



Using the Systemic-Transdisciplinary Approach to Enhance the Operational Reliability and Maintenance Programming of Complex Technical Objects

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The complexity of technical objects is constantly increasing. A single accident or failure on such complex technical objects may cause large human losses, inflict damage on the environment, and be accompanied by severe economic losses. Generally, these single accidents and failures are caused by force-majeure circumstances. These circumstances can be identified, as well as further controlled using the methodology of various types of systemic approach. These types of systemic approach are enhanced not only by the new mathematical methods, but also by the general philosophical solutions. The methodology of systemic-transdisciplinary approach particularly uses models of spatial, time and information units of order. These models are the

result of using the philosophical concept of a single world. These models with total isomorphism allow for more in-depth studies of non-biological, biological and social objects. The findings of such studies may provide a basis for enhancing the reliability of existing methods for monitoring complex technical objects.

Keywords: Systems thinking, systems approaches, reliability optimization, risk assessment.

1 Introduction

In cases of high reliability of existing methods for monitoring technical objects of various types from a car to a nuclear power plant it is impossible to

completely eliminate the risk of accidents and failures caused by force-majeure circumstances. Force majeure means the reasons of unexpected occurrence of unforeseen malfunctions and accidents of technical objects. The role of these reasons is played by numerous non-critical deviations of conditions and parameters on the technical object normal operation. Separately, these non-critical deviations (factors) have no considerable impact on the technical object safe operation. However, systemic imposition of such natural, anthropogenic and social factors can induce sudden malfunctions and accidents of technical object. Thus, in order to minimize the risk of accidents and failures it is necessary to enhance the concepts of existing methods for monitoring technical objects with the concept and methodology of systemic approach. It bears reminding that only 50 years ago the prominent mathematicians R.E. Kalman, P.L. Falb, M.A. Arbib in their book "Topics in mathematical system theory called the systemic approach as "a fascinating but unsystematic area" [1]. Attempts to order the systems thinking have led to the formation of at once several types of systemic approach over the last 50 years. All types of the systemic approach differ in the borders of theoretical concepts and practical possibilities. The rationale for these differences is found in the systemic approach classification. Professionals developing and maintaining complex technical objects should have a general idea of the classification of systemic approach types and their differences.

2 Brief Description of Systemic Approaches

2.1 Systemic-disciplinary and Systemic-interdisciplinary Approaches

The systemic approach classification is represented by two main groups of approaches [2]. The first group of approaches consists of systemic-disciplinary and systemic-interdisciplinary approaches. These types of systemic approach do not depend on general philosophical solutions and the world view in its general scientific sense. Therefore, the relationships between the technical object and natural processes occurring in the surrounding world are not paramount in the concept of these types of systemic approach. This specific feature was precisely described by the academician of the Russian Academy of Sciences, the

author of the functional system theory P.K. Anokhin. He said: "A researcher, who works in a specific field of science (biology, physics, physiology, medicine), is primarily interested in the fact that the systems theory was included into his intellectual status as an easy-to-understand scientific movement that significantly ensures the progress of his specific scientific paper. As a rule, this category of researchers pays little attention to the general philosophical and methodological discussion of the systems theory, since such a discussion usually does not establish the concept-based bridge between the system philosophy and its application to any object of interest" [3]. For this reason, the systemic-disciplinary and systemic-interdisciplinary approaches are more dependent on the empirical description of the systems research procedures and on the object modeling techniques in the system image supported by the strict mathematical expression.

Simplification of the complex technical object image with its systemic-disciplinary and systemic-interdisciplinary modeling leads to release of the object from certain characteristics. These characteristics are not essential for solving a specific problem from professional point of view. In this case, there is a risk that these unaccounted characteristics may stand in as the factors that can provoke the occurrence of force-majeure circumstances under certain specific conditions. Taking this circumstance into account, the document "A World in Motion – Systems Engineering Vision 2025" the International Council on Systems Engineering, states: "It is therefore important to develop a scientific foundation that helps us to understand the whole rather than just the parts, that focuses on the relationships among the parts and the emergent properties of the whole. This reflects a shift in emphasis from reductionism to holism. Systems Science seeks to provide a common vocabulary (ontology), and general principles explaining the nature of complex systems" [4].

2.2 Systemic-multidisciplinary and Systemic-transdisciplinary Approaches

The concept and methodology of systemic-multidisciplinary and systemic-transdisciplinary approaches possess the required scientific basis referred to in "A World in Motion – Systems Engineering Vision 2025". These approaches form the second group in the systemic approach classification. It

should be noted that these approaches are less dependent on the empirical description of the systems research procedures supported by the strict mathematical expression. They are more dependent on the general philosophical solutions, image of the general scientific world view, which significantly affect the content of the ontological and gnoseological aspects of system studies of any objects, including technical objects. Put simply, the attitude toward the complex technical objects is formed not from the object itself, but from the philosophical image of the world view. In this case, the reliability enhancement of control methods of technical objects necessarily occurs with the consideration of the following aspects:

- heuristic, systematic and world outlook functions of general scientific world view;
- visions of space, time and information as philosophical categories that are directly relevant both to the fundamental objects (World, Universe) and to technical objects.

