Section 2. Materials Science

https://doi.org/10.29013/ESR-22-11.12-10-13

Tokarev Michael Valentinovich,
PhD, Corporation AXIS Ltd.

COMPLEX, MODEL, SYSTEM

Abstract. The article discusses artificial, natural systems and complexes. Natural systems cannot be such, because, by definition, a system is a set of elements and relationships between them. Unlike artificial systems, in natural systems it is often impossible to establish such sets. Scientists are forced to build models of natural systems and subject the models themselves to system analysis.

Keywords: system, system environment, neural systems and complexes, system analysis, element, relationship.

There are dozens of definitions of the concept of "system". It was originally introduced about 110 years ago by the Russian philosopher A. A. Bogdanov [9], who defined "tectology", a general organizational science. In the 1930s, Bogdanov's ideas were developed by Ludwig von Bertalanffy [7]. The most detailed analysis of existing definitions is given in the work of V. N. Sadovsky [11].

It is not necessary to address all the differences in systems terminology from different scholar's works. Our task is to present differences in the understanding of artifact systems from models of systems and complexes of loosely coupled elements.

The article by M. V. Tokarev [2] argues that a system should be understood only as artificial systems, since by any definition the elemental composition of the system and the relationship between the elements are known to the researcher. When analyzing natural systems, the researcher is forced to move from the real system to its model. In the textbook by A. M. Korikov [10], a unique idea is given: that the research is often based not on the properties of the system, but on the properties of the subject studying the system.

So, for the time being, we exclude artificial systems from consideration, since they are created exactly the way a person expects to create them: elements, relationships, target function, the relationship of the system with the environment.

The composition of a natural system is seldom thoroughly known to the researcher. He does not know the full functionality of the elements of the system, which are almost always heterogeneous, their interrelations. Such systems do not have and cannot have goal function, since the goal is a subjective concept. For example, what is the goal of the lymphocyte, destroying bacteria or dead cells? If we assume that he acts on the principle of nutrition, then what should he do when there are no bacteria? And why does it kill some bacteria that it cannot absorb with reactive oxygen species or nitric oxide. If its goal is to heal the body, then must you also assume that it has a nervous system, or even a brain?

Researchers are forced each time to build a model in the context in which they are interested in this object. Take for example any "system" of a living organism. An animal's digestive system includes specific organs, from a biologist's point of view. But the more scientists study this system, the more they understand that it cannot be considered in isolation from the circulatory system, the nervous system, and even the motor system. The further the researcher goes into the relationship of these systems, the more he understands that the whole organism is a system and the study of individual organs is riskily with an incomplete understanding of their functioning.

But as soon as the researcher enters the organismic level, he immediately encounters the environment of the organism, which significantly affects him. The learning process becomes infinite.

In this case, researchers build a model of the system, including essential elements, functions, and relationships in it. At the same time, the scientist is guided by his goals, which impose additional restrictions on the model. Any scientist understands that modeling always leads to loss of information about the object, simplification. The main modeling criteria in the case of a system analysis of natural objects should be the following:

1. The composition of the elements of the model system is formed from those that are essential for the researcher;
2. Only significant interactions in this context are defined between elements;
3. The goals of the researcher should in no case be transferred to the object under study;
4. From the environment of the model, it is necessary to highlight significant impacts on the model system, inputs. It is also necessary to evaluate the impact of the system on the environment;
5. At the level of the elements of the model, it is necessary to investigate their internal composition and the influence of the internal functions of the elements on the function of the entire model system;
6. When analyzing the elemental composition, it must be borne in mind that the selection of individual elements makes sense only when the functioning of these elements affects the system function.

When these conditions are met, the object model can be considered in turn as a system, and a systematic approach and system methods of analysis can be applied to it.

Let's take the solar system as an example. A non-specialist believes that the Sun, 8 planets and, possibly, satellites of these planets are considered as elements of the solar system. But if we ask an astronomer about the limits of the solar system, he will name as elements the Kuiper belt, which extends far beyond Neptune – 25 angstroms, or almost twice as far from the Sun as the last planet. At a distance of another 20 angstroms, the heliosphere ends, up to the boundaries of which the Sun still affects cosmic bodies with the solar wind – a continuous stream of charged particles. And after a few dozen angstroms, the Oort Cloud provides a potential border to the solar system. Here, astronomers could draw the boundary of the solar system, but, firstly, the exact distance to this cloud cannot be measured, and secondly, the cloud itself is only an assumption, because artificial satellits have not yet reached it. And it is impossible to establish the exact distance from the when the solar wind is completely negated by the interstellar medium. If we go further, consider entities outside the solar system, it is necessary to take into account the influence on it of the surrounding stars in the Galaxy, and the black hole in the center of the Galaxy, around which all the stars surrounding the solar system revolve. When modeling such an object, scientists are forced to initially indicate what is included in the model and what is excluded. And already such a model, as artificially created in the imagination of a scientist, can be analyzed as a system.

