

A Knowledge-Management System for the Innovation-Strategy Development of SME Enterprises

Sławomir Kłos^(✉), Katarzyna Skrzypek, and Karol Dabrowski

Department of Computer Science and Production Management,
University of Zielona Góra, Zielona Góra, Poland
s.klos@iizp.uz.zgora.pl

Abstract. Product and process innovations determine the competitiveness of manufacturing enterprises. The evaluation of a prototype of a new product or technology is a very-important process which sets the strategy of manufacturing or service enterprise development. Research-and-development-processes are expensive and time-consuming. But the most important for a manufacturing or service enterprise is the effectiveness of these processes (as measured by the market success of a product or innovative technology). In this paper is proposed a model for a knowledge-management system for innovation-processes improvement and enterprise-strategy development. The system is aimed at small and medium-sized manufacturing or service companies. The model of the system was created on the base of the results of survey research made in 112 Polish small and medium-sized enterprises. Illustrative examples are given.

Keywords: Knowledge management · Innovation strategy · Survey research · Small and medium-sized enterprises (SME's)

1 Introduction

Effective knowledge-management systems in high technology small and medium-sized enterprises should support research-and-development projects and innovation processes. The improvement of R&D processes is critical for the business strategy of manufacturing enterprises and wrong decisions can even result in the bankruptcy of the company. The most-important problem of small and medium-sized enterprises for new product or technology development is limited resources. Innovation projects are expensive and time-consuming and the results are not guaranteed (a relatively high probability of failure). Therefore, developing and implementing methods and tools for knowledge management to support the R&D strategy of SME's is very important in, inter alia, facilitating the reduction of resource requirements.

There are many research publications in the field of knowledge and innovation management. Dickel and Moura developed a model to measure organisational performance with a focus on knowledge management and innovation management [Dickel]. They used a quantitative research study, in the form of a multi-case study applied to three companies in the metal-mechanic sector in Brazil. The proposed model could be an effective tool for assessing organisational performance in that, in its application, the

surveyed organisations have already been able to identify their main weaknesses and to use the reported results to improve their management. Forsman has studied what kinds of innovations have been developed in small manufacturing and service enterprises and what has been the degree of innovation capacity which small enterprises possess. Roper and Dudas analysed the determinants of companies' innovation outputs and provided new information on the relationship between knowledge stocks, as measured by patents, and innovation-output indicators [3]. They found that existing knowledge resources have moderately negative rather than positive impacts on companies' innovation outputs and knowledge flows derived from internal investment, and external search dominate the effect of existing knowledge resources on innovation performance. Nowacki and Bachnik used a concept of eight processes of knowledge management and identified three broad categories of knowledge management innovations in an organisational context [4]. From the analysis of small, medium-sized, and large companies in Poland it turned out that the investigated enterprises were not very innovative in the area of knowledge management. Donate and Guadamillas suggest that managers should focus their attention on knowledge exploration and utilisation practices, along with a raft of "organisational enablers", in order to achieve high levels of innovation results for the company [5]. They provide new empirical evidence on the relationships between knowledge management, organisational elements such as culture, leadership, HR practices, and innovation, in a large sample of companies. Open innovation establishes the flow of the internal and external information of organisations [6]. Talke, Salomo and Kock point out that the influence of top management teams (TMT) should be crucial, since innovation strategies are shaped at the top-management level [7]. Their study investigated how TMT characteristics affect a company's strategic innovation orientation, and how this related to innovation outcomes and company performance. The results indicate that TMT diversity, measured as heterogeneity in the educational, functional, industry, and organisational backgrounds, has a strong positive effect on a company's innovation orientation.

In this paper a model is proposed for a system for effective knowledge management and strategic-decisions support in the field of innovations. The model was prepared on the basis of the results of a pilot survey conducted in 112 small and medium-sized Polish manufacturing and service enterprises. The main research problem in the paper is formulated as In a small or medium-sized manufacturing or service enterprise, what functions of the knowledge-management system can effectively support innovation management in terms of the strategic development of the enterprise? The model of the knowledge-management system includes its functionality prepared on the basis of the expectations of the investigated manufacturing and service companies. In the next chapter the results of the survey research are presented.

