AN ANALYSIS OF THE IMPLICATIONS OF INSERTING AVAILABILITY INTO THE MATRIX OF THE VIABILITY FACTORS FOR THE MILITARY TECHNICAL SYSTEMS

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Abstract: *The increasingly urgent need to align the Romanian military logistics to the modern requirements of the hybrid war, asymmetrical conflicts, NCW (Network Centric Warfare) etc. and the innovative realities of today's battlefields (see the Ukrainian conflict) requires a maximum efficiency of the use of military technical systems. Accordingly, it is necessary to increase their viability level. But, this concept has not been established itself in the general terminology of the military science domain. It is still under study although it appeared almost fifty years ago, being proposed since the 70s of the last century and forcefully brought back into discussion at the beginning of the 2000s. Taking into account the latest researches in the field, which demonstrated the existence, but also the necessity to insert new factors and sub-factors of viability, an updating of the proposed initial formula is required in order to estimate the mutual influence of viability factors/sub-factors. This article aims to demonstrate the implications of inserting a new factor into the viability matrix: the availability of military technical systems.*

Keywords: *viability, availability, influence, factors/sub-factors, formula*

1. INTRODUCTION

The accelerated evolution towards a modern army based on the quality of the military technique equipments, the specific training of the soldiers who maneuver them and the optimization of the procedures have been requiring the implementation at the basic level of new concepts into the general field of military sciences. In this new conceptual terms family we can list "the capability" (in Romanian dictionaries the word "capabilitate" did not exist thirty years ago, but it had imposed using the analogy with the English term "capability" and of course the larger meaning into the military field), NCW (*Network Centric Warfare*), the action/intervention capabilities, the intervention on the military target objective and the *War on Effects.* All these new conceptual terms have imposed themselves in analyzing of this universal but permanently present evil in history which is armed conflict.

Along the same line is the concept of "viability". The term has been widely used in the civil field especially for road construction, electronics and cybernetics. It was proposed to be used in the field of military science in the 70s of the last century, after that it was used as main influencing factor on the action intervention (see [7] source) and it was deepened and carefully studied in [6]. From then until now, the concept continues to impose itself at a not very accelerated pace.

Pursuant to [6, pp. 236] *the viability is the reliability of the military technique assets to which a practical and tactical assembly of measures and preoccupations is added (the capacity of military technique assets and people to avoid the wastage, to avoid in time the enemy's gun strikes and their ability to fast recover their strike, fire, maneuvers and protection capacities) that guarantee the fulfillment of the intervention.*

This is an official/formal definition. Also, according to the same source, determinants to calculate/determine/estimate the viability of a system are the viability factors, namely: *1. the performances of military technique assets, 2. the reliability, 3. the efficiency of maintenance and maintainability works, 4. traffic specifications, 5. combat service, 6. combat service support (logistics), 7. the quality of the substructure, 8. the management of the human resources and 9. the co(-)operation for support.*

By in-depth analysis of the concept [6], the schematic interdependence of the viability factors was established, their mutual influence was estimated and a mathematical formula was established according to the final conclusions.

Subsequent studies ([1], [2], [3], [4] and [5] to be seen) have made changes in the initial level of the study. So, the necessity of new viability factors/sub-factors taking into considerations and new possibilities of the viability concept to be expanded through extrapolation to other domains, wider ([5] and [8]), or narrower ([1] and [2]) were demonstrated. The identification of new sub-factors of viability is generous and useful in the perspective of increasing the degree of complexity of the use of military technical systems according to NATO requirements.

This is the trigger factor for the present study. In the new context and level/stage of researching, it is necessary to update the factors and sub-factors that influence viability and by default, as a result of this, drawing up a new interdependence schemes, as well as the mutual influence estimation formula. Also, through what are going to be presented, the importance of the conceptual enforcing of the term will be demonstrated.

2. NEW CONCEPTUAL APPROACHES

First of all, it is necessary to develop a much simpler but at the same time clearer definition of viability. Taking into account all the studies to date (implicitly all factors and sub-factors imposed by reality, or proposed by researchers in the field) it can be stated that:*" viability is the complex property of a system, characterized by a multitude of interdependent factors and sub-factors, through which that system demonstrates that, to a greater or lesser degree, it corresponds/does not correspond to the purpose for which it was designed"*.

Ideally, there would be a mathematical formula for calculating the viability of a system. But until its specifically development, the interdependence schemes and estimation formulas of mutual influence of viability factors/sub-factors can be drawn up as intermediate stages.

