



## Ensuring Sustainable Development of the Enterprise During the Transition to Industry 5.0

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### ABSTRACT

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The prerequisites for the study were the strengthening of signals for the development of Industry 5.0. The main purpose of the article is to model the sustainable development of the enterprise in the context of the transition to Industry 5.0. To do this, the scientific task will be to select and implement a methodological approach with elements of modeling to ensure sustainable development. The object of the study is the sustainable development of the transportation and travel enterprise. The basis of the methodology is the modern technique of functional modeling of planning and management decision-making. For this, a modern modeling method using graphic language technologies was chosen. The obtained results of the study have elements of novelty through the presented two directions for ensuring sustainable development for a really practicing enterprise. It is determined that the preparation of entrepreneurial and production activities before the introduction of Industry 5.0 is not an easy and fast process, but it is completely justified today. The innovativeness of the results obtained is presented in the form of a sustainable development model. The study has limitations and they consist in using the experience of the previous industrial revolution and exclusively take into account the theoretical vision of Industry 5.0. Further research will include benchmarking to better understand the work of sustainable development.

## 1. INTRODUCTION

Currently, the fourth industrial revolution is taking place, the designation of which is the term "Industry 4.0". It is customary to single out a number of stages in the development of the productive forces of mankind. Stages 1.0 and 2.0 were associated with the development of agriculture. The third stage is the industrial revolution, the beginning of the mass use of industrial production. Stage 4.0 includes a period of general computerization, including technological equipment and product manufacturing steps. The essence of the new revolution is that the material world is combined with the virtual one, as a result of which new cyber-physical complexes are born, united in one digital ecosystem. Stage 5.0 should cover all stages of the product life cycle [1].

In anticipation of the future Industry 5.0, two worlds must be considered together: the virtual world, implemented by the Internet of Knowledge, and the real world, implemented by the Internet of Things. It is expedient to build the Internet of Knowledge on an ontological methodology, which is based on the world of virtual agents that have an object-function and are able to generate new data based on the available information. A significant segment of the implementation of Industry 5.0 technologies is urban urbanization, the digitalization of which

will improve the well-being of citizens, including by creating its digital component, as well as accelerate the transition to sustainable development.

Today, enterprises should build an enterprise management system based on sustainable development, it is this management that helps to ensure its financial stability, competitiveness, effective functioning in the market, organization of production focused on reducing harmful emissions into the atmosphere, reducing the material consumption of manufacturing products, improving the jobs of workers and the growth of the social level of the population. It is the current mechanism of sustainable development that allows enterprises not only to easily adapt to environmental changes, but to constantly develop.

The business environment of an enterprise is constantly changing, which means it opens up new opportunities and at the same time creates certain restrictions and creates threats. The successful functioning of the enterprise is possible only with its constant adaptation to external conditions and requirements. These are the conditions for the transition to a new level - Industry 5.0. The innovativeness of the results obtained is presented in the form of a sustainable development model.

The structure of the article implies a review of the literature,

presentation of the main methodology, description of the main results of the study and their discussion, drawing conclusions.

## 2. LITERATURE REVIEW

Sustainable development is devoted to a significant number of publications. Scientists discuss the interpretation and assessment of the sustainable development of various socio-economic systems, its components and criteria for their assessment.

The sustainable development of entrepreneurial structures, according to the authors [1-3], is not only a new scientific and practical concept, but also a prerequisite for ensuring the continuous evolution of the national and socio-economic system, as well as in the world as a whole. According to scientists, it is undeniable that the social and environmental aspects are fully integrated into the concept of sustainable development of structures and systems of macroeconomic and microeconomic levels.

As rightly noted by scientists and practices [4, 5], the stability and balance of individual subsystems are signs of sustainable development of the system as a whole. Violation of the balance between individual subsystems indicates the inconsistency of the development of a particular object (country, region, industry, enterprise) of the concept of sustainable development. The result of economic development in the socio-economic system is the provision of not only material, but the entire set of human needs, including spiritual, social, environmental and others.

A significant number of scientists [6, 7], in one voice, say that in the end, only those economic entities that quickly respond to the needs of society that arise in its various areas can be viable and effective, and firstly accept the concept of sustainable development in Industry 5.0. Sustainable development can be ensured only on the basis of innovation. The introduction of innovations in enterprises contributes to the sustainable development of industries, territories, as well as countries as a whole. And for this purpose, enterprises should have appropriate internal potential and favorable external conditions, in particular, it is necessary to create conditions for the development of small and medium enterprises.

