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APPLICATION OF ARTIFICIAL INTELLIGENCE SYSTEMS IN THE PROCESS OF CREW TRAINING

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ABSTRACT: The article considers the issues of managing the process of integrated training of orbital space station crews in the context of conversion to advanced digital smart technologies, computer-assisted training and artificial intelligence. The proposed approach is based on the use of automated information systems to support the planning and management of crew training on integrated and special-purpose simulators using an artificial intelligence technology.

KEYWORDS: artificial intelligence, cosmonaut training, automatic information system, information support

I. INTRODUCTION

The application of advanced digital, smart technologies, robotic systems, new materials and design techniques, creation of large data processing systems, computer-aided learning and artificial intelligence (AI) are relevant for various branches of science and technology, including manned space programs. Some technology concepts and pilot systems based on the AI (3-D computer vision, automated systems for planning and evaluating the activities of cosmonauts, inquiry and communications system) were developed in the industry over several decades [1, 2, 3]. Cosmonaut training is one of the most important issues of the manned flights program. Its final stage is a comprehensive crew training, aimed at forming necessary professional qualifications of crew members for performing IVA operations in accordance with the objectives of this type of training [4]. The comprehensive crew training due to the difference in technological features of the training process is currently divided into: comprehensive training of spacecraft crews (the Soyuz spacecraft); comprehensive training of orbital space station crews (the ISS crews). The training of the TMV crews is carried out on integrated and special-purpose simulators of the spacecraft. The training of the TMV crews in Russia has traditionally been formed on the basis of the methodological, technological and organizational principles of the "Voskhod" and "Soyuz" spacecraft programs. The training of the TMV “Soyuz” crews is based on the practice of several basic flight operation modes (orbital injection, rendezvous, docking, descent and landing). The same crew training technique was successfully used to train cosmonauts on the “Salyut” program, when an orbital piloted complex comprised a single inhabited module with a limited number of onboard systems. (Fig.1).

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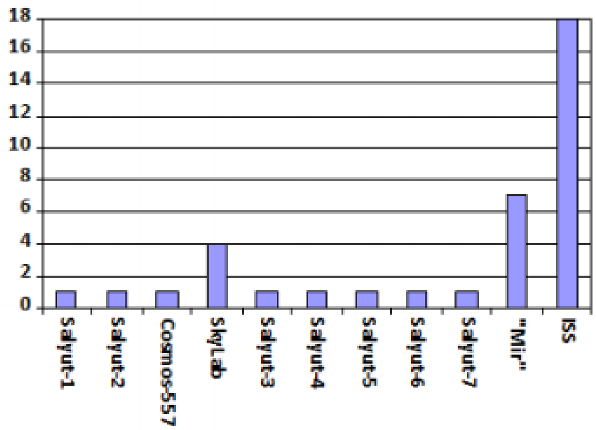

Figure 1: Number of modules of orbital stations

The training experience of the "Mir" crews showed the necessity to improve the technique of the simulator training of space crews. This was due to the complex configuration and increased volume of the orbital station. The use of new technologies and control systems during creation of the International Space Station led to the fact that the number of flight operations, carried out aboard the ISS has increased 100-fold by 2010 in comparison with the number of those, which were performed aboard the "Mir" orbital station.

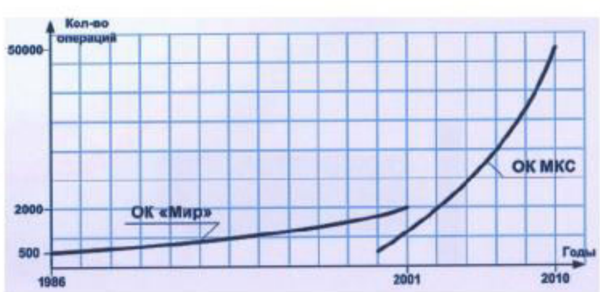

Figure 2: Dynamics of the flight operations performed aboard the orbital stations

