

# Innovative Development of Mechanical Engineering Complex Based on Project Management

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**Abstract.** The relevance of the study is driven by peculiar features of the current economic model characterized as rapidly changing and requiring maximum flexibility from all market agents. In this situation such factors as scientific, technological, innovative, informational development come to the fore. Accordingly, it is necessary to choose adequate methods for the management of key industries, which include mechanical engineering. In our opinion, for the purposes of mechanical engineering further development it is necessary to develop a strategy for the scientific and technological development of the entire complex aimed at modernizing the material and technical base, organization, technology, socio–environmental sector, personnel and information support of production, increasing the investment attractiveness of mechanical engineering and expanding the markets for domestic products sale. To overcome the crisis, the main strategic objective of the Russian government should be to recover and ensure intensive growth of domestic markets for industrial products consumption. This is only possible with the implementation of many large infrastructure projects that will ensure domestic demand. Project management, which gradually replaced traditional management, is based on the preliminary development of a comprehensive system model in order to achieve the original goal and is aimed at implementing this model within the specific time frames. It is important to keep in mind that the objective in project management is usually distinguished by elements of novelty and, therefore, the project itself is original, non–traditional. The concept of project portfolio management should be defined separately. Project portfolio management helps determine the optimal level of investment for each project, which should be well combined with each other and not contradict the overall strategic plan. The result is the best balance between current and new strategic initiatives. At the same time project portfolio management is a tool for achieving strategic goals (including industry goals).

## 1. Introduction

Today mechanical engineering is a combination of research, production and service enterprises and organizations, which activities are aimed at creating high–tech and innovative equipment. This industry is the main system–forming element of the economy of any developed country. It includes heavy and power engineering, which provide for the production of mechanisms for the exploration, extraction and processing of minerals, aggregates for hoisting and transport industries, equipment for power plants and nuclear power plants; machine tool industry, which ensures the production of metal–cutting machines, forging machines, metalworking presses, stamping and forging machines, woodworking machines, CNC machines; transport engineering, including diesel locomotive building, shipbuilding, automotive industry, aviation industry, space rocket industry; agricultural engineering;



precision engineering; mechanical engineering for light and food industries. According to the statistics, mechanical engineering in developed countries accounts for 25–35% of GDP. However, the sectoral structure of the economy is gradually changing and transforming, i.e. structural changes in the economy occur under the influence of various factors (scientific and technological progress, foreign economic relations, demographic factors, social factors, psychological factors, etc.). Today the issue of structural changes in the current economy is urgent, as the sanctions have aggravated demographic issues, investment problems, the technological lag, shortages of domestic products, etc. [10]. Despite this mechanical engineering retains a leading position in the formation of GDP [17]. The most significant factor determining changes in the sectoral structure of industry is scientific and technological progress, and its main areas are automation and mechanization of production, improvement of technologies, specialization and cooperation of production. The sectoral structure of industry has been changing and improving all the time under the influence of scientific and technological progress.

In the last decade the dynamics of engineering industry development largely reflected the state of the Russian economy as a whole and resembled a sinusoid, where the decline at the turn of the decade was caused by the consequences of the global financial and economic crisis. In this regard it seems appropriate for us to distinguish the following three periods: 2004–2007 – the period characterized by a steady growth; 2008–2009 – the period of a crisis collapse; 2010–2013 – gradual restoration of pre-crisis positions, stabilization and a subsequent slowdown in the industry growth.

Before the crisis the machine–building industry was characterized by high and steady growth rates. By 2007 the volume of shipped products increased by 82% as compared to 2004, the number of unprofitable organizations decreased from 2.3 thousand to 0.86 thousand (–141%), which contributed to an increase in the balanced financial result by more than 2.8 times.

