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RISK MANAGEMENT IN PROJECTS FOR THE CONSTRUCTION OF WEAPONS AND MILITARY EQUIPMENT

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The relevance of the article is based on the high level of unpredictability and risk in projects for the creation of weapons and military equipment, especially during the period of the full-scale invasion of Ukraine by the Russian Federation. The purpose of the study is to develop a mechanism for risk management in projects for the creation of weapons and military equipment in Ukraine. The author analyses the implementation of typical activities during the management of a project to create (modernise) a sample of weapons and military equipment (WME), taking into account the stages (relevant stages) of project implementation, consisting of: requirements formulation, development, implementation, and operation. It is noted that it is equally important to ensure the required level of quality when managing a project to create (modernise) a WME sample. At the same time, it is necessary to take into account the influence of external factors on the properties (indicators) of the WME sample and its internal factors. It is also noted that external factors of influence on the domestic WME samples being created (modernised) are factors (objects) of the external environment that affect the sample and are not its internal elements, as well as change its properties and determine the general requirements for it (operational and strategic, operational and tactical, system engineering). It is emphasised that effective management at defence industry enterprises, taking into account the internal and external environment, especially under conditions of uncertainty and risk, requires the use of project management models and methods, and the process of project risk management usually involves the following procedures: risk management planning; risk identification; qualitative and quantitative risk assessment; risk response planning; risk monitoring and control.

Introduction

The development of new models of military equipment and weapons in the context of full-scale military aggression is an urgent task.

As the authors note [1, p. 19], "...constantly gaining experience and optimising the structure, management system, logistics, forms and methods of armed struggle, today the Armed Forces of Ukraine (AFU) are an alloy of professionalism and courage, clear management decisions, thanks to international partners, the level of equipment with high-tech weapons is constantly growing, which proves its effectiveness on the battlefield every day".

Effective management at defence industry enterprises, taking into account the internal and external environment, especially in conditions of uncertainty and risk, requires the use of project management models and methods [2, p. 248].

The object of study of this paper is the risk management processes in the defence industry.

The subject of the study is risk management in projects for the development of weapons and military equipment.

Review of scientific literature

According to Professor O. Butnik-Siverskyi, "...in the current conditions of martial law, innovations are of particular importance, as they are the basis of industrialisation, which plays a key role in diversifying the economy and overcoming its structural weakness. Industry, in particular the military-industrial complex, is the engine of innovation, productivity growth and exports [3, p. 50].

Equipping the Armed Forces with the latest types of weapons and military equipment (WME) depends, in particular, on the ability of the defence industry to introduce the latest technologies, ensure a high scientific and technical level, novelty, patentability and patent purity of WME samples [4, p. 43].

The war, in which Ukraine is conducting a comprehensive defence to repel the large-scale hybrid aggression of the Russian Federation, combines the features of network-centric armed struggle, wars of the fourth and sixth generations. Ways and means of warfare are constantly being supplemented by innovative methods and improved with the help of new technologies [5, p. 29].

The Guide to Managing Risks, Issues and Opportunities for Defence Acquisition Programmes defines risks as "...Risks are probable future events or conditions that could adversely affect programme objectives related to cost, schedule or performance [6, p. 9].

"Project risk is a potential, quantifiable probability of unfavourable situations and related consequences in the form of additional costs, loss of resources, loss of income, and losses during project implementation" [7, p. 158].

"...Risk management is the activity of the management and employees of an institution to identify, assess, determine how to respond to identified and assessed risks, review identified and assessed risks to identify new and changed risks" [8, p. 18].

The relevance of the chosen topic is due to the high level of unpredictability and risk in projects for the creation of weapons and military equipment, especially during the period of a full-scale invasion of the country by the Russian Federation.

The purpose of the study is to develop a risk management mechanism for arms and military equipment projects in Ukraine.

Presentation of the main material

The implementation of typical activities during the project management of the creation (modernisation) of a sample of weapons and military equipment (WME), taking into account the stages (relevant stages) of project implementation, consists of: requirements formulation, development, implementation, operation. At each stage of the sample's condition, certain complex measures are taken:

– analysis of external factors affecting the properties of the sample under study;

– development of the concept for creating and shaping the technical outline of the sample;

– preparation and approval of organisational documents for the creation of the sample;

– implementation of an advance design to determine the basic requirements for the sample;

– development of the tactical and technical task (TTT);

– development of a preliminary design;

– development of a technical design;

– development of working design documentation;

– submission of the sample for testing;

– training of personnel for the sample maintenance and its application;

– commissioning and adjustment works;

– conducting preliminary tests;

– conducting state tests;

– commissioning;

– analysis of the functioning of the sample (amendments to the documentation);

– checking its current scientific and technical level;

– carrying out repair or restoration work;

– making a decision to dispose of the sample;

– making a decision on the need to modernise the sample;

– making a decision on the need to develop a new sample [9, p.15].

