Vitasystems Theory for Aircraft Industry Development[*]

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1 Introduction

The origin of the concept and theory of vitasystems is connected with the task of restoring the Russian aircraft building industry, the degradation of which occurred in the post reorganisation period. At the beginning of the century, in 2001–2006, commissioned by the Russian Industry and Energy Ministry, a number of research projects to find rational ways to organise aircraft industry in new public and technological conditions.

The applied result of these works, in particular, was recommendations for the creation of modern integrated production structures (holdings). The scientific result of these studies consisted in new methods of analysing the so-called ‘system-attractive’ and ‘system-efferent’ factors that contribute to the creation or collapse of organisational and technical systems containing an active element-human. These methods and the obvious conclusion that the dynamics of the development of organisational and technical systems occur cyclically in the phase space of a limited number of subspaces (categories) formed the basis for the vitasystem concept and the beginning of the vitasystems theory.

Formally, a model or canonical model of the behaviour of complex systems containing an active unit was proposed. It was quite simple and at the same time universal for describing the behaviour of a wide class of organisational and technical systems.

The first publications, including the concept of vitasystem (refer to Ayupov and Plyaskota, 2009; Ayupov et al., 2009).

The purpose of this paper is to assess the current level of the vitasystems theory development and its place in the problems of analysis (synthesis) of aircraft industry.

2 Fundamental aspects of the vitasystems theory

Vitasystem (from lat. Vitalis – vital and ancient Greek σύστημα – whole, composed of particles, compound) – a system whose elements are materialised and/or presented in one form or another (not necessarily formalised) interests, needs, knowledge, skills and habits of people (in a broader interpretation – of any living organisms) that are in relationships, relations, interactions with each other and form a certain biohybrid integrity and unity (http://cyclowiki.org/wiki/%D0%92%D0%B8%D1%82%D0%B0%D1%81%D0%B8%D1%81%D1%82%D0%B5%D0%BC%D0%B0).

In general terms, the vitasystem is a material product of the activity (existence) of a certain subject or some of their community - people (living organisms). The main goal of any vitasystem is to satisfy the desires and needs of the subject. When a certain community of people (living organisms) acts as a subject, the needs, being the goals of creation and functioning of vitasystems, are formulated in integral form, thanks to a rather universal process of transformation (reduction) of private desires and interests expressed and represented by the leader. To describe the functioning of vitasystems, the extended interpretation of the space-time continuum is used. In addition to the traditional time and space dimensions, energy, matter (as forms of existence of matter) and information (as a measure of structural and functional complexity and the diversity of material objects and information about such) are used as independent measurements in the models of vitasystems dynamics.

The creation and use of vitasystems as applied to the scientific and technical sphere is viewed, on the one hand, as a result of the materialisation of the interests of some community of people, and, on the other hand, as a tool for creative human activity (Alakoz et al., 2015). Vitasystem theory is concerned with the study of vitasystems. The latter, being a branch of the systems theory is in its infancy, is interdisciplinary and takes some intermediate position between the doctrine of the biosphere V.I. Vernadsky (in its biosocial aspect) and the theory of active systems (in the technical and economic aspect) (Burkov and Novikov, 1999).

The economic aspect of the origin of vitasystems is associated with the W. Leontief input-output model (Leontief, 1986). The representation of vitasystems by canonical graphs goes back to the works of Medelyanovsky and Vodyakha (2004). Some analogues of the vitasystem approach from the point of view

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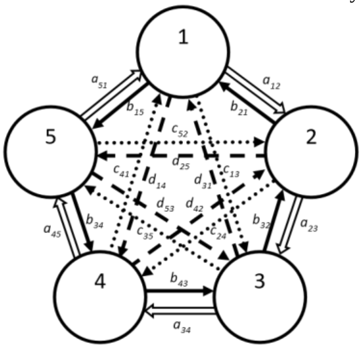
of formalising system analysis can be considered the project evaluation and review technique (PERT) (US Government Printing Office, 1958), and the technology of structured analysis and design technique (SADT) (Marca and McGowan, 1987), implemented in a series of standards IDEF. In a sense, the vitasystems and the vitasystem approach are related to the widespread concept of BPR (Business process reengineering) (Kotler et al., 2016).

3 Basic aspect of the vitasystems theory

For convenience, and also starting from the content of the extended continuum, in which any material objects develops, it was suggested to limit the number of subspaces describing the behaviour of vitasystems to five.

Any vitasystem can be represented as a graph. The graphical representation of the socalled canonical model of the dynamics of the vitasystem is shown in Figure 1. Its vertices somehow reflect the subspaces (categories) of needs, knowledge, skills, experiences, and resources of various kinds (see Table 1). Also these vertices are projected on the categories of an extended continuum: space-time-matter-energyinformation. In particular cases of application of vitasystems to developing or organisational and technical systems, the vertices of the corresponding graph of the canonical model reflect the accepted forms of activity or phases of the life cycle of a particular product.

