Mathematical Framework for Ensuring the Functional Stability of Organizational Systems Using Ordinal Scale

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Abstract

The paper addresses the challenge of ensuring the functional stability of an organizational system, with a focus on the application of ordinal scales. It outlines a method for assessing redundant resources through expert evaluation of the potential for replacing functions performed by system elements that are currently non-operational. Additional approaches to identifying redundancy are also explored. The assessment of function replacement is conducted using ordinal scales to evaluate performance quality. The overall functional quality of the organizational system is determined by measuring the deviation of the new system configuration's quality from the "ideal" configuration.

Keywords

functional sustainability, organizational system, redundancy, ordinal scales

1. Introduction

The key properties of complex systems that define their functional stability are reliability, survivability, and fault tolerance [1, 2]. Functional stability, in essence, integrates all these characteristics [3, 4]. This paper addresses a task best understood through the concept of functional resilience [5, 6], which is achieved by employing various types of redundancy [7] and redistributing resources to mitigate the effects of emergencies [8, 9].

The functional sustainability of an organizational system refers to its ability to preserve its management structure and continue performing its primary functions, for which it was originally designed [10, 11]. The importance of studying and ensuring the functional sustainability of organizational systems stems from several factors:

1. The rapid pace of change in the modern world and the necessity for these systems to generate automated, adaptive responses to environmental challenges.
2. The need to address disruptions caused by internal problems that periodically affect the functioning of system components.
3. The significant role of subjective factors in decision-making, requiring careful consideration of the human element at every stage.
4. The interdependence among the various elements of the organizational system.

2. Organizational systems

Currently, there are over a hundred definitions of the term *system* [12]. Broadly, a system is an integrated set of elements and the relationships between them. These elements and their interrelationships possess specific properties. A complex organizational system consists of a structured set of elements and relationships, characterized by defined properties and organized to perform specific functions.

An organizational system is a type of system designed to coordinate the actions of its components to achieve shared goals. It is typically a human-machine or socio-technical system [12]. An element

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of a system refers to a part that cannot be further divided based on the chosen criterion for system decomposition. The collection of objects within a system constitutes its *composition*, also known as the *elemental composition*. The *structure* of a system is defined by the set of relationships among its elements, which are essential to fulfilling the system's purpose.

Evaluation involves collecting information about a system's state, the dynamics of its functions, and its performance outcomes to assess how effectively they align with its objectives. Depending on the research focus, evaluation may examine the system's internal functioning—reflected in the relationships among its elements—or its external functioning, which considers interactions with the surrounding environment.

By a problem we understand [12] the triple of sets

$$< S, O, T >, \quad (1)$$

where S – a set of states (situations);
O – a set of operators for transferring one state to another;
T – a given (target) set.

In organizational systems of type (1), a task is defined as a situation encountered by an element of the system—a subject who recognizes that the situation involves a specific goal, the achievement of which is their responsibility and depends on performing certain established functions. Every task has a goal and an object to which the goal is directed.

The functional sustainability of complex organizational systems [1] is a comprehensive property encompassing reliability, survivability, and fault tolerance. As a result, assessing the quality of an organizational system's functioning is a complex and pressing challenge [13].

To ensure the functional sustainability of a type (1) organizational system, several implementation stages must be considered.

1. **Analytical Stage:** This stage involves identifying redundancies in the functionality of system elements to utilize them in non-standard situations.
2. **Identification Stage:** During this stage, an abnormal situation is detected, and its level of danger and the need for a response are classified. The abnormal situation is recognized and categorized accordingly.
3. **Mitigation Stage:** This stage focuses on addressing the consequences of an emergency by deploying internal reserves, such as redundant functions within the system's elements. At this point, the quality of possible functional responses is evaluated, and an optimal compromise solution is selected.

In addition, evaluation procedures may be applied at each stage:

- determining the quality of the redundancy reserve created in the system;
- identification of critical elements of the system and assessment of their characteristics [14];
- determining the level of impact on the system in a hazardous situation;
- assessing the state of the organizational system and points of redundancy to maximize the impact on functional resilience;
- calculation of the integral quality of functioning of a complex organizational system.

When determining the reserves of an organizational system by identifying additional functions of its elements, it is necessary to:

- identify sources of determining reserves;
- Identify ways to define and assess redundancy to ensure functional resilience;
- apply tools to identify, assess and ensure the functional sustainability of a complex organizational system.

Such tools for implementing procedures to ensure functional resilience in an organization may include:

- application of testing tasks;
- holding competitions to fill vacant positions;

- conducting preferential voting among middle managers to determine candidates for replacement of functions [15];
- studying the peculiarities of the organization's corporate culture [16];
- improving corporate culture to facilitate the replacement of functions in non-standard situations [16];
- application of procedures for ranking the capabilities of system elements to perform certain functions, i.e. decision-making in ordinal measurement scales [17].

