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THE VIABILITY AS AN EMERGENT PROPERTY OF SELF-ORGANIZING SYSTEMS

The necessity of a man-machine system considering as a self-organizing one is shown. The most significant difficulty in such a system is the study of its emergent properties. The paper focuses on viability as an emergent property of the system. The concepts of hardiness, human factor, system resources, biosystem were considered. It allowed proposing the viability's concept of a self-organizing system based on biomimetics principles. The roadmap of convergent research and analysis of the man-machine system's viability is presented. The convergent approach to the self-organizing system's viability is realised in the proposed roadmap.

Keywords: *viability, self-organizing system, man-machine system, emergence, hardiness, human factor, resources.*

Introduction

The problem of forecasting man-machine systems' functioning is one of the critical issues today to ensure the safety of complex objects of any purpose (complex technical, social, economic and other systems). The problem is formed by the intersection of interrelated subproblems, including:

– individuality (physiological, psychological, professional, etc.) of the person that makes a decision in the system;

– significant amounts of information, its diversity, the complexity of processing and display to ensure the functioning of the man-machine system;

– the presence of latent states and risks to the functioning of elements of man-machine systems, etc.

However, the greatest difficulty is researching and considering man-machine systems' emergent properties because they arise due to the interaction of structural elements of the system - man, machine and environment - and are not additive. It should be noted that today in the arsenal of ergonomics, engineering psychology, occupational physiology and other scientific areas, there are a large number of methods that study the various properties of man-machine systems. Their primary purpose is to determine the degree of conformity of the man-machine system's certain elements to human capabilities to ensure coherence between them. Ultimately, we assess the convenience and safety of individual components, not the system as a whole. However, today, to effectively manage the system and ensure its operation's safety, it is necessary to evaluate its emergent properties such as viability, reliability, etc. And in this case, the man-machine system is better to study and analyse as a self-organizing system. The estimation of the emergent properties of a self-organizing system allows:

– to analyse the interaction of the system with the external environment;

– to research the internal structure of the system and the hidden connections that affect the reliability of operation;

– evaluate the system's integral properties, such as efficiency, usefulness, self-organization, controllability, reliability, resistance to interference, etc.

In the frames of the classical approach to assessing the safety of the man-machine system [1-3], we receive only some of the above results, which reduces research reliability.

Therefore, today there is a new stage of interest in the concept of "viability" and the development of the theory of viability of self-organizing systems: the viability of sensors in extreme conditions, the viability of economic and social networks, metal structures, human and technical complexes in complex conditions. It happens because viability is an emergent property of the system that covers system-forming factors and hidden interconnections [4, 5]. Thus, viability holistically reflects the efficiency and optimality of a self-organizing system's functioning. In practice, viability is the ability of a system to retain the properties required for operation under unfavourable conditions that don't appear under the regular operating mode (for technical systems) and can cause damage (failure) of system elements. Moreover, viability as an emergent property of the system can explain the phenomenon of "human factor" and many failures in complex systems guided by humans.

Viability (as an emergent property of self-organizing systems) cannot be considered without

studying the resources that affect self-organizing systems' elements and determine their reliability. The application of a resource strategy is necessary to analyse and describe a self-organizing system's functioning through the coordination and distribution of system resources between its elements to ensure its goals.

The Problem Formulation

Thus, there is an apparent **systemic contradiction** in the study of self-organizing systems: a divergent estimation of self-organizing systems using various often unrelated characteristics. However, in this case, there's necessary to use a convergent approach that considers the system's emergent properties, which play an essential role in ensuring the system's security.

The purpose and objectives of the article

In this regard, **research work aims** to develop a concept of the convergent study of a self-organizing system's viability as an emergent property.

Discussion of Results

Viability of self-organizing systems: human factor and human resources. The term "Viability" is used by various sciences. There are several definitions of this concept and related concepts of "hardiness", "resilience", "stamina" in the works of W. Ashby, A. Bogdanov, I. Schmalhausen, E. Durkheim and others, namely:

– in the works of W. Ashby, viability is the ability of the system to maintain its characteristics within specified limits;

– in Bogdanov's research, viability is dynamic stability in average environmental conditions;

– from Khazov's and Razumovsky's point of view, viability is a combination of the system's stability and its adaptability, its self-identity and conformity, usefulness, suitability, optimality and nonoptimality;

– Makhnach considered viability as "a person's ability to manage own resources: health, emotional, motivational, volitional, cognitive spheres, in the context of social, cultural norms and environmental conditions";

– Laktionova considers viability as "the ability of a person or group to develop despite destabilising events and difficult living conditions";

– in the ergonomic sense, viability is a property that combines the system's stability and adaptability and ensures its safety, reliability, and optimality.

Thus, the functioning and properties components of the self-organizing system determine its viability that, in turn, defines its emergence. Accordingly, arises the problem of choosing the research methods, analysis and evaluation of viability.