With the onset of the crisis the emerging trends towards a gradual improvement in the state of domestic mechanical engineering resulted in a subsequent slowdown in growth rates, a decrease in the volume of output and, consequently, a decrease in the share of engineering products in the manufacturing sector of the Russian Federation (18.8% in 2009, which is typical for 2004). Negative growth rates of output products in 2009 (–7% versus 2007 and –20.6% versus 2008), a drop in exports (–9% versus 2007 and –21.5% versus 2008), a decrease in investments in fixed assets by 33 billion roubles per year (–15.4%) worsened the functioning of the mechanical engineering complex of the state that had already been inefficient.

The rise in the cost of money forced even prosperous enterprises to curtail investment programs or significantly reduce them.

Anti-crisis measures introduced at most enterprises in the industry assumed austerity measures to save resources, time, and money. In the most difficult situations it was necessary to reduce production capacities and staff (–12.4% as compared to 2007). An increase in the number of unprofitable engineering organizations by more than one and a half by 2009 as compared to 2007 again exposed the long-known problems of the complex:

- The critical state of the material and technical base.
- Significant technological gaps in comparison with Western enterprises.
- Low profitability of the industry.
- Low investment attractiveness.
- The underdeveloped system of industrial cooperation (industrial subcontracting).
- The implementation of investment projects with a distortion towards equipment that do not affect the modernization of engineering, the enterprise management system, and personnel training.

In addition, the cornerstone is often not a new product and modernization for it, but an increase in the production capacities for the release of an obsolete product [1].

The financial crisis made adjustments in the intensive modernization and an increase in the investment attractiveness envisaged by the State Comprehensive Program for the Development of Mechanical Engineering in Russia. In addition, a number of sub-sectors, such as automotive,

shipbuilding, and space rocket ones, affected the reduction in funding within the framework of federal targeted programs.

Nevertheless, as part of measures to resolve unsustainable situations, the state took a number of anti-crisis measures, some of which had a positive effect on the state of specific sub-sectors. For example, we are talking about the implementation of the Vehicle Scrappage Program for 2010–2011 financed from the state budget. The result of the program was an increase in car sales in the Russian Federation by 30% in 2010 as compared to 2009 (1.9 million cars), in 2011 the growth was 39% as compared to 2010 (2.7 million cars) [15].

In general, the post-crisis period marked by the growth in 2010–2012 gradually stabilized and by 2018 three sub-sectors of engineering showed a 2% increase in the output as compared to 2012. So, the state of the industry cannot be called excellent, especially against the background of the European and global growth in the car market.

According to RIA Rating experts, in 2018 an increase in mechanical engineering output amounted to 3.6%. A year earlier this value was almost twice as high – 6.9%. At the same time there was a significant drop in dynamics in the fourth quarter, when the decline in production amounted to more than 2% as compared to the same period in 2017. The best result, as in 2017, was demonstrated by automotive engineering. A positive dynamics was also recorded in the production of electrical equipment, but in both of these sectors the growth rate was lower than in 2017. The slowdown in automotive engineering was due to a reduction in the financing of soft loans and soft leasing of motor vehicles. In addition, in the second half of the year the growth in consumer automobile lending began to fade quickly, and demand for trucks began to decline due to the completion of a number of large infrastructure projects. According to the results of 2018, the worst result among engineering industries was noted in the production of other vehicles and equipment, while a year earlier the growth was recorded here. Defence products occupy a large share in this industry; therefore, its results are, as a rule, subject to high volatility. The negative result in agricultural engineering is due, again, to a reduction in the financing of state support measures (subsidizing enterprises in the amount of 25% of the price of equipment). It is noteworthy that in the fourth quarter the percentage of subsidies increased to 30%, as a result of which the dynamics of production in agricultural engineering, unlike other industries, began to improve. So, the result of 2018 once again demonstrated the dependence of the Russian mechanical engineering complex on the state patronage [18]. Such a situation does not contribute to the recovery of previously lost positions in the engineering industry and requires the formation of a new development strategy for the engineering complex, which must include an innovative component.