Thus, first of all, all the characteristics on which the viability of a system depends must be determined. In relation to [6], which I consider the most complex study dedicated to the subject, the following differences also appeared:

- pursuant to [4], but mostly [2] (pp. 24-29), the influence on viability of ergonomics and the necessity to introduce this concept into the matrix of factors/sub-factors of viability were demonstrated; that is right, it deals with aspects of military ergonomics; in the first situation it is about military ergonomics in general and in the second the author refers strictly to the ergonomics of the FPS 117, TPS 79R, P-18 and P-37 military radars; the direct influence of military ergonomics (as well as ergonomics in general) on the performance of military equipment and indirectly on viability (as sub-factor) is demonstrated;

- pursuant to [3] (pp. 10-17), availability, keeping quality and durability are suggested as new viability factors/sub-factors as follows: availability as a reliability sub-factor and keeping quality and durability as maintenance sub-factors of viability; unfortunately, the study shows deficiencies from the point of view of organization, synthesis and even the constancy of the new ideas implemented, the author not being very consistent in maintaining his opinions.

In conclusion, if the influence of ergonomics on the performance of military technical systems is demonstrated and the concept is clearly imposed as a sub-factor of viability, the implementation of the other three concepts, availability, keeping quality and durability as factors/sub-factors of viability require a deeper analysis.

Due to the complexity of the required demonstrations, in the present paper only the availability is going to be analyzed.

3. THE ANALYSING OF POSSIBILITIES TO INSERT THE AVAILABILIY IN THE MATRIX OF VIABILITY

As it is known from the specialized literature, the availability is the feature of/the possibilities of a technical system to perform its specific tasks at a certain time. The availability can be influenced by complex aspects related to: reliability, maintenance system, the technical system maintainability, keeping quality and updating features.

Depending on the complexity and according to the specifications related to systems life cycle management (SLCM), the availability is classified into:

-**intrinsic availability [A_i]** (also called availability ratio or proportion of active time) - availability of the product itself; it depends only on the system reliability and its accessibility for repairs; intrinsic availability does not depend on time and it is presented as a constant value;

-**achievable availability [A_a]** – the maximum availability that can be practically achieved; it depends on the reliability of the product, its accessibility for repairs and the efficiency of the organization and execution of maintenance;

-**operational availability [A_o]** - availability obtained during the exploitation period but, in addition to the achievable availability, it takes into account by the delays on the logistics chain during the supply, maintenance and administration of the program.

The concept of availability and the classification of different types of availability can thus be summarized according to Table 1.

Table 1..

Availability type	**Specifying the type of availability**	**Factors which influence the types of availability**			
		The system reliability	**Maintainability (accessibility to maintenance operations)**	**Maintenance system**	**Logistics chain delays (supplying, maintenance, administration of the program)**
Intrinsic	of the product itself				
Achievable	it can be practically achieved				
Operational	obtained during the exploitation period				

The necessary parameters for the mathematical expression of these three types of availabilities are presented in Table 2.

Table 2.

Parameter	The explanatory formula of parameter	The explanation of the terms from parameter formula
MTBF - Mean Time Between Failures	$MTBF = \frac{T_{up}}{N_F}$	T_{up} – total operating time from the analyzed time period N_F – number of failures during analyzed time period T_{DF} – total time when the equipment was damaged during analyzed time period (non operative equipment) N_{PM} – the number of maintenance actions, other than repairs, in the analyzed time period T_{PM} – the medium period of maintenance actions, other than repairs
MTTR – Mean Time To Repair	$MTTR = \frac{T_{DF}}{N_F}$	
MTBMA – Mean Time Between Maintenance Actions	$MTBMA = \frac{T_{up}}{N_F + N_{PM}}$	
MMT – Mean Maintenance Time	$MMT = \frac{N_{PM} \cdot T_{PM} + N_F \cdot MTTR}{N_F + N_{PM}}$	
MLDT – Mean Logistics Delay Time	No formula (it is the effective measured time)	

Thus, the three types of availabilities can be expressed mathematically, as follows:

$$A_i = \frac{MTBF}{MTBF + MTTR} \tag{1}$$

$$A_a = \frac{MTBMA}{MTBMA + MMT} \tag{2}$$

$$A_o = \frac{MTBMA}{MTBMA + MMT + MLDT} \tag{3}$$

If A_i is the availability ratio, then an unavailability coefficient can also be defined, in the form:

$$C_i = 1 - A_i \tag{4}$$

or

$$C_i = \frac{MTTR}{MTBF + MTTR} \tag{5}$$

Also, continuing the line of deductions, a proportion of availability can also be defined, under the formula:

$$R_a = \frac{MTTR}{MTBF} \tag{6}$$

Thus, it can be easily observed that, mainly through its complex formula, the operational availability is in direct connection with other factors/sub-factors of viability, as follows:

- MTBMA - it is influenced by the maintenance system and the reliability of technical systems as factors of viability;
- MMT - in addition to MTBMA it is influenced by the maintainability of technical systems (sub-factor of viability);
- MLDT – it is influenced by the performance of the logistics system in general, as a result of the implications that the material goods supply chain, the maintenance system and the administration of the program may have.

4. THE PLACE OF AVAILABILITY IN THE FACTORS/SUB FACTORS VIABILITY MATRIX

The purpose of presenting the various terms and the mathematical formulas which connect them each other from the former chapter aimed the undeniable connection between the analyzed concept of availability and other factors/sub-factors of viability.

Thus, taking operational availability into consideration (as the most complex concept among the three availability concepts presented), it can be easily deduced and mathematically expressed - see (7) formula - that availability (*A*) is a function that depends on:

1. maintenance system (*M*),
2. technical systems reliability (*F*),
3. overall maintainability (*m*), but also
4. logistics structure (*L*) through which it is ensured all what it is necessary to military technical systems under analysis.

$$A = f(M; F; m; L) \tag{7}$$

Thus, according to (7) formula, but also taking into account the other formulas (1) – (6), it results that the availability can be considered to be a primary influencing factor of the viability of a military technical system. In this situation, maintenance, reliability and logistics become sub-factors of viability.

The most complex, updated (compared to the work [6]) and correctly argued representation scheme of the factors and sub-factors of viability was the one proposed in the work [4]. That matrix is presented in Fig. 1.

In accordance with what has been demonstrated up to this point, a new matrix of viability factors/sub-factors can be suggested as you can see in Fig. 2.

Within Fig. 2 it can be seen that, in contrast to Fig. 1, certain viability factors have been renamed according to the new NATO requirements (see source [12]) and the new factors/sub-factors already demonstrated to be part of the matrix under discussion have been inserted. We can already notice the appearance of viability sub-factors on two levels (1, respectively 2) because maintainability has been "downgraded" to a lower level as a viability level 2 sub-factor due to the fact that the maintenance system has been proven that influence viability through availability.

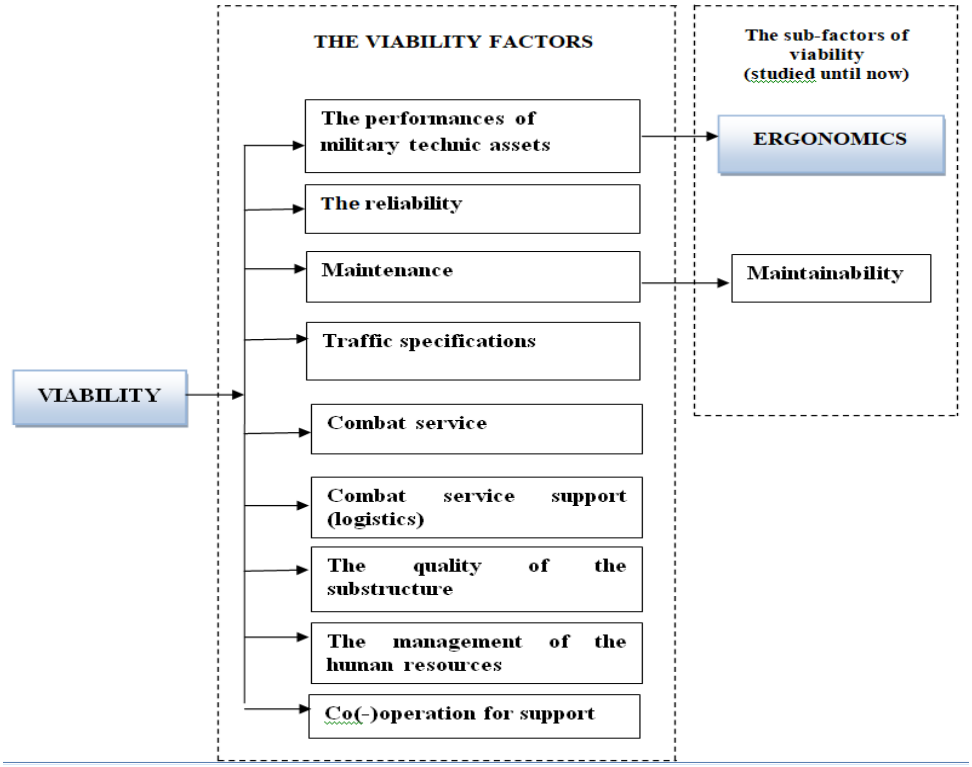

FIG. 1 The matrix of viability factors/sub-factors (with the insertion of ergonomics as a new sub-factor) according to [4]

