Edited by
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PROJECT MANAGEMENT IN THE MILITARY FIELD: PERSONAL EXPERIENCE OF UKRAINE

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The monograph covers a wide range of theoretical and practical aspects of project management in the defence sector of Ukraine. It offers modern approaches to the implementation of project and portfolio management, the development of innovations in the military sphere, and the training of military personnel using the latest technologies. The results and recommendations presented are aimed at improving the efficiency of defence resource management, creating and developing new capabilities of the Armed Forces of Ukraine, and ensuring their readiness to perform strategic tasks in the face of modern challenges.
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ABSTRACT

The modern world is characterised by high dynamism of change, which requires all areas of activity, including the defence sector, to constantly improve and adapt. Effective achievement of strategic goals in modern realities is impossible without the introduction of project management into the activities of the Ministry of Defence of Ukraine, the Armed Forces of Ukraine and other components of the Ukrainian defence forces.

The monograph is devoted to the study of the theoretical foundations and practical aspects of project management in the context of the defence sector of Ukraine. It is the result of many scientific studies and practical experience gained in the process of reforming Ukraine's defence management, which allowed us to solve a number of scientific problems to improve it. The monograph consists of four sections, each of which covers important aspects of project management in the defence sector.

Section 1 "Project Management in the Ministry of Defense of Ukraine and the Armed Forces of Ukraine" analyses the implementation of programmes, project management and project activities in the Ministry of Defence of Ukraine, the General Staff of the Armed Forces of Ukraine and other military command and control bodies. This section discusses the theoretical and methodological foundations of programme and project management in the Ministry of Defence of Ukraine and the Armed Forces of Ukraine. The significance of programmes and projects in the development of the national theory of military construction is substantiated and serves as a basis for improving the scientific and methodological framework for assessing the effectiveness of creating new capabilities and developing existing ones.

In Section 2 "Recommendations on the implementation of portfolio management in the defense management system of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine" taking into account the specifics of the defence sector, military strategy and public administration, the authors substantiate the application of an integrated portfolio management approach in the Ministry of Defence of Ukraine, the Armed Forces of Ukraine and other components of the defence forces, which combines strategic, systemic, project and process-oriented approaches, as well as the management of the In order to develop effective recommendations for the implementation of portfolio management in military management bodies, the factors that can complicate this process (systematic underfunding of the defence sector, lack of qualified personnel, lack of modern information systems, corruption, post-Soviet corporate culture) are outlined.

In addition, a model of planning, programming, budgeting, execution (hereinafter – PPBE) is proposed (development and use of the project management architecture – PPBE in the daily activities of the Ministry of Defence of Ukraine; architecture of defence programmes based on existing organisational structures and functional groups of capabilities; architecture of project management,

programmes through portfolios by their types and functions; architecture of planning and development of projects through their creation, development and execution, utilisation; architecture of capabilities). Recommendations are made for the implementation of portfolio management, taking into account the proposed model of the PPBP (development of a regulatory framework, organisational and administrative documents on portfolio management; creation and reorganisation of project portfolio management functions; staff development; organisation of providing the portfolio of projects, programmes and individual projects with the necessary resources; development of leadership skills of project, programme and portfolio managers; attraction and retention of qualified personnel).

The relevance of the issues covered in Section 3 "Development of innovations in the field of military combat at sea" is primarily related to the lack of research on the development of asymmetric means of warfare at sea in the face of superior enemy forces, primarily maritime unmanned systems (vehicles) and unmanned aerial vehicles, as well as the specifics of managing their creation and development. The results of analytical studies of the development of maritime robotic systems, in particular, unmanned maritime systems (vehicles), allowed to identify the main trends and directions of their further improvement, as well as to outline the specifics of managing the processes of their creation and development.

Chapter 4 "Modern approaches to project management in the training of naval officers. Use of simulation technologies" is dedicated to project management in the defence sector on the example of a virtual project for the training of military navigators using the VSTEP (NAUTIS) and MORILD simulation platforms. These platforms allow exercises to be conducted in scenarios that are as close as possible to real combat conditions. This experience is a valuable example of an innovative approach to military training in Ukraine, which can also be useful for other countries facing similar challenges.

Thus, the monograph covers a wide range of theoretical and practical aspects of project management in the defence sector of Ukraine. It offers modern approaches to the implementation of project and portfolio management, the development of innovations in the military sphere, and the training of military personnel using the latest technologies. The results and recommendations presented are aimed at improving the efficiency of defence resource management, creating and developing new capabilities of the Armed Forces of Ukraine, and ensuring their readiness to perform strategic tasks in the face of modern challenges.

KEYWORDS

Project, portfolio, programme, project management, portfolio management, defence sector, defence planning, capabilities, capability development, risks, maritime robotic system, situational awareness and reconnaissance system, unmanned maritime system (vehicle), unmanned aerial vehicle, development, maritime warfare, asymmetric maritime operations, modelling, virtual reality.

CIRCLE OF READERS AND SCOPE OF APPLICATION

The monograph "Project management in the military field: personal experience of Ukraine" is the result of a thorough research and analysis of current trends in defence management. It contains practical recommendations and methodological approaches that can be used to implement project management in the Ministry of Defence of Ukraine, the Armed Forces of Ukraine and other components of the defence forces. The authors hope that this work will be a useful resource for military command and control bodies of the Ministry of Defence of Ukraine, the Armed Forces of Ukraine and other components of the defence forces of Ukraine, analysts, researchers and anyone interested in improving the efficiency and strategic development of the national defence system.

The results of the research presented in this monograph can be used in

a) implementation of projects and portfolios at all their stages (initiation, planning, execution/monitoring, completion);

b) implementation of an information systems integration plan to support project and portfolio management in the units of the Ukrainian defence forces at the operational and strategic levels;

c) development and implementation of personnel training programmes and courses for project and portfolio management in the units of the defence forces of Ukraine at the operational and strategic levels in military educational institutions and military educational units;

d) introducing virtual simulators into the educational process in military educational institutions to train naval officers;

e) development of a regulatory framework for the creation of structures and standard staffs, staffing lists in the units of the security and defence forces of Ukraine at the operational and strategic levels;

f) development of the latest models of weapons and military equipment of the national defence industry;

g) international cooperation.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Russian-Ukrainian war has become a catalyst for the reform of the defence management system, highlighting the need to improve the methodological foundations of project management in the defence sector to ensure readiness to protect state sovereignty and territorial integrity and effective management of defence projects at all levels.

The object of research is the defence management system of the Ministry of Defence of Ukraine, the Armed Forces of Ukraine and other components of the defence forces.

The subject of the study is project and portfolio management as a tool for optimising the management of defence resources to achieve strategic goals.

The purpose of the study is to increase the efficiency of defence resource management in the interests of defence programme objectives by introducing a promising project management methodology.

Effective management of the defence sector is one of the most important tasks for any state, especially in the context of current geopolitical challenges. The introduction of project management in Ukraine's defence sector is a strategic step that will optimise the use of resources, increase transparency and accountability, and ensure the achievement of national security goals.

This monograph "Project management in the military field: personal experience of Ukraine" explores the theoretical foundations and practical application of project management in the defence sector of Ukraine. The manuscript offers both a theoretical foundation and specific recommendations for the effective implementation of portfolio management.

Objectives of the study:

– to analyse the current state of project and portfolio management in the defence sector of Ukraine and identify the main problems;

– to consider various scientific and theoretical approaches to project and portfolio management and their applicability to the defence sector;

– to develop a portfolio management model that would meet the current needs of the defence sector of Ukraine;

– analyse possible risks and barriers to the implementation of portfolio management;

– to develop recommendations for the implementation of project and portfolio management in the defence sector of Ukraine;

– to analyse regulations on the development of the Navy of the Armed Forces of Ukraine in terms of maritime robotic systems;

– analyse the impact of the theatre (area) of operations on the development of marine robotic systems;

– to study the use of marine robotic systems in the conduct of military operations at sea;

– to develop recommendations for the development of marine robotic systems;

– to analyse modern technologies for training military officers;

– to develop recommendations for improving the officer training programme.

The relevance of the study is driven by the need to increase the efficiency of defence resources in the face of a limited budget and growing threats in the country's defence sector. The introduction of project management will optimise costs, increase transparency and accountability, and ensure that the strategic goals of the defence sector are achieved.

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CHAPTER 1

PROJECT MANAGEMENT IN THE MINISTRY OF DEFENSE OF UKRAINE AND THE ARMED FORCES OF UKRAINE

ABSTRACT

In this section, an implementation of program and project management and project activities in the Ministry of Defense of Ukraine, the General Staff of the Armed Forces of Ukraine, and other military Commands/Headquarters is given, special attention is paid to the developed theory and practice of project management in the Ministry of Defense of Ukraine and the Armed Forces of Ukraine.

The theoretical and methodological foundations of program and project management and project activities in the Ministry of Defense of Ukraine and the Armed Forces of Ukraine, which evolve the national theory of military development and are the basis for improving the scientific and methodological apparatus for evaluating the effectiveness of creating new, developing and maintaining existing capabilities of the Armed Forces of Ukraine, are studied.

The theoretical and methodological foundations of project management in the Ministry of Defense of Ukraine and the Armed Forces of Ukraine can also be used by other components of the defense forces at the stages of their project's execution (initiation, planning, monitoring, and completion).

KEYWORDS

Project management, Ministry of Defense, Armed Forces, defense planning, capability development.

The Ministry of Defense of Ukraine, the General Staff of the Armed Forces of Ukraine, and other military commands and headquarters are taking steps to implement program and project management and project activities.

Based on the project management standard (ANSI PMI PMBOK) and a series of standards (ISO 21500), the Project Management Guidelines [1] and two standards for program and project management in the Ministry of Defense of Ukraine [2, 3] were developed to define the project management procedures to ensure their timely implementation with optimal usage of resources and achievement the goals of defense reform.

In addition, the Instruction for the Organization and Implementation of Defense Planning in the Ministry of Defense of Ukraine, the Armed Forces of Ukraine, and other components of the defense forces was approved [4], which defines program and project management as a component of management activities aimed at achieving the goals of programs and individual projects and implementing changes. A set of programs (projects) for developing the defense forces' capabilities involves the formation of programs (projects) based on the program and project management methodology.

Project management in the Ministry of Defense of Ukraine and the Armed Forces of Ukraine (hereinafter referred to as PM in the MoD and the AFU) is done by applying knowledge, skills, and experience to obtain the necessary results defined by the project objective [3]. This activity is also characterized by uniqueness, novelty, uncertainty, and risks. Within the framework of the PM in the MoD and the AFU the following activities are organized and carried out [1]:

– analysis and justification of the need for the project;
– defining the goals, conditions of implementation, and performance indicators of the project;
– interaction between project participants and stakeholders;
– risk analysis and management;
– implementation of the planned work;
– monitoring and control of project implementation;
– controlled and coordinated changes to the project;
– timely information on problematic issues;
– analysis, dissemination, and implementation of the acquired knowledge.

The difference between PM in the MoD and the AFU and day-to-day management lies in their different purpose:

Project management – to increase the rationality of strategic decision-making and manageability of processes aimed at creating and developing the necessary capabilities of the Armed Forces, taking into account the defined goals and limited resources (budget, time, materials, etc.);

Day-to-day management – to supervise, direct, and control the performance of tasks (operations) performed as part of day-to-day activities.

Project activities are outside the scope of day-to-day activities due to time constraints, but there are some points of intersection. Day-to-day activities are carried out within the framework of functional tasks by the MoD and AFU structural units, and initiatives that arise to make the necessary changes to day-to-day activities can be implemented as projects.

Project management, in addition to directly achieving clearly defined goals, also allows for additional benefits (positive effect) from the aggregate and coordinated implementation of project programs, namely:

– improve the efficiency of financial and human resources usage;
– eliminate duplication of planned works;
– optimize the working time of officials involved in projects;
– systematize the time and organizational framework of projects;
– increase the predictability and manageability of project execution from start to finish.

For example, the project to introduce program and project management in the MoD and the AFU, launched in 2016, is being implemented by the MoD's Department of Military Policy and Strategic Planning. During this period, project teams launched and implemented more than 100 projects in the MoD and the AFU [5], which were to be included in the State Program for the Development of Capabilities of the Ministry of Defense of Ukraine and the Armed Forces of Ukraine.

Examples of projects implemented in 2017–2024 include the following:

1) formation of a military unit by one of the Service Commands of the Armed Forces of Ukraine;

2) transformation of the command-and-control system of the Armed Forces of Ukraine within the framework of the implementation of the Law of Ukraine "On National Security of Ukraine" and other long-term planning documents;

3) certification of Special Operations Forces units in the NATO Response Force (NRF);

4) separation of *force employment* functions from *force generation* functions in the command-and-control system of the Services and individual Branches of the Armed Forces of Ukraine;

5) expansion and improvement of the defense forces airfield network, etc.

Thus, now, the PM in the MoD and the AFU is aimed at improving the rationality of strategic decision-making and the manageability of certain processes in the creation of new capabilities, development, and maintenance of existing capabilities of the Armed Forces, as well as at maximizing the effect of the funds allocated for defense.

At the same time, the implementation of program and project management in the MoD and the AFU has encountered some difficulties due to:

– conservative view of certain officials on the organization of the project management system;

– entrenched experience in managing day-to-day operations and complying with regulatory decision-making procedures;

– training of personnel who should be simultaneously involved in the development and implementation of projects, etc.

This requires a comprehensive study since the effectiveness of PM in the MoD and the AFU is important for completing the use of a process approach to daily activities (transition from a linear-functional to a matrix-process management model). This also applies to the introduction of Results-Based Management, Quality Management, and Risk Management. To ensure interoperability with the EU, it is also necessary to explore benchmarking tools such as management excellence models (CAF) and maturity models (CMM-like models).

1.1 DEVELOPMENT OF CAPABILITIES OF THE ARMED FORCES OF UKRAINE AND OTHER COMPONENTS OF THE DEFENSE FORCES

For today, one of the main tasks of the Ministry of Defense to develop the capabilities of the Armed Forces of Ukraine and other components of the defense forces in the context of the

Russian-Ukrainian war and limited defense spending is to obtain the maximum possible effect from the funds allocated.

The publication [6] presents views on improving the national defense management system and introducing program and project management tools into the activities of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine, and other components of the defense forces. The author proposes a conceptual model of the programs and plans structure in the defense management system, which incorporates the principles and approaches adopted in NATO member states, as well as modern business practices adapted for program and project management of the development of defense forces.

According to the basic axiom of the functional systems theory, the purpose (mission) of an organization is realized through its main activities (main processes), and favorable conditions for the implementation of the main activities are formed through auxiliary processes – management and support [7–9]. However, the list of main processes (areas) of defense management in Ukraine is similar to those in the United States [10]:

– *Capabilities Integration and Development (JCIDS)* management system;
– *Planning, Programming, Budgeting*, *and Execution* (*PPBE*);
– *Defense Acquisition System* (*DAS*);
– *Systems Engineering* (*SE*);
– *Operations Planning* (*OpsPlan*);
– *Capabilities Portfolio Management* (*CPM*).

The Ministry of Defense of Ukraine (MoD) is responsible for formulating and managing defense policy; the Commander-in-Chief of the Armed Forces of Ukraine (CinC) is responsible for defining the strategy; the General Staff of the Armed Forces of Ukraine (GS) is responsible for defining the required forces; the Cabinet of Ministers of Ukraine (CMU) is responsible for procurement quality and creating favorable conditions that increase the success of defense projects/procurement and provide state quality assurance.

In defense management in Ukraine are also involved: the Supreme Commander-in-Chief of the Armed Forces of Ukraine (SCinC), procurement agencies, branches of the Armed Forces, the Verkhovna Rada of Ukraine (VRU), i.e., the legislative body of the state and the executive authority in the form of ministries, agencies, services, as well as defense-specific elements (CinC, GS). In general, this corresponds to the distribution of responsibilities between the state authorities [11].

The distribution of power can also be traced through the distribution of responsibility for processes within the matrix-process model of management. Overlaying the model of the network of processes of key public administration players in the defense sector (**Fig. 1.1**), it is possible to see the role of the MoD represented by the Minister as a "corporate architect of defense".

It should be noted that "architectural decisions" (**Fig. 1.1**) are implemented by the legislative body of the state (VRU), while political decisions are made by the first person of the executive branch (the President – the SCinC). The GC is responsible for the development and implementation of the military component of the state strategy, while the SCinC makes military and political decisions in cooperation with other branches of power, and the VRU approves the budget, including defense expenditures.

In addition:

1. The GS develops a model of the future Armed Forces by the needs for the implementation of capabilities in military operations (campaigns).
2. The CMU coordinates program development by the budget approved by the VRU.
3. The Services of the AFU – formulate requirements for meeting needs (procurement).
4. Research Agencies are looking for new solutions, and Procurement Agencies are procuring goods, works, and services, taking into account their life cycle and risks.
5. Joint Forces – realize the acquired capabilities on the battlefield.
6. Developers, producers, and suppliers – develop, produce, and supply goods, works, and services in the interests of the defense forces.

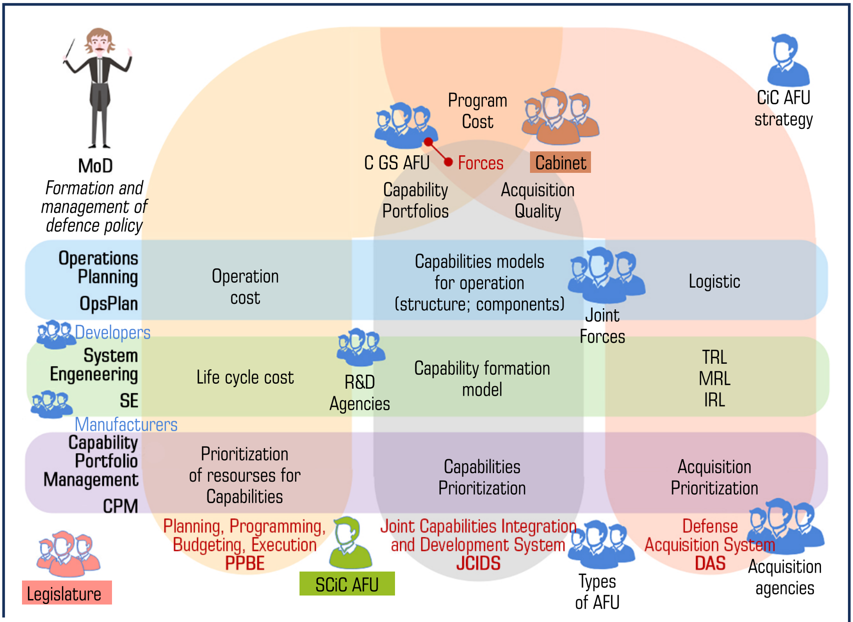


Fig. 1.1 Problem areas of the defense management process network in Ukraine

Fig. 1.1 also shows problem areas (areas of conflict of interest) in the network of defense management processes. Problem areas arise at the intersection of processes, i.e., at the points of transfer of goods, works and services, or the points of transfer of control from one process to another. There are four zones between the three basic processes (*PPBE*, *JCIDS*, *DAS*): formed forces/formed capabilities; capability portfolios (ability to form the required effects); features of defense programs (quality of results, scope of work, number of resources, time characteristics; quality of defense procurement).

Nine critical areas between the basic processes and the other three have been identified. These critical areas should also be considered. Let's call these points according to a simplified scheme – "1+3".

For example, for the *OpsPlan* process (**Fig. 1.1**), the critical points of interaction with the *PPBE*, *JCIDS*, and *DAS* processes will be: the cost of operations/campaigns, the model of operation capabilities (operation design) and their components, and the logistics of operations. For the *SE* process – the cost of the life cycle (capability, sample of weapons and equipment, unit, etc.), the model (roadmap) of capability development, and the nature of supply sources (models of technological and production readiness levels). For the *CPM* process – prioritization of resources for capabilities, prioritization of capabilities, prioritization of procurement.

Therefore, no one project to develop the capabilities of the defense forces or development program in the defense sector can avoid the need to consider these critical points as part of risk management activities.

In contrast to the processes outlined in the *DODAF*, there are some historically established differences in Ukraine (**Fig. 1.2**):

– *Capabilities Integration and Development System* – corresponds to the system of capability development;

– *PPBE* process – the strategic planning process and the budget process;

– processes within the *Acquisition System* – refer to defense procurement;

– instead of *Systems Engineering*, there is life cycle management (mainly for weapons and military equipment) [12];

– *Portfolio Management Capabilities* does not have a direct equivalent (portfolio management is only being implemented, but there are some measures to *ensure* the efficiency of the use of budget funds.

Operations Planning (OpsPlan) should be noted separately as an activity with known differences and similarities.

The need to implement certain projects and programs for the development of the defense forces is determined based on an analysis of plans for future operations. A convenient tool for visualizing such an analysis is the "operation design" [13].

Knowing the required list of effects that should be formed in the operational area and maintained for a certain period [14], as well as the *gap* between the assessment of the existing and required level of capabilities, it is possible to form a list of measures to acquire the required level of capabilities. This does not contradict the previous concept of "combat readiness – combat capability", taking into account both the level of task performance to create the required effect (corresponds to the concept of "*capability*") and the volume of similar tasks (corresponds to the concept of "*capacity*"). Conceptually, the Ukrainian term "capability" covers both areas, but the build-up of forces and means of the defense forces without improving the methods and forms of warfare is referred to as typical scaling projects (creation/reduction of typical organizational structures), and projects to develop the capabilities of the defense forces mainly include projects that change most of the components of capabilities.

The algorithm for selecting the type of project to develop the capabilities of the defense forces is shown in **Fig. 1.3**.

Projects to develop the capabilities of the defense forces (**Fig. 1.3**) cover various aspects of improving activities or changing approaches to generating the required effect and are referred to as intensive development measures. Extensive development measures include projects to change the size of the defense forces.

The creation of new capabilities, development and maintenance of existing capabilities of the defense forces is carried out by the basic components of capabilities using the program and project management methodology.

At the same time, all management decisions aimed at developing the capabilities of the defense forces should be made, taking into account the full life cycle of capabilities to ensure their realism and efficient use of resources [4].

This can be seen in the V-shaped systems engineering diagram applied to the activities of the defense planning cycle (**Fig. 1.4**) using an approach known as the "quality deployment function" or "quality house".

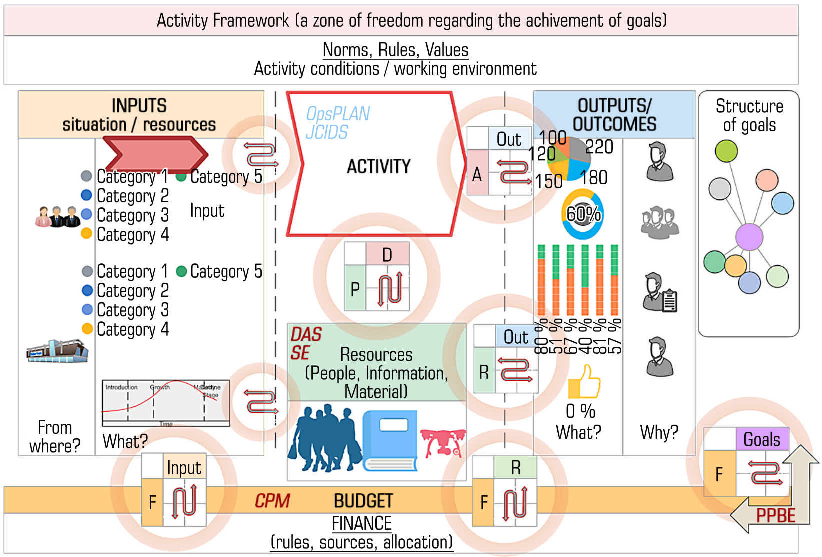


Fig. 1.2 Place of individual defense management processes in the overall defense system
Note: defense activities – OpsPlan and JCIDS processes; resource activities – DAS and SE processes; activities to set goals and finance the achievement of these goals – PPBE and CPM

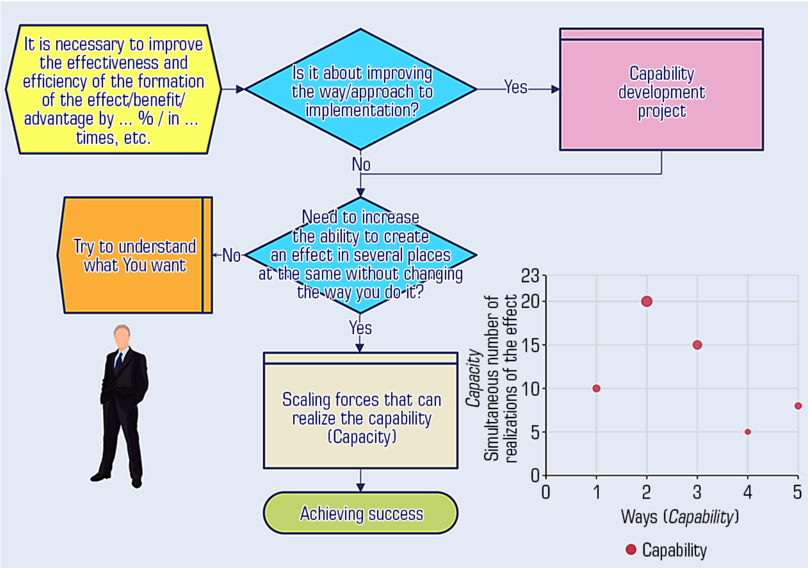


Fig. 1.3 Algorithm for selecting the type of project to develop the capabilities of the defense forces

Also, the activities of the defense planning cycle are presented in the form of an algorithm with the main documents' linkage (**Fig. 1.5**) following the scheme adopted in the *IDEF 3* standards.

In addition, **Fig. 1.5** shows the approximate distribution of responsibility for organizing the stages of the algorithm between the 'J'-structural units of the headquarters.

Based on the results of the main activities of the defense planning cycle (**Fig. 1.5**), documents (capabilities catalog) are developed to coordinate the required effects and tasks for developing the capabilities of the AFU, forces and means of other components of the defense forces (the basis for determining standard requirements for capability holders).

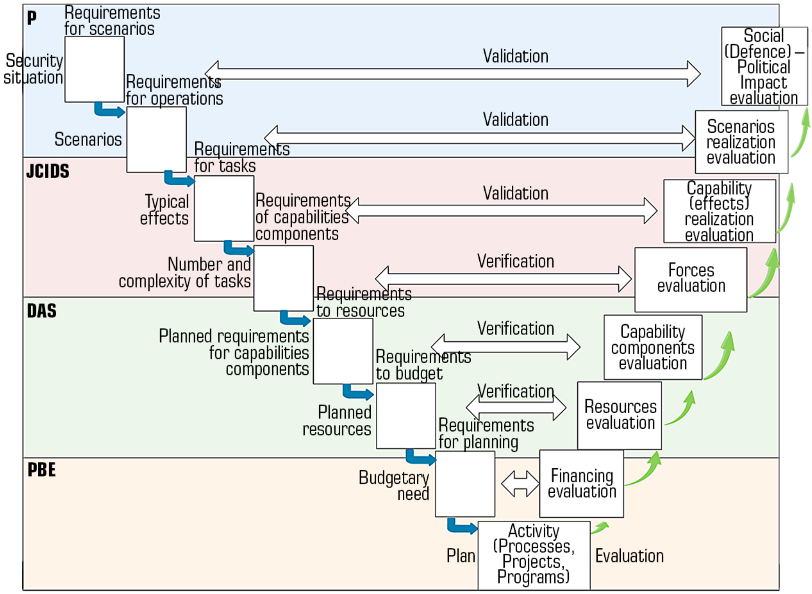
The main ways to improve PM in the MoD and the AFU to ensure the effective development of the capabilities of the Armed Forces of Ukraine are as follows:

– implementation and use of modern project management methods and tools (*PMBoK*, *PRINCE2*, and *Agile*) [2, 3, 15];

– organization and conduction of training (advanced training courses) for personnel on project and program management, in particular, at the National Defense University of Ukraine;

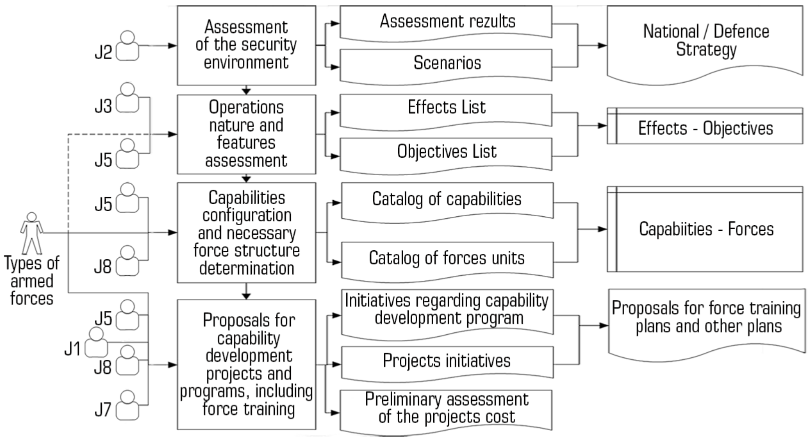
– establishment of a Project Management Center (Project Office) in the MoD that will provide advisory and methodological assistance in project implementation;

– making the necessary changes to regulatory acts, guidelines, and methodological documents in the defense sector.



⬡ **Fig. 1.4** Activities of the defense planning cycle with overlapping areas of coverage of basic defense management processes

Note: the measures in the blue and yellow zones correspond to the PPBE process; the measures in the pink zone correspond to JCIDS, and the measures in the green zone correspond to DAS



⬡ **Fig. 1.5** Sequence of the main activities of the defense planning cycle

Therefore, the project should be considered as a unique set of interrelated activities aimed at achieving certain strategic goals for the development of the capabilities of the Armed Forces (defense forces) within a limited time and resources [4].