The heuristic and world outlook functions of general scientific world view set the fundamental differences between the systemic-multidisciplinary and systemic-transdisciplinary approaches. These differences between the systemic worldview are obvious to philosophers, but not so obvious to security professionals of complex technical objects. Therefore, it is appropriate to briefly explain the essence of these differences.

The concept of systemic-multidisciplinary approach is based on holism. Holism, in a broad sense, is a position in philosophy and in science on the problem of the relationship between part and whole. This position is based on the qualitative originality of the whole in relation to its parts. In ontology, holism is based on the principle: the whole is always more than the sum of its parts. The epistemological principle of holism says: the knowledge of the whole must precede the knowledge of its parts. In a narrower sense, holism is understood as the “philosophy of integrity” developed by the South African Philosopher J. Smuts, who in 1926 coined the term “holism”. The whole world consists of parts. These parts outside the entire are of independent sense. The concept and the view of the whole world do not forbid the existence of other entire worlds. The use of holism principles can be demonstrated by the following reasoning as applied to technical objects. For example, the existence of a particular car does

not interfere with the existence of other types of technical objects. Parts of the car have an independent meaning outside the car. For example, an automotive headlamp can be used as a flower bowl. The wheel can be used as the main element of a water mill. It is important to emphasize that there is the own order of parts interaction inside a car, tractor, airplane, rocket, nuclear power plant as whole technical objects. For this reason, it is necessary to justify the completeness of a set of object parts as a system in each specific case within the framework of systemic-multidisciplinary approach, and then to identify or subjectively establish the order that determines the interaction of these parts. At the same time, the environment surrounding the technical object is not part of it. This environment is included in the scope of the systemic-multidisciplinary approach in the event that a technical object as a system needs to overcome or use its influence. For example, to overcome air resistance or use it as a support part for an airplane wing. The obvious combination of parts of a technical object as an entire system currently satisfies the professionals who design and operate such technical objects. As a result, it is possible to maximize the effectiveness of existing methods for monitoring the overall condition of technical objects using the Systemic-multidisciplinary approach. But this systemic approach also does not allow identifying, controlling and taking preventive measures of the accumulation of factors that provoke a sudden manifestation of force-majeure circumstances.

The concept of systemic-transdisciplinary approach is based on a unicentrism. In a broad sense, unicentrism is a position in philosophy and in science on the problem of the correlation between the single and its fragments. This position is based on the isomorphism of the universal order of the structure of fragments of space, attributes of information and periods of time that determine the one world. In ontology, unicentrism is based on the principle: the one world is represented as the sum of ordered fragments of space, attributes of information and periods of time that determine the unity of goals and results of the development of phenomena and processes of reality. The epistemological principle of unicentrism says: the knowledge of the one world must be preceded by the selection of appropriate models of spatial, informational, and temporal units of the universal order. In a narrower sense, the unicentrism is understood as the “philosophy of unity” developed

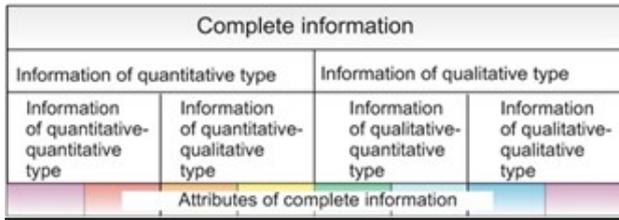


Figure 1: Systemic-transdisciplinary model of information unit of order [5] (p. 69).

by the Russian philosopher Vladimir Mokiý. He also in 2010 introduced the term "unicentrism". The united world is the one world. Any objects at all levels of the reality of a one world are its natural elements/fragments. Therefore, the main condition for the existence of a one world is the existence of a universal order in it. From the name it follows that this objective order must manifest itself everywhere: in every element/fragment of this world, in every interaction of these elements/fragments at every level of reality. As a result, the same order should ensure the achievement of activity goals and results of all these elements/fragments and synchronize these goals and results. For this reason, a single world is a one orderly medium.

The major attribute of this one orderly medium is the potentiality (latent force), which is naturally present in it. Within the framework of the single-centrism concept, the definitions of these philosophical categories are as follows:

- *Space* is a form of potentiality existence;
- *Information* is a form of potentiality manifestation;
- *Time* is a form of potentiality conversion;

The universal order plays the role of a transdisciplinary system in relation to the forms of potentiality of a one world. This particular universal order manifests in the forms themselves, in the interaction of these forms, as well as determines their unity.

From this point on, it is possible to redirect the visions of space, time and information as philosophical categories into methodological categories that are nearly related to all elements/fragments of a one orderly medium. To do this, it is enough to present a transdisciplinary system in the form of three units

of order: model of spatial, information and time unit of order [5].

