MODELLING THE DEVELOPMENT OF THE AUTOMOTIVE SUPPORT OF THE ARMED FORCES OF THE REPUBLIC OF AZERBAIJAN

Aziz TALIBOV

Azerbaijan Republic War College of the Armed Forces

Abstract: *The paper investigates the process of providing automotive technical support for the Armed Forces of the Republic of Azerbaijan by using synergetic-bifurcation theory of system development. Based on expert evaluations and statistical data of the auto-technical support of the Armed Forces during 1991–2019, recorded progress trends of the compound's elements of auto-technical support are recorded. The paper focuses on studying the conceptual model of improvement of the auto-technical support system. The opportunities of development of the auto-technical support of the Armed Forces is investigated based on the phases-time characteristics of system's elements in bifurcation space. In this respect, the bifurcation model of the auto-technical support system is constructed and the functional dependence between elements of functioning system factors are defined.*

Key words: *truck technical support, bifurcation, dependence function, system elements, period of progress.*

1. INTRODUCTION

The creation of the modern army of Azerbaijan dates back to the period when Azerbaijan regained its state independence. During this period, Azerbaijan faced a decline in the military field. In the condition of the termination of all types of economic ties, the absence of military industry and a lack of military personnel made it very difficult to form a new disciplined army of Azerbaijan from the scattered parts and remnants of the Soviet Army. In particular, the auto-technical support (ATS) of the Armed Forces of the Republic of Azerbaijan was faced with great problems and its development underwent trials and tribulations [1]. The study of these phenomena from the point of view of bifurcation transitions and jump points is one of the effective tools for studying these processes.

1.1. Analysis of recent research and publications

In recent decades, many scientific papers have been devoted to new approaches to the study of complex developing systems, including ATS of the Armed Forces, from the standpoint of synergetics and catastrophe theory [2; 3; 4]. In these works, it is noted that in its evolution the ATS system goes through phases of sustainable development, which under certain conditions can be replaced by phases of instability. This happens when the system reaches certain critical parameters: a critical level of security of troops with material resources, technological degradation, a decrease in stocks of material resources, etc. When the material support system experiences stress beyond these critical values, it enters a new dynamic mode. At the transition point, bifurcation occurs, that is, switching from one method of provision to another. Since the critical values of the parameters for complex systems are not known, the very entry of the system into the bifurcation mode is precisely unpredictable.

2. FORMULATION OF THE PROBLEM

In Azerbaijan, the foundation of a professional army was laid between 1993 and 1994. It was during these years that the scientific principles of the creation of the army were laid down, the formation of troops and material and technical support were taken under control. The formation period of the Azerbaijan Army overlapped with the transitional period in the economy of Azerbaijan. The experience of international history has shown that in transitional periods the country's economy is experiencing the greatest difficulties in production forces and in economic relations. For this reason, the problems that arose have a negative impact in the field of automotive support, which is important in the construction of the Armed Forces. From this point of view, the study of the problem of technical support in transition periods based on new approaches is very relevant for military science.

In the present article, the development trend of the ATS of the Armed Forces of the Republic of Azerbaijan between 1991 and 2019 are studied and, on the basis of this, a synergetic-bifurcation model that describes this development is elaborated and proposed.

2.1. Statement of the main research material

The history of the formation of the Armed Forces of the Republic of Azerbaijan in 1991-2019 can be divided into four periods:

- The first period: 1991-1994, years of active fighting;
- The second period: 1995-1998, the strengthening of the defense after the ceasefire;
- The third period: 1999-2005, the improvement of the structure of troops and military service;
- The fourth period is between 2006-2019, the period of comprehensive development of the Armed Forces.

At these stages, all elements of the ATS system, including the automotive service that controls this system, underwent numerous changes. The lack of supply connections and the restoration of some of them by unusual methods caused the branching of the ATS system in some areas, disappearance, etc. [1]. This stimulates the formation of cycles (ups and downs) in the development of the ATO system. Satisfying demand causes the transition of the quality of the ATO system from one form to another. Aging (depreciation) of equipment, a drop in its quality capabilities leads to an increase in quality requirements in ATS troops [5]. The development cycle of the ATS system is due to the demand of the troops and processes in the economic system, such as production and consumption.