To implement procedures for the transition to a new worldview [18, 19] by elements of the organizational system, to facilitate the transfer of the functioning of some elements to a hard mode if necessary to ensure functional stability in non-standard situations:

- it is possible to humanize the activities of organizational system elements by applying the arsenal of digital humanities;
- add elements of artificial intelligence to perform some functions and transfer to it the provision of certain functions in complex non-standard situations;
- Identify problems that arise at different stages of decision-making, formalize them and automate them to ensure response to emergency situations;
- create a register of functions of the system elements, ensure their complete list and adequate assessment of their importance and quality of performance;
- implement projects to formalize business processes in the organizational system;
- optimize the organization's business processes on graphs;
- analyze and apply cognitive research tools to ensure functional resilience;
- Analyze the organizational structure using standard tools, such as RACI, to identify areas for optimizing the performance of system elements;
- Analyze the competencies of the system elements, conduct personnel assessment and certification;
- use a combination of different sources to identify, evaluate and use excess reserves in the organizational system: personnel assessment, motivation research, improvement of corporate culture [16], etc.

Of course, on the way to such formalization, problems should be identified [20, 21], and a significant number of obstacles and challenges should be overcome:

- resistance to the established corporate culture and certain elements of the organizational system for which the working conditions are significantly changing;
- to appear, convince and compensate for the obvious reduction in freedoms and increase in the load on the system elements;
- minimize the ability of system elements to maneuver in response to unexpected external influences or internal force majeure;
- reduce the ability of the system elements to use creativity and thus the level of motivation of some of them;
- artificially isolate certain functions to ensure an easier transition to an emergency situation;
- formalize all the functions of the system elements, and simplify some of them to ensure interchangeability of the system elements.

Clearly, not all problems can be formalized, and a mathematical model cannot be constructed for every case [22, 23]. In many practical situations, such a comprehensive approach is unnecessary [24]. Instead, it is possible to propose constructive methods to enhance the formalization of the organizational system and support the automation of processes, thereby improving its functional stability:

- building the functional structure of the organizational system and the scheme of interconnections between its elements;
- performing linguistic analysis of the functional responsibilities of the system elements to automatically detect possible overlaps and eliminate duplication;

- identifying keywords in functional responsibilities and calculating similarity measures of keyword sets for different elements of the system;
- build membership functions of the influence of elements on the system's activity and the mutual influence between elements;
- use of preferential voting [15] as a tool for determining interchangeability between elements and transferring the performance of certain functions in emergency situations;
- holding competitions to fill vacant positions in order to identify overskills a priori and ensure that the register of additional functions is filled;
- Ensuring confidentiality, equality, and fairness at the initial stages of the competition;
- holding competitions at all possible stages of the HR management cycle – recruiting, adaptation period, determining motivation, replacement if necessary, identifying additional functions, etc.

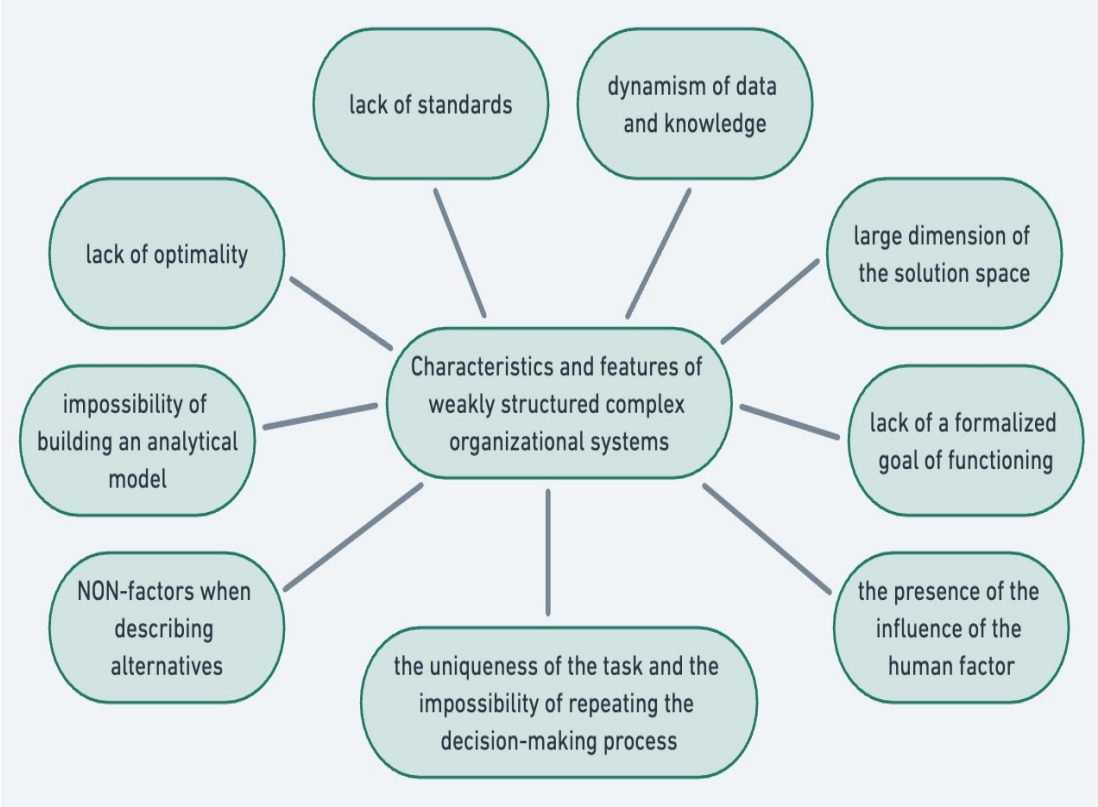

Figure 1: Key characteristics and features of organizational systems

When determining ways to find additional performers of system functions and resources to ensure internal replacement of functions, different sources and different ways to overcome the situation in case of a shortage of performers in emergency situations can be used [25, 26]:

- use of third-party resources;
- combining functions whose emphasized performance can be ignored for some time;
- cancellation of functions whose performance is insignificant compared to the importance of other functions – temporarily, for a specified period or for the entire period of the system's operation;
- temporary reconfiguration of the system – with a certain time of return to the Status Quo, or for an indefinite period;
- delegating to key elements of the system those functions that may not be performed if some elements leave the system, defining the responsibility of key elements of the system for the entire cycle of functioning of their area of responsibility – as the responsibility of department heads for the educational process at the departments;

- temporary consolidation of positions together with the functions performed by the system elements in these positions;
- defining a backup position that can be assigned to functions that are currently out of the system in the event of an emergency;
- application of the strategy of "diffusion of positions" – when the "anti-structure" approach is introduced, i.e., the return of the organizational system to the family stage of functioning;
- generating other unpopular approaches with regular determination of their impact on the functioning of the system as a whole;
- centralization of some families of functions to minimize the efforts of elements and localize responsibility;
- transferring some functions to the online mode by using additional technical means;
- unification of functions to increase the degree of similarity between the functionality of individual elements of the system;
- simplification of functions with a tendency to reduce them to elementary ones in order to increase the number of elements that can replace them.

2.1. Properties of organizational systems

Most organizational systems are reasonably and naturally weakly structured complex systems [27, 28]. This is due to their purpose and conditions of their functioning. In this regard, organizational systems have specifics to ensure their functional sustainability. The main characteristics and features of complex organizational systems are shown in Figure 1.

2.2. Some definitions

Each vector score creates an image of a certain object that has the corresponding properties for the decision maker. The brightest, most contrasting images for experts are those that correspond to only the best and worst scores for all criteria.

Definition 1. The utopian (ideal) point (object, alternative, etc.) is the point a^+ with coordinates $a^+ = \left(\min\limits_{i\in I}\rho_1\omega_1^i, \ldots, \min\limits_{i\in I}\rho_m\omega_m^i\right)$,

where $\rho_j, j \in J$ –are the elements of the vector of parameter weights;

$\omega_j^i, i \in I, j \in J$ –are the normalized values of the characteristics of the alternatives.

Definition 2. The dystopian point (object, alternative, etc.) is the pointa^- with coordinates. $a^- = \left(\max\limits_{i\in I}\rho_1\omega_1^i, \ldots, \max\limits_{i\in I}\rho_m\omega_m^i\right)$

Definition 3: Vector estimates that have only the best and worst values for all criteria are called reference situations.

Definition 4. The rectangle whose vertices are the pointsa^+ anda^- is called the decision utility field.

Definition 5. The values of the elements of the vector $a_i^E, i \in J,-$ are the reference (normative, true, ideal, measured, known, desired, etc.) values of the $i\ -_{\text{th}}$ characteristics of the alternative.

2.3. Hierarchical structure of the organizational system

The mathematical model of the problem of decision coordination in a three-level hierarchical control system is considered, consisting of the following subsystems:

- of one subsystem (SS-H) of the top level (denoted by the index 0);
- n_1 middle-level subsystems (SS-M) isolated from each other with a set of indices ;$I_1 = \{1, \ldots, n_1\}$
- n_2 subordinate systems of the setI_1 of isolated subsystems of the lower level (SS-L) with a set of indices $I_2 = \{n_1 + 1, \ldots, n_1 + n_2\}$.

The scheme of interrelationships between subsystems of different levels of the three-level hierarchical organizational system is shown in Fig. 2.

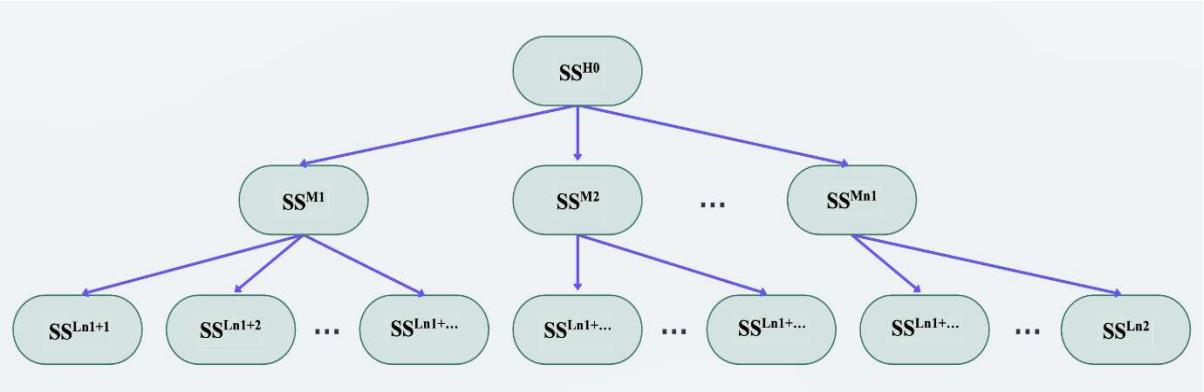

Figure 2: Schematic diagram of the three-level hierarchical structure for ensuring the sustainable functioning of the organizational system

Personnel management in a complex organizational system is a critical and multifaceted task. Figure 3 illustrates the framework and interconnections of personnel management tasks.