2 The Results of the Pilot Survey Research

The pilot survey research was conducted in 112 manufacturing and service companies and included questions concerning of companies' strategy, innovations and knowledge. The first question was formulated as *Which element of the enterprise's strategy is the*

most important for its development (in terms of revenue growth)? The answers were rated on a scale from 1 to 5. The summary results of answers are presented in Fig. 1.

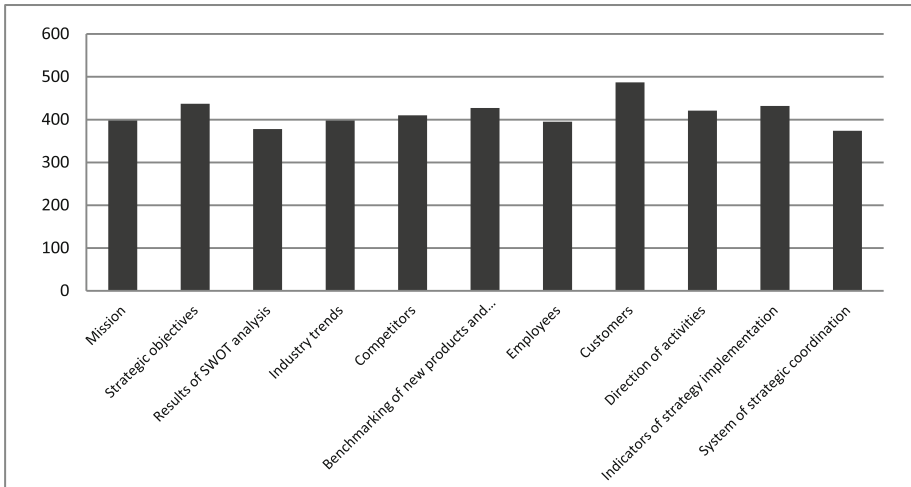


Fig. 1. The results of the survey research – the impact of strategy on the enterprise's development

For the respondents the most-important components of strategy for the business development are the results of customer-satisfaction analysis and properly formulated strategic objectives (and indicators of the strategic implementation). Another important aspect of the research is the analysis of new products and technologies. The results of the research confirm that the development of innovative products and technologies should be stimulated and verified by the customers' evaluation process. It means that for new-project development knowledge about new products, technologies and customer satisfaction (preferences) is crucial for the strategy of innovations.

The next question directed to the respondents was *What knowledge is the most important for strategic development preparation and implementation?* The results of the survey research are presented in Fig. 2. All the answers are concerned with knowledge about business partners. For example, *the IT system* is concerned with knowledge about the IT systems of business partners. The analysis of the presented results shows that the most important for strategic development is knowledge about business partners' products, services and technologies. For effective implementation of new products and services knowledge about the core competences of business partners is also very important. Knowledge about business partners' organisation models and IT systems has relatively little impact on product development. It is interesting to note that knowledge about business partners know-how (patents and licences) is also not crucial for new-product development.

The last question analysed in the paper was *What methods and technologies determine the strategic competitive advantage of the company?* The results of the research are presented in Fig. 3.

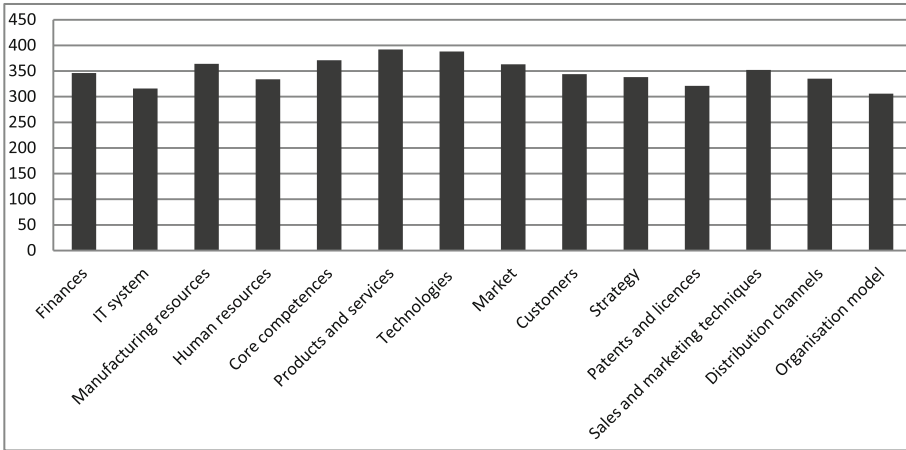


Fig. 2. The results of the survey research – the impact of knowledge about business partners on the enterprise's strategic development

