

# The Combat Effectiveness Model of Air Operation Centre in Times of Peace, Crises and War

Nad'a JELÍNKOVÁ<sup>a</sup> and Vojtěch MÁJEK<sup>b</sup>

<sup>a</sup> Nad'a JELÍNKOVÁ, Department of Air Defence Systems, University of Defence, Brno, Czech Republic, e-mail: nadajelinkova@centrum.cz

<sup>b</sup> Vojtěch MÁJEK, Department of Air Defence Systems, University of Defence, Brno, Czech Republic, e-mail: vojtech.majek@unob.cz

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## Abstrakt:

For the realistic war games simulation there is a need to express operator abilities by a mathematical function. This paper deals with the combat effectiveness model of the air operation center (AOC), which is derived from the theory of probability. This model describes the analysis and the quantification of stressful factors that the operator can meet in time of peace, crises and war. The model is simply applicable to every entity in the command and control structure and it provides for evaluators quite accurate results about the combat effectiveness. It can be used for training and exercises purposes or more precisely for simulations representing the human behavior. Instead of possible evaluation, the paper contains the key factors which influence the working process and some important results clarifying the impact of the 24hours duty at human organism.

*Key words:* Behavioral science, Simulation, Control and Reporting Centre, Theory of probability, Numerical algorithms, Human factor, Work conditions

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## 1. Introduction

The valuable job performance is the entire part of the air traffic control in the NATO Integrated Air Defense System (NATINADS). There are lots of methods for evaluation of operational personnel. In real world, almost all methods are based on qualitative evaluation of personnel abilities. There exist only interdisciplinary and psychological studies which represent the descriptive model. These descriptive models are not proper to use for purposes of this type of simulations and insufficient when we need to describe the manpower for modeling of war games. The scope of this paper is to define the operator's performance in relation to its personal skills and values, specific working conditions, training and exercise, etc. It is intended to define the combat effectiveness model.

## 2. Problem Formulation

There exists nor the methodology, neither the respective manual which can simply evaluate the weaknesses of the working personnel. There exists no possibility to express the degradation of the combat effectiveness and no way of checking and evaluating the working process. The subject of all factors influencing the manpower is solved in the thesis called Model of combat readiness of air operation centre in time of peace, crises and war in the depart-

ment of Air Defense Systems at the University of Defense in Brno.

## 3. Problem Solution

There are many factors influencing the combat effectiveness. Many of them can be interpreted in relation to the command and control process (C2 process). Moreover, there are some characteristics which appear in crises situations only. These are, but not limited to individual characteristics and behavior and team characteristics. The combat effectiveness model attempts to emphasize the importance of human being in complicated and unique military systems. This model follows on the conceptual reference model of C2 published by NATO Research and Technical Organization [1] represents on Figure 1. This conceptual model addresses the variables and the relationships between and among them that describe human characteristics and behaviors that may affect the quality of decision making in C2 processes.

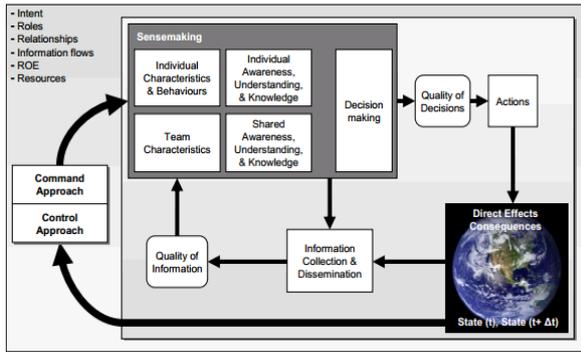


Figure 1: The conceptual reference model of command and control process [1]

The combat efficiency comprises of two parts – the technology and the manpower which characterizes the ability to work. This paper deals with the second part (Figure 2).

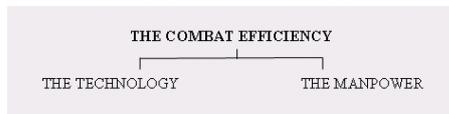


Figure 2: The combat efficiency

The definition of the operation centre (for purposes of controlling the combat effectiveness) is as follows - a set of agents and relations defined for controlling and evaluation of the combat effectiveness for purposes of evaluation the human characteristics and behavior (Figure 3).