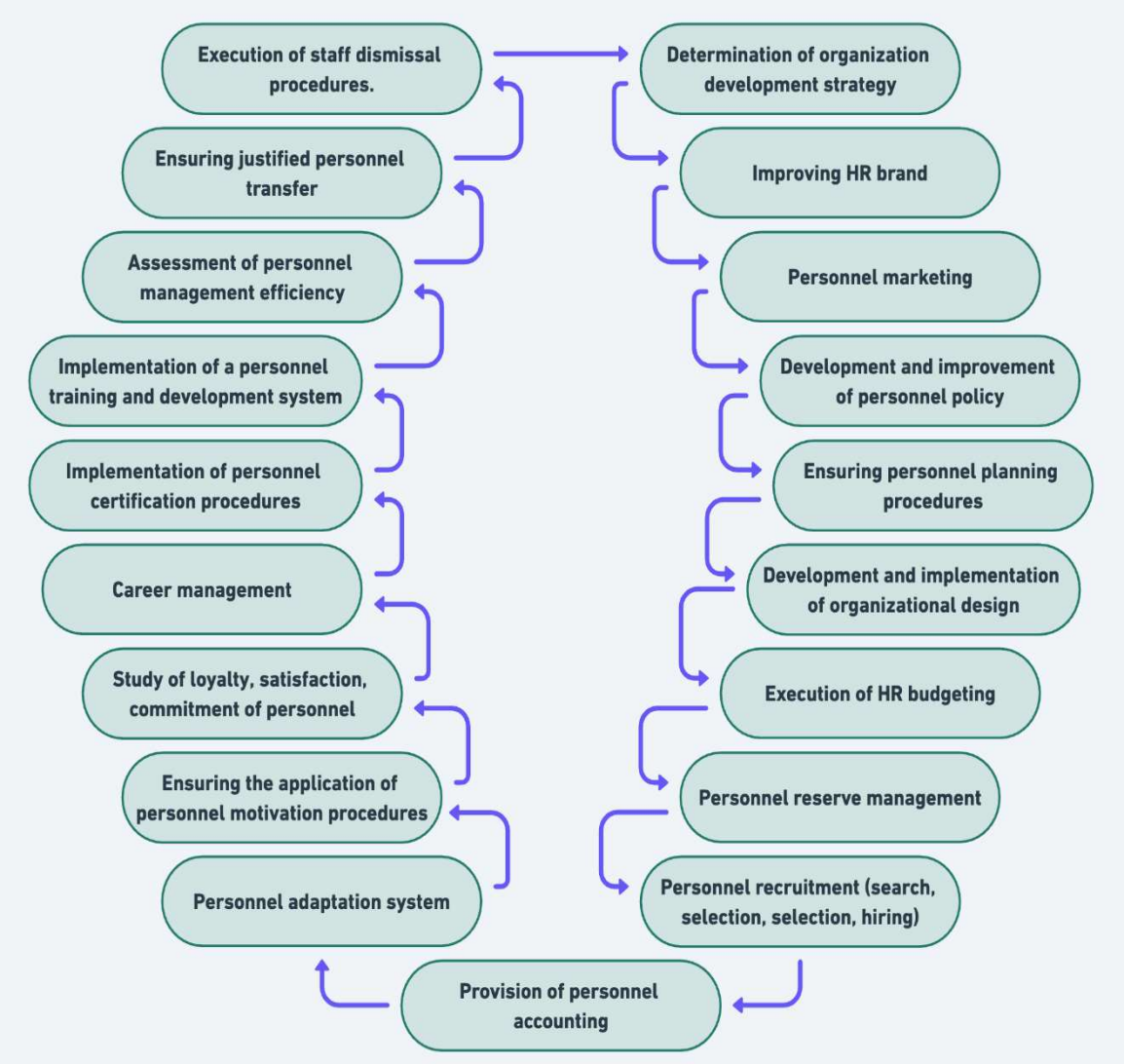

Figure 3: Human resource management scheme of a complex organizational system

2.4. Personnel management of a complex organizational system

An important aspect of ensuring the systematic and sustainable management of a complex hierarchical organizational system is the management of the personnel of this system [29, 30]. This activity of the organizational system is an important element of identifying redundancies in the organizational system and reasonably ensuring a fair assessment of personnel at different parts and stages of the personnel management cycle [31, 32]. Here is a scheme of personnel management of a complex hierarchical organizational system.

