



Print ISSN: 1738-3110 / Online ISSN 2093-7717
 JDS website: <http://www.jds.or.kr/>
<http://dx.doi.org/10.15722/jds.20.09.202209.39>

Implementation of Digital Management System for the Enterprises Development and Distribution in Aviation Industry

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Received: July 29, 2022. Revised: August 24, 2022. Accepted: September 05, 2022.

Abstract

Purpose: At the industrial sites of aviation enterprises there is a significant optimization of the main production processes through the use of advanced digital technologies. The most promising are the latest technologies of industrial Internet of Things, active use of big data and practical application of artificial intelligence in production. **Research design, data and methodology:** The process of creating a competitive product in the high-tech aviation sector is actively linked to the investment appeal of aircraft and helicopter construction products, which is built on the basis of reducing production and time costs through the creation of an effective digital system. **Results:** The aviation cluster of Rostec State Corporation is currently being transformed in a significant way. The leading enterprises of the Russian aviation industry are actively mastering cooperation schemes using integrated digital management principles and the widespread introduction of digital products from leading Russian vendors. **Conclusions:** Following the transition to electronic aircraft design technologies and modern materials in the production of aircraft, UAC continues to improve all production processes through robotization and optimization of technological processes, due to the introduction of aircraft assembly technology in accordance with digital models.

Keywords : Digital economy, Industry digital transformation, Aviation industry enterprises, Production organization, United Aircraft Corporation, Distribution

JEL Classification Code : L11, L16, L93

1. Introduction

It is reasonable to consider the concept of adaptive management system of technical development of high-tech aviation enterprises in Russia, which are part of the aircraft building complex of Rostec State Corporation, as a complex process that includes organization, planning, motivation, control and coordination. It is also necessary to conduct organizational and economic analysis from the perspective

of building a unique system of variables, the structural composition of which includes such components as purpose, communication means and level of readiness of subjects. Created modern system has certain properties, such as: integrity, separateness, emergence, multiplicity, synergy and non-additivity. For example, large machine-building complexes of Russia, including aerospace complexes, are most characterized by active manifestation of the synergy effect. At present, it is necessary to solve a complex task

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associated with the development of a unique multi-component digital environment for the organization of effective work of United Aircraft Corporation (UAC) high-tech enterprises. Setting such a large-scale task is related to the fact that working in the complex conditions of modern digital production, it is necessary to promptly obtain verified information, which is precisely the key factor that subsequently determines the degree of efficiency of UAC high-tech enterprise. In order to significantly increase the degree of efficiency of the high-tech enterprise in the created digital environment, it is necessary to organize and launch certain procedures for the inclusion of a set of elements and various tools included in digital transformation, to define explicit channels of communication and transmission of large data sets (Nguyen & Hoang, 2022). It is also necessary to make a list of digital platforms and technologies, software and databases for the various complexes of the enterprise management system. It is obligatory to take into account such systems, whose profile of activity is directly related to production management. The aim of the research conducted by the authors is to develop new theoretical and methodological aspects of building the concept of adaptive management system for the technical development of UAC high-tech aircraft enterprises under the conditions of ongoing digital changes within enterprises and with significant variability of external institutional factors (Budiman et al., 2022; Cui et al., 2022).

2. Theoretical Basis

Many scientific works and studies by Russian and foreign authors are devoted to the problems of development and subsequent adaptation of organizational systems: Fischer et al. (2020), Zarean et al. (2022), Nesi Bubicz et al. (2021), etc. In the works of these authors, the issues related to determining the level of impact of ongoing changes in digital environment on the management systems of knowledge-intensive enterprise were not raised, and the methodology of adaptive transformation of management systems in knowledge-intensive enterprises, which is the basis of digital economy, was absent or not fully elaborated Galankashi et al. (2022). The basis of the mechanism aimed at the adaptive development of the management system is to create a unified holistic system, which will determine the order and structure of the relation of various individual subsystems and components, with its central link should be a process of adaptive transformation, which can be implemented by supporting subsystems of information, tools, methods, software, hardware and human resources (Zapata-Roldan & Sheikh, 2022; Qian et al., 2022).

