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I. Stanovska, DSc, Assoc. Prof.,
I. Prokopovych, DSc, Assoc. Prof.,
O. Stanovskyi, DSc, Prof.,
M. Kostina
Odessa National Polytechnic University, 1 Shevchenko Ave., Odessa, Ukraine, 65044; e-mail: i.v.prokopovich@opu.ua

THE PROJECT STATUS MORPHOLOGICAL INDICATOR AND METHOD OF ITS EXPRESS EVALUATION

І.І. Становська, І.В. Прокопович, О.Л. Становський, М.М. Костіна. **Експрес-вимірювання стану проекту за допомогою морфологічного показника.** Кожне антикризове втручання в проект фактично руйнує його початковий план, – останній все більше відрізняється від реальності, а якщо таких втручань багато, то від первісного плану може взагалі нічого не залишитися! Моделі, які використовувалися при первинному плануванні проекту стають неадекватними, що миттєво та негативно відбивається на точності та ефективності антикризових морфологічних рішень. Команда проекту після кожного структурного втручання повинна швидко розпочати створення нового плану, для чого її необхідно забезпечити новою методологією антикризового управління проектами на основі морфологічного експрес-аналізу організаційно-технічних систем для оцінювання поточного стану проекту. Для антикризового управління будь-яким об'єктом за зворотним зв'язком необхідно мати можливість відносно швидко вимірювати параметри стану цього об'єкту як реакції на управлінське втручання. Тому метою наукового дослідження, в якому складним об'єктом був проектний менеджмент, стало створення методу експрес-вимірювання стану проекту за допомогою вперше запропонованого морфологічного (структурного) показника. Побудовано систему управління антикризовою діяльністю складних технічних систем на основі зворотного зв'язку по відхиленню поточного плину проекту від планового. Запропоновано новий комплексний параметр **М**, який однозначно та репрезентативно відбиває морфологічне відхилення поточного плину проекту від планового. Показник представляє собою добуток комплексної ймовірності спроможності проекту подолати наслідки кризи без зупинки або зміни загальної його структури та вартості такого подолання. Комплексна ймовірність обчислюється як корінь квадратний від суми квадратів ймовірностей компенсації кризи технологічними, варіаційними та креативними методами. Це дозволило використовувати цей показник в якості критерію необхідності початку процесу морфологічної протидії відповідним кризам. Визначені складові комплексного параметру **М** та методи їхнього експрес-вимірювання та розрахунку. На підставі проведених досліджень розроблено схему підсистеми комп'ютерної підтримки прийняття проектних рішень в плануванні і виконанні антикризового проектного управління «COCAST» (Copper Continuous Casting Projects). Практичне використання результатів дослідження було виконано в умовах діючого підприємства за рахунок власних коштів. Було досягнуто зменшення запланованих строків будівництва на 7,4 %, та вартості на 5,9 %. Продукція нового цеху дозволила досягнути підвищення конкурентоспроможності підприємства.
Ключові слова: антикризове управління, стан складної системи, морфологічний показник, експрес-вимірювання, ймовірнісне оцінювання

I. Stanovska, I. Prokopovych, O. Stanovskyi, M. Kostina. **The project status morphological indicator and method of its express evaluation.** Every crisis intervention in a project actually destroys its original plan – the latter is more and more different from reality, and if there are many such interventions, there can be nothing left from the original plan! The models used in the initial planning of the project become inadequate, which immediately and negatively affects the accuracy and effectiveness of anti-crisis morphological decisions. The project team, after each structural intervention, should quickly begin to create a new plan, which should be provided with a new methodology of crisis management project based on morphological rapid analysis of organizational and technical systems to assess the current status of the project. For crisis management of any feedback entity, it is necessary to be able quickly measure the parameters of the state of that object in response to management intervention. Therefore, the purpose of scientific research, in which the complex object was project management, was to create a method of rapid measurement of the project status using the first proposed morphological (structural) indicator. The system of crisis management of complex technical systems is built on the basis of feedback on deviation of the current flow of the project from the planned one. A new complex parameter **M** is proposed, which uniquely and representatively reflects the morphological deviation of the current flow of the project from the planned one. The indicator is the product of the complex probability of a project's ability to overcome the effects of a crisis without stopping or changing its overall structure and the cost of such a solution. Complex probability is calculated as the square root of the sum of the squares of crisis compensation probabilities by technological, variational, and creative methods. This made it possible to use this indicator as a criterion for the need to start the process of morphological response to the respective crises. The components of the complex parameter **M** and methods of their express measurement and calculation are determined. Based on the research, a scheme for the computer support subsystem of decision making in the planning and execution of the Copper Continuous Casting Projects (COCAST) crisis management project was developed. The practical use of the results of the study was carried out in the operating company at its own expense. The planned construction time was reduced by 7.4 % and cost by 5.9 %. The production of the new workshop made it possible to increase the competitiveness of the enterprise.
Keywords: crisis management, complex system state, morphological index, rapid measurements, probabilistic evaluation

