UDC 681.5: 517.977

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METHODS TO IMPROVE THE RELIABILITY OF ORGANIZATIONAL-TECHNICAL SYSTEMS

Annotation. *In the article the subjective factors that affect the reliability of the automated control systems of complex systems is analysed. The analysis of the properties, models and management methods for systems of varying degrees of complexity are spend. Lack of appropriate methods and means for forming reasoned decisions about managing of large systems in a critical mode operation is revealed. Advisability of using distributions approximating models for large systems in the form of shells substantiated.*

Keywords: *a large distributed system, a critical mode of operation, continuous model, decision support system, reliability of operation*

Introduction

A characteristic of modern industrial complexes is large branching of processing subsystems, the large number and diverse nature of equipment, complexity of control algorithms. All this the occurance ofthe problems in the operational management of large technical systems, due to the lack of methods and tools for reasoning control decision-making, especially under time pressure.

Analysis of recent research and publicatsons

Management systems in the organizational and technical systems have a hierarchical structure, where all levels use the automated dispatch control systems (ADCS) for operational management, connected to each other. Among the most important operating and technical characteristics, which determine the effectiveness of the objects, the reliability, vitality and non-failure operation occupy a special place [1]. Reliability of operation - it is the ability to keep the stability of the planned operation of the process, which is the absence the forced termination of the process (disruption) and a wrong of its execution in relation to the planned (faulty actions) [2].

Reliability of complex systems is dependent on multiple factors, without which it is impossible to ensure the safety and reliability of individual types of equipment and entire systems [3]. All the factors which affect the reliability of specific equipment such as Automated Control System (ACS) of complex systems are shown in Fig. 1.

Most significant impact on the the reliability of complex highly responsible systems have the reliability of operational staff [70], ie the action of the subjective factors on the operating system.

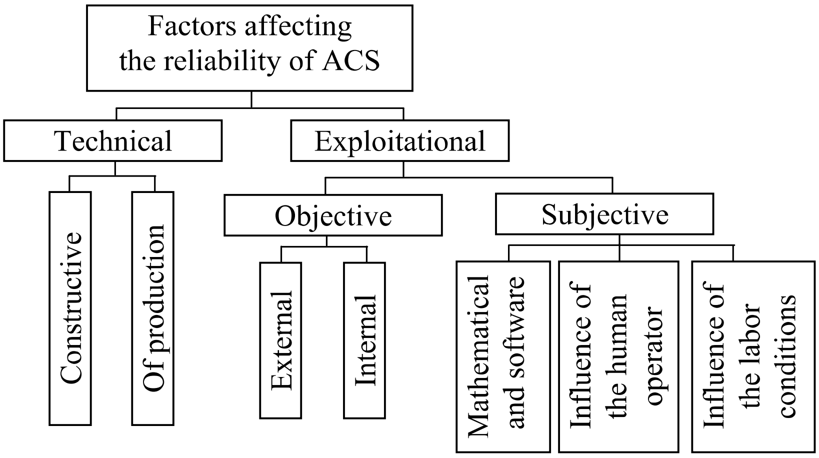

Figure 1 – Factors affecting the reliability of the ACS

Numerous studies have found that from 25 till 40% of ACS failures is caused by defects of the service such as: violation of instructions, mistakes in the perception of signals, delay and errors in the operator's actions, etc. In many industries, the percentage of staff failures is the sufficiently large. For example, about half of emergencies at nuclear power plants, including the most serious, directly or indirectly related to the human operator errors [2]. Operator error statistics is shown in Fig. 2.

Mistakes are maded at three structural levels of activity:

- At the task level (incorrect identification or wrong decision);
- At the level of operations (wrong choice or erroneous execution);
- At the level of actions (wrong choice or erroneous execution).

The structure of the automated dispatch control system, which is used for the operational management of modern production [4], shown in Fig. 3. Automation work station (AWS) allows dispatchers to directly monitor the status indicators and form executive management of equipment by a telecommunications technology.

Usual problems wich periodically solved at the operational management are [5]:

1. Assessing the current state of the control object (system).
2. Determining the deviation of object motion from the desired trajectory.
3. The solving problem of finding the optimal control (forming control actions for the coming period).

