ON CLASSIFICATION OF AUTOMATED SYSTEMS

Dolgov, Ivan S., *Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*

ABSTRACT

The article deals with the problems of creating a unified classification of automated systems. The urgency of the problem is justified. From the standpoint of dialectical explanation the properties of objects are analyzed and identified. Signs of belonging to classes, categories, position of systems in categorical ranks, hierarchy of types are described. The author's version of a universal classification is offered.

Keywords: railway, infrastructure, management, decision-making, automated systems, classification, dialectical method

Background. *In the discussion on any automated systems authors directly or indirectly indicate classification, characteristic signs of the system, which allows to range it in a class. Therefore, when colleagues and myself as the developers faced the task of creating the concept of automated systems of control and optimization of solutions for prevention of emergency situations on railway transport, an obvious question immediately arose about the place of such a system among other automated systems.*

Objective. *The objective of the author is to consider possible options for classification of automated systems.*

Methods. *The author uses general scientific method, statistics, comparative analysis, graph construction.*

Results.

Common approaches

Typically, systems can be classified depending on the task, and automated systems (hereinafter – AS) can be characterized by one or more attributes. However, when using well-known approaches, features of the system appear as separate concepts. For example, there are following options of AS classifications:

- *general (enlarged) classification;*
- *on purpose;*
- *on direction and types of activities;*
- *on scale;*
- *on scope of application;*
- *on industry and type of production;*
- *on performed functions;*
- *on methods used;*
- *on method of architecture organization;*
- *on use mode;*
- *on degree of tasks structuring;*
- *on nature of information presented;*
- *on logical organization of information;*
- *on operation conditions in terms of information protection.*

Some classifications are absolutely synonymous, the other overlap and include the same systems:

- *enlarged classification ↔ classification on organization of information processes;*
- *classification on direction of activity ↔ classification on purpose.*

In general, it is believed that for classification of AS features it is necessary to use those properties of the designed objet that are most for it in the real world [1]. It can be concluded that enlisted classifications are used to identify in the project key features of described system or class of systems and are not intended to systematize AS, so the challenge to get universal classification of systems for scientific and educational purposes remains relevant.

As part of this classification, the author attempts to find characteristic features and unifying concepts, systemize titles of class units with a wide lexical meaning, their location in evolutionary and hierarchical ranks.

Dialectical substantiation

At some point of the way to understanding research problems it is necessary to explain dialectically the object (dialectic coordination and subordination), determine the properties of the object in view of its development. As a result, categorical (evolutionary) ranks are constructed that reflect the dynamics of the object development, the sequence of events and serve as a theoretical understanding of studied forms and states. More complex correlation of forms of object consists in constructing logical-dialectical models [2]. The matrix of this model has a form shown in Pic. 1.

This model is used in preparation of technical systems classification, shown schematically in Pic. 2. Next, the text considers automated systems, the order of the elements in evolutionary ranks based on properties of objects is explained.

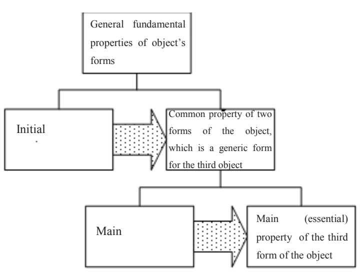
About systems

The concept «system» has a long history, originating from ancient times. Since then, depending on the context the word is used in different meanings and has dozens of definitions. AS as technical systems are a set of material objects of artificial origin and can be determined by a combination of interacting elements organized to achieve one or more goals [3]. For us it is important that AS have key attributes of systems, they are holistic: their properties are not equal to the sum of properties of elements, relationship of elements is stronger than ties of elements with the environment; they are structural: they can be described with a structure that dictates behavior of the system; they are hierarchical: each element of the system itself acts as a system. These properties are the basis of this classification.

