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FEATURES OF APPLICATION OF THE TECHNOLOGY OF DIGITAL COUNTERPARTS IN AVIATION EQUIPMENT

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Abstract

The article is devoted to the analysis of the features of effective application of digital counterparts in aviation technology. The authors define the goal of developing a digital counterpart, which is to ensure the replacement of expensive natural stands and flight tests through the use of sensitive and certified calculated mathematical models. The structural composition of the technologies included concept of the digital counterpart is given. The use of digital counterparts technology in the virtual high-tech enterprise digital environment, which combines practice-oriented training with the ability to collaborate on information technology improvements. The study examines elements of the 3D-CAE platform used to solve engineering analysis and digital counterparts. Noted that in order to technologically improve the methods and rules of working with the "digit" it is necessary to take into account the special requirements related to the cybersecurity of digital technologies. It is pointed out that digital counterparts are a good tool for increasing efficiency and transparency, it allows you to trace the vital stages of the products created, provide tools to improve regulatory and supervisory functions. The authors come to the conclusion that the digital counterpart is not currently a universal solution, because the creation of unmistakable programs is almost impossible, so it is worth thinking about validating and verifying the counterparts, checking the software ensuring that the task is being implemented correctly by comparing it to the required properties.

Keywords: Prototyping, digital twin development, industry digitalization, systems modeling, engineering analysis.

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1. Introduction

The digital transformation of the process of creating aircraft is not just a trend, but a real change of the basic approaches in the aircraft industry. We are talking about a comprehensive change in all interconnected decisions for all stages of the aircraft's life cycle - from the concept and the first center line to the development of documentation, testing, launching into mass production, support for aircraft operation.

Artificial intelligence is the main assistant in the accumulation, analysis and transmission of data in a unified format, and 3D-programs helps to reduce designing by half. All drawings torn are quickly adapted and transferred from paper to special five-coordinate machines. Creating a wide range of mathematical modeling is impossible without widespread use.

Digitalization is understood, first of all, as a tool for transforming business models of a high-tech enterprise to a new level of efficiency, i.e. transition to fully automated digital production, automated intellectual support in real time, constant interaction with the external environment, access to the border of one enterprise, promising integration into a global industrial network of things and services. Nowadays, a promising industrial appearance can be described very briefly as an industrial Internet, by analogy with the usual virtual network or the fast-growing Internet of things. At the same time, digitalization has a number of nuances, and the term “digital counterpart” itself is interpreted differently (Tolstykh, Gamidullayeva, & Shkarupeta, 2018).

The purpose of using modern life cycle management technologies in the development of aviation equipment is to achieve and control tactical-technical and operational-technical, target efficiency criteria set in tactical and technical assignments to the aviation complex. Modern technologies also allow to improve the quality of products created, reduce production time, optimize costs by using automated end-to-end support at all stages of the product's life cycle (CICI) of all its processes development, manufacturing and operation (Kritzinger, Karner, & Traar, 2018). The high efficiency of the use of UTI technologies for this task can only be achieved in the development, manufacture and operation of aircraft by documentation strictly electronically, with the use of digital technologies (CT) when all data on the products are structured in the management system of the SCI (Borovkov & Ryabov, 2019).

A digital counterpart is a better version of the digital model. The essence of digital lookalikes technology is that special sensors are installed on the digitized product, scanning the technical condition of all systems, nodes and units. This data is synchronized with the digital model. Accordingly, it is possible to quickly track all the negative changes in the aircraft and any other sample of military and civilian equipment. Virtual testing takes place a digital twin of the future machine or part of it until the result is achieved. This is how all new aircraft are designed, including fifth-generation aircraft: T-50 and Su-35S fighter jets, Yak-130 combat training aircraft, passenger airliners, including the famous MC-21.

2. Problem Statement

Explore the feasibility of using digital technologies in the implementation of the technology concept "Industry 4.0." Analyze the role and importance of using simulation technology to develop and create digital

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counterparts. Identify the main components and features of the business model of the new technology concept "Industry 4.0" and the problems of its implementation.

