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Innovatization of entrepreneurship in virtual reality: digital duplicates, Internet of Things, robotics

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1 Introduction

In modern business in Ukraine are widely used technologies of information retrieval systems Internet, advertising and sale of goods on Internet, electronic payments, electronic tenders, electronic card payments (including payroll), automated systems of salary accounting and reporting processes, electronic systems of protection and fire safety, electronic systems of information collection of control and measuring devices, mobile and selector communication, etc.

The concept of digital twinning has already become widespread in industrial production, but its benefits for the logistics industry are just beginning to show. For example, DHL in its Next Generation Wireless Logistics Review identified digital twinning as a new direction for growth. Digital duplicate is useful where access to main system is difficult or impossible (as in the case of a spacecraft), or it is costly (creating a costly product with a high degree of complexity: a large conveyor, powerful turbine or aircraft engine, and the cost of design error is very high), or it is associated with destructive phenomena (crash tests of new car models involve the destruction of expensive physical samples).

Digital double allows to reduce as much as possible delay time at natural tests. During the Fourth Industrial Revolution, digital duplicates became part of the "perfect storm" that combined the Internet of Things, robots, artificial intelligence, and automation. But interest in digital duplicates has spread far beyond production. A study by analysts at Markets&Markets indicates that digital counterpart market will grow from $ 3.8 billion in 2019 to $ 35.8 billion by 2025 due to the great interest in this technology from the pharmaceutical and defense industries [2].

2 EXPERIMENTAL ANALYSIS

Valuable in the scientific sense of research in digital entrepreneurship are the scientific works and practical works of such well-known scientists as R. Azum, W. Isaacson, D. Lichtblau, T. Stock and J. Seliger. It deserves due attention in terms of studying the prospects, directions and mechanisms of smart-industry development in the era of digitalization, which was engaged in well-known researchers and economists, namely: G. Androschuk, K. Alekseeva, Y. Bazhal, V. Vyshnevsky, V. Vitlinskyi, V. Geets, G. Davtyan, J. Zhalilo. Economists from Ukraine are also actively involved in research and development in terms of doing business that seeks to combine digital technology, security and economic success and issues of quality digital business management.

Among them are the names of J. Arnautov [3], E. Avdeev [4], N. Andrusyak [5], L. Boldyreva, A. Vichugova [6], O. Goloborodko, M. Zgurovsky, O. Kryvoruchko [7], N. Kraus, K. Kraus [8], P. Leonenko, O. Manzhura [9–10], A. Maslov [11], O. Marchenko [12–15], V. Osetskyi [16–17], V. Shtepa [18–19] and others. But, at the same time, a significant number of topical issues such as: characteristics of the problems and management of digital duplicates; preliminary recommendations in terms of quality control and management of digital duplicates in production; the process of creating and using digital duplicates; the content of work of digital duplicates in new and operating enterprises remains little studied in the future.

The aim of the article is to study the advantages of digital duplicates in terms of virtual reality. Representation of factors that should be considered before the introduction of digital duplicates in virtual reality. Finding out the peculiarities of the implementation of projects involving digital

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duplicates, the criteria for this type of duplicates. Substantiation and disclosure of successful experience in the implementation of digital duplicate technologies.

3 RESULTS

3.1 The concept of digital duplicates

Digital duplicate is a virtual copy of a physical product, process, or ecosystem. It is used to create a simulation that can be updated and changed to a greater extent in the real world, and to reflect any actions that occur with physical object. Digital dual device consists of making decisions based on various assumptions. Tests are performed on virtual analogue without the need to interfere with the work of real, usually expensive, objects [2].

In today's business environment, the principles of digitalization of business are as follows: interoperability, operational interaction, integration (interoperability), virtualization, decentralization, real-time interaction, service orientation, modularity, training and continuing professional education, synergy and emergencies. So, it is not surprising that the concept of digital duplicates is attributed to Industry 4.0 and digitalization of production, the origins of this concept originated much earlier than the 2010s. This concept continues the CALS and PLM methodologies that emerged in the early 21st century. Product Life Cycle Support or CALS (Continuous Acquisition and Life Cycle Support) involves the continuous integration of CAD, CAE, CAM, MRP, ERP, SCM and CRM systems used in design, manufacture and operation of high-tech products. Product data management systems (PDM) are responsible for data integration.

