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SYSTEM OF BALANCED INDICATORS FOR NEW PRODUCT DEVELOPMENT STRUCTURES TAKING INTO ACCOUNT CUSTOMER SATISFACTION

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A B S T R A C T

This study considers the usage of balanced scorecard for planning and operative management of organisations responsible for developing new products. It is proposed to use five perspective of strategic map, taking into account the key strategy - development and commercialization of the intellectual activity results. In addition to four standard projections it is suggested to use the Customer Satisfaction projection.

This perspective includes the goals of increasing characteristics of the input flow developments coming or being created at the enterprise. It also reflects the quality objectives regarding the products created in the enterprise.

For each goal, indicators for monitoring their implementation are defined.

This balanced scorecard can be used as a starting point in building a model for evaluating organisational structures, and also develops the theory of planning and management development and production processes.

1. INTRODUCTION

For the building an effective system of planning and operational management of the organisation's structures responsible for the development of new products it is necessary to determine the strategic purposes of the development company of additive manufacturing and carry out their decomposition to the level of separate units. It is sufficient to choose only these purposes which can be influenced by the activity of development units. Monitoring the implementation of objectives is carried out through the indication system where every aim is assigned to key performance indicators.

Nevertheless, the aim of selecting the main points and indicators of their achievement for the organisational structures, working on creation of additive products, becomes non-trivial.

In rates elaboration it is essential to point out that realisation of new products, also in the additive technologies, being implemented within the project activity, which is oriented on meeting requirements of all projects' stakeholders. A balanced scorecard (BSC) is the most used instrument to identify strategic rates and metrics of their implementation (Bisbe & Barrubes, 2012). This method is considered to be more versatile from the management point of view, since such a

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system of goals can be used in different spheres on various levels of management.

Methodology of setting strategic objectives on the basis of a balanced scorecard has been used for a long time and recognised by many managers as an effective instrument for planning and managing. A traditional scorecard, proposed by Kaplan and Norton (2009), includes four projections: finances, processes, market and people.

Nowadays, it is important to notice that the external environment of the companies, developing additive technologies, becomes dynamic and non-permanent and the rate of technology diffusion is constantly increasing, which leads to a reduction in the life cycle of new product development projects. The focus of project management is shifting from meeting the project objectives and a product delivery to meeting client's requirements and supplying value.

However, in this interpretation, the indicators do not cover areas related to the supplying value to the customer of new products and stakeholders. Usage of unified projections seems insufficient, since it does not reflect the specifics of the activities of individual departments involved in the development of new products, and also does not allow assessing how the delivered results satisfy the customer. After all, in the end, it is this factor that determines the efficiency of the functioning of the entire system. In this regard, the formation of a modified system of balanced indicators of new product development structures, taking into account customer satisfaction, becomes an urgent task.

Many domestic (Batukova & Belyakova, 2015; Chmyshenko, & Satenaeva, 2019; Ermolenko et al., 2021; Kankhva, 2019; Kolegova & Zakharova, 2018; Shevchenko, 2017; Tsygankov & Petrunina, 2022; Utkin & Shitik, 2020; Utkin et al., 2020; Utkin & Tikhomirova, 2020) and foreign (Bohm et al,, 2021; Brimelow et al., 2022; Davenport, 2018; Farci, 2021; Frederico et al., 2020; Hansen & Schaltegger, 2017; Pierce, 2022) researchers, considering the application of a balanced scorecard for management structural subdivisions of enterprises note the need to form additional projections that meet the strategic goals and industry specifics of specific enterprises

2. BUILDING A STRATEGIC MAP

As a methodological basis for the study, recommendations were used on the formation of a balanced scorecard of the Group of Companies Project Management Institute (2021).

In the context of project management for the development of new products in the additive industry, in order to determine new projections of the balanced scorecard, it is advisable to refer to modern project management standards. In the latest edition of the Guide to the Project Management Body of Knowledge, Guide to the PMBOK, 2021 (Chistyakova & Yudin, 2022) from the leading American project management institute PMI, the fundamental principle is the delivery of value, not the product of the project, since it is this fact that ensures maximum satisfaction of stakeholders, and the customer of new products in the first place. It must be understood that it is customer satisfaction that determines the fulfilment of the goals of the "Market" projection and determines the level of achievement of the company's financial goals, which are the dominant projection in the balanced scorecard.