The model of spatial unit of order allows for giving the grounds for the physical and/or logical object boundaries, as well as the nature of relationship of elements within these boundaries. The model of information unit of order allows for giving the grounds for the necessary and sufficient amount of information on the object, as well as describes the overall condition of this object. The model of time unit of order allows for the organization of potentiality conversion from the original volume to the results that will be used in the subsequent processes of its conversion.

Complex technical objects are often created in the image and likeness of natural objects and processes. So, technical objects help to converse or immediately converse the potentiality of a single world, potentiality of cosmic and planetary matter. This fact suggests that all non-biological, biological, social and technical objects can be modeled, learned, described and researched using the concept of single-centrism and the methodology of systemic-transdisciplinary approach. In this case, the systemic-transdisciplinary models of units of order possess the property of total isomorphism. Isomorphism of models of spatial, information and time units of order is manifested in the structure of space fragments, information signs, and time periods [5]. According to L. Bertalanfy, such isomorphism is a fundamental condition for creating a general systems theory as a scientific discipline in its own right.

How practically useful for systems thinking is the transition of philosophical categories into systemic methodological categories? In 1953, theorist of practicality and economist Bross defined the value of the benefit in this way: "The court of the highest resort - is not a brilliant verbal argument, not a massively sound abstract principle, and even not a clear logic or mathematics, but this is the result in the real world". In order to show the usefulness of systemic-transdisciplinary models of spatial, time and information units of order, it is necessary to demonstrate their ability to substantiate, calculate and lay the spatial, time and information factors. These factors can cause accidents and failures of complex technical objects due to force-majeure circumstances. Brief description of these models is displayed below.

Group I (Warm Colour Tones)				Group II (Cold Colour Tones)			
H	He	Li	Be	B	C	N	O
HYDROGEN	HELIUM	LITHIUM	BERYLLIUM	BORON	CARBON	NITROGEN	OXYGEN
	F	Ne	Na	Mg	Al	Si	P
	FLUORINE	NEON	SODIUM	MAGNESIUM	ALUMINIUM	SILICON	PHOSPHORUS
	S	Cl	Ar	K	Ca	Sc	Ti
	SULFUR	CHLORINE	ARGON	POTASSIUM	CALCIUM	SCANDIUM	TITANIUM
	V	Cr	Mn	Fe	Co	Ni	Cu
	VANADIUM	CHROMIUM	MANGANESE	IRON	COBALT	NICKEL	COPPER
	Zn	Ga	Ge	As	Se	Br	Kr
	ZINC	GALLIUM	GERMANIUM	ARSENIC	SELENIUM	BROMINE	KRYPTON
	Rb	Sr	Y	Zr	Nb	Mo	Tc
	RUBIDIUM	STRONTIUM	YTRIUM	ZIRCONIUM	NIOBIUM	MOLYBDENUM	TECHNETIUM
	Ru	Rh	Pd	Ag	Cd	In	Sn
	RUTHENIUM	RHODIUM	PALLADIUM	SILVER	CADMIUM	INDIUM	TIN
	Sb	Te	I	Xe	Cs	Ba	La
	ANTIMONY	TELLURIUM	IODINE	XENON	CESIUM	BARIUM	LANTHANUM
	Ce	Pr	Nd	Pm	Sm	Eu	Gd
	CERIUM	PRASEODYMIUM	NEODYMIUM	PROMETHIUM	SAMARIUM	EUROPIUM	GADOLINIUM
	Tb	Dy	Ho	Er	Tm	Yb	Lu
	TERBIUM	DYSPROSIUM	HOLMIUM	ERBIUM	THULIUM	YTTERIUM	LUTETIUM
	Hf	Ta	W	Re	Os	Ir	Pt
	HAFNIUM	TANTALUM	TUNGSTEN	RHENIUM	OSMIUM	IRIDIUM	PLATINUM
	Au	Hg	Tl	Pb	Bi	Po	At
	GOLD	MERCURY	THALLIUM	LEAD	BISMUTH	POLONIUM	ASTATINE
	Rn	Fr	Ra	Ac	Th	Pa	U
	RADON	FRANCIUM	RADIUM	ACTINIUM	THORIUM	PROTACTINIUM	URANIUM
	Np	Pu	Am	Cm	Bk	Cf	Es
	NEPTUNIUM	PLUTONIUM	AMERICIUM	CURIUM	BERKELIUM	CALIFORNIUM	EINSTEINIUM
	Fm	Md	No	Lr	Rf	Db	Sg
	FERMIUM	MENDELEVIUM	NOBELIUM	LAWRENCIUM	RUTHERFORDIUM	DUBNIUM	SEABORGIUM
	Bh	Hs	Mt	Uun	Uuu	Uub	Uut
	BOHRIUM	HASSIUM	MEITNERIUM	UNUNNIUM	UNUNUNIUM	UNUNBIUM	UNUNTRIUM

Figure 2: Systemic-transdisciplinary table of chemical elements [5] (p. 78).

2.3 Systemic-transdisciplinary Model of Information Unit of Order

Information is a form of potentiality manifestation. Therefore, everything that we can observe and feel, everything that is connected with the manifested matter, is demonstrated by the systemic-transdisciplinary model of information unit of order (see Figure 1).

