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**DEVELOPMENT OF VIRTUAL AND AUGMENTED REALITY  
AS ELEMENTS OF STIMULATING TECHNOLOGICAL  
ENTREPRENEURSHIP**

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**Abstract**

Virtual and augmented reality (VR/AR) technologies have received a high development level in the entertainment and marketing markets, but this is not the limit, but only the first stage of their implementation. The most promising products in terms of economic impact are based on VR/AR technologies in the field of industrial production, education, healthcare, and consumer services. The results of the study show that companies, scientific and educational organizations of Russia have significant technological reserves that allow them to occupy leadership positions on the world market in a number of segments. The aim of the study is to develop a solution to increase the number of companies involved in the formation of digital economy markets, promote the acceleration of the introduction of new products and services based on virtual and augmented reality technologies, ensure their competitiveness and overcome technological barriers. Achieving the stated goal and overcoming technological barriers should be achieved, among other things, through the development of a digital platform designed to create solutions (mathematical models, digital technologies, research tools, methodological recommendations and products for users) based on motion capture technologies in VR/AR, feedback interfaces and sensors (VR/AR), VR/AR content development tools and user experience improvement technologies that ensure the transformation of priority socio-economic sectors. The effect of the digital platform introduction should also be the entry of domestic players in the future 4-5 years to the international market of VR/AR solutions with a target share of more than 15% of the global market of VR/AR technologies.

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## 1. Introduction

Virtual and augmented reality tools are the key to a fundamentally new level of human interaction with the digital world, which plays an increasingly important role in the global economy, politics, and social relations (Ministry of Digital Development, Communications and Mass Media of the Russian Federation, 2017). Virtual reality (VR) technology is a complex technology that allows to immerse a person in an immersive virtual world using specialized devices (virtual reality helmets). Virtual reality provides a complete immersion in the computer environment that surrounds the user and reacts to his actions in a natural way. Virtual reality constructs a new artificial world that is transmitted to a person through his senses: vision, hearing, touching and others (Kshniakin et al., 2021).

A person can interact with a three-dimensional, computerized environment, as well as manipulate objects or perform specific tasks. In its simplest form, virtual reality includes 360-degree images or videos. Achieving the effect of full immersion in virtual reality to the point where the user cannot distinguish the visualization from the real situation is the task of technology development. Augmented reality (AR) technology is a technology that allows to integrate information with real-world objects in the form of text, computer graphics, audio and other representations in real time. The information is provided to the user using a heads-up display (an indicator on the windshield), augmented reality glasses or helmets (HMD), or another form of projection of graphics for a person (for example, a smartphone or projection video mapping). Augmented reality technology allows to expand user interaction with the environment.

## 2. Problem Statement

The main objective of the development of VR/AR technologies is to create conditions for increasing the number of companies involved in the formation of digital economy markets, helping to accelerate the introduction of new products and services based on virtual and augmented reality technology and ensuring their competitiveness, overcoming technological barriers by creating groundwork and achieving targets for the development of "end-to-end" digital technology of virtual and augmented reality. Currently, VR/AR technologies have received the most serious development in the entertainment and marketing markets, but this is not the limit, but only the first stage of their implementation. The most promising products in terms of economic impact are based on VR/AR technologies in the field of industrial production, education, healthcare, and consumer services. Wide application of VR/AR technologies contributes to the development of the country's economy, an increase in efficiency of industrial enterprises, formation of new approaches to the learning process and improving the education level, quality improvement of health care and accessibility of health care through remote presence of physician. At the same time, VR/AR technologies create the latest ways of communication and consumer services, form mass media for the modern generation (Ministry of Digital Development, Communications and Mass Media of the Russian Federation, 2017). Overcoming technological barriers and supporting Russian companies that create products based on the application of VR/AR technologies allow them to achieve business results which can be compared with the world-class industrial products. This technological basis is also important for the formation of competitive advantages in the key economic segments, and for occupation of a significant share of the Russian and global markets.