In this regard, the issues of including customer satisfaction criteria in the balanced scorecard are an important task of strategic management.

Within the framework of this study, in addition to the traditional four projections, it is proposed to introduce another one that reflects the degree of customer satisfaction with new products.

Table 1 reveals the essence of each projection (perspective) in accordance with the main strategy of the enterprise - the development of additive equipment.

For enterprises developing new equipment, it is required to define key indicators for each perspective.

Table 1. Essence of projections (prospects) of the balanced scorecard

Perspective	Description
Finances	It reflects the key financial and economic goals of both individual organisational structures for the development of new products, and the entire enterprise. Includes income and expense components
Clients (market)	Includes goals aimed at working with intermediate (within the distribution network) and end users and consumers of services and products, created on the basis of additive technologies
Processes	Reflects the key goals of creating, developing and improving individual processes for developing new products at the enterprise, interaction between all departments of the company
Staff training (Potential)	Includes goals related to the creation and development of internal points of growth, the improvement of the personnel component, as well as the increase in the efficiency of distribution and use of various types of resources or the creation of new ones
Customer Satisfaction	Indicates the goals of increasing the qualitative and quantitative characteristics of the input stream of developments coming and being created at the enterprise. It also reflects the goals of quality and individual parameters regarding the products created at the enterprise in accordance with the stage of development or life cycle

As key financial indicators, we highlight:

- Increase in net profit. This indicator is used if the company does not have a significant increase in the scale of activities (an increase in the number of employees, the number of products created, etc.). In this case, the positive dynamics in the company will be associated with a reduction in the required investments, a reduction in R&D costs, or an increase in the effectiveness of the transfer process. Otherwise, the indicator may show negative dynamics and not be the basis of an effective management tool;
- Increase in revenue. It is an alternative to increasing net profit if the company constantly increases the range of products through self-development and commercialization.

In order to define metrics from a market perspective, it seems necessary to identify specific customer segments for an additive manufacturing company.

Intermediate and end users of the results of the activities of innovative enterprises involved in the development of additive equipment, as well as their partners, can be called:

- Industrial enterprises using additive technologies directly in production processes, tooling, prototyping or on repair lines of their own equipment;
- Enterprises engaged in research, development and engineering of products using additive equipment;
- Scientific and educational institutions that use additive technologies as part of the educational process (for example, "tochki rosta" project);
- Distributors and dealers focused on the sale of additive equipment, materials and related products;
- Individuals using personal equipment (3d printers, 3d scanners) for personal use or as part of a craft activity.

Based on the analysis of identified stakeholders in the use of additive equipment, a number of goals can be identified for the “market” perspective:

- Ensuring the versatility of equipment for additive manufacturing. It is determined by the range of supported materials for manufacturing, the ability to configure 3D printing parameters to solve different types of tasks, the availability of support for various production technologies;
- Formation of a perception of the correspondence between the price and quality of additive equipment in terms of their consumer and technical characteristics;
- Ensuring a high degree of integration of additive manufacturing software systems with enterprise automated control systems;
- Reduced requirements for 3D printers and users of additive process control equipment, regardless of the type of device, the task being solved, and the industry of application;
- Ensuring the availability of all elements of the additive manufacturing ecosystem for the full production cycle, including the manufacture and preparation of material, the creation of 3D models, management software, additive manufacturing, devices for post-processing and testing of finished products;
- Formation of a high degree of integration of additive equipment into production chains for the production of final products.

One of the main goals of the "processes" perspective is to create an effective mechanism for the development of new additive equipment of the required quality with the optimal use of enterprise resources. It is the organisation of the activities of individual organisational structures in terms of development quality requirements, the operational management of departments and the distribution of resources between them that can achieve this goal.