## **2. Main principles of the strategy for mechanical engineering innovative development**

The essence of the innovation strategy for mechanical engineering development is in structural and qualitative transformations expressed in a set of goals, objectives and organizational measures that contribute to their achievement, are aimed at creating competitive advantages in the long term through the most complete use and development of industry resources. The mechanism for implementing the strategy is comprehensive modernization of the engineering complex.

The complexity and dynamism of the external environment is determined by two groups of principles for the elaboration of a strategy for the development of mechanical engineering in Russia – general and private. General principles include:

- Scientificity, the use of data and conclusions of various scientific studies in the process of strategy elaboration.
- A systematic approach that ensures the formation of a strategy closely interrelated with the external environment.
- Purposefulness, focus on solving specific problems and achieving strategic goals for the development of the complex.
- An integrated approach to the study, which involves taking into account all the links of strategic planning from goal setting and analysis to strategy implementation.

- Decomposition (division) of the strategy into blocks.
- Private principles include:
- Consistent coverage of all areas of industry development.
  - The use of a single methodological approach when developing strategies for the entire complex and its sub-sectors.
  - Development of such a system of strategic analysis, which would facilitate the receipt of information that has both theoretical and applied value.
  - Providing conditions for the development and implementation of the innovative potential of the industry.
  - Social responsibility, taking into account the need to improve employment and enhance labour stimulation in the industry.
  - Environmental safety of the activity and its results.

The strategy for the innovative development of engineering in Russia is of particular importance associated with the central role of the complex among other sectors of the economy, resource intensity and a significant scientific potential.

In order to introduce progressive changes in mechanical engineering, it is necessary to have a scientifically based strategy for its development taking into account changes in market conditions, forms and methods of state regulation, providing for the possibility of diversification and repositioning of the complex.

A strategic resource for the development of mechanical engineering is technology. It forms the basis of the production potential. Changes in the quality of technological resources determine the dynamics of product quality. Production technology management is the most important factor in the dynamics of technical and economic indicators that determine the trends of economic performance in the context of the interaction of factors of the external and internal environments of the enterprise.

So, the strategic goal for the development of the Russian mechanical engineering complex should be the creation of new innovative machine-building sub-sectors and development of traditional machine-building sub-sectors oriented to modern production standards and investment demand, and the transformation of the machine-building complex into one of the main sources of sustainable economic growth.

The large growth of deficit of many resource types and their presence in Russia expand their importance as a global trading resource platform. Considering the inevitable increase in prices for hydrocarbons, sea, rail, and pipeline transport will become increasingly important in transportation. The geographical position of Russia allows it to become a global hub between the EU, China and Japan. Of course, in this case mechanical engineering can act as a locomotive of the country's industrial growth. Such ideas are based on the possibility of overcoming the crisis through the implementation of infrastructure projects both local (construction of a new bearing plant) and global ones (creation of continental oil and gas pipelines, offshore development).

We need projects with a large multiplier lever. So, today the projects in which each monetary unit invested by the state will set in motion the largest possible volume of Russian producers from various industries and generate the largest possible GDP are more important. This is how the priority of infrastructure projects is determined.

The implementation of large innovative infrastructure projects with a large positive multiplier effect will give Russia sustainable positive economic development based on the domestic market and will provide a stable GDP growth [16].

### 3. Project management in mechanical engineering

The fundamentals of strategic planning and management provide management with broad potential opportunities, since they facilitate systemic thinking [3].

We can mention the following characteristic features that distinguish the strategic management of mechanical engineering scientific and technological development:

- The need to develop alternative strategies that take into account the specifics of the industry, market conditions and the nature of competition.
- Available functional programs for the industry development.
- Outer orientation.
- Anticipation and response to changes in the internal and external environments.
- Special role of the information system.
- Importance of the qualification level of enterprise management.
- Taking globalization processes into account when developing and implementing strategies formulated on the basis of empirical research.

To overcome the crisis, the key strategic task of the state should be the intensive growth of domestic markets for the consumption of engineering products. This is possible through the implementation of a large number of large infrastructure projects that can provide for domestic demand.