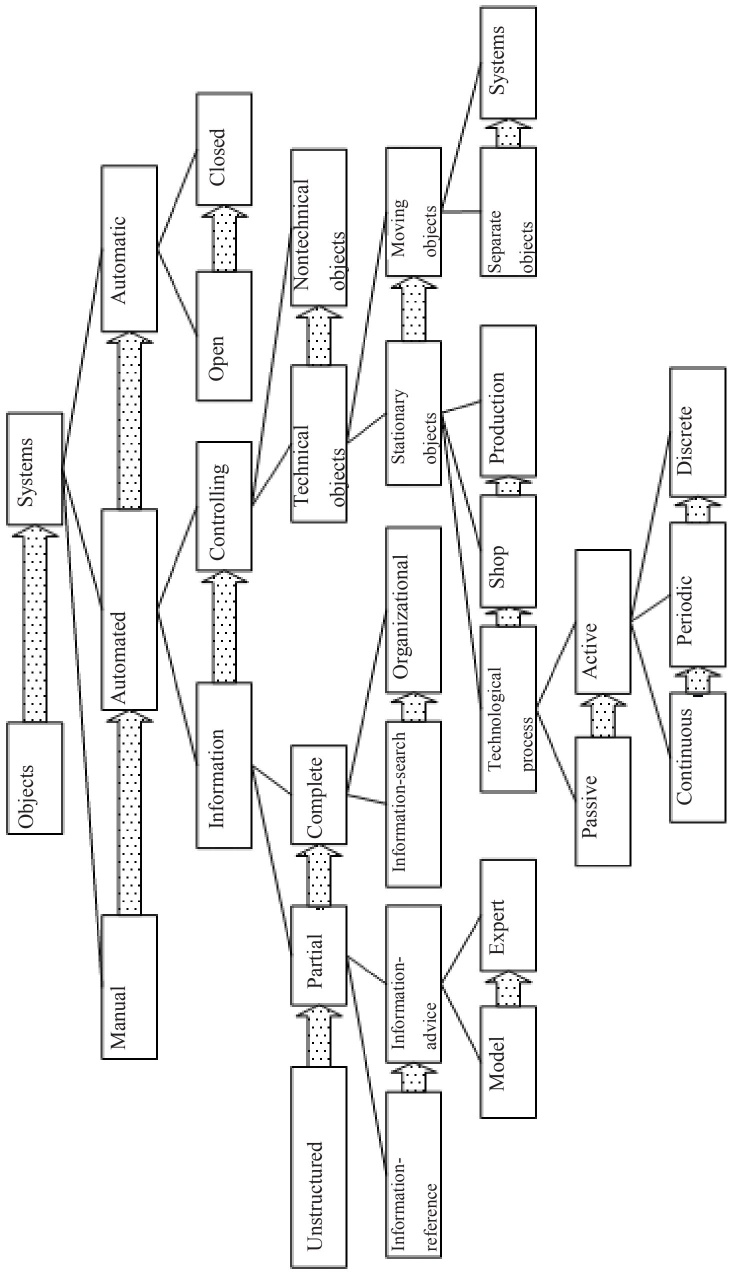
About degree of human intervention

In the first approximation, the classification is based on the degree of human involvement in the generation of control actions: from full participation through partial participation to a lack of participation. Accordingly, going from a primitive to a perfect type, evolutionary series is built:

manual systems → automated systems → automatic systems.



Pic. 1. Matrix of a logic-dialectical model.



Pic. 2. Classification of technical automated systems.

Manual systems are those in which information processing is performed by man without using any additional (technical) tools.

Automated systems

Systems that are the subject of this study, in accordance with enlarged (global, total) classification and synonymous classification of AS on organizing information process are divided into:

information →controlling.

Information systems, or supporting systems, collect and issue to operator information for effective decision-making. They are intended to work in open control scheme: the operator interacts with the system without taking into account its current state. Controlling systems (or functional) are supporting systems (that is based on means and methods) and the object (target) of the control for which control actions are generated. By and large, information systems have also an object of management – data, but the difference lies in object properties. Data are intangible, immaterial, while during control it is necessary to interact with real material objects.

Controlling systems

For classification of controlling systems we will analyze the nature of the control object: it is a machine, apparatus, device, i.e., equipment or objects of social, economic nature, sometimes with non-deterministic qualitative and quantitative characteristics:

ACS of technical objects → non-technical objects.