3. Methodology

The research methodology for the development of a digital multicomponent environment in UAC aviation industry enterprises includes the following set of stages:

- developing digital concept and strategy of the enterprise;
- conducting an analysis and assessment of the current digital "maturity" of the enterprise in order to identify priority objectives for digital transformation;
- organizing a mechanism for selecting the most effective model for shaping the future digital environment.

It is impossible to create a digital environment for a high-tech UAC enterprise without launching a mechanism for digital transformation of the existing business processes at the enterprise. One of the key directions of digital transformation at the enterprise is, undoubtedly, the use of a variety of modern telecommunications technologies, such as the industrial Internet, for example (Nguyen & Hoang, 2022). The use of various digital information technologies makes a tangible contribution, directly to the development process and in the subsequent functioning of digital environment (Budiman et al., 2022; Cui et al., 2022). The study of the implementation of the complex of digital information technologies includes the following active measures:

- development within UAC enterprises of a special complex of virtual production and technical divisions;
- conducting work in the field of organization of public-private partnership;
- providing support mechanisms for logistics activities;
- development of mechanisms to develop innovations and their application at the enterprise;
- conducting a set of works on reengineering of business processes;
- using information technologies for the development of electronic form of trade;
- ensuring the necessary procedures related to the protection of information that is in the current digital environment of the enterprise from access by third parties.

4. Results

The authors believe that only the joint work of all systems of complex support of UAC high technology enterprise activity allows achieving the set objectives of adaptive development of modern production management system (Figure 1).