2.5. Personnel management of a complex organizational system

Figure 4 shows the main stages of the HRM cycle, which make it possible to best identify, evaluate and accept the excess capabilities of the elements of the organizational system, i.e. its personnel [33, 34]. The stages shown in Figure 4 are key in the preparation of a reliable and up-to-date database and knowledge base that allow to ensure the functional stability of a complex hierarchical organizational system [35, 36].

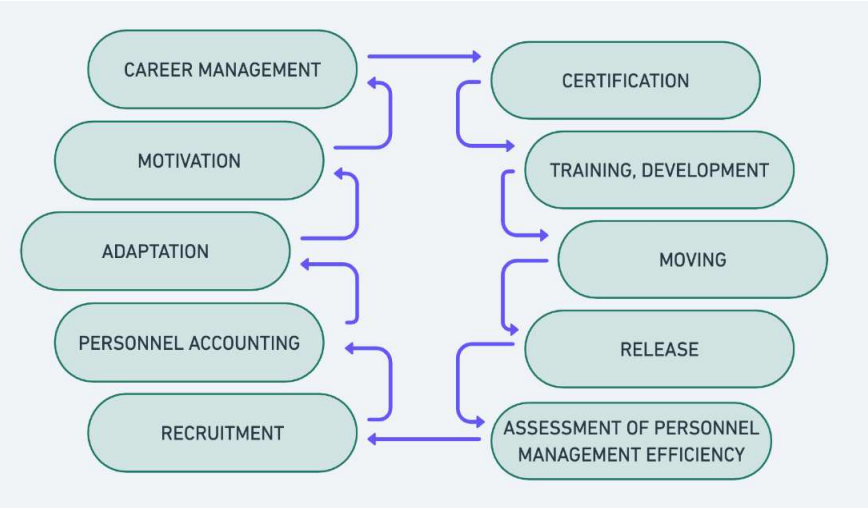

Figure 4: Stages of HR management in a complex organizational system that are key to ensuring functional sustainability

3. Functional sustainability of organizational systems

Let there be a set of indices of information security functions that the system must provide. We will assume that there are$n$. Let us denote the set of all functions performed by the system by ,$A = \{a_1, \dots a_n\} J = \{1, \dots, n\}$. Note that the number of functions of a complex system can be hundreds or thousands of units. The functions performed by different elements of the system are not duplicated, i.e.$n = \sum_{i \in J} n_i$ – each function in the system is unique:$A^{i_1} \cap A^{i_2} = \emptyset, i_1, i_2 \in J$, where$\emptyset -$ is an empty set.

3.1. Causes of disturbances and failures in organizational systems

Complex organizational systems have many peculiarities to ensure their functional sustainability and distinguish them from other complex systems. These features are mainly related to the presence of the human factor. Let's list the main causes of disturbances and possible failures in complex organizational systems that require response and decision-making to ensure functional sustainability:

- are on sick leave;
- are on annual vacation;
- are on unpaid leave;
- sent on a business trip;

- are missing for unknown reasons;
- are on an official vacation;
- dismissed from work for various reasons;
- are violators of labor discipline;
- are on study leave;
- absent due to force majeure;
- are undergoing adaptation and therefore perform their functions poorly;
- involved in conflict situations;
- demotivated employees, etc.

In all of the above cases, the functional stability of a complex hierarchical organizational system will be threatened, since not all functions of the system are performed properly [37]. Moreover, it should be emphasized that in this section we are talking about a systemic organizational system in which most business processes are formalized, mechanisms and procedures for the transfer of functions are provided, etc. [38, 39].

The main way to ensure functional stability is to reconfigure the system. Here is the definition of this action, which is one of the important components of ensuring the functional stability of the organizational system [2, 9].

Reconfiguration is the implementation of an automatic or automated restructuring of the structure of the organizational system's functions and the exchange of information between system elements or a change in the functioning algorithm to achieve the greatest efficiency in achieving the functioning goal with the available system's working resources.

In other words, when some elements of an organizational system fail, the functions they used to perform are taken over by other elements. This redistribution is not done spontaneously, but by evaluating different exchange options, weighing possible consequences, taking into account limitations on the ability of elements to carry additional loads, etc.

3.2. Mathematical model of organizational system functioning

Suppose that a complex organizational system has a matrix of functions performed by the elements of this system:

$$F^i = (f_i^0, f_i^1) \quad (2)$$

where $f_i^0 = \left(f_{ij}^0, j = 1, \ldots, n_i\right), i \in I -$ is the vector of the main functions of the $i -$ th element of the system,

$f_i^1 = \left(f_{is}^1, c_{is}, s \neq j \in \{1, \ldots, n_i\}, s = \{1, \ldots, v_i\}\right), i \in I -$ is the matrix of adjacent functions of the$i -$ th element of the system,

$c_{is}, s \neq j \in \{1, \ldots, n_i\}, s = \{1, \ldots, v_i\}, i \in I -$ the level of quality of performance of $s -$ the related function by i element of the system.

Let $A^i, i \in J$, denote the subset of functions performed by the$i -$ m element of the system.