Complete information is represented by its two classical types in this model: Information of quantitative type and Information of qualitative type. Further, each type of information is represented by its main subtypes of information: Information of quantitative-quantitative type, Information of quantitative-qualitative type, Information of qualitative-quantitative type, Information of qualitative-qualitative type. Eight Attributes of complete information finish the differentiation. Each attribute of complete information is indicated by a specific color.

Let's consider the use of model of information unit of order on the example of a nuclear power plant (NPP). In this example, the common for the territory, where the NPP is located, for the NPP itself, and for the processes of its operation is that they consist of atoms of chemical elements. So, the analysis of the detection of risk factors for accidents and failures begins with the traditional periodic table of chemical elements. After the location of chemical elements in

the systemic-transdisciplinary model of information unit of order, this table is as follows (see Figure 2).

Chemical elements in the environment rarely exist in their pure form. They are part of chemical molecules and complex chemical substances. However, the need to achieve the goal (transform the potentiality), as well as the need to achieve a strictly defined result of such a transformation, requires a certain order in changing activity.

Simply said, first the chemical elements of Group I (Warm Colour Tones) are transferred to the active state. In this case, the chemical elements of Group II (Cold Colour Tones) are transferred to a little active state. The chemical elements of Group II (Cold Colour Tones) are transferred to the active state upon reaching the certain results [6]. In turn, the chemical elements of Group I (Warm Colour Tones) are transferred to a little active state. It is assumed that the peak of activity and passivity of two groups of chemical elements should be equal in absolute value. Such parameters of activity and passivity of groups of chemical elements provide a stable functionality of objects.

2.4 Systemic-transdisciplinary Model of Spatial Unit of Order

The model structure of spatial unit of order is combined with the model structure of information unit of order (see Figure 3). Minimal spatial fragments

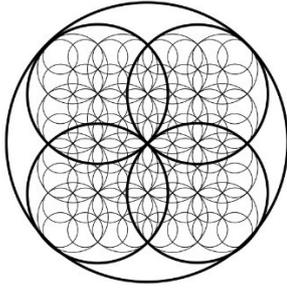


Figure 3: Systemic-transdisciplinary model of spatial unit of order [5] (p. 89).

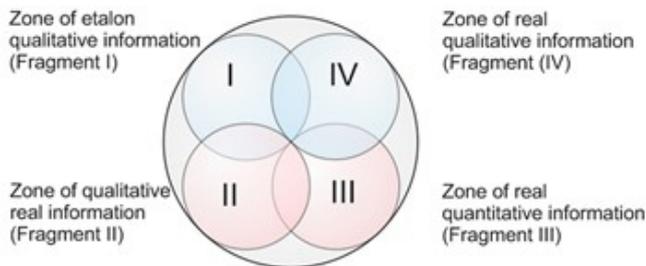


Figure 4: Scheme of zones of functional predisposition [5] (p. 90).

in this model play the same role as Attributes of complete information. These spatial fragments need to double their size three times to match the size of the main spatial fragment.

The same order separates Attributes of complete information from the complete information itself. The systemic-transdisciplinary model of spatial unit of order is directly relevant to the biogeocenose separation of planetary surface. An example of appearance of micro biogeocenose spaces is the view of cracked bottom of a dry lake. Such micro biogeocenoses are the natural fragments of larger biogeocenoses. The systemic-transdisciplinary model of spatial unit of order allows calculating the entire matrix of natural dimensions of planetary biogeocenoses.

It is important to emphasize that regardless of the model size of spatial unit of order, its main spatial fragments are called “zones of functional predisposition”. The essence of functional predisposition determines the belonging of the spatial fragment to a specific type or subtype of complete information. Fragments II, III are related to the information of quantitative type. Fragments I, II are related to the information of qualitative type (see Figure 4).

It is essential to show by experiments that the processes in zones (I and II) tend to achieve the rated

parameters that set the homeostasis and determine the required focused useful result of potentiality conversion. The processes in zones (III and IV) tend to display the parameters corresponding to the real dynamic response to the influence of external factors. The interaction of parameters of spatial fragments within the framework of a spatial unit of order determines the stability level of the entire object and each fragment

2.5 Systemic-transdisciplinary Model of Time Unit of Order

The model structure of time unit of order is also directly relevant to the model structure of information unit of order (see Figure 5). In this case, the major types, subtypes and features of complete information correspond to: the Supporting waves, the Calibration waves, the Setting waves and the Basic wave. Each wave is associated with a corresponding period of time [7].