3. Research Questions

With the development of the manufacturing process, high-tech enterprises have new technologies that allow to improve the quality of manufactured products in a qualitative way. The development of the "Industry 4.0" technology concept has allowed enterprises to apply digital counterparts technology, so it is necessary to analyze the key features of the effective application of this technology in aviation technology within the framework of the implementation of the National Program "Digital Economy of the Russian Federation" approved by the Presidium of the Presidential Council for Strategic Development and National Projects (Minutes No. 16 of December 24, 2018).

4. Purpose of the Study

Analyze the possibility of using the 3D-CAE platform for use by domestic aviation companies in the development of digital counterparts. Explore the possibility of cross-border and cross-industry enterprise interaction to create a single digital environment. Identify potential threats from the possibility of using digital dual technology by high-tech aviation companies.

5. Research Methods

The research methods use an analytical assessment of the forecasts of the development of digital enterprise technologies, presented by Siemens PLM Software experts. The study is based on a comprehensive analysis and subsequent assessment of the main results of the implementation of the processes of technological transformation of the industry, followed by the identification of its key areas and directions. The analysis is based on the materials of domestic and foreign scientists, data presented by leading high-tech enterprises. A detailed analysis of the 3D-CAE platform, part of Teamcenter software product company Siemens PLM Software, which contributes to quality improvement of competitiveness through product improvement and efficiency growth development processes.

6. Findings

The use of digital counterparts technology can be implemented in a unique digital environment of the "Virtual High-Tech Enterprise" that combines unique practice-oriented training of specialists with the ability to organize working together on information technology improvement projects. After performing four steps - virtual design, virtual production, launching real production and creating an aircraft - the digital twin allows you to take into account all the features of the operation of the aircraft or helicopter. The data coming in at this stage of the life cycle can be used to refine and modernize the product, as well as lay the groundwork for the development of promising products. According to Siemens PLM Software experts, the introduction of digital technologies in the passenger plane project with a capacity of 150-170 people can

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reduce the annual development costs by 290-300 million euros, including by speeding up the process certification (Zelentsova & Tikhonov, 2019).

The introduction of a digital counterpart production technology makes it much easier to design products in accordance with the requirements of technology and quality. The digital counterpart contains many interconnected factors related to real production. Both traditional technologies and additive manufacturing processes and mixed processes are supported. Product use data is transferred to digital production process twins. As businesses begin to generate the most profit, selling additional services rather than the products themselves, modeling the behavior of products during operation becomes a primary step. Digital counterparts create the fabric of the new economy by weaving not one but two strands, ensuring its strength and reliability. The virtual and real aspects of the digital lookalike complement each other at all stages of the life cycle. Siemens PLM Software technologies enable high-tech enterprises to implement the concept of "digital twins." The development company integrates all digital processes into a single, one-size-fits-all format and provides access to all employees involved in the project in an effort to create a comprehensive digital lookalike. A comprehensive digital counterpart is an interconnected combination of digital twins of the product being developed, manufactured and manufactured. It combines requirements with production and operation to continuously improve the product and its production, reduces the development cycle, increases efficiency and flexible adaptability to changing market requirements, allows to embody more innovative ideas in life. To be effective in the modelling process, experts' knowledge and practical experience in organizing workflows must be taken into account. Let's look at the components of the platform used by experts to solve many of the problems in the field of engineering analysis. The 3D-CAE platform allows you to work on the creation of digital lookalikes includes the following elements (Nilen & Holmstrom, 2015):

1. Multidisciplinary integration. This integration allows for a well-established multi-physical modeling process, and if the process is constantly optimized in terms of several of the most important parameters of the product at the same time, you can achieve that numerical modeling will become an engine in design;

2. Associative CAE modeling. The impact of a single platform on the cost of ownership and the timing of the development of digital lookalikes allows:

- To reach the set development deadlines faster than 24%;
- More effective to fit into the planned budget of 7%;
- Reduce the cost of owning sae products by 50%;
- Reduce development time by 37%;
- Reduce the load of calculated machines by 8%.

3. Openness and scalability;

4. Link to 1D functional simulations and tests;

5. Manage SAE data and processes.

Digital counterparts are most applicable where complex technical facilities require skilled specialized support, the objects themselves are operated over a long life cycle in significantly different conditions, including in hard-to-reach places, and with many instances of a technical object. If we talk about

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industries, today a significant effect of the digital twin is achieved in energy, aircraft engines and systems, complex industrial and medical equipment, transport systems.