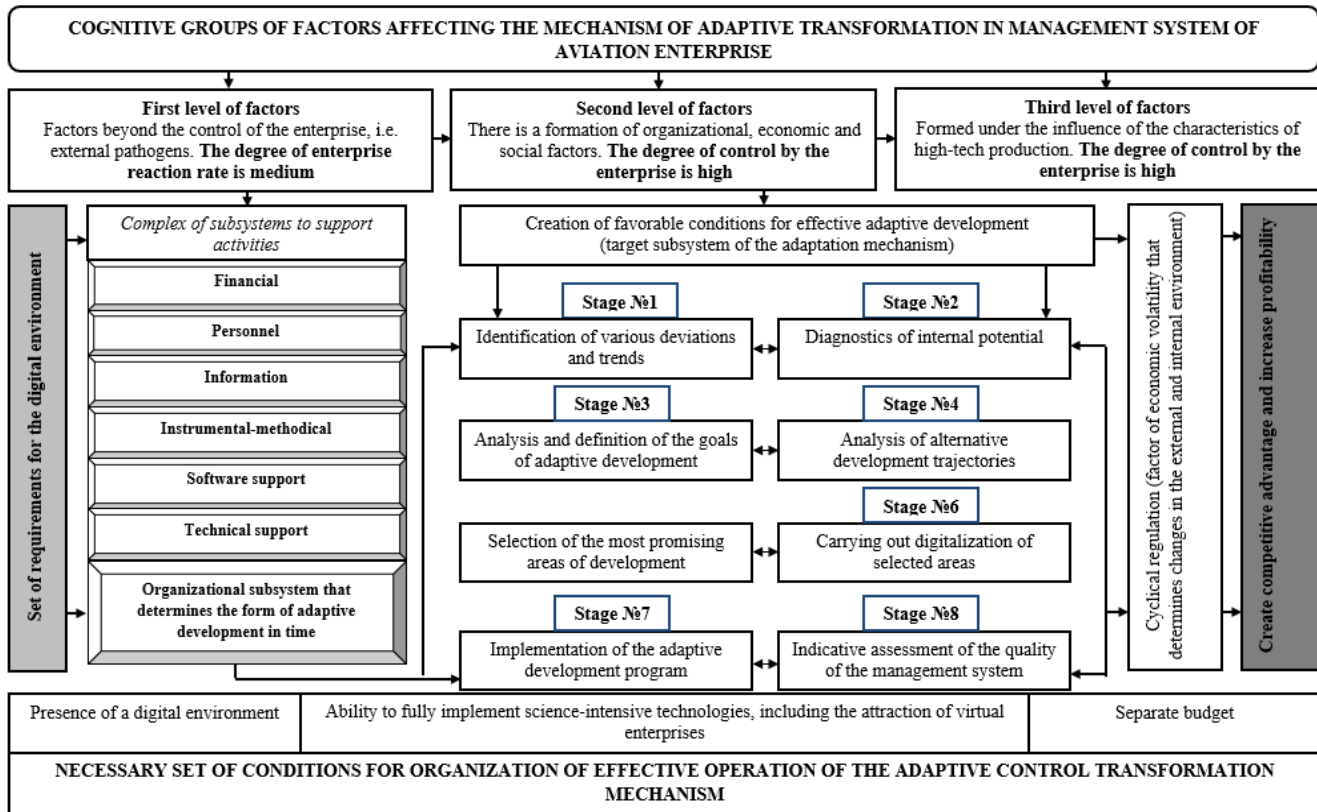


Figure 1: Structural Content of the Mechanism of UAC Aviation Enterprise Management System Transformation in the Digital Environment

Generalized analysis of cumulative views on the existing problems in the sphere of management of UAC high-tech enterprises and their subsequent generalizations allowed developing an updated concept of adaptive development of management system at high-tech enterprise (Table 1), structural aspects of which can be considered with the following provisions:

1. The process of adaptive development of the management system is characterized by evolutionary development in close combination with revolutionary transition of various elements of the management system from one qualitative state to another, which is caused by a high degree of variability of digital environment;
2. Development of the management system based on the work of adaptive mechanisms is constructed on a certain transformation of subsystems of the management system in strict accordance with the various requirements of digital environment, which are objective conditions for the effective and long-term functioning of knowledge-intensive enterprise;
3. The purpose of the development of adaptive management system consists in the ability to ensure the

qualitative and effective functioning of various subsystems included in the complex of the management system of knowledge-intensive enterprises, through the competent implementation of a number of reactive and preventive measures, the direction vector of which involves maintaining a certain level of compliance between the external digital environment and the internal potential of the enterprise;

4. The dominant groups of factors determining, the process of adaptive development of the management system are the increasing complexity of certain groups of links within the management system and its subsystems, dynamic technological progress, as well as the growth of the volume of data at all hierarchical levels of management;
5. Ensuring timely adaptive development of the management system in a changing digital environment, requires the implementation of functional areas that determine the current trends associated with the development of knowledge-intensive industries, and the exclusion of those groups of functions that cannot be aligned with the current approved development strategy of the enterprise.

Table 1: Key Aspects of the Concept of Management System Adaptive Transformation for UAC Knowledge-intensive Enterprises in a Changing Digital Environment

Goal of transforming the adaptive management system	Comprehensive provision of quality and efficient operation of all major subsystems of the knowledge-intensive enterprise management system, through the implementation of a set of preventive measures necessary to maintain the level of compliance between the changing external environment and internal management subsystems, which is realized through prompt response to changes in digital environment
Objectives of adaptive management system transformation	Prompt identification of problems/deviations from the basic requirements of the information and digital environment
	Increase agility of knowledge-intensive enterprise to ensure the necessary level of compliance between enterprise systems and changes in digital environment
	Development of business processes with a high level of adaptability, which will allow to take into account the various changes in the level of consumers' needs of enterprise products
	Material and human resources must be used in a rational manner in order to minimize the costs associated with development and adaptation
	Elaboration of the strategy aimed at the dynamic development of the management system of knowledge-intensive enterprises, taking into account a certain influence of external environment factors
Basic principles of adaptive development of management system	Perspectivity is based on a certain need to take into account key features of digital environment and the analysis of economic development options
	Permanence implies continuous and qualitative process of management system development
	Parallelism is based on practically simultaneous development of absolutely different subsystems included in the management system
	Self-development is necessary for qualitative improvement of the components of management subsystem by means of using an internal set of resources
	Flexibility allows reconstructing operatively the tools and methods of management, operating at science-intensive enterprise

Note: compiled by authors.

The mechanism and tools of project management are designed to solve these problems and effectively implement the strategy for the innovative development of aircraft manufacturing enterprises and build a management structure that will allow switching to less costly resources, as well as improve product quality. The tools for project management of innovative activities of aviation industry enterprises include:

First group. Enterprise R&D management:

- management of the innovative potential of the enterprise;
- managing project implementation parameters.