Literary research on this issue has shown that today in the study of the self-organizing systems' viability, the emphasis is on determining the human's viability as a key link [6, 7]. Still, it is only one element, not the system in the whole. And here, it is necessary to mention the principle of emergence, which is to search the object's unique properties (in this case, viability), to find out their sources (external and internal), to understand their genesis [8]. Thus, it is important to find such properties of each component - man, machine and environment – that affect the formation of the self-organizing system's viability as a whole.

Human as the self-organizing system's component has many properties and characteristics (stress resistance, resistance to physical and mental fatigue, resistance to monotony, etc.). They, in a specific manner, affect the formation of system viability. However, hardiness is worth special attention because it is a human's integral characteristic, which allows him to resist situations and overcome life's difficulties, transforming them into a situation of development [9, 10]. Hardiness is a crucial person's trait that mediates the impact of stressors, allows you to cope with distress effectively and always in the direction of personal growth, and is closely related to self-motivation. Thus, human's hardiness has a direct impact on the development of a self-organizing system.

Human's resources determine his hardiness. Today there are different views on the definition of this concept. Still, in the frame of work, human's resources are the whole set of available material and nonmaterial, external and internal means to ensure his performance in various conditions [11].

An essential condition for effective human development and increasing his hardiness is the investment of his own resources. Resources investment creates conditions under which a person to obtain new resources and use existing ones. Thus, there is a so-called "resources cycle" from the efficiency of which depends on the level of human hardiness. However, most people invest their resources intuitively, which can lead to both positive and negative results. The negative consequences lead to the depletion of the resource, are the cause of human's stressful conditions leading to his erroneous actions and dangerous situations. The constant transformation of requirements to the human increases the likelihood of dangerous situations. In this regard, the formation of human skills in managing his resources is necessary for creating new approaches to ensuring the human's hardiness as an element of complex man-machine systems. This skill will allow the human to determine what resources he needs for further development.

The role of technology in the self-organizing system functioning is to increase human activity efficiency. Therefore, technology should be comfortable and safe to operate that is realized in its ergonomic characteristics. For today, there are a lot of studies that assess the impact of technology's ergonomic characteristics on the man-machine system functioning. The primary purpose

of such researches is to establish which technology's characteristics need to be changed to reduce the possible negative consequences of their impact on the system's functioning. Based on the research results that were conducted over the past decade [12, 13], we established the following pattern: the most significant increase in the self-organizing system's viability occurs when the ergonomic machine's properties optimal suit the human's natural physiological and mental characteristics.

Another component of a self-organizing system – the environment - is often studied according to the established list of indicators such as air temperature, relative humidity, the illumination level of the work surface, noise and vibration levels, electromagnetic fields and radiations, etc. [14]. However, in recent years, the working environment ecologization issue got widespread, which led to new environmental safety assessment indicators determining the impact of ecological conditions on the employee [15-17]. Moreover, today it makes sense to talk about the working environment eco-friendliness as an integral characteristic because, for completeness of information, it must assess both traditional environmental factors (temperature, humidity, etc.) and new (eco-friendliness of elements and characteristics workplace). Thus, we can talk about eco-friendliness as a property that affects a self-organizing system's viability formation.

Human factor. The analysis of the self-organizing system's viability gets to take into account the transition from Industry 4.0 to Industry 5.0. A matter of common knowledge that Industry 4.0 is a man-machine interaction in which a human makes decisions; Industry 5.0 is an era of intelligent automation when there is not just man-machine interaction, but man-machine unification. At the same time, in Industry 5.0, human no longer has a priority role in decision-making. It leads to the problem of human perception of control decisions by artificial intelligence. Nevertheless, the combination of human's capabilities with intelligent systems allows using a human's mental potential and creative abilities to improve a self-organizing system's efficiency. However, it can provoke severe problems in man-machine interaction in a few years because of the too-close intertwining of human and machine, the diffuseness of the boundaries between human and technical solutions. It complicates the understanding of whether there is human error or technical miscalculation. As a consequence of man-machine interaction's complexity, most of the properties of self-organizing systems will become emergent; it highlights the need for their study and analysis.

Thus, viability is an emergent property of a complex self-organizing system, determined by human hardiness, the ergonomics and eco-friendliness of the environment and the degree of manifestation of the phenomenon of the human factor (Fig. 1).