Other objectives of this perspective are the key processes of infrastructure functioning:

- Ensuring that the input flow of developments is consistent with the planned one. Depending on the enterprise under consideration and its economic and social characteristics, it is necessary to determine the possible speed of development, the severity of input quality requirements, the number of considered quality indicators of the developed products, etc. However, regardless of these features, the key task is to adjust the parameters of the structures organisations responsible for development, in such a way that the planned qualitative and quantitative indicators of those entering the development structure are observed;
- Increase in the speed of development of new products at the enterprise. At each stage, various activities can be carried out to develop and strengthen the potential of the company's structures, including the development of competencies, the provision of resources. As a result, the company increases the scale of activities, expands the range, or improves the products or services provided;
- Increasing the success of ongoing R&D and R&D to create new additive equipment. The main task of the departments of the enterprise responsible for the development of new products is to bring innovation to the final stage of the life cycle.

Therefore, it is important to select projects that have a high potential for practical value;

- Improving the management system of new product development structures to help achieve the company's key goals set for the short or medium term.
- As for the “potential” projection, based on the activities of the development structures, the following key goals can be distinguished:
- Reducing the shortage of resources, primarily financial, required for the development of new products;
- Increasing the degree of mutual use of the obtained results of intellectual activity both within one organisational structure and within the entire organisation;
- Lack of unused resources. When the development structure is running for a long time, a surplus or completely unused resources may be formed. A typical example is information resources, but it can also apply to material resources arising in the form of residuals as a result of improper planning.

The “customer satisfaction” perspective is aimed at evaluating and developing projects for the development of new products in the enterprise and includes the following goals:

- Qqualitative development of the developed additive equipment. Innovative companies should not only strive to increase the range of products or carry out periodic updates, but also ensure that they meet or outstrip the existing world technological level for each type of additive equipment;

- Formation of protectable results of intellectual activity on the basis of increasing the research potential. Taking into account the considered approaches to assessing the effectiveness of organisational structures involved in the development of new products, it was found that the possibility of forming titles of protection plays an important role. If the enterprise is engaged in the development of media materials and research in the field of additive technologies, then it is additionally necessary to evaluate them;

- Increasing the efficiency of the approaches, methods and models used to develop new products. The key task in this case is to choose the best control actions to ensure the stable development of organisational structures and, as a result, increase the development speed, the maximum number of simultaneously created products, and other indicators characterising the development efficiency;

- Ensuring a synergistic effect within the framework of the interaction of individual organisational structures for customer satisfaction in the development of new products. First of all, this can be seen in a comparative analysis of the effectiveness of their functioning, which causes competition between departments and orientation to the leader. Secondly, it is important to transfer projects for the development of new products between individual organisational structures both as part of the direct development process and in the case of a return for revision with a feedback mechanism;

- Reduction of technological gap time (the time between the obsolescence of the current product and the release of a new one). The result of the activity of the process of developing new products is not only its creation and introduction to the market, but also the provision of the required parameters of commercialization and the achievement of the required sales volume;

- Reduction of terms of commercialization of innovations. With a decrease in the duration of the life cycle of goods and increasing digitalization, which further accelerates this process, it is required to introduce mechanisms for the rapid introduction of innovation to the market.

To display interrelated goals, we will form a strategic map without specific indicators for monitoring their implementation. As the main financial goal, they chose "increase in revenue". As a result of the analysis of the selected goals, key relationships between them were established.

Most of the indicators of the “Customer Satisfaction” perspective contribute to the achievement of the goals of the “Processes” and “Potential” projections, with the exception of the goal “Reducing the time of commercialization of innovations”, which is aimed at increasing the company's revenue as a whole.

It is important to note the impact of all goals of the Process projection on all goals of the Market projection, which is associated with meeting the needs of intermediate and end users of additive equipment by increasing the efficiency of the development process.

The reverse situation is with the goals of the "Market" projection, which have a general impact on the financial goal of the functioning of both individual organisational structures of development, and the entire enterprise as a whole. The result of the construction of a strategic map by the authors is shown in Figure 1.

The recommended number of indicators for one goal is no more than 2-3. Based on the analysis of indicators for assessing individual infrastructure facilities of the enterprise, we selected and adapted the indicators presented in Table 2.

The indicators obtained make it possible to evaluate the organisational structure involved in the development of new products, in general, taking into account the current strategy - the search, selection, development and

commercialization of the results of intellectual activity in the field of additive technologies.

To obtain an integral indicator, depending on the characteristics of the strategy of a particular organisational structure, it is required to determine their significance (Tsygankov et al., 2017). In addition, any organisational structure for stable and long-term development must have the property of homeostasis.