The product lifecycle management technology itself fits into the concept of PLM (Product Lifecycle Management) – an organizational and technical system that supports all information about the product and related processes from design and production to decommissioning. One of the goals of CALS/PLM technologies is to create virtual productions, where the development of specifications for software-controlled process equipment is distributed in time and space between several autonomous organizations to accelerate and optimize the development and production of products. In the leading countries of the world for the development of CALS/PLM-technologies standards for electronic data exchange, electronic technical documentation and manuals for process improvement are being developed [20].

However, since 2010, when the term Big Data appeared, the popularity of CALS/PLM has been rapidly declining. The concept of virtual production is embodied in the form of a digital double, because it is from the second half of 2010 that computing power allowed to create almost identical copies of real physical objects and processes in real time [21]. Due to this, as well as the development of Big Data and the Internet of Things (IoT), the ideas of CALS/PLM were continued in Industry 4.0. Interactive data collection from IoT devices allows you to monitor and even control an object or process online. For example, Apache Kafka together with Spark, Storm, Flink or NiFi provide continuous aggregation and online processing of operational data. And the Apache Hadoop ecosystem is responsible for the reliable storage of this information and data from CAD, CAE, CAM, MRP, ERP, SCM, CRM, and even SCADA systems.

In addition, digital duplicates are actively using another trend technology Industry 4.0 – augmented and virtual reality (AR/VR). This allows you to simulate almost any situation and clearly represent the internal structure of complex systems, from living organisms to space satellites. Thus, digitalization of industrial enterprises, which develops digital duplicates of industrial objects and processes, has become a modern embodiment of CALS/PLM-ideas, significantly expanding their original scope [4].

Digital duplicates are created on the basis of a specialized platform. Such platforms are manufactured by both global fans such as Siemens and Dassault Systemes, and small companies such as Xcelgo. The choice of vendor depends, first, on the specific tasks of the digital duplicate. For example, Siemens is targeting its digital dual hardware platform, and Xcelgo's solution is better suited

for modeling production systems. In particular, the conditions for checking the operating modes of the platform are formed in the execution of instructions that can be edited.

3.2 Features of the process of using digital duplicates

Having digital duplicate for the created object provides a significant increase in efficiency for all project participants. The developer creates a quality system faster, radically reducing system debugging time. The client receives a thoroughly tested system in all possible modes with increased reliability. In this sense, digital counterpart is a tool to radically reduce the risks of large technical systems projects. The use of digital duplicate changes the application to the knowledge and experience of a specialist in the subject area of the customer's business: these specialists write scenarios to test the future system, form a checklist, which is then irradiated in full finished digital dual system [22].

Digital enterprise offers tangible benefits through the operation of digital duplicates, which are a virtual representation of the actual system. They allow you to get an idea of the entire life cycle of equipment and optimize it – both for new and existing plants and projects [23].

The creation of a digital duplicate takes place at the design stage of a new system. After that, as the object is completely designed, a static model of digital dual device is created on the basis of CAD-models in the CAD system or 3D-models of objects. It essentially describes the architecture of the object, the location of the system equipment in the workspace. In the next stage, the static model "comes to life" describes the workflows, moving to a dynamic model system. This is not just a visualization of what is happening in the system. Digital dual must reproduce systematic control in the same way as the physical system. In order to write algorithms for controlling digital dual devices, such algorithms are created for the purpose of a real system. If you connect algorithms on digital duplicates, you can get algorithms that will work exactly on a real system (Figure 1).

