

STRATEGIC PLANNING OF SAFETY-ORIENTED SYSTEMS BASED ON THE DIGITALISATION OF HUMAN RESOURCE MANAGEMENT

Oleh I. Kovalchuk¹, Roman T. Ratushnyy¹, Lilia Y. Balash¹, Myroslav S. Koval¹

¹Lviv State University for Life Safety

Correspondence: o.kovalchuk@ldubgd.edu.ua

Abstract

This article substantiates a comprehensive methodology for the strategic value-based management of territorial safety systems (TSS) projects, integrated within a digitalised framework of Human Resource Management (HRM) and adaptive resource allocation. The study aims to develop a portfolio-hybrid management framework that incorporates advanced models and tools to maximise stakeholder value under conditions of high entropy and severe resource constraints. To achieve this, the research evaluates the current state of academic foundations and practical applications in TSS management, justifying the transition toward syncretic and hybrid methodologies. The research utilizes a systems-value approach, drawing on the principles of P2M and PMBOK 7 to model security projects as complex socio-technical systems operating across municipal, regional, and state levels. The methodology integrates geographic information systems for spatial optimisation, alongside neural network modelling to predict volunteer availability and rescuer competencies in accordance with IPMA ICB 4.0 standards. The authors have codified the value of security projects into a four-tier structure: basic, additional, added, and systemic value. Systemic value is characterised as a synergetic effect derived from integrated portfolio management and the rational synchronisation of shared resources. The proposed information technology leverages computational intelligence and ERP (Enterprise Resource Planning) systems to enable real-time resource monitoring and the automated selection of optimal project implementation scenarios. The implementation of the proposed methodology transforms the reform of security systems from fragmented initiatives into a scientifically grounded strategy. By accounting for the variable configuration of the project environment and the specific “index of vulnerability” of critical infrastructure, the approach ensures maximised societal value, risk minimisation, and enhanced public protection despite limited financial capacities.

Keywords: territorial safety systems, strategic planning, portfolio-hybrid management, project, digitalisation of HRM, resource management, information systems

Introduction

The current state of territorial safety systems (TSS) in Ukraine is insufficiently effective, resulting in significant human losses and the destruction of material resources during emergencies. The main reason for the low effectiveness of reforms

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is the lack of systematic assessment of project value and the disregard for the specifics of the project environment during planning. Rural territorial communities (OTC) require particular attention, as they remain the most vulnerable due to their remoteness from existing fire and rescue units (FRU). To address these issues, we propose using a portfolio-hybrid management methodology based on a systemic-value approach to forming portfolios of civil protection development projects (CPDP). Development projects are viewed as complex organisational and technical systems operating at three hierarchical levels: community, regional, and national.

The article analyses modern approaches to security project portfolio management. In contemporary scientific discourse, the issue of systematically assessing the value of territorial safety system (TSS) development projects occupies an important place, given the need to reform the State Emergency Service of Ukraine (SES) and increase the level of protection of the population. A review of the literature allows us to identify several key areas of research: methodological approaches to management, the concept of hybrid projects, the role of geoinformation technologies, and the impact of European integration.

The fundamental principles of TSS development management are laid down in the scientific work by Tryhuba and Ratushny (2025), which justifies the transition from the fragmented implementation of local initiatives to a portfolio-hybrid management methodology. The author argues that traditional approaches do not take into account the multi-hierarchical structure of security (public, regional, and state levels), which leads to low project value for stakeholders. Similar ideas on hybrid management of infrastructure programmes based on knowledge convergence mechanisms are developed by Zachko and Kobilkin (2020), emphasising the transition from reactive to proactive management methods.

In scientific literature, hybrid projects are considered to be repetitive or to have products with known consumer properties, which allows their results to be modelled at the planning stage. Koval (2021) indicates that simulation modelling of HP is the basis for adequate forecasting of value indicators and selection of optimal scenarios for system development. Tryhuba (2021) proposes classifying the value of HP into four types: basic, additional, added, and systemic, with systemic value arising from the synergistic effects of holistic portfolio management.

Recent studies (Tryhuba & Koval, 2021) focus on the use of geographic information systems (GIS), in particular the OpenStreetMap (OSM) framework, for spatial analysis of territories and the minimisation of emergency response times. Gryshchenko (2025) demonstrates that the introduction of GIS into the processes of restoring territorial communities reduces costs by 10–15% through accurate modelling of risk areas and infrastructure damage. There are also publications on the application of deep learning and neural networks to predict object availability in dynamic project environments.

