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SYSTEMS CONCEPTION OF PROBLEM-SOLVING

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Abstract: *The present paper deals with the causes that gave rise to Bertalanffy's General Systems Theory and Brno philosophy of systems methodology. It analyses what is a systems conception of the selection of method for solving a specific problem that is completely ignored by the current university teaching practice.*

Keywords: Problems, General Systems Theory, Systems methodology, Systems approach, Systems thinking, System of essential variables.

1. Introduction

Life in the sense of a whole formed by all living organisms in specific conditions of life within the Earth history puts different tasks on individuals. A term of a task is understood in the sense of responsibility delegated to humans (from their environment or by themselves, which is the case of the so-called self-motivation) to execute something on a certain entity (object, subject, process, etc.). If an individual knows the algorithm of how to accomplish a specific task, and if he/she has all that is essentially needed to implement the algorithm, it is the task of the type of labour. In the opposite case, it is the task of the type of problem. To solve this, it is necessary for the person to implement the following types of activities: informational, creative, evaluative, decision-making and executive.

The level of problem-solving depends on the level of knowledge of investigator (both in general and subjective meaning) about the characteristics of the entity. An important milestone at the general level was the period after 1926 in the field of philosophy (Jan Christiaan Smuts was the first who used the word holism in his book Holism and Evolution), and the period around 1950 when the Austrian biologist and philosopher Ludwig von Bertalanfy published his article "General Systems Theory - A New Approach to Unity of Science ".

Let us ask a question: "What was this milestone like?" A holism predecessor was called reductionism. It is a school of thought that tries to explain the facts on complex entities so that these are converted into simple parts through which the problems can be solved

Unsustainability of reductionism can be traced as early as at the beginning of the thirties of the last century when, with such objects, the "problems" with determination of their global characteristics and behaviour began to appear as they were considered only on the basis of the characteristics and behaviour of their isolated elements. Experiments showed that the resulting behaviour of objects did not reflect reality. In 1940, when searching for a solution to a military problem of Bell Telephone Laboratories for NASA, the analyses of the results showed the identical solution to the problem. The behaviour of the object as a whole was different from the behaviour that the object showed when considering only the characteristics of individual isolated elements of the object. It was verified that this discrepancy was not a random phenomenon, but it is one of the fundamental laws of our world. It is related to holism (Gr. "holon" = whole), which is also a philosophy assigning objects with those characteristics which are not derivable only from their isolated elements.

The importance of the above-mentioned milestone in the transition period from reductionism to holism is that the analyses showed that in problem-solving, the entities have to be understood not only as a set of their elements but equally important are also the bonds between these elements. A set of entity elements and the bonds between them was termed a structure of the entity and the corresponding characteristic of

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the entity is its structuring. In England, for the entity with these characteristics, the term "real system" was used. Issues that were addressed to the systems (problems of systems) were also marked as system problems.

2. Methods

All the above-mentioned findings represented a new paradigm in solving the problems in real systems. This was well reflected in the emergence of **General Systems Theory**, which was endeavoured by Austrian biologist and philosopher **Ludwig von Bertalanffy** around 1950, when he was looking for common patterns of both living and social real systems. He reasoned that these include openness (there exist energy, mass and information interactions between the elements of real system and their environments), complexity (in terms of internal interactions among elements of the real system and external interactions between the real system and its environment), feedback between the internal and external bonds, dynamic equilibrium, transformational relationships between the inputs into the real system and outputs, dedicated target behaviour of the real system and self-organizing processes in the real system. All this was considered to be characteristics of real systems, in other words, **systems characteristics**.

A systems theory needed for its existence an appropriate **theoretical and methodological discipline**. This should become: a discipline marked as **Systems analysis and synthesis** and **Systems engineering**. However, this was, in its infancy, drowning in "poverty of funds" needed for holistic solutions to problems. It was because appropriate theories, approaches and methods were not known, but mostly there was a lack of powerful computational tools. Although everything changed after the discovery and development of computers, because this allowed for the emergence of new methods and approaches to solving of holistic problems, the systems engineering was still getting into internal problems. It has been suffering from these problems up to now; among others, due to the changes in the entire "engineering". New engineering disciplines are being formed, e.g. information, knowledge, software, safety, risk, quality engineering, etc., which absorb many aspects of systems engineering so that the systems engineering suffers from "comminution". Both of these disciplines, while offering methods to solve systems problems, did not indicate how the specific system problem should be selected using a particular method for its solution, or on what basis the new theories should be created, failing to choose from.

At present, the following fact is also characteristic: the existence of computers enabled the development of numerical methods to solve professionally-varied problems by computational modelling. One of the best known, most versatile, and widely used methods is the finite element method. It is used in continuum mechanics, magnetism, electromagnetism, etc. Currently, it is a methodical top. If you are asked to solve the problem, solvable by FEM, you would select this method without being interested in any philosophising about a systems selection of method.

It can be stated that the publication "General Systems Theory-A New Approach to Unity of Science" was not followed by any other publication on a systems methodology. This is probably one of the reasons why there is currently such a poor situation in the systems approach to solving the problems that the individual meets in his/her environment or through his/her self - motivation.

A publication gap in the methodology of real systems was filled with a book written by Janicek (2014). It defines this methodology as an abstract entity with the following elements:

- **Systems approach** – is a generalized and sophisticated creative methodology of thinking and acting, applicable to any system entities. It consists of a sequence of conscious, describable, performable, or even formalized activities respecting **the attributes of the systems approach** that include all relevant facts in relation to the entity.
- **Systems disciplines**-are multifield disciplines that are applicable to the analyses and problem-solving in a specific group of scientific and practical fields (technical, medical, veterinary, agricultural, nature, philosophical, etc.). E.g. in technical sciences, these disciplines include: logic, mathematics, physics, systems engineering, cybernetics, systems dynamics, mechanics (solids, thermal, aero, hydro), statistics, logistics, deterministic chaos, self-organization, experiment, expert engineering, risks engineering, limit states.
- **Systems algorithms** are generalized algorithms for solving the problems in real systems of different disciplines (technical, social, socio-technical, technical and organizational), in their Hard systems, Soft

Systems, and Hard-Soft Systems.