The dependence of the expected results of the development of the capabilities of the Armed Forces (defense forces) on each other is presented in the form of a pyramid in **Fig. 1.6**.

The top of the pyramid of expected outcomes of capability development (**Fig. 1.6**) is the "quality of outcomes", which depends on the completeness of the work performed, the duration of the work, and the number of resources allocated.

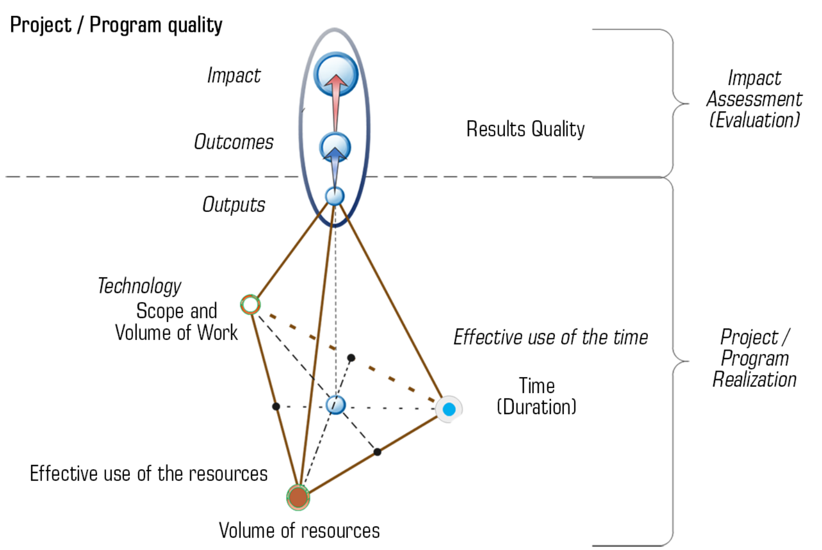


Fig. 1.6 Pyramid of expected results of capability development of the Armed Forces of Ukraine (defense forces)

Based on the results of the study of the MoD and AFU personnel training on project and program management (advanced training courses), a list of questions was identified to facilitate the understanding of officials (project teams) of the essence of the basic components of capability (**Table 1.1**).

Using the basic components of the capabilities (**Table 1.1**), the officials (project team) are offered standardized interview questions.

Strategic decisions aimed at creating and developing the capabilities of the Armed Forces (defense forces) should be made taking into account the full life cycle of capabilities to ensure their relevance and efficient use of resources [1].

Table 1.1 Basic components of the capability

Abbre-viation	Title	Essence	Question
D	Doctrinal framework	Existence of concepts, guidelines, principles of application, standard operating procedures and other governance documents	Do you know what to do, when and how to do it?
O	Organization	The organizational structure of the relevant forces and means that create the appropriate capability	How is responsibility for activities (processes, projects, capacities) distributed?
T	Preparation	The existence of a system of training of relevant forces and means that create a certain capability, individual and collective training of personnel, training of headquarters and military formations	How to maintain the skills of personnel at a given level?
M	Resource support	Provision of the necessary weapons and military equipment, equipment, supplies and consumables, as well as financial resources	How to equip staff to perform tasks efficiently?
L	Quality of management and education (Leadership)	Strategic level: availability of an adequate level of professional training of the leadership at all levels, a system of military education and science that ensures the reasonable development and use of troops (forces). Operational level: implementation of current principles of activity (principles of operational art, quality, risks, human management, etc.). Tactical level: personal, team, command leadership, team building	How to outperform the enemy in terms of the quality of management decisions?
P	Staff	Availability of qualified and motivated personnel	Where can we find people, who will effectively and efficiently perform tasks in accordance with the organizational division of responsibilities?
F	Military infrastructure	Availability of facilities and separate structures intended to ensure the fulfillment of armed struggle tasks by troops (forces), as well as to accommodate and ensure their vital activity	How can we adapt the environment for our comfort and efficient, effective performance of tasks?
I	Compatibility	Doctrinal, operational and technical compatibility of forces and means for joint actions within the defense forces and multinational formations	What conditions must be met to be able to complete the task together?

Mixing the definition of capability in accordance with the Australian version [14] and the essence of the capability components according to the *DOTMLPFI* model, the capability model can be presented in the form of a coherent sentence (**Fig. 1.7**): "personnel (people), equipped with weapons and military equipment, in an environment adapted by infrastructure, using tactics appropriate to the strategy, structured to ensure manageability in units (groups), motivated to fight and able to make more correct than the adversary of the decision, properly prepared (trained), compatible in all these components within and with external subjects and objects, able to achieve goals (results) in given conditions with given success rates/to form the necessary effect within a certain period in a certain operating environment and maintain this effect for a certain time" [14].

The directions for the implementation of Ukraine's military policy and the development of the capabilities of the Armed Forces (defense forces) are defined in the Strategic Defense Bulletin [16].

The strategic goals of the development of the Armed Forces (defense forces) and the expected results of their achievement, taking into account current challenges and threats to Ukraine's national security in the military sphere, are determined when planning the development of capabilities for the medium and long term in the course of operational planning [1]. The strategic goal, the strategic aim of the project, and the lower-level objectives should be coordinated with each other (**Fig. 1.8**).

To formulate the goals of the project for the development of the MoD and the AFU capabilities, it is advisable to apply a methodological approach based on the *SMART* and *DOTMLPFI* components (**Fig. 1.9**) that involves checking whether the goals meet the following criteria [1]:

1. *Specific* – What to do + no interpretation.
2. *Measurable* – A criterion for achieving a goal (quantity – numbers, quality – specifications, cost – monetary unit).
3. *Achievable* – Within the limits of knowledge, experience, and workload.
4. *Relevant* – Is the goal important to achieving a higher-level goal?
5. *Time-bound* – Correlation with a specific time (start – finish).

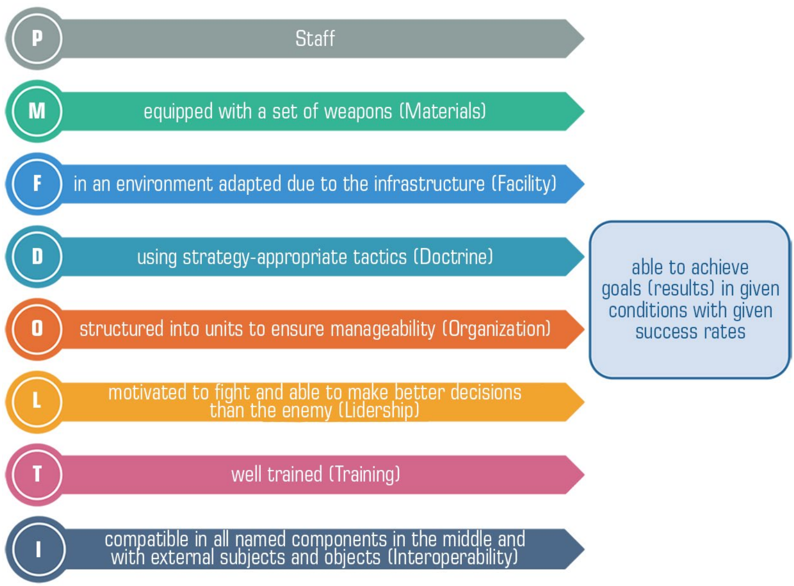


Fig. 1.7 Capability model with DOTMLPFI components in the form of a coherent sentence

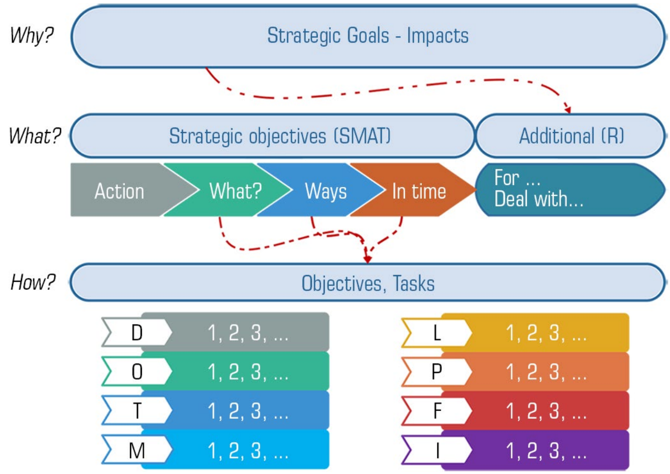


Fig. 1.8 Linkage between the objectives of the capability development project according to the approach adopted by the Ministry of Defense of Ukraine

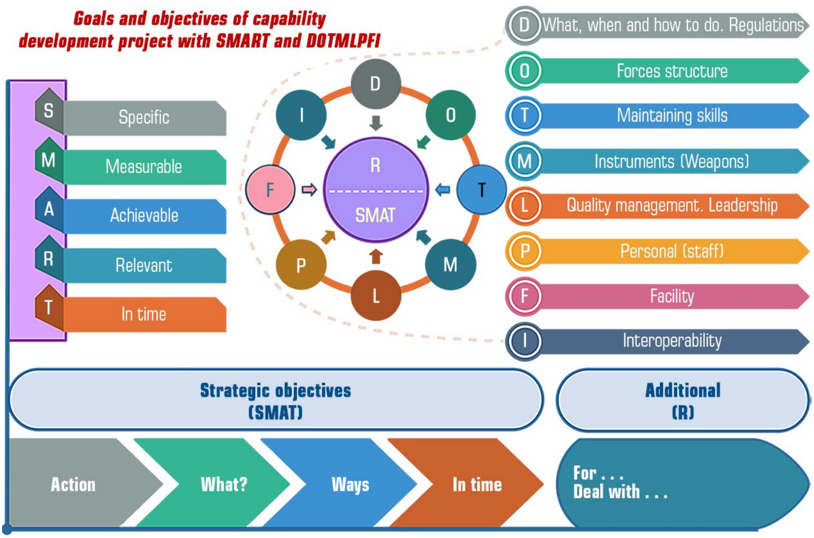


Fig. 1.9 Formulation of project goals with consideration of SMART and DOTMLPFI components

The application of the proposed methodological approach to defining the goals of the MoD and AFU capability development project increases the likelihood of achieving them and makes it possible to measure the strategic goal.

Using the algorithm for determining strategic goals proposed by the authors in [17], it is advisable to formulate the strategic goals of the project in the following sequence:

1) a mission statement should be defined to briefly explain the purpose of the organization, its objectives and core values, and to correspond to the main areas of its activities;

2) based on the mission, develop strategic goals that outline the relevance of the AFU (defense forces) activity in the context of changing internal and external factors;

3) to determine the degree of the goal achievement (development of the defense forces), it is necessary to determine the criterion of compliance of the achieved results with the goal (effect);

4) to clarify the purpose of the development of the AFU (defense forces), in case of changes in the factors that affect the implementation of strategic goals, to adjust them.

In publication [18], effectiveness is considered as the level of compliance of the achieved results with the set goal, which gives a positive effect from the implementation while rationally using available resources.

Using the proposed approach [18], the efficiency of achieving the strategic goal of the project is proposed to be evaluated by the expression:

$$Q_{SG} = f\left(S_{SG_{in}}\left(n_{jm}, k_{jm}\right)\right) \Rightarrow \max, \tag{1.1}$$

where Q_{SG} – a generalized indicator of the project's strategic goals achievement; S_{SGi} – the indicator of the i-th strategic goal achievement $i = 1, \ldots, N$, where N – the number of strategic goals, $S_{SGi} \in [0\ldots1]$:

– *unsatisfactory* achievement of the strategic goal $S_{SGi} \leq 0.3$;

– *satisfactory (pessimistic)* achievement of the strategic goal $0.3 < S_{SGi} \leq 0.4$;

– *average (most desirable)* achievement of the strategic goal $0.5 < S_{SGi} \leq 0.6$;

– *high (optimistic)* achievement of the strategic goal $S_{CSi} \geq 0.7$;

– n_{jm} – indicator of the strategic goal achievement $j = 1, \ldots, M$, where M – the number of tasks in the strategic goal;

– k_{jm} – the coefficient of the strategic goal importance;

– f – the value of the target function of the strategic goal efficiency, $f \rightarrow \max$.

To acquire the value of the efficiency of achieving the strategic goal, it is necessary to rank the tasks that affect the achievement of the strategic goal and determine their degree of importance.

The issue of determining the coefficient of the task importance is a poorly structured problem, characterized by the presence of both well-formalized components and components and relationships that cannot be assessed using objective methods.

In this regard, it is advisable to use the method of expert evaluations. One of these methods is the hierarchy analysis method, which, unlike analytical methods, allows for the ranking of the strategic goal's tasks by all the defined characteristics with a certain degree of compromise. This will make it possible to more fully evaluate the impact of each task on achieving the goal, both the strategic goal and the degree of implementation of the entire project.

Applying the hierarchy analysis method [19], the first step is to decompose and structure the problem in the form of a hierarchy. The hierarchy is built from the top (the goal of the problem to be solved is determined), through the intermediate levels of the hierarchy (indicators on which the subsequent levels depend) to the lowest level, which is the list of tasks (**Fig. 1.10**).

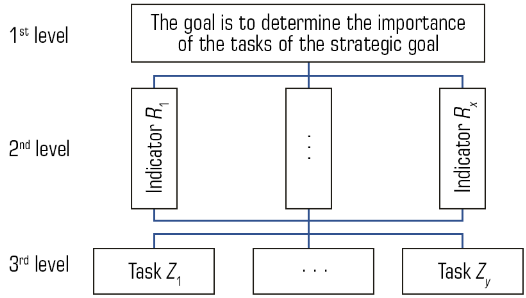


Fig. 1.10 Hierarchical representation of the problem

After decomposing the problem at the second stage of the method, at each level of the hierarchy it is possible to form a matrix of pairwise comparisons of elements E_t of size $T \times T$ (**Table 1.2**). Using a nine-point scale, experts at the second level of the hierarchy make a comparison of the impact of the indicator on the goal, and at the third level of the hierarchy – a comparison of the task according to the indicator.

Table 1.2 Matrix of pairwise comparisons

Elements	E_1	E_2	...	E_t
E_1	1	a_{12}	...	a_{1t}
E_2	a_{21}	1	...	a_{2t}
...	...	...	...	...
E_t	a_{t1}	a_{t2}	...	a_{3t}

The experts' evaluation is made in the form of weight ratios t–x of the elements, which are determined by the importance of the elements among themselves (**Table 1.2**), and their weights can be written in the following form:

$$a_{12} = \frac{\omega_1}{\omega_2}; \; a_{1\xi} = \frac{\omega_1}{\omega_\xi}, \tag{1.2}$$

where ω – the ratio of the weight.

It is important to understand that if $\omega_1, \omega_2, \omega_3, \ldots, \omega_n$ are not known in advance, then the pairwise comparison of elements is carried out using subjective judgments of experts, quantified on a scale (**Table 1.3**).

Table 1.3 The scale of relative importance

Degree of importance (score)	Definition	Note
1	Equal importance	Two factors contribute equally to achieving the goal
3	Moderate predominance of one factor over another (weak significance)	Experience and judgment provide a small advantage to one factor over another
5	Significant or strong relevance	Experience and judgment provide a strong advantage to one factor over another
7	Very strong or obvious significance	The advantage of one factor over the other is very strong
9	Absolute importance	The evidence in favor of one factor over the other is highly convincing
2, 4, 6, 8	Intermediate values between adjacent scale values	They are used in compromise cases

In the third stage, let's synthesize the results acquired. Here, from the group of pairwise comparison matrices, it is possible to calculate the value of local priorities that indicate the relative influence of a set of elements on the element adjacent to the upper level. To do this, it is necessary to calculate the eigenvectors P for each t-th matrix of pairwise comparisons, and the result is normalized for each row to determine the geometric value according to the dependence [19]:

$$P_t = \sqrt[t]{\frac{\omega_1}{\omega_1} \times \frac{\omega_1}{\omega_2} \times \ldots \times \frac{\omega_1}{\omega_t}}, \; t = \overline{1, T}. \tag{1.3}$$

Then, according to the following dependence, the value of the priority vector x is calculated:

$$x_t = \frac{P_t}{\Sigma_t P_t}; \; t = \overline{1, T}; \; \Sigma_t x_t = 1, \tag{1.4}$$

where x_t is the priority of the t-th element.

After conducting all pairwise comparisons and entering the eigenvalue data, it is necessary to determine the degree of consistency characterized by the consistency index IY.

The consistency of local priorities of pairwise comparison matrices is calculated as follows:

– determines the sum of judgments (elements) of each column of the pairwise comparison matrix:

$$z_{it} = \sum_{i} a_{it}, \; i = \overline{1,I}; \tag{1.5}$$

– the value of λ_{max} for which the sum of the first column is multiplied by the value of the first component of the normalized priority vector, the sum of the second column by the second component, and so on:

$$\lambda_{max} = z_1 x_1 + z_2 x_2 + \ldots + z_i x_t; \tag{1.6}$$

– the consistency index is calculated:

$$IY = \frac{\lambda_{max}}{T-1}, \tag{1.7}$$

and for an inversely symmetric matrix always λ_{max}.

Then, using hierarchical synthesis to weigh the priority vectors with indicator weights and calculate the sum of all the respective weighted components of the priority vectors of the hierarchy level below.

The priorities are synthesized from the second level of the hierarchy downward. In this case, the importance coefficients of the alternatives within the group are determined by a dependency:

$$k_{im} = \sum C_{nj} b_{jl}, \tag{1.8}$$

where b_j – the priority of the j-th indicator, $j = \overline{1, J_t}$; J_t – the number of indicators that characterize the goal; C_{nj} – the priority of the impact of the functioning of the n-th task on the j-th indicator, $n = \overline{1, N}$; N – the number of tasks of the strategic goal.

Thus, the method of hierarchy analysis allows ranking the tasks of strategic goals of projects (programs) by all the defined characteristics with a certain degree of compromise and can be used as one of the tools of program and project management.

1.2 PECULIARITIES OF PROJECTS (PROGRAMS) ELABORATION FOR THE DEVELOPMENT OF THE ARMED FORCES' CAPABILITIES

The general scheme of the defense planning process is given in the publication [4]. This process is conditionally divided into five blocks/stages (planning, programming, budgeting, performing tasks within the framework of accepted practice, and implementing development activities (changing accepted practice)). In general, this model is presented in Section 1.1 (**Fig. 1.1–1.15**).

At the same time, it makes sense to consider in more detail the specifics of the stages and the relevant links between the stages. As can be seen, the stages of strategic decision-making and, accordingly, the blocks of activities in the Ministry of Defense of Ukraine are conditionally divided by analogy with the PPBE process.

The block of "planning" activities (**Fig. 1.11**) is designed to formulate strategic goals and allocate responsibility for these goals: development of the Joint Operational Concept, the Military Security Strategy of Ukraine, Strategies for the Development of Services and Individual Branches of the Armed Forces, the Strategic Defense Bulletin, and concepts for the development of Services and Branches of the Armed Forces.

It can be said that the content of this block of activities corresponds to the content of the formation of the motivational layer of the Corporate Architecture according to the *TOGAF* model [22, 23], that is: determining the circle of stakeholders at the state level; establishing assessments of their needs, interests and intentions; forecasting possible scenarios of situation progress; determining the list of effects and indicators of the conditions for their formation and requirements for the ability of the defense forces to form them; prioritizing ways to form effects (capabilities); features of the forces and means that should be involved in the implementation of the capability. The latter – without specifying the amount of forces and means (*capacity*).

Although the concept of an "architectural approach" is not widespread in the sphere of public administration in Ukraine, including the security and defense sector, during the spring and summer of 2024 the set of activities was accomplished under the leadership of the Minister of Defense as part of the project to develop a model of the "Integrated Defense System of Ukraine". In the initial stages of this project, the Minister of Defense is assigned the role of "Defense System Architect".

From another perspective, the model of the defense policy management cycle is very similar to the "corporate architecture cycle".

Let's compare the block of "Programming" activities from the model of the Department of Military Policy and Strategic Planning of the MoD with the corresponding stages of the architectural cycle. According to the "architectural approach", it is necessary to have a description of the process model of activities "as is" and "as should be". This description already contains elements of capabilities, sometimes in the characteristics of functional areas of activity, but more correctly – the ability to form the required effects in the working environment. After that, it is necessary to have a model of capabilities "as it is" and "as it should be" and the distribution of involvement of capabilities in the realization of capabilities, and to a greater extent, processes. After that, it is necessary to understand the procedure of transition from the existing to the required architectural model. All three stages of the architectural cycle – regarding processes, forces and means, and the order of transition from one architectural model to another – are covered by the "Programming" block of activities.

Namely, the block of "Programming" activities (**Fig. 1.12**) covers the development of proposals for the Government of Ukraine's activity program, the Defense Plan of Ukraine and interagency, departmental and sectoral capability development programs.

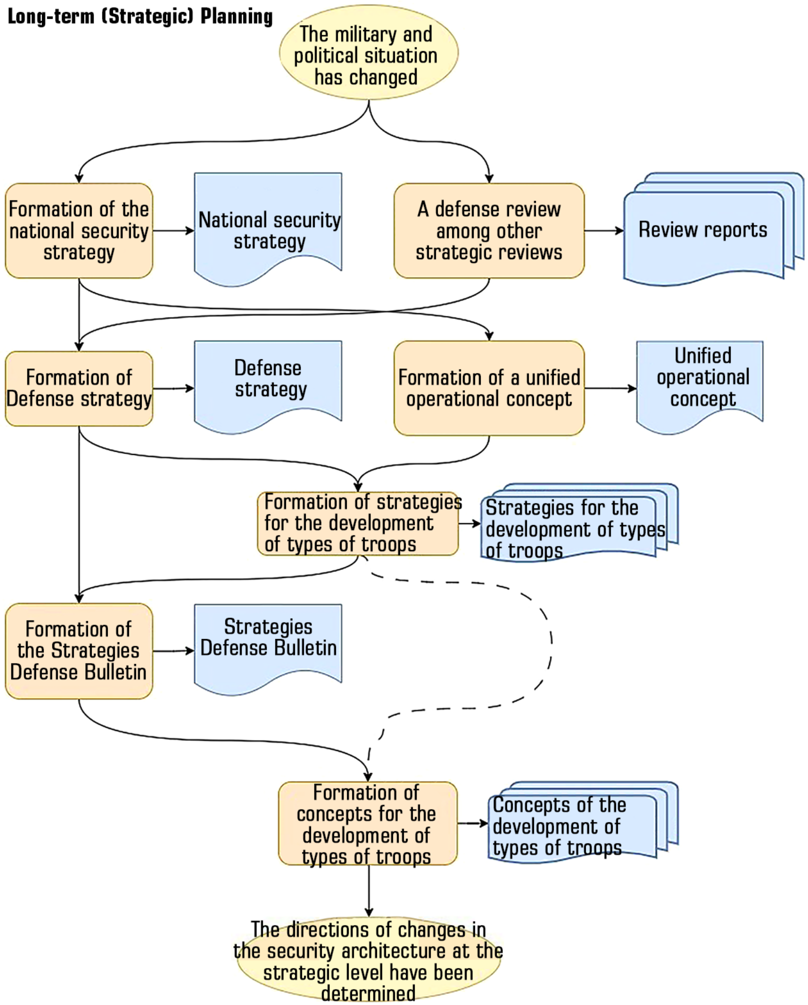


Fig. 1.11 Block of "Planning" activities

It should be noted that it is at the programming stage that the procedure and system for monitoring and evaluation of programs should be laid down. In Ukraine, such practices were actively introduced in the central governmental bodies on the eve of signing the Association Agreement with the European Union in 2012. However, these practices were not extended to the security and defense sector.

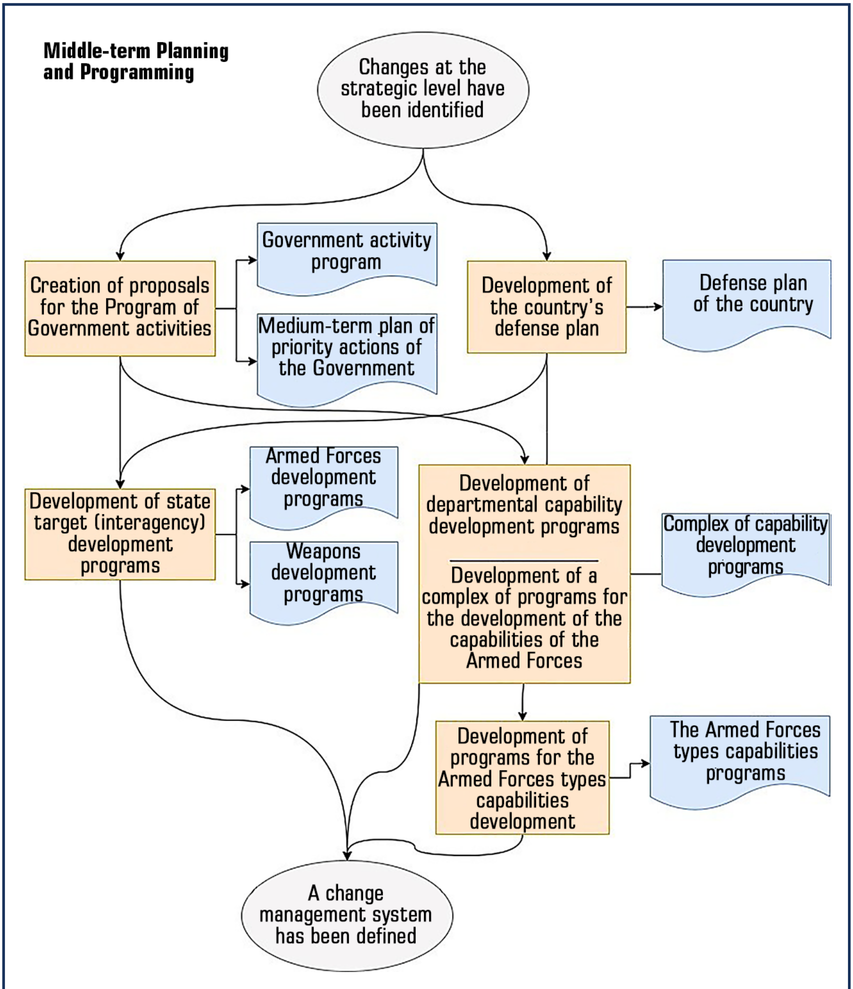


Fig. 1.12 Block of "Programming" activities

Another feature of programming in the field of management of the Ministry of Defense of Ukraine is the Service-based approach to the Armed Forces capability development programs. Due to the limited experience in implementing projects and programs for the Armed Force's capabilities development, it is not yet possible to assess the effectiveness of this approach, but most expert events on the organization of capability development programs mention the risks to the integrity of the capability development system, taking into account the peculiarities of joint operations.

Such risks are an organic feature of hierarchical vertically integrated organizational structures/ functional organizations.

Although the "budgeting" block of activities (**Fig. 1.13**) is defined as the next block of activities after the "programming" block, in reality, both of these blocks are parallel and consecutive steps of the iterative cycle: after proposals on the content of development programs, the possibilities for their financing are assessed; after that, several cycles of adjusting programs and, accordingly, budget activities take place. The content of budgeting activities in the context of the subject of this paper is as follows: to determine the sources of funding and the procedure for funds spending on development programs and projects, as well as other activities in the defense sphere.

The block of "budgeting" activities (**Fig. 1.13**) covers measures to plan the activities of the Government and finance the activities of the MoD and the AFU for the current and two following years, including procurement plans for several years and allocation of necessary funds from the state budget.

Thus, budgeting is a complex task: It is necessary to envisage the possibility of financing the needs for resources for several years (in Ukraine – three years), to determine the structure and procedure for managing budget expenditures in the conditions of dynamic changes in the political, military and, above all, economic situation in and around the country.

Another peculiarity of budgeting for defense activities in Ukraine is that state agencies and services often belong to a direct power vertical from the ministries, but planning, programming and financing procedures are mostly departmentalized. Therefore, coordination of activities for the maintenance and development of defense forces at the interagency level and about joint operations is quite difficult to be effective. It is enough to compare the planning and financial documents of the Land Forces Command of the Armed Forces of Ukraine and the National Guard of Ukraine. Even within the Ministry of Defense, some structures have significant peculiarities in terms of programming and budgeting: The MoD Main Intelligence Directorate, the State Special Transport Service, and others.

According to the classical *TOGAF* architectural cycle, after planning development activities, the following should be done: actually, implement the planned activities; support the implementation through assistance to the executors, additional corrective and preventive measures; evaluate the success of the activities, etc. This can also be seen in the *PPBE* model's block of activities according to the MoD.

The peculiarity of the implementation stage in Ukraine is that the block of "implementation" activities (**Fig. 1.14**) is divided into two parts, namely: a block of capability development projects and programs and a block of capability support activities. The above corresponds to the well-known model of "intensive" and "extensive" progress, but the ratio of the scale of these activities should be decided at the programming stage.

The application of the program-project approach to the organization of activity as a methodological approach in the military sphere is quite organic. This is because C2 of combat operations is project-based in the conditions of military crisis. An interesting comparison of the *MDMP* military decision-making procedure and the *PM BOK v.3* project formation procedure is made in [24].

However, combat operations C2 is usually attributed to special "crisis" activities, and project and change management activities to "calm" activities ("tame crisis").