An effective tool for determining the significance of indicators in the presence of statistical data is neural network analysis, which demonstrates qualitative results when working with such complex systems (Davenport, 2018; Moskalev et al., 2020; Pierce, 2022).

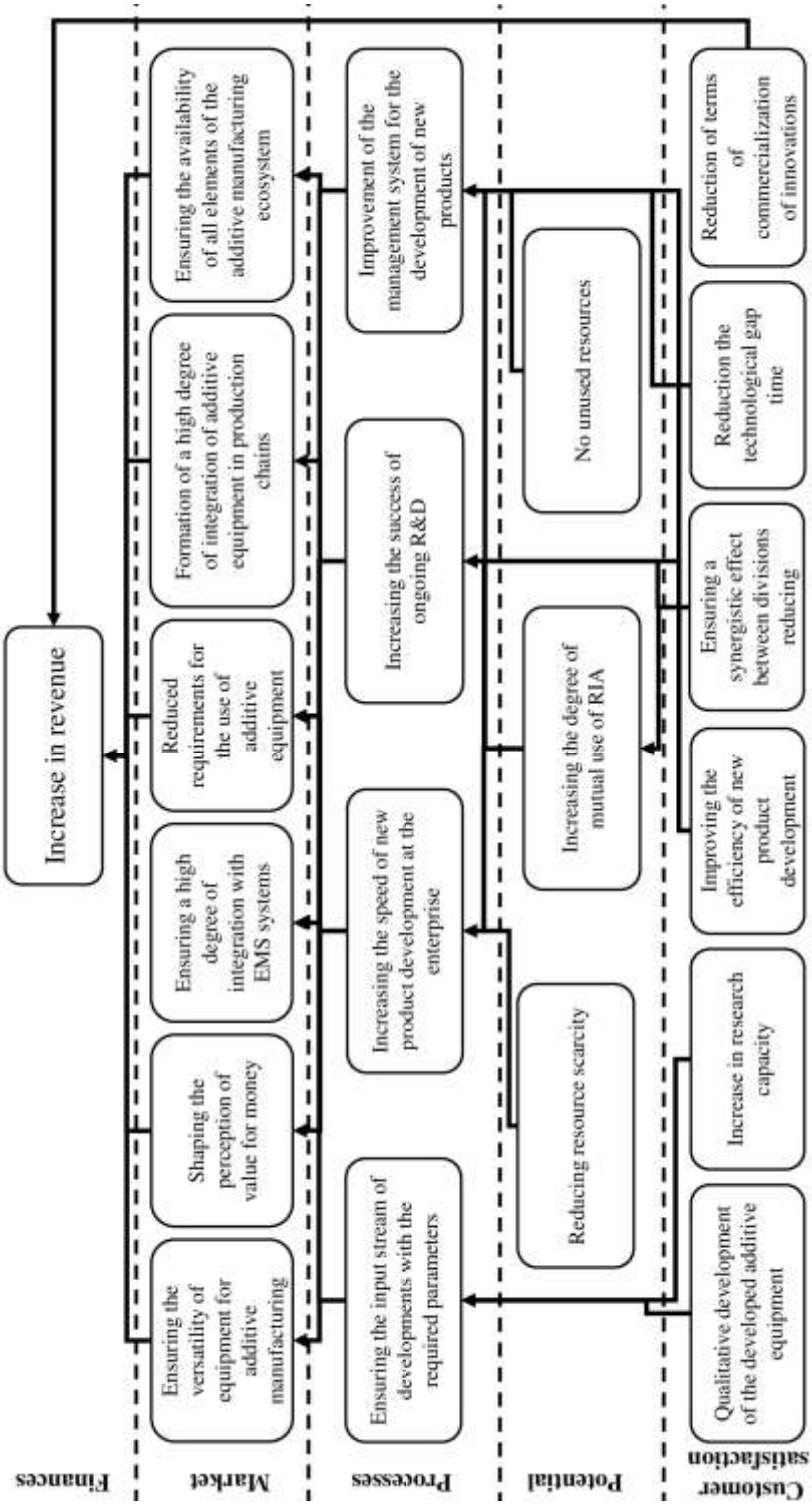

Figure 1. Strategic map

Table 2. Indicators of achieving the strategic goals of the organisational structure for the development of additive equipment