We agree with the thesis in the scientific literature [8, 9] that Industry 5.0, on the one hand, becomes a source and a stimulant of competition, providing new opportunities for development, as well as other generations of contradictions and problems of local and local and local general civilizational scale. In our opinion, theoretical and methodological terms are systemic asymmetry of socio-economic development, caused by the growing interdependence between the entities of macro and micro levels.

As for the sustainable development of the enterprise, most scientific literature [10-12] considers two categories: the sustainable development of the enterprise in the current period; Dynamic sustainable development of the enterprise. Scientists of the enterprise in the current period are interpreted by scientists as its ability to carry out economic activity in each individual moment in the conditions of uncertainty of the

influence of the external environment, which violates the normal functioning and development of the enterprise. Processing sustainable development of the enterprise characterizes the process of its development, constancy and continuity of changes in the direction of Improvements to transfer the company to a qualitatively new level of activity. The peculiarity of the dynamic sustainable development of the enterprise is that at each stage there is a "correction" of qualitative changes, improvements based on cyclic reproduction of a constant system of the functions of the enterprise. This new stage is the Industry 5.0.

Due to the analysis of the works, a conclusion was drawn, which requires further study of the issue of ensuring the sustainable development of the enterprise in the transition to Industry 5.0.

## 3. METHODOLOGY

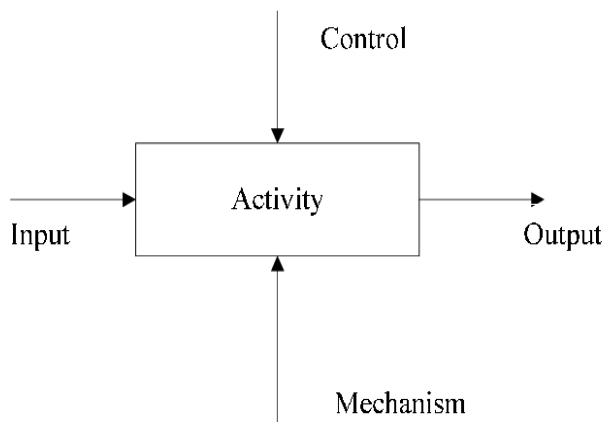
### 3.1 Peculiarities of using SADT family methods

Let's apply the SADT modeling technique. The description of a system using SADT is called a model. SADT models use both natural and graphical linguistics. To convey about a particular system, the source of natural linguistics is the people describing the system, and the source of the graphic language is the methodology of structural analysis and design. The SADT graphical language is formalized in a quite definite and unambiguous way, due to which SADT allows one to describe systems that, until recently, have not been adequately represented. Based on the SADT methodology, in particular, the well-known IDEF0 methodology has been developed.

The process of ensuring sustainable development from the point of view of a functional approach is a set of continuous and coordinated activities, i.e. management functions, where each function is also a process and consists of a series of connected actions. To build a holistic model for ensuring sustainable development, we will use the widely used SADT methodology - the methodology of structural analysis and design, which is a set of methods, rules and procedures designed to build a functional model of the system. This choice was made due to the fact that this methodology is universal and can serve as the basis for planning, development and management in the sustainable development system.

### 3.2 Description of the use of the IDEF0 method

We will use the IDEF0 functional modeling methodology, which allows us to describe the provision of sustainable development using a sequence of standard steps. This notation is distinguished by a convenient way of displaying the system being modeled, the absence of restrictions on the mathematical description of decomposition blocks, and the accuracy of iterative modeling. Another advantage of this methodology is the ability to move on to functions that characterize production efficiency and develop models whose function is to improve technology. Process modeling in the IDEF0 methodology begins with the creation of the so-called context diagram, which is the system under study in the form of a rectangle reflecting the process (Figure 1).



**Figure 1.** An example of the structure of the context diagram according to the proposed modeling technique  
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Further, the block representing the system as a single module is detailed in another diagram using several structural units connected by interfaces. These blocks are the main sub-functions. The performed decomposition reveals a complete set of subfunctions, each of which is represented by a structural unit, the boundaries of which are defined by interface arcs. Each of these sub-functions can in turn be decomposed in a similar way for a more detailed view. In this case, each private function can always contain only those elements that are included in the original function. Also, the model cannot ignore any elements, the parent box and its interfaces provide the context. The methodology is a subsystem of diagrams with accompanying documentation that breaks down a complex object into components.