A significant part of the literature is devoted to analysing successful foreign models of civil protection. In particular, it considers the experiences of the United States (FEMA), Germany, and Denmark, where voluntary fire brigades play a key role in the security system (ranging from 72% to 97% of personnel). Koval et al. (2024) examine the role of the EU Civil Protection Mechanism (UCPM), which Ukraine joined in 2023, as a platform for sharing knowledge and resources, and for standardising procedures for responding to large-scale disasters.

The latest developments, in particular Malanchuk (2025) offer an adaptive value-based approach based on combining agile management with rigorous mathematical risk modelling. This approach allows the project portfolio architecture to be adjusted in real time in response to environmental changes, which is critical for security systems.

A review of the literature confirms that systematic assessment of the value of CSE projects requires integrating a portfolio-hybrid methodology, modern GIS technologies, and consideration of project-specific environmental conditions to create the most effective protection for communities.

Each country has its own characteristics and approaches to the formation of civil protection systems. However, there are common features related to the existence of a special state coordinating body that ensures the development of a strategy, its justification and implementation in the field of civil protection. In the United States, the central body is the Federal Emergency Management Agency (FEMA). This agency is independent and reports directly to the US President. FEMA's main tasks include the formation and development of federal and local civil protection systems, as well as training rescuers to respond to emergencies. At the same time, in the United States, about 72% of civil protection forces are made up of volunteer rescuers. At the same time, it is stipulated that PRFs involving volunteer rescuers should be established only in settlements with a population of more than 2,500 inhabitants. Most PRFs involving volunteer rescuers are located in rural areas.

A distinctive feature of these emergency services is that volunteer rescuers perform their duties free of charge. At the same time, they are mentally convinced of their civic duty to protect the territories and objects where they live from emergencies. At the same time, volunteer rescuers in the United States receive several social benefits, including additional annual leave.

At the same time, based on their analysis of several factors, some scientists argue that Germany's civil protection services are the most effective. In this country, civil protection services have a dual purpose, with each reporting to the Federal Ministry of the Interior (Bundesministerium des Innern, BMI). This ministry is responsible for the forces and means of protection against emergencies. At the same time, Germany has the largest number of volunteer rescuers. They make up about 97.45% or 1,055,255 people of the total number in the country.

Each of the fire brigades in Germany is an independent structural unit and there is no state authority to manage them. There are specific regulations governing the formation of professional and voluntary fire brigades. In particular, settlements with a population of over 90,000 require the creation of professional fire brigades, while those with a smaller population require the creation of voluntary fire brigades, which must include professional firefighters in their structure. In addition, Germany regulates the creation of voluntary fire brigades in organisations with more than 30 employees at the legislative level. Volunteer rescuers receive remuneration at their main place of work, funded by local budgets. Rescuers in Germany receive a number of social benefits, including free insurance, work experience in the PRF, motivational rewards for individual years of service in the PRF, exemption from military service, and the provision of necessary equipment and uniforms.

In some countries, civil protection systems are being established and developed using similar approaches and principles. In particular, agencies similar to FEMA in the United States have been established in countries such as the United Kingdom (the Department for Civil Protection, which is part of the Home Office), Germany (the Federal Office for Civil Protection, which reports directly to the Chancellor), France (the National Directorate for Civil Protection, which is part of the Ministry of the Interior), and Italy (the National Civil Protection Service, which is part of the Ministry of Civil Protection). (National Emergency Protection Administration, part of the Ministry of the Interior), Italy – (National Emergency Protection Service, part of the Ministry of Civil Protection), Austria – (Emergency Response Service). It should also be noted that in most states, there is dual subordination. Overall coordination and development of civil protection is carried out by the Civil Protection Department of the Ministry of the Interior, while specific tasks are organised and carried out by specially created committees in individual counties, communities, counties, districts and municipalities.

There are also some peculiarities in the formation and development of the Civil Protection Service in the Netherlands. In this country, its territory is divided into 12 approximately equal districts, each of which has its own provinces. In each province, the civil protection service is headed by a chief who reports to the provincial commissioner. There are two types of civil protection services in the Netherlands: regional and local. Local civil protection services are public services managed by mayors, and at the level of individual districts, a council has been created, which includes the mayors of the communities. At the same time, a distinctive feature of the development of civil protection services in Denmark is that they include about 80% volunteers. Most of them (over 50%) are part-time volunteer rescuers scattered across 14 municipalities and two special territories: the Faroe Islands and Greenland.

Digitalisation enables the use of simulation exercises and disaster modelling to continuously assess unit effectiveness. In particular, the experience of the European

Union shows that the certification of rescue teams necessarily involves participation in such digital simulations, which guarantees high operational standards. Thanks to deep learning methods, it is possible to predict volunteer availability in rural communities. This allows HRM systems to intelligently form project teams, selecting the most qualified volunteers for specific tasks based on big data analysis.