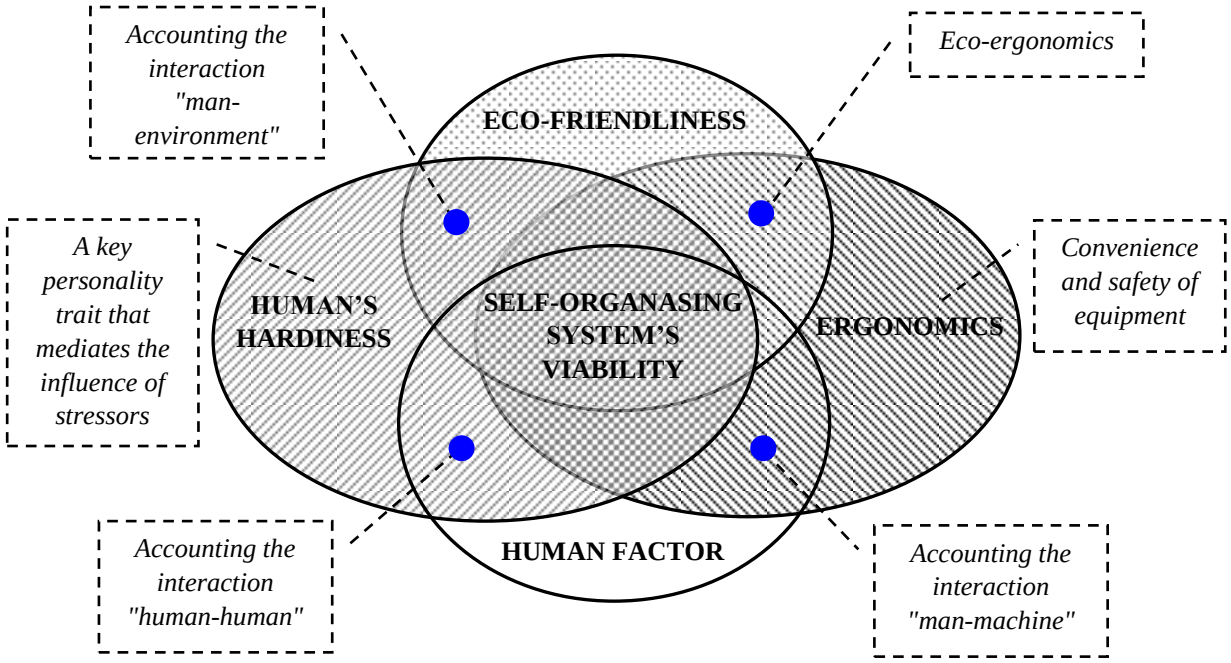

Fig. 1. Viability as an emergent property of a self-organizing system

Resource strategy and self-organizing system's viability. Resource strategy refers to strategic management. Strategic proactive management in man-machine systems is the pledge to safety because it allows mastering the human factor impact on the system's viability and the efficiency of its operation. Fig. 2 shows a schematic diagram of the structure and relationships of the self-organizing system's resources, the human factor and their impact on its viability.