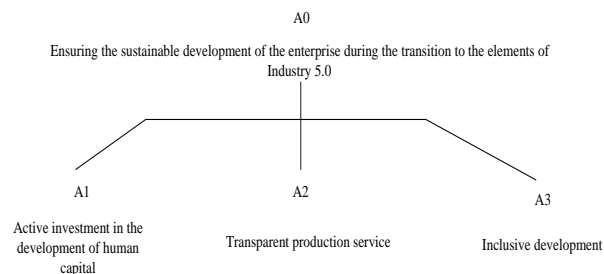
Interface arcs are often referred to as flows or arrows. The interface arc represents the element of the system that is processed by the function block or has other effect on the function displayed by this function block. Graphically, it looks like a one-way arrow.

To start modeling, we had to choose a specific practical socio-economic system that requires sustainable development and can serve as a good example of the proposed methodological approach. We chose the service enterprise "Innovative terminal LEO". The company actively delivers all goods and provides travel services. Why did the choice fall on him? There are two main criteria here: 1. The company is already using modern elements of Industry 4.0: cyber-physical systems for data protection; 3D printing for certain parts; fully automated production and logistics sphere of service. 2. Needs sustainability as discussed with management. That is why it is ready for the transition to Industry 5.0.

#### 4. RESULTS OF RESEARCH

The main purpose of our model in the enterprise "Innovative terminal LEO" is A0 and it will consist in ensuring the sustainable development of the enterprise during the transition to the elements of Industry 5.0.

First of all, it is necessary to classify the main sub-functions (in our case, stages) that should be performed to achieve the main goal A0 (Figure 2).



**Figure 2.** The main stages that should be performed to achieve the main goal A0  
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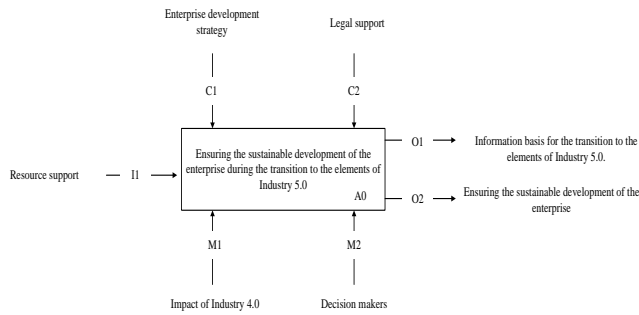
We characterize our own vision of ensuring the sustainable development of the enterprise "Innovative logistics terminal LEO" through the key stages presented during the modeling:

A1. Active investment in the development of human capital. This implies large-scale investment in human capital, the intellectual "saturation" of mass professions, the creation of favorable conditions for the all-round, creative development of man. The consequence of this will be an increase in labor productivity in various areas of economic activity; intellectual capacity building and sustainable themes of socio-environmental and economic growth; permanent modernization of the structure of the economy in accordance with changes in the situation on world markets.

A2. Transparent production service. A transparent production service that allows an enterprise to identify and evaluate uncertainty in the process of implementing production schemes and operating equipment. Such a service requires the use of innovative forecasting tools, where data is systematically processed for timely use. The implementation of the Internet of Things provides the basis for the use of "smart" technologies and "smart" indicators. The core of transparent service technologies is an intelligent computing engine containing software for implementing preventive modeling and management functions.

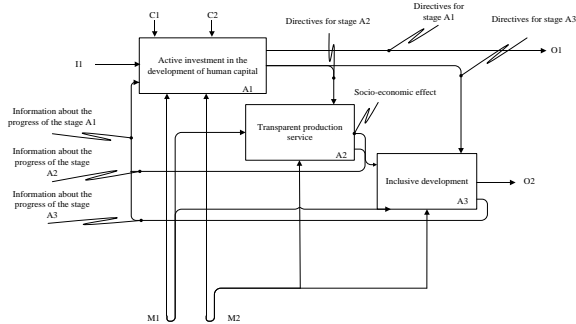
A3. Inclusive development. The basis of inclusive development is social justice, the protection of human rights and freedoms and the greening of activities. According to many foreign researchers, the development of an inclusive development model will help bring the world economy out of regression and stagnation, and will also stimulate an environmentally consistent socio-economic growth of business entities at the micro and macro levels.

Further, it is necessary to identify all additional processes that may accompany the achievement of A0 throughout the entire simulation. They will be based on the conditions of the methodological approach shown earlier in the text in Figure 1. Thus, on its basis, we build our structural context diagram of the enabling achievement of A0 at the service enterprise "Innovative terminal LEO" (Figure 3).