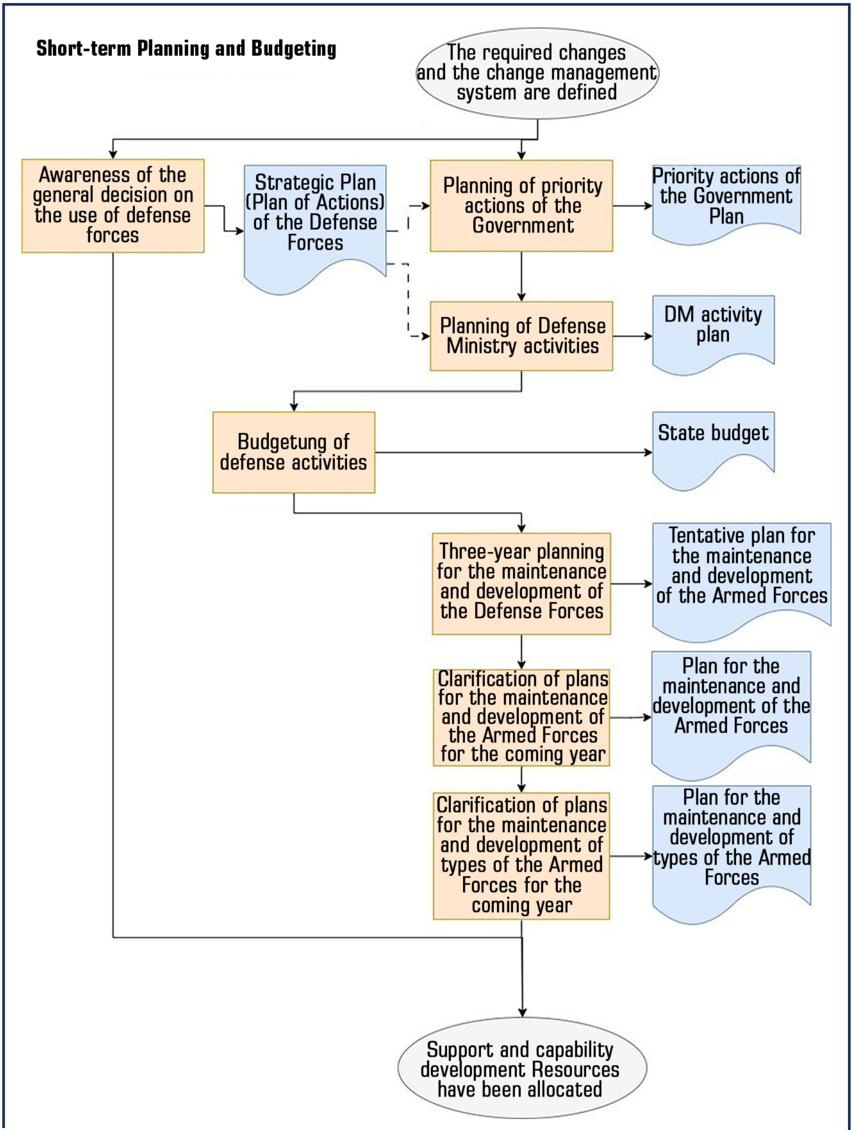


Fig. 1.13 Block of "Budgeting" activities

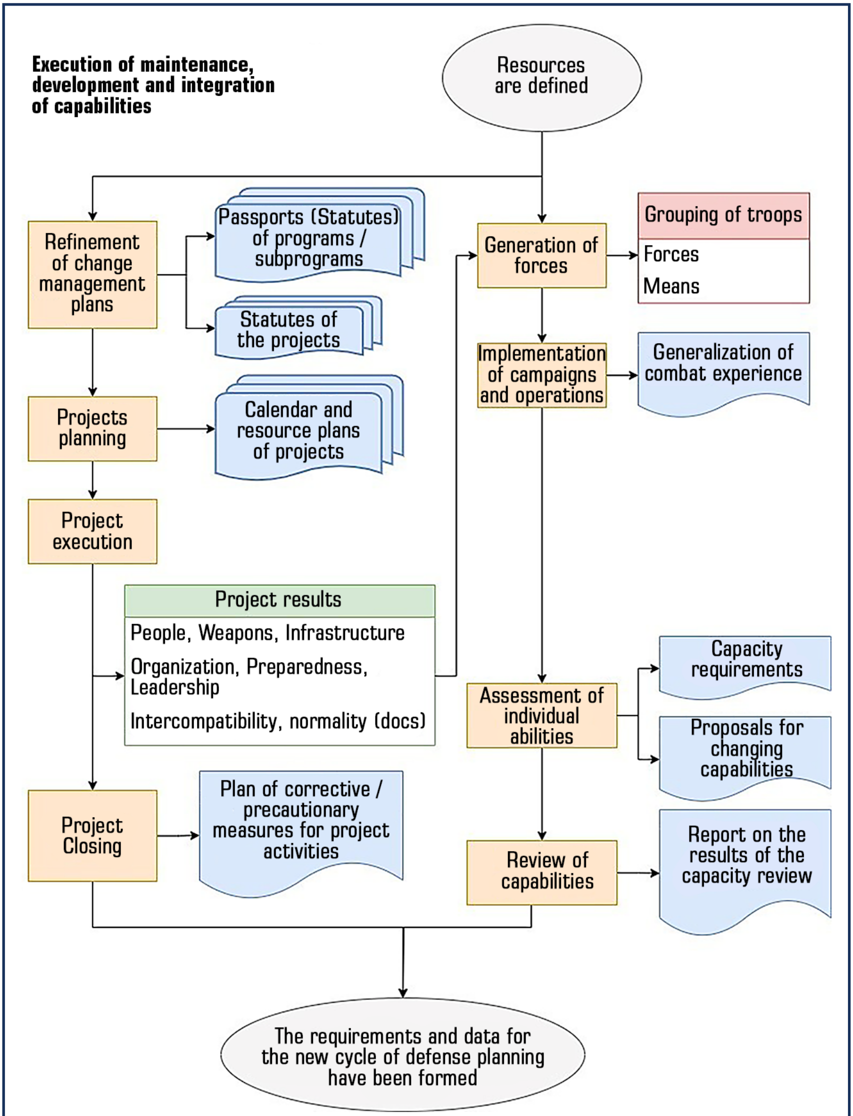


Fig. 1.14 Block of "Execution" activities

An important question is how to manage the programs and projects of force development in times of crisis, especially a military crisis. Let's consider this from the perspective of well-known approaches to change management. The section on change management [25] provides a scheme for classifying changes by the following criteria: Duration of change {Long; Short} and Scope of change {Small; Large}, and the description includes another criterion – Pace of change, which is the ratio of the Scope of change (Volume of changes) to the Duration. In our opinion, one more feature is missing: Context {Internal; External}. The inclusion of this additional feature on Context has an internal connection with Statistical Process Management in terms of finding special causes of deviations or classifying causes that the organization can or cannot influence. If to add the mean scores to the above model {Magnitude of change: Minor, Major, Very Major; Duration of change: Short-term, Long-term, Very long-term; Causes: Internal (controllable), External (uncontrollable), Mixed}, let's get a more convenient version of this model (**Fig. 1.15**).

The full list of situations can be presented in the form of a matrix:

$$Change \supseteq \left\{ \begin{bmatrix} S_1T_1I & S_1T_1C & S_1T_1E & \dots \\ \dots & \dots & \dots & \dots \\ \dots & S_3T_3I & S_3T_3C & S_3T_3E \end{bmatrix} \right\} = S * T * R,$$

$$S = \{S_1, S_2, S_3\},\ T = \{T_1, T_2, T_3\},\ R = \{Internal, Composite, External\}, \tag{1.9}$$

where *Change* – the superset of characteristics of the state of change; * – the sign of the fold; *S* – the vector of *Scale* values; *T* – the vector of *Time-bond* values (duration of changes); *I*, *C*, *E* – the vector of values of the origin of the causes of change (Internal, Mixed, External).

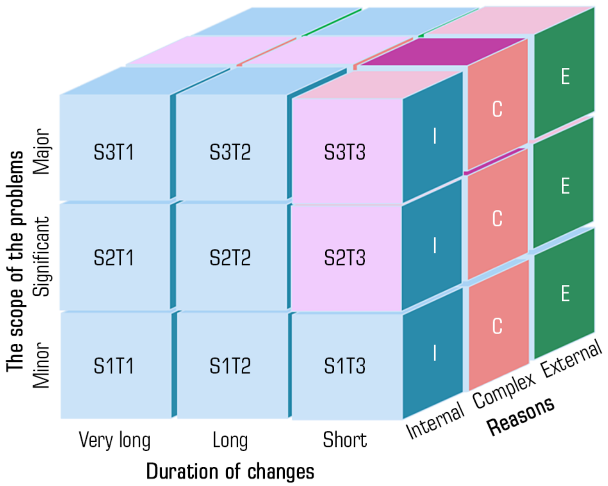


Fig. 1.15 Classification of changes by characteristics of changes and the nature of their causes

At first glance, the most comfortable situation is when the scale of the problems is small, the duration (time allotted for changes) is long, and the reasons for the changes are internal (under our control):

$$SChange_{easy} = \{S_1 T_1 I\}. \qquad (1.10)$$

Accordingly, the most difficult option is:

$$SChange_{hard} = \{S_3 T_3 C\}. \qquad (1.11)$$

However, the presence of people in the management contour leads to the need to take into account the so-called "subjective factor". This, again, is illustrated in [25] by the perception of "boredom" of long-term "insignificant" changes. Taking into account the psychological characteristics of a person, the most difficult changes are those that require changes in the nature of the actions of the actors (MoD, General Staff). Thus, the general expectation is that the highest probability of implementing the managed (proactive) changes corresponds to medium-scale, medium-term changes with a complex list of reasons (possibly a slight predominance of internally managed reasons).

Let's consider the conditions and features of changes in the management of projects (programs) to develop the capabilities of the Armed Forces in a "crisis".

When analyzing the current state of a project (program), it is necessary to assess in detail how the crisis has affected resources (financial, human, material) and the results of the main activities. It is important to understand which project (program) tasks require urgent adaptation or can be postponed.

Next, it is necessary to identify risks, describe possible risks associated with the crisis (economic, political, social), and their impact on the project (program) implementation.

In times of crisis, it is important to focus resources on the most important (critical) projects that have the greatest effect on preserving or developing the existing capabilities of the Armed Forces.

Therefore, projects (programs) should be adaptive to allow for rapid review and reprioritization in line with changes in the security environment.

A key aspect is to build an effective project (program) management system for developing the capabilities of the Armed Forces in a "crisis" to manage the necessary changes, optimize the use of available resources, engage key stakeholders, and maintain communication.

To do this, it is important to constantly monitor the status of projects (programs) and their compliance with strategic goals. Regular evaluation of performance will help to quickly identify deviations and manage the necessary changes. Performance evaluation standards may change in line with changing conditions and new goals.

It is also important to maintain transparent and regular communication with all project participants. A crisis can be long-lasting and have a negative impact on the morale of participants, so attention should be paid to supporting people by providing them with proper information and emotional support.

In conditions of uncertainty (full or partial), it is advisable to evaluate several scenarios and develop alternative changes to ensure the full implementation of projects (programs). This will help to respond quickly to different crisis scenarios.

Thus, monitoring the status of projects (programs) to develop the capabilities of the Armed Forces in a "crisis" will help to adapt the strategy, and management approaches, prioritize projects, optimize resources, and effective communication (transparent, clear, and timely information transfer).

1.3 RESULTS-ORIENTED APPROACH TO PROJECT MANAGEMENT IN THE MINISTRY OF DEFENSE OF UKRAINE AND THE ARMED FORCES OF UKRAINE

Project management in the MoD and the AFU is provided for [26]:

a) understanding and continuously meeting the requirements of the military leadership;

b) reviewing projects from the perspective of creating additional value for the Armed Forces;

c) achieving the effectiveness of defense planning processes;

d) improving project management based on the evaluation of the effectiveness of intermediate results of achieving project (program) goals.

A results-oriented approach to PM in the MoD and the AFU requires managing both effectiveness and efficiency.

On the other hand, effective PM in the MoD and the Armed Forces requires high-quality monitoring and control by the project program manager (project sponsor, coordinator, customer) to make timely adjustments during project implementation and to identify which projects require more attention.

The monitoring and control tool is the Status Report [2], which is provided by the project (program) manager in the management vertical.

Practices of monitoring and evaluating government policies, programs, and projects are widespread in various fields and developed countries [22, 23, 27–37]. Initially, these practices were applied in the social sphere of public administration, and later they were extended to other areas, including security and defense.

The World Bank and international institutions were the first to implement such practices. A significant obstacle to the use of monitoring and evaluation of projects and programs at the national (intergovernmental) level was the different understanding of the concepts (indicators) of "effectiveness" and "efficiency" by the subjects of relations management. Subsequently, methodological techniques were developed to harmonize these indicators [31], as shown in **Fig. 1.16**.

The system of indicators (**Fig. 1.16**) is grouped into the so-called "direct" efficiency and effectiveness indicators, as well as into economic/resource effectiveness groups.

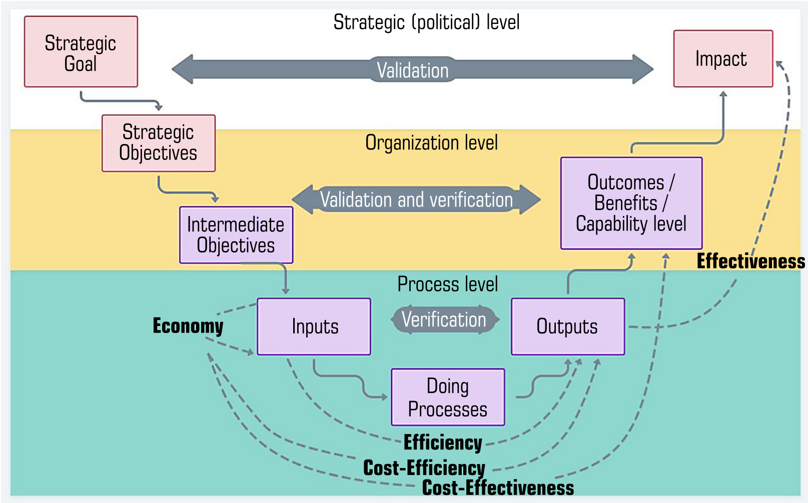


Fig. 1.16 The system of indicators

In the context of the MoD and the AFU, a simple example (case) of the tactical level can be considered. Let's assume that an enemy of up to a company (up to 100 soldiers) is attacking in the area of responsibility of a tactical unit. Over a certain period, they managed to destroy 10 enemy targets. Then the questions are:

– effectiveness – how did the inputs (100 enemy soldiers and your forces) turn into a changed enemy (90 intact/10 destroyed enemy targets and the remnants of your forces)?

– effectiveness (effect) – how outputs (direct results of activities) determine the advantages, benefits, or effects on the battlefield, *for example*: were we able to stop the enemy's offensive?

– resource/economic efficiency – how money/resources are converted into activity outputs: how much does it cost to destroy 10 enemy targets?

– resource/economic efficiency – how money/resources are transformed into effects, advantages, benefits: how much does it cost to stop an enemy offensive, or how much does it cost to ensure the safety of navigation in the near sea area?

As it is possible to see in the practice of the MoD and the AFU, everything above the middle line of the figure (**Fig. 1.15**) is referred to as performance indicators, and everything below it is referred to as efficiency. At the same time, the results are often not divided into outputs, benefits, and final impact. Meanwhile, modern models of planning, support, monitoring, and evaluation of government projects and programs have been implemented in Ukraine for some time in the areas of regional development programs, healthcare projects, and projects of the National Bank.

The "classical" approach to organizing project monitoring and evaluation involves the implementation of typical activities such as planning; data collection; evaluation; and reporting. However, the basis of monitoring and evaluation activities is the establishment of clear and measurable goals, indicators and criteria.Before starting the project, the project manager and the head of the monitoring and evaluation team should agree on the following issues: a list of indicators, rules for collecting data, rules for evaluating the collected data, rules for publishing data, etc.

The strategic goal of the project to develop the capabilities of the Armed Forces should be aligned with the ultimate impact of the project – the ability of the Armed Forces to effectively perform their tasks, and the development program – on the military-political situation, for example:

– the strategic goal of the project is to increase combat effectiveness/efficiency by improving the strike (intelligence, maneuver, defense, logistics) capabilities of the Armed Forces;

– the strategic goal of the program is to gain air superiority in the European theater of operations by improving the maneuverability of the air component of NATO forces in Europe.

Therefore, the strategic goal of the project (program) should include the names and characteristics (assessments) of the specific effects expected from its implementation (improved capability, improved performance), for example:

– the strategic goal of the project is to "improve the striking capabilities of the artillery units of the Armed Forces by transferring two artillery brigades to (*name of the artillery system*) by (*end-date*)";

– the strategic goal of the program is "to improve the maneuverability of the air component of NATO forces in Europe by building five mobile airfields based on the *DABS* system for $204 million".

The achievement of partial objectives and the strategic goal of the project (program) must be evaluated. Evaluation indicators and criteria should be selected according to certain requirements (rules). The most well-known are:

– *SMART – Specific, Measurable, Achievable and Attributable, Relevant and Time-Bound*;

– *CREAM – Clear, Relevant, Economic, Adequate and Monitorable*;

– *SPICED – Subjective, Participatory, Interpreted, Cross-checked, Empowering and Diverse*.

The MoD uses the *SMART* model because of its prevalence among project management professionals in Ukraine, as well as specialists from partner countries. Based on the data on the identified indicators, evaluation, monitoring and control are carried out.

"Evaluation" is carried out to obtain indicator scores at a specific time and place in the project area. "Monitoring" is the tracking of changes in the status/values of indicators over time to determine when management intervention is needed. "Control" means making management decisions/corrective actions based on monitoring data to bring the object of control to a certain state. It is quite common for the concept of "Control" to combine the other two concepts – "Monitoring" and "Evaluation".

Every project and every program of projects has its ultimate *impact*. For beginners and when changing the direction of work of a program and project management specialist, it is important to provide examples of how to define different formulations at different levels of management and in different areas.

At the **strategic level** – by areas:

1. *Increasing defense capability*, for example: "strategic goal" – strengthening the state's ability to defend its sovereignty and territorial integrity; "indicator" – the status of the readiness of the Armed Forces to act in various scenarios, including evaluations obtained during exercises and simulations.

2. *Technological development*, for example: "strategic goal" – development and integration of advanced technologies to improve defense capabilities; "indicator" – the number and effectiveness of implemented innovative technologies.

3. *Interoperability*, for example: "strategic goal" – strengthening the effectiveness of military cooperation at the national and international levels, in particular with allies and partners; "indicator" – the progress towards achieving a certain level of interoperability with allied forces.

At the **operational level** – by areas:

1. *Education, professional development and training,* for example: "strategic goal" – the development of professional skills and competencies of military personnel for the effective performance of tasks; "indicator" – the score of the growth of the level of qualification, based on the results of tests and exercises, and the conduct of combat operations.

2. *Logistics support*, for example: "strategic goal" – optimization of logistics processes and support systems to increase the efficiency and readiness of troops; "indicator" – reduction of response time to logistics requests and increase in unit satisfaction.

3. *Command and Control*, for example: "strategic goal" – improvement of command-and-control systems and communications to enhance coordination and decision-making, improve the quality of leadership decision-making, increase the resilience of the command-and-control system, etc.; "indicator" – the score of the increase in the speed and accuracy of decision-making based on feedback from military commanders, the number of cases of loss of control, etc.

At **the tactical level** – by area:

1. *Ensuring the effectiveness of combat operations*, for example: "strategic goal" – improvement of combat capability, including firepower, mobility and level of protection of troops (forces), etc.; "indicator" – estimates of the increase in accuracy/accuracy, efficiency, range of fire, mobility and survival/losses in combat conditions.

2. *Life safety (force protection)*, for example: "strategic goal" – strengthening the ability to protect military personnel, facilities and resources from threats; "indicator" – the level of the loss's reduction or attacks on military facilities and personnel.

3. *Innovation and experience management*, for example: "strategic goal" – ensuring tactical superiority through the development and acquisition of new weapons and equipment, changes in tactical techniques, etc.; "indicator" – the number of new weapons systems and tactical techniques that have been introduced and the volume of their impact on tactical superiority.

At the **socio-economic level of management** – by area:

1. *Economic*, for example: "strategic goal" – impact on the economy through defense orders, job creation, and development of the defense industry; "indicator" – increase in defense orders and their impact on the gross domestic product.

2. *Social responsibility*, for example: "strategic goal" – social integration of servicemen and their families, as well as veterans and persons equated to them; "indicator" – data on employment, education and social security.

3. *International cooperation*, for example: "strategic goal" – expanding and deepening international relations through joint defense initiatives and programs; "indicator" – the number of international exercises, operations, or programs in which the state participated; the number of harmonized capabilities between armed forces of different states/agencies.

A good source of examples of the strategic goals and objectives of programs and projects in the defense sector are already implemented programs and projects, both within the state and in other countries.

Consider examples where the "strategic goal" of the program is the readiness of the defense forces to act in various scenarios, and the "strategic objective" is focused on intelligence excellence. The "indicators" for assessing the level of intelligence capability development should reflect both the effectiveness of intelligence activities and their impact on overall defense capability.

A preliminary list of "indicators" for the program of intelligence capabilities development by area could look like this:

1. *Accuracy and relevance of intelligence*, for example: "share of accurately confirmed intelligence" – the percentage of intelligence that has been confirmed to be accurate during operations; "time to intelligence update" – the average time required to update intelligence.

2. *Intelligence area/intelligence coverage*, for example: "geographical area" – the size of territory regularly covered by intelligence activities; "variety of intelligence sources" – the number of types of sources used (electronic, human intelligence, space intelligence, etc.).

3. *The level of responsiveness/flexibility of intelligence capabilities*, e.g.: "response time to intelligence challenges" – the speed with which intelligence services can respond to changing operational conditions or requests; "flexibility of intelligence systems" – the ability of intelligence systems to quickly adapt to new types of military threats or tasks.

4. *Integration of intelligence for decision-making*, for example: "the level of intelligence use in strategic decision-making" – an assessment of how intelligence affects strategic planning and strategic decision-making; "the effectiveness of communication channels" – an assessment of the speed and reliability of intelligence transmission to relevant units and commanders.

5. *Development of the technological base*, for example: "innovations in intelligence equipment" – the introduction of the latest technologies and means in intelligence activities; "level of modernization of intelligence systems" – progress in modernizing existing intelligence systems and equipment.

It is also proposed to consider several well-known methods for use, for example, when initiating a program to develop the intelligence capabilities of the Armed Forces:

1. *Case Studies* – description and analysis of specific cases where intelligence had a decisive impact on strategic decision-making. This may include situations where intelligence has helped to identify and prevent threats, or where it has been used to formulate strategic initiatives.

2. *Surveys and interviews* – collecting feedback from key stakeholders, including military leaders and strategists, on how they use intelligence in their planning and decision-making. This will help to understand the impact of intelligence on decision-making.

3. *Scenario modeling and wargaming* – the use of scenario modeling and wargaming to assess the impact of intelligence on strategic decisions. This will allow to simulate different scenarios in which intelligence can be used to achieve the desired results (effect).

4. *After Action Reviews* – conducting an expert assessment based on the results of certain tasks to analyze how intelligence affected actual operations and their results. This helps to assess how effectively intelligence was used during planning and execution.

To use these methods, it is advisable to involve specialists from different levels of management (strategic, operational, tactical) and areas of activity (infrastructure development, defense procurement, territorial defense, etc.) in the monitoring and evaluation group.

In monitoring the implementation of projects (programs), it is important to use statistical methods that allow to identify the causes of deviations between expected and obtained results and minimize negative consequences (risks).

CONCLUSIONS

Project management in the Ministry of Defense of Ukraine and the Armed Forces of Ukraine is important for making rational decisions at various levels of military management and for managing individual processes, projects, and programs to develop the capabilities of the Armed Forces, taking into account the defined goals and limited resources (budget, time, materials, etc.).

The theoretical and methodological foundations of program and project management and project activities in the Ministry of Defense of Ukraine and the Armed Forces of Ukraine, which develop the national theory of military construction and are the basis for improving the scientific and methodological apparatus for assessing the effectiveness of creating new, developing and maintaining existing capabilities of the Armed Forces of Ukraine, are investigated.

Based on the results of the study, a list of questions has been identified that will facilitate the understanding of the essence of the basic components of the capability by officials (project teams).

The results-based approach to project management in the Ministry of Defense of Ukraine and the Armed Forces of Ukraine proposed in this section groups the system of indicators into the so-called "direct" efficiency and effectiveness indicators, as well as into economic/resource efficiency groups. The peculiarity of the results-based approach is that it combines known methods, processes and concepts that characterize the long-term aspect, and formalizes the essence of defining the strategic goal and indicators using examples.

The practical value of these and other research results has been confirmed by acts of implementation in the Ministry of Defense of Ukraine, as well as implemented in the educational process of the National Defense University of Ukraine.

The theoretical and methodological foundations of project management in the Ministry of Defense of Ukraine and the Armed Forces of Ukraine can also be used by other components of the defense forces at the stages of their projects (initiation, planning, execution/monitoring, completion).

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CHAPTER 2

RECOMMENDATIONS ON THE IMPLEMENTATION OF PORTFOLIO MANAGEMENT IN THE DEFENSE MANAGEMENT SYSTEM OF THE MINISTRY OF DEFENSE OF UKRAINE, THE ARMED FORCES OF UKRAINE AND OTHER COMPONENTS OF THE DEFENSE FORCES OF UKRAINE

ABSTRACT

Portfolio management is an integral component of project activity and includes a set of interrelated organizational processes and methods that allow to manage projects, project programs and other activities (hereinafter referred to as portfolio components) aimed at realizing the goals of defense programs in the most effective way. Portfolio management provides a consistent approach to the management of portfolio components, which allows: aligning costs with the goals and performance indicators of defense programs; optimize the use of resources; maximize benefits from the resources involved; define and agree on the expectations of interested parties; ensure transparency of implementation of portfolio components and their status. Portfolio management is a continuous decision-making process whereby the list of portfolio components is subject to periodic review to align with defense program objectives. Portfolio components can be changed, accelerated, delayed or discontinued. The need to implement best practices in portfolio management in military management bodies is due to the need to reform the defense management system and bring it closer to Euro-Atlantic principles and standards.

For this purpose, taking into account the specifics of the defense sector, military strategy and public administration, the manuscript substantiates the application of a comprehensive portfolio management approach in the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces, which combines strategic, systemic, project and process-oriented approaches , as well as risk management and focus on results) and portfolio management implementation methods and tools (capacity analysis, project priority matrix, value-complexity matrix, scenario analysis, key performance indicators, benefit tracking, portfolio dashboard, balanced scorecard, "bubble chart", portfolio archive). In order to develop effective recommendations for the implementation of portfolio management in military administration, the factors that can complicate this process are outlined (systematic underfunding of the defense sector, shortage of qualified personnel, lack of modern information systems, corruption, post-Soviet corporate culture).

In addition, the PPBE model is proposed (development and use in the daily activities of the Ministry of Defense of Ukraine of project management architecture – PPBE; architecture of defense programs based on existing organizational structures and functional groups of capabilities; architecture of project management, programs through portfolios by their types and functions; architecture planning and development of projects through their creation, development and implementation, utilization; architecture of capabilities of types, branches of troops, commands). Recommendations were given on the implementation of portfolio management taking into account the proposed PPBE model (development of the regulatory framework, organizational and administrative documents on portfolio management; creation and reorganization of project portfolio management functions; improvement of staff qualifications; organization of providing the portfolio of projects, programs and individual projects with the necessary resources; development of leadership qualities of individual project, program and project portfolio managers; creation and modernization of infrastructure for project portfolio management).

KEYWORDS

Portfolio, project, program, portfolio management, defense management, risks.

Effective management of the defense sector is one of the most important tasks for any state, especially in the conditions of modern geopolitical challenges. The implementation of portfolio management in the defense sector of Ukraine is a strategic step that will optimize the use of resources, increase transparency and accountability, and ensure the achievement of national security goals.

This work is devoted to the study of the theoretical foundations and practical application of portfolio management in the defense sector of Ukraine. The manuscript offers both a theoretical foundation and specific recommendations for the effective implementation of portfolio management.

The aim of research is to develop a recommendation on the implementation of portfolio management in the defense management system of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine.

Tasks of the research:

– analyze the current state of portfolio management in the defense sector of Ukraine and identify the main problems;

– consider various scientific and theoretical approaches to portfolio management and their suitability for the defense sector;

– develop a model of portfolio management that would meet the needs of the defense sector of Ukraine;

– analyze possible risks and barriers to the implementation of portfolio management;

– develop recommendations for the implementation of portfolio management in the defense sector of Ukraine.

The relevance of research is due to the need to increase the efficiency of the use of defense resources in the conditions of a limited budget and growing threats in the country's defense sector. The implementation of portfolio management will allow to optimize costs, increase transparency and accountability, and ensure the achievement of strategic goals of the defense sector.

The scientific novelty of the research lies in the development of a comprehensive model of portfolio management, which takes into account the specifics of the defense sector of Ukraine.

The practical significance of the research results can be used as a basis for the development of practical tools for the implementation of portfolio management in the defense sector, in particular, the pilot implementation of a new model of air defense on the basis of a specific type, a separate type of troops (forces) of the Armed Forces of Ukraine.

2.1 THEORETICAL FOUNDATIONS AND PRACTICAL METHODS OF PORTFOLIO MANAGEMENT IN THE DEFENSE MANAGEMENT SYSTEM OF THE MINISTRY OF DEFENSE OF UKRAINE, THE ARMED FORCES OF UKRAINE AND OTHER COMPONENTS OF THE DEFENSE FORCES OF UKRAINE

2.1.1 JUSTIFICATION OF SCIENTIFIC AND THEORETICAL APPROACHES TO THE IMPLEMENTATION OF PORTFOLIO MANAGEMENT IN THE DEFENSE SECTOR

Portfolio management is an integral component of project activities and includes a set of interrelated organizational processes and methods that allow to manage projects, project programs, and other activities (hereinafter referred to as portfolio components) [1] aimed at the effective implementation of the goals of defense programs. The portfolio management itself provides a consistent approach to the management of portfolio components, which allows: aligning costs with the goals and performance indicators of defense programs; optimize the use of resources; maximize benefits from the resources involved; define and agree on the expectations of interested parties; to ensure transparency of implementation of portfolio components and their status [2–4]. Portfolio management is a continuous decision-making process whereby the list of portfolio components is subject to periodic review to align with defense program objectives. Therefore, portfolio components can be changed, accelerated, delayed or terminated.