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1. Introduction

Any crisis management of complex systems, especially at bifurcation points, requires information on how certain structural interventions in the project will affect its further development [1]. This information can obtain either by forecast calculations or by a direct assessment of the "first steps" of the project development after the crisis "catastrophe". It is clear that such management should be calculated and carried out as soon as possible and in conditions when it is not clear that we will "save": money, time, resources, environment, and so on. Only the mission and goal of the project remain the main ones.

In crisis management of complex systems, the input and output parameters of such management and methods of their determination are of great importance. Since in project management the list of parameters that can be directly and quickly measured (time, estimates, effective methods, etc.) is very small, an important component of crisis project management are methods and models that assess the results of crisis management of project managers on indirect indicators. This is, for example, a complex indicator "Morphological" – indicator **M**, associated exclusively with the structure of management processes.

2. Analysis of recent publications and problem statement

The management of any feedback system involves constant monitoring of the state of this system. This state in such a management scheme is a function of two processes: natural development and response to management action. When managing complex, multifactorial processes, such a summary assessment is usually possible only by direct measurement of some indirect parameter by which you can, first, assess the current state, and secondly, determine the direction and magnitude of the control action [2].

Note also that the study deals with morphological (structural) control, during which the corresponding object can be changed "only" the list of individual elements and the parameters of the relationship between them.

In the management process take into account the distribution of complexity in groups: technical, organizational, environmental [3]. But the state measurement cannot be performed unambiguously. The main reason is the lack of a metrological parameter to assess the complexity of the control object.

In some cases, this uses SWOT-analysis (strengths (*S*) and weaknesses (*W*) – factors of the internal environment of the object of analysis, (ie those that the object itself is able to influence), opportunities (*O*) and threats (*T*) – environmental factors (ie those that can affect the object from the outside, which are not controlled by the object) [4].

Finding the direction of development of a complex system after the next management action is a task of optimization choice, because the latter can be quite a lot. The target function of this choice may be different technical and economic characteristics. Most often in organizational systems for the target function choose the risks of completion of the project in a given time [5].

Risks create "gaps" in communications (connections) [6], which affects the complexity and reliability of systems [7]. To compare the reliability of variants of "new" structures, which in the conditions of overcoming crises are unscheduled, methods of measuring complexity are offered [8]. Such methods should be fast in online management. They should allow rapid analysis and decision-making when only qualitative information is available [9], and therefore rely on conceptual models and experimental evaluations [10, 11].

Therefore, the main problem to be solved in the presented study is to increase the efficiency of organizational and technical systems of crisis management by creating new models and methods of morphological system analysis.

3. Purpose, objectives and scientific novelty of the study

The aim of the work was to develop and implement new models and methods of morphological analysis of organizational and technical systems of crisis management to improve the efficiency of such management. Management efficiency was understood as improvement compared to the plan of such key project indicators as time, cost, product quality parameters, interaction with the environment, relationships in the project team, etc., or at least the preservation of planned indicators in project crises.

To achieve this goal, the following tasks **were solved.**

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1. Build a crisis management system for complex technical systems based on feedback on the deviation of the current course of the project from the planned.

2. To propose a new complex parameter (indicator **M**), which unambiguously and representatively reflects the morphological deviation of the current course of the project from the planned one.