**Figure 3.** Structural context diagram of enabling achievement of A0 at the service enterprise "Innovative terminal LEO"  
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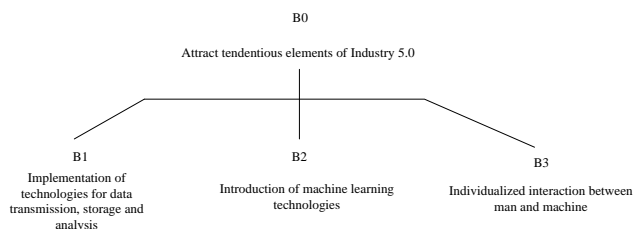
Thus, we will model the decomposition of the general type of A0 achievement, which will ensure sustainable development for the enterprise we have chosen during the transition to Industry 5.0 (Figure 4).



**Figure 4.** Decomposition of the results of modeling the achievement of A0 at the service enterprise "Innovative terminal LEO"  
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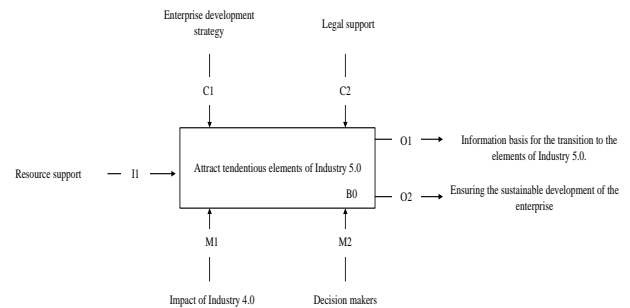
Decomposition is a process of achieving A0 in the form of blocks, gradually moving from one to another (i.e., the execution of one process leads to the beginning and execution of another). Each process has some directives (control, monitoring).

Of course, the above measures, according to the current decomposition of the sustainable development model for the company "Innovative terminal LEO", are not enough. That is why, as part of our study, we propose additional paths through modeling (Figure 5).



**Figure 5.** The main stages that should be performed to achieve the main goal B0  
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Thus, we have a new modeling goal: B0 - to attract tendentious elements of Industry 5.0. Its achievement is possible with the enabling elements presented in Figure 6.



**Figure 6.** Structural context diagram of enabling achievement of B0 at the service enterprise "Innovative terminal LEO"  
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For the enterprise "Innovative logistics terminal LEO", the following tendentious stages of gradual transition to the conditions of Industry 5.0 should be distinguished:

B1. Implementation of technologies for data transmission, storage and analysis. Data is the fuel that fuels an innovative industry. Modern progress in data connection, storage and analytics, including cloud and peripheral systems, is the basis not only for the development of entire sectors of the global industry, but also for the development of each individual production.

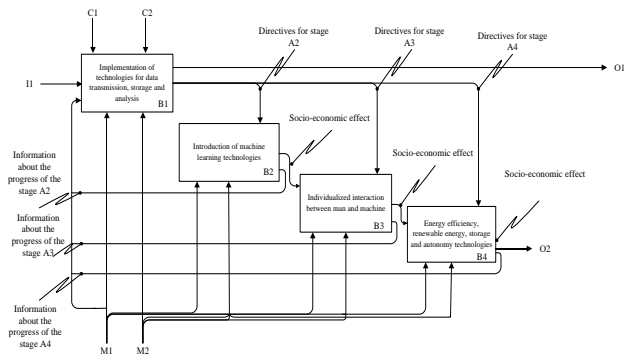
B2. Introduction of machine learning technologies. Machine learning and artificial intelligence technologies give quantum acceleration to the development of innovations, improve the quality of production, providing the necessary tools for modern production processes.

B3. Individualized interaction between man and machine. Individualized human-machine interaction is the most important difference of Industry 5.0 - the reintroduction of the human factor into processes and systems automated to hyper-efficiency with the help of the latest information technologies. In a certain sense, the human element "returns the soul" to the production process through the possibility of collaborative production - the imagination and flexibility of the human worker are empowered and improved by the ability to use collaborative works. The combination of smart machines and human ingenuity will enable true "mass personalization" and will drive global manufacturing forward.

B4. Energy efficiency, renewable energy, storage and autonomy technologies. The transition from fossil fuel vehicles to electric vehicles is accelerating. At the same time, the penetration of wind and solar energy continues to grow due to lower related costs and economies of scale in battery production. Advances in autonomous technology are setting the stage for new transportation business models, improving safety and reducing pollution.

Thus, we will model the decomposition of the general type of B0 achievement, which will ensure sustainable development for the enterprise we have chosen during the transition to Industry 5.0 (Figure 7).

Thus, we have presented two key models for ensuring sustainable development for a particular enterprise in order to gradually move towards the trends of Industry 5.0.