Figure 1 Graphical representation of the canonical model of vitasystem dynamics



Source: Alakoz et al. (2015)

Table 1 Categories (vertices of a graph) of the vitasystems canonical structure

Notation	*Informative content in various problems vitasystem study*
1	Needs, goals, requirements for the vitasystem, justification of the target task
2	Idea, creative design, innovative groundwork, the method of creating a vitasystem, knowledge
3	Vitasystem resources: temporary, spatial, financial, material, information, energy, raw materials, personnel, administrative, etc.
4	Creation of a vitasystem, technology of transformation of initial resources, production, skills in a broad sense
5	Use of the vitasystem, application to destination, operation, re-structuring, repair, recovery, disposal, skills, etc.

Four kinds of connections (laws) reflect different types of relationships between categories. Because of the different physical content of these connections, the graph of the canonical representation of the vitasystem (see Table 2) turns out to be edgeinhomogeneous. In other words, its adequate description is possible with the help of four two-dimensional matrices (in terms of the number of connection types) or a (2, 2)-tensor. Any vitasystem has the following properties:

- *Self-similarity (fractal property):* any category, element or some of their sub-sets of a particular vitasystem can be represented as a separate vitasystem (the latter acts as a vita-subsystem).
- *Vastness:* the space of vitasystems consists of interconnected vita-subsystem of a different genus.
- *Hierarchy:* vitasystems interact both in the order of subordination (according to the purposes) of the lower levels to higher ones (strict hierarchy) and subordination along the horizontal principle (on one hierarchy level - a non-strict hierarchy).
- *Universality:* every person and / or group of people united by any conceivable trait (be it an industrial collective, a tribe, a party, a people, a community, a state, etc.) are immersed in the space of vitasystems, and with the development of civilisation, this immersion becomes more and more profound (the number

of vitasystems to which a particular subject has an attitude increases). In relation to other living organisms, this property remains relevant, but the development of human civilisation has a negative effect on the development of individual vitasystems of predominantly natural origin.

- *Goal setting:* the general goal of any vitasystem, regardless of the presentation (consideration) level, is the desire to preserve its integrity, i.e., conformational stability of the structure of the vitasystem for a certain time, as a rule, given from the outside (from the side of the vitasystem of a higher hierarchical level, often defined only contextually).

The application of the theory of vitasystems to the solution of applied problems of analysis (synthesis) of organisational and technical systems of any purpose is carried out with the help of the so-called vitasystem approach. The basic principles of the vitasystem approach are as follows.

1 The principle of *functional expediency*, according to which the world of vitasystems is not only structurally and functionally complex dynamic (time-varying) and spatially-spaced systems, but also any objects related in one way or another to the satisfaction of human needs, since the main component of any vitasystem is a person – a subject endowed with desires and needs.

2 The principle of *(semi) openness*, according to which the objective function of the vitasystem can be achieved through selective interaction with the external environment: there is no possibility to buy a hanger, one turns to the procedure of hammering a nail.

3 The principle of *nesting*, according to which each object that appears in the vitasystem, can also be considered as a vitasystem: carnations, a hammer, a stepladder, a cabinet, etc. - in the history of their origin they are described by the same phases of the life cycle as the created with their help the design. In contrast to the ‘fractal nesting’, based on the structural similarity of systems at different levels of the hierarchy, in this case only the similarity of the phases of the life cycle is used.

4 The principle of heterochrony between material and information processes, according to which the transitions between adjacent material stages of the life cycle of vitasystems (categories or forms of activity) occur relatively slowly compared to transitions in the ‘rays’ of the pentagram of the canonical graph model. The latter correspond to the laws of ‘agreed submission (obedience)’ and ‘resistance (negation)’, are of a virtual nature and are associated with the exchange of information between categories (components) of vitasystems.

5 The principle of sufficient awareness, which implies that the deficit of data in interphase transitions of the vitasystem or negative information (relative to a specific vitasystem) in any phase can lead to its degradation up to the termination of functioning.

Table 2 Types of relationships between categories (vertices of the graph) of vitasystems

Notation	*Name*	*Informative content in various problems vitasystem study*
a	Creation law	Constant change of one category to another production transitions between forms of activity
b	Law of counteraction or response	Feedback, making adjustments to the course of events and thereby creating the basis for an independent self-governing existence and development of the phenomenon (subject)
c	Law of agreed submission (obedience)	Maintenance of order, security and self-preservation of the structure of the process, measures of prior approval
d	law of resistance (negation)	aspiration to force majeure, separatism or to dictate to the general course of events, up to the denial of the previously formed order

In recent years, a number of important scientific results have been obtained in the field of the theory of vitasystems. In particular:

- in 2016, it was proposed to use non-Archimedean metrics to describe the dynamics of vitasystems (Alakoz et al., 2016a)

- in 2017, the research group of the present article (ANO ISAPFB), together with the Research Institute of Normal Physiology RAS named after PK Anokhin, obtained a number of results in the field of fundamental processes of structuring living and nonliving matter (Alakoz et al., 2017)

- in 2018, a number of results were obtained in the field of application of sensible logic in modelling problems of intelligent aerospace complexes.