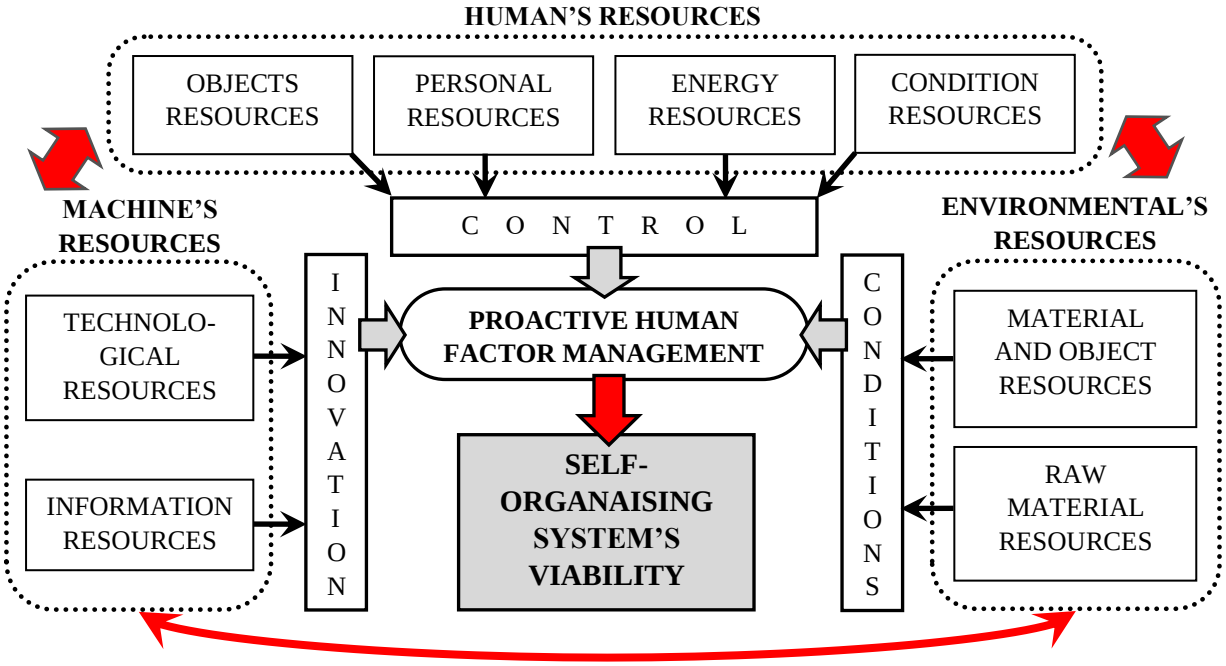

Fig. 2. Resources of the self-organizing system, human factor and viability

Based on the laws of efficiency of the "resources cycle" and human factor management shown in Fig. 2, a matrix for determining the self-organizing system's viability is proposed (Fig. 3).

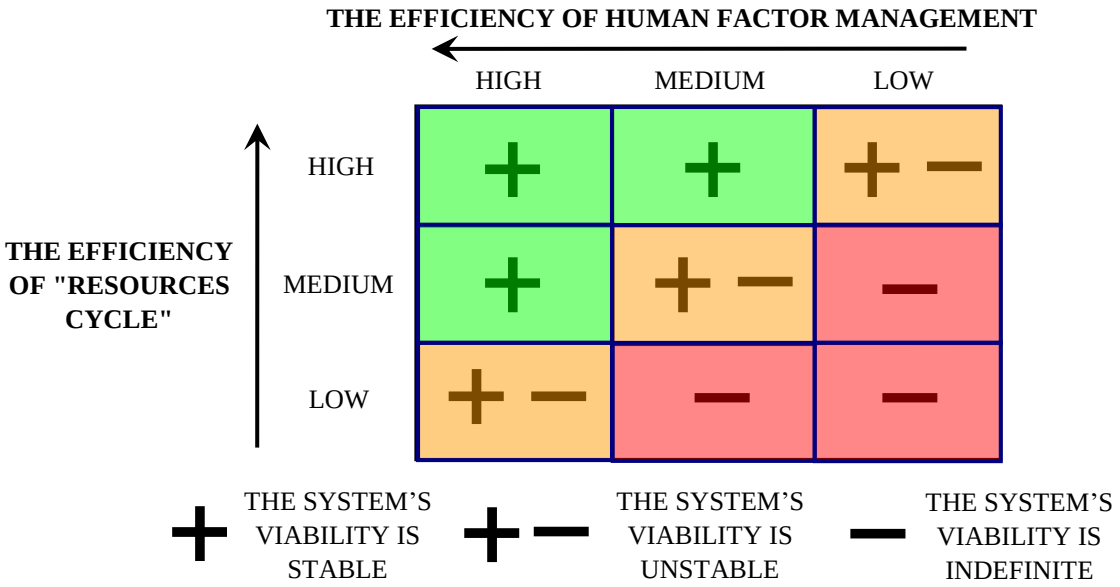

Fig. 3. Matrix for determining the self-organizing system's viability

Thus, the resource management strategy allowed us to propose the concept of the self-organizing system's viability researching as its emergent property based on biomimetics principles.

It is a new view on self-organizing systems from the standpoint of evaluating their emergent properties, which they get through the combination of resources and competencies, in contrast to the classical ergonomics approach to man-machine systems, which evaluates only specific properties of the system's components. The essential concept's difference is applying universal nature principles, natural science principles to complex information and communication man-machine systems. The basic principle of natural processes and phenomena is to counteract external influences and coordinate the activities of all components of the natural environment so that their interaction gives: the possibility of developing systems, some activity result and, the essential, ensure survival. Survival is a crucial problem of complex systems, so much attention is paid to the development of reliability, fault tolerance, safety, viability and dependability theories. Key provisions of the concept:

– research and analysis of the man-machine system as a self-organizing system, the main characteristics of which are openness, nonlinearity and dissipation;

– accounting the biological principles of man-machine system existence and functioning, the application of the principles of human factors engineering to increase the system's viability;

– design of the human-machine system through the selection the most effective for its options for resources convergence of its components, i.e. to coordinate the activities of the system's elements so that their resources would be fully involved, but would not reach a depletion state and constantly renewed;

– evaluation of the man-machine system not from the standpoint of its current efficiency, but in terms of the possibility of effective operation for a long time under the condition of harmonious interaction of its components;

– determining the optimal level of the system's viability and, if necessary, the most appropriate ways to adjust it. In this case, it is meant that the system gets to have a certain inherent only its viability level, i.e. it is necessary to find for it "golden intersection". Otherwise – a significant decrease or increase in the system's viability can lead to unpredictable negative consequences.

Note that, within the concept, the study of the complex system's viability should be performed accounting the existence of human in this system. Let's analyse self-organizing systems through the prism of human factor engineering.