3. Determine the components of the complex parameter M and methods of their rapid measurement and calculation.

4. Perform a practical test of research results and evaluate their technical and economic efficiency.

The scientific novelty of the work is that for the first time the indicator and the method of its measurement for estimating the results of anti-crisis project management in terms of morphological deviation of the real project from the planned one are proposed. The indicator is the product of the complex probability of the project's ability to overcome the effects of the crisis without stopping or changing its overall structure and the cost of overcoming it. The complex probability is calculated as the square root of the sum of the squares of the probabilities of crisis compensation by technological, variational and creative methods. This allowed us to use this indicator as a criterion for the need to start the process of morphological response to relevant crises.

4. Development of a method of rapid measurement of the project status using a morphological indicator

4.1. Crisis management system of complex technical systems based on feedback on the deviation of the current course of the project from the planned

As a rule, anti-crisis management should be proactive [12, 13] and fast [14]. Therefore, it is desirable to organize on the principle of "feedback" (Fig. 1). Even in the APCS, where all the values of the parameters are known quite accurately, and the control effect is usually one, the organization of feedback management is a very difficult task.

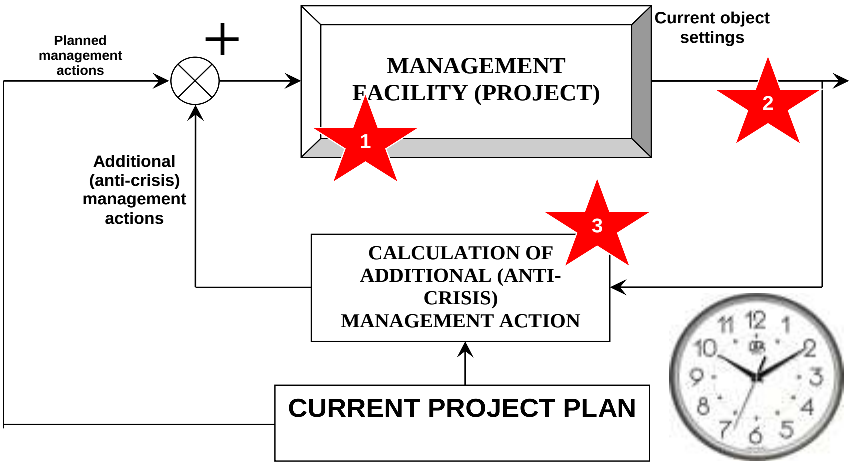

Fig. 1. Organization of project management according to the "feedback" scheme: 1 – access point for assessing the current state of the project; 2 – access point for assessing and forecasting the project response to additional anti-crisis management actions; 3 – access point, where the project manager can optimize and speed up the calculation of additional (anti-crisis) management actions

There can be tens of control parameters in project management [15], in addition, all parameter values are stochastic, up to complete latency. To implement the principle of "feedback", the crisis management manager must have three main support tools (Fig. 1).

First, it must have a set of methods for obtaining the most complete and reliable information about the current state of the project.

Secondly, it must have a set of methods for obtaining the most complete and reliable information about the results of the management impact on the object (project management results).

Third, it must have methods for the fastest and most effective conversion of second information into adjustment of control influence.

4.2. Complex parameter (indicator M), which unambiguously and representatively reflects the morphological deviation of the current course of the project from the planned

To assess the results of anti-crisis project management in terms of morphological deviation of the real project from the planned, consider the morphological indicator **M** – the deviation of the project and the method of its measurement. Indicator **M** is the product of the complex probability of the project's ability to overcome the effects of the crisis without stopping or changing its structure |**p**| at the cost of such overcoming C_{build})

$$\mathbf{M}=|\mathbf{p}|\cdot C_{\text{build}}. \tag{1}$$

The structure (1) of the indicator **M** is similar to the structure of another indicator – *R* for risk assessment [16], namely, the product of the cost of its compensation C_{comp} on the probability of occurrence of a risk situation *p*:

$$R=C_{\text{comp}}\cdot p. \tag{2}$$

It is obvious that expression (2), when the risk situation has already occurred, splits into two obvious ones: $p=1$; $R=C_{\text{comp}}$, which allows you to accurately determine the actual cost of risk. In fact, expression (1) differs significantly from "basic" expression (2), because the probabilities *p* and **|p|** significantly differ in content.