Thus, based on the obtained research results for the period of 1991–2019 transitional processes in the national economy, expert evaluations of anti-terrorist operation specialists in the Armed Forces of the Republic of Azerbaijan, experience in a number of foreign countries [6-8], a conceptual model for improving quality (efficiency) of ATS systems is proposed (Fig. 1).

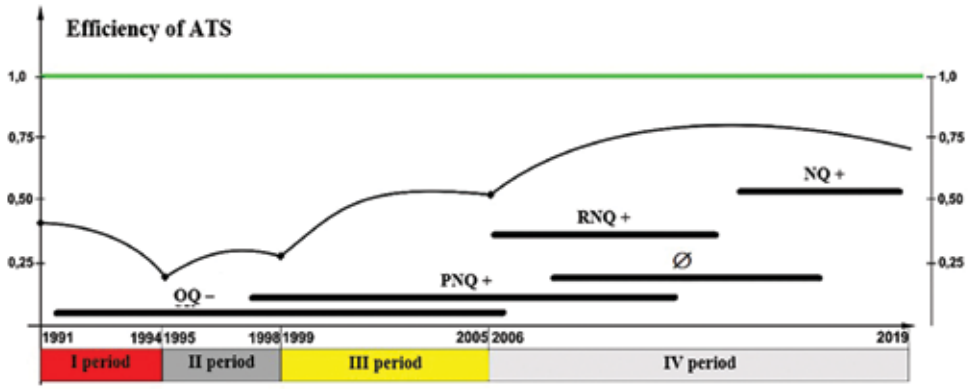

Fig. no. 1 A conceptual model for improving the effectiveness of ATS between 1991 and 2019

Here, solid black lines show: OQ – period of old quality, PNQ – period of possible new quality, RNQ – period of real new quality, NQ – period of new quality, ∅ – period of disappearance of the old quality.

As it is seen from the model, in the first period there is a weakening of the general indicators of the ATS and a gradual loss of the values of old qualities. The main reason for this, was the loss of supply connections and the discrepancy between the new and the required, the need as a result of the war for the intensive provision of equipment, the formation of an ATS control system, a large loss of military equipment and, at the same time, a low possibility of restoration. Despite all this, the remaining untapped reserve from the time of the Soviet troops was used up, and the repairing enterprises worked at full capacity. During this period, the failure of old qualities was associated with the arising conditions.

In the second period, there was a possibility of a new quality of work in the field of restoration of communications, management and capabilities of the elements of the ATS system, and it necessitated the transition to a real new quality. During this period, the implemented process of the system's activities led to bifurcation changes in the ATS system: the creation of new supply chains, the solution of mobilization tasks in a distinctive format, the restoration of failed numerous equipment, the approval of the original full-time management structure, etc.

In the third and fourth period, the following works caused many new qualitative changes in the field of army build-up: innovations in the field of army formation, updating of equipment, bringing guidance documents in line with modern requirements, improving personnel training, supporting friendly states, introducing best practices, etc. However, as can be seen from the model, the effectiveness of the ATS system has not reached its maximum value. The analysis showed that the effectiveness of the ATS system depends on the maximum indicators of the interconnection (correlation) of the elements of the system, impeccable planning and optimal management. The process of changing the elements of the ATS system in the framework of the abovementioned periods was investigated based on the theory of bifurcations.

In the theory of transition processes, along with the concepts of transition and crisis in the military-economic sphere, the concept of bifurcation is the main one. It shows a bifurcation, branching, decomposition, decline and turn in the process of the system [9]. The bifurcation in the field of army build-up should be understood as a qualitative-quantitative event, i.e. division of a single whole (system, process) into several parts, quantitative voids and accumulations, losses and gains (Fig. 1). If we denote the events of losses by the minus sign "–" and the events of acquisitions

by the plus sign "+", then in the bifurcation field one can observe the course of efficiency decline processes ("–" events), as well as stability and growth ("+" events). All "currents" have the nature of trends; their quality is probabilistic. The beginning of each course has the character of possibility – decline, preservation or rebirth.

Places and processes of quality change, indicated by a positive sign, have the character of fluctuations. In these turbulent movements, new qualities are born that create the conditions for reducing the entropy of quality and its transition to a new level, it is possible to complete the synthesis of opposites in them. The new quality is the result of the process of negation-negation of the old quality [10-12]. Bifurcation processes first form favorable conditions for the formation of new qualities in the bifurcation field, and then their formation, i.e. the bifurcation field is an area of qualitative probabilities. Bifurcation crises (transitions) occur periodically and even cyclically, noting small and large historical development cycles: from catastrophe to catastrophe, alternating with stability, development and degradation.