As noted above, the system's viability problem is an issue of the human factor, an essential aspect of which is the human's viability. Human viability is a human reserves and resources system considering in the framework of bio-genetic, psychological and environmental contexts. Viability is the harmony of the coexistence of multilevel properties, in which some defects of lower-level properties are compensated by higher-level properties [18]. Human's viability can eliminate risks in a complex system; however, the human himself brings into the system unpredictability by his mistakes.

Human error is one of the crucial causes of risky events. Individual and systemic approaches are used in human factor management today. According to the individual approach, dangerous actions occur primarily due to aberrant mental processes and countermeasures aimed mainly at reducing unwanted human behaviour changes. According to the system approach, errors are a consequence of system problems in the system's organisational structure. The central idea of prevention is the idea of systemic protection. For example, according to the Swiss cheese model, the system's design involves the detection of possible hidden failures and the creation of a structure where human error is impossible or not a threat. This model of mastering the human factor is the basis for Japanese strategies for quality assurance: Total Quality Management, lean production, Six Sigma, Kaizen and Kairyo, Gemba Kaizen, Method 5S. All these strategies are based on the principle of human actions total management to avoid mistakes. And this is the problem because a person in the system should not make decisions that are not provided by the regulations. According to clear instructions and the lack of ability to make independent decisions, human activity in the system is a rigidly ordered system (equilibrium), which over time tends to self-destroy. That is why the above models of man-machine systems do not work today and do not give the same result as a few decades ago. The modern man-machine system must be self-organizing. It gives the system the opportunity for constant development and ensuring readiness for constant transformations under external and internal stressors. Just as the biological system "human's organism" exists through the processes of homeostasis, adaptation and compensation, providing dynamic equilibrium, so modern man-machine system must be designed to ensure balance under conditions of constant fluctuations state and influences. Under such conditions, the man-machine system can function effectively for a long time, independently determining the critical moments in work and levelling them, just as it happens in natural ecosystems.

Thus, research and analysis of man-machine systems' human factor problem prove the need to move from considering the man-machine system as a rigidly ordered system to a self-organizing system. It can be done using biomimetics, which aims to analyse the principles of living systems' structural and functional organisation to use their formation's laws and principles to create the most optimal solutions. The main focus is on identifying the essential functional dependencies and principles of survival, self-renewal, redundancy, which provide biosystems with flexibility and survivability in difficult living conditions [18]. In this context, self-organizing systems' emergent properties are key to ensuring their continuous development and survival. The principles of self-similarity and natural harmony, structuring forms and processes, open new possibilities. It manifests in the arise of such areas as biodesign, biosystem design, nanobiodesign, biocybernetics, information visualization using natural analogues and adaptive properties of systems [18]. Of the existing types of biomimetics – biological, theoretical and technical – the most significant interest is technical because it allows us to create models for solving engineering problems. In work, we apply the technical biomimetics principles to increase the man-machine system's viability and, accordingly, optimise the man-machine system elements' interaction. Based on this, within the framework of the developed concept of the self-organizing system's viability study, a roadmap of convergent study and analysis of the man-machine system's viability was developed (Fig. 4).