Two fundamentally important points can be distinguished in each wave in the model of time unit of order. The first point describes the completion of the wave (time period). So, this point is called “reference point”. The potentiality conversion processes reach their purpose and the corresponding results at this point. The second point is located in the middle of each wave (time period). So, this point is called “critical point”. At this point, the potentiality conversion processes are evaluated for the creation of all the conditions that allow the object to achieve the intended purposes and results. There is a certain order of successively repeating four specific periods in each wave (time period) in order to make the potentiality conversion process irreversible. These periods have different duration and different purpose. The longest period in this sequence is the period of stable functional state of an object. The object overall condition during this period is described as resistant to the influence of external and internal factors. The second and third periods are the period of predisposition to prevention and the period of predisposition to adjustment of the object overall condition, respectively. The fourth period is the period of special susceptibility of the object to the negative influence of external and internal factors. The practical basis of this period is that it immediately precedes the critical and reference points of the Setting waves. It is the insufficient preparation of conditions for achieving purposes and

results, as well as incomplete achievement of purposes and results that makes an object particularly susceptible to the negative influence of external and internal factors. It is important to emphasize that all the periods in the framework of the model of time unit of order are repeated every year throughout the lifetime of an object.

3 Identifying Factors Contributing to the Emergence of Force-majeure Circumstances

3.1 The Spatial Factor

The universal order, which stipulates the unity and isomorphism of the structure of space fragments, periods of time and features of information in each model of unit of order, is not an abstract phenomenon. In fact, it manifests itself in the form of an objective managerial force. This force is variously known in science as: “Driesch entelechy”, “Bleuler’s Mneme”, “guiding force of Claude Bernard”. Within the framework of modern systems thinking this force is called the “objective systemically important factor”. This factor is in a direct relationship with the purpose and results that the objects pursue.

The practical influence of this managerial force is directly dependent on two factors: object overall condition and territory of the biogeocenose, on which the object is located, as well as the functional predisposition zone in which this force is applied. Figure 6 shows the result of an experiment on the formation of salt crystals (NaCl) from its supersaturated solution.

The multiplied experiments revealed the following regularity: the consistent deviation of the territory overall condition from its historically-developed value was inevitably accompanied by a difference in the quantitative and qualitative characteristics of salt crystals in areas of different functional predisposition [8]. The greatest deviation was always observed in fragment No. 4.

Such experiments were carried out with the involvement of various test-objects. Aquatic plants and microorganisms, complex organic and inorganic chemicals, crystal oscillators, and test cubes of structural concrete take on the role of such test-objects. In all cases, a result was obtained similar to the experiment with NaCl. For example, crystal oscillators located in fragments No. 3, 4 significantly

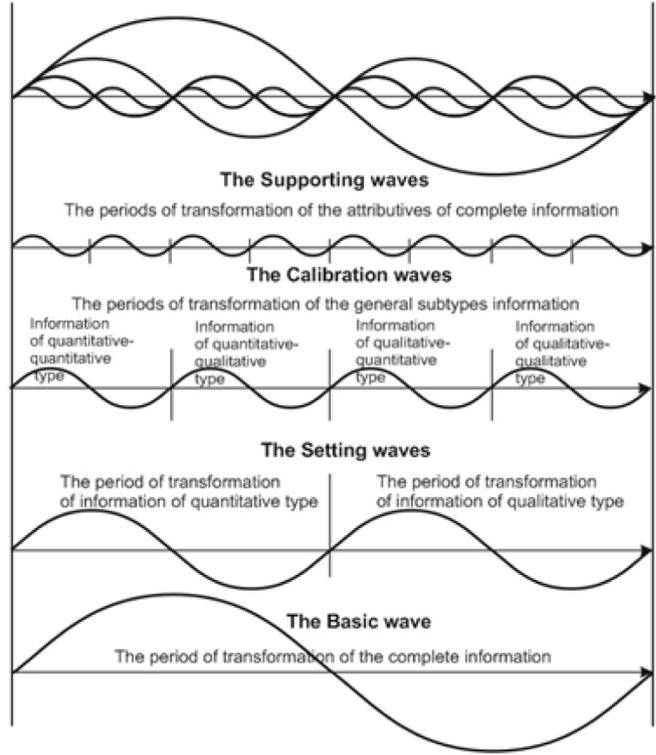


Figure 5: Systemic-transdisciplinary model of time unit of order [5] (p. 125).

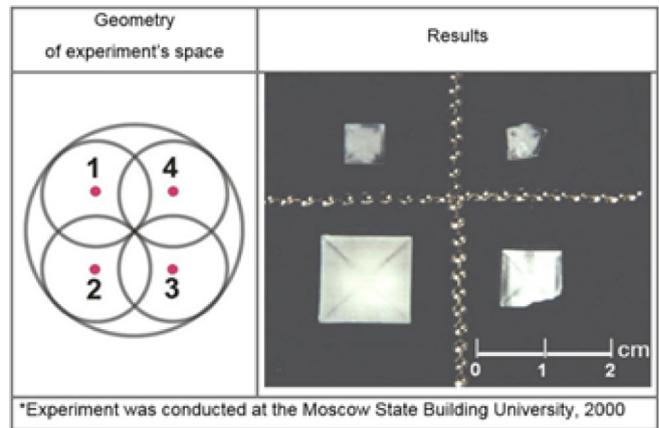


Figure 6: Change of size and form of crystals of common salt.

reduced their own basic oscillation frequency. Cubes of structural concrete frozen in fragments No. 3, 4 crumbled with less physical activity than cubes frozen in fragments No. 1, 2. These experiments suggest that if the safe operation of a complex technical object includes the reliability of load-bearing structures, and the reliability of materials of which the main components and parts are made, then the enhancement of the reliability of existing methods for monitoring the technical objects should take into

account the influence of so-called objective spatial factor. Simply said, the safety of a complex technical object from force-majeure circumstances begins with justifying the choice of a construction site. Preliminary work on the identification of natural structure of spatial fragments (functional predisposition zones) will make it possible to justify the choice of a construction site for a complex technical object with certain features of process technology.