Synergo-bifurcational quality selection can be described as follows: there is an old quality and a new quality (Fig. 1). A new quality is presented in opportunity and in reality. The old quality disappears (falls), i.e. reaches the point of loss of old quality (∅). This point is at the same time a synergetic-bifurcation point from which a new quality begins.

Thus, the synergetic-bifurcation process of interactions and synthesis is a multi-coordinate and system-driven process.

According to Figure 1, the horizontal coordinate reflects the 4 periods described above for the development of army build-up of the Armed Forces of the Republic of Azerbaijan from 1991–2019, which mean the transition from the old quality to the new, and the vertical one – the effectiveness (pairs of opposing qualities) of the army build-up, which is measured in the range of 0÷1. Values characterizing the degree of efficiency are reflected on the corresponding rays of the coordinates. The combination of the coordinate points identified in this way by a common closed line will make it possible to outline the boundaries of the most probable quality formation, as well as its state from the point of view of stability – instability.

Based on expert assessments and statistical data, the development trends of the components of the ATS system were investigated. To this end, the following characteristics of the development of elements ($p_i, i = \overline{1,14}$) were considered:

1) acquisition of new automotive vehicles (AV) (p_1);

2) planned provision of troops with automobile assets (p_2);

3) effectiveness of the interaction of the system elements (p3);

4) indicators of transportation efficiency (p_4);

5) level of the training of engineering personnel (p_5);

6) capabilities of the technical service (TS) and repair crews (p_6);

7) status of the parks (p_7);

8) provision of an untapped reserve and its echelons (p_8);

9) coefficient of technical preparedness of vehicles (TPC) (p_9);

10) completion of drivers and their level of training (p_{10});

11) the capabilities of repair enterprises of the army (p_{11});

12) completion of the service with junior specialists and their level of training (p_{12});

13) mobilization training and resource management level (p_{13});

14) condition of vehicle warehouses (p_{14}).

Fig. 1 summarizes the results of studies of the time dependences of the indicated 14 characteristics of the elements of the ATS system in the bifurcation field. It can be seen from the figure that the dependences are described by the "assembly" type which consistently changes and it is described by the following formula [9]

$$p=x^4+ax^2+bx \quad (1)$$

with points of return (smooth change of development phases). Inside the return points, there are two different values of x, which give local minima of the function p (x) for each pair (a, b).

The return points in the phase space (a, b) near the catastrophe point, showing the geometric location of the "assembly" type bifurcations, separate the region with two stable solutions (development or decline) and the region with one solution (transition points). The geometry of the points of return is usual when studying what happens with bifurcations of the "assembly" type when adding a new parameter b to the control space. By changing the parameters, it can be found that there are points in the space (a, b) at which stability is lost, that is, on this curve a stable solution can suddenly "jump" to an alternative value (also stable) [13-15].

The characteristics of the development of the studied elements make it possible to determine the causes of bifurcation recessions and give a forecast for the future. Let us analyze separately, for example, 8 characteristics of the development of ATS.

1. Acquisition of new automotive vehicles

As can be seen from Figure 1, the Soviet army carried out a planned upgrade of AV and the total number of equipment of the first category

was 50%. However, in periods I–III the small supply of new equipment to the armament of the Azerbaijan Army, losses in battles, an increase in equipment failures as a result of intensive operation, and wear and tear of the equipment caused a drop in the TPC. At the end of the third period and the beginning of the fourth period, the process of equipping troops with new equipment began. This process became more intense after 2010, and a>0 was observed for the indicated period. The start of production of "MAZ" automobiles in the Republic of Azerbaijan has further accelerated the supply of equipment in the armament of the army.

2. Planned provision of troops with automobile assets

In military units remaining from the Soviet army, vehicle bases, repair enterprises, and militarized colonies, automobile assets were taken in an amount close to normal. This includes untapped supplies, repair kits and equipment for the current supply. However, the bulk of these assets was used during the first period. Structural changes in the army, deployment of military units and equipment, necessitated the planned provision of troops with automobile assets. Despite all these, security issues were not effectively resolved in terms of creating a supply chain, as well as in terms of planned deliveries. By the end of the second period, automobile assets stored in warehouses (except for unnecessary spare parts) have been completely used.