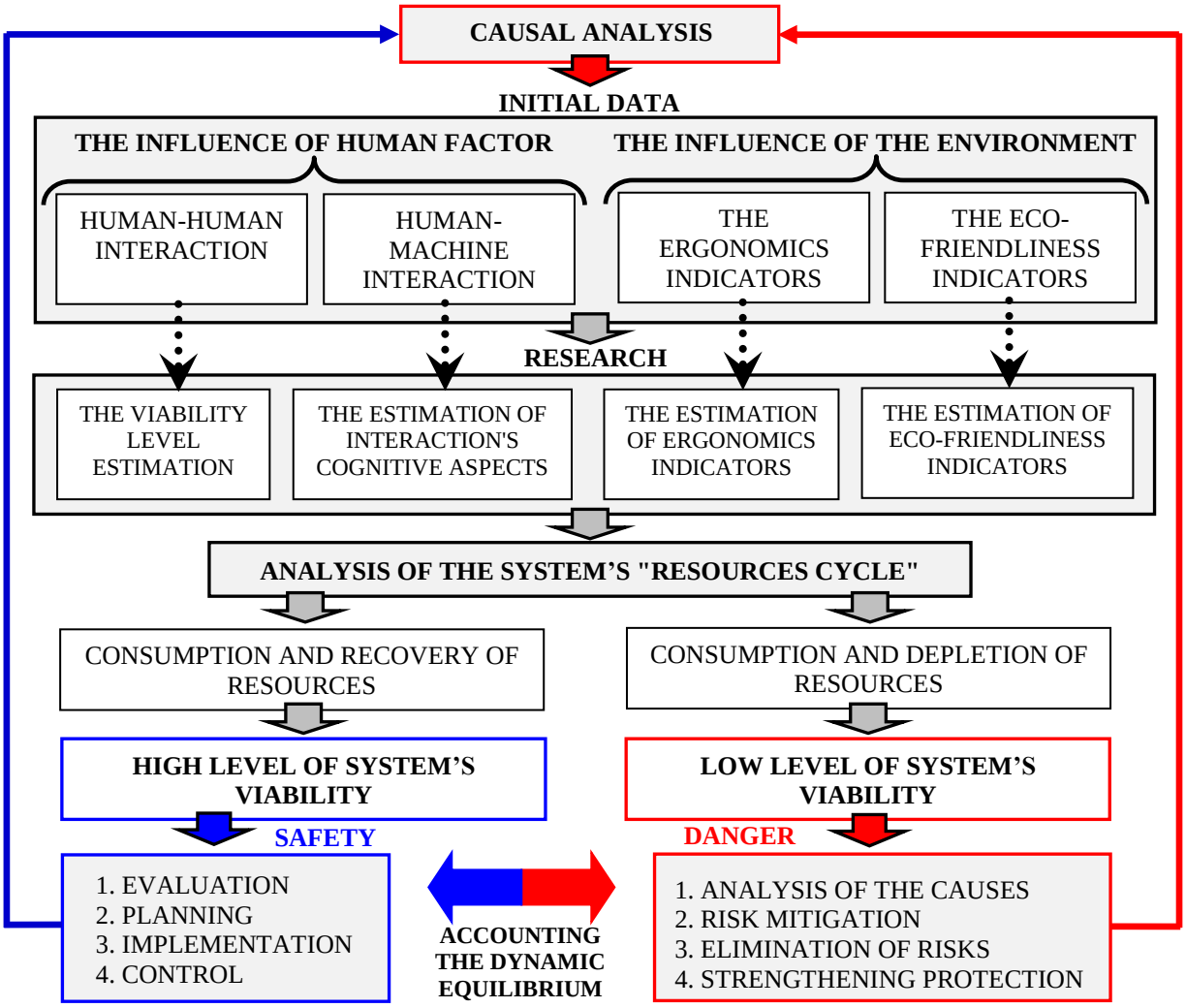

Fig. 4. The roadmap of convergent study and analysis of the man-machine system's viability

The roadmap of convergent study of the self-organizing system's viability allows realising a systematic assessment of the system's components that determine the system's viability, analyse system's resources and, by the results, choose the further direction of the system development. Disclosure of methods and criteria for assessing the system's ergonomics and eco-friendliness characteristics, man-machine interaction's risks, and the cognitive aspects of human-human interaction was not the purpose of work. However, it should be noted that the concept and methods were tested, and they proved effectiveness. Approbation was conducted at the workplaces of the following employees: bank branch operators (15 employees); employees of the personnel department and accounts department of the industrial enterprises (36 employees); university students (300 students).

The study was conducted three years in a row to obtain adequate results. It gave the following results:

– approbation of the method in workplaces related to the use of computers revealed direct correlations: a) between human viability and ergonomics of technology (correlation coefficient r-Spearman = 0.87); b) between human viability and eco-friendliness (r-Spearman correlation coefficient = 0.92); c) between the efficiency of the "human resources cycle" and the ergonomics of technology (r-Spearman correlation coefficient = 0.88); d) between the efficiency of the "human resources cycle" and eco-friendliness (r-Spearman correlation coefficient = 0.85). It confirmed the assumption that viability is an emergent property of a self-organizing system.

– using of methods for estimating the eco-friendliness and ergonomics of the workplace, the viability and "human resources cycle" to assess different types of complex man-machine systems allowed to work out their mechanism and make the necessary adjustments to improve their accuracy;

– collected data on how the viability of a complex self-organizing system changes under the influence of various factor that can be used to predict the system development trajectory.

Conclusions

The essential idea of work is to look at the man-machine system as a self-organizing system that is open,

nonlinear and dissipative. The most significant difficulty in such a system is the study of its emergent properties because they arise due to the interaction of all structural elements of the system – human, machine and environment – and are not additive. Any man-machine system has many emergent properties, but the work was focused on viability. It allows covering the system-forming factors and hidden relationships in the system, reflects the efficiency and optimality of the self-organizing system fully. Also, the viability as a system's emergent property can explain the existence of the "human factor" phenomenon and many failures in complex systems controlled by a human.

Information search on this issue revealed a systemic contradiction in the study of self-organizing systems is a divergent assessment of self-organizing systems using different and often unrelated characteristics, while a convergent approach is needed accounting for the system's emergent properties, which play a key role in ensuring system's safety. To resolve this contradiction, the viability concept, human factor, system resources were studied. It allowed proposing the concept of viability as an emergent property of a self-organizing system based on biomimetics principles. The concept is based on the resource strategy of a self-organizing system and the biomimetics principles. They are aimed to analyse the principles of living systems' structural and functional organisation to use the laws and principles of their formation to create the most optimal solutions. The roadmap for convergent research and analysis of the man-machine system's viability, which implements a convergent study of the self-organizing system's viability, allows us to assess the components that determine the system's viability, analyse system resources and, by the results, choose the system's development trajectory.