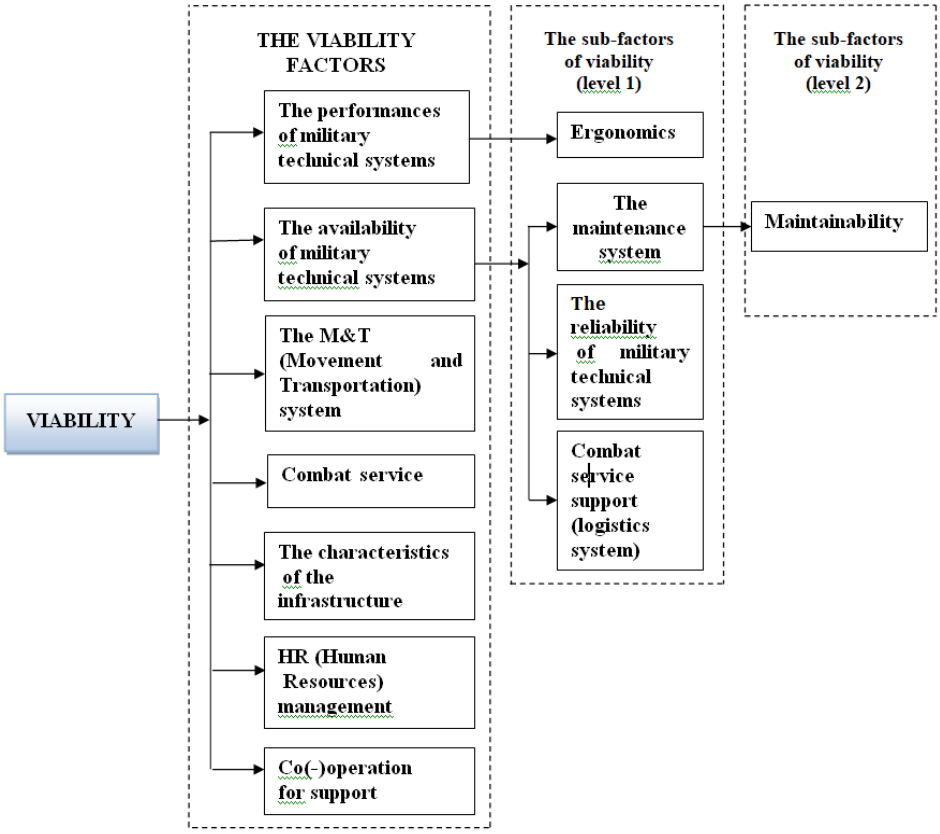

FIG. 2 The updated viability factors/sub-factors matrix

5. CONCLUSIONS

With the deepening of studies in the field of viability, the representative matrix of its influencing factors/sub-factors becomes more and more complex. At the same time, methods of mathematical calculation are being identified more and more precisely to the extent to which a military technical system is, or is not viable, corresponds/does not correspond to the purpose for which it was created.

Thus, there are already in-depth studies on the calculation of the availability of a technical system (see sources [10] and [11]). The performance of equipments is known and they are anyway determined by the specifications that are drawn up when purchasing the equipment. Without them being fulfilled, that military equipment would have nothing to be on the battlefield. The other factors, respectively sub-factors, also present more or less rigorous mathematical calculation systems.

Another indirect method for calculating the viability of a military technical system is the one proposed in [8], which has as key elements of the algorithm the operational military criteria that any military equipment must meet. However, this calculation method cannot be generalized. It can only be applied for specific cases.

In conclusion, from my point of view, the construction of a formula for calculating the viability of a military technical system is a good method in order to develop a method of evaluating how an equipment corresponds to the purpose for which it was created. The drawing up of a complete matrix of viability factors/sub-factors is only an intermediate stage, absolutely necessary, in order to achieve this objective.

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