Second group. Enterprise resource management:

- enterprise investment management;
- project performance management.

The authors assessed the innovative activity (IA) of the enterprises under study, aimed at a more complete account of the parameters of IA, as well as at comparing the actual level of IA and the newly obtained results. The assessment was based on enlarged modules for assessing readiness levels: technologies (RLT); production (RLP); integration (RLI); systems (RLS). Based on these assessment modules, the authors have formed a comprehensive set of indicators and a general indicator for assessing IA.

$$IA = 4 \times \sqrt{RLT \times RLP \times RLI \times RLS}. \quad (1)$$

The growth of IA is reflected by the formula:

$$\Delta IA = IA_n - IA_e, \quad (2)$$

where IA_n is the level of IA newly obtained, IA_e is the existing level of IA of the enterprise.

The authors carried out an expert assessment of the studied enterprises of the industry for the development of IA with the introduction of project management (Table 2).

Table 2: Evaluation of Performance Indicators of the Enterprises under Study with the Introduction of Project Management

Period	Aviaagregat		
P			
Number of failures and defects in the implementation of projects reduction, %			
c			
I			

Note: compiled by authors.

The data in the Table 2 indicate that there is a pronounced growth dynamics of indicators in the implementation of project management, even at a small part of the objects. This is especially evident in time indicators and indicators of project cost reduction. Promising directions for the development of IA are offered by cooperation and integration of participants in the cluster program of the Russian aircraft industry to create production chains, which currently involve innovation centers and

centers of technological competence that are part of Russian corporations.

5. Discussion

The authors propose the following set of active components for the formation of an adaptive digital management system for the technical development of UAC high-tech enterprise, which includes three blocks.

First block. Structural components necessary for the implementation of digital transformation mechanism of UAC high-tech enterprise:

- development and digital design (application of Automatic Device Model Synthesizer-system (ADMS) supervisory control of the distribution network, which includes support for Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Distribution Management System (DMS), Outage Management System (OMS), etc.);
- digital factory (application of a set of special systems for optimization and various processes in the field of production and economic activity management, Material Requirements Planning (MRP), Mobile Edge Computing (MEC), Element Management System (EMS), etc.);
- warehouse logistics and digital warehouse (using a set of systems for dispatch management, collection, analysis and processing of large data array and electronic document management within the enterprise, Supervisory Control and Data Acquisition (SCADA) and Supply Chain Management (SCM));
- distribution and e-commerce organization (e-commerce online payment suite, Electronic Data Interchange (EDI), InterBank, etc.);
- digital assurance and operation (systems used to organize and support management at the operational stage of the product life cycle, Product Lifecycle Management (PLM) and Continuous Acquisition and Life cycle Support (CALSS));
- digital recycling services (providing information support for all phases of product decommissioning, PLM).

Second Block. Highlighting the highest-priority digital technologies from the total number of private digital platforms:

- “end-to-end” technologies based on digital solutions;
- adaptive technologies of automated functions;
- manufacturing technologies based on the artificial Internet;

- additive manufacturing technologies (3-dimensional printing, for example, of aircraft individual elements);
- digital twin technologies;
- computing in digital cloud services;
- technologies based on digital solutions aimed at data protection;
- artificial intelligence.

Third block. Unique digital spaces created and maintained by enterprise networks:

- special network based on intelligent digital sensors that perform real-time monitoring of technological processes;
- secure networks based on Virtual Private Network (VPN) technologies;
- hybrid and one-dimensional Computer Based Training networks.

Developing a digital environment in a high-tech enterprise is aimed at integrating a set of business solutions based on the most innovative digital technologies, including means of passive and active data protection. The large-scale digitalization of management subsystems and the use of technological platforms for computing in the “cloud” will require the creation of a unique multi-component data protection system. The practical implementation of such advanced digital technologies is undoubtedly an incentive to integrate a set of advanced protection tools. It should be noted that the need to create a single center to manage all processes in the field of information security, as well as to ensure the smooth functioning of information protection tools, in real time, is significantly increasing at all high-tech enterprises.