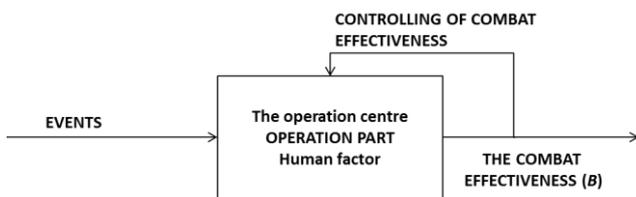


Figure 3: Modeling of the combat effectiveness

For evaluation of combat effectiveness I defined these parameters:

- $B$  - the coefficient of combat effectiveness, i.e. the executive probability of system;
- $Kp_i$  - the coefficient which describes the influence of working conditions at manpower;
- $Ks_i$  - the coefficient describing the influence of stress at manpower.
- $v$  - the coefficient describing the level of training, i.e. the combination of knowledge and skills.

The combat effectiveness model comprises of three basic steps. Every step describes the factors which can influence the manpower. At first, there is a need to describe the events, which incomes into the system. The events, which are entering into the system, are character-

ized by its influence. At first, they can have the devastating impact at the operation centre and then the combat effectiveness is defined as  $B = 0$ . These events are, but not limited to nuclear explosions, destructive attacks at manpower, natural disasters etc. Second types of events are not devastating for operations centre, but can seriously increase the level of stress. For example, these events can be very stressful: the hijacked aircraft, the air attack or situations in which the aircraft is used for terrorist purposes.

The training and exercise is the next step in the validation of manpower. Only well trained and exercised personnel ensure the valuable work performance. The knowledge is the basics for praxis and without sophisticated training methodology is impossible to reach for job experiences. The possible way how to describe the training and exercise is expressed as follows:

- the knowledge is excellent, it is possible to contemplate the perfect performance  $v = 1$ ;
- the knowledge is satisfactory, or more precisely the knowledge are sufficient for job performance  $v = 0,9$  up to  $0,99$ ;
- the failure in knowledge has negative impact of job performance, however it doesn't evoke the fundamental errors  $v = 0,8$  up to  $0,89$ ;
- the knowledge is insufficient  $v = 0,79$  and lower.

The working conditions are very specific at air operation centre, which is located and built to be able to operate continually. This centre is an underground workplace, which can withstand the serious air attacks and miscellaneous types of combat events. All this events should probably have a negative impact on a manpower. The possible way of evaluation is expressed on Figure 4:

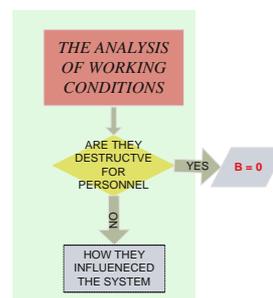


Figure 4: The evaluation of working conditions

From the theory of probability is obvious, that the devastating working conditions mean for system the lower job performance. The system is not working only in case of such conditions, which are all destructive simultaneously. These working conditions are possible to describe in a parallel make (Figure 5):

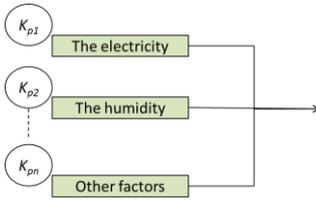


Figure 5: The parallel make of working conditions

Then is the possibility to express the  $Kp$  as follows:

$$Kp = 1 - (1 - K_i)^n, n \in N \quad (1)$$

where:  $n$  – number of elements

The coefficient of one particular agent of working condition is possible to describe as follows:

- The working conditions don't influenced the manpower  $Kp = 1$ ;
- The working conditions slightly influence the manpower  $Kp = 0,9$  up to  $0,99$
- The working conditions significantly influence the manpower  $Kp = 0,89$  up to  $0,51$
- It is not possible to work in these working conditions  $Kp = 0,5$  and lower.

The manpower in contrast to the technology is characterized by its fluctuating performance. This part of paper discusses the variables that describe key cognitive issues involved in individual sense making process [1]. Understanding individual characteristics and behaviors requires an understanding of the following:

- behavior – for example a memory performance, a response speed, a risk taking of self-monitoring etc.;
- individual cognitive abilities – for example a general intelligence;
- personality and values – an emotional stability, conscientiousness, an agreeableness, an openness to experience, an extraversion or decision style and a problem solving style;
- physical abilities – a physical strength, a physical flexibility, a motor skills etc.;
- dynamic factors/state – a blood sugar, a physical health or a sleep deprivation.

A detailed description of every factor (individual or team) is stated in the conceptual reference model [1].