Infrastructure projects should be aimed at the construction of energy facilities, roads, oil platforms, and pipeline systems, automobile manufacturing, aircraft construction, shipbuilding, etc. These projects are based on engineering products. The gradual slowdown in the growth of mechanical engineering in 2012–2013, the reduction in financing of a number of state programs aimed at industry support and development, as well as the difficult geopolitical situation force to turn to alternative ways of managing machine–building enterprises within the framework of a public–private partnership through the mechanical engineering complex project management based on project financing.

In addition, there is a problem with the updating of the structure of the mechanical engineering complex in Russia. It seems that project ties can form the basis of the modern structure of the Russian mechanical engineering complex. So, specific structural entities (having a development vector, time frame and systemic ties) will be the strength of such a structure. They will potentially become the basis for the implementation of strategic measures by the state (in accordance with the goals and objectives in the field of mechanical engineering development through economic resources and regulations), which are based on a specific result.

In the 1980–1990s project management became a sphere of professional activity. New generations of computers and information technologies make it possible to more effectively use the methods and means of project management in the context of planning, scheduling, control and analysis of time, resources, cost, etc. All over the world activities aimed at identifying and summarizing the best project management experience are actively developing.

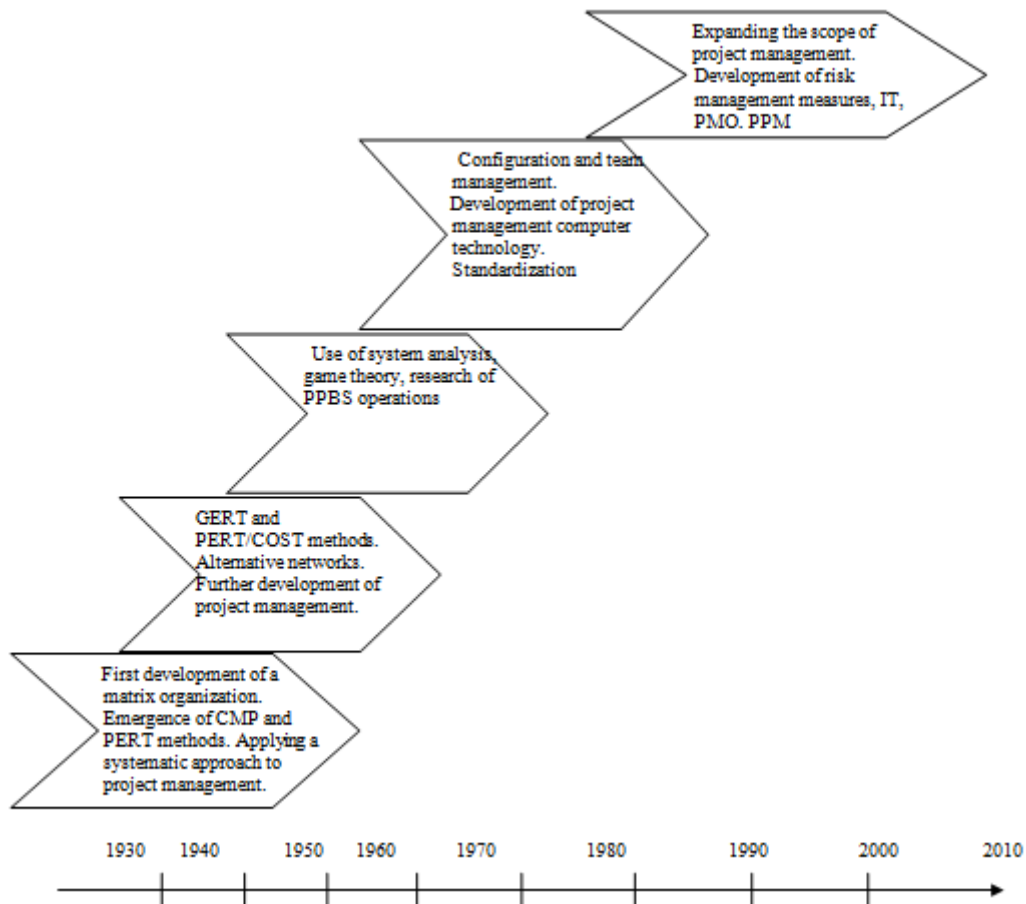
Over its 70–years' development, the concept of project management evolved from an approach inherent only in large state projects with a technical bias to a complex methodology for managing organizational processes, including the areas of healthcare, information technology, marketing, and sales (see. Fig. 1).

