# The Role of the Human Factor in the Control of Highly Important Automated Objects

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*Abstract* – **The article is dedicated to the search for a solution to the problems associated with the "human factor", topical in the complex control systems. The necessity of the creation of complex models that reflect the behavior of the operator in the automatic control systems is substantiated. Functions of man are structured depending on the used by him mechanisms of representation and processing of the information.**

*Keywords* – **Automated systems, Man – operator, Informational model, Behaviour.**

## I. Introduction

The main features of the modern stage of development of the technics is characterized by the emergence of complicated, large-scale technical complexes with general automation of the control processes of the technical objects, and the universal influence of the technics on the nature and society. To the class of the complicated technical objects can be related the energy complexes (nuclear power plants), oil production complexes on land and at sea, space navigated and transport ships and orbital stations, the large tonnage vessels, various types of automated production and the military equipment. Main factor determining the reliability and safety of the operation of such kind of ergadic systems (ES) is the appearance of many systemic properties: diversity, instability, interconnection nonlinearity interactions in the object; complicated and insufficiently studied physical and chemical nature of the processes of operation of the systems (for example in nuclear power plants); nonstationary extreme environmental conditions (e.g., space). Thus, the safety of man depends on the design of the very technical means and as well on the nature of the human interaction in this kind of complex systems.

The creation of new computers and software is one of the most dynamically developing areas of modern engineering. Every 1-2 years in the global market, new more efficient working models of personal computers appear and in the areas of software is seen a real boom. Computer science constantly require new professionals of a highest level. One of the main requirements to them is not only the narrow specialization, but also the inter-disciplinarity. Besides the traditional knowledge of hardware (computer hardware equipment) and software (software tools) such specialist are needed knowledge for many other areas: psychology of thinking and perception, social psychology, applied linguistics, ergonomics and design, cognitology. So the computer science give a new impetus and a certain synthesis between the natural, technical and human branches of knowledge.

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Technosphere and its components (artificial large systems) are created by people, as it should be manageable and not out of control. Technical and technological advances in the recent years in industry and transport contributed not only to increase of the productivity but the complicated and dangerous technologies and extreme conditions created prerequisites for violations of the workflow, occurrence of erroneous actions, threat of emergencies. In carried out studies it was found that the reasons for the many of the errors in the operator activity, as well as for failures of the technics are caused by distortion of the information interaction in the system "man-machine" [1-3]. On the one hand the occurrence of erroneous actions in the solving of the operator tasks is accompanied by the increase of mental tension and stress, and on the other - the complexity, responsibility and the danger of the operator activity determine those conditions that often lead to incidents, accidents and catastrophes [4].

## II. The Human Factor in Perspective Information Technologies

Modern highly responsible systems as well the complex information and control systems (ICS) are complicated man-machine complexes that combine the action of various technical devices and groups of people. The term "human factor" and its role in the information technologies is not limited to the field of engineering and psychological and ergonomic problems. In the contemporary socio-technical and informational sphere the human factor is seen as a crucial factor for successful, efficient and quality work, considering not only in manufacturing but also in the social sphere, innovation control, economics, etc.

In the existing systems for information support main attention is focused on anthropometric, physiological, mental and physiological characteristics of the operator, which in turn determines the structure of these systems - the types of displays, the sets of data models, the form for submitting of the information for the subject of control and also any other information necessary for its evaluation. An information for the subject of control is provided to the man- operator and usually are not taken into account all factors, such as: how necessary is this information for the operator; the operators possibilities to process the information; the methods of information processing by the operator; the compliance of the information to the tasks he solves; the working conditions and so on [5, 6].

Based on this, the methods for the development of the system for information support of the operator to assess the object of control should include the following components:

– analysis of the information support of the process for *assessment of the control object by the operator;*

– determination of the information signs providing assessment of the object of the control and justification of the composition of the information elements presented on the means for displaying of the information for operational evaluation of the object control;

– development of the structure and the requirements for the form of the data elements that best correspond to the nature of the operator in assessing the object of the control.

Following the positions of the information approach, fundamental issues of cognitive psychology are worked out, namely: how does one collect (perceives), encodes (learns), storages (commits to memory), interprets (thinking, reasoning) and uses language and other behavior) information. The Man`s functional state and activity have been analyzed. The activity is taken in as activity on purpose related to the solution of professional tasks: aim assignment, motivation, information processing, decision making, planning and forecasting, and implementing activities. Functional status is associated with influence of adverse or extreme conditions and factors leading to stress, anxiety, fatigue, emotional symptoms (irritation, fear, etc.).

The analysis of the reasons that cause changes in the functional state of the operator, shows that they can be divided into two main groups: reasons related to the physical characteristics of the influencing factors and reasons determined by the information structure and the content of the signals [3, 7]. Obviously, the type of the control panel and the panels for the displaying of the information give possibility to modify the data structure for the implementation of the operational tasks. The analysis of the changes in the psycho-physiological characteristics of the operator allows considering that the physiological indicators play a role of state variables and specify the conditions of the behavior of the system. The study of the nature of these changes play a role of an indicator of the stability of the operator's work.