- **Systems thinking** – is thinking in terms of generalized theory of systems and systems methodology, and at the same time it is an intersection of progressive structural and mental types of thinking (analytical, synthetic, creative, divergent, productive and comprehensive).

The use of **systems terminology** is a must.

Up to now, it has been not possible to define the term of systems conception, which is contained in the title of the paper. It is an approach to any activity undertaken on the entity when a systematically thinking individual uses a systems methodology.

2.1. Structure of systems approach

First subgroup: premises (assumptions) for application of systems approach

Attribute A0 – definition of "entity of interest" for subject;

Attribute A1 – requirement of term purity;

Attribute A2 – correct identification and formulation of problem.

Second subgroup: approaches to analysed entities

Attribute A3 – structured (to consider elements of entity and bonds between them);

Attribute A4 – purposeful (to assess the essentiality of characteristics, properties, behaviour);

Attribute A5 – comprehensive (in all internal and external relations);

Attribute A6 – hierarchical (bonds, interactions, activations, processes, states, manifestations, consequences);

Attribute A7 – oriented (orientation - temporal, causal, hierarchical).

Third subgroup: assess the characteristics of entities from these perspectives;

Attribute A8 – assess the entities in terms of openness (isolated entity, closed, open);

Attribute A9 – assess the entities in terms of level balance (in relation to the structure and activities of subjects);

Attribute A10 – assess the entities in terms of dynamics (i.e. changes over time);

Attribute A11 – assess the entities stochastically (stochasticity and determinism of variables and processes;

Attribute A12 – assess the states and target behaviour of entities;

Attribute A13 – assess the entities in terms of occurrence of deterministic chaos and self-organization.

Fourth subgroup: all human activities have to be at contemporary level;

Attribute A14 – use the latest knowledge of science and technology;

Attribute A16 – create “algorithms of activities“;

Attribute A17 – analysis, verification and synthesis of results concerning the problem-solving process (in general, the activities).

Fifth subgroup: deal with ethical aspects

Attribute A18 – responsibility for the credibility of the results of problem-solving process;

Attribute A19 – maintain all ethical standards (general, personal, social, geo-environmental);

Attribute A20 – monitor the methods of results implementation.

3. System of essential variables

In the sense of the attribute A7, a causal problem is considered in relation to a certain entity Ω. This problem is characterized by the fact that the input in the algorithm of its solution is represented by the causes (activations), which evoke the internal processes, while outputs are manifestations induced by these processes. In everyday life, when solving a practical problem, we always consciously or unconsciously analyse what its solution essentially depends on. The same is true for professional and scientific problems. The systems methodology for the "identification" of all the important components of the system produces a system of essential variables $\Sigma(\Omega)$ which is a set with the following subsets. This system is the basis for finding a credible and effective methods to solve the problem. The following is a list of subsets:

- **Subset S0 –** environmental variables v_0 describe the **elements in the environment** of entities.
- **Subset S1 –** object variables v_1 describe **the topology and structure of the entity**.
- **Subset S2 –** bond variables v_2 describe **essential bonds and interactions** between the entity and its environment.
- **Subset S3 –** activation variables v_3 representing such **activation of the entity Ω** from its environment that evokes processes on this entity.
- **Subset S4 –** affecting variables v_4 from the environment **affect the processes on the entity**.
- **Subset S5 –** structural and characteristics variables v_5 expressing the **characteristics of elements of entity structure** on which the problem is solved (characteristics: geometric, structural, physical, mechanical and technological).
- **Subset S6 –** process variables v_6 describing the **processes** on the entity transforming the entity into different **states**.
- **Subset S7 –** manifestation variables v_7 expressing **the entity manifestations** in relation to its environment.
- **Subset S8 –** consequential variables v_8 describing **the consequences of entity manifestations** on the environment or on the entity itself.

For all of these variables, their characteristics must be listed in accordance with the attributes of the systems approach, i.e. whether they are open variables (closed, isolated), dynamic (static), stochastic (deterministic), whether the occurrence of deterministic chaos and self-organization can be expected.

4. Selection of method for problem-solving

We have arrived at this situation. On the one hand, we have a system of variables $\Sigma(\Omega)$ to solve a specific problem; on the other hand, there is a set of potentially applicable (potential) methods to solve it. This set is part of the knowledge database of the individual. Its scope and depth are individual. The investigator, when selecting a method to solve the problems, faces the following decision-making activity: " Is there, among potential methods of problem-solving, such a method that it is able to comply with all the variables of the system $\Sigma(\Omega)$ with the respective characteristics?" Answers may include the following:

1) Yes. Then the respective method is accepted to solve the problem.
2) Partly. Then the following problem has to be solved: How is the solution to the problem affected, if certain variables of the system $\Sigma(\Omega)$ are neglected? Is this the issue of the consequences of using simplifying assumptions?
3) No. Investigation must continue to find a new method of problem-solving. It may not be easy, if at all possible.

5. Conclusions

We believe that the present text is understandable. Those who are familiar with the above-mentioned topic so that the text appears to them as useless, sorry. For those, who wish to extend their knowledge in this subject-field, the said publication on systems methodology is recommended. It is used to solve various scientific and professional problems as (Fuis et al., 2008, Fuis, 2004).

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