

Educational digital complex for the specialists training in the operation of information and communications equipment for space purposes

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Abstract — The concept of creating an educational digital complex for the specialists training in the operation of information and communications equipment for space purposes is outlined. The goals and objectives of the digital educational complex development are formulated. As a result, a single digital educational space has been created for specialist training in the operation of information and communications equipment for space purposes based on the interaction and integration of military and civilian educational institutions and enterprises of the Russian space industry.

Keywords — *information and communications equipment for space purposes, professional competencies, digital educational complex, training technologies and techniques.*

I. INTRODUCTION

The success of the implementation of the program for launching integrated launch vehicles (ILV), as well as the management of spacecraft (SC) orbit group (OG) of the Russian Federation (RF), is largely determined by the quality of specialists training in the operation of ground-based space infrastructure (GBSI) facilities. Among the GBSI facilities, a special place is occupied by information and communications complexes for space purposes providing communication and data transfer between all subjects of space activity. The development of telecommunication technologies in the XXI century has largely affected the information and communications equipment for space purposes. However, the training system in this knowledge-consumptive field was not fully prepared for the technological breakthrough.

The direction of education system development of the Russian Federation, taking into account the avalanche-like development of digital and telecommunication technologies, is determined by the “Modern Digital Educational Environment in the Russian Federation” priority project [1]. Moreover, the term “modern digital educational environment” is most often understood as the totality of “online courses” in various disciplines of higher and special vocational education [2]. This approach has been

described in a number of foreign papers [3-5] and works well for the formation of competencies in the specialties of natural science and the humanities [6-15], while for specialties with a narrow applied focus, for example, in the areas of aircraft control, military equipment and other sophisticated technological equipment, the approach associated with the development of training complexes is widely used [16-20]. In this case, simulator complexes are a computer, semi-scale or even full-scale model of a real model of equipment or a real process [16-20]. In the development of simulator complexes, as well as in “online courses” development, modern digital technologies, for example, “augmented reality technology” [20] and “web technologies” [16], are widely used. And, finally, it must be added that the requirement to create training equipment (TE) is included in terms of reference for the development of new models of space, military and special equipment. In this case, developers, as a rule, rely on a set of special functional requirements for the corresponding model (prototype) of space or military equipment, as well as on a number of governing documents of Roscosmos, the Ministry of Defense of the Russian Federation [21] and GOST [22]. At the same time, the limited material resources allocated for the TE creation, as a rule, force developers to follow the path of introducing modern digital technologies.

Curious to relate, the main weak point of the dominant trend [23] is the formation of competencies of the bachelor, master, and especially the specialist set by the federal state educational standards. Indeed, the predetermined competencies formation is the task of balancing the amount of knowledge and experience in solving specific practical problems inherent in a particular profession. If a specialist is only using the “online courses”, they can obtain practical and specific skills for solving tasks only in theory. For a number of professions, this may be permissible, but there are many technical specialties that require direct experience of working on specific equipment (a technical system or complex). Such specialties include those focused on the development and operation of information and communications equipment for space purposes.

Obviously, all three of the above areas of the modern digital technologies introduction into the educational process may be considered as the implementation of a digital educational environment in the broad sense. The establishment of an interdepartmental digital educational cluster for specialists training in the development and operation of information and communications equipment for space purposes is a successful result of combining all three of the above areas, when the result is simultaneously an open system that provides educational services to a potentially unlimited number of users, allows to create highly specialized competencies in the development and operation of information and communications equipment for space purposes and at the same time is an integral part of several samples of space and military equipment developed as part of the relevant experimental design work. This publication is devoted to the description of the creation and structure concept of an interdepartmental digital educational cluster for training specialists in the development and operation of information and communications equipment for space purposes.

II. THE PURPOSE, STAGES OF CREATION AND COMPOSITION OF THE EDUCATIONAL DIGITAL COMPLEX FOR THE TRAINING OF SPECIALISTS IN THE OPERATION INFORMATION AND COMMUNICATIONS EQUIPMENT FOR SPACE PURPOSES

The works on the analysis of the satisfaction degree of the Federal State Educational Standard requirements, performed in the period from 2010 to 2017, revealed the following negative trends in training for the Russian space industry [1-3, 6-11]:

- the system of professional and vocational and job training in operating organizations is based on an outdated educational and methodological base, it does not use modern technical training aids (TTA) and, in particular, educational and training aids (ETA), and cannot provide the required level of training for independent work;
- the system of additional professional education is largely formal, it does not use modern TTA and does not allow to form the required set of skills for practical work on modern communication equipment;
- the successful fulfillment of the tasks for launching the ILV and managing SC OG during the flight development tests and regular operation substantially depends on the quality of specialists training in the GBSI operation.