The intermediate fundamental result is the formulation of the problem of the possibility of modelling ‘techno-genetics’ of organisational and technical systems based on nonArchimedean metrics on the categories of vitasystems – some digital analogue of the spiral DNA code of living organisms.

The present article does not stay alone in studying the problems of structuring systems and describing complex interdisciplinary issues with relatively simple methods. Simplicity is rather conditional, since the combinatorial variability of the representation of vitasystems with the help of a graph of five vertices and four types of connections between them exceeds 1,000,000 variants (if exactly, 1,069,742).

At the Belarusian National Technical University, at the Department of Intelligent Systems under the leadership of A.V. Gulai a number of studies have been carried out in the field of modelling spatially distributed vitasystems (the authors call them Vitaenvironment) (Gulay et al., 2016).

In the USA, some people from the Los Alamos Laboratory created the Institute of ‘Complexity’ (SFI), one of whose laboratories is studying the principles of structuring living matter – from individual cells to social and human-hybrid systems. In general, they have focused their attention on collective behaviour and collective intelligence (Flack, 2012). At the same time, the theory of vitasystems is aimed at creating interdisciplinary technologies of engineering creativity.

Interdisciplinary problems of diagnosing and predicting the behavior of complex technical and socio-economic systems in the field of critical infrastructures, key resources, key assets and an open market for space, undersea, and below-ground systems are studied by an international team of scientists from Old Dominion University, Norfolk, Virginia, USA (Adrian V. Gheorghe, Polinpapilinho F. Katina, C. Ariel Pinto, Joseph M. Bradley, Patrick T. Hester), Horia Hulubei National Institute of Physics and Nuclear Engineering Bucharest, Romania, (Dan V. Vamanu), Action4Value GmbH company, Kirchzilte, Germany (Roland Pulfer).

The attention of these authors is focused not on technology engineering creativity, but on engineering management, aimed at minimising the risks in creating and managing the sustainability of critical infrastructures, key resources and key assets in difficult situations. This allows their results to be used in a qualitative and quantitative assessment of the development potential of vitasystems created and existing according to such indicators as vulnerability, susceptibility (Gheorghe et al., 2018) and interdependence (Katina et al., 2014).

4 Vitasystems and aircraft building

It is emphasised that the mechanisms of structuring of living and inanimate nature are unified at all levels, including levels of air traffic management and creation of aerospace systems.

As applied to aircraft building in general, the vitasystem approach is embodied in the activity of the general constructor of aviation equipment.

In essence, the revival of the institute of general designers at the state level, about which it was repeatedly stated, contributes to the fact that the five categories of vitasystems begin to work in full accordance with their canonical model – the concentration of the needs for the development of aircraft construction (category 1), scientific and technical reserve (category 2), centralised financial, information and personnel support (category 3), production technologies (category 4), technical exploitation regulations (category 5) in the undistracted management links and the establishment of information links between them contribute to the formation of a fully connected graph of relations between the vitasystem categories that reflect the respective forms of activity of the aircraft building industry.

In accordance with Alakoz et al. (2016b), aviation production management can be centralised when management functions are concentrated in a separate, external category and/or distributed, when managerial functions are essentially entrusted to separate forms of activity (categories). Self-regulation of vitasystems is also possible with the autonomous interaction of the corresponding forms of activity, which requires for external analysis external evaluation, in particular, with respect to the external vitasystem.

Vitasystem approach naturally supports the integrated innovative development of digital technologies in the aircraft industry, which requires:

- transdisciplinary digitalisation systems covering the scientific, experimental, production, test areas, technology parks, organisational, credit, financial and other infrastructure development industry
- dynamic infrastructure restructuring for the integration of breakthrough solutions into high technologies

- coordination of innovation and investment activities not only in the aerospace sphere, but also in related high-tech areas
- agreed export-oriented and import-substituting policies
- consolidation of current, mid-term and long-term interests of manufacturers and consumers of aviation equipment and aviation services.

5 Conclusions

The theory of vitasystems is in its infancy. Its main problems are:

- lack of universal methods for metering the quality of vitasystems and their elements (categories and relationships between them)
- the absence of applied methods for assessing and maintaining the structural integrity of vitasystems
- creation of 'techno-genetic' models of organisational and technical systems of a wide range of nomenclature on elements of vitasystems
- creation of interdisciplinary technologies of engineering creativity and their introduction into the practice of management of organisational and technical systems, etc.

Regardless of which type of management organisation the consumer (the customer, the user) is leaning towards, he always uses the vitasystem approach and evaluates them in turn, according to the canonical categories of the vitasystem (the forms of activity or phases of the life cycle of aircraft building). This process is essentially subject to the natural optimisation of the creative activity of each person and the collective participating in the aircraft industry. If the decisions taken, used in the current activities of a single department, the whole enterprise, or the industry as a whole, do not rely on evaluating the results of creative activity (responsibility, success and shortcomings) in the relevant phases (categories) and their final results, then it could be confidently said, at least, about the lack of optimality in both the individual forms and levels of the vitasystem model, and the vitasystem that describes the aircraft building industry as a whole.

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