 ISSN 1562-9945

4. Implementing the control (adjustment of the system state - returning it to the given trajectory).

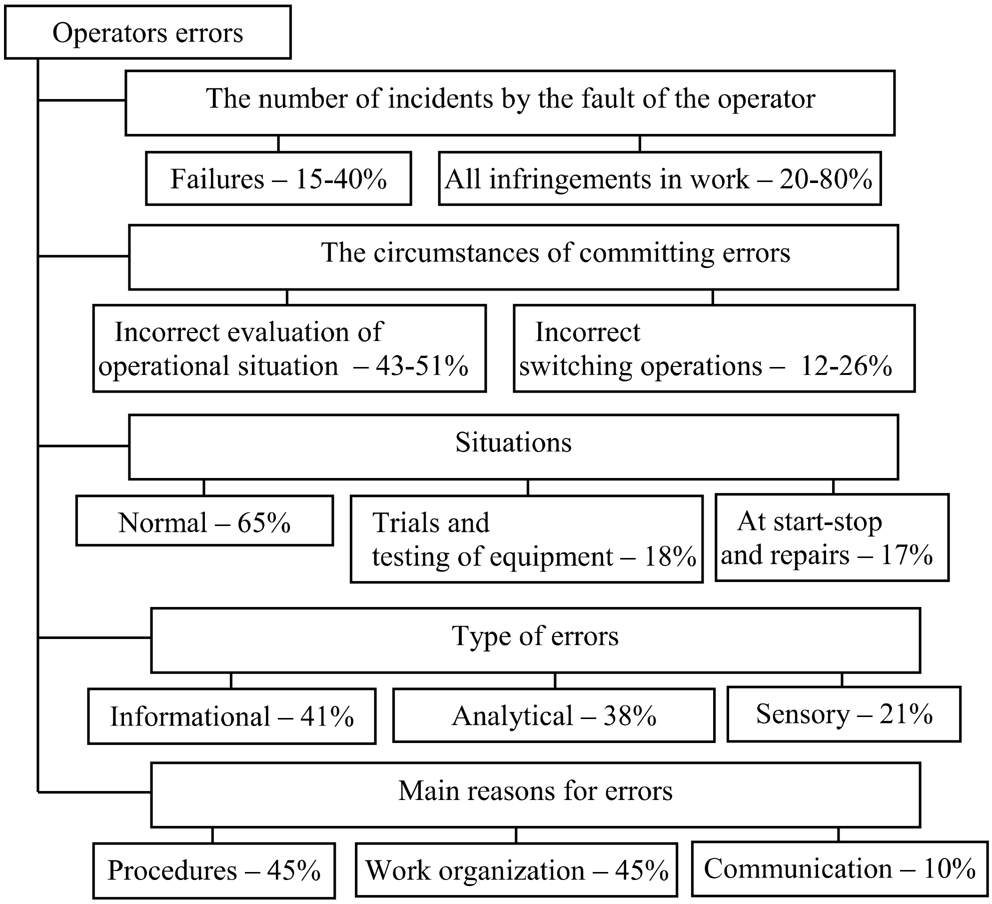

Figure2–Operatorserrorsstatistics

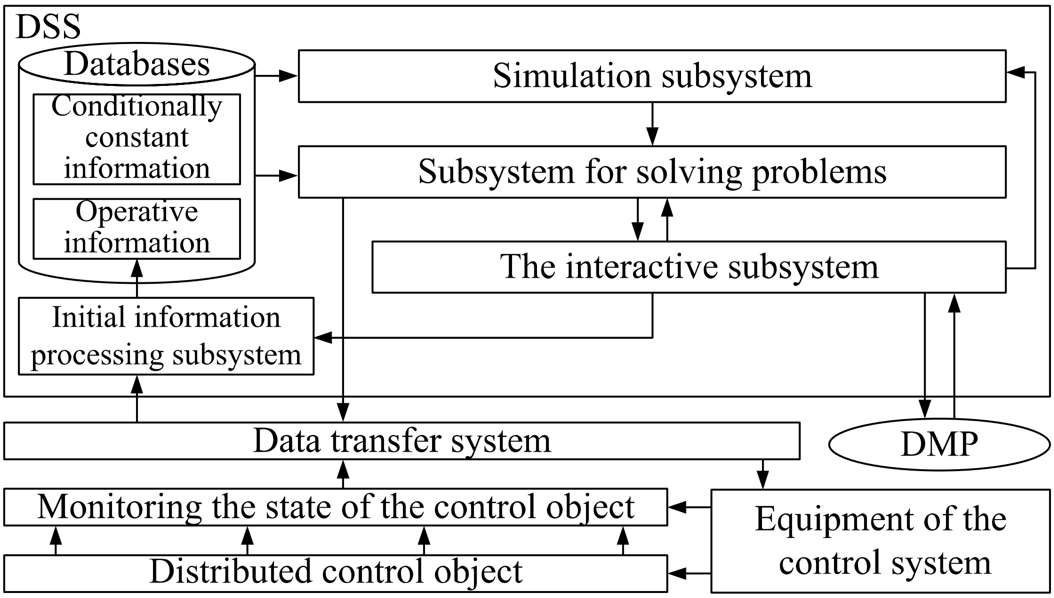

Figure 3 – Structure of ADCS for the operational management of modern production

Calculation of optimal control can performed in the dispatcher's AWS, by a decision support system (DSS), which structure is show in Fig. 3. The problem of ensuring reliability ADCS is becoming a key problem of modern engineering. A large proportion of errors due to the imperfection of methods and tools for operational decision-making, task complexity, and lack of time [1].

At shortage of time to making ground decision in a critical mode of a large system operation and the risk of transition to the disaster regime, the precise control of this system is not essential; we need just a good, qualitative assessment of possible control [6].

Statement of the problem research

In this regard, the actual problem is to find the mathematical apparatus, development of methods for constructing models that will determine the conditions for the transition of the system in the critical mode, then in the emergency and disaster mode, as well as the development of management techniques that will stabilize the state system in real time.