According to the classical approach, the portfolio management process is carried out within two continuous cycles: the cycle of portfolio formation and the cycle of its implementation (**Fig. 2.1**).

In an organization that has a three-year strategic planning cycle, the portfolio formation cycle will begin and end within the same period (**Fig. 2.2**). This constraint can also be represented by the budget planning cycle. Portfolio tasks are determined during strategic planning or state budget planning. The purpose of the Government's portfolio is to organize the implementation of tasks and implement the Government's strategy, ensuring resource efficiency by coordinating projects and programs within a certain period of time.

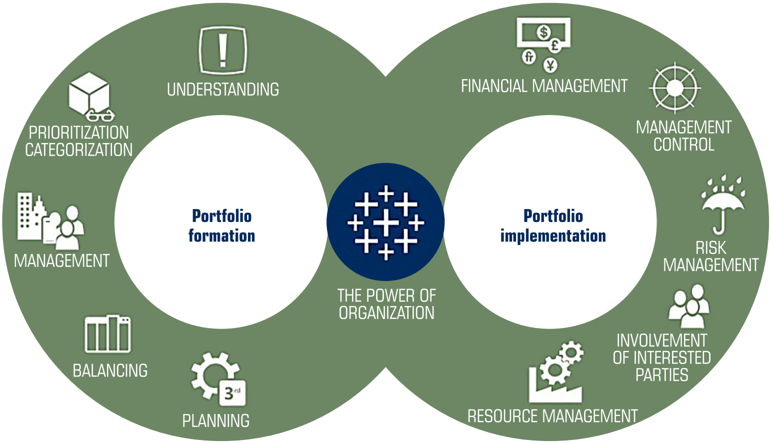

Fig. 2.1 Cycles of portfolio management

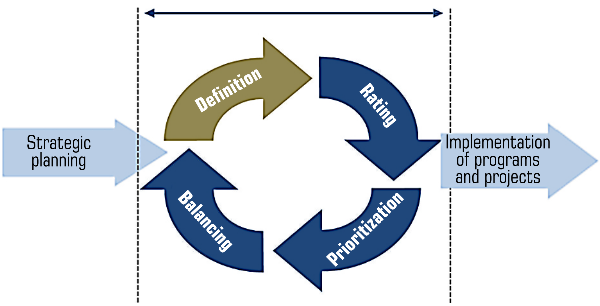

Fig. 2.2 The cycle of portfolio formation in the public sector

In the defense sector, projects are determined before the portfolio is formed. Three stages of the portfolio formation cycle are important for portfolio management: evaluation; prioritization; balancing.

All actions and activities at all stages of the portfolio life cycle, in particular the three mentioned above, should be aligned with the following portfolio management objectives:

– maximization of portfolio value;

– matching the portfolio with the corresponding strategy;

– portfolio balancing.

That is why portfolio management in the defense sector of Ukraine is a complex and multifaceted process that requires the application of scientific and theoretical approaches taking into account the specifics of this sector, military strategy and state administration. The choice of scientific and technical approaches in the field of defense should also be justified by goals and objectives, the nature and specificity of the situation, the availability of data and resources, urgency, security conditions, changes in the external environment, integrations with other management systems, etc. Below are the key scientific and theoretical approaches:

I. A strategic approach to portfolio management focuses on aligning projects and programs with the strategic goals of the defense sector. The integration of portfolio management into the strategic framework of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces is important to ensure the coherence of all initiatives with the national defense strategy. Such coordination is necessary to achieve the country's overall security goals at the strategic level of the theater of operations. Thus, according to the Strategic Defense Bulletin of Ukraine [5], the main strategic goals of the defense sector include such aspects as: effective defense management and a system of joint leadership of defense forces and military management in the Armed Forces, carried out on the basis of democratic civilian control and other principles and NATO standards; professional and motivated personnel, which ensures high combat readiness of the defense forces; modern and effective military equipment and weapons that meet the requirements of modern military conflicts; development of the military-industrial complex, in particular support of domestic manufacturers of military equipment and technologies; ensuring cyber security and information security, which is an important aspect in modern military conditions. Thus, the strategic goals defined at the state level are aimed at strengthening the defense potential of Ukraine and ensuring national security. The components of the portfolio are selected and prioritized based on their contribution to the implementation of strategic tasks and long-term goals of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine. This scientific and theoretical approach allows to optimize the use of resources by focusing on projects and programs that have the greatest impact on achieving strategic goals. This approach is important for effective management in the defense sphere, as it contributes to the rational distribution of resources and ensuring high combat readiness and national security of Ukraine.

II. The system approach is an important scientific and theoretical approach to the management of complex systems such as the defense sector. It provides consideration of the military command body as a complete system where structural elements interact with each other. This allows to effectively manage the entire system, taking into account the interrelationships between its components. The main features of the system approach include [6]: a clear definition of goals, where each structural element of the military management body has its own goals, but the main goal is to increase the efficiency of the entire specified body; establishing a hierarchy of goals helps to better direct efforts to achieve strategic goals; revealing the synergistic essence of the value of the portfolio, where its component affects others.

In our opinion, the application of the system approach can be justified by two key axioms: target orientation and functionality. *The axiom of goal orientation* outlines a system that has goals that determine its structure, functions, and behavior. In the context of portfolio management, this means defining strategic and tactical objectives, such as ensuring national security, increasing the combat capability of the armed forces and efficient use of resources. Defining goals allows to direct resources and efforts to achieve specific results. Prioritization of projects and programs involves determining priorities among the various components of the portfolio, which helps to allocate resources in such a way that the most important for achieving goals receive adequate funding and support, optimizing the use of resources and focusing attention on the most important areas. Analysis of the achievement of goals helps to evaluate the effectiveness of implemented projects and programs, including evaluation of results, impact on defense capability and national security, which allows for timely adjustment of strategies and decisions on continuation, modification or termination of individual initiatives. Taking into account changing conditions and new challenges allows to adjust goals and adapt the portfolio of projects and programs in accordance with new requirements. Flexibility in achieving goals allows the system to remain effective even in changing conditions. For example, if in the defense sector there is a task of modernizing military equipment and improving cyber security, portfolio management will be aimed at identifying and implementing projects that most contribute to the achievement of these goals, namely: the purchase of the latest weapons systems, the implementation of new cyber protection technologies, personnel training and other measures. The use of the axiom of target orientation helps to concentrate efforts on achieving strategic priorities and ensure the maximum efficiency of the use of resources in the defense sphere.

The axiom of functionality states that any system is created and exists to perform certain functions or achieve certain goals. A functional approach helps to understand the purpose of the system and its effectiveness. In the context of defense portfolio management, this means defining various functions, such as ensuring national security, territorial defense, maintaining stability and readiness of the armed forces. Determining the main functions helps to understand which projects and programs are necessary to fulfill them. Allocation of resources by function ensures efficiency and effectiveness of activities, as different functions (airspace protection, cyber security, logistics, etc.) may require different types of resources and technologies. Analyzing the performance of functions allows to identify weaknesses and improve the system, making informed decisions about the continuation, modification or termination of certain components of portfolio management. Adaptation to changing conditions ensures that the system quickly adapts to new conditions and challenges by changing functions or adding new ones. For example, if new threats appear, the system can adapt by implementing new features to neutralize them. In defense portfolio management, a functional approach can be used to identify key areas of development, such as weapon modernization, cyber defense development, and personnel training. Each of these areas performs certain functions important for ensuring defense capability, and the allocation of resources and management of portfolio components will be carried out taking into account these functions. In view of the above, the axiom of target orientation and the axiom of functionality are important for portfolio management in the defense sphere. The choice between them depends on the specific context and emphasis. The axiom of target orientation emphasizes the achievement of specific strategic and tactical goals, the axiom of functionality – the performance of the necessary functions to ensure the effective operation of the system. In our view, both axioms are relevant to portfolio management in the defense sector, helping to define and ensure the necessary functions to achieve the overall objectives of the system. Thus, a systemic approach helps to take into account the complexity of the defense sector, including its technical, organizational and human aspects. Moreover, its application to the defense sector helps to ensure more efficient management, reduce risks and provide an integrated approach to portfolio management.

III. The project approach is a methodology aimed at effective project management. It is based on systematic planning, execution and control of each stage of the project in order to achieve the set goals [7]. The project approach can be applied to various aspects of portfolio management in the defense sector of Ukraine, in particular: selection of portfolio components that have the greatest impact on achieving strategic defense goals; prioritization of projects and programs taking into account their importance, resource limitations and risks; optimization of the use of resources, such as budget funds, human resources and material and technical support; assistance in monitoring and evaluating the progress of projects and programs, as well as in determining the necessary adjustments. Thus, thanks to the project approach, the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine can clearly define the goals, tasks and stages of their implementation, which contributes to a more structured and controlled management of resources, which is important in conditions of limited funding and other resources. A clear distribution of tasks and responsibilities in projects creates a basis for increasing the motivation of personnel, their involvement in the process of project implementation, and also contributes to the general increase in the level of responsibility and professionalism among both military personnel and civilian personnel. Also, the project approach ensures better coordination between different military administration bodies involved in the implementation of the same portfolio, which helps to avoid duplication of efforts and increases synergy between different structures. Within the framework of the project approach, each portfolio project or program has clearly defined goals, deadlines and responsible persons, which increases transparency and accountability in the process of implementation of defense portfolios, which is important for preventing corruption and misuse of funds. In the conditions of an intense war with Russia, the application of the methodology of the system approach allows to quickly adapt to changing conditions and new challenges and timely identify and eliminate problems, as well as adjust strategies to achieve the set goals. It promotes the implementation of the latest technologies and innovations in the defense sphere. Thanks to clear planning and project management, it is possible to implement modern technologies more efficiently, which increases the combat capability and technical level of the Armed Forces of Ukraine. Therefore, the application of the project approach in the defense sector contributes to: improvement of planning and coordination; increasing transparency and accountability; increasing staff motivation; optimizing the use of resources; quick adaptation to changes; implementation of innovations.

IV. In defense management, the application of a ***process-oriented approach*** is based on the understanding that the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine have a system of interconnected processes, each of which affects the achievement of goals. This approach includes the following aspects: *structural* (the military management body considers all its processes as interconnected at different levels of management, which indicates a connection with the system theory, where processes interact with each other and external factors); *functional* (management of processes in the context of such classical functions of defense management as planning, organization, leadership, control); *substantive* (the top management of the military management body, performing the role of decision-making, distributes resources, responsibility and appoints its owner for each process defined in this organization) [8]. The application of a process-oriented approach in the field of defense of Ukraine also has a number of important advantages that contribute to increasing the efficiency, coordination and stability of defense processes. Here are the main ones: it allows to standardize and systematize all actions and operations in the defense sphere, which makes it possible to form a unified approach to the performance of tasks at different levels; clear definition and description of processes helps management to better understand, control and manage activities thereby ensuring more effective planning, implementation and evaluation of the results of defense measures; optimization of processes allows to reduce costs by eliminating duplication of actions and reducing unnecessary time and resources; promotes better coordination between various units and structures in the defense sphere, ensuring more coordinated work and improving interaction between all participants in the process; a clear description of the processes ensures transparency and accountability at all levels of management, which makes it possible to monitor the execution of tasks and effectively evaluate the results in order to prevent corruption and misuse of resources; allows to quickly adapt to changes in the external environment and new challenges, especially during a full-scale war with Russia; contains mechanisms for constant analysis and improvement of processes, thereby promoting the implementation of innovations and new approaches that increase the effectiveness of defense operations; provides a clear definition of roles and responsibilities, which facilitates the training and training of personnel, thereby increasing the professional level of military personnel and civilian personnel involved in defense processes. In general, the application of the process approach in the defense sphere of Ukraine allows to ensure systematization, transparency and efficiency of management, which is critically important for ensuring the national security and defense capability of the country.

V. It is worth considering such a modern scientific and theoretical approach as ***risk management***, where projects and programs can have a high level of uncertainty and complexity. Given this complexity, risk management mechanisms become a set of tools and methods that help avoid or reduce the impact of possible risks on the activities of the defense sector [9]. The principles of risk management, such as identification, assessment, planning, monitoring, prevention and reduction of risks, allow to ensure a systematic approach to risk management and ensure effective control over them. These principles are the basis for the development of risk management strategies and plans, which are essential to ensure the safety and success of defense sector operations.

The application of this approach should become a crucial part of strategic planning and decision-making [10], as it helps to identify potential threats and risks to achieve the strategic goals and objectives of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine. Additionally, this iterative approach, which focuses on fewer deliverables in a shorter period of time, allows for stakeholder feedback between sprint planning sessions. It also encourages sprint retrospectives, which help teams learn from their successes and failures [11].

The application of the methodology of the scientific and theoretical approach to risk management has a number of advantages, especially in the context of portfolio management in the defense sector. Thus, this scientific and theoretical approach allows to identify in advance potential risks and undesirable events that may affect the activities of the defense sector. Therefore, military management bodies make it possible to take measures to prevent or reduce their impact and to focus resources on the most significant risks and use them effectively to reduce the likelihood of negative consequences. In addition, the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine can be more prepared for the occurrence of undesirable events or crisis situations, which allows for a faster and more effective response. Risk analysis helps clarify information and justify decisions based on objective data, which improves the quality of decisions made. This increases the trust of the public, partners and investors, as it shows that the organization takes a responsible approach to possible threats and knows how to manage them effectively. In general, due to the implementation of effective risk management, military authorities can adapt to changing conditions, optimize the use of resources, make informed decisions and be ready for emerging challenges. This, in turn, contributes to increasing the level of preparedness for crisis situations and strengthening confidence in the defense sector.

VI. The use of a ***results-based approach*** in portfolio management has a number of important advantages that contribute to increasing the efficiency, transparency and accountability of defense projects and programs, in particular: it focuses on the achievement of specific, measurable results, which allows to clearly define the goals of each component of the portfolio and ensure that all efforts are focused on achieving these goals; promotes better planning and prioritization of projects and programs for more efficient allocation of resources among portfolio components, focusing them on those that have the greatest impact on the country's defense capability; provides for regular monitoring and evaluation of achieved results; enhances the management of defense projects and programs through accountability and transparency, allowing all stakeholders to see how resources are being spent and what results are being achieved; contributes to the optimization of the use of financial, human and material resources through an orientation towards results, which allows timely identification of inefficient components of the portfolio and redistribution of resources to more priority directions; promotes better coordination between various divisions and departments involved in the implementation of defense projects and programs by increasing the level of cooperation and interaction through the specification of expected results and those responsible for their achievement; adapt to changes in the external environment and new challenges, which ensures quick changes to projects and programs to achieve maximum efficiency; ensures the stability of the defense system due to a clear focus on achieving key goals and continuous improvement of management methods, thereby increasing readiness to respond to various threats and challenges. Therefore, the application of a results-based approach to portfolio management in defense management allows for more efficient use of resources, increased transparency and accountability, and the achievement of specific, measurable results that are critical to strengthening the country's defense capabilities.

The scientific and theoretical approaches proposed by us regarding portfolio management in the defense management system of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine are strategically important tools for the effective use of resources, the achievement of national security goals and the improvement of the country's defense capabilities. The selection and substantiation of scientific and theoretical approaches makes it possible to draw a conclusion regarding the proposal of an integrated approach that combines strategic, systemic, project and process-oriented approaches, as well as risk management and a focus on results, which is key to the successful implementation of portfolios in the defense sector. The key advantages of this approach are: the components of the portfolio are related to the strategic goals of the state; effective use of budget funds, human resources and material and technical support; increasing transparency and accountability; quick adaptation to changes, reduction of risks and improvement of the quality of decision-making; stimulating the implementation of new technologies and approaches. The defense sector of Ukraine needs to transform traditional approaches to portfolio management into more modern and effective ones, combining various scientific and theoretical approaches, which will provide a comprehensive analysis of problems and the development of effective solutions. This requires the training of highly qualified specialists in the field of portfolio management and the implementation of modern information systems, which will allow automating portfolio management and increasing its efficiency.

2.1.2 OUTLINE OF RESEARCH METHODS IN DEFENSE MANAGEMENT

In Ukraine, the implementation of effective portfolio management methods in the defense sector is an urgent task in the context of strengthening the national defense capability and ensuring the country's security. In connection with geopolitical realities and internal challenges – the war with the aggressor Russia, modern Ukraine is under increased pressure regarding the need to optimize defense costs, effective use of resources, and improvement of military and technical support. The implementation of a comprehensive approach to the management of portfolios of projects and programs in the field of defense aims to ensure the strategic goals of the state, reduce risks and increase the effectiveness of management decisions. In particular, this covers the selection of optimal investment projects, management of resources and costs, as well as increased transparency and accountability in management. It is the informed choice of portfolio management methods that will help to effectively implement these tasks. International normative documents outline a number of methods and tools for carrying out portfolio management, which we consider appropriate to apply in the sphere of defense of Ukraine. In particular, this is ***a capacity analysis*** – a method aimed at analyzing the organization's ability to find sources of financing and implement selected projects. The essence of the method is to analyze the capabilities available in the organization to determine the gap between the required and available capabilities. Constraints related to internal resources can be satisfied through external resources, so the portfolio manager must compare the availability of external resources with the set of required capabilities within the portfolio. Human resources should be directed to projects or programs that bring the greatest benefit to the organization, since resource allocation is a portfolio constraint. Organization of such distribution should be carried out at the stage of portfolio formation. That is why the application of this method in the defense sphere of Ukraine is an important tool for effective resource management, planning and implementation of defense projects or programs. This method makes it possible to assess the current and future capabilities of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine, as well as the defense-industrial complex (hereinafter referred to as the defense industry) of the country, which is critically important for ensuring national security. Below are the main aspects of the application of this method:

1. Determination of key capabilities that are necessary for the implementation of strategic tasks in the field of defense (combat capabilities, logistical capabilities, technical support, cyber security, etc.).

2. The assessment of current capabilities includes an analysis of the current state of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine, as well as the country's defense industry (technical condition of equipment and weapons; qualification and training of personnel; logistical capabilities and support; infrastructure and technological base; operational capabilities and combat experience).

3. The analysis reveals gaps between current capabilities and those required to achieve strategic goals (insufficient technical equipment; problems with logistics and provision; insufficient training and qualification of personnel; deficiencies in infrastructure and technological capabilities).

4. Development of a strategy and portfolios for its implementation (portfolios of modernization of equipment and weapons, development of infrastructure, implementation of new technologies and innovations, etc.).

5. Helps prioritize portfolio components. Projects or programs that contribute most to filling critical gaps and enhancing key capabilities are given priority.

6. Regular monitoring and evaluation of the effectiveness of the implementation of portfolios, which allows to track progress in achieving the necessary capabilities and make adjustments to strategies and plans.

7. Facilitates prompt response to changes in the external environment and strategic conditions, which includes adaptation of plans and projects in accordance with new challenges and threats.

Application examples:

1. Modernization of military equipment: a capability analysis that identifies obsolete models of equipment in need of modernization or replacement will contribute to the development of an appropriate modernization portfolio taking into account the latest technologies.

2. Development of cyber capabilities: in the context of cyber threats, which are growing during the Russian-Ukrainian war, the analysis of capabilities may reveal an insufficient level of protection of information systems, which will lead to the launch of a portfolio to improve cyber security.

3. Logistics improvement: Identifying problems in logistics capabilities can trigger the portfolio to improve supply, transportation and inventory management systems.

In this way, the capability analysis method is an important tool in the portfolio management of the defense sphere of Ukraine. It helps to effectively assess current and required capabilities, identify gaps and develop strategies to fill them.

In addition, let's consider it expedient to use the method of ***cost-benefit analysis*** – assessing the strengths and weaknesses of programs/projects and determining which of them provide the best balance. This assessment leads to greater benefits/strengths and lower costs/weaknesses. In this analysis, costs and benefits are expressed in monetary terms over a period of time to provide a common basis for comparison. Especially in connection with the complex challenges and threats of the defense management system of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine, it is advisable to use this method to: determine whether it is worth investing in specific defense programs and portfolio projects, comparing the expected benefits with expenses; effective distribution of the defense budget of military administration bodies, determining priorities and allocating resources for the most effective measures; making strategic decisions in the field of defense, such as the acquisition of new technology or the conclusion of international agreements; predict the possible consequences of decisions in the field of defense, helping to avoid unforeseen problems in the future; promoting greater transparency in the management of defense resources, which is important for maintaining public trust and international cooperation.

Thus, the application of this method can help military administrations to use their defense resources more effectively, ensuring security and protecting national interests in the face of geopolitical challenges.

If there are projects or programs that require resources that cannot be made available at the same time, the portfolio manager can use a ***project priority matrix*** – a weighted multi-criteria assessment to determine the best possible implementation of these projects. Projects are evaluated on the basis of criteria that the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces of Ukraine consider relevant and consistent with the organizational strategy. In addition, these criteria are weighted based on their relative importance. Each criterion is evaluated for each project and then multiplied by the corresponding criterion weight to calculate the overall project score and rank the projects. Application of the Project Prioritization Matrix method in portfolio management in the field of defense of Ukraine is extremely important for several key reasons: it helps to effectively allocate available resources (financial, human, material) between projects of greatest importance to national security and defense; allows to systematize the decision-making process, providing an objective assessment of each project based on defined criteria, such as strategic importance, urgency, cost, risks, etc., contributing to the transparency and validity of decisions; focuses on projects and programs that most correspond to the strategic goals and tasks of the defense sphere of Ukraine; allows identification and assessment of risks associated with each component of the portfolio, which is important for making informed decisions about their implementation, thereby reducing the likelihood of implementing projects or programs with high risks that may not justify the invested resources; allows to quickly respond to changes in external conditions and priorities; allows to single out portfolio components that are aimed at the implementation of new technologies and innovations in the field of defense, which is critically important for maintaining the competitiveness and efficiency of military management bodies. Therefore, the Project Priority Matrix method is an important portfolio management tool in the defense sector of Ukraine. It promotes efficient allocation of resources, supports strategic planning, minimizes risks and ensures adaptability to change, which ultimately strengthens the country's defense capability.

Moreover, it is worth emphasizing the importance of using such a method as ***a value-complexity ratio matrix*** – prioritization, which is used to rank a set of project or program needs in a portfolio for the most effective achievement of the final goal. A portfolio manager can identify a set of projects or tasks that need to be prioritized. Ratings for each project/task are assigned based on factors such as value to the customer, value to the military administration, etc. Weights are applied to each of these factors to calculate their value to these organizations. Similarly, implementation complexity can be calculated based on the effort required given the number of man-hours, schedule, and resource availability.

These two scores are then plotted for all projects or tasks on the Value and Complexity Matrix, as shown in **Fig. 2.3**.

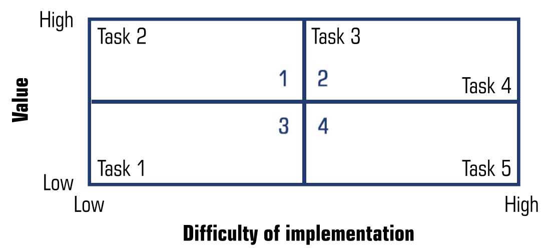

Fig. 2.3 Value and complexity matrix

Based on the obtained points, various projects or tasks fall into four squares of the "Value and Complexity" matrix (**Fig. 2.3**):

– Priority 1: High value, low complexity – quick win;
– Priority 2: High value, high complexity – should be started as soon as possible;
– Priority 3: Low value, low complexity – it is possible to focus on them later;
– Priority 4: Low cost, high complexity – should be done last.

The application of the matrix of the ratio of value and complexity in portfolio management in the field of defense of Ukraine can significantly increase the effectiveness of decision-making regarding the implementation of projects. This tool helps to evaluate and compare projects in terms of their value and complexity, which is of great importance in the context of limited resources and high requirements for defense products. Here are the main aspects of the effectiveness of the application of this matrix:

1. Allows to identify projects that bring the most value for the least cost and effort. This is especially important in the defense sector, where resources are often limited and the need for high-performance solutions is critical.

2. Helps establish priorities among various projects. Projects with high value and low complexity can be implemented as a priority, providing a quick and significant effect for the country's defense capability.

3. Contributes to strategic planning, allowing to better understand which projects are most in line with the strategic goals of the defense sphere of Ukraine. This provides a more balanced approach to investing in the development of defense capabilities.

4. Helps to identify projects and ensure their more thorough analysis and planning, or even abandoning them in favor of less complex but effective solutions.

5. Allows to maintain a balance between short-term and long-term projects, ensuring both quick wins and strategic initiatives that require more time and resources.

6. Promotes transparency and clarity in communications between different departments and management, which helps avoid misunderstandings and ensures a unified vision of priorities and strategies.

7. Helps to identify projects that, despite the high complexity, can bring significant innovative benefits by providing reasonable support for such projects, which is critical for maintaining the technological level of the defense industry.

The matrix of the ratio of value and complexity is an effective tool of portfolio management in the sphere of defense of Ukraine. It helps to optimize the allocation of resources, prioritize projects, improve strategic planning, minimize risks, effectively manage the project portfolio, improve communication and support innovation.

The purpose of ***analyzing "what if" scenarios*** is to construct several alternative solutions. Possible solutions are found by using a combination of current and potential projects and analyzing the impact of each solution on the performance and cost of the portfolio. What-if scenarios are based on a set of assumptions and conditions that must be carefully evaluated to be as realistic as possible: costs, schedules, dependencies, synergies, benefits, and consequences must be accurately estimated.

Key performance indicators (KPIs) are quantitative indicators that provide insight into key performance indicators. It is important to distinguish between two types of project-related KPIs.

The first type of KPI measures the effectiveness of the current project and is usually associated with value added management indicators. The second is used to measure progress toward project goals or objectives and is commonly known as Critical Success Criteria. Using both types of KPIs is a best practice in project communication and reporting and increases the likelihood of project support from sponsors and stakeholders. KPIs should be chosen based on the priority goals of the project. Different stakeholders should be identified to continuously review the performance and provide recommendations in case of any deviations. Portfolio managers should hold periodic meetings with program or project managers and other stakeholders to monitor KPIs and provide feedback.

Benefit tracking can be used to measure the extent to which a portfolio's intended benefits are being achieved. When a program or project is initiated, benefit tracking begins and continues throughout its life cycle, even after its completion. Benefits tracking involves creating a benefits plan matrix that documents lists of planned benefits and identifies critical success factors and key performance indicators. This matrix should be monitored throughout the entire period of implementation of programs and projects within the portfolio. Once the program or project is complete, identified benefits should continue to be reviewed and analyzed to identify areas for development and measure results using metrics.

The portfolio dashboard provides management with a quick overview of the portfolio. It summarizes the key performance indicators of portfolio components and becomes a means of communication within management to make decisions about continuing or terminating initiatives, assessing funding levels or resolving resource issues. A portfolio dashboard should be designed to address key performance indicators that are important to the organization. Program, project or operational reports become an important source of information for portfolio monitoring, control and decision making. The portfolio monitoring panel is also an input to the portfolio formation process if the portfolio needs to be re-evaluated or optimized due to performance issues with one or more portfolio components. Portfolio monitoring dashboards should be archived at appropriate regular intervals. Regular reporting is the result of the activity of the monitoring panel. Reports should be produced as standard practice and provided to portfolio stakeholders and relevant governing bodies. Consult the Stakeholder Matrix for additional guidance.

The basis of ***the balanced scorecard*** is the organization's strategies, which are implemented and controlled using the four components of the balanced scorecard. These four components consist of clearly defined business perspectives:

1. Financial part: measures the final results provided to the interested parties. Examples of financial metrics are budget, risk assessment, cost-benefit, funding, and utilization metrics.

2. Internal business processes: focuses on the key internal processes that drive business. Examples of internal business process measurements are process automation, process bottlenecks, duplication of activities between functions, number of activities per function, and process alignment.

3. Customer component: focuses on customer needs and satisfaction.

Examples of customer measurements are customer engagement, customer service effectiveness, customer market share, customer satisfaction, and quality metrics. The practical application of portfolio management can be extended by using a portfolio stakeholder matrix and a portfolio communication plan. These artifacts can be developed further to focus on long-term portfolio effects in a commercial context.

4. Knowledge, learning and growth: Focuses on how to train employees, how to acquire and retain knowledge, and how to use it to maintain a competitive advantage in the markets. Examples of measuring knowledge, learning, and growth are satisfaction, training and development opportunities for employees, employee turnover, and the level of knowledge required to perform a job.

Because these four components are interdependent, they must be regularly measured, analyzed and improved together in order for the organization to thrive and grow.

Bubble charts are a type of chart that can be used to visualize data points that have three values. It displays a circle ("bubble") in a certain position relative to two orthogonal axes. Two values are used to define the position on each axis, while the third value defines the size of the "bubble". In a more advanced form, it is possible to specify even more values for each data point using bubble color, fill pattern, and more. Because such advanced visualization can make the chart more complex, it is recommended that it is possible to limit itself to three values for each data point.

The purpose of ***the portfolio archive*** is to create a central database for managing and maintaining programs, projects, resources and other information to support portfolio investment decisions. It can be hosted in a database and accessed through a web page or other type of application, allowing the portfolio management team to have secure access to the data. Such an archive should be updated frequently with key information on programs/projects submitted for consideration, as well as on the status of current investments. This tool should separate investments into different stages of portfolio management, such as candidate, active, closed and rejected programs and projects. This gives a clear idea of the necessary actions and allows to track the decisions that have already been made.