The current issues of the ISS crew training using the integrated and special-purpose simulators are characterized by: 1. increasing number of flight operations performed aboard the ISS; increase of complexity of the cosmonaut training; sophistication of material and technical facilities and communication equipment. 2. a significant increase of data flows used in the training process; the information rate exceeds the capacity of its processing by a decision maker (training instructor). 3. Increasing number of types of training, training bases (Russia, USA, Europe, Japan, and Canada) and as a consequence, rigid requirements to the training periods. 4. Lack of time for decision-making, and as a result, failure to take into account a piece of useful information. This leads to erroneous decisions in the process of training. Additional resources may be needed to correct the consequences of erroneous decisions. The process of the crew training includes planning, activity arrangement and performance control. In order to achieve the goals of crew training, it is necessary to optimize the use of appropriate resources. [1]. The Fig. 3 demonstrates the structure of a training session with the use of full task simulators. The stepping up requirements for the quick decision-making has led to the need to develop a computer-assisted control in the subject area of cosmonaut training. Due to the complexity of this type of training, as a rule, the decision-making process cannot be formalized on the basis of a single mathematical model. The current stage of development of computing facilities allows solving this problem through the use of artificial intelligence systems. In this particular case, the artificial intelligence is understood as an ability of automatic or automated systems to perform the functions of human intelligence, that is, to make optimal decisions on the basis of the

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gained experience and analysis of the external influences.

The artificial intelligence can be used primarily in planning and evaluating the quality of cosmonaut training.

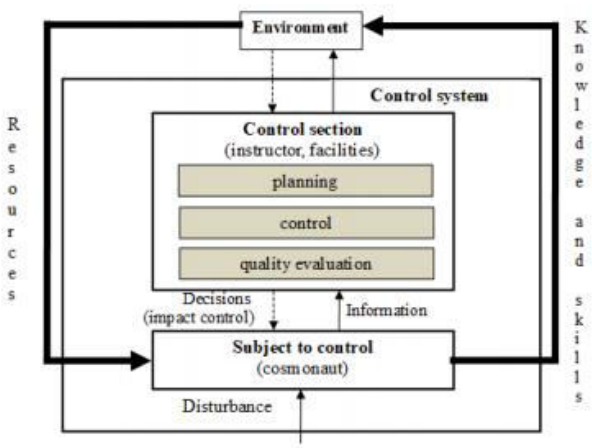

Figure 3: Structure of the training process

In order to create the artificial intelligence to provide a simulator training of cosmonauts, it is necessary to: • understand the goals, objectives, functions of the entire system of crew training with the use of integrated and special purpose simulators; provide and use the necessary data at various levels of training, presented in the form of information flow diagrams; apply the classification and coding systems for flight operations and emergency situations; master the methodology of creating conceptual and information-logical models, which reflect the interconnection of information; create and store information arrays on data medium, taking into account that this will require modern software [3]. The process of the simulator training of the ISS crews can be divided into four interrelated components: 1. formation of a simulator training program, which represents a sequence of training sessions and exercises to be worked out by a crew. 2. Compilation of a training sequence diagram. 3. Control of crew training process 4. Evaluation of cosmonauts' performance during a training session. Automated control of the ISS crew training has resulted from the need to record large amounts of information (the number of flight operations aboard the ISS reaches several thousand) and to take into account all factors affecting the planning and control of training sessions.

An automated control of the training process can be based on the use of integrated automated training system (KAOSPK), which is the interaction of the simulator system itself and the automated information system intended for planning and conducting the training sessions (AISPPT). The integrated automated training system combines the simulator system (including instructors' terminals and crews' interfaces) with the terminals designed to train crews and instructors for each training session (Fig. 4). The use of such a system allows reducing dataflow processing time by applying appropriate software, interactive systems and databases. In this case, both the logical-analytical process of planning and control, and the preparation of documents necessary for conducting the training, become automated. Besides, all operations can be performed by an instructor from the same workstation. The automated information systems involve the participation of humans and the use of technical means for data processing, but the major functions are carried out by the computer.