Література

1. Kleiner B.M. Macroergonomics: Analysis and design of work systems / B.M. Kleiner // Applied Ergonomics. – 2006. – Vol. 37, Is. 1. – P. 81–89.

2. Wilson J.R. Fundamentals of systems ergonomics/human factors / J.R. Wilson // Applied Ergonomics. – 2014. – Vol. 45, Is. 1. – P. 5–13.

3. Carayon P. Human factors of complex sociotechnical systems / P. Carayon // Applied Ergonomics. – 2006. – Vol. 37, Is. 4. – P. 525–535.

4. Johnson Ch.W. What are emergent properties and how do they affect the engineering of complex systems? / Ch. W. Johnson // Reliability Engineering & System Safety. – 2006. – Vol. 91, Is. 12. – P. 1475–1481.

5. Kalantari S. Emergence phenomena in self-organizing systems: a systematic literature review of concepts, researches, and future prospects / S. Kalantari, E. Nazemi, B. Masoumi // Journal of Organizational Computing and Electronic Commerce. – 2020. – № 3. – P. 224–265.

6. Махнач А.В. Жизнеспособность человека как предмет изучения в психологической науке / А.В. Махнач // Психологический журнал. – 2017. – Т. 38, № 4. – С. 5–16.

7. Лактионова А.И. Структурно-уровневый анализ феномена жизнеспособности человека / А.И. Лактионова // Институт психологии Российской академии наук. Организационная психология и психология труда. – 2017. – Т. 2, № 4. – С. 106–133.

8. Коросов А.В. Принцип эмерджентности в экологии / А.В. Коросов // Принципы экологии. – 2012. – № 3. – С. 48–66.

9. Maddi S.R. Hardiness and Mental Health / S.R. Maddi, D.M. Khoshaba // Journal of Personality Assessment. – 1994. – Vol. 63, № 2. – P. 265–274.

10. Nayyeria M. Prediction well-being on basic components of hardiness / M. Nayyeria, S. Aubia // Procedia – Social and Behavioral Sciences. – 2011. – Vol. 30. – P. 1571–1575.

11. Protasenko O.F. Human Resources Are a Factor in Applying of Man-Machine Systems Safety / O.F. Protasenko, G.V. Mygal // Комунальне господарство міст. – 2020. – Том 6, Вип. 159. – С. 139–146.

12. Raziqa A. Impact of Working Environment on Job Satisfaction / A. Raziqa, R. Maulabakhsh // Procedia Economics and Finance. – 2015. – № 23. – P. 717–725.

13. Garbie I.H. An experimental investigation on ergonomically designed assembly workstation / I.H. Garbie // International Journal of Industrial and Systems Engineering (IJISE). – 2014. – Vol. 16, № 3. P. 296–321.

14. Parsons K.C. Environmental ergonomics: a review of principles, methods and models / K.C. Parsons // Applied Ergonomics. – 2000. – Vol. 31, Is. 6. – P. 581–594.

15. Мигаль Г.В. Проблеми сучасної ергономіки: визначення структурної надійності / Г.В. Мигаль, О.Ф. Протасенко // Комунальне господарство міст. – 2019. – Том 5, Вип. 151. – С. 81–86.

16. Мигаль Г.В. Нові поняття сучасної ергономіки / Г.В. Мигаль, О.Ф. Протасенко // Открытые информационные и компьютерные технологии – 2018. – Вып. 79. – С. 162–171.

17. Протасенко О.Ф. Дослідження й аналіз показників екологічності робочого середовища / О.Ф. Протасенко // Комунальне господарство міст. – 2017. – Вип 7 (146). – С. 127–132.

18. Мигаль С.П. Біоніка в дизайні просторово-предметного середовища : навч., посібник / С.П. Мигаль, І.А. Дида, Т.Є. Казанцева. – Львів : Видавництво Львівської політехніки, 2014. – 228 с.

References

1. Kleiner, B.M. (2006). Macroergonomics: Analysis and design of work systems. *Applied Ergonomics, 37 (1),* 81–89.

2. Wilson, J.R. (2014). Fundamentals of systems ergonomics/human factors. *Applied Ergonomics, 45 (1),* 5–13.

3. Carayon, P. (2006). Human factors of complex sociotechnical systems. *Applied Ergonomics, 37 (4),* 525–535.

4. Johnson, Ch.W. (2006). What are emergent properties and how do they affect the engineering of complex systems? *Reliability Engineering & System Safety, 91 (12),* 1475–1481.