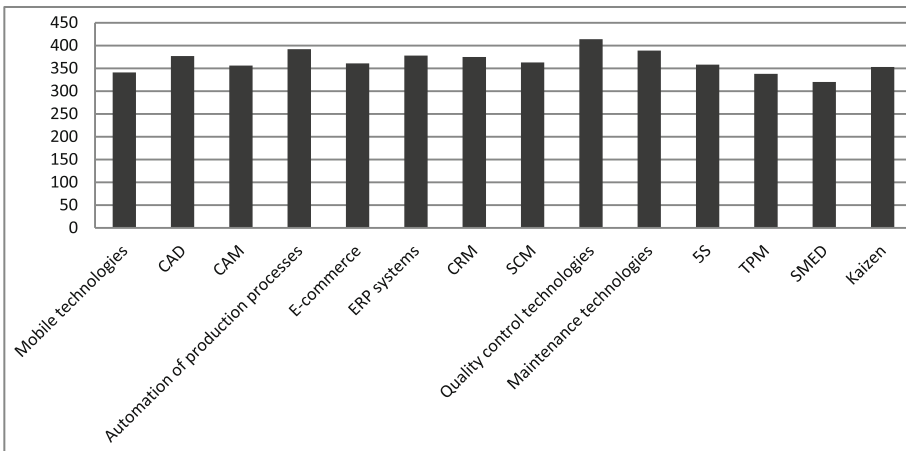


Fig. 3. The results of the survey research – the impact of methods and technologies implementation on the enterprise's strategic development

For the studied enterprises, the most-important methods or technologies which determine the strategy of company development are technologies supporting quality control and the automation of production processes [8]. Kaizen methods and mobile technologies have a relatively small impact on enterprises' strategic development. The survey research enables us to define assumptions and limitations for knowledge-management systems focused on new-product and technological development. In Fig. 4 a model for knowledge-management-system implementation is proposed.

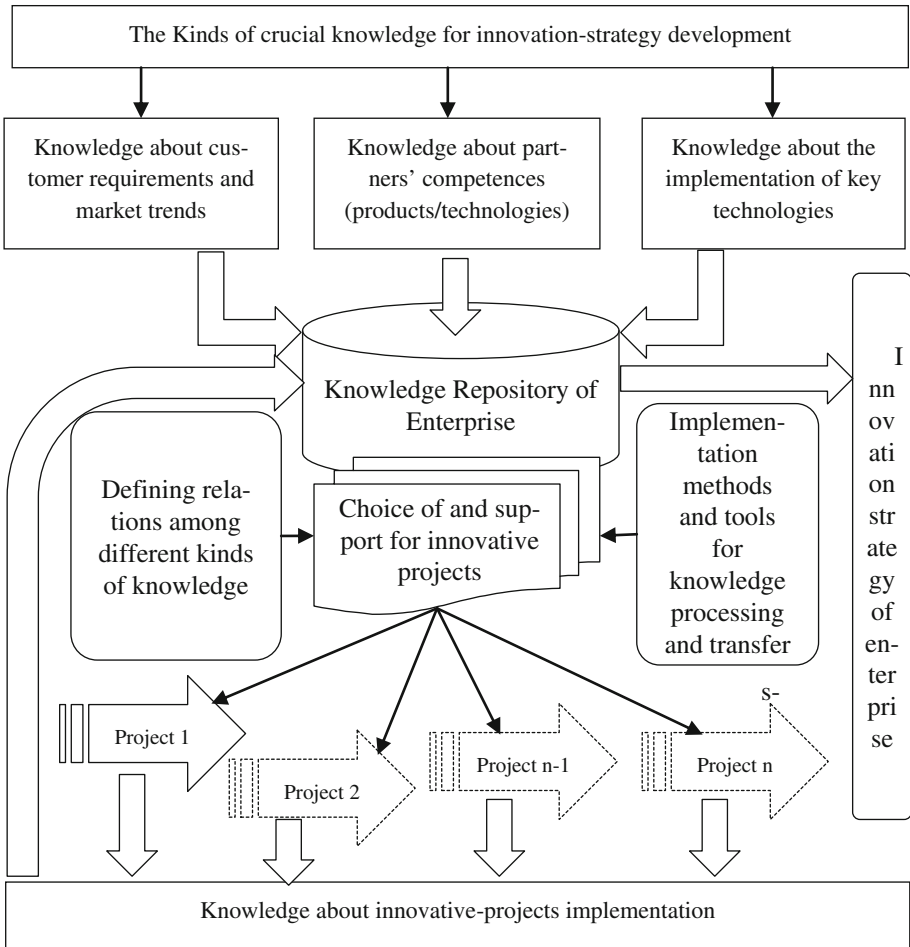


Fig. 4. A model for knowledge-management-system implementation for innovation-strategy development