An example of control over non-technical objects is the class of automated systems of organizational control

(ASOC), designed to automate functions of management personnel – management of teams of people in economic and social systems.

As the main distinguishing feature of technical objects we shall consider dynamism, interaction mode with the environment. We can say that a dynamic object is a qualitative development of a static one, so we will arrange systems according to their mobility:

ACS of stationary objects → moving objects.

The former include:

• technological process control systems (ACSTP);

• production control systems, shop (ACSP);

• flexible production systems (for example, transport and warehousing).

Obviously, shop as a component of production represents a set of equipment operating within the established technological process. ACS of enterprise are different in objectives and structure, depending on the served industry; in this case, the system controls the production process as a whole, i.e. a set of primary and secondary – technological, information, transport processes, so it is logical to call it ACS of production. We get the evolutionary series:

ACS of technological process → shop → production.

According to the orientation of the process and the source of energy technological processes can be classified as passive or active. Passive processes do not require additional energy costs for influencing the object of labor, active processes are accompanied with direct impact of the means used on labor subject:

passive → active.

According to the way of organization of the active technological process processes should be distinguished as:

• single;

• periodic;

• discrete;

• continuous.

In the continuous process technological operations are made as long as raw materials, energy, control actions arise. Ongoing work cannot be interrupted and continued with the same operation. In case of a periodic process, a limited number of products is created during a certain time period, activity has measured results, but cannot be suspended. Discrete processes have clearly defined beginning and end and regulated breaks, the work can be stopped and resumed at any stage of technological operation without reducing the specified quality level.

It turns out that the periodic process has features of discrete and continuous: several periodic processes may form a discrete process, but each of them will be continuous or a set of continuous processes. Individual processes can be viewed as a special case of the discrete. The raw materials and the finished product are the natural resources, as well as physical objects or data flow. As a result, we have the following evolutionary series:

continuous processes → periodic→ discrete.

Examples include: systems of monitoring and control of energy resources (ASMCR), systems of operational dispatch control (ASODC), systems of operative control of production processes (MES-System – «manufacturing execution system»), combining production systems and production lines.

ACS of moving objects are divided into:

ACS of separate objects → systems.

Individual objects – vehicles, trains, ships, aircraft, space vehicles, military equipment. Systems are a set of individual objects – power system, air traffic control systems, railway, troops, weapons, fighting control systems. For example, air traffic control systems, ship automation systems, fire control systems.

Information systems

During classification of information AS search for combining concepts was particularly complex due to intensive development of this class of systems. Typically, a series of constantly arising in the process of engineering and economic activity objectives can be formalized; such tasks are called structured (formalized). Semistructured AS are less formalized (we know only part of elements and relationships), belong to the category of analytic, fuzzy, intelligent and make up the majority. There remains a certain amount of unstructured (non-formalized) tasks. A conclusion was made about feasibility of evaluating AS on the degree of structuring information: working with unstructured data, semi-structured and structured:

unstructured →partial → complete.

The class of complete AS include:

information-search → organizational.

The sole purpose of information-search AS is search for information among large amounts of data. Their base is constituted by software for organizing of input and storing information (search array), processing requests or support full dialogue with the user. A typical example here are library AIS (electronic catalogs of libraries – ALS, AILS, ALIS).

Organizational AS are some industrial ASCP, general control systems that organize economic, business or exploring activities. The qualitative difference between the control object – information – does not allow to unite them with ACS of non-technical objects (for example, staff) or ACS of technical objects (including production). Organizational automated systems provide the administrative needs of the enterprise in the field of document management; they are qualitatively superior as compared to information-search, because, coupled with the solving search problem, provide the required level of data processing. They include AS of scientific research (ASSR, ASSTR), to a certain extent – ERP-system («enterprise resource planning»), MIS- and EIS-systems («management information system» and «executive information system»), automated systems of technological preparation of production (ASTPP).

The partial AS include:

information-reference → information-advise.

Information-reference systems are less developed, passive. They give an access to semistructured data in the database, carry out its partial processing, may find connections between elements and are mainly engaged in creation of management reports, providing information support. The information is presented to the user upon request.