Thus, the use of the methods and tools proposed by us is an effective mechanism in the defense management system of the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces. They reflect the complex nature of the management of defense projects and programs, and ultimately help to achieve strategic goals with optimal use of resources.

2.2 THE PATH TO EFFECTIVE DEFENSE MANAGEMENT: CHALLENGES AND SOLUTIONS

2.2.1 MODEL OF THE PROCESS OF PLANNING, PROGRAMMING, BUDGETING AND IMPLEMENTATION IN THE DEFENSE MANAGEMENT SYSTEM OF THE MINISTRY OF DEFENSE OF UKRAINE, THE ARMED FORCES OF UKRAINE AND OTHER COMPONENTS OF THE DEFENSE FORCES OF UKRAINE

Modern challenges in the field of national security and defense require the Ministry of Defense of Ukraine to transition to a more efficient and transparent system of managing defense projects, programs and portfolios. Current practice is often characterized by fragmentation, insufficient coordination, and the lack of a unified approach to project planning and implementation. In order to solve these problems, it is proposed to implement the PPBE, which will combine strategic goals, programs and budgets into a single comprehensive plan. This approach is based on the principle that budgets are formed from programs, programs from requirements, requirements from tasks, and tasks from national security goals. The purpose of implementing PPBE is to ensure consistency of actions of all participants in the portfolio management process; increase; cost optimization and achieving the maximum effect from investments; ensuring openness and control over the portfolio implementation process; quick response to changes in the external environment and internal needs. PPBE provides for:

1. Development and use in daily activities of the Ministry of Defense of Ukraine of project management architecture – PPBE, namely: Capability Program and determine its structure; The list of capabilities, the order of their evaluation; procedure for short, medium and long-term planning; development and approval based on the results of project planning, project programs, project portfolios; budgeting of projects, project programs and project portfolios; monitoring and control of the state of implementation of projects, project programs and project portfolios.

2. Build the Defense Program Architecture based on existing organizational structures and functional groups of capabilities, in particular:

– institutional capabilities – the capabilities of the Ministry of Defense of Ukraine and the capabilities of the General Staff of the Armed Forces of Ukraine;

– operational, combat and special capabilities – capabilities of the Ground Forces of the Armed Forces of Ukraine, the Air Forces of the Armed Forces of Ukraine, the Naval Forces of the Armed Forces of Ukraine, joint intelligence (the Main Intelligence Directorate of the Ministry of Defense of Ukraine), the Command of the Logistics Forces of the Armed Forces of Ukraine, the Command of the Medical Forces of the Armed Forces of Ukraine, the Main Directorate of Communications and Cyber Security of the General Staff of the Armed Forces of Ukraine, the Airborne Assault Forces of the Armed Forces of Ukraine, the Special Operations Forces of the Armed Forces of Ukraine, the Territorial Defense Forces of the Armed Forces of Ukraine, the Command of the Support Forces of the Armed Forces of Ukraine, the State Special transport services of the Ministry of Defense of Ukraine, the Military Law and Order Service of the Armed Forces of Ukraine and the Unmanned Systems Forces of the Armed Forces of Ukraine;

– functional groups: formation of state policy; planning the development of troops (forces); command and control; intelligence; application; software; communication and information systems; protection and survivability. Areas of expenditure – weapons and military equipment, personnel, infrastructure, operational costs;

– functional groups (based on domains, organizational structures, functional groups), namely:

– institutional capabilities – the capabilities of the Ministry of Defense of Ukraine and the capabilities of the General Staff of the Armed Forces of Ukraine;

– combat and special capabilities – command and control (Command of the United Forces of the Armed Forces of Ukraine), conducting operations on land (Command of the Ground Forces of the Armed Forces of Ukraine), conducting operations in the air (Command of the Air Forces of the Armed Forces of Ukraine), conducting operations at sea (Command of the Naval Forces of the Armed Forces of Ukraine), special actions of the Special Operations Forces (Command of the Special Operations Forces of the Armed Forces of Ukraine);

– joint capabilities for operations (combat operations) – the capabilities of joint development (Main Development Directorate of the Ministry of Defense of Ukraine), logistics support, medical support (Command of the Medical Forces of the Armed Forces of Ukraine), communication and information systems (Main Directorate of Communications and Cyber Security of the General Staff of the Armed Forces of Ukraine), preservation of combat capability of troops (forces) and destruction of the effectiveness of enemy troops (forces) and weapons (Command of Support Forces of the Armed Forces of Ukraine), contribution to public safety (Military Law and Order Service of the Armed Forces).

3. The architecture of project and program management through portfolios provides for the following portfolio types and portfolio management functions. Types of portfolios: portfolios of projects, types of project programs (individual branches, commands, forces); portfolios of weapons and military equipment; infrastructure portfolios; ITC portfolios. Functions of portfolio management: provision, redistribution, balancing of resources between projects to achieve goals within the framework of priorities; analysis, monitoring, control, evaluation of the status of project implementation; compliance with the methodology; requirements for the system of training Managers of projects, programs, portfolios; integrity, timeliness, reliability of data, their processing in modern information systems; determining the effectiveness of resource management at all stages of project implementation, project programs and project portfolios; analysis, monitoring of the influence of interested parties.

4. The architecture of project planning and development involves their creation, development and execution, disposal. Planning using the methodology (DOTMLPFI) involves: work planning; resources; their value; performers; budget by category (personnel, weapons and military equipment, infrastructure, operation).

5. Architecture of capabilities of types, branches of troops, commands. Building programs based on the organizational structures of the Armed Forces of Ukraine, rather than domains (air, land, water) and functional groups.

Planning stage:

– a report on conducting a defense review;
– national security strategy of Ukraine;
– military security strategy of Ukraine;
– unified operational concept;
– strategy for the development of the Armed Forces of Ukraine;
– bilateral capacity development plan;
– strategy for the development of types, types of troops (forces).

Therefore, modern challenges in the field of national security and defense require the Ministry of Defense of Ukraine to transition to a system of managing defense projects, programs and portfolios based on the principles of efficiency, transparency and coordination. The existing fragmentation and lack of a unified approach to project planning and implementation become an obstacle to achieving strategic goals. Implementation of the system of planning, programming, budgeting, implementation and evaluation will contribute to ensuring the coherence of actions, optimizing costs and achieving the maximum effect from investments. This approach will allow not only to increase the efficiency of project management, but also to ensure openness and control over the processes of implementation of defense programs. Summarizing, the PPBE implementation in the Ministry of Defense of Ukraine will be a key step in strengthening the country's defense power and ensuring national security in the face of modern challenges and threats.

2.2.2 IDENTIFICATION OF THREATS AND DEVELOPMENT OF RECOMMENDATIONS FOR THE IMPLEMENTATION OF PORTFOLIO MANAGEMENT IN MILITARY ADMINISTRATION

The current state of the defense sector of Ukraine is characterized by significant challenges that require a complex and systematic approach to solving them. The defense sector of Ukraine, like many other spheres, inherited certain features of management from the Soviet system. However, modern realities require flexibility, innovation and transparency from the military administration. Let's analyze in more detail the key problems that hold back the development of the defense sector.

One of the most acute problems is the systematic underfunding of the defense sector. This leads to outdated weapons, the lack of modern technologies and the inability to respond to changes in the security situation in a timely manner. Initiatives for early response are not funded on time and in full, current changes are made to the Development Management Plan or the Indicative Development Management Plan, which make it impossible to carry out consistent continuous work on projects or programs, lack of implemented processes of economic analysis of the effectiveness of spending funds and decisions made in time. In addition, the insufficient financial support of military personnel led to a shortage of qualified personnel in the defense sector. During the time of independence, the Ministry of Defense of Ukraine, the Armed Forces of Ukraine and other components of the defense forces did not prioritize the development of institutional capabilities, namely the development of the management system and the human capital (resources) management system. Due to the lack of clear career planning and an insufficiently developed motivation system, military administrations face the problem of losing qualified specialists. There are no calculations of the cost of training and maintenance of a specialist, the cost of its loss and/or inappropriate recruitment. As a result, low efficiency of project and program management, difficulties in adapting to new technologies, and high staff turnover.

It is worth defining such a problem as the lack of modern information systems. In recent years, the Ministry of Defense of Ukraine and the General Staff of the Armed Forces of Ukraine have been implementing a system of monitoring and control over project activities based on Microsoft Project Server. The implementation is slow as a result of the lack of a single protected branched ITC, the difficulty of accessing the already created protected circuit of project activity participants, the lack of appropriate computerized workplaces and the compliance of the system with strict requirements for access to consolidated information according to the requirements of the List of Information of the Ministry of Defense of Ukraine, which contain official information [12] and the Compendium of State Secret Information [13].

Corruption is a serious problem in the defense sector. It manifests itself in various forms, such as kickbacks, bribes, promotion of non-competitive contracts and misuse of budget funds [14]. According to Transparency International, the global amount of corruption fraud in the defense industry is about 20 billion dollars per year [15]. Non-transparency and inefficiency of procurement: Corruption schemes lead to the fact that contracts are awarded not to companies that offer the best terms, but to those that are willing to pay higher "kickbacks". As a result, the purchase of low-quality equipment, inflated prices and delays in deliveries. Moreover, the political aspect of corruption can influence the choice of portfolio components, contractors and the allocation of budget funds, which will lead to the implementation of ineffective projects or programs that do not meet the real needs of the Armed Forces of Ukraine. In addition, there is often a conflict of interest when officials who make decisions about procurement and projects have a personal interest, which inevitably leads to corruption. Corruption schemes often lead to delays in approval and contracting procedures, which delays the implementation of projects or programs and reduces their relevance. Corruption scandals undermine citizens' trust in state institutions, which makes it difficult to carry out reforms and modernize the country's defense sector. Corruption demotivates honest employees and encourages corrupt behavior, which leads to an outflow of qualified personnel and a decrease in overall work efficiency.

We consider it necessary to outline such a threat to the implementation of portfolio management as a post-Soviet corporate culture. Corporate culture is an important aspect of enterprise management, which determines values, norms of behavior and common approaches within the organization. Let's consider some key aspects of post-Soviet corporate culture [16]:

– decision-making based on data, not on the basis of reliable relationships/trust;

– the attitude towards mistakes is not punishment, but work on the gained experience and aiming at improvement;

– measuring the effectiveness of spending budget funds as taxes paid by citizens of the country;

– openness and transparency of reporting and corresponding communication with society.

For the successful development of the defense sector of Ukraine, it is necessary to carry out complex reforms aimed at overcoming existing problems. This requires joint efforts by the state, civil society and international partners. Significant results in strengthening the country's defense capabilities can only be achieved under the condition of effective fight against corruption, modernization of the management system and provision of sufficient funding. Implementation of portfolio management in the defense sector of Ukraine is a complex and multifaceted process that requires significant resources and overcoming a number of obstacles. Let's offer the following recommendations for its successful implementation:

1. Development of the regulatory framework, organizational and administrative documents on portfolio management:

– issuance of an order of the Ministry of Defense on the implementation of portfolio management;

– development of the procedure for the formation of project portfolios, planning and management of financial resources;

– determination of success indicators, procedures for evaluating the effectiveness of the project portfolio, the procedure for monitoring and controlling the implementation of project programs and programs;

– creating a system of forecasting, studying and overcoming risks in portfolio management, documenting and implementing the acquired experience;

– development of documentation templates for portfolio management and making changes to the methodology and templates of program and project management;

– determination of the order of interaction with external and internal interested parties;

– development and approval of the Methodology after the "pilot" implementation of the military standard for project portfolio management.

2. Creation and reorganization of project portfolio management functions by:

– determination of the main requirements for the prospective organizational structure of project portfolio management within the framework of defense programs;

– analysis of the organizational structure of project management, project programs and portfolios;

– development and implementation of a list of typical positions, military accounting specialties, states, staff lists of portfolio management units in the Ministry of Defense of Ukraine, the General Staff of the Armed Forces of Ukraine and other military management bodies in the system of the Ministry of Defense of the country;

– development of criteria for selecting candidates for positions in portfolio and program and project management;

– development of a phased plan for the implementation of a new project portfolio management structure;

– carrying out an assessment of the portfolio management activity of structural subdivisions based on established KPIs.

3. Improving the qualifications of personnel by:

– assessment of the competences of the personnel of the structural divisions involved in the management of project portfolios in order to identify gaps in knowledge, skills and abilities;

– professional development of teachers in program and project and portfolio management;

– inclusion in the training programs of masters of military administration, L3, L4 and L5 courses of the project portfolio management section;

– development of course training programs and inclusion of courses for training specialists in project portfolio management in the Catalog of advanced training courses (retraining, retraining) in higher military educational institutions, military educational units of higher education institutions and institutions of professional pre-higher military education;

– conducting trainings and seminars with qualified specialists and experts in the field of project portfolio management;

– ensuring staff access to online resources, educational platforms, electronic libraries, webinars and other forms of self-education.

4. Organization of providing the portfolio of projects, programs and individual projects with the necessary resources by:

– determination of the types of resources necessary for the implementation of projects and project programs (human, financial, material, informational);

– creation of a register of priority portfolio projects to provide them with resources, including supply and distribution schedules;

– implementation of methods for optimizing the use of resources, such as joint use, redistribution and cost minimization;

– development of a control system for the use of financial resources to prevent overspending and inefficient use;

– development of effective personnel management systems, including motivation, division of duties and evaluation of work efficiency;

– implementation of information systems and software for project management and monitoring the use of resources;

– assessment of the effectiveness of resource use after completion of programs, projects and individual projects, analysis of experience gained and improvement of management processes.

5. Development of leadership qualities in managers of individual projects, programs and project portfolios by:

– determination of directions for the development of leadership skills in the short-term and long-term perspective;

– conducting trainings, seminars, webinars on the main aspects of leadership, such as strategic thinking, change management, socio-psychological management skills, effective communication and team motivation;

– conducting activities to improve interaction and team spirit among managers and their teams;

– conducting regular assessments of progress in the development of leadership skills with the help of surveys, tests and feedback;

– facilitating the participation of portfolio and project managers in professional conferences and seminars for the exchange of experience and knowledge.

6. Attracting and retaining qualified personnel by:

– formation of requirements for personnel, programs and courses for the training of specialists by positions in the planning, programming, budgeting, implementation (hereinafter – PPBE) in educational institutions of the Ministry of Defense abroad (in military educational institutions of the partner countries of the North Atlantic Alliance);

– creation of a motivational package for further service for those who received education abroad in the management of PPBE processes;

– implementation of rotation of portfolio management specialists;

– implementation of international internship practice;

– creation of a database of project portfolio management specialists.

7. Creation and modernization of infrastructure for portfolio management by:

– implementation of specialized software products, such as Microsoft Project, Microsoft Project Server and for effective management of projects and project portfolios;

– organization of trainings for personnel in order to improve their knowledge and skills in using specialized software products;

– provision of constant technical support and consultations for users of new information systems and tools;

– creation of a single database for storing information about projects and portfolios with the possibility of quick access and updating;

– use of analytical tools for data processing and analysis, which allows making informed management decisions.

8. Establishing interoperability within the framework of project portfolio management by:

– use of a single IT platform for project portfolio management;

– implementation of uniform standards and methodologies for managing a portfolio of projects and projects to ensure a unified approach to their management;

– development and use of unified templates for planning, reporting and documentation of projects and project portfolios, which contributes to consistency and comprehensibility of processes;

– organization of meetings of managers and members of project teams to exchange experience and information.

Thus, the result of the implementation of portfolio management will be the establishment of a system of coordinated management of project activities at the level of portfolio management within the framework of defense programs of the Ministry of Defense of Ukraine, the General Staff of the Armed Forces of Ukraine, the commands of the Armed Forces of Ukraine, the Main Directorate of Intelligence of the Ministry of Defense of Ukraine, the State Service of Special Transport of the Ministry of Defense of Ukraine and in the future other components of the defense forces of Ukraine.

Let's consider it expedient that the indicators of such implementation will be:

– regulatory framework (orders, doctrines, regulations, methods, military standards) for portfolio management;

– portfolio management system with detailing of functions at operational and strategic levels in the system of the Ministry of Defense of Ukraine;

– the organizational structure of managing and coordinating the management of portfolios of projects and programs;

– entry into the list of military accounting specialties of officers of the military accounting specialty;

– passports of portfolio management positions;

– a system of professional and course training for portfolio management of projects and programs;

– changes to educational programs and training courses for personnel to manage portfolios of projects and programs;

– personnel policy with recruitment, retention, conditions of vertical and horizontal rotation of involved qualified personnel;

– informational support of processes and communication for the implementation of projects and programs for portfolio management.

Therefore, the implementation of portfolio management in the defense sphere of Ukraine is strategically important and necessary for increasing the efficiency and transparency of management. The results of the implementation will be reflected in the creation of a legal framework, improvement of organizational structures, improvement of staff qualifications, provision of necessary resources and implementation of modern IT tools. This will contribute to the strengthening of defense readiness and ensure the achievement of the strategic goals of Ukraine's national security in the face of modern global challenges.

CONCLUSIONS

The implementation of portfolio management in the defense sector of Ukraine is a strategically important step for increasing the efficiency of resource use, achieving national security goals, and strengthening the country's defense capabilities. For the successful implementation of portfolio management, it is necessary to apply a comprehensive approach that combines various scientific and theoretical approaches, such as strategic, system, project, process-oriented, risk management and focus on results. Each of these approaches has its advantages and complements each other. The strategic approach ensures the consistency of the portfolio with national goals, the systemic approach allows to consider the portfolio as a single system, the project approach focuses on the implementation of individual projects, the process-oriented approach ensures the effectiveness of processes, risk management minimizes negative consequences, and the focus on results guarantees the achievement of set goals. In addition, it is proposed the use of such methods as capability analysis, cost-benefit analysis, project priority matrix, value-complexity ratio matrix, what-if scenario analysis, and others. These methods allow to make informed decisions about portfolio formation, project prioritization, resource allocation, and results monitoring.

The implementation of portfolio management in the defense sector of Ukraine is a complex and multifaceted process, the result of which will be the creation of an effective management system that will optimize the use of resources, increase transparency and accountability, as well as ensure the achievement of strategic national security goals. That is why it is proposed the implementation of a model of planning, programming, budgeting, implementation and evaluation in the defense sector of Ukraine as a strategically important step to increase the efficiency of defense project and program management. This model will overcome the existing problems of fragmentation, lack of coordination, and lack of a unified approach to project planning and implementation, which are characteristic of the modern defense management system. PPBE will ensure consistency of actions of all participants in the portfolio management process, optimization of costs and achievement of the maximum effect from investments. The implementation of this system will contribute to increasing transparency and control over the processes of implementation of defense programs, and will also ensure a quick response to changes in the external environment and internal needs. Moreover, the recommendations outlined by us for the implementation of portfolio management into the defense management system will contribute to: increasing the efficiency of the use of resources for the performance of tasks for the development of capabilities defined by defense planning documents through their rational distribution and optimization to achieve the maximum effectiveness of projects; manageability and effectiveness of the implementation by the structural divisions of the Ministry of Defense of Ukraine, the General Staff of the Armed Forces of Ukraine and other military administration bodies, the State Special Transport Service of the Ministry of Defense of Ukraine, tasks and measures of defense program projects and portfolios of projects on the development of personnel, weapons and military equipment, provision of material and technical means, infrastructure, ensuring the conduct of hostilities; economic substantiation of the results of achieving the benefits of programs and portfolio projects, risk control; transparency and openness in decision-making by improving communication with interested parties and ensuring their trust in portfolio management; effectiveness, transparency and manageability of capacity development management.

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CHAPTER 3

DEVELOPMENT OF INNOVATIONS IN THE FIELD OF MILITARY COMBAT AT SEA

ABSTRACT

The relevance of the issues highlighted in this section is primarily related to the insufficiency of research on the development of asymmetric means of combat at sea in the conditions of overwhelming enemy forces, first of all, maritime unmanned systems (apparatus) and unmanned aircraft systems, as well as peculiarities of managing their creation and development.

The experience of combat operations at sea during the Russian-Ukrainian war proved that thanks to the use of modern technologies, Ukraine was able to turn the tide of the war in the Black Sea and dislodge the Russian Black Sea Fleet from the occupied Crimea. Using maritime unmanned systems (apparatus) and unmanned aircraft systems in the strike version, the Defense Forces of Ukraine destroyed or damaged more than (about three) two dozen enemy ships and boats, as well as damaged a number of port facilities. At the same time, before the beginning of the full-scale aggression of the Russian Federation against Ukraine, the development of unmanned maritime systems (apparatus) was not foreseen at all. The first samples of these complexes were created only in the summer of 2022 on an initiative basis, and already in November of the same year, the creation of the world's first "fleet of maritime (sea) drones" was announced. And if at the initial stage their development took place decentralized, by the efforts of various departments, in the version of "unmanned brander", then in the future complexes with various weapons (reactive volley fire systems, sea mines, etc.) were developed, and the range of their tasks expanded significantly. Therefore, for the more effective development and use of maritime unmanned systems (apparatus), there was a need to create a separate type of troops within the Armed Forces of Ukraine with corresponding functions – the Forces of unmanned systems.

The object of research is maritime robotic systems. The subject of research is the development of maritime robotic systems in the interests of performing tasks with the Defense Forces of Ukraine. The results of analytical research on the development of maritime robotic systems, primarily maritime unmanned systems (apparatus), are highlighted, which made it possible to identify trends and directions for their further development, as well as to identify the peculiarities of managing their creation and development.

KEYWORDS

Maritime robotic system, situational awareness and intelligence system, maritime unmanned complex, unmanned surface vehicle (USV), unmanned aircraft complex, development, combat at sea, asymmetric actions at sea.

As it is known, achieving success in the fight against the enemy largely depends on the chosen strategy and available forces and means. In the conditions of the Russian-Ukrainian war at sea, taking into account the significant advantage of the enemy in general military capabilities, an important factor is the use of asymmetric methods and means of influence. One of these tools is, of course, robotic, autonomously operating, unmanned aerial systems (UASs) and unmanned surface and subsurface systems (complexes). In the conditions of the armed aggression of the Russian Federation (RF) against Ukraine, the conduct of asymmetric actions at sea has acquired diversity in the application of both technical means and specific forms of application.

At the same time, the analysis of the conduct of combat operations at sea during the full-scale armed aggression of the Russian Federation against Ukraine indicates that the use of classic forms of employment of ships of the Naval Forces (Navy) of the Armed Forces (AF) of Ukraine led to losses among personnel and ships. In the course of hostilities in 2022, the enemy destroyed the "Slovyansk" patrol boat, amphibious assault boat "Stanislav", the minesweeper "Genichesk" [1–3]. This led to the maximum limitation of the ships employment in the future during combat operations at sea.

A person, his/her life and health, honor and dignity, inviolability and security are the highest social value in Ukraine. Implementation of this norm of the Constitution of Ukraine is the main goal of the national security policy [4].

In the conditions of the unprecedented spread of information and robotic technologies in the world, it was Ukraine in the conditions of the Russian-Ukrainian war that achieved intellectual superiority (intellectual leadership) over the enemy, which ensured the success of operations at sea.

One of the ways to implement the main goal of the state policy of national security in the war at sea is the use of unmanned sea vehicles (USV), which allows personnel to be in places protected from enemy attacks, thereby not risking their own lives and health during hostilities.

Therefore, the issue of preserving the life and health of servicemen of the Defense Forces of Ukraine (DFU) in confrontation with the enemy through the USV, which allows to prevent losses among personnel during the armed struggle at sea and inflict maximum losses on the enemy, is relevant.

3.1 ANALYSIS OF REGULATORY ACTS ON THE DEVELOPMENT OF THE NAVY OF THE ARMED FORCES OF UKRAINE IN THE PART RELATED TO MARITIME ROBOTIC SYSTEMS

As a result of the occupation of the Crimean Peninsula in the spring of 2014, the Navy of the Armed Forces of Ukraine lost more than 80 % of their assets and capabilities. In the future, the Armed Forces of the Russian Federation continued to conduct actions at sea aimed at causing economic damage to Ukraine by hindering its maritime activities. Thus, in March 2014, units of the Armed Forces of the Russian Federation established control over Ukrainian gas production facilities on the shelf of the Black and Azov Seas, and in 2018, the Russian Federation began conducting actions to obstruct commercial shipping to Ukrainian ports of the Sea of Azov. The need to counter the armed aggression of the Russian Federation from the sea, to return control over the captured territories and water areas, to ensure the protection of the state's national interests at sea required the restoration of the relevant naval capabilities of the Navy of the Armed Forces of Ukraine in the shortest possible time. At the same time, Ukraine did not have the appropriate financial resources to create in the short- and medium-term perspective a fleet comparable in terms of quantity and quality to the Black Sea Fleet of the Russian Federation. The aforementioned required finding ways to achieve parity at sea with the enemy by adopting samples of weapons and military equipment within the framework of the allocated financial resource for the development of the Navy of the Armed Forces of Ukraine to conduct asymmetric operations, including maritime robotic systems (MRS). The analysis of the directions of development of samples of naval weapons of the leading maritime countries shows that in the specified period there was an active development of the above-mentioned systems [5–14]. As the subsequent experience of the Russian-Ukrainian war at sea in 2022–2024 proved, they became one of the most effective means for conducting asymmetric actions at sea.

In order to study the trends in the development of innovations in the field of military combat at sea after the beginning of the armed aggression of the Russian Federation against Ukraine in 2014, in particular, in relation to the creation of the Armed Forces of Ukraine, an analysis of the relevant regulatory and legal acts on the development of the Armed Forces of Ukraine that were developed (existing , in which changes were made), in the chronological sequence of their development (clarification).

One of the first documents that determined the views on the development of the Navy of the Armed Forces of Ukraine after the beginning of the armed aggression of the Russian Federation against Ukraine for the long term was the "Strategy of the Naval Forces of the Armed Forces of Ukraine 2035" [15]. According to the specified document, in the period up to 2035, a gradual (in three stages) expansion of the naval capabilities of the Navy of the Armed Forces of Ukraine is planned, taking into account forecasted threats, economic opportunities and development priorities. At the first stage (until 2025), the development of capabilities to ensure control over the territorial waters of the state and beyond them (up to 40 nautical miles from the coast) is envisaged. At this stage, the main priority was the creation of a situation awareness system in the near sea zone with the aim of timely detection of the enemy and its intentions, providing information on a real time scale to all components of the defense and security forces of the state, ensuring the mutual exchange of information with NATO member countries and other partner countries, the second priority is the formation of the ability to prevent enemy actions in the near sea zone, the third is the acquisition of the ability to effectively control coastal waters, rivers and protect the state's ports. At the second stage (from 2025 to 2030), the development of capabilities to ensure the protection of Ukraine's national interests at sea within the exclusive (maritime) economic zone of Ukraine is envisaged. At this stage, the main priority remains the system of situational awareness and intelligence, the second priority is the provision of effective control of the water area in the air, surface and underwater areas within the exclusive (sea) economic zone of Ukraine for a specified period of time, the third is the formation of capabilities for the destruction of objects enemy at long range. In the third stage (from 2030 to 2035), the further development of the capabilities acquired during the first and second stages, their expansion to protect the national interests of Ukraine in the world ocean is foreseen. At this stage, the main priority is the acquisition of the ability to ensure the effective control of a certain area of sea water in the zone of interests of Ukraine together with the naval forces of NATO member countries and partner countries, the second priority is building up the ability to inflict a given degree of damage on enemy objects as at sea as well as on land, the third is the formation of capabilities to limit any actions of the enemy, including the prevention of the possibility of deploying its forces to carry out an act of aggression from the sea direction. At the same time, in equipping the Navy of the Armed Forces of Ukraine with weapons and military equipment, priority was supposed to be given to surface forces, which should be able to perform tasks of controlling the water area, and the execution of tasks to destroy enemy objects was supposed to be carried out using high-precision weapons (anti-ship missile systems) of ships, shore and aviation based [15]. Acceptance of MRS into the Navy of the Armed Forces of Ukraine was not considered by the specified document.

The next normative legal act, which determined the directions of the development of the naval potential, was the Resolution of the Cabinet of Ministers of Ukraine dated December 18, 2018 No. 1108 "On Amendments to the Naval Doctrine of Ukraine for the Period Until 2035" [16]. Thus, the main directions of its development in the part related to the adoption of samples of weapons and military equipment into the combat composition of the Navy of the Armed Forces of Ukraine included the construction of modern ships (boats), aircraft of naval aviation, anti-ship complexes of sea, air and shore bases. At the same time, one of the directions of strengthening the forces and means of the Navy of the Armed Forces of Ukraine and the Costal Guard of the State Border Service of Ukraine in the Sea of Azov is defined as the creation of the necessary military potential in peacetime and a special period, including at the expense of multi-purpose small-sized surface platforms, in particular unmanned and unmanned aerial vehicles.

Another document that defines promising ways of development of the Navy of the Armed Forces of Ukraine is the "Doctrine of the Naval Forces of the Armed Forces of Ukraine" [17]. This document envisages the development of the Naval Forces of the Armed Forces of Ukraine in accordance with the stages and priorities defined in [15]. At the same time, promising directions for the development of weapons and military equipment were determined:

– maritime component – building up the ship fleet by building (purchasing): multi-purpose ships of the "corvette" class, missile boats, landing ships, patrol ships and boats, unmanned subsurface vehicles (USSV) of various purposes, auxiliary vessels of various purposes, carrying out modernization and planned repairs warships, boats, and auxiliary vessels of the Navy of the Armed Forces of Ukraine and other components of the security and defense sector; revival of underwater and minesweeping forces; creation of the Unified system of coverage of the situation at sea;

– coastal component – equipping coastal military units (subunits) with the latest weapons, in particular – coastal antiship missile complexes;

– aviation component – ensuring airworthiness and modernization of the existing fleet of naval aviation aircraft; development of a patrol aircraft; purchase of specialized helicopters; equipping military units (subunits) with reconnaissance unmanned aerial systems [17].