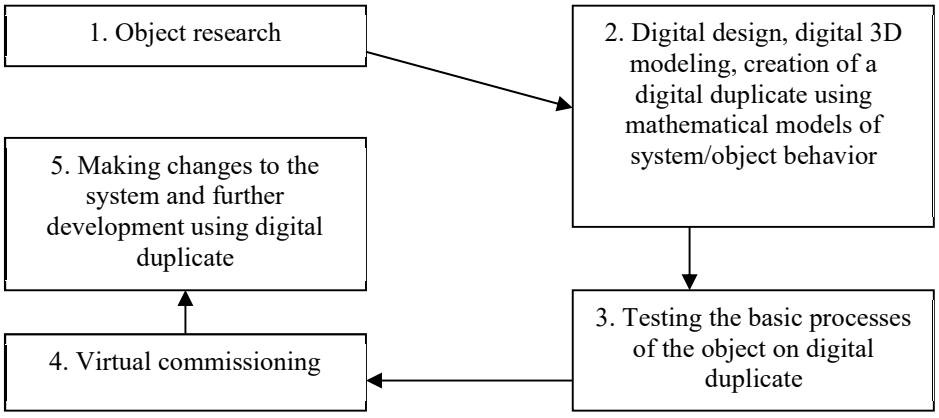

Fig. 1. The process of creating and using a digital duplicate *(author's development)*

Internet of Things (IoT) technology allows you to control devices remotely. In addition, the new method of digital duplicates can create copies of these devices. Digital duplicates are virtual copies of real objects that can be used to test the performance and efficiency of an item or system. Using digital duplicates, engineers can now quickly and easily test new sensors and products, as well as maintain and monitor their condition in a timely manner. Practitioners suggest that digital twin is a virtual interactive copy of a real physical object or process that helps to effectively manage it by optimizing business operations. For example, digital duplicate of the plant allows you to simulate the location of equipment, employee movements, work processes and emergency situations [6].

In essence, digital duplicate is a model of a real-time system that provides a virtual representation of physical assets. It allows you to manage both digital and physical assets as a whole. Digital duplicates have revolutionized the aerospace, manufacturing, engineering and energy sectors by

optimizing design, development, production and management of all aspects of a physical product throughout its life cycle [1].

3.3 Experience and benefits of using digital duplicates

The integrated concept of digital business duplicates consists of three forms: digital product duplicate, digital production duplicate and digital product and production performance duplicate. With extensive expertise in this field and optimized tool, Siemens is the only company to offer a holistic approach. The value of digital duplicate lies in the execution of scenarios and forecasting future performance (Table 1).

Table 1. Contents of digital duplicates at new and working enterprises *(grouped by authors based on source 23)*

Digital duplicates for new businesses	Digital duplicates for working enterprises
Creation of virtual production is carried out at the stage of designing processes and installations. Siemens provides a comprehensive set of tools for the design, modeling and construction of manufacturing enterprises. Using as a basis for collaboration platforms such as COMOS, and ensuring full data integration in the stages from design to design and commissioning, the system developers automatically create a digital duplicate installation with process automation, ready for implementation in real production with minimal effort, which allows you to reduce design costs and reduce production time.	At existing enterprises, technological processes, hardware and software can be used unchanged for decades. However, even in this case, digital duplicate can be very useful for optimizing existing processes and facilities. This digital duplicate allows you to analyze information on the operation of the plant. In this case, modernization and maintenance measures are based on the documentation in its original form and the relevant data on the operation of the plant. This significantly reduces the search time and the number of errors.
In the real world, Siemens' Process Management and Production Operations Management (MOM) systems ensure reliable production operations and help collect the data needed to create digital duplicate. This duplicate, created on the basis of real production systems and enriched with data obtained from Internet of Things, optimizes the production and maintenance of critical facilities.	Thanks to the integrated workflows, created digital duplicate is constantly updated until the end of the service life of the installation – the connection between virtual and real production is carried out in a closed loop.

Digital duplicate technology is one of the fastest growing concepts in Industry 4.0. It is the growth of the IoT industry and cloud technologies that has a significant impact on digital counterpart market. According to Gartner, digital duplicates are used in 13% of organizations implementing IoT projects, while 62% are either already implementing the technology or planning to do so. According to the latest Markets&Markets report, digital counterpart market will grow to $ 35.8 billion by 2025 with an average annual growth rate of 37.8%. Digital duplicate technology is already widely used in industry, but it is no less important for manufacturers. Table 2 presents the advantages of using digital model of duplicates and the factors that should be considered before its implementation [3].