If we move from macro-objects of space to micro-objects, we can give a similar example with the DNA of an organism. During the transcription of DNA into RNA, its rate is influenced by introns, non-coding regions of DNA. This discovery was not made immediately. At first, scientists considered these sites "junk". But later it turned out that the composition of the cell plasma and folded proteins also affect the rate of transcription. Even later, it turned out that even unfolded proteins can affect both the rate of transcription and even its very possibility. The complexity of this seemingly simple system grows so much that the most powerful computers are not enough to process all the parameters. And all this happens in a tiny "system" – a cell, about one micron in size. And in addition to DNA transcription, hundreds of other functions are performed in the cell: ion exchange, cell division, energy production, information transfer to neighbors, correction of transcription errors, apoptosis, etc. And in this example, it is important to correctly choose the elemental composition of the system under study, limit the set of analyzed functions, and limit external influence.

If the relationship between the elements of the model is insignificant in the context of the researcher, it is necessary to consider such a model not as a system, but as a complex of loosely connected (unrelated) entities. Here, by a complex, we mean the usual set of similar entities that do not affect each other or their influence is not interesting to the researcher as a context of study.

Take, for example, a pile of sand. It is obvious that the grains of sand act on each other both by weight and by possible bonding forces (wet sand). However, until we examine this heap of sand, for example, as a component of a future concrete mortar or as the contents of an hourglass, it can be considered as a collection of unbound grains of sand or a complex. Unlike the concept of "chaos", the complex singles out entities that are similar in composition, functions, structure in order to distinguish them from the environment. In turn, complexes can also be studied as, for example, a set of natural numbers or a set of letters in the alphabet.

Thus, a researcher who claims to use a systematic approach must be able to separate the terms complex, model, and system. Otherwise, loading the system with insignificant entities will lead to the complication of the model and the impossibility of its analysis.

Artifacts, as systems, are much easier to study. All of them are purposeful systems and fulfill the role assigned to them. It does not matter if these are organizational systems, artificial intelligence systems or just a computer. The analysis of such systems is hardly of interest to scientists. Of course, such systems can also be studied using models, but the strict requirements listed above are not imposed on them, insofar as the composition of the elements and their functions are designed by the developers of such systems, and an objective description of these entities exists. In addition, artificial systems, by definition, are clearly limited in their design and development, unlike natural systems. It is often difficult for natural systems to establish not only the composition of elements, but even their boundaries.

Complexes, models and systems are not only contained in other systems of a higher order, but the elements of which they are composed can be included in other complexes and systems. This greatly complicates the system analysis, since the functions of the elements can be essential for all systems in which they are included. The elements of a system can be affected by entities that are part of other systems, just as the elements themselves can affect other entities. All these considerations greatly complicate the modeling and analysis of natural systems.

Terminology

- System – a set of strongly connected elements, during the interaction of which functions are performed that are not inherent in any of the elements separately (emergence). As a rule, the system is, in turn, an element of the upper-level system, and each of its elements can be considered as a system of a lower order. The main properties of systems are: integrity, connectivity, hierarchy, structuring, purposefulness for artificial systems;
- Element – an entity of any nature that is indivisible at the level of analysis;
- Relationship – a characteristic of the interaction of elements with each other or with the entities of the environment;
- System environment – a system of a higher order, in which this system is included as an element.

References:

1. Edited by George J. Klir. "Trends in General Systems Theory". WILEY-INTERSCIENCE.– New York. 1972.– Chapter II.
2. Tokarev M. V. On The Definition of General Systems theory // European Science Review, East West Association for Advanced Studies and Higher Education GmbH ISSN: 2310–5577. 2014.– No. 3–4.– P. 144–147.
3. Yi Li. "Can The World Be Studied in the Viewpoint of Systems? Division of Mathematics, Foundation, Analysis and Topology, 218 Parker Hall, Auburn University, Auburn, Al 36849, USA.
4. Анохин П. К. Избранные труды: кибернетика функциональных систем.– М.: Медицина, 1968.
5. Афанасьев В. Г. Системность и общество.– М.: Политиздат, 1980.
6. Афанасьев В. Г. Общество: системность, познание и управление.– М.: Политиздат, 1981.
7. Берталанфи Л. Общая теория систем – обзор проблем и результатов // Системные исследования: Ежегодник.– М., 1969.
8. Блауберг И. В., Юдин Э. Г. Становление и сущность системного подхода.– М., 1973.
9. Богданов А Всеобщая организационная наука (тектология).– М., 1965.
10. Основы системного анализа и теории систем: учебное пособие / А. М. Кориков, Е. Н. Сафьянова; ред. Ф. П. Тарасенко; Томский институт автоматизированных систем управления и радиоэлектроники.– Томск: ТГУ, 1989.– 208 с.
11. Садовский В. Н. Основания общей теории систем. Логико-методологический анализ.– М., 1974.