Purpose and objectives of research

The goal of research is to improve the efficiency of operational management of modern organizational and technical systems through the development of scientific and technical bases, principles and methods, which solves the problem of forming an optimized control in critical operation modes.

The main material of research

Organizational and technical system calledsuch set of technical systems, which operate in interconnection with each other and with the staff. Theycould be considered (accordingGlushkov) as aclassoflargesystems [7].

Stages of system evolution and comparative characteristics of their properties, models and management methods for systems of varying degrees of complexity are show in Fig. 4 [8].

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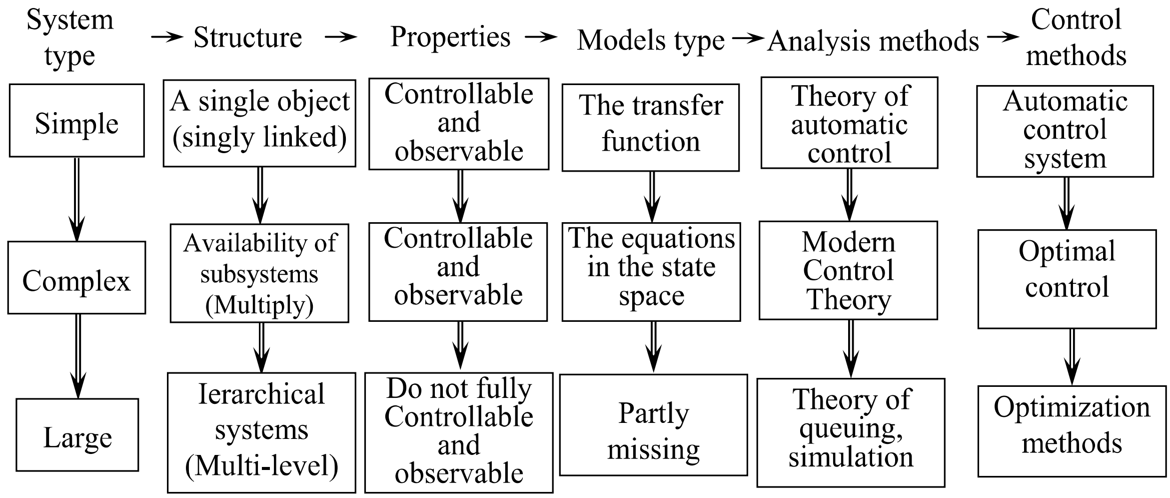

Figure 4 – Stagesof systems evolution

Table 1 shows the characteristics of efficiency using of existing models and management methods, which are use in different operation modes of large systems.