Thus, this document provided for the construction (procurement) of a number of MRS for the needs of the Navy of the Armed Forces of Ukraine, namely, UUV for various purposes, as well as unmanned aerial systems (UAV) in the reconnaissance version.

The next legal act that determined the ways of development of the Defense Forces of Ukraine, including the Navy, was the "Military Security Strategy of Ukraine" approved by the Decree of the President of Ukraine dated March 25, 2021 No. 121/2021 [18]. This document provides for the use of the DFU in the course of ensuring the military security of the state of the latest high-tech and highly effective means of armed struggle, in particular, the production and equipping of the DFU with modern weapons, military and special equipment, provision of means of attack, including unmanned and robotic ones.

Approaches to the MRS development at sea changed radically only after the full-scale armed aggression of the Russian Federation against Ukraine and the successful experience of their use against enemy forces in the Black Sea. Thus, at the beginning of 2023, the Decree of the President of Ukraine dated 06.02.2023 No. 51/2024 was issued regarding the creation in the structure of the Armed Forces of Ukraine of the Forces of Unmanned Systems as a separate type of forces [19] with the aim of increasing their capabilities in relation to the use of unmanned and robotic air, sea and land systems, ensuring readiness for use of such systems as intended. At the same time, according to information from open sources, it is known that in August 2023, a separate brigade was created within the Navy of the Armed Forces of Ukraine for the USV use [20]. The foreseen organizational measures in the system of the Armed Forces of Ukraine, which are aimed at improving the functions of generation and employment of units of unmanned and robotic air, sea and ground systems, testify to the understanding of the leadership of the state and the DFU of the role of the need to implement innovations in the field of military combat at sea, in particular, regarding the development and build-up MRS capabilities.

Separately, it should be noted that currently in Ukraine there is no legal framework regulating the production, certification, licensing, operation and application of MRS.

The analysis of the normative legal acts on the development of the Navy of the Armed Forces of Ukraine in the part that concerns the MRS shows that they take into account global trends regarding the use of the latest high-tech means of conducting armed combat at sea. However, the specified documents, developed (refined) before the beginning of the full-scale armed aggression of the Russian Federation against Ukraine, were mostly declarative in nature, without disclosing the role and place of the MRS in achieving the goals of the DFU use at sea, specifying the tasks that they can rely on, etc. At the same time, as a result of the successful use of unmanned naval and unmanned aerial systems against ships (boats), as well as enemy infrastructure facilities in the Black Sea, these issues were reflected in the relevant legal acts, which had a positive impact on the MRS development.

3.2 THE INFLUENCE OF THE THEATER (AREA) OF MILITARY OPERATIONS ON THE DEVELOPMENT OF MARITIME ROBOTIC SYSTEMS

The characteristics of the theater (area) of military operations are of great importance for the use of any forces and means, including USV. During the study of the characteristics of the theater (area) of military operations, this study examines the set of natural characteristics of the water area where the USV is used by the Defense Forces of Ukraine, namely the Black Sea.

Considered:

– general physical and geographical conditions (parameters of the theater, nature of the shores, topography of the bottom, straits, bays, and others);

– hydrometeorological conditions, which consist of meteorological (types of weather; air temperature and humidity; winds; fogs; visibility; radar observability; cloudiness and precipitation; local weather features; special meteorological phenomena) and hydrological (fluctuations in the water level) that vary in time and space and currents; water temperature and density; ice regime of ships [21].

The dimensions of the theater of war allow effective USV use.

The USV has a tactical range of up to 500 miles, which allows it to carry out the task of inflicting damage on enemy surface targets in the Black Sea.

The low, flat shores in the northwestern part of the Black Sea allow choosing up to 30 accessible places for launching USV into the water with the help of special equipment.

The shallow, flat relief of the bottom in the northwestern part of the sea allows the use of sea mines of various types in this area, setting them with the USV help.

Low temperatures in the northwestern part of the sea in the period December-March cause ice formation, which excludes the USV use in the coastal strip and especially in estuaries and rivers in case of their freezing, at the same time, such phenomena are observed quite rarely.

A change in temperature, high humidity causes condensation, which in turn causes fogging and corrosion.

Cloudiness, precipitation, fog also have a significant impact on the USV use, as they limit the operation of communication and video surveillance systems.

The high transparency of the atmosphere determines that visibility usually reaches the maximum natural limits (10–12 miles) [22]. This confirms the need to apply USV in the dark. The duration of the dark time is 7–14 hours.The nature of winds and waves have a distinct seasonal character. In winter, strong (4–7 points) and stormy (over 6 points) weather prevails, which prevents the USV use.

Great depths and small dismemberment of the shores with such winds cause strong agitation, both in open parts of the sea and in coastal areas.

Excitement above 3 points, which excludes the USV use, which can be expected in winter with a probability of up to 40 %.

In summer, the average wind speed does not exceed 3–4 points. The probability of storms does not exceed 10 %.

The nature of changes in water temperature and sound speed, water transparency, salinity and water density do not significantly affect the USV application.

In general, the physical and geographical conditions of the Black Sea favor the use of existing USV types by the Defense Forces of Ukraine. The exception is the winter period, due to excitement and the effect of low temperatures. This requires further improvement of their tactical and technical characteristics for the possibility of use in difficult weather conditions.

3.3 EXPERIENCE IN THE USE OF MARITIME ROBOTIC SYSTEMS DURING MILITARY OPERATIONS AT SEA

The experience of using unmanned systems (aviation, surface, ground) in real combat conditions is taken into account, and the results of the application analysis are implemented, both to improve the technical characteristics of the specified systems, and to improve the control system of unmanned systems. The development of modern unmanned aerial and surface systems was significantly influenced by the experience of their use during the armed aggression of the Russian Federation against Ukraine. From the first days of the full-scale invasion, the existing "Bayraktar TB-2" UAV were actively used to repel armed aggression, including in the Black Sea. In modern conditions, the successful combat experience of this complex was gained by Azeybardzhan during its military campaign in Nagorno-Karabakh [23]. In the sea direction, these complexes were mostly used for conducting reconnaissance and defeating small-sized ships and boats that do not have their own complexes and air detection means targets and air defense. For ships of the class of frigates, corvettes and those of their size, equipped with modern means of detecting and destroying air targets, the "Bayraktar TB-2 UAV" became an easy target when entering the affected zone. Therefore, their use was limited to the task of highlighting the situation in individual areas. The need for a further struggle for the sea and the lack of ships in Ukraine equivalent in class to the fleet of the Russian Federation in the Black Sea required an asymmetric response. In an initiative manner, several power structures began to develop and, most importantly, immediately implement USV projects that would be able to solve important tasks, namely, to end the dominance of the Black Sea Fleet of the Russian Federation in the Black Sea, or at least in its northwestern part. USV not an invention of the Ukrainian military and extremely complex engineering structures and are used all over the world: both in the military and in civilians, in particular for research purposes. In the fall of 2016, the private shipbuilding company "Unik Yachts" in the city of Mykolaiv presented the "Shadow" project USV, which according to the development strategy of the State Border Service of Ukraine as of 2020 was supposed to be in its arsenal for patrolling the coast [24].

Many countries use USV on water for patrolling, reconnaissance and mine clearance tasks. It's cheap and safe. For the first time, USV was used against a large warship by the Yemeni Houthi rebels, so in January 2017, the frigate of the Saudi Arabian Navy "Al-Madinah" was unexpectedly attacked by USV in the open sea. As a result of the incident, the ship was damaged, two sailors died. But the superiority in the use of USV in the Black Sea as a shock weapon in modern conditions belongs to the DFU. On October 29, 2022, in the Sevastopol Bay, the "Admiral Makarov" frigate and the "Ivan Golubets" minesweeper were successfully attacked by unmanned surface attack systems. There were probably attempts to use similar complexes earlier, because according to the Russian occupation authorities, on September 21, 2022, an unidentified USV was found on the coast of the city of Sevastopol, which was towed into the sea and destroyed by detonation by the forces of the Black Sea Fleet of the Russian Federation.

Taking into account the first success in the USV employment and their obvious cheapness compared to the targets they are capable of hitting, already in November 2022 the state leadership announced its intention to create a fleet of Ukrainian-made USV. However, a centralized management system for the creation, testing and application of unmanned surface systems and unmanned systems in general, such as the Defense Advanced Research Projects Agency (DARPA) in the US Department of Defense or the State Administration of Defense Science, Technology and Industry (SASTING), as in China, has not been established. Each structure followed its own path and obtained results in the struggle for the sea, creating units and a system for managing this process independently.

The Navy of the Armed Forces of Ukraine, which at the end of 2021 received the "Bayraktar TB-2" UAV, actively used them at the beginning of the full-scale invasion and, according to information from open sources, using this complex, they attacked and destroyed or damaged seven Russian boats in the Black Sea. Of them, there are four patrol boats of project 03160 "Raptor", one patrol boat of type KS-701 "Tunets", one landing boat of project 02510 "BK-16", one landing boat of project 11770 "Serna" with an anti-aircraft missile system on board. Undoubtedly, the "Bayraktar TB-2" UAV was and is involved in carrying out the tasks of covering the situation on the Black Sea, but there are no open data on the number of objects detected with their help, and even more so on the damage inflicted. Nevertheless, these are the first unmanned systems that came to the defense of the Black Sea with the beginning of the military aggression of the Russian Federation against Ukraine [25].

The next step in the application of unmanned systems at sea was the USV creation. Thus, the Security Service of Ukraine (SSU) together with the Navy of the Armed Forces of Ukraine and private companies worked on the USV creation in the summer of 2022. Later, the SSU made public information about the independent creation of the "Sea Baby" USV. With great probability, it can be stated that according to the USV, the Sevastopol Bay was attacked in November 2022 and three vessels of the Black Sea Fleet of the Russian Federation were damaged. In 2023, "Sea Baby" USV was transformed into a universal platform with various functions. They successfully attacked the Crimean Bridge in July 2023, destroying one span and damaging the bridge support, as well as nine more ships and vessels of the Black Sea Fleet of the Russian Federation during 2023. In May 2023, the medium reconnaissance ship of project 18280 "Ivan Khurs" was attacked and damaged in the Black Sea, in August 2023 – the large amphibious ship of project 775 "Olenegorsky Gornyak", the anti-sabotage boat of project 21980 "Grachonok" near the Novorossiysk naval base, and in the Kerch Strait – Project 52 "Sig" oil tanker. Near the city of Sevastopol, in the sea, a small project 1239 "Samum" hovercraft and a project 22160 "Serhiy Kotov" patrol ship were attacked and damaged in September, and in October – the SB-565 "Professor Mykola Muru" rescue tugboat, patrol the ship of the project 22160 "Pavlo Derzhavin" and the hydrographic boat of the project 23040 "Volodymyr Kozytskyi", which performed the task of searching for mines near the city of Sevastopol. In this way, the structural divisions of the Security Service of Ukraine, following their own path, created USV, improved and successfully implemented their application in the Black Sea.

The Main Intelligence Directorate (MID) of the Ministry of Defense of Ukraine (MDU) followed a similar path, albeit with a slight delay in time. The creation of "MAGURA V5" USV became known during its demonstration at the International Defense and Industrial Exhibition, which was held in the city of Istanbul in July 2023. However, we had to wait a few more months for confirmation that this was indeed an active USV. The combat use of "MAGURA V5" became known in November 2023, when two Russian amphibious boats stationed at the Black Sea base of the temporarily occupied territory of the Autonomous Republic of Crimea were attacked and destroyed. It was one landing craft of project 11770 "Serna" with an armored personnel carrier on board and landing craft of project 1176 "Akula". Already in January 2024, the missile boat of the project 1241.1 "Ivanovets" was hit by the MID using the "MAGURA V5" USV and sank as a result. The next target of "MAGURA V5" USV in February of the same year was the large amphibious ship of project 775 "Cesar Kunikov" near the city of Alupka, as a result of which it sank. In March, the patrol ship of project 22160 "Serhiy Kotov", which was on patrol in the Kerch Strait, was sunk. Attacks on Vuzka Bay in Crimea and the Crimean Bridge area in May and June 2024 destroyed two patrol boats of the KS-701 "Tunets" type, the project 12150 patrol boat "Mongoose" and the project 498 tugboat "Saturn" [26].

Therefore, from the beginning of the armed aggression due to the threat of attacks by the USV, the fleet of the Russian Federation in the northwestern part of the Black Sea was forced to stop military activities such as patrolling, sea transportation, significantly reduced the conduct of reconnaissance with the use of ships, and was also forced to relocate the main forces of the fleet to the Novorossiysk naval base and build a new base in Ochamchira (Abkhazia). A positive consequence for Ukraine was the restoration and increase of sea transportation in the Black Sea from the ports of Odesa.

Out of all the destroyed and damaged ships, boats and vessels of the Russian Federation, and this number is 60 units, USV accounted for half of them, while it should be noted that the greatest successes in destroying enemy watercraft were achieved by "MAGURA V5" USV. This is confirmed by the statement of the deputy commander of the NATO Joint Forces Command, Rear Admiral Timothy Henry, in his interview on June 29, 2024. After all, if to compare the technical characteristics, from open sources, of USV, then with almost the same dimensions, both complexes have a length of about 5.5 meters, and a width of 1.5 meters, but the larger warhead of the "Sea Baby" is from 450 to 850 kilograms compared to "MAGURA V5" – up to 320 kilograms, then the mass of the warhead is not a decisive factor when the ship is destroyed. It is logical to assume that such a factor is the number of USV involved in the attack, or the choice of the place of damage to the ship [27–30].

In addition to the above-mentioned USVs, the power structures of Ukraine, together with the enterprises of the defense-industrial complex (DIC), carry out the development and production of about eighteen UAVs, three USVs In addition to the already known "Sea Baby" and "MAGURA V5", in 2024 the Navy of the Armed Forces of Ukraine in the city of Odesa at the security forum in the Black Sea region "Black Sea Security Forum 2024" presented a new development, namely USV, which was named "Stalker 5". The cost of this project is 60 thousand EUR, USV, which has a range of up to 600 kilometers, a gasoline engine allows to develop a speed of about 75 kilometers per hour, a length of 5 meters and a width of 1.2 meters. The warhead has a mass of 150 kilograms. And the complex itself is a platform that can be used both in the strike version and for the performance of other tasks: logistics, reconnaissance, patrolling [27].

At the same time, at the conference on the defense cluster "Brave1", USV of three models were presented: "Toloka TLK150", "Toloka TLK 400", "Toloka TLK 1000". It is obvious that this development will increase the capabilities of the DFU in the Black Sea to attack surface ships of the Russian Federation, and possibly submarines.

Such a number of unmanned systems definitely requires their systematization. First of all, it is necessary to summarize the experience of their creation and development, the experience of application and also the development of directions for further development. It is necessary to understand that the enemy does not stand still. In addition to creating its USV, it is creating and improving a defense system against attacks from the sea. It is necessary to take this into account in the further development of unmanned systems and to improve not only their technical component, but also the methods of application. Such a complex issue can be solved only by combining the efforts of various structures that participate in the process of creating and using unmanned systems under a single leadership. Expanding the functionality of unmanned systems only pushed the country's leadership to create a new type of forces in the structure of the Armed Forces of Ukraine – the Forces of Unmanned Systems. The creation of such a command made it possible to turn the "Army of Drones" project into a state institution that will deal with its implementation. In essence, this command must accumulate all experience, as well as establish a system of obtaining experience directly from the battlefield for a timely response to both technological changes and the tactics of using robotic systems.

It will definitely be interesting for further development to take into account the experience of the world's leading countries in applying USV. For example, the US is already deploying unmanned boats to monitor the enemy's actions at sea. So, for example, in October 2023, USV took part in an operation to track Iranian warships in the Strait of Hormuz.

China developed the USV of the L30 project, which it demonstrated in 2022. The Chinese army used this boat several times during landing exercises, when approaching the landing bridge, the amphibious assault ships launched USV, which followed the shore, identified and destroyed obstacles, thus clearing the way for the ships.

In 2017, the Israeli Navy deployed the Seagull project USV to intercept enemy boats and protect its coastline.

Thus, today there is a tendency to create USV-based universal platforms that are capable of performing the entire range of tasks that rely on surface and underwater ships and boats.

3.4 DEVELOPMENT OF MARITIME ROBOTIC SYSTEMS BASED ON THE EXPERIENCE OF THE RUSSIAN-UKRAINIAN WAR AT SEA

The experience of the Russian-Ukrainian war at sea showed that the USV due to the ease of manufacture, low cost compared to warships and boats and, as a result, the possibility of their mass production, have now taken a dominant position in the fight against enemy surface ships. As mentioned above, the defense-industrial complex of the state in the interests of the Defense Forces of Ukraine has developed and continues to develop samples of maritime robotic systems in recent years.

The development of maritime robotic systems developed for the needs of the Defense Forces of Ukraine during the Russian-Ukrainian war is considered below, and the main trends in their development are determined.

Ukraine uses a rather innovative approach in the application of maritime robotic systems, in particular, USV. Most of the countries of the world currently use these devices for reconnaissance and search purposes, but it was Ukraine that used USV equipped with an explosive substance to damage enemy warships and support vessels, as well as sea and coastal facilities of its infrastructure.

The first recorded case of the USV use by Ukraine was its detection by the enemy on one of the beaches of the city of Sevastopol on September 21, 2022. At the time of discovery, it was unknown who owned this device, who was its manufacturer and its purpose. It was equipped with a Starlink antenna, a camera on the stern, as well as other sensors and lighting devices. It has been speculated that this is a semi-submarine that can submerge and stay under water for some time. It has been assumed that this is a reconnaissance USV, but with the possibility of being equipped with ammunition and using it as a floating bomb. Some experts suggested that the sensors on the front of the ship could be used as a laser target detection system. It has been also suggested that this USV is one of the coast guard systems that the USA handed over to Ukraine in April 2022 [31].

The main components of USV discovered in the city of Sevastopol (**Fig. 3.1**).

At the same time, the reason why the USV attack on the ship of the Black Sea Fleet of the Russian Federation on September 21, 2022 was foiled was the shutdown of the Starlink satellite system, which was used to control the device, on the instructions of the owner of the said satellite system, Elon Musk. The reason for which he gave the instruction to stop the operation of the satellite communication was the fear of retaliatory actions of the Russian Federation. Because of this, USV suddenly lost contact when approaching the coast of Crimea and was thrown onto the coast [32].

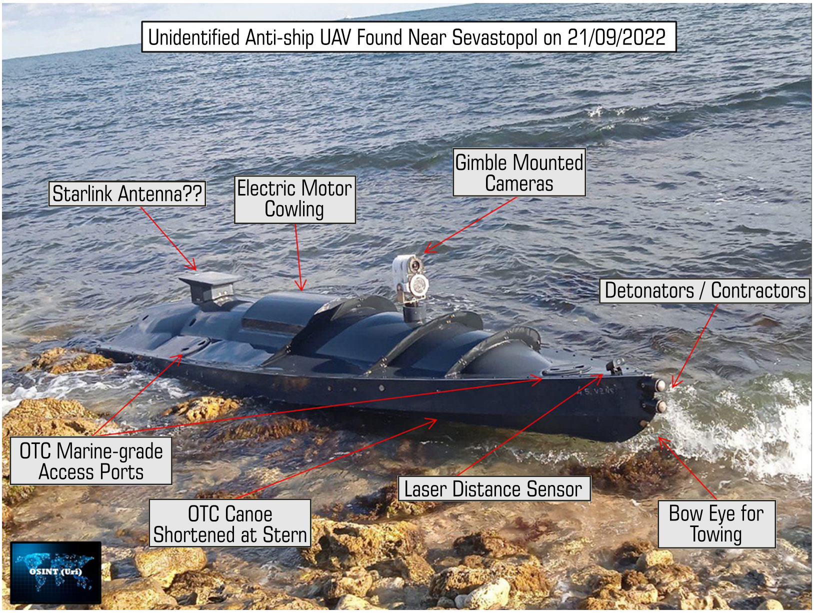

Fig. 3.1 The main components of USV discovered in the city of Sevastopol
Source: [31]

There is no information in open sources regarding the USV control scheme during application. But it roughly looks like this (**Fig. 3.2**).

The first successful case of defeating ships of the Black Sea Fleet of the Russian Federation using USV occurred on October 29, 2022, when the Defense Forces of Ukraine carried out a combined attack on the enemy's naval base in the city of Sevastopol with sea and air drones. At the same time, 9 maritime unmanned surface and 7 unmanned aerial vehicles were used [33]. It should be noted that such a large-scale operation took place for the first time in world history.

According to the Ministry of Defense of the Russian Federation, the attack was repelled and only one ship ("Ivan Golubets" sea minesweeper) was "insignificantly damaged", but according to military experts and OSINT analysts, the consequences of this attack were more significant. It was reported that several more ships were damaged, in particular the frigate "Admiral Makarov", which is the carrier of cruise missiles based on the Kalibr and which, after the destruction of the "Moskva" cruiser, is considered the flagship of the Black Sea Fleet of the Russian Federation. It is likely that the attack on Russian ships in Sevastopol on October 29, 2022 was carried out using USV of the same type that was discovered on September 21 in the city of Sevastopol.

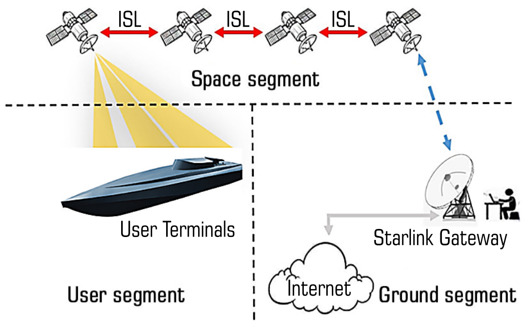

Fig. 3.2 Approximate scheme of the control system of the first USV samples

The next stage in the development of domestic USV was the development of the Magura V5 (Maritime Autonomous Guard Unmanned Robotic Apparatus V-type) device by the Ukrainian state enterprise "Spetstechnoekport" – this is a Ukrainian multi-purpose maritime unmanned device developed for the DMS of the Ministry of Defense of Ukraine (**Fig. 3.3**). It can perform surveillance, reconnaissance, patrolling, search and rescue operations, mine warfare, fleet protection and combat missions. The possibility of using "Magura V5" as part of several drones (swarm) is not excluded [34]. The hydrodynamic body and smooth profile allows this device to move stealthily, and also ensures its maneuverability. At the same time, the advantage of "Magura V5" is that no complex infrastructure is required for their launch, no special platforms (slips) are required for launching the device.

Also, according to data from open sources, it is known about the installation of P-73 air-to-air anti-aircraft missiles at the indicated USV (**Fig. 3.4**) [35].

The need to equip USV with means of combating enemy aircraft is connected with the experience of their use during the Russian-Ukrainian war. Taking into account that aviation is a sufficiently effective means of detecting and destroying USV on sea crossings, there is a need to install appropriate means of destruction on them, primarily anti-aircraft missile systems, which was implemented on the "Magura V5" USV.

Fig. 3.3 "Magura V5" USV appearance
Source: [34]

Fig. 3.4 "Magura V5" USV appearance with installed P-73 air-to-air missiles
Source: [35]

A comparative analysis of the tactical and technical characteristics of the specified domestic USV is given in **Table 3.1** [34, 36].

Another domestic development of USV is "Sea Baby" (**Fig. 3.5**). According to the leadership of the SSU, this device is the result of many months of development, which began after the full-scale invasion of the Russian Federation into Ukraine. It is exclusively developed by the SSU, no private firm was involved in its development.

Table 3.1 Comparative analysis of tactical and technical characteristics of USV of the 1st generation and "Magura V5"

No.	Characteristic	Type of unmanned surface vehicle	
		Unmanned surface vehicles of the 1st generation	**"Magura V5"**
1	Length	5.5 m	5.5 m
2	Operational radius of action	up to 400 km	up to 416 km
3	Range of travel	430 miles (800 km)	450 miles (833 km)
4	Combat load	up to 200 kg	320 kg
5	Maximum speed	43 knots (80 km/h)	42 knots (78 km/h)
6	Ways of navigation	automatic GNSS, inertial, visual	satellite communication/radio network

Fig. 3.5 "Sea Baby" USV appearance
Source: [37]

Models of the specified USV at the end of 2023 already had several redundant communication systems, were made of inconspicuous materials and had warheads of up to 850 kg, compared to 108 kg in the first versions. In the last months of 2023, Sea Baby has transformed from a kamikaze to a multi-purpose platform that can perform various tasks and is constantly being improved. Thus, in January 2024, the SSU presented the "Sea Baby", equipped with 2–6 jet flamethrowers similar to the RPV-16, and in May of the same year, guides for launching 122-mm rockets of the "Grad" system were installed on the "Sea Baby" (**Fig. 3.6**).

Fig. 3.6 "SeaBaby" USV appearance with guides for the use of 122-mm shells
Source: [38]

Comparative characteristics of "Magura V5" and "Sea Baby" USVs are shown in **Table 3.2**.

Table 3.2 Comparative characteristics of "Magura V5" and "Sea Baby" USVs

No.	Technical characteristics and combat capabilities	"Magura V5"	"Sea Baby"
1	Length, m Width, m Height above the waterline, m Speed: cruiser, knots maximum, nodes Range, miles Carrying capacity, kg	5.5 1.5 0.5 22 42 More than 500 Up to 320	7.0 2.0 0.7 22 42 Up to 450 Up to 850
2	Conducting intelligence Coverage of the surface situation, classification of targets Damage to surface ships (boats), other surface targets, surfaced submarines, hydraulic structures, etc. Search, detection, identification of mine-explosive, combined and non-explosive barriers Breakthrough of the enemy's barrage and network barriers in the places of basing and anchorages of ships and vessels Ensuring covert delivery of ammunition, weapons, and special means to the area of use with return to the specified area (to the return point) Support of search and rescue operations at sea	+ + + – – + –	+ + + – – + –

It should be noted that not only surface USV, but also underwater ones are being developed for the DFU needs. Thus, Ukrainian volunteers are developing the "Marichka" (**Fig. 3.7**) UUS, which has a declared range of more than 1,000 km. The main task of this device is to destroy bridges, coastal structures, submarines, and ships. If necessary, it is also capable of conducting reconnaissance and transporting cargo.

Fig. 3.7 "Marichka" UUV appearance

The organization "AMMO UKRAINE" is engaged in the development of "Marichka" UUV. It has protection against the effects of radio electronic warfare systems of the Russian Federation, in addition, it cannot be pinpointed by most radars, scanners and echo sounders. Some of the specifications of the mentioned device have been made public along with video recordings of its tests, but the manufacturer is not disclosing its other specifications for security reasons. In its own videos, the developer talks about the use of the device and its advantages: it is invisible to many radars, scanners and echo sounders, has a standby mode, can be turned on by a timer or by a signal, and due to its size, it can carry a powerful ammunition or other payload. Currently, it is known that the length is 6 meters, the width is 1 meter, and the range is 1000 km.

The next UUV sample developed for the DFU needs is the "Toloka TLK-1000" (**Fig. 3.8**) – an autonomous UUV manufactured by LLC "Intelli" (Ukraine) with a range of up to 2000 km, automatic target search and capture, which can carry up to 5 tones of the explosive substance. It was developed in order to solve a complex strategic problem – the destruction of large-scale objects, such as the Crimean bridge, as well as other significant military, infrastructural and naval targets.

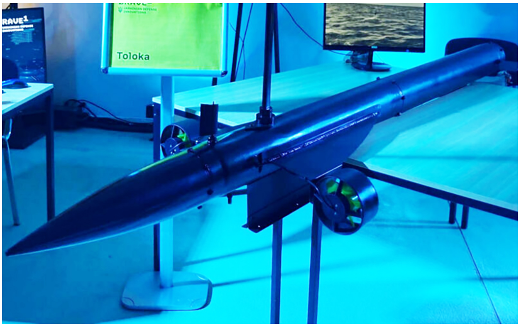

Fig. 3.8 "Toloka TLK-1000" UUV appearance

"Toloka TLK-1000" can destroy hydraulic structures and ships of any size in its path, which allows it to perform various military tasks. With its ability to destroy large ships, it can be used to block enemy sea lanes. Also, "Toloka TLK-1000" can continue the mission in autonomous mode when it goes out of range of telemetry, which allows it to perform missions at a long distance from the base.

Comparative characteristics of "Marichka" and "Toloka TLK-1000" UUVs are shown in **Table 3.3**.

Table 3.3 Comparative characteristics of "Marichka" and "Toloka TLK-1000" UUVs

The name of the unmanned subsurface vehicle	"Toloka TLK-1000"	"Marichka"
Range, nautical miles	650	540
Battery life, days	90	–
Length, m	12	6
Diameter, mm	1000	1000
Battery capacity, kW	300	–
Hybrid power plant	+	–
Nominal speed, knots	4	–
Maximum speed, knots	5	–

CONCLUSIONS

The analysis of the development of the domestic MRS showed that their most intensive development took place precisely during the Russian-Ukrainian war at sea. Early planning to equip the Defense Forces of Ukraine with maritime robotic systems before the start of full-scale armed aggression of the Russian Federation against Ukraine, although it took into account the experience of the world's leading countries in the development and use of the latest high-tech means of conducting armed warfare at sea, did not allow determining priorities in their purpose and the necessary number for effective performing tasks at sea. It was after the full-scale invasion of the Russian Federation into Ukraine and the beginning of hostilities at sea that the specific tasks that the MRS are capable of performing were determined, the corresponding models were developed and tested in practice. The actual result of their application, taking into account changes in the composition and position of the enemy's forces and countermeasures against these systems had the greatest influence on the MRS development.