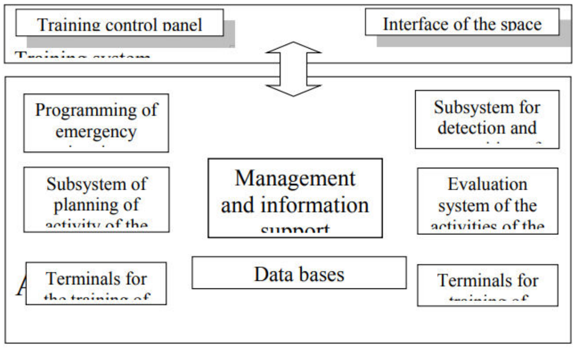

Figure 4: Scheme of the integrated automated training system

The integrated automated training systems should provide: descriptions of flight operations and scenarios of emergency situations; proximate order of flight operations and emergency situations; information support of cosmonauts and instructors upon request; reference information for the instructor on the ongoing flight operations and emergency situations; automated compilation of training sequence diagrams; software to download the scenarios of emergency situations for the upcoming training sessions; emergency scenario training; detection of crew errors in the process of training; detection of simulator failures in the course of training, their correlation with the planned emergency situations; regulatory requirements for the crew's actions in nominal and off-nominal situations; options for changing the course of the training (training sequence diagram). The indicated tasks can be combined into five groups (subsystem) according to their functional characteristics: management and information support subsystem; data input subsystem; detection and recognition subsystem; crew activity planning subsystem; crew performance rating subsystem.

The mode of interaction between the system's components while in operation depends on the type of the problem being solved. Considering the widespread use of artificial intelligence systems, they can be classified by: the area of use; applicability of information; automated functions; degree of automation functions performed; degree of structuredness of the current tasks. In cosmonaut training, AI-based automated systems can be classified, for example, by purpose and by nature of the information presented.

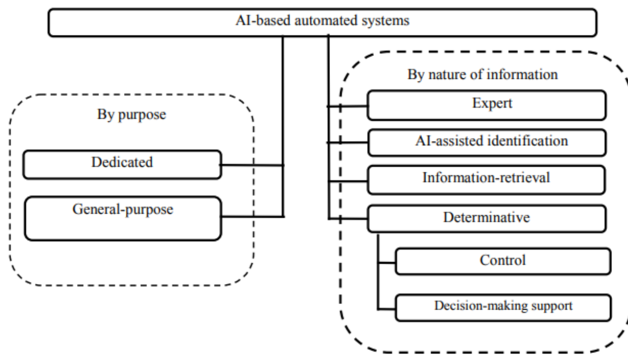

Figure 5: Classification of automated training systems using artificial intelligence to train cosmonauts

By the nature of the information use AISPPT refers to a class of information-determinative systems, which carry out all information processing operations according to a specific algorithm. Such systems can be classified according to the degree of impact of the resulting information on the decision-making process and divided into two classes of systems: control systems and decision-making support systems. AISPPT can be referred to control information systems. These systems produce information on the basis of which a person makes decisions. These systems are characterized by computationally intensive tasks and large data volumes. The development of AISPPT elements is carried out by using systems of visual object-oriented programming and object-oriented databases. Thus, the automated control of comprehensive simulator training of orbital space station crews requires the synthesis of software and information support of modular AI systems in order to create integrated automated training systems. The proposed structure of AISPPT system requires the development of basic mathematical models, focused on solving issues within each subsystem. The goals of using the automated information systems are: improvement of quality of crew training; flight safety; reduction of instructors' labor contribution in planning and conducting simulator training. Further development of the integrated automated training system involves the use of artificial intelligence methods. This will make it possible to introduce a cosmonaut's individual training, taking into account his personality, to compile his "passport", which will contain data on his successes in mastering the course content, check test results, etc. Based on these data, the system will allow generating additional tests and tasks for more successful mastering of the training documentation.

CONCLUSION

The introduction of AI technology will also contribute to the development of joint teamwork of cosmonauts, through the implementation of various scenarios on simulators, which can only be solved by a coordinated work of each cosmonaut in his workstation. This will require the development of dedicated software to create a user-friendly interface. But there's no doubt that the quality of training, and the volume of educational material will recoup the expenses connected with the development of AI technology as a part of the crew training system.

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