Equally important when managing a project to create (modernise) a WME sample is ensuring the required level of quality. In this case, it is necessary to take into account the impact of external factors on the properties (indicators) of the WME sample and its internal factors.

External factors of influence on the domestic WME samples being created (upgraded) are factors (objects) of the external environment that affect the sample and are not its internal elements, as well as change its properties and determine

the general requirements for it (operational and strategic, operational and tactical, system engineering).

Uncertainty and risk during the development of WME prototypes have an ambiguous impact on the effectiveness of the development (modernisation) of WME prototypes. Some of them directly affect the design elements of the prototype, while others affect the duration of its operation or determine the conditions of its use, which affects the overall effectiveness of WME use.

When managing a project to create (modernise) WME samples, risks must be taken into account, including risk assessment and management.

Ensuring a high level of quality of complex weapons and military equipment (WME) of the Armed Forces of Ukraine (AFU) is one of the most important issues during their development. This process must be managed at all stages of the life cycle (LC).

The requirements to meet the development (modernisation) deadlines and to be cost-effective in project management are crucial for the state customer, the Ministry of Defence of Ukraine, as well as for the enterprises of the domestic military-industrial complex (MIC) due to the limited time available for the development of a large range of WME, preparation of their production, possible complications in the conditions of armed conflict regarding the import of WME and ammunition, as well as significant resource constraints at all stages of the life cycle inherent in the conditions of a special period [9, p. 15].

Therefore, managing the project of creating complex WME samples using the lean principle is a top priority.

Risk is inherently linked to decision-making. Decisions are made under conditions of certainty (the outcome of a decision is known), risk (there is a certain probability that an event will occur and some assessment can be made), and uncertainty (the probability and consequences of an event cannot be predicted. Decision-making processes in project management take place under conditions of uncertainty, that is, under the influence of factors such as incomplete knowledge of the situation, the presence of chance, and force majeure. Thus, project implementation takes place under conditions of uncertainty and risk. These two categories are interrelated [10, p. 24].

Uncertainty is incomplete or inaccurate information about the conditions of project implementation, including related costs and results. Sources of uncertainty include:

– the stochastic nature of the processes taking place in business and society;

– the lack of information necessary to justify and make project decisions;

– the influence of subjective factors on decision-making (the level of qualifications of executors, their psychological state, deliberate concealment of information, etc.)

According to the degree of probability of an event occurring, we distinguish between complete uncertainty, partial uncertainty, and complete certainty. All aspects of life and business involve risks. In general, risk reflects our lack of knowledge about future events. We call favourable events opportunities and unfavourable events threats. Risk is the possibility or threat that the results of specific actions may deviate from the expected ones. Project risks are a set of risks that threaten the implementation of an investment project or may reduce its effectiveness (commercial, economic, budgetary, social, environmental, etc.); a set of circumstances under which the probability of achieving the project's goals is reduced or eliminated; a set of risks that threaten the economic efficiency of the project, which is expressed in the negative impact of various factors on cash flows. Risk has three main attributes:

1) a risk event;

2) probability;

3) consequence (risk effect) [10, p. 25].

There are several types of events that pose a risk to a project:

– Cases that may occur.

– Cases that will have major consequences if they occur.

– Events that are beyond your control.

– Things you know very little about.

There are two types of risk associated with project preparation and implementation: systematic and unsystematic. Systematic risk refers to factors external to the project, such as the state of the economy as a whole, and is beyond the general control of the project. Examples of systematic risk include political instability and taxation conditions, i.e. factors related to government actions. Other types of systematic risk reflect the impact of competitive environment factors, such as overall market demand, the level of competition, and prices for raw materials and labour in the industry. These factors must be considered because the project is too small to influence changes in these factors. An unsystematic risk is one that is directly related to the project. The level of profitability of production, the period of construction start and the construction process itself, the cost of fixed capital and productivity are all types of unsystematic risk. Other types of unsystematic risk include external factors that can be controlled or influenced within the project. These include project staff salaries, sales prices for project products, supplier prices for raw materials, and even government taxes, such as customs and excise duties, and other types of taxes.