Project management, which gradually replaced traditional management, is based on the preliminary development of a comprehensive system model in order to achieve the original goal and is aimed at implementing this model within the specific time frames. It is important to keep in mind that the objective in project management is, as a rule, distinguished by elements of novelty and, therefore, the project itself is original, non–traditional.

The successful use of the methodology and principles of corporate project management makes us thinking about the prospects for the application of project management at the macro level: as part of management of a megaproject, industry or the whole region. For example, the implementation of megaprojects such as Universiade 2013, Olympic Games 2014, FIFA World Cup 2018, Skolkovo, New Moscow, GLONASS require the state to create the necessary regulatory, infrastructure, methodological and information base in the field of public project management.

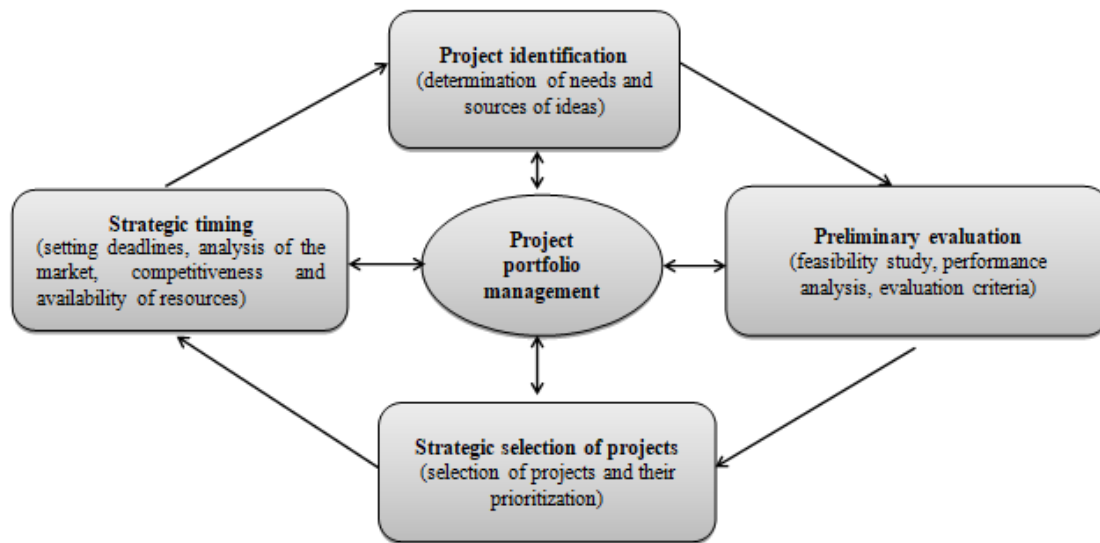
In the process of managing the region's industry it is necessary to solve a huge number of problems and the time for taking a decision is, as a rule, limited. The number of projects to be managed can reach several tens and even hundreds at the same time, and there may be a few more on the way. For the purposes of structurization, the unity of command, elimination of duplicate activities, balancing

resources and formulation of common principles for project management, it is possible to create a portfolio of projects – a set of projects (usually interconnected or related) combined together for the purposes of effective management to achieve strategic goals.