The solution to the problem of improving the quality of specialists training in the operation of information and communications equipment for space purposes should be associated with a qualitative improvement in the practical skills of specialists, as well as mastering new competencies at the required level, such as:

- the ability to justify and evaluate the technical characteristics of spaceborne and ground-based communication complexes, communication systems with manned SC, communication systems of SC for various purposes and to develop proposals for their improvement;
- the ability to conduct television, radiotelephone communication sessions, data exchange sessions with

transported manned ships, and intended use of information and communications equipment for space purposes;

- the ability to manage the resources of the ground, telecommunication network and the administration of the communication system of space complexes;
- the ability to provide informational interaction between space radio-technical complexes of control, navigation, telemetry and single time service in the control loop of the SC OG for various purposes;
- the ability to analyze the causes of failures in composite communication channels in telecommunication networks of space complexes, in radio engineering control and navigation systems, to restore the operability of telecommunication systems of space complexes.

The educational digital complex is designed to train specialists in the operation of information and communications equipment for space purposes on behalf of the Russian Ministry of Defense, the Roscosmos and the military-industrial complex, it is an innovative development of the federal level in the field of education, which implements an effective training technology.

The authors first developed and created [24]:

- the EDC concept of specialists training in the operation of complex geographically distributed technical systems, in particular, information and communications equipment for space purposes;
- educational technologies, taking into account the peculiarities of interagency training of specialists in the development and operation of information and communications equipment for space purposes];
- unique educational tools for the main areas of training for the development and operation of information and communications equipment for space purposes.

The system of interconnected geographically distributed digital educational complexes implements the functions of integrated practical training in operating skills of information and communications equipment systems for space purposes based on network technologies and distance learning techniques.

The basic principles underlying the development of the educational digital complex include:

- the principle of digital educational environment openness;
- the principle of invariance to the direction and form of specialists training in the digital educational complex (DEC);
- the principle of continuity and compatibility with other EC;
- the principle of universality of the DEC components.

The idea of DEC creation included the following successive stages.

Stage 1 (period of 2010-2012). Assessment and analysis of the satisfaction level of federal state standards requirements for the specialists training in the development and operation of information and communications equipment for space purposes.

As a result, it was shown that the existing specialists training system in the development and operation of information and communications equipment for space purposes does not allow achieving the goals of the Federal State Educational Standard in terms of the formation of the required professional and professionally specialized competencies.

Stage 2 (2012). Development of tasks for the EDC establishment.

Development of the task included the following elements:

- 1) development of an implementation plan for the EDC;
- 2) task for the educational programs development by creative teams of the A.F. Mozhaysky Military-Space Academy, Bauman Moscow State Technical University and Amur State University;
- 3) assignments for the development of educational and training means by the creative team of the A.F. Mozhaysky Military-Space Academy;
- 4) assignments for the development of information educational tools by the creative team of the A.F. Mozhaysky Military-Space Academy;
- 5) assignments for the development of training technologies and teaching methods by creative teams of the A.F. Mozhaysky Military-Space Academy, Bauman Moscow State Technical University and Amur State University.

In accordance with the implementation plan, EDC was developed in three directions, namely, in the establishment of three digital educational complexes interconnected through the central element of the EDC:

1. Interuniversity digital educational complex (IUDEC), in which the main elements are the A.F. Mozhaysky Military-Space Academy, Bauman Moscow State Technical University, Amur State University (Blagoveshchensk city),
2. Military-space digital educational complex (MSDEC), consisting of: A.F. Mozhaysky Military-Space Academy, the Plesetsk Cosmodrome and the Titov Main Test and Space Systems Control Center (MTSSC)
3. Space Engineering Digital Educational Complex (SEDEC) consisting of: A.F. Mozhaysky Military-Space Academy, the Vostochny Cosmodrome and the Baikonur Cosmodrome.

Stage 3 (period of 2012-2014). Development of an interdepartmental digital educational cluster for the specialists training in the development and operation of information and communications equipment for space purposes.

Stage 4 (period of 2014-2018). Implementation and testing of new effective training technologies based on the use of an interdepartmental digital educational cluster for specialists training in the development and operation of information and communications equipment for space purposes.

Each of the above-mentioned digital educational complexes (IUDEC, MSDEC, SEDEC) has a typical structure and includes four interrelated elements:

1. Educational programs of higher education in the specialties of 11.05.04, 24.05.06 and 24.03.01, secondary vocational education in the specialty of 11.02.11 and additional professional

education in the specialty of "Application and operation of space complexes communication systems".

2. Educational tools for subsystems of the telecommunication infrastructure of the Baikonur and Vostochny Cosmodromes, namely: Educational tools of the telecommunication support system for the Baikonur Cosmodrome; educational tools of the satellite communications subsystem of the Vostochny Cosmodrome; educational tools of the satellite communications center of the Vostochny Cosmodrome; educational tools of the digital complex for switching and distribution of television information of the Vostochny Cosmodrome; educational tools of hardware-software complex for measuring digital paths of the Vostochny Cosmodrome; educational tools of the Vostochny Cosmodrome common timing system; educational tools of Primorka-M satellite communications system. The typical composition of educational and training tools from the DEC includes a program and methodical complex (PMC), an information and reference system (IRS), a knowledge testing system (KTS), and a simulator complex (SC).