Heuristic H1. We will assume that the integral quality of the system's functioning is ideal at the time of the start of ensuring its functional sustainability. The ideal integral quality of the organizational system will be denoted by .F^I

Heuristic H2. Interchangeability exists in every organizational system. The quality of replacement of a system element that has temporarily or permanently failed may be critically low and even dangerous for the further functioning of the system. But it always exists and can be classified or digitized, for example, using expert methods.

Heuristic H3. By means of expert evaluation, it is possible to establish the differences in the quality of replacing the performance of any function from the set (1) by the main element of the system with the performance of the same function by some adjacent element in ordinal scales.

3.3. Replacing those functions that have become inactive

Let's assume that for each function, the quality of its performance has been determined by experts

in ordinal scales. For example, let's assume that the information about the quality of a certain function with the index $j, j = 1, \ldots, n$, contains the following ranking:

$$c_{ij} \prec c_{i_1 j} \approx c_{i_2 j} \prec c_{i_3 j} \approx c_{i_4 j} \approx c_{i_5 j} \quad (3)$$

where c_{ij} – is the level of quality of performance by the system element with the index$i, i \in I$, of the function with the index$j, j \in J = \{1, \ldots, n\}$.

Heuristic H4. We will assume that at the initial stage, the elements of the organizational system perform their functions perfectly.

It is known that in expert evaluation tasks there are no standards, only relations between elements are considered.

Heuristic H5. Let's put the vector of indices in accordance with the multiple comparison (3)

$$v_j = (i, i_1, -i_2, i_3, -i_4, -i_5), \quad (4)$$

where$i, i_1, i_2, i_3, i_4, i_5$ – are indexes of elements that can perform a function with an index $j, j \in J$.

Vector (4) corresponds to the following distances to the ideal performance:

$$d_j = \left(d_{i_1 j}, d_{i_2 j}, d_{i_3 j}, d_{i_4 j}, d_{i_5 j}\right). \quad (5)$$

According to heuristic H5, which establishes the form of formula (4), the values of the elements of vector (5) will be as follows:

$$d_{i_1 j} = 1; d_{i_2 j} = 1; d_{i_3 j} = 2; d_{i_4 j} = 2; d_{i_5 j} = 2. \quad (6)$$

Note that the options for performing the function$j, j = 1, \ldots, n$, in the new conditions, taking into account the distances (6), use non-strict rankings (quasi-orders, quasi-series) that set the ratio of preference between the quality of function performance in ordinal scales.

To generate possible options for the configuration of the organizational system in the new conditions, we search for possible options for replacing the element with the index$i, i \in I$, that has failed with an element with an index from the set of elements that are presented in the ranking of the form (2).

Heuristic H6. The quality of organizational system functioning depends on the deviation of the initial "ideal" system configuration compared to the new system configuration generated on the basis of choosing a new option for performing functions by elements.

4. Conclusions

This paper addresses the mathematical support required to ensure the functional stability of complex hierarchical organizational systems. It examines the distinctive characteristics of organizational systems and highlights how they differ from other types of complex systems. The inherent weak structural organization of organizational systems is substantiated. Various strategies for reconfiguring an organizational system in response to abnormal situations are explored, along with potential causes of such situations that necessitate decision-making to maintain the system's functional stability.

The paper proposes evaluating the quality of an organizational system in a newly configured state by measuring its deviation from the initial nominal performance of its elements. Furthermore, the concept of *distance* is introduced to quantify the difference between the initial quality of the organizational system and its proposed new configurations under altered functional conditions.

References

[1] Mashkov Oleh, Bychkov Alexey, Kalahnik Ganna, Shevchenko Victor, Vyshemyrska Svitlana, Application of the Theory of Functional Stability in the Problems of Covering Territories by Sensory Networks, in Lecture Notes in Data Engineering, Computational Intelligence, and Decision Making, 149, 2023.

[2] Oleksandr G. Dodonov, Olena S. Gorbachyk, Maryna G. Kuznietsova Dynamic Reconfiguration in Automated Organizational Management Systems // Selected Papers of the XX International Scientific and Practical Conference "Information Technologies and Security" (ITS 2020). CEUR