The adequate model of man should meet two basic requirements: on the one hand to reflect the individual, the most important from the standpoint of the problem aspects of his behavior in the information control system, and on the other – to be added in the formalization of the general pattern of the examined system. By the man - operator, presumably, is expected such behavior, which includes informal, emergency elements, i.e. those that can not be reduced to the cybernetic model. It is advisable in this case to use a systematic approach where the control is studied not as directly feeding of a control signal, but as a procedure for the coordination of the structure (contextual link) of the data, which operates the object (in which role in this case is the person involved in the technological process) and the subject of control. As a unifying approach could be taken such human models that reflect his ability to self-organization (ongoing structural adaptation) in the changing conditions.

Human behavior in these systems can be structured by different signs, forming the so called "behavioral space" [8, 9] shown in Table 1. The analysis of this description, appended to the different functions of the operator in the control processes makes it possible to draw the conclusion that in the current conditions, distinct boundary between them disappear. For example the term "operator" applied to a man, remote-controlling a drone (UAV) uses almost all positions in Table. 1, and in the realization of positions 1.3; 1.4 and 3.3 are included not only the cognitive but also creative resources, integrating into its activity context-independent and context-dependent control. At the same time, it is widespread the opinion that the role of the operator is limited in positions 1.2; 1.4; 2.1; 2.2; 3.1; 3.2, where the subjectivity of the operator is regarded as a disadvantage. So it makes sense and becomes important the structuring of the man place depending on the used by him mechanisms for representation and processing of the information.

TABLE 1
„BEHAVIORAL SPACE” OF THE MAN-OPERATOR

| Sign | Content | Characteristic |
|---|---|---|
| 1. Tasks of the man-operator | 1.1. Planning of the activity | In autonomous mode |
| | 1.2. System programming | According to the process tasks |
| | 1.3. Operative control of the process fulfillment | Checking and confirmation that everything is in the limits of the foreseen plan |
| | 1.4. Intervention (going out of the automatic mode) | Assigning of new goals in emergency situations |
| | 1.5. Self-training | Periodic, after several cycles |
| 2. Physi-ological functions | 2.1. Sensor | Access to the indicator board, monitoring, perception |
| | 2.2. Cognitive | Assessment of the situation, taking of a local decision |
| | 2.3. Responding (effective) | Working off the taken decision |
| 3. Activity levels of man | 3.1. Practical (routine) | High sensorimotor and cognitive efficiency. Availability of routine, conventional actions. |
| | 3.2. Normative | Conscious activation of specific rules (instructions) in the memory. No new rules. |
| | 3.3. Based on knowledge | Complicated situations requiring new rules and decisions. Use of cognitive recourses for taking new decisions. |
| 4. Levels for acquisition of new knowledge | 4.1. Knowledge for argumentation | Knowledge for proof and expression on an interdisciplinary level. Verbal form. |
| | 4.2. Knowledge used in the real practice | Still verbalized but also reflex. |
| | 4.3. Experience | Knowledge at a deep, unconscious level. Provide insight type decisions. Intuitive form. |

Organization and professional preparation of operators of UAV involve professional check of candidates and organization of training and control of acquired knowledge are on base of trainers and educated systems. For candidates, who are assessed are defined required knowledge for work and how they offer higher capability during their activities [10].

## III. Recognition of the Subjective Factors in the Control Process

Considering the systemic-structural organization of the complex human-technical system, the control is seen as a multitude of situations, consisting of a subset of design situations (formal and informal) and a subset of potential control situations, the occurrence of which is possible at change of the statutory conditions for the operation of the object or the environment. The professional functions of the operator in such situations are determined by the dynamics of the control processes and are heterogeneous in their content. When implementing control modes of low degree of automation, they are reduced to a comparison of the actual and normative parameters of the system, control of the program for the functioning of the individual blocks and assessment of the reliability and the effectiveness of the control under quantitative criteria. At modes of a high degree of automation, the operator is obliged to conduct a qualitative assessment, to make sense of and interpret the arising situations and to coordinate the programs for control of all subsystems and the complex as a whole.

In clarifying the reasons for certain events, man usually can not be excluded with all its complexity and multi-variability. Staff requirements increase rapidly and it is important to anticipate and describe human errors, taking into account their importance in the design and the development of the systems. A thorough analysis of the working conditions in each separate case is required at a minimum. This is determined by experts, but it is common to believe that it is characteristic to man to make mistakes, and also that he can always be forced to enhance the quality of his execution. In this sense malfunctioning of the system is caused either by a human mistake or by inconsistency between man and machine due to improper design. The idea is during the development of the design criteria to compare the different categories of mistakes with a simple model of the activity of the man-operator.

Example of the modeling of a man as a unit of the control system. The greatest interest are those models where the man is a part of the control system. In this sense, it is better to introduce a parameter to the internal activity of the man that influences and modifies the output vector of the system as shown on the exemplary generalized diagram of Fig. 1.