**Figure 1.** Evolution of project management.

The concept of project portfolio management should be defined separately. Project portfolio management is focused on identifying, selecting, financing, monitoring and maintaining the optimal mix of projects needed to achieve the organization's goals and objectives. Portfolio management should include consideration of the total costs, risks and returns of all projects in the portfolio, including the "trade-offs" between them. Intelligent project portfolio management helps to determine the optimal level of investment for each project, which should be well combined with each other and not contradict the overall strategic plan. The result is the best balance between current and new strategic initiatives. At the same time project portfolio management is a tool for achieving strategic goals (including industry goals). In general, project portfolio management looks as follows (see Fig. 2):



**Figure 2.** Project portfolio management diagram.

So, the following should be noted as advantages of project management for the innovative development of mechanical engineering:

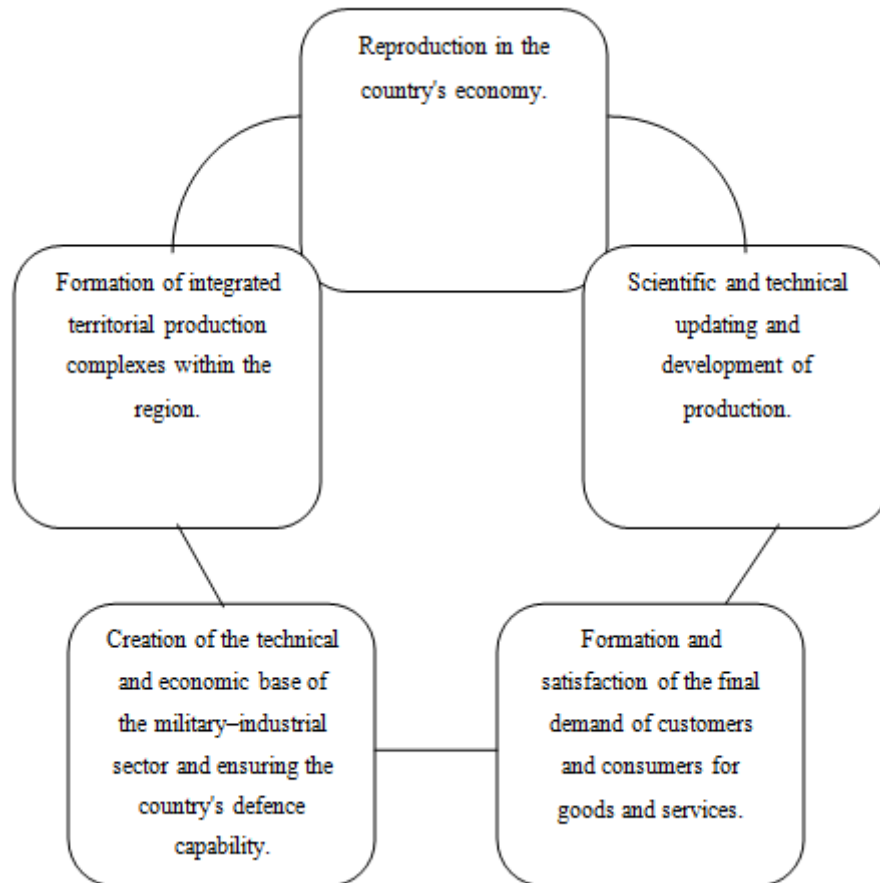
- A decrease in the number of failures associated with the inconsistency of resources used plus a reduction in the duration of the entire set of works.
- A decrease in the total need for resources and a decrease in the total project cost, which leads to getting an economic effect.
- A possibility to regulate project management procedures.
- Investment efficiency determination and analysis.
- Use of mathematical methods to calculate time, resources, and cost parameters of projects.
- Centralized storage of information based on the work schedule, resources and costs.
- A possibility to quickly analyze the impact of changes in the schedule, resource support and project financing.
- Provision of a supervision body for projects implementation monitoring.
- Project risk accounting and management.
- Provision of works quality control.
- Management and control of supplies and contracts while ensuring project activities.