Workshop Proceedings (ceur-ws.org). – Vol-2859 ISSN 1613-0073. URL: http://ceurws.org/Vol-2859/paper13.pdf.
[3] Sobchuk, V., Olimpiyeva, Y., Musienko, A., Sobchuk, A. Ensuring the properties of functional stability of manufacturing processes based on the application of neural networks. CEUR Workshop Proceedingssthis link is disabled, 2021, 2845, pp. 106-116.
[4] Hryhorii Hnatiienko, Tetiana Babenko, Larysa Myrutenko, Oleksii Hnatiienko and Yerulan Kurbanbek. Taking into account the Presence of Critical Elements to Ensure the Functional Stability of the Organizational System / CEUR Workshop Proceedings, Volume 3680 // DTESI 2023: Proceedings of the 8th International Conference on Digital Technologies in Education, Science and Industry, December 06-07, 2023, Almaty, Kazakhstan.
[5] Zamrii I. V., Sobchuk A. V., Laptev S. O., Lapteva T. O. Algorithm for Monitoring and Forecasting Functional Resilience of Complex Information-Technical Systems // ISSN 2412-4338 Telecommunications and Information Technologies. 2022. No. 1 (74) - 2022. DOI: 10.31673/2412-4338.2022.010414.
[6] Sanchis R., Poler R.: Definition of a framework to support strategic decisions to improve Enterprise Resilience / IFAC Proceedings Volumes Volume 46, Issue 9, 2013, Pages 700-705.
[7] Openko P. V., Barabash O. V. Analysis of the Place of Functional Resilience in Relation to Known Properties of Information Systems // Modern Trends in Science: Abstracts of the X International Scientific and Practical Internet Conference, April 2-3, 2020. - Dnipro, 2020. - Vol. 2. - 781 pages. - P. 133.
[8] Sabatino M.: Economic crisis and resilience: Resilient capacity and competitiveness of the enterprises / Journal of Business Research Volume 69, Issue 5, May 2016, Pages 1924-1927.
[9] Oleksandr Dodonov, Olena Gorbachyk, Maryna Kuznietsova. Automated Organizational Management Systems of Critical Infrastructure: Security and Functional Stability // Selected Papers of the XXI International Scientific and Practical Conference "Information Technologies and Security" (ITS 2021), Kyiv, Ukraine, December 9, 2021/CEUR Workshop Proceedings, 2021, 3241, pp. 1-12. URL: https://ceur-ws.org/Vol-3241/paper1.pdf.
[10] Volodymyr V. Pichkur, Valentyn V. Sobchuk Mathematical models and control design of a functionally stable technological process // Journal Of Optimization, Differential Equations And Their Applications (JODEA). Volume 29, Issue 1, June 2021, pp. 1-11, DOI 10.15421/141905
[11] Kravchenko, Y., Vialkova, V. The problem of providing functional stability properties of information security systems // Modern Problems of Radio Engineering, Telecommunications and Computer Science, Proceedings of the 13th International Conference on TCSET 2016, 2016, pp. 526-530.
[12] Bykov V. Yu. Models of organizational systems of open education: Monograph - K.: Atika, 2009, - 684 p.
[13] Hnatiienko H., Snytyuk V., Tmienova N., Zatonatskiy D. and Zhylinska O. Mathematical Support of the Task of Determining the Strategic Directions of Development and Priorities of the Organization / CEUR Workshop Proceedings, Volume 3347, Pages 169 - 184, 2022 // 9th International Scientific Conference "Information Technology and Implementation", IT and I 2022, Kyiv, November 30 - December 02, 2022
[14] Hryhorii Hnatiienko, Vladyslav Hnatiienko, Ravshanbek Zulunov, Tetiana Babenko, Larysa Myrutenko. Method for Determining the Level of Criticality Elements when Ensuring the Functional Stability of the System based on Role Analysis of Elementpits / CEUR Workshop Proceedings, Volume 3654, Pages 301 - 311, 2024 // Proceedings of the Workshop Cybersecurity Providing in Information and Telecommunication Systems (CPITS 2024), Kyiv, Ukraine, February 28, 2024.
[15] Hryhorii Hnatiienko, Oleksii Hnatiienko, Oleh Ilarionov, Oleksii Ivanchenko, Vitaliy Snytyuk. The Method of Determining the Priority of Candidates by Means of Preferential Voting Based on an Algebraic Approach / CEUR Workshop Proceedings, Volume 3538, Pages 232-244, 2023 // Selected Papers of the III International Scientific Symposium "Intelligent Solutions" (IntSol-2023). Symposium Proceedings Kyiv - Uzhhorod, Ukraine, September 27-28, 2023.
[16] Hnatiienko, H., Hnatiienko, O., Tmienova, N., Snytyuk, V. Mathematical Model of Management of the Corporate Culture of the Organizational System / CEUR Workshop Proceedings, Volume 3624, Pages 250-265, 2023 // Selected Papers Selected Papers of the X International Scientific