Digital HRM tools facilitate the exchange of innovative approaches between countries. For example, this helps adapt successful models of voluntary fire protection in the United States (FEMA) or Germany (BMI) to Ukrainian realities, where more than 70% to 97% of rescuers are volunteers.

Materials and Methods

Maximum value for stakeholders of TSS development projects can be ensured through the use of the safety-oriented portfolio-hybrid management methodology, which involves the development and use of methods, models and tools that take into account the specific features of the project environment (the presence and territorial location of settlements in the ATC (service area), the number of residents, as well as the presence of potentially dangerous objects in each of the ATC settlements, the presence and condition of the road network, the availability of resources, the presence of sources and the amount of funding for individual projects, etc.).

Another important component that significantly affects the value of TSS development projects is the finite number of configuration object parameter options, which greatly influence the set of possible scenarios for their implementation and the architecture of safety-oriented systems. The selection of effective options for configuration object parameters, TSS development project implementation scenarios, and safety-oriented system architecture from the available set can be carried out on the basis of modelling their products – hybrid projects implemented by each of the created elementary TSS. It is this modelling that will ensure adequate forecasting of cost indicators, which form the basis for developing effective safety-oriented systems and their conceptual plans.

The study applies a safety-oriented portfolio-hybrid management methodology using a scenario-based modelling approach. The research procedure consisted of the following steps:

1. Identification and characterisation of ATC settlements, including population, infrastructure and risk factors.
2. Definition of configuration object parameters and possible system architectures.
3. Development of alternative implementation scenarios.
4. Modelling of hybrid project outcomes for each scenario.
5. Comparative analysis based on cost indicators and system effectiveness criteria.

Results and discussion

An analysis of the formation and development of TSS in EU countries indicates that, in order to improve the effectiveness of protecting the population from emergencies and ensuring their timely resolution, the efforts and resources of the state, regions, and communities are being pooled. Currently, TSS in Ukraine, which are part of the State Emergency Service, are operating inefficiently. In particular, this is due to a significant number of emergencies that result in loss of life and substantial material damage. This is evidenced by State Emergency Service statistics on trends in the number of emergencies and in loss of life during emergencies.

The number of casualties in Ukraine remains unchanged, highlighting the need to reform the State Emergency Service and develop TSS. Establishing effective TSS in Ukraine is a top priority for both the development of the State Emergency Service and ensuring national security.

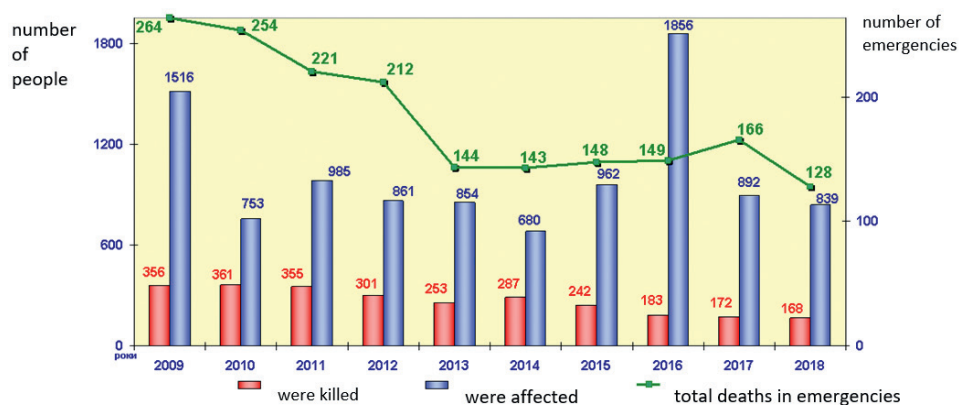


Figure 1. Trends in the number of emergencies and related casualties

Source: State Emergency Service of Ukraine

When examining the state of emergency situations within individual administrative regions of Ukraine, it becomes evident that they vary in number and type and depend on the region's natural and climatic conditions as well as the presence of potentially hazardous facilities within its territory. For example, the chart below shows changes in the number of state- and regional-level emergencies in the Lviv region, indicating an overall positive trend.

