Case study of an effective system of process synchronization within the framework of the development of an integrated scientific and technical programme

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Abstract. Implementation of the outputs of intellectual activity related to manufacture of high added value products may be complicated due to the lack of additional resources of industrial enterprises in the context of the economy stagnation. The given Integrated Programme is the programme of a complete innovation cycle formed on the basis of the priority scientific and technological areas highlighted in the R&D Strategy. For the successful implementation of the Programme, it is necessary to identify the needs of large enterprises of the operating sector of the economy in high-tech production processes and to coordinate the potential of implementation with scientific organizations.

1. Introduction
The development of a non-resource economy rests on the establishment of high-tech production based on breakthrough scientific results. The implementation of the results of intellectual activity in the manufacture of high added value products may be complicated due to the lack of additional resources of industrial enterprises in the context of the economy stagnation. To address these issues, close interaction between scientific organizations generating various technological developments and industrial enterprises carrying out their activities in the areas of research of scientific organizations is required. The risks of doing business, the complexity and length of administrative procedures, access to capital, regulative and informal community norms are of particular importance. In world practice, various state tools are used to support cooperation between scientific organizations and operations of the operating sector of the economy, the Russian Federation is no exception. [1, 2]

Lately, the Federal Target Programme (FTP) "Research and Development in Priority Areas of Development of the Scientific and Technological Complex of Russia for 2014-2020" has become the most powerful tool for supporting possible cooperation. The programme was approved by the Decree of the Government of Russia dated May 21, 2013 No. 426 and it was focused on conducting and financing the studies which would result in specific developments and products. There is no plan to extend that federal program after 2020. [3]

The development and implementation of integrated scientific and technical programmes of a complete innovation cycle and integrated scientific and technical projects of the full innovation cycle are provided for by the Strategy of Scientific and Technological Development of the Russian Federation approved by the Decree of the President of the Russian Federation of 01.12.2016 No. 642,
being one of the main mechanisms for achieving results in the priority fields of scientific and technological development of the Russian Federation. Such programmes and projects include all stages of the innovation cycle - from obtaining new fundamental knowledge to its practical use, development of technologies, products and services and bringing them to the market. The rules for the development, approval, implementation, adjustment and completion of integrated programmes and integrated projects were approved by the Decree of the Government of the Russian Federation dated February 19, 2019 No. 162. [4,5]

In 2019, the Administration of the Kemerovo Region, together with large industrial enterprises of the region and the Kuzbass Research and Academic Centre (RAC “Kuzbass”), developed an application for an integrated scientific and technical programme “Development and implementation of a complex of technologies in the field of solid minerals exploration and mining, industrial safety, bioremediation, new products developed through advanced coal raw materials processing with a consistent decrease in the environmental load and risks to the life of the population ”(short name - "Clean coal - Green Kuzbass"). The application was submitted to the Priority Coordinating Council and received its support. Thus, the Kemerovo Region and the RAC “Kuzbass” stand among the pioneers in the implementation of the respective priority of the Strategy for Research and Technological Development of the Russian Federation.

“Clean Coal - Green Kuzbass” is a complete innovation cycle programme developed on the basis of the priority scientific and technological areas highlighted in the Research and Technological Development Strategy. During the implementation of this programme, a mechanism is formed for interaction between leading scientists who have made a significant contribution in scientific and technical developments pertaining to the issues of the programme, stakeholders representing the current sector of the economy interested in using the scientific and technical outputs of the integrated programme and participating in the implementation of their activities with the purpose of manufacturing products and provision of services, representatives of regional government and public corporations. Thus, in the development of the Programme, a certain consortium is formed - a temporary union of scientific and educational organizations, scientific organizations and large companies doing their business in the presented topic of this Programme.

The Ministry of Energy of the Russian Federation is the responsible Contractor-coordinator of the implementation of the Clean Coal - Green Kuzbass Programme, the co-contractors include the Ministry of Science and Higher Education of the Russian Federation, the Ministry of Industry and Trade of the Russian Federation, the Ministry of Digital Development of the Russian Federation. The Integrated Programme was initiated by the Kemerovo State University - the largest university in Kuzbass, a center for scientific and technological development and innovation, implementation of educational programs.

The participants in this Integrated Programme include 5 universities (3 Kuzbass universities and 2 universities based outside the Kemerovo region - Kuzbass), 9 research institutes (5 Kuzbass scientific institutes and 4 - based outside the Kemerovo region - Kuzbass), and 3 small innovative companies. Decree of the Government of the Russian Federation No. 162 dated February 19, 2019 defines industrial enterprises planning to implement the results of scientific activities into production as the customer.

The Programme "Clean Coal - Green Kuzbass" has 15 industrial partners, companies - customers of the Programme, and consists of 29 projects. Each project presents one of the activities of the Integrated Programme, its implementation is expected to bring the planned outputs within a certain time frame. One of the main conditions for the project to be included in the Programme is the implementation of its objectives, the interest of the relevant business sector in the results of the development and its readiness to implement the results.