3. Information educational tools responsible for the formation and visualization of the theoretical basis in the field of development and operation of information and communication tools.

4. Training technologies and methods of conducting classes, which include:

- technology of training under the higher education program in the specialty 11.04.05 "Information and communication technologies and special communication systems";
- technology of training under the program of secondary vocational education in the specialty 11.02.11 "Communication networks and switching systems";
- technology of training under the program of additional professional education;
- training technologies for professional and vocational training programs;
- distance educational technologies in the IUDEC, SEDEC, MSDEC;
- private methods of conducting classes in the disciplines of "Special-Purpose Radiocommunication Systems", "Communication Networks and Switching Systems", "Special-Purpose Radio-Relay and Satellite Communication Systems", "Protection of Special-Purpose Information and Communication Systems", "Special-Purpose Multichannel Communication Systems", etc.;
- methods of using the program and methodological complex when conducting various types of classes.

An analysis of the experience in implementing the EDC, which is a unique combination of modern network technologies, the latest achievements of the space industry and the military-industrial complex, the requirements of the Federal State Educational Standard, the experience of creating elements of a digital educational environment, the professionalism of practicing specialists in the space industry and education, suggests that an effective technology with signs of novelty learning has been created.

The learning technology takes into account the possible distance between the participants of educational process. In addition, the widespread use of modern network technologies has allowed to obtain a new quality of the training methodology, namely:

- students have the opportunity to gain skills in the development and operation of information and communications equipment for space purposes, taking into account the most relevant experience gained by leading industry experts;
- specialists of the space industry have an opportunity to broaden their horizons and improve theoretical training by leading experts in the field of education - scientists, teachers and methodologists of the A.F. Mozhaysky Military-Space Academy, Bauman Moscow State Technical University, Amur State University and other universities of the Russian Federation;
- working programs of academic disciplines in the DEC specialties take into account the best practices of specialists in the development and operation of information and communications equipment for space purposes, thematic plans and methodological recommendations fully utilize the EDC capabilities for organizing information exchange between all subjects of educational activity, regardless of their geographical location.

The educational digital complex operates on the basis of the A.F. Mozhaysky Military-Space Academy, Bauman Moscow State Technical University, Amur State University, the Baikonur, the Vostochny and the Plesetsk Cosmodromes, as well as MTSSCC for more than four years. The DEC development and modernization makes it possible to create a network of digital educational complexes on a unified methodological, technical and technological basis, providing comprehensive training for specialists in the development and operation of ground-based space infrastructure.

The EDC introduction allowed us to achieve a significant social and economic effect:

1. To exclude emergency launches of space rockets associated with an insufficient level of specialists training in the development and operation of information and communications equipment for space purposes, and to reduce material damage during the operation of ground-based space infrastructure facilities.
2. To create an interdepartmental digital educational space for specialists training in the operation of information and communications equipment for space purposes based on the interaction and integration of military and civilian educational institutions.
3. To create an interdepartmental educational and material base for specialists training in the development and operation of information and communications equipment for space purposes.
4. To reduce the cost of retraining and advanced training of specialists from remote areas by several times.

III. CONCLUSION

The EDC introduction in the universities' educational process, as well as in the process of job and vocational training of

enterprises in the space industry and the military-industrial complex made it possible to provide a significant contribution to the digital economy development of the Russian Federation by improving the quality of specialists training in the development and operation of information and communications equipment for space purposes with a simultaneous reduction of the cost of preparing process for such training, as well as making a significant contribution to the development of digital educational environment of the Russian Federation by creating an open educational information system for a potentially unlimited number of users.

A single digital educational space has been created for specialists training in the operation of information and communications equipment for space purposes based on the interaction and integration of military and civilian educational institutions.

The EDC development contributes to the development of the digital educational environment and the competency-based approach to the implementation of educational programs of higher, secondary and additional professional education in the specialties "Information and communication technologies and special communication systems", "Aircraft control systems", "Missile systems and astronautics", "Networks communications and switching systems" and "Application and operation of space complexes communication systems".

Developed EDC is used in the implementation of educational programs based on the new educational Federal State Educational Standards 3++ in the specialties 11.05.04, 24.05.06 and 24.03.01, secondary vocational education in the specialty 11.02.11 and additional vocational education in the specialty "Application and operation of space complexes communication systems" and allows to provide the necessary level of specialists competence.

Based on the results of the EDC and its elements introduction and implementation, 12 scientific articles, 26 educational publications (including 4 textbooks) were published, 36 acts were received from educational, research, production and operating organizations, as well as 16 certificates of registration of an electronic resource in the Science and Education United fund of electronic resources, which confirms the DEC compliance with the federal level, including the requirements for the use of educational publications in the educational process of universities.

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