### 3. Research Questions

Development of a digital platform designed to create solutions (mathematical models, digital technologies, research tools, methodological recommendations and products for users) based on motion capture technologies in VR/AR, feedback interfaces and sensors (VR/AR), VR/AR content development tools and user experience improvement technologies that ensure the transformation of priority sectors of the economy and social sphere. Conducting research work aimed at developing new technologies and improving existing technologies, developing methods and methodological recommendations, as well as conducting a comparative analysis of existing technologies and products to ensure conditions for overcoming technological barriers of the roadmap for the development of "end-to-end" digital technology of virtual and augmented reality. Development and implementation (commercialization) of digital products and services using virtual and augmented reality technology, aimed at expanding the virtual and augmented reality market, creating new markets of the digital economy due to the creation of new technologies and methods, and involving new participants on the digital economy market.

### 4. Purpose of the Study

The infrastructural digital platform is an important tool for various kinds of research and development, which makes it possible to collect, evaluate the correctness and process information (including big data). The potential effect of the platform is also in the implementation of a synergistic effect from the partnership of different market participants of the selected end-to-end technology, as well as the emergence of the possibility of joint development of the necessary standards by the community, the development of draft regulatory legal acts, and personnel training.

Potential members of the platform being developed will be:

- end consumers of products and services;
- development teams;
- groups for testing products and services;
- investors (development institutions, venture funds, etc.);
- teams for developing educational products for platform participants;
- manufacturers and distributors of the required equipment;
- auxiliary specialists necessary for developers: engineers who provide a specific service to development teams, technology brokers, profile and business experts, fundraising specialists, including foreign ones, lawyers, translators, specialists in foreign markets, patent attorneys and others;
- organizations - monitors of the status of implementation of profile roadmaps (centers of competence of the national program "Digital Economy", federal and regional executive authorities).

The infrastructure solution of the platform being developed should include integrated modules that allow efficient operation of both the entire system and its individual elements. It is important to implement the ability to integrate external subsystems via API (programmable interaction protocol). API should ensure simple and fast communication of all elements of the developed digital platform (not only system and service modules, but also custom ones), its flexible functionality that enables the integration with new services (that can be external independent information systems). This protocol also provides an easy way to

communicate via the client-server model through REST services (REpresentational State Transfer). This component of the digital platform should be based on sufficient documentary support to create new infrastructure modules and ensure smooth functioning of existing services on the developed digital platform. The infrastructural digital platform should be freely accessible by system users using a web interface.

## **5. Research Methods**

The basis for the formation of the developed digital platform is based on the scientific and methodological approach of module construction. The system modules of the developed digital platform provide functioning of the platform in general and such its characteristic feature as integrity. It can be considered as the main tool that controls the platform operation. The task of ensuring information security of its functioning is also becoming important within the framework of the digital platform (Volkodaeva & Balanovskaya, 2020).

The platform software should include the following interconnected system modules:

1. The Content Management module is an information system for ensuring and organizing the joint process of creating, editing and managing the content of the platform. All data provided by both the platform users themselves and external user services should be depersonalized, that is, pass organizational and technical measures designed to eliminate personalized information in the accumulated data sets. An internal unique key identifier will be used to receive, store, and update user data.

2. The Billing module is an automated system for accounting for services provided, charging them and invoicing them for payment. Billing should allow to store the history of transactions, create (initiate) transactions, conduct transaction operations at the stages of the business process, cancel transactions, transfer data to an external service of the bank using the API, and receive the results of the transaction. Transactions related to the processing of personal data, ensuring the security of the connection, interaction with the bank and other operations related directly to the movement of funds should be carried out by an authorized payment service (a third party in agreement with the organizers of the platform).

3. The Marketplace module is a system for organizing access to the platform's products (goods and services), which includes tools for creating products, publishing and organizing access to them, paying for and delivering products, and providing technical support to users.

4. The Data Lake module is a storage for a large amount of structured and unstructured data generated or collected by platform participants.

5. The "Information Environment" module is a system in which communication between platform participants is carried out.

6. Module for fault tolerance and data security.

It also provides for the development of service modules. Service modules are an important factor in the organization of the platform work, although unlike system modules, the platform can function without them. The main task that the service modules perform is research of human behavior in virtual reality, methodological recommendations for improving the user experience and mechanisms of designers of virtual reality environments, as well as libraries of objects and virtual reality scenarios.