5. Kalantari, S. (2020). Emergence phenomena in self-organizing systems: a systematic literature review of concepts, researches, and future prospects. *Journal of Organizational Computing and Electronic Commerce, 3,* 224–265.

6. Makhnach, A.V. (2017). Human resilience as a research object in psycology. *Psycologycal journal,* 38 (4), 5–16.

7. Laktionova, A.I. (2017). Structural-level analysis of resilience phenomenon. *Scientific e-JOURNAL "Institute of*

psychology Russian Academy of Sciences. Organizational Psychology and Labor Psychology", 2 (4), 106–133.
8. Korosov, A. (2012). An emergent principle in ecology. *Principles of the Ecology, 3,* 48–66.
9. Maddi, S.R., & Khoshaba, D.M. (1994). Hardiness and Mental Health. *Journal of Personality Assessment, 63 (2),* 265–274.
10. Nayyeria, M., & Aubia, S. (2011). Prediction well-being on basic components of hardiness. *Procedia – Social and Behavioral Sciences, 30,* 1571–1575.
11. Protasenko, O.F., & Mygal, G.V. (2020). Human Resources Are a Factor in Applying of Man-Machine Systems Safety. *Municipal economy of cities, 6 (159),* 139–146.
12. Raziqa, A., & Maulabakhsh, R. (2015). Impact of Working Environment on Job Satisfaction. *Procedia Economics and Finance, 23,* 717–725.
13. Garbie, I.H. (2014). An experimental investigation on ergonomically designed assembly workstation. *International Journal of Industrial and Systems Engineering, 16 (3),* 296–321.
14. Parsons, K.C. (2000). Environmental ergonomics: a review of principles, methods and models. *Applied Ergonomics, 31 (6),* 581–594.
15. Protasenko, O.F., & Mygal, G.V. (2019). The issues of the modern ergonomics: the structural reliability definition. *Municipal economy of cities, 5 (151),* 81–86.
16. Protasenko, O.F., & Mygal, G.V. (2018). New concepts of modern ergonomics. *Open information and computer integrated technologies, 79,* 162–171.
17. Protasenko, O.F. (2017). Ergonomics aspects of ecological safety. *Municipal economy of cities, 7 (146),* 127–132.
18. Mygal, S.P., Dyda, I.A., & Kazanceva, T.E. (2014). Bionika v dizajni prostorovo-predmetnogo seredovishcha. *Vidavnictvo L'vivs'koï politekhniki*, 228 p.

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ЖИТТЄЗДАТНІСТЬ ЯК ЕМЕРДЖЕНТНА ВЛАСТИВІСТЬ САМООРГАНІЗОВАНИХ СИСТЕМ

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Основна ідея роботи – погляд на людино-машинну систему як на самоорганізовану систему, яка є відкритою, нелінійною і дисипативною. Найбільшу складність у такій системі становить дослідження її емерджентних властивостей, оскільки вони виникають унаслідок взаємодії усіх структурних елементів системи – людини, техніки і середовища – і не є адитивними. Будь-яка людино-машинна система має цілу низку емерджентних властивостей, проте у роботі увагу сфокусовано на життєздатності, оскільки вона дозволяє охопити системоутворюючі чинники та приховані взаємозв'язки у системі, цілісно відображає ефективність і оптимальність функціонування самоорганізованої системи. Також життєздатність як емерджентна властивість системи здатна пояснити існування феномену "людського чинника" та значної кількості відмов у системах, що керуються людиною. Аналітичне вивчення цього питання дало змогу виявити системне протиріччя в дослідженні самоорганізованих систем – дивергентне оцінювання самоорганізованих систем, за допомогою різноманітних і часто не пов'язаних характеристик, тоді як необхідним є конвергентний підхід з урахуванням емерджентних властивостей системи, які відіграють ключову роль у забезпеченні безпеки функціонування системи. Для вирішення цього протиріччя досліджено поняття життєздатність, людський чинник, ресурси системи, що дозволило запропонувати концепцію життєздатності як емерджентної властивості самоорганізованої системи на основі принципів біоміметики. У концепції поєднано ресурсну стратегію самоорганізованих систем і принципи біоміметики, спрямовані на аналіз принципів структурно-функціональної організації живих систем з метою використання законів і принципів їх формотворення для створення найбільш оптимальних рішень. Дорожня карта конвергентного дослідження й аналізу життєздатності людино-машинної системи, у якій реалізовано конвергентне дослідження життєздатності самоорганізованої системи, дозволяє системно оцінити складові, які визначають життєздатність системи, проаналізувати ресурси системи і обрати подальший напрямок розвитку системи.

Ключові слова: *життєздатність, самоорганізована система, людино-машинна система, емерджентність, життєстійкість, людський чинник, ресурси.*