3. Effectiveness of the interaction of the system elements

Considering that in the first period the automotive service was not fully formed and the work carried out in this area was in the active phase, a positive trend in the systemic activity of the elements could be noted. However, in 2005-2006, a bifurcation transition point and a degradation process were observed (a<0). This state of bifurcation is explained by the lack of application of new achievements in the field of ICT, the decline in old qualities in the field of repair and maintenance, and the delay in applying new qualities.

4. Indicators of transportation efficiency

At least 3 points of phase change are observed in the characteristic of the progress of this element. Despite the phase of increase in efficiency at this stage in the bifurcation field, this total indicator did not exceed 0.25. The main reason for this low value of efficiency is the delay in the transition to a new qualitative level in the bifurcation process.

5. Level of training of engineering personnel

This quality characteristic in the ATS system is very important. In the absence of a strong personnel potential, the process of developing

a system in a bifurcation field is very difficult. As a result of the involvement of specialists from the Soviet army and civil engineers, a positive trend was observed in the first period. In 1995-2005, the level of training of automobile specialists was high. However, since 2003, for various reasons, there is a shortage of specialists in this field.

6. Capabilities of the technical service and repair crews

In the development of this element, the indicator a>0 continued until 1995. This indicator in the characteristic of the dynamics of development is associated with a sufficient number of maintenance and repair workshops remaining from the Soviet army, as well as a sufficient number of appropriate equipment and machine tools in car parks. Along with this, in 1991-1999, the presence of experienced platoon commanders and warrant officers of technical services, as well as soldiers with special technical education and experience in the Soviet army, had a positive impact on this characteristic.

7. Status of the parks

During the formation of the Azerbaijan army, permanent car parks were located only in settlements. Field automobile parks were improved by 2010, and based on some of them the construction of permanent parks began. For this reason, there is a positive trend in this characteristic.

8. Provision of an untapped reserve and its echelons

In the first period, a sharp decline was observed in this characteristic. In the troops, including the bases, the untapped stock was completely depleted during the fighting.

Based on this analysis, we may come to the conclusion that the characteristics of the development of elements of the ATS system affect the activity of the system as a whole. From this point of view, the task of finding the function of the dependence of the general indicators of the system on the abovementioned parameters is an urgent task.

To simplify the calculations for the indicated elements of m = 4 periods, we consider the values of n = 14 development characteristics. Assume that the dependence of F on variable parameters is linear:

$$F(c,x) = c_1x_1 + c_2x_2 + ... + c_nx_n \quad (2)$$

Here, $x = (x_1, x_2, ..., x_n)$ – is the vector of variables, $c = (c_1, c_2, ..., c_n)$ – is the vector of unknown coefficients.

Thus, c_j parameters in n numbers should be found based on $x_1, x_2, ..., x_n$ values in m numbers. The problem is to find n dimensional c vector. Vector c can be found by the least squares method. From the statistics the $(x_{i1}, x_{i2}, ..., x_n)$, $i = 1,2,...,m$ values of $x_1, x_2, ..., x_n$ variables and $y_1, y_2, ..., y_m$ values of $F(c, x)$ function are known. Then, you can write a multivariables linear dependence:

$$y_i = c_1 x_{i1} + c_2 x_{i2} + \ldots + c_n x_{in}, \quad i = 1,2,\ldots,m \quad (3)$$

We write the vectors Y, c and the matrix X in the form:

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ . \\ . \\ . \\ y_m \end{bmatrix}, \quad X = \begin{bmatrix} x_1, x_2 \ldots x_{1n} \\ x_2, x_2 \ldots x_{2n} \\ . \\ . \\ . \\ x_{m1}, x_{m2} \ldots x_m \end{bmatrix}, \quad c = \begin{bmatrix} c_1 \\ c_2 \\ . \\ . \\ . \\ c_n \end{bmatrix} \quad (4)$$

We introduce a new function:

$$Q(c) = \sum_{i=1}^{n} [y_i - (c_1 x_{i1} + c_2 x_{i2} + \ldots + c_n x_{in})]^2 \quad (5)$$

c vector can be found from the minimum condition for the function Q(c): $\frac{\partial Q(c)}{\partial c} = 0$ (6)