For businesses and the economy, these ecosystems, including digital twins, are a good tool for increasing efficiency and transparency, allowing you to trace the vital stages of the goods and services created, to provide the necessary tools to improve regulatory and supervisory functions. Applying the concept of a digital doppelganger gives an additional insight into the economic nature of an asset, identifies ways to reduce its value of ownership (TCO - Total Cost of Ownership) and provides insight into how to make it more expensive with minimal cost environmental and social aspects (Akhmetshin, 2017).

The effectiveness of the use of digital counterpart technologies is determined through the end result, so for example, when creating such promising engines as PD-14 and SaM-146, the use of digital technologies allowed to obtain the first natural sample, meeting the requirements of a technical task, in 3.5 years. Previously, this took much longer. Therefore, first of all, it is a reduction in the production time of the first natural sample that meets the requirements of the technical task (TK). Secondly, it is a reduction in the cost of the life cycle, the hours of operation of the product (of course, the key here is getting the data out of service, what is called Big data) (Tikhonov, Sazonov, & Novikov, 2019).

The digital counterpart, if implemented as an electronic original of the entire set of technical documentation about the product in the electronic technical archive, allows to turn electronic data about the product into the most important end-to-end and transparent The business resource of the company, which provides the development and support of competitive products, reducing the time it comes to the market, improving the quality and reducing the cost of design, production and support. The digital counterpart should also provide a replacement or substantial reduction in expensive in-kind stands and flight tests through the use of sensitive and certified calculated physics and mathematics models. At the same time, the need for a systematic approach to the introduction of digital testing technologies at all stages of the SCI is constantly being identified, which ensures not only a reduction in the number of in-kind tests through a computational experiment, but also a calculated confirmation of the achieved in the early stages of AT development and estimated control of TTH and ETH levels in operation (Rios, Mas, Oliva, & Hernández, 2018). The main difficulty is not development itself and even validation (convergence check) of the model, as the presentation of the results of the simulation as evidence for government tests and certification in connection with the imperfect regulatory framework. In addition to technological improvements in the methods and rules of working with the "digital" modern environment dictates special requirements related to the cybersecurity of digital technologies. For more than 10 years, the company has been using mathematical modeling techniques, including in the development, testing and maintenance of such machines as Su-57, Su-35, SSJ-100, etc. Hundreds of mathematical models and dozens of methods of confirmation of compliance have been developed (Guryanov, Zakoldaev, & Shukalov, 2018).

Using of digital counterpart technology by high-tech aviation companies in the creation of products and products will allow them to significantly reduce not only temporary, financial, but also other resource costs by about 10 times. According to leading experts, the costs associated with the development of new production technologies (including technologies in the field of digital counterparts) will cost Russia about 148 billion. rub. until the end of 2024 (Tolstykh et al., 2018).

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7. Conclusion

Nowadays, a digital counterpart is becoming the good manner for any developer. It includes the most accurate characteristics of each gear. The digital counterpart simplifies the process of reproduction of the product, establishing its experimental and serial production. Also, a digital layout is needed to speed up the repair and modernization of military or civilian equipment. The widespread use of digital counterpart will result in significant savings in material and human resources and productivity gains, both in the defense complex and in the civilian sector. The digital counterpart allows you to select the most appropriate scenarios of technological processes to avoid failures and force majeure. Such experiments do not involve serious financial costs: the specialist calculates a problem in artificially created conditions, analyzes. With digital simulation of processes, you can not only avoid failure, but also anticipate it. The system independently tests the damage, guided by the readings of sensors, it decides to switch modes to ensure stability of work.

The digital counterpart is not a universal solution for designing new engines. The more critical the program is for business, the more expensive the defects in it. The point is that the slightest margin of error in the creation of a digital model can cause a serious accident. Creating a priori unmistakable programs is almost impossible, so it is worth thinking about validation and verification of counterparts, checking the software for the correctness of the task by comparing with the desired properties. To check the correctness of the digital model is another extremely urgent task of digitization of production. Given that if you have a digital counterpart, real tests don't actually apply, a program error can lead to serious negative consequences.

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