On the basis of the conducted research the most-important kinds of knowledge for project development in a company could be defined. On the basis of the survey research three general kinds of knowledge resources for innovations development are identified:

- knowledge about customers and market trends,
- knowledge about business partners,
- knowledge about key technologies.

For the support of innovation projects implemented in a company a database and the correlation between different kinds of knowledge should be established. The knowledge-management system should support decisions about innovative project selection and implementation. A very important function of a knowledge-management system is proper knowledge processing and transfer. The structure of projects for new-product or

technological development should be properly defined. Especially important is to define the level of the projected costs and assumed profits of the innovation. Each innovative project implementation results in a new knowledge (experiences, the implementation of new methods and tools, etc.) which is important for the knowledge-management system. Therefore, the system should include tools which facilitate the securing of knowledge about project implementation. The knowledge-management system is an important tool for defining the innovation strategy of an enterprise.

In the next chapter an example is presented of a knowledge-management system for innovation-strategy development.

3 The Knowledge Management System for Innovation-Strategy Development – Case Study

Let us consider the small manufacturing enterprise *Alpha* in the mechanical engineering sector. The core competences of the company lie in the design and production of furnaces for the heat treatments of metals. The products are very complex and innovative. The furnaces are included in production lines dedicated, inter alia, to the automotive and aerospace industries. The company has 15 years' experience in design products and technologies for the heat treatments of metals. Each new order involves a prototype which must be created with the comprehensive commitment of customers and business partners (material suppliers, subcontractors, etc.). The work-breakdown structure of the innovative product is presented in Fig. 5. The furnace system includes 14 key subsystems, which are not always produced by the *Alpha* company, but are very often researched and developed by external research centres or institutes. The manufacturing

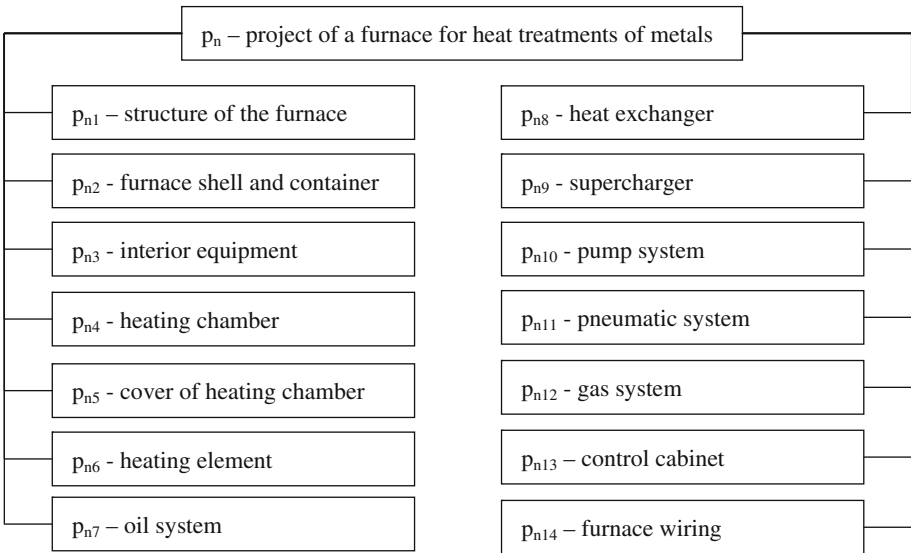


Fig. 5. An example of an innovative-product work-breakdown structure

of the system is often commissioned to external business partners who make the elements of the subsystems on the basis of assigned construction documentation. That means that the product is prepared and allocated into the ambient industry. The knowledge related to the project is also shared around, and without an effective knowledge-resource-planning system it can be lost. On the other hand this knowledge should be accessible to the cooperating companies in limited portions to avoid the possibility of the loss of core competences. Therefore, to support the overall projects implementation a knowledge broker should be engaged who will be responsible for the knowledge transfer to external organisations.