Table 2. Advantaches of using digital duplicates in virtual reality *(group be outsours based on surce 2; 3)*

Advantage	Content and characteristics during the application
Operational assessment of risks and production time	With the help of digital duplicate, companies can control the quality of a product before it appears in the real world. Because digital duplicate is a copy of the planned production process, experts may notice any process failures before the product goes into production. Thanks to digital duplicates, you can increase the intensity of testing by 10 times and reduce by 85% the labor resources involved in design process. In general, engineers can restructure the system by generating unexpected scenarios, studying the system's response, and creating mitigation strategies. Thus, new technology allows for better risk assessment, accelerate the development of new products and increase the reliability of production lines.
Improving	Process automation and round-the-clock access to system information can increase productivity

interaction within teams	and efficiency. Yes, in the team, developers can pay more attention to creating new elements, rather than monitoring and checking once again already running.
Intelligent service	Because digital duplicate IoT sensors generate big data in real time, businesses will be able to analyze internal statistics and detect any system failures in advance. This allows companies to move to intelligent service, while increasing the efficiency of the production line and reducing operating costs.
Improving financial decision-making process	In the virtual model, you can also specify the cost of materials and labor costs. As a result, companies can make faster and more efficient decisions in financial sense: whether the value is calculated correctly, what can affect it, and so on. You can also use digital duplicates to avoid financial losses due to reduced productivity. For example, previously business owners had to stop all workflows to test new warehouse modules. Now it all happens virtually and the effectiveness of the settings is easy to check again.
Remote real-time monitoring	When working with a large system, it is simply impossible to check any of its elements at once. However, digital duplicate can be accessed anywhere, allowing users to remotely monitor and control system performance. In practice, engineers have created a warehouse structure with all the necessary technical characteristics. Yes, digital duplicates mimic the operation of a warehouse. Thanks to it is possible to estimate productivity better and to choose the optimum approach at the organization of industrial warehouses in reality.

In logistics industry, the development of digital duplicates for complex infrastructure supply chains, such as ports and large warehouses, is still at an early stage. However, major ports around the world, including Singapore and Rotterdam, are turning to digital counterparts to design, plan and manage their operations. Having digital duplicate, such as a storage room, can significantly increase operational efficiency. Every process that takes place on the site and every piece of equipment will be reflected in a digital mirror, ensuring a constant flow of operational data. There are many advantages: you can quickly detect the inefficiency of certain areas of handling or identify problems with the maintenance of equipment before they affect the throughput [1].

3.4 Main conditions and levels of implementation of digital duplicates in enterprises

In addition, digital duplicate is not limited to collecting data obtained during product development and manufacturing, but continues to collect and analyze information throughout the life cycle of a real object, for example, using Internet of Things (IoT) devices [6]. Factors to consider before implementing digital duplicates in virtual reality are presented in Table 3.

From a practical point of view, it matters for what essence digital duplicate is created. For example, an aircraft engine is a separate object, which would correspond to a very difficult set of complex mathematical descriptions of how it works. This digital duplicate is necessary in order to test on a mathematical model all its capabilities and performance in various situations, including freelance. Another example is the logistics company's sorting center automation system. The sorting system consists of many relatively simple elements (for example, for transporting the conveyor), but for a logistics company it is important not one element, but the entire sorting system, and a digital duplicate is created for the entire production system [22].

Table 3. Factors to consider before implementation digital duplicates in virtual reality *(grouped by authors based on source 3; 1)*

Factors	Characteristic features
Update data security protocols	Gartner estimates that by 2023, 75% of digital duplicates for OEM products connected to the IoT will use at least five different types of integration endpoints. The amount of data collected from the many endpoints is huge, and each is potentially vulnerable. Therefore, before implementing digital duplicate technology, companies need to analyze and update their security protocols. It is worth paying special attention to: - data encryption; - access rights, including a clear definition of user roles; - principles of the least privileges; - elimination of known defects of the device;

	- regular security checks.
Team training	Companies need to make sure that their staff have the necessary skills and tools to work with digital duplicate models.
Data quality management	Duplicate digital models use data from thousands of remote sensors through unsecured connections. Companies should be able to exclude irrelevant data and manage gaps in data flows.