**Figure 7.** Decomposition of the results of modeling the achievement of B0 at the service enterprise "Innovative terminal LEO"  
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## 5. DISCUSSIONS

When discussing the results of the study, one should compare them with similar ones. Such studies on ensuring the sustainable development of the enterprise focus on different aspects of this process. For example, some researchers [13-16] argue that the social responsibility of business is an integral part and a strategic platform for the sustainable development of enterprises at the present stage. The desire of the corporate segment and the business segment to carry out socially responsible business, on the one hand, is due to the growing global and national legislative requirements, and on the other hand, the rational motivation of the entrepreneurs themselves, who understand and are aware of global threats and challenges to humanity. The development of corporate structures, according to the concept of social responsibility of business, not only contributes to maintaining stability and balanced economic growth (by obtaining additional economic benefits), but also provides a number of undeniable competitive advantages.

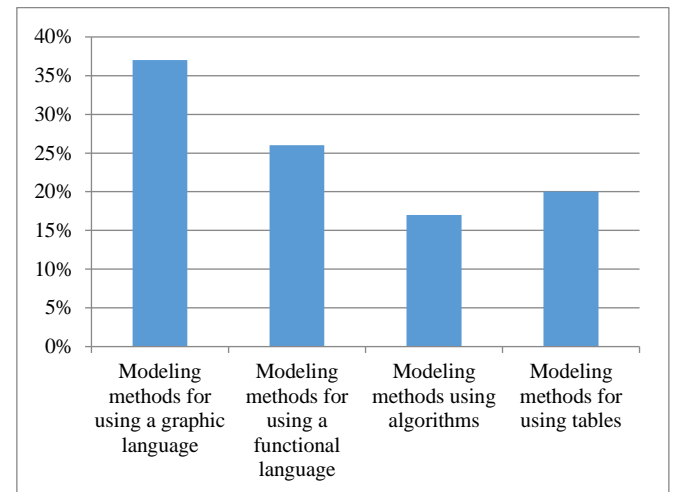
Some authors [17, 18] determined the importance of a company's sustainable development and highlighted the contextual factors of this process. Sustainable development involves the recognition of external requirements, as well as the consequences caused by the activities of the corporation, to take into account opportunities and threats in the process of ensuring its sustainability.

In most of these works, it is noted [19, 20] that in the context of the prospects of Industry 5.0, the business model is a progressive concept with a predominance of the value component that has a positive impact on consumers, the enterprise, the social and environmental environment. A value-oriented approach to business modeling involves the manifestation of corporate social responsibility in the context of general digitalization and global competition, when the economy must become not only circular, but restorative, economical and preserve the biodiversity of the environment.

In general, the use of the methodological approach proposed by us is an actual part of many studies. For example, in general, the use of graphic modeling languages to provide a particular process can be traced in different scientific directions (Figure 8).

However, the distinguishing feature of our study is the emphasis on ensuring the sustainability of enterprises because of the long-term perspective in the transition to Industry 5.0.

We tried to model the processes that an enterprise should follow in order to achieve sustainable development, taking into account the transition to the aspects of Industry 5.0.



**Figure 8.** Analysis of the popularization of the use of the modeling method using a graphical language  
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## 6. CONCLUSIONS

Summing up, we can highlight the following results obtained during the study in the article:

1. A new methodological approach has been proposed to ensure the sustainable development of enterprises. The issue of sustainable development of any enterprise is, first of all, planning and making decisions that are strategic in nature. That is why it is important to have a graphically oriented methodological approach to demonstrate the stages of achieving this sustainable development.

2. A model for ensuring the sustainable development of a particular enterprise is presented, taking into account the opportunities and conditions for the transition to Industry 5.0. The uniqueness of the results is due to the fact that the company is actively using modern aspects of Industry 4.0, and therefore the transition to 5.0 is not new for it and should be.

As part of further research, it is planned to form business models of enterprises on the principles of sustainable development in the context of the transition to Industry 5.0. Namely, cyber-social business models of breakthrough development, which involve the rational combination and implementation of measures of digital, socio-economic, environmental and innovation strategies in order to increase the competitive status of domestic business in the global economic, social and environmental systems.

One of the key solutions to the problem of transition to Industry 5.0 standards should be the correct modeling of sustainable development. To do this, you should plan all the processes to achieve key milestones. The key will be the use of modern machines that can serve all the needs of the enterprise.

The study has limitations and they consist in using the experience of the previous industrial revolution and exclusively take into account the theoretical vision of Industry 5.0. Further research will include benchmarking to better understand the work of sustainable development.

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