3.2 The Time factor

The role of fragments of spatial unit of order, in which there is the greatest deviation of quantitative and qualitative characteristics of test-objects in the model of time unit of order, is played by the periods of special susceptibility of the object to negative influence of external and internal factors. Periods of special susceptibility are formed in a natural way, since they immediately precede the critical and reference points of the Setting waves. Simply said, if the potentiality conversion process by a complex technical object is extremely close to the specified purposes and results, the periods of special object susceptibility to the negative influence of external and internal factors do not manifest themselves. But if this process deviates from the standard for some reason, then more than 80% of all accidents and failures in the operation of complex technical objects occur during periods of special object susceptibility. This consistent pattern was embedded into the dedicated analytical computer program. (Certificate of State Registration of Computer Programs 2012619433 dated August 12, 2012).

Let us introduce several examples of the manifestation of special susceptibility periods of various types of complex technical objects to the negative influence of external and internal factors.

The following results were obtained in the course of the research conducted by specialists of the Institute of Transdisciplinary Technologies. 47 flight accidents (takeoff, landing accidents, in parking point and during taxiing operation) occurred with Boeing airplanes in the period from 01.01.2013 till 03.11.2015, 37 of which coincided with previously calculated intra-annual periods of special susceptibility for aircraft participating in these incidents. The 6 cases of aircraft crashes of 7 coincided with their periods of particular susceptibility. The most illustrative example is the aircraft Boeing 737-500, the tail number VQBBN, Tatarstan airlines. Three flight accidents

involving this aircraft are known. When this aircraft landed at the airport of the Brazilian city of Belo Horizonte in adverse weather conditions in December 17, 2001, it touched the ground before the start of flight strip (1). November 26, 2012, during the flight Kazan-Moscow this aircraft made a crash landing at the airport of Kazan (2). November 17, 2013, the same plane crashed at Kazan airport during the flight Kazan-Moscow (3). The calculation of intra-annual periods of special susceptibility of this aircraft using a special computer program made it possible to determine their calendar duration. Their duration was:

- from August 16 to September 16;
- from November 16 to December 17; >>> (1), (2), (3);
- from February 15 to March 18;
- from May 18 to June 18.

This study outcome indicates that all three flight accidents, including the crash, occurred in the same intra-annual period of special susceptibility of the aircraft.

A similar example can be given with the aircraft Boeing 737-4H6, tail number AP-BJN, Shaheen Air airline. This aircraft had two flight accidents occurred during landing. The date of the first incident is April 22, 2012 (1). The date of the second incident is 30.12.2014 (2). Despite the fact that flight accidents occurred in different years, they stay within the intra-annual periods of special susceptibility of the aircraft:

- from September 21 to October 22;
- from December 21 to January 21 > (2);
- from March 23 to April 23 > (1);
- from June 22 to July 23.

During the same three-year period, 30 flight accidents occurred with Airbus aircrafts: 25 of which coincided with previously calculated intra-annual periods of special susceptibility for aircraft participating in these incidents. All 4 cases of Airbus aircraft crashes coincided with their intra-annual periods of special susceptibility of the aircraft to the negative influence of external and internal factors [9].

A high percentage of coincidence of flight accidents with theoretically calculated intra-annual periods of

special susceptibility of the aircraft to the negative influence of external and internal factors indicates the presence of a real possibility to reduce the number of flight accidents in the range from 80

Similar examples can be given from the results of a retrospective analysis of water transport facilities. There was a wreck of “Bulgaria” diesel-electric ship in Russia on July 10, 2011. This wreck claimed hundreds of human lives. In this case, in the intra-annual period of special susceptibility to the influence of negative factors of the “Bulgaria” diesel-electric ship, information was added on the same periods of special susceptibility of its captain.

The calculated intra-annual periods of special susceptibility of the diesel-electric ship:

- from September 17 to October 18;
- from December 18 to January 18;
- from March 18 to April 18;
- from June 18 to July 19 - (the date of wreck - July 10, 2011).

According to the captain of “Bulgaria” diesel-electric ship:

Intra-annual periods of special susceptibility of the captain of diesel-electric ship:

- from January 3 to February 3;
- from October 4 to November 4;
- from April 04 to May 05;
- from July 4 to August 4 - (the date of wreck - July 10, 2011).