Currently, the presence of a modern Enterprise resource planning (ERP) system and a cybersecurity system are perceived as the highest priorities in the field of digitalization of management. Most organizations have an understanding of these tools, and in half of the organizations these issues are reflected in plans and business models. The most significant innovations in the digitalization of the production process are recognized as additive manufacturing technologies. It can be assumed that this, apparently, applies to those organizations where investments in new equipment have been made. There are also gaps in the digital representation of the product by life cycle (design, production, testing, operation, predictive repair and disposal). Currently, about a third of organizations are not yet ready to use the digital representation of the product life cycle. To develop cooperative ties, we can foresee the growth of complex interaction, which will ultimately lead to the formation of broad, but closed contours of cooperation. However, at present, almost a half of the defense industry organizations demonstrate a low level of readiness for this cooperation (Table 3).

Table 3: Potential for Integration into the Production Chains of Promising Products of High-tech Enterprises

Description of the types of a promising product range (each type implies the possibility of producing technologies, equipment, solutions, etc.) that correspond to the promising demand and promising markets in the digital economy	Type of a promising product range has been studied, and key employees have formed high-quality competencies for it			Accounting in the strategy, programs and plans for the development of the enterprise, as well as in the business model of the enterprise with a backlog for the long term		
	High level	Average level	Low level	High level	Average level	Low level
.	7.5	52.4	42.1	16.2	44.3	39.2
"Big data" and analytics tools based on "big data". Cloud computing
"Industrial Internet" and platforms for Internet industry
Technologies of virtual and augmented reality
N

Note: compiled by authors

The organization of digital management of high-tech enterprises on the basis of a common base of digital environment will allow:

- significantly reducing the level of costs and time associated with the design, implementation, development and technological support of various information systems of high-tech enterprise;
- implementing the possibility of various virtual tests and simulations on the basis of digital twin technologies in order to reduce the number of costly in-situ tests. The application of modern digital twin technology will significantly accelerate the introduction of modern aviation products with high competitiveness indicators to Russian and international market;
- decentralizing procedures for the development and making of management decisions based on the delegation of certain powers to artificial intelligence systems;
- realizing in full horizontal and vertical integration of the complex of management functions at the high-tech enterprise, which will allow carrying out the robotization of the industrial production and the use of machines with computer numerical control (CNC).

Digital environment at a high-tech enterprise of UAC aviation industry makes it possible to launch continuous processes associated with changes in the organization of the production process, which will inevitably lead to a decrease in the stability indicators of the enterprise. In conditions of sufficiently strong volatility of digital environment, there is a definite need to organize the provision of adaptive development of systems for the organization of management of high-tech enterprise on the basis of artificial intelligence. Artificial intelligence technologies will provide an effective solution to a range of tasks in the area of rapid response of

management systems, to internal and external changes occurring.

5.1. Recommendations for Reengineering Various Business Processes at UAC High-Tech Aviation Enterprises in Digital Economy

Reengineering from the position of synthesis of approaches to business process management organization is an effective direction for optimization of almost all processes within a high-tech enterprise. It should be noted that reengineering concepts do not take into account the past approaches to business process management, so, it is believed that reengineering is a combination of previously known concepts. However, it has managed to accumulate a number of new provisions and methods, which were not used together before. By now, in digital economy, the concept of business process re-engineering is one of the most popular business concepts. The authors of the article put forward the postulates of the concept of reengineering in the conditions of digitalization:

- process of changing business processes should be implemented without focusing on the current business process model in the high-tech enterprise, but it is necessary to properly understand the level of problems in the existing process;
- it is necessary to focus on cross-functional business processes, as well as on the degree of work performance within the current business process;
- need for a radical change in the structure of business process, as well as reducing the cycle duration;
- information and digital technologies are the main tools in changing the methods of work within the boundaries of business processes, additional effect is possible only in the case of digital re-engineering;

- process of making adjustments to the current organizational structure and work order of the staff of a high-tech enterprise is accompanied by various changes in the technology of business process implementation. The development strategy of a high-tech enterprise, its business opportunities and organizational structure also change under the influence of reengineering;
- it is necessary to automate only those groups of processes which have already been improved as a result of re-engineering, and as a result proved to be effective from the point of view of financial, material and time expenses;
- process of development of new business processes should be based on the technological basis, which should take into account the degree of possibility to implement business processes, while it is also necessary to consider the level of capability of a high-tech enterprise, i.e. its ability to apply innovative technologies, to transform organizational structures, etc.;
- projected digital environment of a high-tech enterprise should be the main factor that will promote a new approach to the operation of business processes.