Information- advice systems are active AS. On the basis of semi-structured data, they help to prepare alternative solutions and periodically give the user (decision maker) information intended for him, i.e., advice. Having a qualitative superiority in the form of making opportunities for generation and ranking of alternatives, information-advise AS are right in the evolutionary series. Example – decision support systems, DSS-systems, to a certain extent – MIS- and EIS-systems.

Depending on methods and data processing algorithms, information- advice systems are divided into model and expert.

Model AS, among which stands out the first generation of DSS, provide the user with alternative solutions, prepared using the base of models – statistical, financial, mathematical and others. Among the main means of dialogue with such a system are questions like «What if». Among these systems we distinguish environmental and meteorological ones.

Expert AS are designed to replace the human completely in solving problems [4], implementing features and tools of artificial intelligence. Working in a narrow subject area, they are able to accumulate and to adjust knowledge bases with a set of rules for solving a range of tasks, specified by experts. They include DSS of the second and third generations, medical, geological systems. Moreover, this kind of expert AS appear to be more perfect in comparison with the model:

model $\rightarrow$ expert.

Further classification of information AS is possible according to the mode of use: batch processing of information, request-response or dialogue with the user (man-machine procedures). It has long been a tendency to increase the role of graphical representation of information in communication with the user, equipment of AS with user interface [4]. However, among developers there is no clear consensus about the need to use achievements of cognitive psychology for creation of this interface, its design is often left «for later» [6]. The user should be satisfied with all the sides of the product – from packaging and architecture to interface [5], and communication problems of human-computer interaction, resulting from neglecting interface aspect, make it more difficult to work with the system.

As the groundwork for further development of classification we show a possible primary division of automated systems:

open $\rightarrow$ closed.

Obviously, closed systems have the advantage of open, and it implies the presence of feedback, i.e. control action can be adjusted based on the data about the current state of the object.

Conclusions

The article presents the results of systematization of AS, identifies key (characteristic) signs and properties, defines classes with common characteristics. The thesis is accompanied with reasoning. Suggested universal classification helps to more clearly represent purposes of the system, control object, contributes to theoretical understanding of tasks and functions of AS in relation to the purposed area.

For example, an automated system of control and optimization of solutions for prevention of emergency situations on railways (the concept and methodology of it as announced is being developed) can be classified as an information system. According to the degree of structuring of processed data it is partial, information-advice (it ranks and gives alternatives), equally possessing features of model and expert systems (it is a part of the base of models and knowledge base, can replace the decision maker, but is controlled by the operator).

Other examples of the use of proposed classification:

• ACS «Express», being an automated control system of a complex of ticket-cash transactions of issuing and sale of railway tickets contain all features of information complete organizational system;

• EC ASIC as a single platform for control of processes of current infrastructure maintenance of JSC Russian Railways has the characteristics of information complete organizational system, controlling non-technical objects (work groups for repair, modernization, maintenance of railway infrastructure), technical stationary objects (track and structures facilities, distances of electrification and electricity, automation and remote control units) [7];

• AS CRRAR (control of resources, risks at the stages of the life cycle and reliability analysis) is information partial information-advice model system with the possibility of taking into account expert estimates of the frequency of occurrence of hazardous events in rail transport;

• ACS ESPP combines features of information complete organizational system and of a control system of non-technical objects, because it contains information about IT- infrastructure facilities, it controls work groups and tasks distributed between them.

As can be seen from the examples, commercial automated systems have characteristics of different classes of systems, and it does not contradict the proposed classification. On the contrary, classification allows a better understanding of goals, objectives and means of operation of such systems.

Dialectical thinking involves knowledge of either side or details of an object based on the explanation of all its known forms and conditions. This requirement is rather idealistic and too complicated to be realized. And accomplishing its relevant tasks is possible only with the participation of a wide range of researchers. Therefore, it makes sense to further refine the universal classification of automated systems, but already in the process of attracting representatives of related disciplines.

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Information about the author:
Dolgov, Ivan S. – Ph.D. student at the department of Computational systems and networks of Moscow State University of Railway Engineering, Moscow, Russia, idlhero@gmail.com.

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