An approved equilibrium with the client is achieved if the contractor has named and fixed time (deadlines) and resources (estimates) based on the requested parameters. It should be borne in mind that any change in one of the sides of the triangle necessarily entails a change in the remaining two.

Project management involves more than just acknowledging the existence of uncertainty and risks and analysing the damage. Project risks can and should be managed. Risk management is a set of methods for analysing and neutralising risk factors. Risk management is a subsystem of project management. Risk management is the process of identifying, analysing risks and making decisions that include maximising the positive and minimising the negative consequences of risk events; it includes processes related to risk management planning, risk identification and analysis, risk response, and risk control and management within a project. The purpose of project risk management is to increase the likelihood of positive events for the project goals and reduce the likelihood of adverse events [10, p. 26].

According to the PMBOK, the following project risk management processes are distinguished:

– Risk management planning – selection of approaches and planning of project risk management activities;

– Risk identification – identifying risks that may affect the project and documenting the characteristics of these risks;

– Qualitative risk analysis – the process of prioritising risks for further analysis or action, performed by assessing and comparing their impact and likelihood of occurrence;

– Quantitative risk analysis – the process of numerical analysis of the impact of identified risks on the project objectives as a whole;

– Risk response planning – development of possible options and actions that contribute to increasing favourable opportunities and reducing threats to achieving project objectives;

– Monitoring and controlling risks – monitoring risks, identifying remaining risks, implementing the project risk management plan, and evaluating the effectiveness of risk mitigation actions [11].

Figure 1 shows an algorithm for a comprehensive risk assessment. The main indicators that characterize the risk of project implementation may include: the probability of financial losses to the customer if the project is not completed (stopping work before its completion or failure to achieve the results envisaged by this project) or the probability of project failure; mathematical expectation of financial losses to the customer if the project is not completed, i.e. the average value of the customer's useless financial costs until a negative result is obtained, which does not allow further design or to consider that the project