The autonomous non-profit organization "Scientific and Academic Center" Kuzbass "(hereinafter – ANO RAC "Kuzbass") assumed the managing function of the processes among these consortium participants acting as a manager – coordinator.
The effectiveness of the project management methods in the development of new types of products and the modernization of production has been proven by successful international practices. The work planning technique based on project management has become widespread, since it allows a significant gain in time, as well as an accurate project costs estimate both at the planning stage and during implementation of each stage of the project. [6]

2. Planning the Integrated Programme

In order to establish the Integrated Programme, it is necessary to develop a certain set of documents. Lack of any regulatory framework that would clearly regulate the main areas of activity in implementing the Programme and preparing reporting documentation is a big problem in the formation of the Programme. The following documents were applied by the Project Office of RAC Kuzbass as reference regulations: Order of the Ministry of Science and Higher Education of the Russian Federation dated 23.04.2019 No. 37n, Order of the Ministry of Science and Higher Education of the Russian Federation dated 23.04.2019 No. 38n, Order of the Ministry of Science and Higher Education of the Russian Federation dated 23.04.2019 No. 39n, Order of the Ministry of Science and Higher Education of the Russian Federation dated 15.07.2019 No. 500. [7, 8, 9, 10]

The Program passport is the key document in the development of the Integrated Programme. To develop it, it is necessary to collect and summarize materials on all projects that are planned to be included in the Integrated Programme. It is the team of the Project Owner as the Programme participant that shall generate the key information on specific projects. For the correct and explicit presentation of information, the RAC Kuzbass Project Office proposed a template for describing the project, containing such items as description of the project, scientific and technical groundwork, and level of technical readiness of the technology, a phased schedule of work on the project, estimates, and key project risks.

Each project of applied scientific research and experimental development under the Programme presents one of the activities. The implementation of this activity is just a fragment of the life cycle, at the end of which a new high-tech product or service will be brought to the market. In this regard, it is the companies of the real sector of the economy that participate in the formation of research programs and the acceptance of their results. To implement this issue, a template of terms of reference for the Programme projects is proposed. The project terms of reference shall be approved by the project manager, the head of the project owner’s organization, and the head of the industrial partner’s organization. The ToR template, as a rule, contains the following items:- basic information on the project, technical requirements for a scientific and technical product under the project, the composition of the product (goods), requirements for patent protection, a list of main components and materials, a list of technical documentation being developed, timing of R&D, work schedule, a model of project output commercialization.

Assessment of financial solvency, as well as financial justification of the relevance of the implementation of the Programme projects can be implemented using specialized investment assessment programmes. To solve this issue, the specialists of RAC Kuzbass project office used the Project Expert software product from the Expert Systems Company. At the first stage, the sales markets and the range of possible prices for the products planned to be generated under the project were assessed together with the project developers. The production plan is forecasted taking into account the growth rates of production and market needs. Graphic presentation of the sales plan forecast is shown in Figure 1.
Based on the input data, key indicators were determined for each project including gross sales, total direct and fixed costs, the amount of tax payments and net profit. The integral indicators of investment efficiency such as payback period, average rate of return, net present value, and profitability index were estimated.

The software product used makes it possible to assess the impact of growth in direct costs on net present value. To assess this risk, an interval from -20% to +20% was chosen and the calculation was made for each project. If the graph line crosses the abscissa axis at a value of +20%, the project may lose economic efficiency. The results of the analysis are used as the basis for developing a strategy to minimize risks. The analysis results are shown graphically in Figure 2.

A significant difference between an integrated programme and an integrated project is the presence in the integrated programme of an integrated R&D plan (CSRP). R&D plan can be included in the programme as an attachment to the programme passport. The R&D plan describes the research part of the projects (the scientific basis on which each of the projects included in the programme will be based).

3. Organization of the Programme projects implementation
According to the Draft Decree of the Government of the Russian Federation "On approval of the Rules for the provision of grants in the form of subsidies from the federal budget to participants in integrated scientific and technical programmes of a complete innovation cycle, integrated scientific and technical projects of a complete innovation cycle", federal funding is provided directly to organizations that are project owners.
The Integrated Programme is financed from two sources: through subsidies from the state budget and through the customer's own funds. Industrial partners are involved in the implementation of each project, providing extra-budgetary funding in the amount of 75% of the allocated budget funds. In implementation of these projects, key design and technological solutions must be developed and the technologies being developed must be introduced.

The development of new technologies is largely determined by the volume of R&D expenditures, based on the prerequisites of the production function of knowledge. At the same time, the need for close placement of state (mainly fundamental) and private (applied) studies was identified. The indicated territorial proximity leads to more efficient spending of funds, since it allows using the total human capital and the knowledge pool of the regional system, and also intensifies the flow of knowledge from universities to companies. Supporting fundamental studies without a proper increase in corporate R&D, and vice versa, is not effective enough. This feature is also reflected in the ideology of establishing the Integrated Programme formation. The success of such projects directly depends on the interest of large companies in the implementation of breakthrough technologies in their production processes [11, 12, 13, 14].