Project management is a tactical component of the management system, i.e. the toolkit of project ideology, which is based on the following clearly defined categories: management subjects, management objects and management processes. To get the desired result from the results of project implementation, the organization must be well versed in all the intricacies of project management and use a set of knowledge, skills, tools and methods for project works to meet the requirements for the project.

In the modern world any system is subject to change, both internally and externally, has such properties as flexibility and self-organization. None of the developed plans can contain the only one correct list of actions and provide for a complete set of factors affecting the progress of a project. It is not for nothing that large organizations use the “Rolling Forecast” method [14], in which the management team after receiving a report on the actual results generates a forecast for the next period, while revising and updating the forecasts for the interim period. Such measures optimize the risk of incorrectness of the initially drawn up plan and allow for greater flexibility in forecasting. Such actions imply the feedback between the management subject and object and are typical for project management that has a life cycle model and does not fit into the closed loop “directive–execution–control” characteristic of traditional management.

It is important to keep in mind that the objective in project management is, as a rule, distinguished by elements of novelty and, therefore, the project itself is original, non-traditional.

The functions of the regional economy (production, pricing, distribution, exchange, consumption) implemented in order to achieve a high level and quality of life and development of the region should be based on the competent management of the basic industries of the region. Mechanical engineering is a key industry in the Samara region determining its development and containing the following functions:



**Figure 3.** Key functions of the mechanical engineering complex.

In our opinion, the implementation of project management in the regional management structure of the mechanical engineering based on the diagram below (see. Fig.4) in the future will allow not only solving a number of existing global industry problems, but also will allow regaining lost ground.

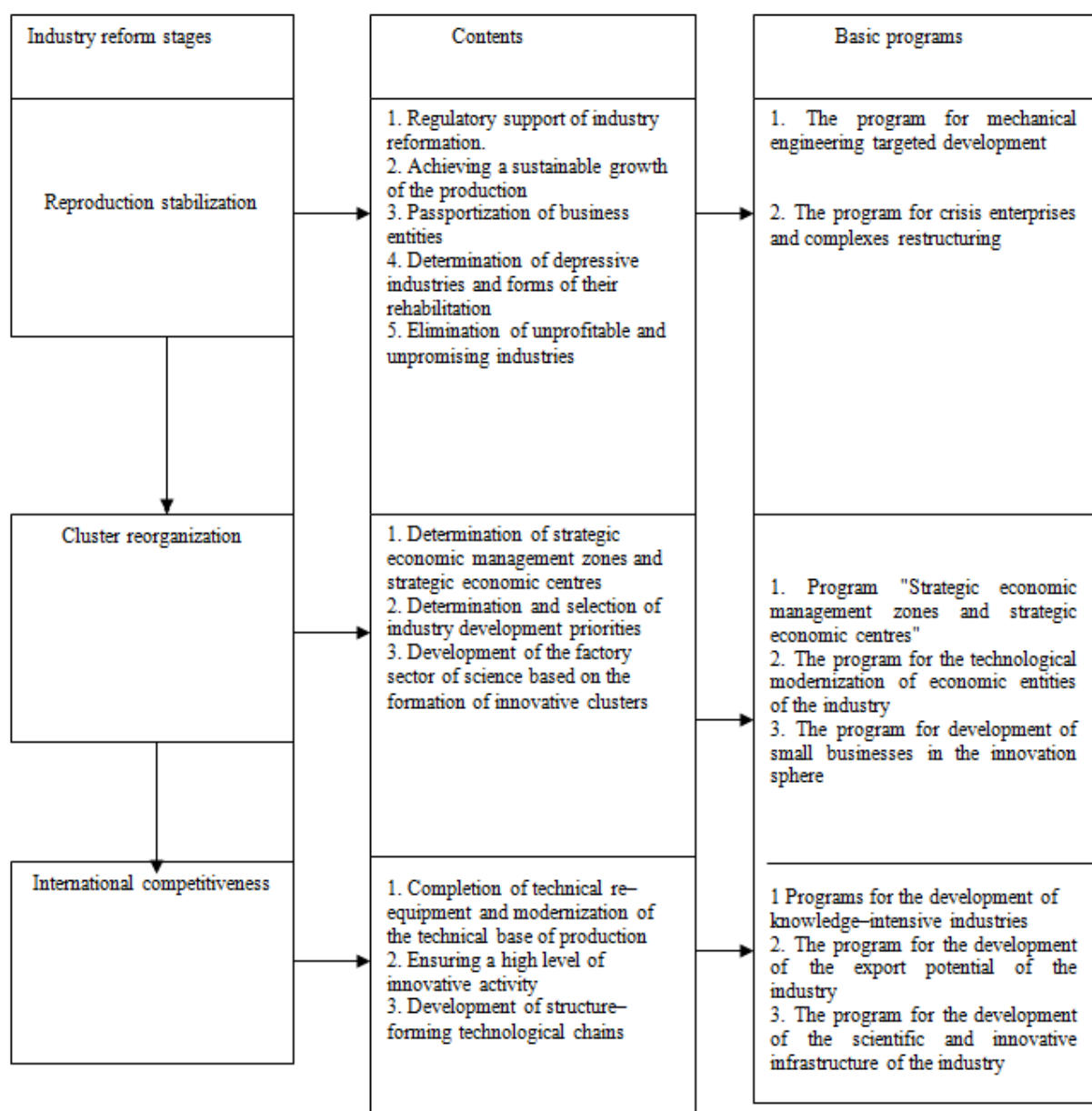
#### **4. Main stages of the implementation of the strategy of mechanical engineering innovative development**