Conference "Information Technology and Implementation" (IT&I-2023). Conference Proceedings. Kyiv, Ukraine, November 20 - 21, 2023.
[17] Babenko, T., Hnatiienko, H., Ignisca, V., Iavich, M. Modeling of critical nodes in complex poorly structured organizational systems // Proceedings of the 26th International Conference on Information Society and University Studies (IVUS 2021), Kaunas, Lithuania, April 23, 2021 / CEUR Workshop Proceedings, 2021, 2915, pp. 92-101.
[18] Maes, G., & Van Hootegem, G. (2019). A systems model of organizational change. Journal of Organizational Change Management.
[19] Ruiz-Martin C., López-Paredes A., Wainer G. What we know and don't know about organizational resilience // International journal of production management and engineering. - 2018. - Vol. 6. - No. 1. - C. 11-28.
[20] Davis, R., & Cates, S. (2018). The Implementation of The Organizational Culture Assessment Instrument in Creating a Successful Organizational Cultural Change. International Journal of Business and Public Administration, 15(1), 71-94.
[21] Nikiforov A. Modeling Complexes of Organizational Management Automated Systems - a Means to Overcome the Management Crisis / Dodonov A., Nikiforov A., Putyatin V., Dodonov V. // Selected Papers of the XIX International Scientific and Practical Conference "Information Technologies and Security" (ITS 2019) Kyiv, Ukraine, November 28, 2019. ISSN 1613-0073 - Vol2577, p. 100 - 115.
[22] Lars Rass, Jan Treur, Wioleta Kucharska, Anna Wiewiora. Adaptive dynamical systems modelling of transformational organizational change with focus on organizational culture and organizational learning. Cognitive Systems Research 79 (2023) 85-108.
[23] Botjes E. A., Mulder H., Nouwens H. Defining antifragility and the application on organization design: - Master Thesis, Antwerp Management School). DOI: 10.5281/zenodo. 3719389, 2020.
[24] Shouvik Sanyal, and Mohammed Wamique Hisam (2018). The Impact of Team Synergy on Work Performance of Employees: A Study of Faculty Members in Dhofar University. IOSR Journal of Business and Management (IOSR-JBM) e-ISSN: 2278-487X, p-ISSN: 2319-7668. Volume 20, Issue 3. Ver. I (March. 2018), Pp. 15-22.
[25] Haack, P., Martignoni, D., & Schoeneborn, D. (2021). A bait-and-switch model of corporate social responsibility. Academy of management review, 46(3), 440-464.
[26] M Clement A. et al. Robustness, resilience: typology of definitions through a multidisciplinary structured analysis of the literature // European Journal of Industrial Engineering. - 2021. - Vol. 15. - no. 4. - C. 487-513.
[27] Marchese D. et al. Resilience and sustainability: Similarities and differences in environmental management applications //Science of the total environment. - 2018. - C. 1275-1283.
[28] Galaitsi S. E. et al. Business continuity management, operational resilience, and organizational resilience: Commonalities, distinctions, and synthesis //International Journal of Disaster Risk Science. - 2023. - Vol. 14. - no. 5. - C. 713-721.
[29] Dodonov, A., Lande, D., Tsyganok, V., Andriichuk, O., Kadenko, S., Graivoronskaya, A.: Information Operations Recognition. From Nonlinear Analysis to Decision-Making. Lambert Academic Publishing, (2019).
[30] Tengblad S., Oudhuis M. A Theoretical Framework for Organizational Resilience //Lisbon. - 2019.
[31] Voloshyn O.F., Mashchenko S.O. Decision-making models and methods: teaching. manual for students higher education closing / Voloshyn O.F., Mashcenko S.O. - 3rd ed. - K.: Lyudmila Publishing House, 2018. - 292 p.
[32] Hryhorii Hnatiienko, Tetiana Babenko. Quantitative Assessment of the Criticality Level of Organizational System Elements / CEUR Workshop Proceedings, Volume 3503, Pages 62-81, 2022 // Selected Papers of the XXII International Scientific and Practical Conference "Information Technologies and Security" (ITS 2022) Kyiv, Ukraine, November 16, 2022.
[33] Palko, D. at al. Cyber Security Risk Modeling in Distributed Information Systems. Applied Sciences (Switzerland) 2023, *13*, 2393. https://doi.org/10.3390/app13042393
[34] Babenko, T., Hnatiienko, H., Bigdan, A. Model for determining the protection level of a complex system / CEUR Workshop Proceedings, Volume 3132, Pages 156 - 165, 2022 // 8th International Scientific Conference "Information Technology and Implementation", IT and I 2021, Kyiv, December 1, 2021 through December 3, 2021, Code 179050.

[35] Bozóki Sándor & Tsyganok Vitaliy The (logarithmic) least squares optimality of the arithmetic (geometric) mean of weight vectors calculated from all spanning trees for incomplete additive (multiplicative) pairwise comparison matrices International Journal of General Systems. 2019. Vol.48, No.4. P.362-381.
[36] N. F. Mahad, N. Mohamed Yusof and N. F. Ismail. The application of fuzzy analytic hierarchy process (FAHP) approach to solve multi-criteria decision making (MCDM) problems. 12th Seminar on Science and Technology Journal of Physics: Conference Series 1358 (2019) 012081 IOP Publishing doi:10.1088/1742-6596/1358/1/012081. To cite this article: N F Mahad et al 2019 J. Phys: Conf. Ser. 1358 012081.
[37] Cao, PP, Zheng, J., Wang, S. et al. Large group decision-making considering multiple classifications for participants: a method based on preference information on multiple elements of alternatives. Complex Intell. Syst. (2023). https://doi.org/10.1007/s40747-023-01209-x
[38] Palko, D., Hnatienko, H., Babenko, T., Bigdan, A. Determining key risks for modern distributed information systems // Proceedings of the II International Scientific Symposium "Intelligent Solutions" (IntSol-2021), Kyiv - Uzhhorod, Ukraine, September 28-30, 2021 / CEUR Workshop Proceedings, 2021, 3018, pp. 81-100.
[39] Hnatiienko, H., Snytyuk, V., Tmienova, N., Voloshyn, O. Determining the effectiveness of scientific research of universities staff / CEUR Workshop Proceedings, Volume 2833, 2021, Pages 164-176 // 7th International Conference ""Information Technology and Interactions"", IT and I 2020; Kyiv; Ukraine; 2 December 2020 through 3 December 2020; Code 167962