Table 1

The influens of models and methods characteristics on the control efficiency

Components	Normal mode	Critical mode	Disastermode
Model	Exact	Approximate	Incomplete
Control	Functional(optimal)	Inefficient	Missing
ControlResource	Satisfactory	Limited	Limited

Solving of problems,arising atthe operational management of large systems can carried out in two ways:

1). Design of partial models [8], ie the use for a large system of simplified solutions obtained using linearization procedures, minimizing and structuring. This is the introduction of restrictions in finding of optimal solution, and naturally makes the achired optimum weak. It is allowed to decrease the effectiveness of the solution due to unnecessary restrictions. At the same time, there is a high probability of determining the local optima for the system parts, which do not lead to the global optimum system as a whole.

2). Construction of generalized approximate models (shells), according to the comparison principle, majorizing behavior of the original system, based on which can be formed a management evaluation close to the optimal. Presentation of a large system can be reduced to a continuous description, which corresponds to the limiting case $n \to \infty$ [9].

Taskinsuchstatementbelongstothenarrowclass, alwayshasasolutionthatcanbequickly (timely) found.

To describe the systems used by the different levels of modeling from micro level, which allows describing the objects with distributed parameters, to a meta-level, intended for the description of distributed objects with lumped parameters (Fig. 5). To build models of complex technical systems the mathematical tool of ordinary differential or integral-differential equations, typical for the formal description of objects with undistracted parameters, is used.

For large developing systems non-linear transformation of input data (vectors of the state, input and output) in the space of a higher dimension can perform.With increasing size of the system (the order of n and approach it to the infinity), it is expedient to use a continuous description of the systems which approximates discrete values in some neighborhood [9].Coordinate transformation from the discrete representation of the continuous allows to change vector and matrix models in state-space by theire continuous analogs - analytical functions.

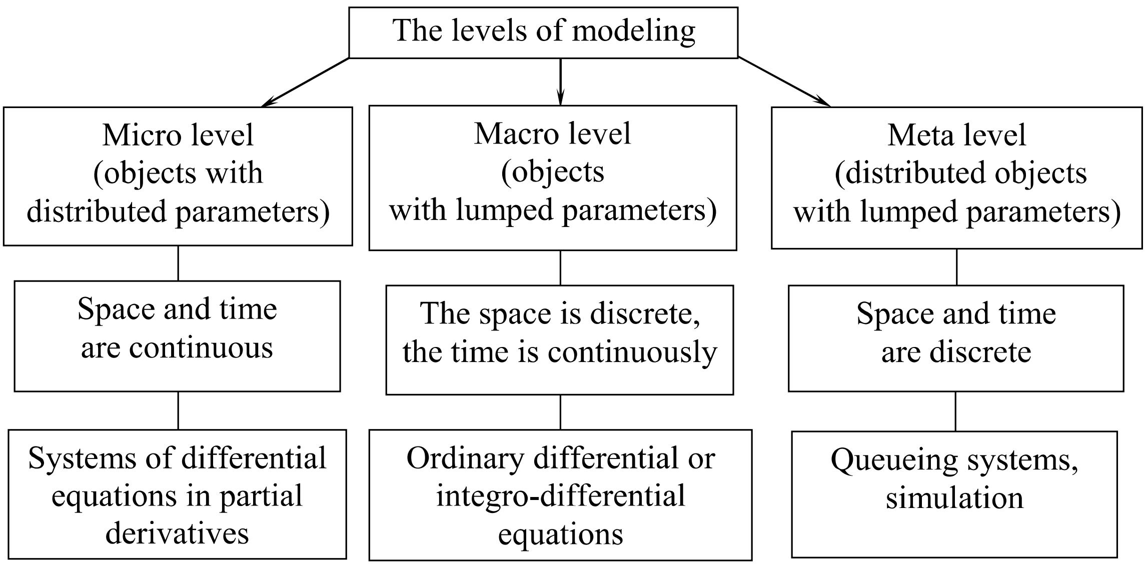

Figure 5 – Types of models and methods for modeling distributed objects

The dimensions comparison of discrete and continuous systems description in state-space is show in Fig. 6.