The Programme "Clean Coal - Green Kuzbass" is designed for 6 years. In accordance with the Programme, during the first three years of implementation, the performers conduct fundamental studies and develop scientific aspects of technologies within the framework of the Programme. Further, it is planned to introduce the technical solutions at the operations of the Programme customers with the attraction of off-budget investments. The final stage of the implementation of each project is putting the developed technical solutions into operation.

The organization of work on the project consists in its structuring, the project is broken down into simpler elements, taking into account all the interrelations and interactions of the system components. The project plan should present a harmonious hierarchical break-down into its constituent parts (elements, modules), which are necessary and sufficient for planning and monitoring of implementation by all the participants. Structuring the project, its simplification by breaking down into component elements (stages, work, and processes) allows you to organize management according to uniform rules. Highlighting individual stages and work within each stage makes it possible to significantly simplify the original problem. [15]

4. Monitoring project implementation under the Programme

In the process of developing an integrated programme, it is necessary to form a list of measures and milestones that can become stages of intermediate and final control of the work implementation under the Programme projects. The following indicators of the Federal plan were taken as target indicators of the Programme "Clean Coal - Green Kuzbass": number of articles published; number of articles published in scientific journals Scopus and / or Web of Science; the number of applications for obtaining objects of intellectual property; the number of developments implemented in organizations; proportion of researchers under the age of 39; the number of jobs created; attracted budgetary investments; attracted extra-budgetary funds.

The task of ANO “RAC “Kuzbass” is to develop a unified organizational approach to following the status of the project and the changes constantly emerging therein. The project manager needs to have up-to-date information on the intermediate results of each step-by-step action, which is the main condition for the successful completion of the Integrated Programme as planned. A clear coordination of work including the development of new technical solutions within the framework of the Programme, replenished by various participants, is the main way to reduce the risks in achieving the set goals. The Autonomous Non-profit Organization "Scientific and Academic Centre "Kuzbass" proposed a scheme for monitoring and control of work under the Programme with the participation of all stakeholders interested in the implementation of the Integrated Programme (Figure 3).
Project monitoring is an integral part of the project management process, which includes a sequence of functions, ranging from observation to assessment of the identified discrepancies between the actual and planned status of projects. Along with monitoring, the tasks of ANO "Scientific and Academic Centre "Kuzbass" include provision of consulting and methodological support to project owners in order to ensure the compliance of projects results and reporting documents as per the established nomenclature of requirements and criteria. If inconsistencies are identified, it is planned to carry out not only an analysis of discrepancies and identification of reasons, but also coordination of

Figure 3. The organizational structure of the Programme “Clean coal – Green Kuzbass”
work with project owners until the discrepancies are completely eliminated and the risks of failure to achieve the specified results within the specified time frame are minimized.

5. Planned outputs of “Clean Coal – Green Kuzbass” Programme

During implementation of the Programme, new production facilities will be established in the region for production of deep coal processing products; technological solutions and digital platforms will be developed and implemented that will contribute to a safer and less costly process of mining, processing and transportation of coal. The Programme provides for projects aimed at improving the environmental situation in the region, at the same time these developments can be implemented in other regions of the country.

The scientometric indicators of the Integrated Programme for the period from 2020 to 2026, as well as the period of its implementation and its scaling, include: the number of published articles in peer-reviewed scientific journals - 625 units; the number of articles published in scientific journals indexed in Scopus and/or Web of science databases - 588 units; the number of applications for documents of title for the results of intellectual activity filed in Russia - 210 units; the number of technological innovative developments introduced in organizations of the real sector of the economy - 82 units; the share of researchers under the age of 39 – 52 persons; the number of innovation projects that received support from state and non-state funds - 82 units.

The estimated indicators are given for the period from 2020 to 2025, including the period for the implementation of the Integrated Programme and its scaling, which cover the total investment of 16 billion rubles (16,213,000,000 rubles), the total gross sales of 22 billion rubles (22,378,552,552 rubles) at the end of 2025, the total output per employee 506 million rubles (506,484,460 rubles) from gross sales at the end of 2025, tax deductions of all projects for the year after the payback period in the amount of 3.6 billion rubles (3,658,395,460 rubles), the total number of jobs created - 1192.

Conclusions

Thus, when developing the Integrated Programme, one should take into account the availability of the scientific innovation potential in the region where the Programme is planned to be implemented. For the successful implementation of the Programme, it is necessary to identify the needs of large operations of the operating sector of the economy in science-intensive production processes and to agree on the possibility of their implementation jointly with scientific organizations. The required investments and the sources of their formation are to be determined taking into account the requirements specified for integrated scientific and technical programmes.

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