To obtain an estimate **|p|** consider a project that contains three levels of Team activity: lower - absorbing, middle – variable and higher – managerial, creative level. At the lower level, the capabilities of the Project Team to deviate from the specified technology, in the general case, are zero. At the intermediate level, the team has the opportunity to choose from a limited range of alternatives. At the top – the project manager can use any methods, including scientific, to solve problems and achieve project goals.

Probabilistic estimation of the contribution to **M** of technological activity p_{tech} (%), which is known to be not unique, can be performed by conventional statistical methods. Probabilistic assessment of the contribution of variable activities p_{var} (%) can be based on known statistical information about crises that have occurred with similar objects or their elements. To determine cognitively the probability of achieving a goal through only creative activities, the project manager can use different methods and sources. These are the results "gained" from their own experience, literature and interactive sessions with Team members, stakeholders and subject matter experts. For example, as this probability, you can use normalized to the world average (100 points) the average creative composition of the IQ_{mean} project team. As a result, we have:

$$|\mathbf{p}|=\sqrt{p_{\text{tech}}^2+p_{\text{var}}^2+\text{IQ}_{\text{mean}}^2}\,. \tag{3}$$

The morphological index also was used as a criterion for the need to start the process of morphological response to relevant crises.

4.3. Components of the complex parameter M and methods of their express measurement and calculation

Determining the components of the crisis of technological activity C_{tech}, which is not unique, can be performed by conventional statistical methods [17]. In addition, descriptions of technologies and complex equipment are usually equipped with information about the reliability parameters of the "weakest links" of the system (bearings, gears, gaskets, valves, etc.). It also contains information about the cost of repairs, which can be used in the C_{tech}.calculations.

Determining the crisis components of a C_{var} *variable activity* can be based on known statistics about risky events that have occurred with similar objects or their elements.

This approach makes the results of the C_{var} determination less accurate than C_{tech}, but their accuracy can be quite satisfactory for project management as a whole.

Perform rationing of the actual cost of compensation for the crisis to the planned by the formula:

$$C_{\text{rat}}=\frac{C_{\text{fact}}}{C_{\text{plan}}}. \tag{4}$$

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Now we will involve in modeling the risks of variable activity project-physical analogy, which in recent years has spread in the theory and practice of project management [18].

We will further consider the change in the probability of occurrence of the risk event Δp_{var} as a signal, and the normalized cost of compensation for its consequences C_{rat} by analogy with the accepted terminology in the theory of information transfer [19]. In this theory, the signal is a symbol for the distance transmission of certain information or messages [20]. An event is a signal only in the system of relations in which the message is recognized as significant.

In project management, the signal is always an event. In other words, a change in the state of any component of a project or program that is recognized by the system logic as significant is a signal.

An event that is not recognized by this system of logical or technical relations as significant is not a signal. The change in the probability of occurrence of the risk event Δp_{var}, which is important in this approach, has the following parameters [21]. The signal duration $T=t_{\max}-t_{\min}$ determines the time interval during which the signal exists (non-zero). There are instantaneous $P\ (t)$ signal power Δp_{var}: $P(t)=(\Delta p_{\text{var}})^2(t)$ and average P_{mean} power:

$$P_{\text{meam}}=\frac{1}{T}\int_{t_{\min}}^{t_{\max}}(\Delta p_{\text{var}})^2(t)dt\,. \quad (5)$$

The dynamic range is the ratio of the highest instantaneous signal power to the lowest: $P_{\max}(t)/P_{\min}(t)$. Finally, the signal-to-noise ratio is equal to the ratio of the useful signal power to the noise power $P_{\text{signal}}/P_{\text{noise}}$.

Signal-to-noise ratio (SNR) is a measure used in science and engineering to determine how much noise is distorted by a signal. It is defined as the ratio of the power of the useful signal to the power of the noise. A ratio greater than 1: 1 indicates that the signal is greater than the noise. Although SNR is preferably used to measure electrical signals, it can be applied to any type of signal.