Description of n-dimensional first order distributed system is converted into a continuous form in which the matrix corresponds to a function of two variables independently of scale n. For distributed systems with second-order, functions approximating the matrix of the

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system depend on 4 variables and vectors - on 2. Forthethirdorder, respectively - on 6 and 3 variables.

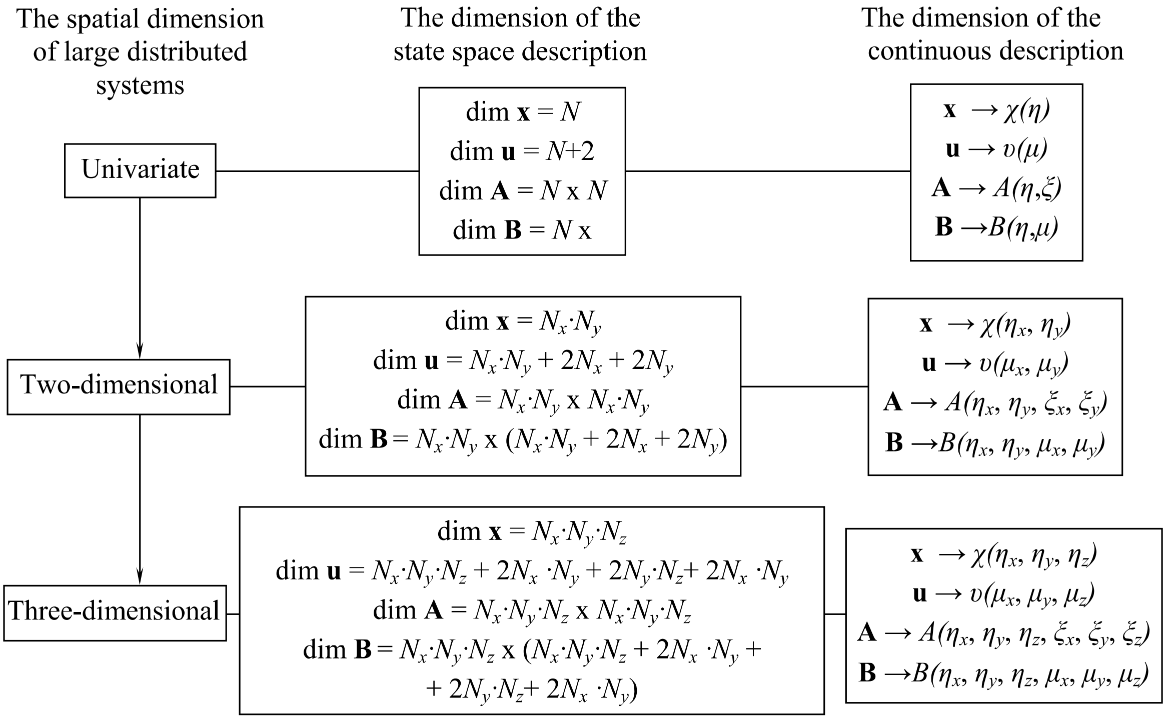

Figure 6 – The dimension of the distributed systems model

This approach avoids the problems in analyzing the large systems, caused by increasing of its dimensions. At the same time optimal control problem for distributed systems can be transformed into a class of problems with partial derivatives.

To improve the efficiency of decision-making of the optimal management of the system in the critical mode of operation is necessary to improve the scheme of interactions DSS units (Fig. 7) [10].

It is necessary to add in the DSS the following elements:

1. Provide the Simulation Subsystem to the pre-fault model, formed based on the continuous model of a distributed system in the form of approximating shells.

2. Add the Prediction of Emergency Subsystem, which analyzes the state of the system based on the surface model and allows us to estimate the stabilization time.