These calculations show that the wreck calendar dates of the “Bulgaria” diesel-electric ship coincide with the intra-annual periods of special susceptibility of the vessel itself and its captain. In combination with negative weather conditions, a catastrophic accident became inevitable due to the fatal imposition of objective (time) and subjective (technical condition) factors.

An example of forecasting the intra-annual periods of special predisposition to the influence of negative factors in complex energy facilities is a major accident at the Sayano-Shushenskaya hydroelectric power station in Russia. The calculated duration of the periods of special susceptibility of the station to the negative influence of external and internal factors was:

- from February 15 to March 18;
- from May 18 to June 18 - (accident was in May 23, 1979);
- from August 17 to September 17 - (accident was in August 17, 2009);
- from November 17 to December 18.

The first accident occurred on May 23, 1979. During the flood, water penetrated into the building of the Sayano-Shushenskaya HPP and flooded the first launch hydro-electric set. The second accident occurred on August 17, 2009. The third and fourth conduits were destroyed as a result of the hydraulic impact, therefore the wall was destroyed and the machine room was flooded. It can be seen that the first accident (May 23, 1979) occurred in the second intra-annual period of special susceptibility, and the second accident (August 17, 2009) occurred in the third intra-annual period of special susceptibility of HPP.

An example of a 100% coincidence of the dates of major accidents with calendar dates of the intra-annual period of special susceptibility indicates that there is a real possibility of forecasting such accidents at any power engineering facility (HPP, NPP, TPP, etc.). However, the ability to predict accidents and failures indicates the possibility of their prevention. The periods of natural susceptibility to preventive effects and periods of natural susceptibility to adjustment of the overall condition of a complex technical object should be used in order to do that. It is meaningful to develop and implement the necessary unscheduled set of preventive and corrective measures for the major components and systems of a complex technical object for these periods. In other words, it is necessary to take into account not only Construction Norms & Regulations, but also their natural susceptibility to accidents over time (time factor) when ensuring the safety of large industrial and power engineering facilities.

3.3 The Information Factor

An example of the formation and appearance of an information factor can be shown using the Systemic-transdisciplinary table of chemical elements (see Figure 2). As mentioned earlier, the activity and passivity of chemical elements of the first and second groups changes periodically. The value of activity and passivity in both groups is equal in absolute

value. The deviation of the state of the biogeocenose territory, on which the complex technical object is located, from its normal can be characterized as follows. In the first case, the activity of chemical elements can significantly exceed this absolute value. And this activity can only slightly decrease, but cannot be eliminated completely. This type of state is called the “first type of imbalance in the activity of chemical elements”. In the second case, the pathological activity accompanies the chemical elements of the second group. This type of state is called the “second type of imbalance in the activity of chemical elements”. A complex technical object is not just located on the territory of a specific biogeocenose. From the standpoint of this biogeocenose, the object is considered as its natural fragment. And this “fragment” is obliged to correspond to the current type of imbalance in the activity of chemical elements of the biogeocenose. It is meaningful to simulate a real situation in order to show how this imbalance manifests itself.

For example, the biogeocenose territory has the second type of imbalance in the activity of chemical elements suggesting a constant increased activity of chemical elements of the second group. A nuclear power plant is built at this territory. The primary process at the NPP is the use of the constant activity of uranium (92) - element of the second group. The NPP technical condition corresponds to the second type of imbalance in the activity of chemical elements, which includes uranium. The automatic control systems of the technological process and technical control will be exposed for the second type of imbalance in improved activity. Thus, the imposition and amplification of negative effect of the three components of the imbalance of activity of chemical elements will begin since the commissioning of NPP in this simulated event.

The negative influence of the spatial factor can be superimposed on the information factor. This factor appears when the NPP is located in functional susceptibility zones III and IV (see Figures 4, 6). As mentioned earlier, there is an activation of nature-transforming activity in these zones. The time factor can also be superimposed on the negative influence of information and spatial factor - intra-annual periods of special susceptibility to the influence of negative factors of the NPP and specific professionals from the maintenance personnel. According to the retrospective analysis of complex

technical objects, this overlap of all factors enumerated causes the inevitability of a major accident or failure due to force-majeure circumstances.

4 Hardware-analytical Complex for Monitoring the Overall Condition of Complex Technical Objects

The difficulty of organization of live control over the increase in the imbalance of a complex technical object state using the philosophical concept of holism is as follows. Due to the fundamental complexity of such an object as an entire system, its adequate knowledge requires the construction of many different models. Each of these models describes only a specific aspect of the system [10]. The object is created from diversified technical elements and assemblies with different initial technical condition and different useful life. Today this circumstance does not allow for choosing a single indicator, according to which one can judge about the reliability and safety of the object as a whole. However, the philosophical concept of single-centrism can be used in order to scientifically substantiate the possibility of such an indicator.. In this case, a complex technical object, being a single functional assembly, will be characterized by the ordered set of its own physical fields (electric, magnet, thermal, acoustic, etc.). These fields impose on each other inevitably within the object technological space. By this, a special interference pattern is formed. Such an interference pattern plays a role of the technical object complex field. This field has not been attracting technical specialists attention until recently. But this complex field is not passive. By the feedback principle, it is able to increase or decrease values of different fields technical characteristics followed by those of their sources (the technical object units, aggregates and systems) suddenly and to the considerable extent. It should be assumed that a certain value (frequency) of this complex field corresponds to the normative object state. In turn, a breaking change in this value (frequency) will indicate the formation of force-majeure circumstances dangerous both for the object itself and for its individual main elements and assemblies [11].