The strategy for the innovative development of mechanical engineering should be developed and implemented in stages. At the first stage one should focus on establishing reproductive stabilization of the industry first of all through the regulatory support of industry reformation, certification of economic entities, conducting a portfolio analysis of the industry on the basis of which depressive industries and forms of their rehabilitation will be determined, unprofitable and unpromising industries will be eliminated, promising enterprises will be determined, points of economic growth for priority financing and achievement will be found as a result of measures taken and a sustainable growth of mechanical engineering profitability. As a tool for the implementation of this stage of the strategy it is



proposed to use the program for the targeted development of mechanical engineering and the program for the restructuring of crisis enterprises and complexes.

The second stage of the strategy for the innovative development of mechanical engineering should be aimed at cluster reorganization. Initially, it is required to determine strategic economic management zones and strategic economic centres, then it is necessary to select priorities for the development of the industry, the basis for the implementation of the strategy should be the development of the factory sector of science based on the formation of innovative clusters. The following programs may become part of the project management of the mechanical engineering industry at this stage of strategy implementation: Program "Strategic economic management zones and strategic economic centres", Program for the technical re-equipment of economic entities of the industry, Program for the development of small businesses in the innovation sphere.



**Figure 4.** Introduction of project management in the regional management structure of the mechanical engineering industry.

The goal of the third stage of the strategy of innovative development of mechanical engineering should be to achieve competitiveness at the international level. For this purpose it is necessary to complete technical re-equipment and modernization of the technical base of the industry, create conditions for ensuring a high level of innovative activity of industry enterprises, organize the operation of structure-forming technological chains and contribute to their further development. It is necessary to implement a number of programs within the framework of project management of the implementation of the strategy for mechanical engineering innovative development: a program for the development of high-tech industries, a program for the development of the export potential of the industry, and a program the development of the scientific and innovative infrastructure of the industry.

## 5. Conclusion

So, the introduction of a project management mechanism in the regional structure of managing the mechanical engineering industry will solve the large-scale problem of modernization and help achieve the innovative development of domestic mechanical engineering through the implementation of targeted programs with targeted funding. At the same time the totality of these programs will have a multiplicative effect, namely, it will allow creating a competitive, innovatively oriented mechanical engineering complex [19].

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