In accordance with the given values of *x* for 4 periods, we can find *c* vector, and as a result of this we determine the analytical form of the $F(c,x)$ function. Given that n = 14 and m = 4, using the Minner function of the Mathcad program, we determine the values of *c* vector:

c_1=0.139; c_2=0.360; c_3=0.532;
c_4=0.001; c_5=0.054; c_6=0.020;
c_7=0.095; c_8=0.045; c_9=0.165;
c_{10}=0.098; c_{11}=0.063; c_{12}=0.053;
c_{13}=0.355; c_{14}=0.016

As a result, the analytical form of the $F(c,x)$ function takes the following form:

$$F(c,x) = 0.139x_1 + 0.36x_2 + 0.532x_3 + 0.001x_4 + 0.054x_5 + 0.020x_6 + 0.095x_7 + 0.045x_8 + 0.165x_9 + 0.098x_{10} + + 0.063x_{11} + 0.053x_{12} + 0.355x_{13} + 0.016x_{14} \quad (7)$$

The analytical form of the function found based on the bifurcation model satisfies the given statistics of these periods. Using this function, you can make a forecast for future periods of the development of the ATS system.

3. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

Studies have shown that in the initial periods (I–III) of the ATS system, because of changes in the organizational and procurement mechanisms, an imbalance in the quality progress was observed. Under transition conditions, independent radical changes in technical support are impossible.

The synergetic-bifurcation model of the ATS system for the Armed Forces of the Republic of Azerbaijan is built in the article. Based on the bifurcation model, an analytical form of the function is found that satisfies the given statistical data for 4 periods of the development of the ATS system.

In the context of the development of the national economy, in order to timely and fully provide the Armed Forces of the Republic of Azerbaijan with equipment and automobile assets, it

is necessary to apply organizational and supply mechanisms. The found function of the relationship between the general indicators of the ATS system and the values of the elements of its activity confirm the importance of developing the system on the basis of new logistics principles.

REFERENCES

[1] Talibov, A.M., *Some theoretical and practical aspects of truck technical support of Armed Forces*, Baku: Proceeding of Azerbaijan High Military School, 2003. (23) 2, pp. 66-68.

[2] Arnold, V.I., *Theory of catastrophes*, V.I.Arnold, Moscow: Fizmat, 1983, 58 p.

[3] Grigorev, Y.P., *The method of improvement of the material support system of Armed Forces based on the logistic*, ScD Dissertation, Saint-Petersburg, 2000, 362 p.

[4] Amozov, V.G. *Modelling and optimization methods of economic relations in material support system of military district*, PhD Dissertation, SPb.: VATT, 1994, 235 p.

[5] *** *Sociology at the point of XXI century. New directions of investigations*, Moscow: Intellect, 1998, 198 p.

[6] Subetto, A.I., *Is an alternative to former economic?* Samara: Journal Volga-biznes, 1995, no 7, p. 28.

[7] Yakovets Y.V., *Sociogenetics: content, regularity, perspective*, Y.V.Yakovets, Moscow, 1992, 88 p.

[8] Kregel, Y., Matsner, E., Graber, G., *Market shock*, Kregel Y., Matsner E., Graber G., Viena: ULIK „Patent“, 1992, 114 p.

[9] Muzika, O.A., *Bifurcation in nature and in society*, Modern knowledge-intensive technologies, 1992, no 1, pp. 87-91.

[10] Хакен, G. Synergy, *Hierarchy of instability in self-organized systems and devices*, G. Хакен, Moscow: Mir, 1985, 424 p.

[11] Loskutov, A.Y., *The basis of multiple systems theory*, A.Y.Loskutov, A.S.Mixaylov; M.-Ijevsk: Institute of computer investigations, 2007, 620 p.

[12] Feygin, M.I., *About double effects of bifurcation memory in the dynamic systems,* Vestnik of scientific technical progress, 2008. V.3, no 7, pp. 21-25.

[13] Sokolov, Y.N., *Single theory of cycle*, Proceeding of cycle processes in nature and society, Stavropol, 1995, pp. 25-32.

[14] Bautin, N.N. Leontovich E.A., *Methods and techniques of quality investigations of dynamic systems on surface*, N.N.Bautin, E.A.Leontovich; Moscow: Nauka, 1990, 488 p.

[15] Berje, P., *Order in chaos. About deterministic approach to turbulence*, I.Pomo, K.Vidal; Moscow: Mir, 1990, 368 p.