The schema of researching the impact of stress at manpower is described on the Figure 6:

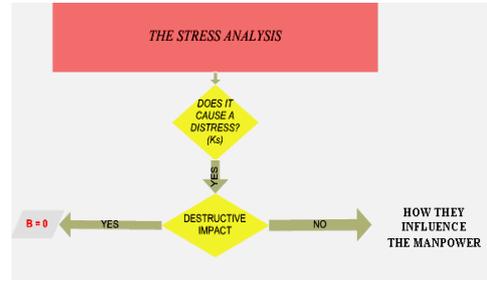


Figure 6: The stress analysis

Each stress agent is indicated by its reliability defined by coefficients  $Ks_i$ . The personnel are able to work in case that the stress doesn't influence him overmuch. The problematic of distress (it means the negative stress) and other parameters influencing the manpower is solved in thesis called Model of combat readiness of air operation centre in time of peace, crises and.

For the purposes of evaluation I set up the  $Ks_i$  paramters as follows:

- The stress is motivating  $Ks = 1$ ;
- The distress is not influencing significantly the performance  $Ks = 0,9$  up to  $0,99$ .
- The distress is affecting the manpower however the experiences and human state enable acceptable performance  $Ks = 0,51$  up to  $0,89$ .
- The manpower is not able to work, there are vital mistakes observed  $Kp = 0,5$  and lower.

The agents characterizing a stress level is possible to illustrate in a serial representation (Figure 7).

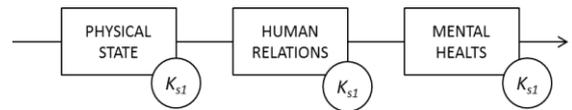


Figure 7: The serial representation of a particular stress agent

The evaluation of work performance depends on evaluator's experiences and knowledges of working conditions and its personality.

The evaluation of all aspects mentioned above is very important to have well trained and exercised personnels, because every validation of manpower is individual process and requires a lot of personal experiences in this specific working place. The overall combat effectiveness is possible to express as follows:

$$B = Kp \cdot Ks \cdot v; \quad (2)$$

where  $Kp, Ks, v \in (0,1)$

The possible simulation of system behavior can be expressed in three states. The first one is good and indicate troublesfree running. The next state demonstrates the crises, so it is possible to expect some difficulties. The worst state means that the stability is disturbed and there are many destructive factors discovered. The curve of the

combat effectiveness will change and move downstairs in time of peace, crises and war (Figure 8):

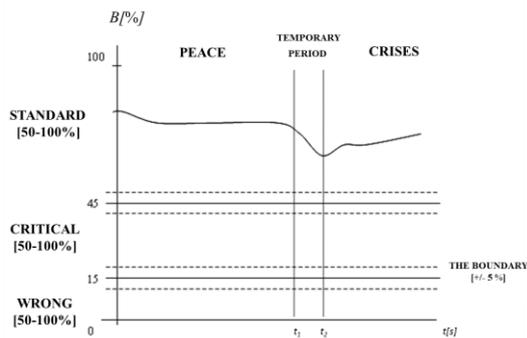


Figure 8: The example of the combat effectiveness curve ( $B$ )

Furthermore I quote some important conclusions mentioned in analysis of my thesis, which followed on many researches elaborated of The Institute of the Aviation Medicine Prague [2] and clarify the reason for preserve 24hours shift at the operations centre.

- In the 24 hours duty can serve only personnel which have adopted these specific conditions. Otherwise the personnel can suffer from many physical and psychological symptoms.
- The speculation about canceling 24 hours duty by the reason of negative incidence at organism are spurious, because well motivated personnel don't suffer from specific working conditions. The 24 hours shifts were established to provide a full combat efficiency – there are some problems which appear during forwarding a duty form one to another; moreover, there exists a fact that the mental performance increases during the shift.
- The performance taking 24-26 hours is risking, because there are many changes especially in mental conditions affecting the performance.
- Vice versa, 12 hours duty is proper in time of crises and war, because the researches demonstrate that a big emotional stress is tolerable for a few hours.

#### 4. Conclusion

It is in the nature of evaluation a human factor and its characteristics to never be “finished.” That is because the manpower is still changing and constantly in progress. The mathematical model of stress represents a significant step forward for the C2 simulation community. For the first time, there is a mathematical specification included a human factor, the working conditions and training skills. All aspects are specified in my thesis in detail.

#### References

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