Purpose	
1. Increasing revenue	1. The percentage of growth in the total revenue of the enterprise 2. The share of the enterprise's revenue received from the sale of additive equipment developed by the organisational structure (or participating in the development)
2. Ensuring the versatility of equipment for additive manufacturing	1. Number of supported types of additive processes 2. The number of tasks solved by additive equipment 3. Number of materials supported for additive manufacturing
3. Formation of the perception of price / quality compliance	1. Percentage of surveyed buyers who believe that the price of additive equipment is too high (the sample should include both legal entities and individuals) 2. The share of abandonment of the purchase due to the high price 3. Percentage of surveyed buyers who believe that the price of additive equipment is too low (the sample should include both legal entities and individuals)
4. Ensuring a high degree of integration with Enterprise Management Systems(EMS)	1. An indicator of the level of integration. Separate objects of additive equipment and the EMS are selected as subsystems
5. Reducing requirements for the use of additive hardware	1. The number of calls of the consulting type on working with equipment to the technical support of the enterprise 2. Percentage of operations for setting up, launching and maintaining additive equipment that require the participation of an operator (not including the preparation of a 3D model)
6. Formation of a high degree of integration of additive equipment in production chains	1. SRL (Kalashnikova et al., 2019; Kalashnikova et al., 2020). Separate objects of additive equipment and production technologies are selected as subsystems
7. Ensuring accessibility of all elements of the additive manufacturing ecosystem	1. The percentage of availability of specialised additive manufacturing equipment to ensure the full cycle of additive manufacturing for a particular type of technology (including software for preparing and working with 3D models, managing and controlling 3D printing, producing materials for additive manufacturing, etc.)
8. Ensuring the input stream of developments with the required parameters	1. Number of developments excluded during the initial evaluation (at the idea stage) 2. Average percentage of deviation of parameter values from the required level for excluded developments
9. Increasing the speed of new product development in the enterprise	1. Average time of work on a project to create a new product in the organisational structure, regardless of the result of the work 2. Maximum time to work on 1 new product development project
10. Increasing the success of ongoing R&D	1. Percentage of completed developments relative to those accepted for work by the organisational structure 2. Percentage of completed developments, relative to entering the organisational structure
11. Improving the management system for the development of new products	1. The degree of contribution to the implementation of the company's key goals. Determined by using expert approaches 2. Change in the integral indicator of the effectiveness of the organisational structure
12. Reducing the resource gap	1. Number of changes to the work plan of the organisational structure due to lack of resources 2. The share of the missing volume of each type of resources relative to the total volume
13. Increasing the degree of mutual use of results of intellectual activity (RIA)	1. Share of intellectual property used at least once in the development of other products 2. The number of RIA not used in the developed products
14. No wasted resources	1. Free capacity 2. Average equipment downtime 3. Share of unused information resources
15. Qualitative development of the developed additive equipment	1. Average increase in the required quality indicators of the developed products relative to the previous development cycle 2. The degree of compliance with the world technological level. Determined using an expert approach
16. Increasing research capacity	1. The share of highly qualified personnel in relation to the total number of employees 2. The share of received protected RIAs relative to the total number of RIAs 3. The number of proposals received for the creation of new products from the employees of the unit
17. Improving the efficiency of new product development	1. Maximum number of development projects implemented by the division 2. The number of re-finishing projects for the creation of new products (returns to the previous stage of development)

Purpose	
18. Ensuring synergies between departments	1. Discrepancy between the performance of the worst and most successful organisational structure 2. Average time to transfer development between organisational units 3. Reduction of development time with the parallel participation of several organisational structures relative to the average development time
19. Reduction of technological break time	1. Duration of the period of decline in sales of a new product from one model range
20. Decrease in terms of commercialization of innovations	1. Average time from receipt of development to the organisation of production and marketing

3. CONCLUSION

The proposed perspective "Customer Satisfaction" includes the goals of increasing the qualitative and quantitative characteristics of the input stream of developments coming or being created at the enterprise. It also reflects the goals of quality and individual parameters regarding the products created at the enterprise in accordance with the stage of development or life cycle.

The developed balanced scorecard can be used as a starting point in building a model for evaluating organisational structures, and also develops the theory of planning and managing development and production processes.

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