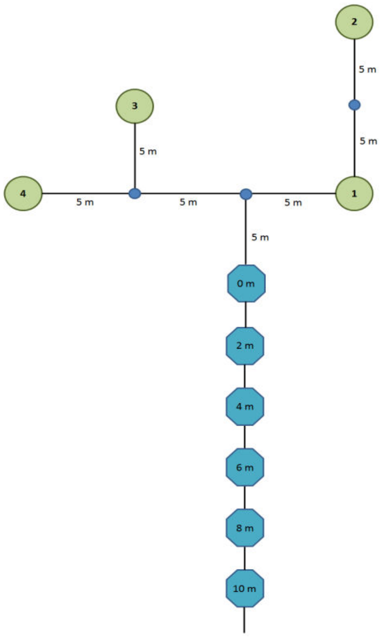

Fig. 4 (Target situation in experiment space) Source: own design

E. Experiment Evaluation

With respect to the goal of the experiment, the measured data had to be evaluated first. The collected data was evaluated in two ways. In one case only the relevant combinations of a dependent variable, more precisely 1:0 combination, were separated and then evaluated. Combination 1:0 represents the desired state, when the enemy was hit by the entity of one's own side, but reciprocally fire was not successful, which means that the enemy tactical entity did not hit the entity of one's own side in the counterfire. This extracted data was recorded graphically and interspersed with polynomial regression of a second order. The resulting regressive curve presents a frequency of the desired relevant combination of the uniparametric (one-dimensional) fire model. The abovementioned is illustrated in Fig. 5.

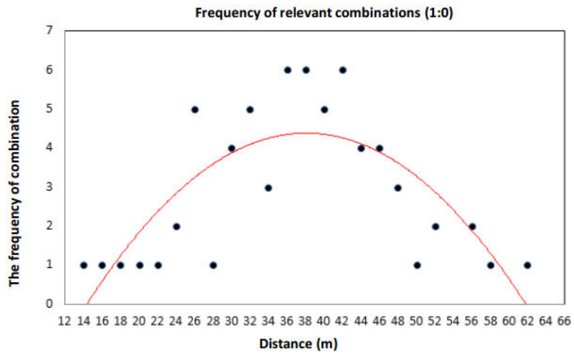

Fig. 5 (Frequency of relevant combination of dependent variable)

Fig. 5 determines the causal relation of a dependent variable (relevant combinations of the entity of one's own side's fire versus the enemy tactical entity) and an independent variable (distance in meters). Individual points in the graph indicate the frequency of the researched variable. The red curve represents a general model of the relevant combination's resulting frequency. The abovementioned illustrates a local extreme (maximum) in the distance about 38 meters from the enemy.

To verify the results the control evaluation by means of success rates of individual tactical entities was applied, when the measured data was recalculated according to (7) indicated into the graph, illustrating individual success rate – See Fig. 6.

$$P_u = \frac{U}{N}; \qquad (7)$$

where: Pu, success rate of a given tactical entity; U, is a number of successful attempts in a given distance, in a given case of hits by the opposite tactical entity; N is a number of all attempts in a given distance.

Fig. 6 clearly shows that the success rate of tactical entities starts diverging from the 34^{th} meter of the distance and a faster decrease is obvious in the success rate trend of the enemy tactical entity. Intuitively, it can be assumed that both trends will have decreasing tendencies, as this evidently happens.

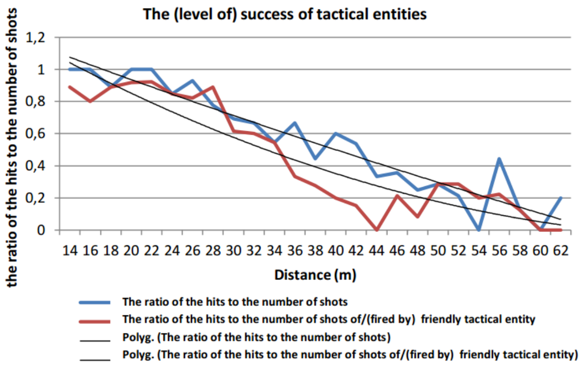

Fig. 6 Fire success rates by individual tactical entities

However, the key aspect dwells in the trend course of the individual success rates based on the polynomial regression of a second order. The success rate of the entity of one's own side under a given distance interval indicates a linear decrease in a success rate trend, while the decreasing trend of the enemy tactical entity indicates a parabolic, i.e. faster decrease in the success rate of fire

Because of the difference in success rates of fire attempts by the individual entities, it is possible to use the courses of the individual trends to construct the fire pragmatism model of one's own entity, which will probably acquire neither square nor linear character. But it will consist of a certain local extreme to which the optimal distance for fire conduct shall be related.

There are more possible approaches to the construction of the fire pragmatism model of one's own tactical entity. One of them can be the recalculation of the measurement results according to (8), which attempts, in its fundamental principle, to eliminate the influence of mutual hits of both entities and prefer distances where the entity of one's own side was capable to hit while the enemy was not. (Fig. 7)

$$P_V = \frac{U_V - U_E}{N}; \tag{8}$$

where: PV, Fire pragmatism rate of one's own tactical entity; U, Number of successful attempts in a given distance, in a given case of hits by the opposite tactical entity; N is Number of all attempts in a given distance.