## 6. Findings

The development of VR/AR technologies will ensure Russia's technological leadership, especially in industry segments. The creation of integrated solutions for healthcare, education, and industry can ensure the digital transformation of relevant industries and stimulate the development of technological entrepreneurship. The development of specialized VR/AR systems for the industrial segment will create universal global standards for the construction and oil and gas industry, mechanical engineering and mining industry, etc. At the same time, the following indicators can be achieved: reducing equipment maintenance costs, reducing the number of errors and downtime (up to 30%); increasing the efficiency of working with engineering 3D models, automatic conversion of CAD models in VR/AR, reducing the design time (by 30-50%), reducing the time of approval and construction of objects (by 7-30%). The achievement of these indicators is confirmed by the experience of implementing VR/AR in international companies, as well as during pilot implementations in Russian industrial companies. The introduction of VR/AR in the educational segment will provide accessible tools for users and supplement training programs with interactive visual VR/AR content in the amount of up to 30% of all educational materials (with priority for subject areas that are not reproduced in traditional formats). This can lead to the following effects: increasing the effectiveness of online education; ensuring continuous professional education; ensuring the availability of quality education in the regions. With the development of the educational projects marketplace, it is possible for Russian companies to get 15% of the global VR education market.

In the corporate sphere, the use of VR/AR technologies can ensure the creation of an effective corporate training system. There is a significant technological groundwork for the introduction of VR/AR technologies in the healthcare sector. Russia can enter the international agenda with breakthrough systems for rehabilitation of patients with injuries of the musculo-skeletal system, recovery after stroke, fight against phobias and high-precision diagnosis of eye diseases (Volkodaeva et al., 2020). Besides, it is possible to achieve a certain reduction in the number of disabled people among the working population by 7% during rehabilitation in VR. Specialized training of doctors, providing continuous medical education and a system of remote presence of a doctor, for example, a surgeon at an operation, will reduce the number of medical errors by 50-80% for those who have been trained using VR/AR technologies. Thus, the introduction of VR/AR technologies will contribute to improving the quality of medical care, including in remote regions of the country, and ensuring maximum efficiency of the population.

For the successful operation of the platform, the following service modules should be recommended:

The module "Design of scenes and objects" is a system design of VR/AR environments combines the developed for the platform objects: first level is a standard 3D models of the domestic environment, 3D models of industrial equipment, standard 3D models of industrial tools, 3D models of objects and subjects for psycho-diagnostics, 3D models of elements from the field of neuromarketing, etc. The second level is the scripts of data interaction between objects and humans in virtual reality; the third level are ready libraries of typical scenes, which include objects, scripts of interaction, and evaluation methods used in most common situations, assessment of behavior, social rehabilitation, labour protection and other situations developed by the participants of the platform. This module provides an opportunity for non-specialists in the field of programming to create interactive VR/AR environments using ready-made objects, scenes and scripts for

solving applied and research tasks. The "Scenes and objects designer" should reduce the threshold for entering in VR/AR development by providing ready-made components and ways of their interaction from among the standard sets of objects and scenarios relevant to the priority areas of the platform's work. In order not to limit the possibility of using the module, including experienced developers, it should be able to use external assets (software components that include graphics, accompaniment or scripts).

Module for analyzing human behavior in a virtual and augmented reality environment – this module should be created on the basis of the most popular situations in which it is necessary to analyze human behavior, interpret the data obtained and return the results with the possibility of applying various methods of evaluating a person to them. Platform user should be able to obtain guidelines to collect data on the subject; to access published on the platform typical scenarios for the analysis of human behavior (employment, evaluation of professional competencies, assessment of the effectiveness of rehabilitation, diagnostics in difficult situations, etc.). To gain access to anonymised data of the analysis of the behavior of other users to build mathematical models, search of correlate, etc.; to access the existing platform assessment methods and interpretation of analysis results; to be able to offer to publish their methods of assessment and data interpretation to expand the possibilities of analysis of human behavior in the environment of virtual and augmented reality using the resources of the platform.

The above list of service modules is not restrictive. The joint use of system modules should enable platform users to initiate the development and publication in the platform Marketplace of new service modules that contribute to solving the tasks of the roadmap for end-to-end digital technologies VR/AR. For these purposes, the platform provides developers with methodological recommendations, technical support, moderation of the created content, as well as involvement of community members in this process by implementing an action plan to promote the platform.