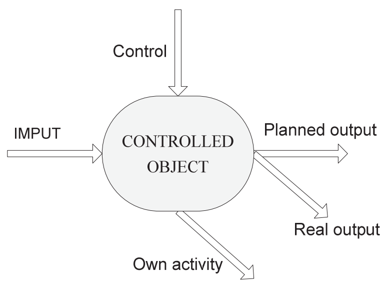


Fig. 1. A man as a unit of the control system

The adequate model of man should meet two basic requirements: on the one hand to reflect the individual, most important from the standpoint of the problem, aspects of his behavior in the ICS, and on the other – be recorded in the formalization of the general pattern of the system in question. By the man-operator, presumably is expected such behavior, which includes formalized, emergent elements, i.e. those that can not be reduced to a cybernetic model. It is advisable to use a systematic approach where control is regarded not as a direct feed of the control signal but as a procedure for coordination of the structure (contextual link) of the data, which operates the object (in which role in this case is the man involved in the technological process ) and the object of control. As a unifying approach could be used such models of man which reflect its ability to self-organization (ongoing structural adaptation) in the changing conditions.

In Fig. 2 is proposed an empirical model of the sequence of the operator actions on sensory, cognitive and motor level consistent with the known pattern of Y. Liu and C. Wu [11, 12]. The model for training and decision taking consists of two interconnected and various by nature flows of information. The first flow is the inherent to human information obtained through sensory organs and in this case qualitative information prevails in him. The other flow essentially is a formalized information with predominant sign quantitative information.

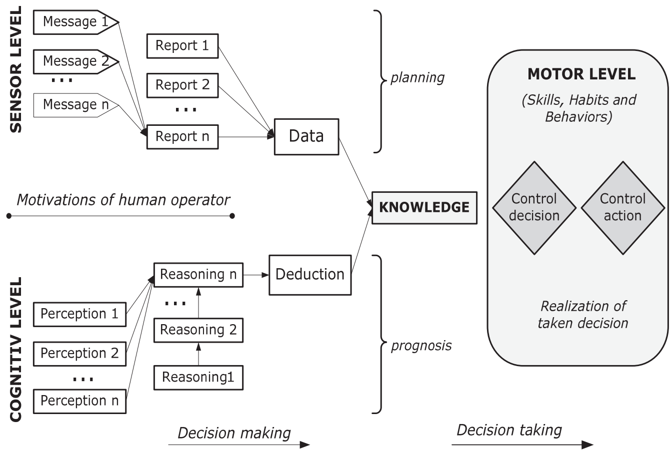


Fig. 2. Model of the operator's functions and decision taking

The solution is mental process (reasoning), deduction and fixed selection of variants of the probabilities of possible results of the implementation of the choices as well as mental comparison with expected optimum result. The decision taking can be defined as a mental process in the formation of the decision and includes: 1) the ability to choose information, to work out options for action and to provide the expected consequences; and 2) to be selected and executed appropriate action, or refraining from activities, or partial activities. This is a choice on several alternative lines of action or options which are determined so, that the selection of one of them to exclude the choice of all the other.

In the structure of such systems should be considered certain properties of the man-operator such as forgetfulness, tendency to make mistakes, volatility of attention and so on. The problem of formalization of the basic behavior patterns and psychological characteristics of man are connected and the attempts to create a mathematical models of his activities in the automation process. The peculiarities of perception and processing of the information by the man in the ICS impose a restriction on the possibility of using of stored data and in the specifying of the intelligence limits could be distinguished two levels of information processing - sensory channels and intellectual potential. On the first level, the transformation of the information is distributed among five sensor perceptions of man (visual, auditory, tactile, olfactory and taste) that have individual limits on the transmission of the information: the visual analyzer provides up to 90% of the total flow of information, but only about 10 % is allocated to the auditory and other sensory channels. On the second level, the intellect creates a model of the environment based on the received data. Because the brain and the nervous system of humans have limited resources, it determines the range of the solved problems. The main limitations of the brain are associated with the processing speed of the information and its final volume storage. Each event from the outside world is estimated by us (consciously or unconsciously) in accordance with our knowledge. The most important conditions that need to be taken into account in the implementation of the decision taken by the operator are: the existence of a deficit of information; shortage of time and lack of experience.

## IV. CONCLUSION

From the said can be concluded that during the creation and the operation of complex systems, their effectiveness will be determined not only by the difficulties in the development of mathematical, software and technological support, but also by the complexity of the reporting of the interaction with the psychological, physiological and social phenomenon called "human factor".

• The identified in the article guidelines and models reporting the requirements to the operator allows to formalize the whole process of functioning of the complex human-technical systems;

• The inherent human mental and professional characteristics (emotions, temperament, sensory-motor, fast-acting, etc.) should necessarily be taken into account when defining the control in the information-control systems;

• The unsanctioned interference of the operator in the system and its mistakes and wrong actions in the control process can lead to serious and unforeseen consequences.

Considering the complexity and the multidisciplinary of the problem, realization of simulation experiments safe for humans and for the technical systems is appropriate. Especially important is the relationship and the complementarity of the various sciences such as engineering and social psychology, physiology, cybernetics, organization and safety of labour, technical aesthetics, medicine, general systems theory, etc.

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