In other words, the signal-to-noise ratio compares the level of the desired signal (for example, the probability of a risk event) and the noise level (for example, the cost of compensation for the latter). The higher the SNR, the less burdensome the “noise”. The signal-to-noise ratio is defined as the ratio of signal power (significant information) to background noise power (unwanted signal).

$$\text{SNR}=\frac{P_{\text{signal}}}{P_{\text{noise}}}, \quad (6)$$

where P – average power. In decibels, the ratio is defined as follows:

$$\text{SNR}_{\text{dB}}=10\log_{10}\left(\frac{P_{\text{signal}}}{P_{\text{noise}}}\right)=P_{\text{signal, dB}}-P_{\text{noise, dB}}, \quad (7)$$

The signal-to-noise ratio in SNR_{dB} decibels was used as a numerical characteristic of the probability of occurrence of a risk event at a variable level:

$$P_{\text{var}}=\text{SNR}_{\text{dB}}. \quad (8)$$

There are no analogues of such risk events for cognitive determination of *risks of creative activity* R_{creat}. The project manager can use various methods and sources to identify the probabilities of risks p_{creat} and financial losses C_{creat}, because the results are obtained from personal experience, literature, structural decomposition of risks and opportunities, interactive sessions with team members, stakeholders and subject experts [22]. For example, as p_{creat} it is possible to use the value of average IQ_{mean} of creative structure of a command of the project received on standard tests normalized to world (100 points): received on standard tests:

$$\text{IQ}_{\text{rat}}=\frac{\text{IQ}_{\text{mean}}}{100}. \quad (9)$$

IQ tests are designed so that the results are described by a normal distribution with an average IQ of 100, and such a spread that 50 % of people have an IQ between 90 and 110 and 25 % – below 90 and above 110 [23]. To combine the obtained values of the probabilities p_{tech}, p_{var} and p_{creat} we build on these values the module of the three-dimensional vector *p* (Fig. 2), which can be calculated by the formula:

$$|\mathbf{p}| = \sqrt{p_{\text{tech}}^2 + p_{\text{var}}^2 + \text{IQ}_{\text{mean}}^2}. \qquad (10)$$

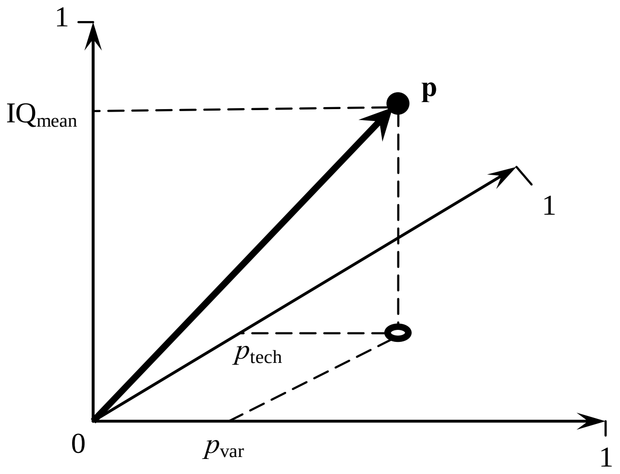

Fig. 2. To determine the three-dimensional vector p of the probability of the project's ability to overcome the effects of the crisis without stopping or changing its structure

Later, the value of this module was used to assess project crises. For example, for the three-component component module presented in (10), you can write an equation to calculate the indicator $\mathbf{M}_3$:

$$\mathbf{M}_3 = \sqrt{p_{\text{tech}}^2 + p_{\text{var}}^2 + \text{IQ}_{\text{mean}}^2}. \qquad (11)$$

Or for the general case:

$$\mathbf{M}_i = \sqrt{p_1^2 + p_2^2 + \ldots + p_i^2}. \qquad (12)$$

Indicator **M** – is a dimensionless number, and therefore its value can be used to assess and compare the current morphological state of the project in crisis management of the latter.

5. Practical test of research results. Construction of a shop for the production of oxygen-free copper wire rod by continuous casting

The shop for the production of oxygen-free copper wire rod by continuous casting was supposed to be built on the sea-bound, on the one hand, and existing buildings and the main city road – on the other, the territory of PJSC "Odessa Cable Plant "Odeskabel".