The conducted analysis of the management of the MRS development allows to conclude that at the initial stage of the Russian-Ukrainian war at sea, their creation and development took place decentralized, by individual components of the Defense Forces of Ukraine (the Security Service, the

Main Intelligence Directorate of the Ministry of Defense, the Armed Forces of Ukraine) in accordance with the tasks, they which were carried out. This led to the appearance of a significant number of MRS samples, including for the performance of the same tasks. As a result, there was a need to centralize not only the use of these systems, but also the management of their development. In the future, this will make it possible to unify MRS samples in accordance with their purpose and tasks, reduce costs for their production, operation and time for training personnel for their maintenance.

Also, based on the results of the conducted research, the main trends in the development of domestic MRSs since the beginning of the military aggression of the Russian Federation against Ukraine were determined, which include:

– the use of remotely controlled USV in order to prevent losses of personnel;

– gradual expansion of the range of weapons and technical means installed at USV;

– further increase in accuracy and range of attack means based on USV, achieving such a scale of impact on the enemy, which is comparable to the effect of missile weapons;

– need to develop both surface and underwater USV;

– expansion of the range of tasks that USV is capable of performing, in particular, with regard to inflicting damage on enemy warships and support vessels, sea and shore facilities of its infrastructure, conducting reconnaissance, monitoring enemy forces and means, issuing target designations, executing hidden mine laying, in including active ones, combating enemy air attack means, conducting demonstration actions, searching for and destroying sea mines, etc.;

– wide use of UAVs of various purposes (reconnaissance, reconnaissance-strike, strike), which allows to significantly expand the capabilities of detecting and inflicting damage on enemy forces and assets;

– the transition of unmanned vehicles to a new technological base, in particular, the use of satellite communication systems for their management.

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CHAPTER 4

MODERN APPROACHES TO PROJECT MANAGEMENT IN THE TRAINING OF NAVAL OFFICERS. USE OF SIMULATION TECHNOLOGIES

ABSTRACT

This chapter of the monograph is dedicated to project management in the military sector, using the example of a virtual project for the training of military officer-navigators. In the context of modern military conflicts, where the demands on the training of military specialists have increased significantly, the introduction of advanced technologies is a key factor for ensuring effective training. This project utilizes VSTEP (NAUTIS) and KILO-VASCO simulation platforms, providing realistic training for officers in a virtual environment. These platforms allow for exercises in scenarios that closely replicate real combat conditions. The chapter examines key aspects of project management, such as planning, resource management, risk management, and the integration of virtual technologies into the training process. Additionally, the effectiveness of the project is evaluated, and its development prospects are outlined. This experience represents a valuable example of an innovative approach to military training in Ukraine, which may also be beneficial to other countries facing similar challenges.

KEYWORDS

Education, project development, project management, simulation, virtual reality.

In the conditions of modern challenges, in particular during armed conflicts, there is a growing need to train military personnel at a high level of professionalism, especially in the field of complex project management. Project management in the military sphere requires special attention to resources, deadlines and quality of execution, because not only the success of training depends on this, but also the safety of personnel and the effectiveness of combat missions.

Today, military projects cannot be imagined without the introduction of the latest technologies that ensure a high level of interactivity and realistic training. This is particularly important for the training of officers responsible for ship management and operations at sea. The implementation of virtual simulations allows to reproduce real combat conditions, where the cadet can train repeatedly without risking health and equipment.

The purpose of this project is to integrate modern simulation technologies into the process of training for naval navigation officers, which will allow them to be maximally prepared for difficult and dangerous situations that they may encounter during real combat operations. The success of such projects depends on effective management, which includes planning, resource management, risk management, and implementation control.

The relevance of the implementation of simulation systems is well illustrated by the incident that occurred in 2018 with the Norwegian frigate "Helge Ingstad". After completing NATO military exercises, the ship collided with an oil tanker due to errors in navigation and insufficient preparation of the crew for working in conditions of limited visibility. This collision resulted in serious damage to the frigate and its sinking. The lack of an opportunity to repeatedly practice critical scenarios, such as difficult navigation in conditions of limited visibility, became one of the reasons for this tragedy [1].

The incident highlighted the importance of introducing modern simulation technologies into the process of training officers, as they allow repeated training in conditions as close as possible to real ones, but without risk to life and equipment. As an instructors, we are convinced that the use of simulations not only increases the effectiveness of training, but also builds the confidence and professionalism of future commanders, which is extremely important in the conditions of modern military operations.

In this introduction, let's emphasize the importance of simulation technologies, in particular the VSTEP (NAUTIS) and KILO-VASCO platforms, which provide realistic learning. The need for an innovative approach to project management in the conditions of modern military conflicts is also emphasized. As instructor who have experience working with young people and a desire to pass on knowledge to a new generation, we are convinced that such technologies not only increase the effectiveness of training, but also form the confidence of cadets in their readiness for real challenges.

4.1 OVERVIEW OF MODERN TECHNOLOGIES FOR TRAINING MILITARY OFFICERS

4.1.1 THE ROLE OF SIMULATORS IN MILITARY EDUCATION: HISTORY AND CURRENT TRENDS

Military education for many centuries was based on the principles of real experience and field training. However, with the development of technology, the question arose about safer and more effective training methods that allow practicing complex combat scenarios without risk to people and equipment. It was then that simulators became an important element of military training.

The first attempts to use simulation technologies in the military field date back to the beginning of the 20th century, when mechanical and electromechanical simulators appeared for training pilots and gunners. Simple mechanical simulators helped the military master the basic principles of navigation and weapon control. For example, during the First World War, flight simulators allowed pilots to simulate flight conditions and various types of combat missions, reducing the need for real flights, which were expensive and dangerous.

During the Second World War, there was a significant expansion of the use of simulators. One of the most famous examples was the "Link Trainer" simulator, which was widely used to train pilots in the United States and Great Britain (**Fig. 4.1**). This simulator allowed pilots to train in low visibility conditions and simulate different situations without having to take to the air, which reduced the number of accidents and losses during training [2].

Fig. 4.1 "Link Trainer" simulator

With the development of computer technologies in the second half of the 20th century, military simulators underwent a significant evolution. Computer systems have made it possible to create much more complex and realistic simulations imitating real combat conditions, including tactical operations, firing from various types of weapons, piloting aircraft, tanks and ships.

An important stage was the introduction of interactive simulators, which allow not only to observe, but also to actively participate in the simulation of combat operations. Simulators such as the early computerized simulators for fighter pilots and tank crews allowed military specialists to train in conditions close to the real thing, but without the risk to men and equipment.

Today, simulation technologies are experiencing a new round of development thanks to the introduction of virtual reality (VR) and augmented reality (AR). These technologies allow to create fully interactive environments that provide high realism and immersion in combat conditions.

One of the key trends is the use of virtual learning environments. VR-based simulators, such as the VSTEP (NAUTIS) and KILO-VASCO systems, provide realistic simulation of combat operations and training in conditions as close as possible to real life. Military specialists can train on virtual training grounds simulating the conditions of real combat, learn to control a ship or practice complex navigational maneuvers. These systems allow cadets and officers to practice scenarios without risk to life and equipment, which significantly increases the effectiveness of training.

Another trend is the use of network simulations, which allow to train entire units in interaction with each other, even if they are physically located in different places. Network simulations provide the ability to simulate complex cross-species operations where interaction between Army, Navy, and Air Force units is critical to mission success.

Thanks to the development of artificial intelligence (AI), simulation systems acquire the ability to automatically adapt the complexity of scenarios according to the level of training of cadets. AI-systems used in simulations can simulate the behavior of opponents or other elements, which allows cadets to practice scenarios that correspond as closely as possible to real combat conditions.

Modern simulation technologies allow not only to simulate combat conditions, but also to evaluate the effectiveness of training in real time. For example, instructors can immediately receive detailed data about the actions of cadets in virtual scenarios, analyze their mistakes and provide recommendations for improving skills.

In addition, simulators can significantly reduce training costs. The use of virtual simulators reduces the need to use expensive equipment and weapons during training, which is an important factor for military budgets, especially in difficult economic conditions and during a high probability of enemy missile strikes with the subsequent destruction of training simulators and platforms.

Thus, simulation technologies have become an integral part of modern military education. They allow to train military officers in safe but realistic conditions, practice multiple scenarios and significantly increase the level of training, which is critically important in today's environment.

4.1.2 OVERVIEW OF VSTEP (NAUTIS) AND KILO-VASCO TECHNOLOGIES: FEATURES AND CAPABILITIES

Modern simulation technologies provide naval navigation officers with the opportunity to repeatedly train in conditions as close as possible to real ones, but without risk to life and equipment. One of the most powerful platforms for such training is the VSTEP (NAUTIS) and KILO-VASCO systems. These technologies have a wide range of functionality and features that allow them to be used for the training of both novices and experienced military specialists.

VSTEP is one of the leading developers of simulation systems for the maritime industry and the military. Their NAUTIS platform specializes in creating realistic simulations for naval officers and ship operators. The main feature of this system is its high realism and modular structure, which allows to configure the simulator according to the requirements of a specific training scenario.

Main capabilities of NAUTIS (**Fig. 4.2**):

1. Realistic simulation: the system provides an accurate reproduction of real marine conditions, including weather conditions, ship behavior and environmental effects on navigation.

2. Modularity: NAUTIS offers various modules for working out specific scenarios – from basic navigation training to complex operations in crisis situations. This allows instructors to choose those scenarios that meet the learning objectives and level of training of the cadets.

3. Interactivity: cadets have the opportunity to fully immerse themselves in the educational process thanks to the possibility of interaction with other training participants. Network mode allows to practice joint operations between several ships or crews.

4. Ability to simulate emergency situations: NAUTIS allows cadets to practice actions during emergency situations at sea, such as collisions, fires or loss of control of a ship or receiving battle damage. This provides the possibility of repeated training without risk to life and equipment.

5. Visualization and reporting: instructors can receive detailed statistics for each training session, including analysis of trainee errors and recommendations for improving skills.

Fig. 4.2 NAUTIS simulator (VSTEP Naval training)

The NAUTIS system is actively used in training centers and academies of the naval forces for the training of officers and personnel. Its capabilities allow to practice both basic navigational tasks and complex operations for managing large navy ships in various conditions [3, 4].

KILO-VASCO technology is another leading solution in the field of virtual simulations for the training of ship operators. This platform offers a wide range of functions for practicing complex maneuvers, managing the ship in crisis situations and coordinating team operations. The peculiarity of KILO-VASCO is that it integrates modern technologies of virtual reality (VR) and augmented reality (AR), which allows cadets to be even more deeply immersed in training scenarios.

Main features of KILO-VASCO (**Fig. 4.3**):

1. Virtual reality (VR): the system supports full-fledged VR scenarios that allow cadets to be in a virtual environment that is as close as possible to real combat conditions. This increases the level of immersion and allows to train in conditions where sudden changes in situations or danger are possible.

2. Augmented Reality (AR): KILO-VASCO integrates elements of augmented reality, which allows virtual objects to be superimposed on the real environment for additional analysis and training. For example, cadets can see additional information about the environment or receive instructions directly during tasks.

3. Customization flexibility: the system allows easy modification of training scenario parameters in real-time, enabling instructors to modify tasks according to the situation. This is useful for working out unusual situations or adapting tasks for cadets of different training levels.

4. Training in multitasking conditions: KILO-VASCO allows to simulate complex operations where the crew has to perform several tasks at the same time. This is important for training cadets to coordinate actions in stressful conditions or during complex operations.

5. Support for training centers: the platform is used in military educational institutions to organize team exercises, where several crews or units can train together to solve joint tasks. Network mode allows to organize joint training regardless of the participants' geographical location.

Fig. 4.3 KILO-VASCO virtual environment (KILO Solutions)

Common advantages and prospects for development. Both VSTEP (NAUTIS) and KILO-VASCO offer exceptional training opportunities for naval officers in modern environments. Both systems are highly flexible and can be used for training in both basic and more complex scenarios. It is important to note that the use of these technologies significantly reduces the costs of real training, and also allows multiple repetition of training scenarios to achieve maximum results.

Both platforms have prospects for development due to the further integration of artificial intelligence and the expansion of opportunities for real-time interaction between teams working on joint tasks. This makes them key tools for training a new generation of military specialists capable of operating effectively in difficult combat conditions.

4.1.3 COMPARISON OF SIMULATION TECHNOLOGIES IN DIFFERENT COUNTRIES AND THEIR USE IN THE MILITARY SPHERE

Modern simulation technologies play an important role in the training of military personnel in various countries of the world. They make it possible to create safe and realistic training environments where the military can train in conditions as close as possible to real combat operations.

However, approaches to the development and implementation of such systems differ depending on the country, technical capabilities and military requirements.

The United States of America is a world leader in the development and use of simulation technologies for military training. One of the best-known examples is the Joint Simulation Environment (JSE), which is used to train pilots and crews of various types of aircraft. This system allows to create integrated training environments for different military branches – Air Force, Navy and Ground Forces. JSE is distinguished by the possibility of simultaneous simulation of operations with the participation of several types of troops, which allows the military to practice interaction in complex combat conditions [7].

In the USA, the Live, Virtual, Constructive (LVC) system is also actively used, which combines real and virtual training components, providing the opportunity to learn both in real conditions and in simulated virtual scenarios. This reduces the costs of real-world training and minimizes risks, while providing soldiers with realistic training conditions [8].

Great Britain has placed great emphasis on the development of simulation technologies to reduce the costs of real training and improve the quality of training of military specialists. One of the most striking examples is the Virtual Battlespace 3 (VBS3) platform, which is used for ground forces training. This system allows to simulate a wide range of combat scenarios, from simple patrols to complex operations involving artillery, aviation and armored vehicles. VBS3 is also actively used by NATO to practice joint military operations [9].

The British military has also implemented the Synthetic Wrap system, which uses virtual technology to train Royal Air Force pilots. It allows to conduct training in conditions close to real combat operations, without the need to fly on real aircraft, which significantly reduces training costs [11].

Germany is also one of the leading developers of simulation technology for military training. Special attention should be paid to the use of Garrison Combat Trainers (GCT), which allow the military to practice combat skills in complex urban environments. These simulators integrate real combat components with virtual ones, which allows to create the most realistic training scenarios.

In addition, Germany actively uses simulations to train military drivers and tankers. Tank simulators like the Leopard 2 Simulator allow crews to practice combat and maneuver tactics in a variety of environments. This reduces the wear and tear of the equipment and allows to improve the qualifications of the crews without risking the equipment [11].

Ukraine is also actively developing simulation technologies for military training, especially given the complex security situation in the region. One of the most important steps in this direction is the implementation of VSTEP (NAUTIS) and KILO-VASCO simulators for the training of navigation officers. These platforms allow to create realistic scenarios of maritime operations, which significantly increases the level of training of officers without the need to go to the open sea.

The Ukrainian army also actively uses simulations to train drone operators and gunners, which allows effective training of personnel even in difficult combat conditions. Given the ongoing military conflict, simulation technology has become a key element in the training of new military personnel.

Different countries approach the development of simulation technologies depending on their military needs and technical capabilities. However, the general trend is to increase the use of virtual training environments that provide realistic combat scenarios without risk to life and equipment. The use of artificial intelligence and integration with real components makes simulations even more effective. A comparison of the simulation systems of different countries shows that they all strive to reproduce combat conditions as realistically as possible, preparing the military for various scenarios of warfare.

4.2 PROJECT MANAGEMENT IN THE CONTEXT OF MILITARY TRAINING

4.2.1 BASICS OF PROJECT MANAGEMENT: PRINCIPLES AND STAGES

Project management is a complex process that involves planning, organizing, controlling, and executing specific tasks to achieve defined goals within a defined time frame and with limited resources. In the military field, project management has its own characteristics, since it is about projects that affect the security, efficiency of military operations and training of personnel. However, the basic principles and stages of management remain constant and are used in many areas.

Basic principles of project management:

1. Clear definition of goals. Every project should have clearly defined, measurable goals. For military projects, it can be, for example, the training of a certain number of cadets or the achievement of a certain level of qualification of officers. The objectives must be aligned with the project requirements and the general strategy of training military personnel.

2. Project management triangle: scope, time, resources. Any project, regardless of its field, has three main components: scope of work, time frame and resources. Changing one of these elements inevitably affects the others. In military projects, this is particularly important, as resources (human, financial or technical) are often limited and time frames are tight due to the need for operational preparation for actual combat operations.

3. Planning. The basis of the success of any project is its careful planning. This involves the creation of a detailed plan that includes all stages of project implementation, task allocation, performance control and monitoring. In military training, this may include the development of training plans, schedules of training modules, and coordination between various training units.

4. Risk management. Military projects are associated with a high level of risks – from technical failures to external threats. Risk management consists in identifying potential problems, assessing the probability of their occurrence and developing action plans to minimize the consequences. This is important to ensure the smooth operation of simulation systems or the execution of training programs in military academies.

5. Flexibility and adaptability. In the context of military training, the ability to adapt a project to changing circumstances is important. For example, new military challenges or technological

opportunities may arise that require changes to existing plans. Flexible project management (Agile) allows to quickly adapt to these changes.

The main stages of project management (**Fig. 4.4**):

1. Project initiation. At the initial stage, the general vision of the project is formed. This stage includes defining the main goals, scope of work and required resources. Military projects are often initiated by leadership or the need to improve certain aspects of personnel training. For example, it can be the development of a new training program based on simulation technologies.

2. Project planning. Planning is the basis for successful project implementation. At this stage, specific tasks are defined, roles and resources are allocated, and key performance indicators are established. For military projects, planning also includes coordination with government agencies and international partners in the case of projects related to NATO or joint exercises.

3. Implementation of the project. The implementation of the project involves the implementation of all planned works and the achievement of the set goals. At this stage, team management, constant monitoring of progress and solving current problems are critical. In military projects, for example, this can be the introduction of new training assets and technologies, such as simulators, into the training process.

4. Control and monitoring. The control stage involves constant monitoring of results and correction of deviations from the plan. Various tools are used for this, such as regular reports, monitoring of budget and deadlines. In the context of military training, this may include monitoring the effectiveness of simulator training and correcting training programs.

5. Completion of the project. Project completion includes the formal completion of all tasks, evaluation of the results achieved, and documentation of lessons learned for subsequent projects. In military projects, this can be, for example, the completion of a training course using simulators and an analysis of the effectiveness of training cadets. The final report may also include recommendations for improving future training programs.

6. Assessment and study of results. After the completion of the project, it is important to evaluate its success and study the experience gained. This allows to identify weak points and develop recommendations for improving the management of future projects. In the military, this may include assessing the level of training of military officers after training in simulators.

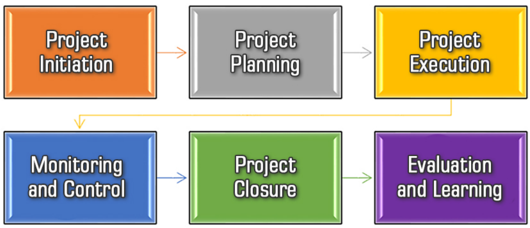

Fig. 4.4 Stages of project management

CHAPTER 4

4.2.2 PECULIARITIES OF MILITARY PROJECT MANAGEMENT: REGULATORY AND LEGAL ASPECTS AND SPECIFIC REQUIREMENTS

The management of military projects has its own characteristics, due to the need to comply with regulatory requirements and standards that regulate this activity at the national and international levels. Special attention is paid to coordination between military units, government bodies and international partners, especially in the context of military coalitions and operations according to NATO standards.

Military projects, in particular those related to the training of personnel, the introduction of new technologies or military operations, are subject to regulation by both national and international acts. In order to effectively manage such projects, it is necessary to adhere to certain requirements and standards aimed at ensuring safety, efficiency and legal compliance.

National normative documents. In many countries, military projects are governed by specific laws, government regulations and Ministry of Defense instructions. This includes the regulation of financial costs, the use of human and material resources, as well as the compliance of measures with the national defense strategy.

For example, in Ukraine, the management of military projects is regulated by the Law of Ukraine "On Defense", the National Security and Defense Strategy, as well as the instructions of the Ministry of Defense regarding the introduction of new military technologies and projects [12].

Norms of international law. Military operations and projects are often implemented under international obligations, especially when a country is a member of coalitions or defense alliances such as NATO. This means the need to comply with the norms of international law, in particular the Geneva Conventions and other documents that determine the rules for conducting military operations and protecting the civilian population.

NATO's requirements for the management of military projects. There are certain standards and requirements for the management of military projects for NATO member countries, as well as for partner countries that cooperate with the alliance. The main regulatory and legal documents that regulate military projects and operations within NATO are NATO guidelines (STANAG), extreme tactical instructions (EXTAC), as well as training and interoperability standards between the military units of member countries:

1. STANAG (Standardization Agreement). STANAGs are NATO's primary documents that govern standardization between member nations' armed forces. Military projects, especially those related to the introduction of new technologies or joint exercises, must meet the requirements of STANAG. For example, STANAG 6001 deals with language training for military personnel to ensure mutual intelligibility during joint operations, and STANAG 4586 with standards for unmanned aerial vehicles used in military operations [13].

2. EXTAC (Extreme Tactical Instructions). EXTAC is a set of instructions that govern the tactical aspects of military operations in difficult or extreme environments. These may be requirements for operations in difficult terrain, poor visibility or combat operations at sea.

EXTACs provide the military with detailed instructions for managing tactical elements during combat operations. For example, EXTAC 1000 determines the coherence of the actions of naval units on the water during joint maritime maneuvering and the implementation of various tactical procedures [14].

3. NATO's "Smart Defense" concept. As part of the Smart Defense concept, NATO aims to optimize the use of resources in military projects through cooperation between member countries and the exchange of technologies. This is aimed at avoiding duplication of military development and improving project coordination. In the context of project management, this means the need for close cooperation between governments, military and industrial partners to ensure the mutual benefit of military innovation [15].

Specific requirements for the management of military projects. Military projects require special attention to security issues. Information related to projects is often classified as confidential or restricted. This means that the management of such projects must meet the requirements of information security, including the preservation of data, providing control over access to documents and technologies.

For military projects related to the introduction of new simulation technologies or training systems, it is necessary to comply with the safety standards for the use of such systems.

Military project management also often requires interaction with civilian entities such as technology manufacturers or equipment suppliers. This interaction must meet both military standards and general legal norms, including contracts, tender procedures and requirements for the quality of products and services.

Projects implemented within the framework of international cooperation, for example, with the participation of NATO, must meet the requirements for the compatibility of equipment, software and communication systems. This involves compliance with technical and functional requirements to ensure interaction between military units of different countries.

Military projects are often implemented in a dynamic situation, in particular in military conflicts or during operational exercises. Therefore, an important requirement for project management is the ability to quickly adapt to changing circumstances and revise the project plan in real time. This includes, for example, changing training scenarios or requirements for simulators during their implementation.

Examples of regulatory requirements in military projects:

– STANAG 2116 is NATO's system of military ranks, which allows to standardize the ranks of military personnel in different countries for joint operations [13];

– STANAG 6001 – language training standards to ensure operational communication between allies [13];

– STANAG 4586 – standards for the integration of control systems of unmanned aerial vehicles of different countries in military operations [13];

– EXTAC 1000 – extreme tactical instructions for conducting military operations in conditions of increased complexity [14].

4.2.3 IMPLEMENTATION OF FLEXIBLE PROJECT MANAGEMENT METHODOLOGIES (AGILE, SCRUM) FOR MILITARY TRAINING PROGRAMS

Agile project management methodologies, such as Agile and SCRUM, were originally developed for the IT field, but over time, their effectiveness has been recognized in many other industries, including military training. The use of these methodologies in military training programs makes it possible to adapt to rapidly changing circumstances, increase the flexibility of training project management, and ensure a timely response to new challenges and needs [16].

Agile is a project management philosophy based on constant adaptation to change, active communication within the team, and rapid response to the needs of the client or end user. Key principles of Agile include:

– iterative process: the project is divided into short cycles (iterations), each of which ends with the presentation of a certain result;

– flexibility: response to changes in requirements even at late stages of project development;

– constant feedback: regular communication with all stakeholders to quickly adjust plans.

SCRUM is a framework within Agile that structures the team's work through short cycles (sprints), regular meetings and progress evaluation. The main elements of SCRUM are:

– SCRUM Team: a cross-functional team that independently organizes its work;

– Product Owner: the person responsible for maximizing the value of the project and managing the backlog;

– SCRUM master: a team leader who supports the team and promotes adherence to the SCRUM process;

– Sprints: short, well-defined periods of time (usually 1–4 weeks) during which a team completes a set of tasks [17].

Implementation of Agile and SCRUM in military training programs. In the context of military training programs, Agile and SCRUM provide an opportunity to effectively manage projects that include the development of new training modules, the implementation of the latest technologies or the organization of training sessions. Military projects are often highly complex and conditions change depending on operational requirements, so flexibility becomes key.

Military training programs must quickly adapt to new threats, technologies and requirements. The implementation of Agile allows military training centers to quickly make adjustments to the officer training program, integrating new training methods or technical solutions without significant delays.

Agile is suitable for projects that involve gradual development. In the context of military training, this may mean that new simulation technologies or training scenarios can be integrated in stages, allowing instructors and cadets to test and refine them at each stage.

Agile emphasizes constant feedback from end users (military officers, cadets, instructors). This allows to receive timely feedback and adjust training programs to improve their effectiveness.

SCRUM allows to break large training projects into short sprints, during which a team of military instructors or training material developers work on a specific set of tasks. This allows to ensure quick results and improve their quality through regular checks.

The SCRUM framework focuses on completing a certain amount of work during each sprint, which allows to quickly track progress and achieve specific results. For military projects, this means that training programs or simulations can be continuously improved based on the results of previous sprints [17].

4.3 PROJECT PLANNING USING VIRTUAL SIMULATORS

4.3.1 DEVELOPMENT OF A TRAINING PROGRAM FOR NAVIGATION OFFICERS: THEORY AND PRACTICE

The training of naval officers is a critical component of naval education, since the accuracy of their skills and knowledge depends on the success of complex tasks in maritime operations. In the conditions of rapid technological development and changing requirements for military operations, training programs must meet modern standards and be adapted to new challenges. The development of such a program requires a combination of theoretical knowledge with practical experience and the use of modern virtual simulators that allow to reproduce the real conditions of combat operations at sea.

The theoretical part of the training program for naval officers includes basic and specialized disciplines that provide the necessary knowledge for decision-making in complex maritime operations. The basis of the curriculum is the study of the following disciplines:

1. Basics of navigation. Includes the study of the principles of marine navigation, the use of navigational instruments, course calculation, ship management in various weather and seafaring conditions. The theoretical part also includes knowledge about the geography of sea routes and the peculiarities of work in different zones of the sea space.

2. Maritime security. Navigation officers must know the basic principles of ensuring safety at sea, including rules for avoiding collisions, actions in emergency situations, management of emergency and rescue operations. The theoretical part covers international safety standards, in particular SOLAS (International Convention for the Safety of Life at Sea) and COLREG (International Regulations for Preventing Collisions at Sea).

3. Maritime law. Officers must know the basic provisions of the law of the sea, in particular the provisions of the United Nations Convention on the Law of the Sea (UNCLOS), and other international treaties that regulate maritime activities. This helps to ensure correct decision-making in difficult situations in international waters.

4. Crew command and control. Training programs should include disciplines related to effective crew management, task allocation, and decision-making in stressful situations. Officers must have knowledge of the command structure on the ship and the specifics of working with the crew.

5. Analysis of combat operations. Includes a theoretical study of the history of military naval operations, strategies and tactics used during combat operations at sea. This allows officers to analyze mistakes and successes of the past and apply this knowledge in their professional activities.

Practical training is an integral part of the training program for navigation officers. In modern conditions, virtual simulators are an important element of practical training, allowing cadets to gain experience in realistic conditions, simulating real combat and navigation operations.

The use of virtual simulators provides unique opportunities to practice complex maritime operations without the need to go to the open sea, which reduces risks and costs. Here are some key aspects of using virtual simulators in the practical training of navigation officers:

1. Simulators such as VSTEP (NAUTIS) or KILO-VASCO allow to create detailed scenarios of combat operations, where cadets can practice tactical maneuvers, react to threats and follow orders in realistic conditions. This includes simulating weather conditions, enemy actions and interactions with other ships.

2. One of the advantages of virtual simulators is the ability to train cadets in challenging conditions such as storms, limited visibility or complex seabed terrain. This allows cadets to gain experience operating a ship in situations that are hard to recreate in real life.

3. Simulators allow to simulate emergency situations such as fires, ship damage or collisions, which are an important part of practical training. This allows cadets to learn the algorithms of actions in emergency situations and improve their skills in responding to danger.

4. Virtual simulators also provide an opportunity to practice teamwork and coordination of actions between crew members. Through interactive training, cadets can learn to work as part of a team, which is an important element of effective ship management.

Integration of theory and practice. One of the important elements of curriculum development is the integration of theoretical knowledge with practical training. This allows cadets not only to learn the theory of navigation and ship control, but also to apply this knowledge in practice during simulations. For example, after studying the theoretical foundations of navigation, cadets can immediately proceed to practicing the acquired knowledge on virtual simulators, simulating real situations.

An important element of the training program is the assessment of the effectiveness of the training of cadets. Simulators provide an opportunity to perform a detailed analysis of each training session, tracking the errors and progress of the cadets. Instructors can receive detailed information about each stage of training, which allows timely correction of the program and improvement of its quality.

The evaluation system must be integrated into all stages of training and include:

– analysis of completed tasks on simulators;
– feedback from instructors and officers;
– assessment of theoretical knowledge of cadets during tests and assessments;
– regular practical tests simulating various combat scenarios and navigational situations.

4.3.2 DETERMINATION OF THE KEY GOALS AND OBJECTIVES OF THE PROJECT

The project to introduce virtual simulators into training programs for naval navigation officers training aims to create a high-quality, realistic and flexible training environment that will provide cadets with the practical skills necessary to perform tasks in real combat conditions. To achieve this goal, it is necessary to clearly define the key goals and objectives of the project.