The benefits that an enterprise receives from digital transformation of business processes depend on the type of tasks performed by employees. The more complex the task, the deeper the level of digital transformation the company needs to increase overall efficiency. According to the level of complexity, the tasks are ranked as follows (from the simplest to the most complex):

- repetitive tasks;
- administrative tasks;
- unit level tasks;
- tasks of the enterprise level;
- expert tasks.

Ultimately, main goal of digital transformation is to ensure that employees perform only expert, ie the most unique tasks that are difficult to copy or accurately replicate. The rest of tasks can be performed with minimal employee participation and with the maximum involvement of powerful digital tools and increase the efficiency of their work. Features of the implementation of projects involving digital duplicates in terms of virtual reality in terms of stages are disclosed in Table 4.

Table 4. Peculiarities of project implementation with the participation of digital duplicates in the conditions of virtual reality *(grouped by authors based on source 22; 20)*

Stages of the project	**Content and characteristics**
Technical	Digital dual platforms are an objectively new phenomenon in the market. In particular, it provides clarity that not all pieces of equipment used in a particular project can be adequately represented by the platform. Then, these or those complex elements either come to create (construct) independently, which is not always a trivial task, or to ask the vendor to work with the platform. However, it should be noted that the vendor platform responds to operational requests at all times if they are interested in ensuring that their product is optimal as required.
Financial	If only the company decides to create digital duplicate, then this project will have to defend before the CFO in part the need to purchase licenses on the platform, and obviously a foreign vendor, and therefore the costs will be quite significant. If the production system is created by external contractors, such as an integrator, then the cost of acquiring a license is borne by the company's partner. To do this, it is important that the integrator constantly executes projects using digital duplicate platforms: then the cost of the platform will not become a separate item in the cost item required by the project. Because customers are often not ready to increase project budgets, for the sake of digital duplicates in the design services.
Terms of designing with the participation of digital duplicates	The timing of such projects depends on the system. In general, they are equated to the duration of the design phase. The expert conducts an empirical pattern: in the project, which takes 8 months, work on digital double adds to the duration of the first phases of development from 2 to 4 weeks, ie a maximum of 1 month. In the future, work with the digital double is carried out in parallel with the planned work on the system.
Improving the quality of design	Improving quality systems using digital duplicate is reflected in the best solutions at an early stage.

For example, DHL named three main challenges in promoting digital duplicates in logistics: cost, accurate asset representation, and data quality. Next-generation wireless and 5G can solve the last two problems. The exact reproduction of digital duplicates depends on the ability to communicate in real time between the physical asset and its virtual display. Given the complexity of modern warehouses and the growing number of automated logistics tools, the collection, transmission and visualization of data into dynamic virtual models have so far been limited by the capabilities of existing wireless networks. Now, thanks to 5G, this problem can be solved.

3.5 Successful experience in the implementation of digital duplicate technology

Digital duplicate can be thought of as a virtual prototype of a real object or process that contains all the data about it, including history and information about the current state. The criteria for digital duplicates are given in Table 5. Interactive analysis of this data using Big Data technologies allows you to effectively perform the following important management functions:

- obtaining accurate information about system performance;
- forecasting future conditions using ML-models of predictive analytics;
- remote control of the object in real time [6].

In terms of data quality, digital duplicates today have to collect data from many sources, both traditional IT systems and many sensors in the physical world. These can be boxes with RFID tags, AVG (cars with automatic control) or pallets with Bluetooth support. All this needs to be coordinated and coordinated through a single high-speed wireless network, which DHL suggests will be based on 5G [1].