Continuous casting of this type is obtained on a multi-stream automatic continuous casting line "UPCAST®" (Outokumpu Group).

In the UPCAST process, a continuous ingot with a diameter of 8 mm is extracted from the melt vertically upwards through a crystallized immersed in the melt. The main elements of the foundry machine are a graphite matrix-crystallizer, a cooling unit and a pull-out device consisting of server-motors, drive and clamping shafts. The copper melt is prepared in a channel induction furnace by remelting copper cathodes M00k and M0K.

The finished products of the shop are copper wire rods, prepared for delivery to customers.

On the basis of the conducted researches the scheme of the subsystem of computer support of decision-making in planning and execution of anti-crisis project management "COCAST" *(Copper Continuous Casting Projects*) is developed.

At the heart of this scheme is an extended database in which all post-iteration information about the process is accumulated.

During the implementation of the project of construction of a continuous casting shop on the territory of the existing enterprise, which is located in the border-controlled zone, the following crisis events occurred:

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– large trees grew on the construction site, which, of course, hindered this construction;

– design documentation for the Finnish multi-stream automatic continuous casting line "UPCAST®" was supplied to the company for foreign currency, which required many approvals at the level of financial, customs and other institutions at the state level;

– the purchase and supply to Ukraine of imported equipment, which is a part of the automated line of continuous casting, also required the same coordination;

– the general design of the shop for the installation of the line and the technical conditions of this installation had to be agreed with the State Institute for the Design of Metallurgical Enterprises;

– according to the project of the continuous casting line, a significant part of it had to be below the zero line (floor level) and, accordingly, required significant ground works in the coastal zone, where the groundwater level is always high;

– as well as any construction, and especially in the above-mentioned conditions, needs careful coordination with such organizations, as fire service, sanitary epidemiological station, etc.;

– the proximity of the State Border of Ukraine provided for the coordination of any construction and operation of large equipment with the border services;

– it was necessary to build the main networks of supply of semi-finished products and export of finished products outside the enterprise to the existing roads, railways and sea routes with the appropriate coordination of additional traffic with stakeholders;

– it was necessary to agree with stakeholders on additional ways and capacities to supply the company with a sufficiently large amount of additional electricity and water.

The construction was carried out in the conditions of the operating enterprise at the expense of own means. The planned construction time was reduced by 7.4 % and the cost by 5.9 %.

The products of the new shop allowed to increase the competitiveness of the enterprise.

6. Conclusions

1. The system of management of anti-crisis activity of complex technical systems on the basis of feedback on deviation of a current project from planned is constructed.

2. A new complex parameter **M** is proposed, which reflects the degree of morphological deviation of the current course of the project from the planned or the degree of crises of technological activity. Indicator **M** is the product of the complex probability of the project's ability to overcome the effects of the crisis without stopping or changing its structure at the cost of such overcoming.

Indicator M can be used as a dimensionless functional for comparing options for anti-crisis actions when assigning verdicts and as a measure of the effectiveness of anti-crisis project management.

3. The components of the complex parameter **M** and methods of their express measurement and calculation are determined.

4. PJSC "Odeskabel" carried out planning and construction with the subsequent commissioning and implementation in the technical and economic activities of the plant for the production of oxygen-free copper wire rod by continuous casting using crisis management system for reconstruction projects "COCAST" (*copper continuous casting*) support making design decisions in proactive construction management. The construction was carried out in the conditions of the operating enterprise at the expense of own means of PJSC "Odeskabel".

The planned construction time was reduced by 7.4 % and the cost by 5.9 %. The products of the new shop allowed increase the competitiveness of the enterprise in the cable industry.

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Становська Іраіда Іванівна ; Stanovska Iraida, ORCID: https://orcid.org/0000-0003-0601-7658
Прокопович Ігор Валентинович; Prokopovych Ihor, ORCID: https://orcid.org/0000-0002-8059-6507
Становський Олександр Леонідович; Stanovskyi Olexsandr, ORCID: https://orcid.org/0000-0002-0360-1173
Костіна Марина Марсівна; Kostina Marina, ORCID: https://orcid.org/0000-0002-0817-4238

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