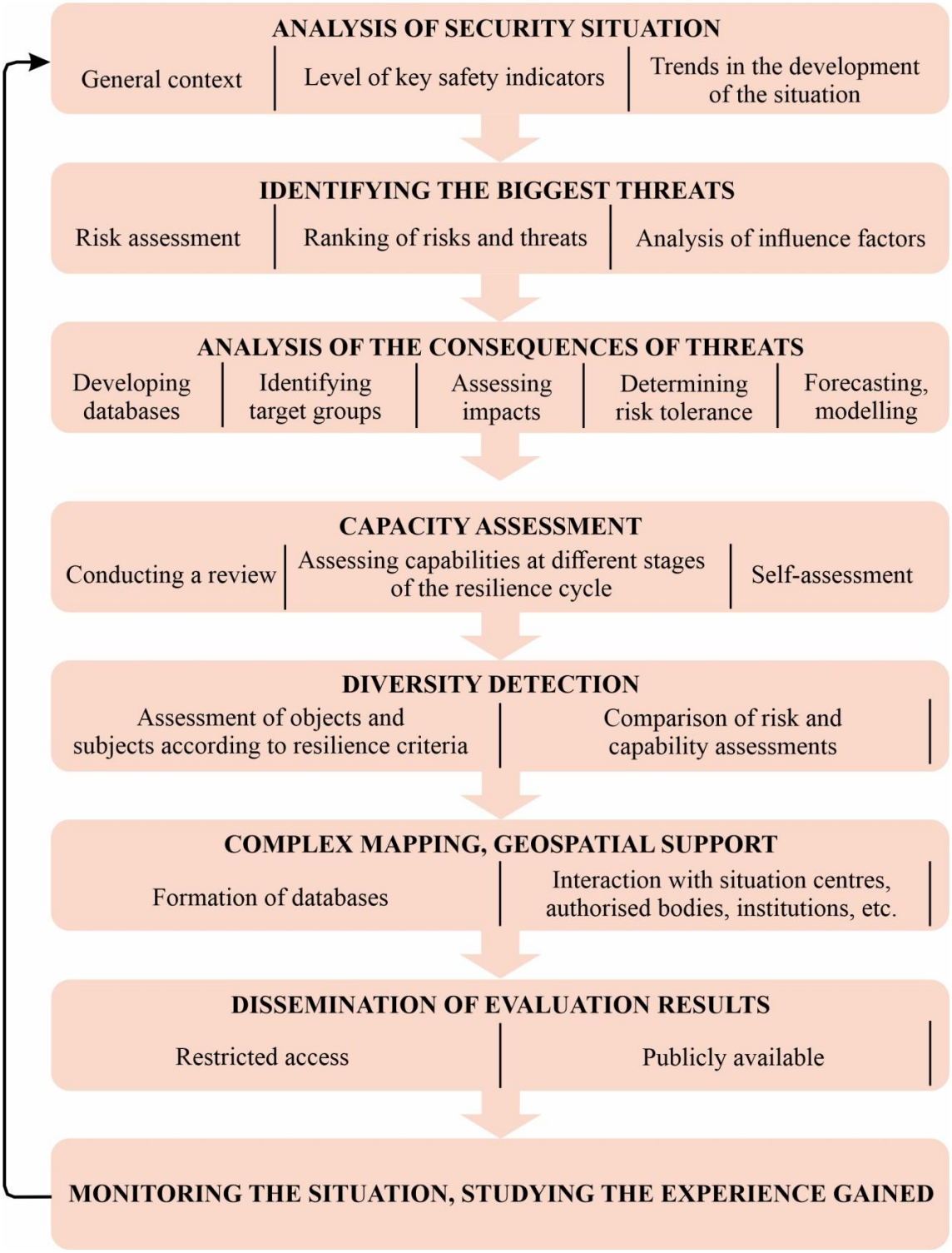

Fig. 1. Algorithm for comprehensive risk and capability assessment, threat identification and vulnerability detection [9, p. 17]

In the absence or insufficient probabilistic data from previous developments, it is necessary to use an approach based on risk assessment under non-stochastic uncertainty [9, p.17].

To assess the risks of implementing WME prototype projects and risk management, it is necessary to develop a scientific and methodological apparatus

adequate to these tasks, which requires appropriate software that will automate the risk management process.

The overall process of implementing a WME sample development project should be systematically streamlined and considered as a dynamic system object of targeted management, taking into account the manifestation of risk factors.

Figure 2 shows a general description of the risk management process.

Fig. 2. General description of the risk management process [6, p. 25]

This figure shows an example of a 5-step management process that can be applied to a specific risk or issue. These steps can be applied at different stages of the programme/project life cycle, but the details of the specific activities will vary depending on the stage of the programme/project. The process of managing individual risks or problems takes place within the framework of the whole system, in which risks affect the structure and content of the programme/project. [6, c. 25]

Planning of the risk management process consists of activities aimed at developing, implementing and documenting measures to be taken within the programme/project to mitigate individual risks. This process should be described in the System Design Plan. For example, the Project Risk Management Process document should describe the expectations for programme risk management, the organisations involved in risk management (such as risk management committees, frequency of meetings and number of members), basic rules and assumptions, categories of potential risks, use of risk management tools, and training of programme staff. In addition, the programme's Risk Management Process document should specify how often the document will be reviewed and updated.

When managing projects, it is important to pay attention to risk identification in time when assessing the feasibility of making certain decisions. The purpose of risk analysis is to provide potential partners with the necessary information and data to make decisions about the feasibility of participating in the project and develop measures to protect against possible financial losses.

The organisation of risk analysis work can be carried out in the following sequence: selection of an experienced team of experts; preparation of special questions and meetings with experts; selection of risk analysis techniques; identification of risk factors and their significance; creation of a model of the risk mechanism; establishment of the relationship between individual risks and the cumulative effect of their action; distribution of risks among project participants; consideration of the results of risk analysis, most often in the form of a report.

Risk analysis is divided into two types: quantitative and qualitative. Quantitative risk analysis should make it possible to determine the number and size of individual risks and the risk of the project as a whole. Qualitative analysis identifies the factors, limits and types of risks. To analyse the risk, the method of analogy, the method of expert estimates, the calculation and analytical method and the statistical method are used.

The method of analogy involves the use of data from other projects that have already been completed. This method is used by insurance companies, which regularly publish data on the most important risk areas and costs incurred.

The expert method, also known as the method of expert judgement, for innovative projects can be implemented by studying the opinions of experienced managers and specialists. At the same time, it is advisable to establish indicators of the most acceptable, critical and catastrophic losses, taking into account both their level and probability.

The calculation-analytical method is based on theoretical concepts, although the applied risk theory is well developed only for insurance and gambling risk.

The statistical method was originally used in the PERT system to determine the expected duration of each task and the project as a whole. Recently, the most commonly used method is the statistical test method (Monte Carlo method). The advantages of this method include the ability to analyse and evaluate different ways of implementing a project.

When considering the methodology for determining risk, it should be noted that the starting point in project risk analysis is to establish the uncertainty inherent in the project’s cash flows. This analysis can be done in several ways, from informal judgement to complex economic and statistical analyses involving hand calculations to large-scale computer models.