Table 5. Categories of digital duplicates *(grouped by authors based on source 6; 2)*

Categories	Characteristic features
Duplicate (Digital Twin Instance, DTI)	data describing the physical object. For example, an annotated three-dimensional model, information about materials and components of the product, information about work processes, test results, records of repairs, operational data from sensors, monitoring parameters, etc.
Prototype (Digital Twin Prototype, DTP)	virtual analogue of a real physical object. It contains all the data for this product, including information from design and production stages, such as product requirements, three-dimensional model of the object, description of technological processes, disposal conditions, etc.
Aggregate double (Digital Twin Aggregate, DTA)	a system that integrates all digital duplicates and their real prototypes, allowing data to be collected and exchanged in real time.

Successful scenarios for the introduction of digital duplicate technology in different sectors of the economy are presented in Table 6. The ultimate goal of digital duplicate in manufacturing industry is to create a closed feedback loop between virtual and real production through the use of the right digital infrastructure. Due to this connection, the duplicate characteristics of real production allows you to develop optimization scenarios in virtual production. After successful modeling and implementation of these scenarios, the cycle begins again.

Table 6. Successful experience in the implementation of digital duplicate technology *(compiled by authors based on source 2; 1)*

Field of application	Brief description, content of the work
Energy sector	In the energy sector, digital duplicates are used to create virtual wind farms, or as they are sometimes called, “wind farms” based on cloud technology. Each wind farm has its own unique structure, like DNA or a fingerprint. Thanks to digital twin technology, engineers can combine and select different turbine configurations, depending on the conditions of the wind farm. As soon as the turbine is put into operation, its virtual copy begins to collect and analyze environmental data in real time, which leads to the creation of more efficient models.
Sphere of hospitality and service	Digital duplicates help to create simulations of real events and situations, and this creates a significant impact on the development of the Industry. For example, in the CKE Restaurants Holdings fast food chain, digital duplicates allow restaurants to work more productively. Digitization has affected the halls for visitors and kitchens, so companies are testing different options, thereby reducing staff rotation and creating more favorable conditions for visitors.
Urban environment	The technology helps city planners better understand and refine factors such as energy consumption. Digital copy of Singapore already exists, and copies of other cities are expected in the future.
Retail	The technology of digital duplicates has recently entered the field of retail, but could be very useful, especially when it comes to modeling the behavior of shoppers. Analytical firm Pygmalios singles out virtual duplicate technology as part of the Retail 4.0 digital retail transformation process, an

	approach that collects detailed real data from the physical retail environment and then uses it to better understand visitor behavior and actions.
Healthcare	Since a virtual image of any real object or environment is created, it is possible to create a "digital patient" – a model of the human body that gives an idea of the state of human health during his life. This is how Philips sees the future of healthcare. The idea of creating a whole digital patient is still far from being realized, but the technology is already being applied to certain parts of the body, which is encouraging. Philips has developed the HeartModel application, which creates a detailed 3D image of the human heart based on ultrasound images. One day, a virtual heart can help save the real thing.

Based on the analysis of literature sources, we concluded that digital transformation of the enterprise is the introduction of modern technologies in its business processes. This understanding involves not only the installation of modern hardware or software, but also fundamental changes in approaches to management, corporate culture, external communications. As a result, the productivity of each employee and the level of customer satisfaction increase, and the company gains a reputation for progressive and modern. The latest digital technologies of the "digitization" process lead to innovative transformations in all spheres of enterprise activity and encourage the creation of new business models.

4 CONCLUSIONS

In conclusion, it is worth noting that new technologies help companies reduce costs, increase productivity and efficiency, as well as optimize maintenance. In particular, it is the technology of digital duplicates in combination with the tools of machine learning and artificial intelligence allows to achieve this without compromising workflows. With this content, digital technology makes it possible not to stop the line to test a new element. Therefore, for manufacturers, the technology of digital duplicates is important not only to improve efficiency, but also to bring the product to market faster.

Guided by a number of topical issues that we have tried to focus on in this article, we remain true to the opinion that it is still important to conduct future research aimed at presenting the effects of digital transformation. Among them, we believe: significant release of working time of employees to focus on more important tasks, reducing the number of specific tasks, improving the coherence of business processes within digital enterprise, accelerating the processing of analytical information for management decisions, etc.

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