The methodology proposed by the authors, which aims to implement the reengineering of business processes based on digital technology, includes the following six steps.

First stage: Carrying out diagnostics of business processes and selecting the highest priority among them.

Executor: management of a high-tech company.

Stage result: extensive list of business processes to be redesigned.

Re-engineering result: efficiently functioning business process in terms of financial and time costs.

Second stage: Analysis of structural and functional part of business process model.

Executor: consultants and project team members.

Stage result: defined the structural and functional model of doing business and identified the basis of groups of deficiencies.

Re-engineering result: efficiently functioning business process in terms of financial and time costs.

Third stage: Organization of work aimed at designing a new organizational and functional business process model.

Executor: consultants and project team members.

Stage result: new organizational and functional model of business processes was developed, and previously identified deficiencies were eliminated.

Re-engineering result: efficiently functioning business process in terms of financial and time costs.

Forth stage: Development of a number of key areas related to digitalization and automation of business processes.

Executor: IT consultants and project team members.

Stage result: extensive list of digitalization areas within the new business process model has been compiled.

Re-engineering result: efficiently functioning business process in terms of financial and time costs.

Fifth stage: Selection and improvement of qualification level of the staff working at the enterprise.

Executor: working group manager.

Stage result: detailed list of staff to work in the new business process.

Re-engineering result: efficiently functioning business process in terms of financial and time costs.

Sixth stage: Ensuring quality control of the updated business process.

Executor: high-tech enterprise management.

Stage result: making a list of defects and problems in the updated business process model.

Re-engineering result: efficiently functioning business process in terms of financial and time costs.

6. Conclusion

The high level of variability in digital environment affects UAC high-tech enterprises, as a result of which they have an urgent need to digitize their business processes. This difficult task cannot be solved in a short period, as only those processes and elements that are currently working qualitatively/efficiently in terms of time and financial costs need to be digitized first. If the process of digitization is subjected to groups of processes with a low level of efficiency, lengthy in time and requiring significant financial costs, it will be impossible to achieve high performance indicators. Consequently, these circumstances force knowledge-intensive enterprises to implement business process re-engineering projects, which already initially involve significant financial investments to upgrade the enterprise. Qualitative improvement of the business structures of a knowledge-intensive enterprise is possible, by applying the concept of reengineering. Digital transformation of organizational structure of knowledge-intensive enterprise is possible only after design-organizational changes. In the process of analysis of foreign and Russian scientific works it was found that the main purpose of implementing the concept of reengineering in the work of business processes is to achieve a certain indicator of competitiveness of high technology enterprise, as well as increasing the quality and efficiency by optimizing the duration of the business process, as well as reducing process cost indicators, by making changes of different types, which

will eventually allow high technology enterprise to adapt to complex and rapidly changing.

The research carried out within the framework of the article allowed the authors to create a digital system for managing the technical development environment of UAC high-tech enterprises, which allows:

1. identifying the different range of problems that arise in the process of discussing the changes made within the management system of UAC high-tech enterprises;
2. making an assessment of the current level of digital maturity of a high-tech enterprise on a fundamentally new basis;
3. developing a number of conceptual proposals aimed at the formation of components included in the structure of digital environment of a high-tech enterprise;
4. transforming the current telecommunication system of high-tech enterprise.

The implementation of management based on the application of digital technologies, within a common digital environment, provides an opportunity to fully realize the entire existing potential of high-tech enterprise and to develop fundamentally new innovative directions on the basis of digital production and technical transformation. The management process of high-tech enterprise in the process of its digital transformation is built on the application of a sufficiently large number of a wide variety of feedback loops, which were promptly created within the boundaries of a single digital environment of high-tech enterprise. Comprehensive implementation of the approach to management activities on the basis of digital technology, allows carrying out prompt and qualitative readjustment of all management systems without exception, taking into account the volatility indicators of digital environment. The process of forming a digital environment at high-tech enterprise allows for the implementation of groups of measures that are associated with the adaptive development of the management system, but only with the use of reasonable digital tools.

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