The main goals of the project:

1. Improving the quality of training of navigation officers. The main goal is to provide effective training of cadets through the use of virtual simulators that allow simulating complex navigation and combat scenarios. This enables cadets to gain experience in realistic settings without risk to ships or personnel.

2. Optimization of the learning process. The use of virtual simulators allows to reduce the costs of real training, reduce the need to use expensive resources and increase the effectiveness of the training process. It also allows to repeat training scenarios as many times as necessary to achieve the appropriate level of training.

3. Adaptation to modern military requirements. In the conditions of rapid changes in technology and threats, it is important to ensure the flexibility of the curriculum. The project aims to create a training environment that can be easily adapted to new requirements or training tasks that appear in the process of military technology development.

4. Improvement of interaction between military units. With the help of simulation platforms, such as VSTEP (NAUTIS) and KILO-VASCO, cadets have the opportunity to practice joint actions between different military units, which is especially important for multinational operations under the auspices of NATO.

The main tasks of the project:

1. Development of educational scenarios. An important task is the development of realistic training scenarios for simulators that cover a wide range of tasks – from navigational operations to combat operations. This should include different weather conditions, emergency scenarios and possible combat operations at sea.

2. Integration of simulators into educational programs. The project should provide for the full integration of virtual simulators into existing training programs for navigation officers. This includes the development of techniques for using simulators in combination with theoretical classes.

3. Provision of technical support and maintenance. An important task is to create an infrastructure for constant maintenance of simulators and ensuring their uninterrupted operation. This involves the training of technical personnel and the establishment of regular monitoring of equipment performance.

4. Assessment of training effectiveness. The project should include mechanisms for evaluating the effectiveness of training based on the use of virtual simulators. To do this, a system for monitoring the progress of cadets and analyzing the results of training should be developed in order to improve the program based on the received data.

4.3.3 STAGES OF DESIGN: FROM THE INITIAL CONCEPT TO INTEGRATION INTO THE EDUCATIONAL PROCESS

Curriculum design using virtual simulators consists of several key stages, starting with a conceptual vision and ending with full integration into the educational process. Each of the stages requires careful planning and interaction between military instructors, technical specialists and the management of educational institutions (**Fig. 4.5**).

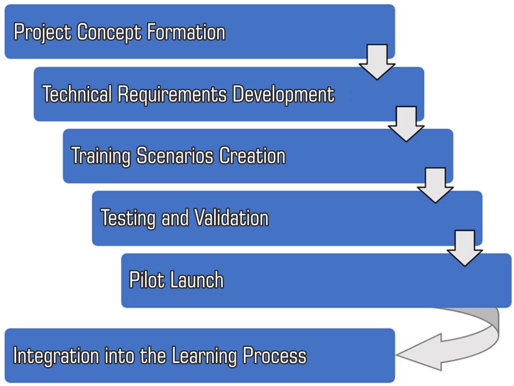

Fig. 4.5 Example of design stages

Stage 1. Formation of the project concept.

The design begins with the development of an initial concept that defines the main directions of the training program, the goals and objectives of the project, as well as the key requirements for the simulation platform.

At this stage, the following aspects are defined:

1. Objectives of the training of navigation officers.
2. Expected learning outcomes.
3. Technical requirements for simulators and equipment.
4. Assessment of necessary resources (human, financial and material).

An important aspect is understanding the specifics of military operations and training tasks that must be reflected in simulators.

Stage 2. Development of the technical task.

At this stage, a technical task is created, which includes all requirements for the development of simulation programs. The technical task defines:

1. Specifications of the equipment necessary for the implementation of the project.
2. Functional capabilities of the simulators to be used.

3. Requirements for educational scenarios.

4. Requirements for the integration of simulators with other educational tools.

Stage 3. Development of learning scenarios.

This stage involves the development of specific training scenarios that will be used in the simulators. Scenarios should reflect a wide range of navigation and combat situations, which will allow cadets to train in different conditions. The main elements of the scenarios are:

1. Simulation of real navigational conditions (weather, currents, seabed landscape).
2. Simulation of combat operations (interaction with the enemy, maneuvers in combat conditions).
3. Working out emergency situations (collision, ship damage, fire, etc.).

Stage 4. Testing and Validation.

After developing simulators and training scenarios, the system is tested. This includes:

1. Checking the functionality of simulators and their compliance with real conditions.
2. Testing different scenarios to ensure their realism and effectiveness.
3. Involvement of instructors and cadets for training and evaluation of the system.
4. This phase also validates the simulators to ensure they meet military requirements and standards.

Stage 5. Pilot launch.

After the testing is completed, a pilot launch of the project is carried out, during which selected groups of cadets are trained on simulators. This allows to get real feedback from users and make the necessary adjustments to the training program. The pilot launch also includes training instructors to work with simulators.

Stage 6. Integration into the educational process.

After a successful pilot launch, simulators are fully integrated into the educational process. This includes:

1. Development of a schedule for the use of simulators.
2. Training of permanent staff for system maintenance.
3. Implementation of the system of evaluation and monitoring of training effectiveness.
4. The integration aims to make simulators a permanent element of the training process, ensuring the continuous training of navigation officers at a modern level.

4.4 RESOURCE MANAGEMENT IN THE PROJECT

4.4.1 HUMAN RESOURCES: INSTRUCTORS, TECHNICAL STAFF AND MILITARY SPECIALISTS

Successful implementation of the project in the field of military training, especially with the use of virtual simulators, requires effective management of resources. This includes the management of both human and material resources that ensure the achievement of the set goals. In this section, let's consider the key aspects of resource management required for the project.

Human resources are one of the most important elements in any project, especially in the field of military training. They include instructors, technical personnel and military specialists who are directly involved in the process of training and maintenance of simulation systems.

The main categories of human resources:

1. Instructors. They play a key role in ensuring quality training of cadets. They are responsible for teaching cadets the basics of navigation, ship control and emergency response. It is important that instructors not only possess theoretical knowledge, but also have practical experience in the maritime field. In addition, instructors should be familiar with the possibilities of virtual simulators and be able to effectively integrate them into the educational process.

The main tasks of instructors:

– preparation of educational materials and training scenarios;

– conducting training sessions on simulators;

– assessment of cadets' training results and feedback.

2. Technical staff. An important element of project management is the technical staff that ensures the proper functioning of simulators and VR equipment. Technicians must have a high level of knowledge in the field of software, VR technologies and simulator maintenance. Their job is to keep the simulation equipment in working order, promptly troubleshoot technical issues, and upgrade systems as needed.

The main tasks of the technical staff:

– installation and adjustment of simulation equipment;

– technical support during training sessions;

– regular updating of software and preventive work with equipment.

3. Military specialists. This is a category of people who are directly trained or are consultants in the process of developing curriculum scenarios. Military professionals provide a hands-on learning experience, sharing their experiences with cadets and helping to adjust training programs to meet the Army's current needs. Often, they also test new simulation scenarios and provide feedback for further improvement.

The main tasks of military specialists:

– consultations on the development of educational programs;

– testing new simulation scenarios;

– evaluation of the effectiveness of training and adjustment of programs.

4.4.2 MATERIAL AND TECHNICAL RESOURCES: SIMULATORS, VR EQUIPMENT, SOFTWARE

Material and technical resources are the basis for the implementation of projects using simulation technologies. These include simulators, VR equipment and software, which are necessary for the effective organization of the educational process.

The main categories of material and technical resources:

1. Simulators. Simulators are the main tool for practical training of navigation officers. They allow to simulate various scenarios, such as navigation in difficult conditions, combat operations or emergency situations. One of the most common simulators in military training is VSTEP (NAUTIS) and KILO-VASCO [3,4,5,6]. They allow to reproduce realistic scenarios with high accuracy and immersion.

The main tasks of simulators:

– simulation of real navigation conditions;

– creation of various scenarios, including emergency and combat situations;

– provision of interactive training for team and individual training.

2. VR equipment. Virtual reality (VR) makes it possible to create even more realistic training conditions, immersing cadets in an environment as close as possible to real combat operations. The use of VR helmets and other devices allows cadets to fully immerse themselves in the learning process, interact with virtual objects and practice tactical maneuvers. VR equipment requires regular maintenance and upgrades to ensure smooth operation.

Main components of VR equipment:

– VR helmets are devices that provide immersion in a virtual environment;

– controllers are tools for interacting with virtual objects;

– motion tracking systems – technologies that allow accurate tracking of cadets' movements in a virtual environment.

3. Software. Software is a critical element in ensuring the efficient operation of simulators and VR equipment. Modern training programs must be integrated with software that allow to create complex scenarios and track the progress of cadets. The software should include a learning management system (LMS) that allows to track the progress of each student and adapt the training programs according to their needs.

The main tasks of the software:

– management of simulation scenarios and control over their execution;

– tracking the progress of cadets and creating reports for instructors;

– update and adaptation of training programs depending on training results.

4.4.3 OPTIMIZATION OF RESOURCES TO ENSURE EFFECTIVE IMPLEMENTATION OF THE PROJECT

Resource optimization is a key factor in the success of any project, especially under tight budget and time constraints. A project to introduce virtual simulators into training programs for naval officers requires careful management of both human and logistical resources to achieve maximum effectiveness.

Optimization consists in ensuring the most rational use of available resources in order to avoid excessive costs, reduce the time for completing tasks and improve the quality of project implementation. The use of optimization approaches makes it possible to increase the effectiveness of training cadets, reduce maintenance costs and ensure flexibility in achieving project goals.

The main strategies for resource optimization:

1. Rational distribution of human resources. For the effective implementation of the project, it is important to ensure the correct distribution of responsibilities between instructors, technical personnel and military specialists. One of the key tools for this is to create a clear system of responsibilities and tasks for each group of personnel.

Instructors. To optimize their work, it is possible to develop clear training scenarios and materials that allow to reduce the time to prepare for each session. Instructors can work in teams to share responsibility for different stages of the training process, allowing them to focus on specific aspects of the training.

Technical staff. It is important for technicians to establish a clear maintenance schedule for simulators and VR equipment. Optimization of technical maintenance will avoid unforeseen downtimes and ensure smooth operation of the system.

Military experts. Involvement of military experts in the development of training scenarios can be optimized through regular meetings with instructors and technical staff. This will make it possible to quickly adapt training programs to new requirements and reduce the time for developing new scenarios.

2. Use of flexible project management methodologies (Agile, SCRUM). As mentioned earlier in section 4.3, the use of flexible methodologies, such as Agile and SCRUM, allows to optimize the project implementation process due to an iterative approach and constant adaptation to changes. This approach is especially useful for projects that require constant updates and adjustments.

Iterative process. Breaking down the project into separate phases allows the instructor and technical staff to focus on specific parts of the project, which reduces the overall workload and reduces the risk of delays.

Regular meetings and feedback. Thanks to regular SCRUM meetings, the team can make changes in a timely manner, which saves time and resources, without redoing already completed tasks in the final stages of the project.

3. Minimization of costs for material and technical resources. Reducing costs for material and technical resources is an important part of optimization. Several approaches can be used for this:

– lease of equipment instead of purchase. For some projects where the use of certain equipment is temporary, it is advisable to consider the option of renting instead of buying it. This will significantly reduce the cost of technical equipment, especially for expensive VR systems;

– modernization of existing resources. In some cases, modernization of existing equipment can be cheaper and more efficient than purchasing new ones. For projects using simulators, it is worth paying attention to the possibility of updating the software, which will allow expanding the functionality of existing simulation systems;

– using cloud-based solutions. Instead of purchasing expensive servers and data storage systems, it is possible to use cloud-based solutions to store training materials and work with simulator data. This will significantly reduce infrastructure costs and provide greater flexibility in data access.

4. Use of multifunctional resources. Another approach to optimization is the use of multifunctional resources. This can concern both human resources and material and technical support.

Cross-functional teams. Involvement of instructors and technical staff in joint work allows to increase the efficiency of the project. Instructors can help technicians set up scenarios, and technicians can provide support during training sessions.

Using simulators for different types of training. Optimization is also about making the most of simulators for different training programs. For example, simulators can be used both for the training of navigation officers and for the training of technical specialists or crew, which allows to significantly expand their functionality.

4.5 RISK MANAGEMENT IN THE PROJECT

4.5.1 RISK ASSESSMENT: TECHNICAL, FINANCIAL, ORGANIZATIONAL RISKS

The first step in the risk management process is their assessment. The risks associated with military training projects can vary, but they can be classified into three main categories: technical, financial and organizational [18]:

1. Technical risks. These risks are related to the operation of hardware, software, simulators and VR systems. Since the project involves the implementation of complex technologies, the following technical risks are possible:

– equipment malfunctions: simulators and VR equipment may fail, which may lead to delays in the training process or the need for urgent repairs;

– failure to meet requirements: software or simulation systems may not fully meet technical specifications or expectations;

– cyber security: as simulators may be connected to networks or used online, there is a risk of cyber threats, including unauthorized access to systems or data.

2. Financial risks. Such risks are related to project implementation costs, financing and possible changes in the budget. The main financial risks include:

– budget overrun: project implementation may require more resources than initially anticipated, resulting in overspending;

– unforeseen costs: additional costs related to hardware repairs, software updates or maintenance may occur;

– instability of funding: military projects may depend on government funding, which may be unstable due to economic or political changes.

3. Organizational risks. These risks relate to the internal structure of the project, coordination between teams and the effective management of human resources.

The main organizational risks include:

– lack of qualified personnel: the project may face a shortage of instructors or technical personnel, which delays implementation or reduces the quality of training;

– inadequate coordination: poor interaction between different project units can lead to delays or errors in the completion of tasks;

– time management issues: failure to meet schedules and deadlines due to poor planning or external circumstances (such as tactical or missile strike alert) can significantly affect project success.

4.5.2 DEVELOPMENT OF RISK MANAGEMENT PLANS AND MINIMIZATION OF POSSIBLE CONSEQUENCES

After assessing the risks, it is important to develop risk management plans that include strategies to minimize possible consequences and prevent negative scenarios.

Strategies for minimizing technical risks. Regular maintenance of simulation equipment and VR systems will allow to identify and eliminate potential problems at an early stage. This involves preventive measures, software updates and equipment testing before each training course.

To reduce the risk of equipment malfunctions, it is advisable to provide for the availability of spare equipment or spare parts that can be quickly replaced in case of breakdowns. This will ensure the continuity of the educational process.

And to prevent cyber threats, it is necessary to implement cyber security measures, including installing modern anti-virus programs, encrypting data and restricting access to the network for unauthorized persons.

Strategies for minimizing financial risks. One of the main steps to minimize financial risks is careful budgeting during the project planning phase. It is necessary to anticipate all possible expenses, including contingencies, and ensure a reserve fund to cover unforeseen expenses.

Regular monitoring of expenses allows timely detection of budget overruns and adjustments to plans. It is important that each stage of the project is under constant financial control, which will avoid significant deviations from the budget.

In the case of financial difficulties, it is worth considering the possibility of attracting additional funding from alternative sources or optimizing costs at certain stages of the project.

Strategies for minimizing organizational risks. It is important to provide the project with qualified personnel, in particular instructors and technical specialists. This can be done by training and retraining existing personnel or by engaging external specialists on a temporary basis.

To minimize the risks associated with poor coordination, it is important to establish regular communication between all project participants. This can be achieved by holding regular meetings, exchanging information through corporate systems, or organizing special trainings to increase interaction between departments [19].

The creation of detailed schedules for the execution of tasks and the constant monitoring of their compliance will avoid delays in the implementation of the project. It is worth implementing project management systems that help track progress and ensure transparency of tasks.

It would also be appropriate to create the so-called "Risk Assessment Matrix". The matrix can look like a table (**Table 4.1**), where the probability of risk occurrence is displayed horizontally, and the level of severity of consequences is displayed vertically.

Table 4.1 Risk assessment matrix

Probability/Consequences	Minor (1)	Moderate (2)	Significant (3)	Critical (4)	Catastrophic (5)
Very low (1)	1	2	3	4	5
Low (2)	2	4	6	8	10
Average (3)	3	6	9	12	15
High (4)	4	8	12	16	20
Very high (5)	5	10	15	20	25

Description of categories:

1. Probability (1–5):

1 – Very low (the risk rarely occurs);

5 – Very high (the risk occurs often).

2. Consequences (1–5):

1 – Insignificant (small losses, does not affect the project);

5 – Catastrophic (the risk can lead to significant losses, project stoppage or serious damage).

3. Risk assessment and action:

– high risk (12–25): it is necessary to implement a risk management plan and means for their minimization (additional technical checks, personnel training, equipment redundancy);

– medium risk (6–11): constant monitoring of the situation and readiness to react quickly to risks (cost control, coordination between teams) are required;

– low risk (1–5): requires periodic monitoring but does not require immediate action.

For example, a cyber threat:

1. Probability: 2 (low, subject to compliance with security measures).

2. Consequences: 5 (catastrophic, may lead to loss of important data or system shutdown).

3. Risk score: 10 (high risk, security systems required).

4.5.3 INFLUENCE OF EXTERNAL FACTORS (POLITICAL, MILITARY, ECONOMIC) ON PROJECT IMPLEMENTATION

External factors such as political, military and economic changes can significantly affect the implementation of the project.

These factors are often unpredictable and can have both positive and negative consequences for the progress of the project:

1. Political factors. The political situation can affect the financing and general direction of the project. Changes in government priorities or political instability can lead to:

– changes in funding: political decisions can affect the project budget, including reductions in government funding or its reallocation;

– changes in defense strategy: political changes may affect changes in a country's military strategy, which in turn may require adjustments to training programs or technological approaches in a project.

2. Military factors. Military operations and combat can directly affect training projects, especially if the training of naval officers is related to real combat needs:

– emergency mobilization of personnel: in the event of hostilities or threats, instructors or cadets may be mobilized to participate in military operations, resulting in the delay or suspension of training programs;

– changes in military priorities: military conflicts may require urgent adjustment of training programs to adapt to new threats or tactical requirements.

3. Economic factors. The economic situation in the country or at the international level can also affect the project:

– inflation or economic crises: economic instability can lead to an increase in the prices of equipment and services, which will affect the financial condition of the project;

– reduction of public expenditures: in the event of an economic crisis, the state may reduce expenditures on defense projects, which may affect the pace of their implementation or even lead to a freeze.

4.6 ASSESSMENT OF PROJECT EFFECTIVENESS AND QUALITY CONTROL

4.6.1 DETERMINATION OF PROJECT SUCCESS CRITERIA

Effective implementation of a project using virtual simulators for the training of navigation officers requires constant quality control and evaluation of results. Evaluating the effectiveness of the project makes it possible to determine how successfully the set goals have been achieved, and to adjust further actions to improve the level of preparation. Quality control is a critical element that allows to ensure the appropriate level of preparation and compliance of the project with established standards.

Project success criteria are key indicators that determine how well the project meets the initial goals and objectives. These criteria vary depending on the specifics of the project and the expected results, but in general, several main categories can be distinguished for training projects using simulators.

The main success criteria:

1. Achieving learning goals in accordance with training standards – learning outcomes. The main criterion for success is the project's ability to ensure the achievement of defined educational goals. This includes training cadets to perform complex tasks at sea, improving their navigation skills and combat readiness. The curriculum must meet the requirements of naval standards and ensure that cadets have acquired the necessary knowledge, skills and abilities.

2. Compliance with quality standards. The success of the project is also determined by its compliance with established quality standards, in particular international standards for the training of maritime officers, such as STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers). Training programs must meet these requirements, and simulation technologies must provide a realistic and effective experience for cadets.

3. Effective use of resources. The success of the project is also measured by the efficiency of the use of human and material and technical resources. This includes optimal staffing, proper simulator maintenance, and cost minimization.

4. Satisfaction of participants. An important criterion is the satisfaction of cadets and instructors. High quality of training, realistic scenarios and ease of use of simulators are indicators of a successful project. Feedback from participants allows to assess the overall level of satisfaction and identify opportunities for further improvement.

5. Continuity of the training process. The success of the project can also be judged by how seamless and seamless the integration of simulators into the learning process is. The project is considered successful if training takes place without significant technical interruptions and the equipment functions stably.

4.6.2 METHODS OF ASSESSING THE QUALITY OF NAVIGATION OFFICER'S TRAINING

Assessment of the quality of training of navigation officers is an important component of the project. For this, various methods are used, which allow to check how effective the training programs are and how well the cadets acquire knowledge and skills.

The main methods of assessing the quality of training:

1. Testing of knowledge, skills and abilities. One of the main methods of evaluation is the testing of cadets to check their theoretical training and skills. Tests may cover topics in navigation, maritime law, maritime safety and crew command. It is important that the testing is adapted to the training level of the cadets and corresponds to the goals of the training program.

2. Practical tests on simulators. Practical tasks, which are performed on simulators, make it possible to assess the level of practical training of cadets in realistic conditions. Cadets can perform tasks related to navigation in difficult weather conditions, emergency situations or combat operations. The assessment is based on the analysis of their actions, decisions and speed of response to changing factors.

3. Error analysis and feedback. After each practical session, an analysis of the mistakes made and feedback from the instructors is carried out. This allows the cadet to understand his/her mistakes and practice correct decisions in subsequent sessions. Feedback helps to improve not only the learning process, but also the instructors themselves in their teaching methods.

4. Monitoring progress. Learning management systems (LMS) allow instructors to constantly monitor the progress of cadets. Such systems store the results of tests, evaluations of practical tasks and general progress, which allows to get a complete picture of the level of training of each cadet.

5. Graded assessments and credit modules. Evaluation of the effectiveness of training can be carried out on the basis of a system of rating evaluations and credit modules. This allows to compare the results of different cadets and identify the strengths and weaknesses of the training program [20].

4.6.3 ANALYSIS OF RESULTS AND CONCLUSIONS REGARDING THE EFFECTIVENESS OF VIRTUAL TRAINING

The last step in the process of evaluating the effectiveness of the project is the analysis of training results and conclusions about the impact of virtual simulators on the training of navigation officers, which should cover several aspects.

The main aspects of the analysis of the results:

1. Comparison of results with initial goals. First of all, the analysis of training results should be aimed at comparing the achieved indicators with the initial goals of the project. This makes it possible to determine to what extent the training program using simulators meets expectations and whether the required level of officer training has been achieved.

2. Assessment of cadets' progress. It is important to analyze the progress of cadets at each stage of training. This gives an idea of how effective each session and scenario was in the simulators. Progress analysis helps identify possible problems in the training program and make timely adjustments to improve efficiency.

3. The impact of virtual simulators on the educational process. One of the key aspects of the analysis is the assessment of the impact of virtual simulators on the quality of training. This includes examining how realistic and effective the simulation scenarios were, how well the cadets responded to them, and whether they improved their readiness for real-world tasks at sea.

4. Cost effectiveness analysis. To assess the overall effectiveness of the project, it is also important to conduct a cost-benefit analysis. This allows to find out whether the investment in the project was justified in view of the achieved educational results. If the educational goals were achieved with lower costs, this indicates a high efficiency of the project.

5. Assessment of participants' satisfaction. Equally important is the assessment of the level of satisfaction of cadets and instructors. If the participants of the training process highly appreciated

the quality of training, the realism of the simulations and the convenience of the equipment, this indicates the success of the implementation of virtual technologies.

Conclusions on the effectiveness of virtual training. Analysis of the results can show significant advantages of using virtual simulators in officer training. The main advantages include the possibility of safely working out complex scenarios, increasing the realism of training, flexibility and reducing costs.

The analysis also allows to identify possible weaknesses or aspects that can be improved. For example, it is possible to improve training scenarios, add more options for the development of events, or improve the user-friendliness of simulators.

Depending on the results of the analysis, it is possible to draw conclusions about how effective the introduction of virtual simulators into the educational process will be in the long term. If educational goals are consistently achieved and the quality of training improves, this indicates the feasibility of further use of such technologies.

4.7 PROJECT DEVELOPMENT PROSPECTS AND FURTHER STEPS

4.7.1 POTENTIAL FOR PROJECT EXPANSION: NEW SIMULATIONS, INTERNATIONAL COOPERATION

The project using virtual simulators for military training has significant potential for expansion both nationally and internationally. This opens up opportunities to create new simulation scenarios and expand cooperation with other countries, in particular through alliances such as NATO.

Military training programs can be significantly expanded through the introduction of new combat simulations. These can be scenarios simulating modern threats such as cyber-attacks, unmanned operations or operations in complex geographic environments. Expanding the library of simulation scenarios will allow cadets to practice new types of tasks and prepare for operations in new conditions.

An important area of expansion of the project is the development of scenarios for joint operations with other military units or military branches. For example, simulations involving interaction between naval, air and land forces will allow cadets to practice coordination of actions in multinational or intergenerational operations.

In addition to combat scenarios, virtual simulators can be used to prepare for peacetime operations such as humanitarian missions, maritime rescue operations, anti-piracy and security in international waters.

International cooperation. Implementation of joint training programs with NATO member countries allows not only to improve the level of training of cadets, but also to ensure their ability to work effectively as part of international military coalitions. Joint simulations will allow cadets to learn to interact with military units of other countries and practice operations according to uniform standards.

International cooperation opens opportunities for the exchange of technologies and best practices in the field of military training. Countries can jointly develop new simulation systems, exchange experience in the use of artificial intelligence in simulators, and create joint innovative projects.

4.7.2 INNOVATIVE APPROACHES TO IMPROVING VIRTUAL MILITARY TRAINING

Innovative technologies and training approaches open new horizons for improving the virtual training of military officers. Modern technologies make the educational process more realistic, effective and adaptive:

1. Integration of adaptive learning technologies. One of the areas of development is the creation of adaptive scenarios that automatically adjust to the level of knowledge and skills of the cadets. This will make it possible to provide an individual approach to each cadet and provide him/her with tasks that correspond to his/her level of training, gradually increasing the complexity of the tasks.

To improve the realism of training, it is possible to implement simulations that simulate stressful situations and test the psychological readiness of cadets to work in extreme conditions. This can be particularly useful for training officers who will direct operations in a combat environment.

2. Use of augmented reality (AR). Augmented reality (AR) can become an important element in the training of military officers. With the help of AR, it is possible to create interactive educational materials that complement real scenarios with virtual objects. This will allow cadets to learn on real objects, while using virtual prompts, additional information and other elements that will help them make the right decisions.

3. Gamification of the educational process. Gamification, that is, the use of game elements in education, allows to increase the motivation of cadets and make the educational process more interactive. Creating rating systems, difficulty levels, and game achievements can help cadets learn better and engage more actively in learning [21].

4.7.3 USE OF ARTIFICIAL INTELLIGENCE AND NEW TECHNOLOGIES IN SIMULATIONS FOR OFFICERS TRAINING

Artificial intelligence (AI) plays an important role in modernizing the simulation systems used in military training. The use of AI opens up new possibilities for creating more realistic, flexible and adaptive simulations.

Artificial intelligence in enemy simulation. Using AI to simulate enemy behavior allows to create more realistic and dynamic scenarios. Intelligent algorithms can control virtual opponents who change their tactics depending on the actions of the cadets, making simulations more unpredictable and effective for practicing tactical skills.

The use of AI in educational systems allows the creation of self-learning simulations that analyze the actions of cadets and adapt scenarios based on their decisions and mistakes. This allows each cadet to go through an individual learning path, which increases the quality of training.

Application of AI to analyze cadets' actions. Real-time analysis of training results AI can be used to automatically analyze the actions of cadets during simulations. AI-based systems can assess cadets' reactions, tactical decisions and actions, providing instructors with detailed reports on training outcomes. This allows to quickly identify weak points and provide recommendations for further improvement.

Modern simulation systems can use AI to continuously monitor and evaluate the progress of cadets. AI analyzes their actions during training and adjusts scenarios to deepen certain skills. This approach allows to increase the individual effectiveness of training and helps each cadet to achieve a high level of professional training.

CONCLUSIONS

The project on the implementation of virtual simulators will significantly improve the process of training for navigation officers. The use of simulations will allow to better master the skills of managing a ship, improve teamwork, increase the level of readiness for real combat tasks, and also reduce training costs. Thanks to the introduction of the latest technologies (VR, artificial intelligence), the educational process will become more interactive and adaptable to the individual needs of cadets.

The results of the implementation of virtual simulators in the educational process indicate several key achievements:

1. Improvement of practical skills of cadets. Virtual simulators will allow cadets to practice realistic scenarios of maritime operations in safe conditions. This will significantly increase their level of readiness to perform real tasks, providing a deeper understanding of complex navigational and tactical processes.

2. Reduction of costs for real training. The use of simulators will minimize training costs, including fuel, ship maintenance, and the organization of real training missions. This will help save resources and make the educational process more effective.

3. Reduction of risks during preparation. Simulating dangerous situations such as accidents, combat operations and natural disasters will allow cadets to learn how to act in crisis situations without risking their lives or the lives of the crew. Thanks to this, training will become safer and more productive.

4. Integration of the latest technologies. The introduction of virtual reality (VR), artificial intelligence (AI) and other innovative technologies will make the educational process more interactive and flexible. Cadets will have the opportunity to undergo individual training programs that allow taking into account their personal needs and level of knowledge.

The use of simulators will improve the professional training of cadets, increase their ability to make decisions in crisis situations, and also help to better prepare for modern threats and challenges. Training programs will become more dynamic and flexible, which will positively affect the readiness of the military to perform complex tasks.

Expanding simulation scenarios will better prepare officers for various types of operations, including multinational missions.

The integration of artificial intelligence will help to adapt training to the needs of each cadet, and will also increase the realism of combat scenarios. International cooperation will ensure the exchange of best practices and allow cadets to prepare for joint operations as part of international coalitions.

The project will have a positive long-term impact on the level of training of military personnel and will create a foundation for the further development of military training programs.

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