The following examples of the kinds of knowledge should be entered in the knowledge database of the *Alpha* company:

- k_1 - patents and utility models,
- k_2 - results of scientific research,
- k_3 - material properties (strength tests, temperature effects, etc.),
- k_4 - technical approvals,
- k_5 - technological-customer requirements,
- k_6 - exploitation-customer requirements,
- k_7 - market trends,
- k_8 - business partners' products,
- k_9 - business partners' technologies,
- k_{10} - experience in other projects, etc.

For each subsystem of the innovative project, the knowledge-demand rate p_{ij} can be calculated as follows:

$$p_{ij} = \sum_{j=1}^m \omega_{ij} \cdot \varphi_{ij} \quad (1)$$

where

- ω_{ij} - the weight of kinds of knowledge $\omega_{ij} = 0, 1, 2, 3, 4, 5$
- φ_{ij} - the demand for knowledge for each subsystem, $\varphi_{ij} \in <0;1>$
- $i = 1, 2, \dots, n$ - number of projects,
- $j = 1, 2, \dots, m$ - number of project subsystems

The innovation strategy governs long-term decisions concerning investments in new products and technologies or R&D activities support. Using index (1) the knowledge requirements for the subsystems of innovative products can be determined. In Table 1 a matrix of knowledge demand for the innovative project is proposed. The knowledge-demand index is calculated on the basis of the number of inquiries (percentage) for each knowledge category. For example the highest number of enquiries for knowledge category k_1 was for subsystem p_{n8} - heat exchange, which is relatively high (15% of all enquiries in category k_1). In Table 1 the fields in which the knowledge-demand index is greater than 0.09 are denoted.

Table 1. The matrix of knowledge demand for the innovative project

φ_{ij}	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9	k_{10}
p_{n1}	0.01	0.18	0.08	0.08	0.09	0.06	0.17	0.05	0.11	0.01
p_{n2}	0.04	0.03	0.08	0.02	0.13	0.11	0.01	0.00	0.15	0.08
p_{n3}	0.10	0.03	0.04	0.10	0.03	0.14	0.01	0.06	0.07	0.07
p_{n4}	0.06	0.04	0.08	0.10	0.03	0.00	0.13	0.04	0.02	0.06
p_{n5}	0.06	0.10	0.08	0.01	0.05	0.05	0.03	0.08	0.05	0.14
p_{n6}	0.04	0.16	0.11	0.14	0.10	0.01	0.00	0.08	0.00	0.00
p_{n7}	0.11	0.08	0.06	0.00	0.10	0.02	0.18	0.07	0.06	0.01
p_{n8}	0.15	0.13	0.10	0.07	0.11	0.13	0.00	0.12	0.14	0.01
p_{n9}	0.05	0.11	0.01	0.02	0.11	0.10	0.13	0.07	0.07	0.07
p_{n10}	0.05	0.01	0.11	0.08	0.02	0.07	0.11	0.06	0.13	0.09
p_{n11}	0.10	0.01	0.02	0.12	0.01	0.06	0.01	0.05	0.08	0.15
p_{n12}	0.07	0.05	0.10	0.10	0.02	0.11	0.01	0.11	0.03	0.15
p_{n13}	0.09	0.01	0.05	0.06	0.15	0.06	0.11	0.13	0.08	0.15
p_{n14}	0.08	0.06	0.08	0.10	0.06	0.07	0.09	0.09	0.01	0.02

The matrix presented in Table 1 shows what kinds of knowledge, and for which subsystems, are important. For example, according to the data the greatest demand on knowledge comes from k_4 , k_5 , and k_7 . For the furnace-wiring subsystem only one kind of knowledge is important - k_4 technical approvals. The results of the analysis of knowledge-demand matrix enable us to determine the required kinds of knowledge and areas (technologies or products/subsystems) which should be supported. For the innovation strategy it means what competences (human resources, training, subcontractors, research institutes, etc.) we should develop to guarantee a high level of innovation. The proposed knowledge management for innovation-strategy development should include the learning tools based on artificial neural networks for the adaptation of the knowledge-demand matrices for customer requirements [9]. Of course, the system should include all the innovative projects being undertaken by the whole of the enterprise (including internal projects).