End services and users are “external” to the overall architecture. End users can be both individuals and legal entities. Their interaction with the platform can be implemented through the web interface, which opens access to all functions of the platform. The system for assessing the perception of marketing incentives by the consumer of goods in virtual reality is a system for studying the consumer's perception of goods in a shopping center, using VR technologies and removing neurophysiological indicators and then analyzing these indicators for marketing purposes. To prepare scenes, 3D objects and scenarios for conducting research in virtual reality, the scene and object designer will be used. Designed scenes and objects can also be made available for later use in the platform. The depersonalized data obtained during the study will be stored using the platform's system and service modules.

Simulator of localization and liquidation of accidents at objects of gas distribution networks and gas consumption using the technology of virtual reality – simulation simulator designed to teach the identification of possible accidents associated with the use of gas; the learning procedure of localization and elimination of accidents at hazardous production facilities; planning of actions on localization and liquidation of accidents at different stages of their development; conducting training activities aimed at improving the effectiveness of emergency protection systems and reduce the consequences of accidents. The module for analyzing human behavior in a virtual and augmented reality environment will allow, along with assessing the correctness of the sequence of actions during localization and elimination of accidents, to assess such qualitative characteristics as the degree of mastering skills, the level of stress in

situations that go beyond the scope of training scenarios, the speed and confidence of decision-making, the identification of personal psychophysiological features to develop recommendations for improving the effectiveness of occupational safety of a particular employee.

Hardware and software complex for psychological testing in the field of occupational safety and risk management at the enterprise designed to improve the effectiveness of occupational risk management, reduce the risk of adverse situations and reduce injuries at work by timely determining the mental abnormalities of employees (Ashmarina et al., 2020; Ermolaev et al., 2019). Module of analysis of human behavior in the virtual and augmented reality will reveal the following mental characteristics: the tendency to deviant behavior for assessing the risks of employees of enterprises and facilities, working in shifts, the tendency to the risk behavior of personnel performing high-risk, revealing a propensity to depression to reducing the risks of personnel working in shifts and/or in the far North, identifying signs of stress and professional burnout.

The system for tracking marker objects and feedback in mobile augmented reality devices is a software package that includes the server software infrastructure of augmented reality and the tools of the developer of augmented reality applications for mobile devices: tablets and smartphones. The server infrastructure of the system will be developed using the platform's system modules. Algorithms and components will be available to developers using the platform to build solutions using augmented reality technologies. Hardware and software complex simulator for training, testing the knowledge and skills of the conductors of passenger cars designed to teach the main official duties of the conductor in the train route; control of knowledge and verification of the necessary professional skills of the conductor of the passenger car; mastering the main regulatory documents and job description of the conductor of the passenger car. The module for analyzing human behavior in a virtual and augmented reality environment will reveal the psychological characteristics of the trainee, such as: a tendency to addiction, signs of psychopathology, a tendency to deviant and delinquent behavior, and other soft skills that are not detected by conventional (traditional) methods of controlling the knowledge and skills of a passenger car conductor. Timely identification of these signs will reduce the risks associated with injuries in railway transport, poor-quality performance of their duties as a passenger car conductor. This list of user services is not restrictive and can be expanded.

## **7. Conclusion**

For customers of products and research services, the platform provides access to a wide range of developers of software or hardware-software solutions, service specialists, a tool for attracting third-party investments – as a result, reducing the cost and accelerating the development of software and hardware-software solutions, testing. For the rest of these categories of participants, except for monitor organizations, their integration within the platform ecosystem is to expand the market for services/goods already provided/produced by them, increase the efficiency of activities, including through the formation of new division of labor systems, for developers–also through access to development and debugging tools (one of the services of the claimed platform is a virtual reality scene designer, libraries of standard objects and scenarios, methodological recommendations for developing VR/AR content and methods for studying human behavior in VR/AR).

The development of the direction of VR/AR user application will allow creating services for socially important areas, for example, work with the disabled (navigation with augmented reality for the visually impaired), the development of the cultural component (navigation and excursions to cities, museums). As a result, this will contribute to improving the image of Russia as a tourist-attractive country, increasing the attendance of cultural objects with the involvement of a youth audience.

As a result, Russia in the future 4-5 years has the potential to become a visible player on the international market of VR/AR solutions and take more than 15% of the global market of VR/AR technologies. At least three Russian companies will be able to occupy more than 30% of one of the priority markets by 2024. As a maximum, Russian technologies will set industry standards in the world, especially in the areas of industry, medicine and education. The development of VR/AR technologies will have an impact on the place of the Russian Federation in the international rankings of digitalization and on increasing of the final position of the country.

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