These theoretical assumptions made in 2008 were embodied by the specialists of the Institute of Transdisciplinary Technologies in a unique hardware-



Figure 7: The appearance of the indicator device (with the cover removed) [5] (p. 109).

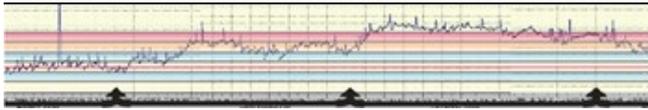


Figure 8: The graph of monthly increase in the deviation of the object overall condition from the normal to critical values [5] (p. 111).

analytical complex. In the classification of non-destructive testing methods the description of the method used in this complex is as follows:

1. By the nature of interaction of physical fields with a controlled object - resonant;
2. According to the primary information parameter - frequency;
3. According to the method of obtaining primary information - parametric.

The main element of this complex is a special indicator device. This device is used to control the complex field.

The indicator device is able to enter into a resonance state with the object complex field and record changes in its magnitude. Resonance state is achieved by simulating the working panel of the indicator device of the structure of the physical (technological) space of an object (see Figure 7).

The recording elements of the indicator device are crystal oscillators. Crystal oscillators located at certain points in the design of the indicator device operating panel, experience the influence of this object complex field. The result of this effect is a change in their base frequency within statistically significant limits. In turn, the amount of change in the base frequency is an indicator of the susceptibility of the object elements and assemblies to an accident or an unscheduled stop (see Figure 8).

The hardware-analytical complex consists of the required number of indicator devices. Each indicator device is a self-contained unit for power and software. The quartz generator module has been thermostated at the level of $+40 \pm 0,5$, at the environment temperature change from $+10$ to $+30$. The quartz generator frequency is 256 kHz. The indicator device controller measures the quartz generator signal period in microseconds and is accurate to six decimal places. The indicator device range of tasks includes automatic measurement of the value of the complex technical object complex field every three hours 24 hours a day. An automatically measurement of the complex field value of a complex technical object every three hours around the clock is entrusted with the task. The measurement results are stored in the indicator device memory for seven days. The number of indicator devices is calculated based on the design features of a technical object and the territorial location of its main technological elements, but not less than one indicator device per object.

The accumulated primary information of the indicator devices is processed by a special analytical computer program (Certificate of State Registration of Computer Programs 2009615359 dated September 25, 2009). This program installed on a remote computer is capable to access and remove the primary information from the memory of indicator devices in automatic mode using wired or cellular communication. The program presents it in a form that is convenient for human perception by saving and accumulating primary information. The substrate of graphs is carried out taking into account the classification of hazard levels accepted in the state or taking into account the wishes of professionals serving a complex technical object.

The value of primary information of control over the overall condition of a complex technical object, as well as its main elements, increases from year to year. This is due to the fact that it is possible to analyze the dynamics of changes in the state of the object complex field in the periods immediately preceding failures and equipment accidents. Subsequently, such changes in the parameters of the state of the object complex field can serve as a signal for a reasonable forecast and prevention of typical accidents and unscheduled stops. The programs that ensure the indicator device operation and the analytical program have certificates of registration.

5 Conclusions

Existing methods for monitoring the technical objects have proven their reliability. However, the complexity of technical objects is constantly increasing. In this case, a single accident or failure on such complex technical objects can lead to large human losses, be accompanied by significant losses in the economy or cause damage to the environment. Generally, these single accidents and failures occur due to force-majeure circumstances. In turn, the force-majeure circumstances are triggered by the imposition of spatial, time and information factors. These factors manifest themselves and are subject to control as a result of engaging the concept and methodology of those types of a systemic approach that improve the systemic thinking with general philosophical solutions. In particular, the methodology of the systemic-transdisciplinary approach uses models of spatial, time and information units of order. These models with total isomorphism are used to study complex non-biological, biological and social objects. This circumstance allows not only to substantiate the presence of these factors, but also to describe their negative impact for all types, including complex technical objects.

It is important to emphasize that the systemic-transdisciplinary approach allowing the identification and control of the imposition of these factors does not compete and does not replace the existing control methods based on the concepts and methodologies of other types of classical and systemic approaches. In this case, we should give evidence of the possibility of strengthening these methods. The systemic-transdisciplinary approach that emerged as a purely theoretical approach will certainly develop under the constructive influence of practitioners who operate complex technical objects and monitor their condition. As a result, one can express the hope that this development will let us to overcome the uncertainty in the reliability of control and safety of complex technical objects, which exists due to the absence of accounting the negative influence of spatial, time and information factors.

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