The scenario method provides pessimistic estimates of the risk of an investment project. Therefore, it is recommended to use scenario analysis only in cases where the number of scenarios is normal and the values of the factors are discrete. If the number of scenarios is very large and the values of the factors are continuous, it is recommended to use simulation modelling.

The Monte Carlo method is based on the use of simulation models that allow you to create a certain number of scenarios that are consistent with the specified constraints for a particular project.

In practice, this method can only be applied with the use of computer programs that allow you to describe predictive models and calculate a large number of possible scenarios. The mathematical dependencies obtained in the calculation of economic efficiency indicators serve as forecast models. All variables that affect the final result should be identified as accurately as possible, with a description of the degree of these dependencies.

Now let's look at ways to reduce and counteract risks. There are the following groups of risk mitigation methods:

– technical methods based on the implementation of various technical measures, such as fire control systems, electronic banking, etc.

– legal methods, such as insurance, collateral, forfeit (fine, penalty), guarantee, deposit, etc.

– organisational and economic methods include a set of measures aimed at preventing risk losses in the event of unfavourable circumstances, as well as compensating for them in the event of losses [12, p. 130].

The most common methods of risk reduction are:

– distribution of risk between project participants;

– insurance;

– reserving funds to cover unforeseen expenses;

– neutralisation of partial risks;

– reducing the risk in terms of financing.

Risk allocation is carried out in the process of preparing the project plan and contract documents. A decision tree model can be used to quantify risk allocation in projects. In this case, each participant performs the scope of work planned by the project and bears the appropriate share of the risk in case of project failure. But the investor is at the greatest risk. Therefore, it should be borne in mind that the difficulty of finding an investor tends to increase with the degree of risk borne by the investor.

Risk insurance is a system of compensation of losses by insureds in the event of insured events from special insurance funds formed by insurance premiums paid by insureds. This is usually done through property and casualty insurance.

In addition to insurance, reinsurance and co-insurance may be used. Reinsurance is insurance under which an insurer transfers part of its risk liability to other insurers. The purpose of such a transaction is to create a stable and balanced "insurance portfolio" to ensure stable and profitable operation of insurance companies. Co-insurance is a method of levelling and distributing large risks among several insurers. Each of them enters into a separate agreement with the insured. However, there may be a leader insurer that takes on the functions of the organiser [12, p. 131].

Creating reserves of resources to cover unforeseen expenses allows you to compensate for the risk that arises during the project implementation process and, thereby, compensate for project failures. It is a way of dealing with risk, which involves establishing a correlation between the potential risks that affect the cost of the project and the amount of costs required to overcome project failures. Part of the reserve should always be in the hands of the manager, and the other part should be managed by other participants in accordance with the contract.

The first step in using this method is to assess the consequences of risks, i.e. the amounts to cover unforeseen expenses. All risk analysis methods can be used. The next step is to determine the structure of the contingency reserve and the purposes for which the reserve should be used.

Partial risks are risks associated with the implementation of individual stages (works) of the project, but which do not directly affect the project as a whole.

The project financing plan must take into account such risks as the risk of project unviability, tax risk, risk of non-payment of debts, and risk of project failure.

Risk management is carried out at all stages of the project life cycle through monitoring, control and necessary corrective actions. This is done by the project manager in close cooperation with all project participants [12, p. 132].

Figure 3 shows the main planning, management, and additional planning and risk management processes of the project for the creation of weapons and military equipment in Ukraine.

Open Plan is a professional project management system characterised, among other things, by powerful resource and budget planning tools that make it much easier to find the most efficient allocation of resources and schedule them.

Fig. 3. Conceptual model of risk management in projects for the development of weapons and military equipment

Risk analysis in Open Plan is implemented by the following means:

– procedures for entering optimistic and pessimistic parameter estimates for certain or all project activities;

– performing Monte Carlo risk analysis to calculate the probability of completing the project on time;

– preparing reports used to analyse the impact of uncertainty on project implementation.

The Monte Carlo simulation method used for risk analysis is a synthesis of sensitivity analysis and scenario analysis. This is a complex technique that has only a computer implementation.

Conclusions

The article considers the possibilities of reducing and counteracting risks. The most common methods of risk reduction are presented. A conceptual model of risk management in a project to create weapons and military equipment has been built. The professional project management system Open Plan is characterised by powerful tools for resource and budget planning, as well as risk analysis.

The use of the recommendations in the study will help bring the issue of risk management in arms and military equipment projects to a qualitatively new level.

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