IV. Comparison of the Experiment's Results with the Initial Model

Experimental model verification in the area of tactical activities and activities is demanding in many respects (time, effort, finance, volume of concerned personnel etc.) and represents an iterative and long-term process. The control experiment of the fire pragmatism model's partial components could not be carried out within the research.

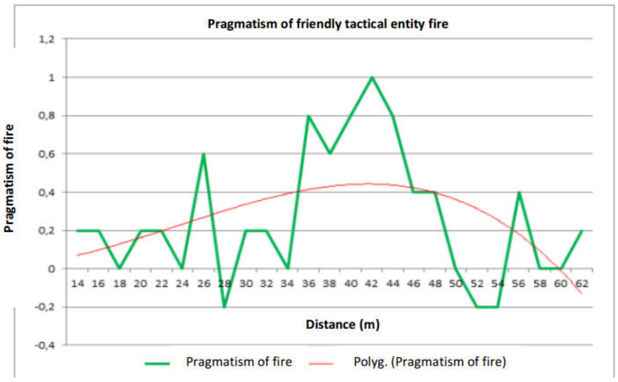

Fig. 7 Fire pragmatism

When considering the execution options, it was decided to carry out only the experiment verifying the course of the uniparametric model of fire, where the limiting conditions did not allow for verifying or repairing its original characteristics, which were related to other properties (precision, range of fire etc.) of supposed weapon types. Therefor it is necessary to consider this experiment type to be an approach demonstration and demonstration of opportunities for future experimental activities carried out in this respect, for instance, in terms of practical occupations.

Despite the limited conditions, accompanying the experiment, it is possible to obtain fairly valuable data from its results, especially verification of the trend course of the empirically constructed mathematical fire model, consisting of a local extreme, particularly global maxi-mum, relating to a certain target distance (the enemy tactical entity).

When looking at the shape of the theoretical curve of fire pragmatism and polynomic trend of a third order of the experimentally measured data, it is evident that the individual shapes are similar. Thus we can support the empirical assumption that there exists an area of distances, where a high probability of hit on the moving target from the stationary position is constantly present, but its counter reaction does not represent a significant risk for the stationary target with the decreased surface exposed to counterfire, See Fig. 8.

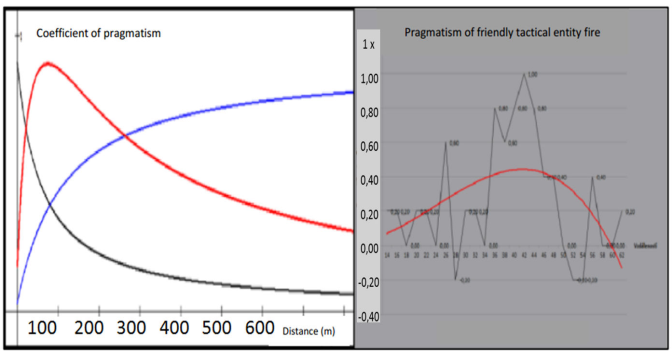

Fig. 8 Comparison of theoretical model course and fire pragmatism curve

V. Conclusion

The findings gathered here refer to the trend that indicates considerable potential of the modelling approach to commanders' decision-making activities and its utilization within the decision-making process of preparation and conduct of military operations. Constructing relevant models of tactical activities and solving operational-tactical tasks are not usually easy, as shown by the initial procedures in this study, and to reach their solutions, applicable in practice, there might be yet a long journey ahead (iteration cycle of experiments, evaluation and model adjustments). Nevertheless it is possible that in the future operational environment the dispositions of this model base will essentially support commanders, who will be able to utilize them (generating quality variants of activities, reacting to given operational situations in real time).

The significance of achieved results of the addressed problem refers to research and development in the field of a decision-making process, its automation and implementation of new approaches, which have not received appropriate attention by ACR so far, and above all, the area of modelling support of the decision-making processes on a tactical level. Thus, it is not surprising that ACR is lagging behind some of the advanced foreign armed forces, USA in particular, and what remains is to hope that we will be able to change this poor situation in the near future.

References

[1] Babbie, E. R. The practice of social research. 12th ed. Belmont, CA: Wadsworth, c2010. 530 s. ISBN 978-049-5598-428.

[2] Miovský, Michal. Kvalitativnípřístup a metody v psychologickémvýzkumu. Praha: Grada, 2006. 332 s. ISBN 80-247-1362-4.

[3] Mokrá, Ivana; Mazal, Jan; Stodola, Petr. The tactical strike modeling. In: *Recent Advances in Energy, Environment & Economic Development*. Paris: WSEAS Press, 2012, p. 280-285. ISSN 2227-4588. ISBN 978-1-61804-139-5.

[4] Mokrá, Ivana. Modeling approach to the specific tactical activities. *World Academy of Science, Engineering and Technology, Phuket*, 2012, vol. 72, no. 12/2012, p. 1176-1179. ISSN 2010-3778.

[5] Veber, Jaromír, a kolektiv. *Management: Základy - prosperita - globalizace*. 1. vyd. Praha: Management Press, 2005. ISBN 80-7261-029-5.

[6] Welch, David A. *Decisions, Decisions: The art of effective decision making*. First. Amherst, New York: Prometheus Books, 2001. ISBN 978-1-57392-934-9.