3. Decision-making unit must supplemented by an appropriate method of formation of large system control of the equipment for the forthcoming period, taking into account the current state and prediction of disturbing conditions.

4. Provide back-up data transfer system to the informational subsystem. In the transition the critical situation in disaster mode, as usual, there is the physical destruction of not only the individual elements of distributed objects, as well as and informational connecting objects.

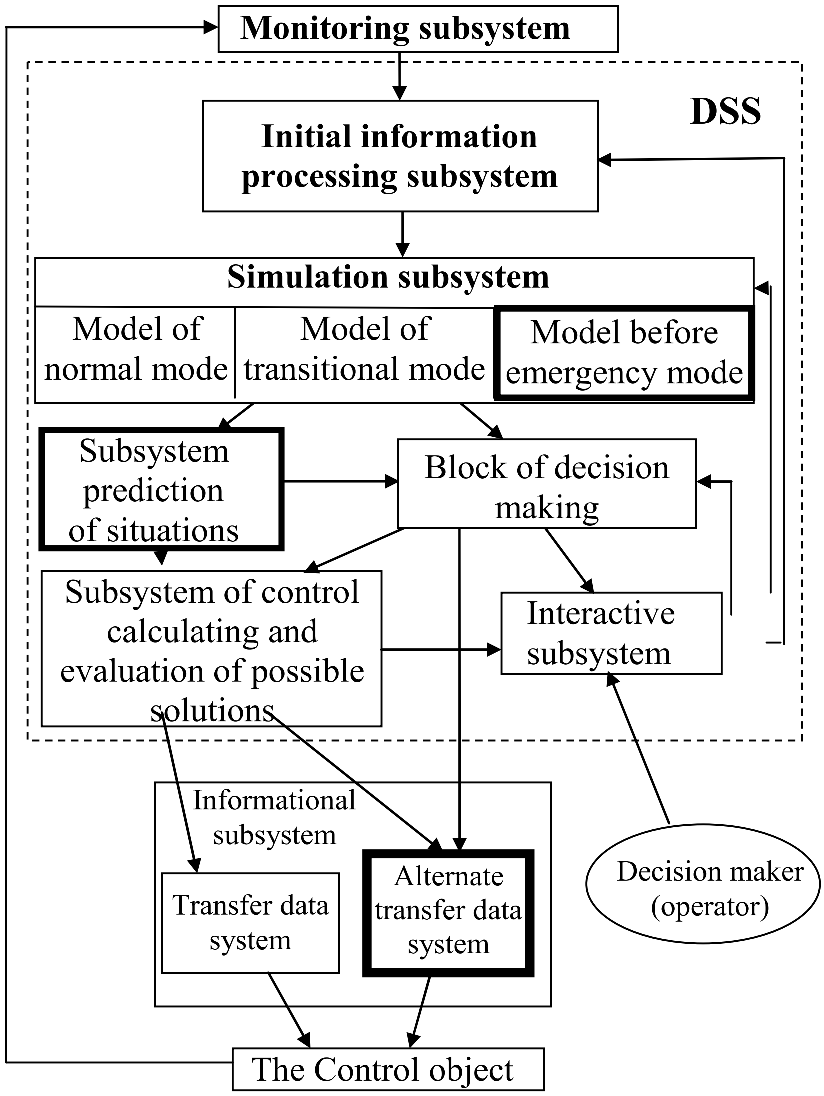

Figure 7 – The scheme of interaction between sub systems DSS

Conclusions and prospects for further research

Theresearches are baseontheconceptoftheuseofinformationmanagementsystemstocontrolamodernindustrialcomplex.

The method of constructing continuous models in the form of surfaces, based on the principle of majorization, allows creating models of geographically distributed objects to predict the state of the object, identify the location of critical nodes in real-time systems and to assess the remaining time to stabilize the operation.

 ISSN 1562-9945

Improving the decision support system at the automated dispatch control systems by adding a module assessing the state of the distributed object subsystem forecast the dynamics of distributed object, methods of synthesis of the optimum (sustainable) management based on the use of continuous models, makes it possible to improve the reliability of operation of organizational and technical systems by forming more informed and timely decisions in operational management, especially in critical modes.

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 ISSN 1562-9945