The methodology for implementing the knowledge-management system for innovation-project development is presented in Fig. 6. In the first step of the methodology, the research tools for the identification of vital knowledge in the company should be developed. It means that surveys addressed to customers, employees and business partners should be prepared. On the basis of the results of the research the most-important kinds of knowledge for the enterprise can be defined. In this stage of the methodology the tools for knowledge recording and transfer should be proposed. Next, the work-breakdown structure of the project should be devised and on the basis of the kinds of knowledge and the scope of the projects the knowledge-demand matrix can be developed.

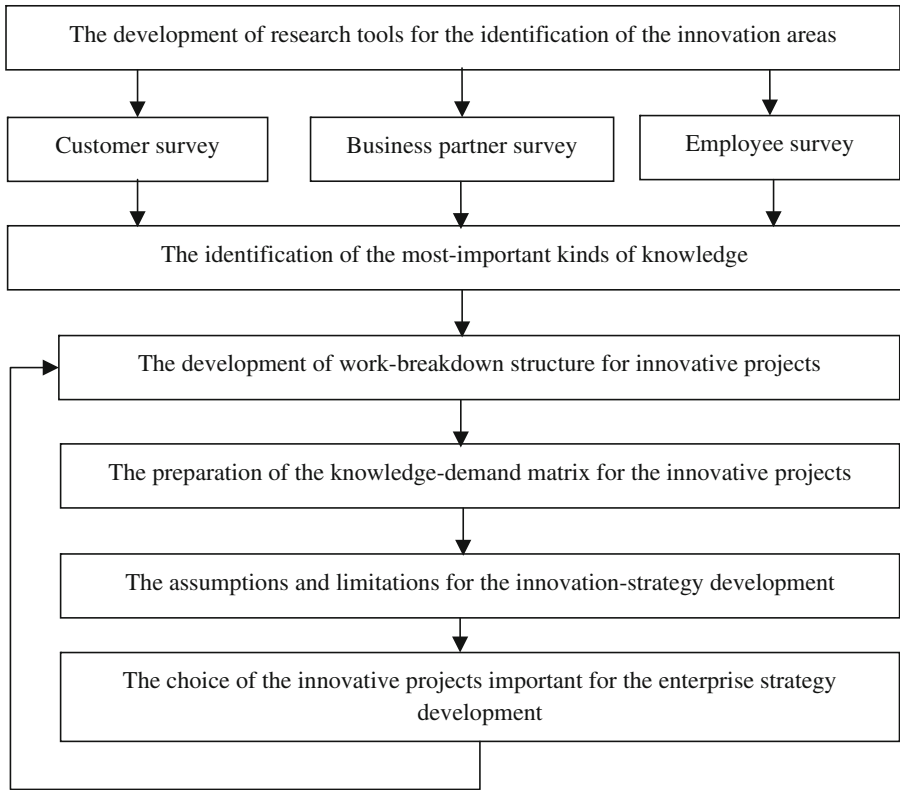


Fig. 6. The methodology of knowledge management system implementation for innovation-strategy development

On the basis of the analysis of the knowledge-demand matrix, the assumptions and limitations of the innovation strategy can be formulated. The assumptions and limitations enable us to support the decision as to which innovative projects should be developed. The innovation strategy can be enhanced by drawing on the feedback as the last stage, and the developing of the work-breakdown structure of new innovative projects.

4 Conclusions

Many SME's do not have a development strategy, and especially an innovation strategy. But for high-tech engineering innovation enterprises this kind of strategy is crucial and in the long-term perspective determines market success or failure. The most-important resources for each innovative company are knowledge and experience, which decide about the implementation of projects (innovative products, technologies or services). In this paper a model of knowledge-management-system implementation for innovation-strategy development is proposed. The model is prepared on the basis of survey research of 121 Polish manufacturing or services SME's. In addition, the methodology of

knowledge-management-system implementation for innovation-strategy development is presented. The methodology is based on a knowledge demand matrix. The matrix enables us to identify the innovative components of products, services or technologies which should be included in the strategy for the enterprise's development. The proposed methodology of innovation-strategy development can be relatively easily implemented in engineering-to-order enterprises [10]. It requires simple tools for project development for a knowledge-management systems. In further research, an integrated tools for knowledge- and project-management systems will be developed.

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