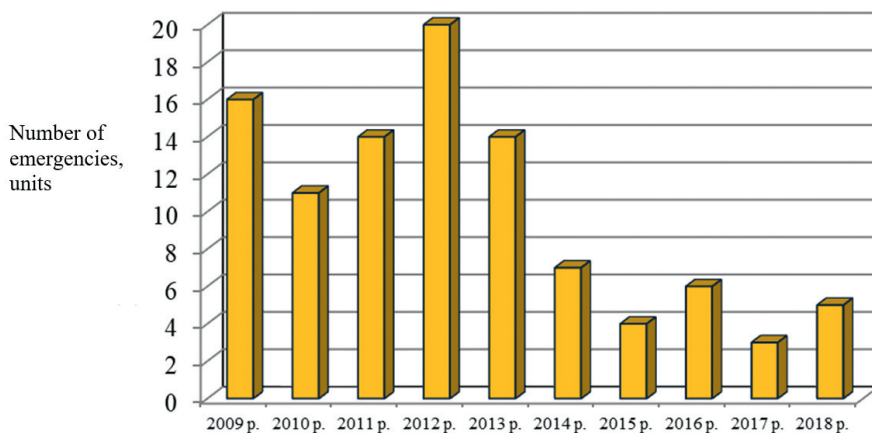


Figure 2. Number of emergencies that occurred in the Lviv region

Source: State Emergency Service of Ukraine

However, the variation in the number and nature of emergencies points to the need to develop a strategy for the development of individual regional TSSs that takes their specific characteristics into account, which forms the basis of the relevant projects.

In recent years, Ukraine has paid increasing attention to reforming the State Emergency Service and creating effective TSBs. A number of measures are being implemented in the state to reform the State Emergency Service. Thus, a strategy for reforming the State Emergency Service has been developed, regional programs and project portfolios are being implemented in the administrative regions, and a number of local projects for the development of TSBs of united territorial communities (UTC). Their investment is being funded by both the state and local budgets of individual regions and the UTC. However, they do not ensure the creation of maximum value for UTC residents. This is because they do not provide for the development of conceptual plans for TSS development projects and for their systematic implementation as part of project portfolios, based on the portfolio management methodology. Reforming the State Emergency Service and creating effective TSS is possible only with the systematic formation of PRTSBs and their high-quality management.

An analysis of several academic papers indicates that researchers in Ukraine are paying due attention to both analysing the current state of transport safety systems and identifying ways to address the challenges to their development. At the same time, the lack of well-founded scientific and technical measures, as well as technical developments for the development of civil protection systems, the number of emergencies, and their negative consequences remain critical and require immediate changes to the structure of the State Emergency Service and the

organisation of its activities. This applies in particular to rural communities, which are the most vulnerable to emergencies.

Across Ukraine, local teams are being established within amalgamated territorial communities (ATC) to enhance protection against emergencies and ensure a timely response should they arise. At the same time, a number of challenges arise concerning the coordination of activities between existing fire and rescue units of the State Emergency Service and the local emergency response teams established within these communities as a result of project implementation.

Based on an analysis of statistical data on the progress of projects to establish local team units within certain amalgamated territorial communities (ATCs) in Lviv Oblast, it can be noted that these projects are operating inefficiently. In particular, these projects were implemented without a systematic justification of their feasibility or alignment of the project's configuration with the characteristics of the project environment. At the same time, their implementation was carried out without using project and portfolio management methodologies, which fails to ensure the quality of implementation and the formation of an effective project portfolio within a given administrative territory, within a limited budget and taking into account the specific project environment. All of that indicates that the value of such projects for stakeholders is minimal.

Maximum value for stakeholders in TSS development projects can be ensured through the use of the TSB project portfolio hybrid management methodology, which involves the development and application of methods, models and tools that take into account both the characteristics of the specific project environment (the presence and geographical location of settlements within the ATC, population size, as well as the presence of potentially hazardous facilities in each of the ATC's settlements, the existence and condition of the road network, resource availability, the sources and volume of funding for individual projects, etc.). Another important component that significantly influences the value of TSS development projects is the finite number of options for configuration object parameters, which in turn shape the set of possible implementation scenarios and the architecture of the safety system.

The selection of effective options for configuration object parameters, implementation scenarios for TSS development projects, and the architecture of the safety system from among the available set can be carried out on the basis of modelling their products – hybrid projects implemented by each of the created elementary TSBs. It is this modelling that will ensure adequate forecasting of value indicators, which form the basis for effective safety systems and the development of their conceptual plans.

Systematic assessment is impossible without identifying specific objects of the project environment configuration, which include:

1. Territorial characteristics: location of settlements, their area and configuration.
2. Demographic indicators: population size and building density.
3. Infrastructure factors: the condition and network of roads that directly affect the arrival time of rescuers.
4. Levels of danger: the presence of potentially dangerous objects and the forecast frequency of emergencies.

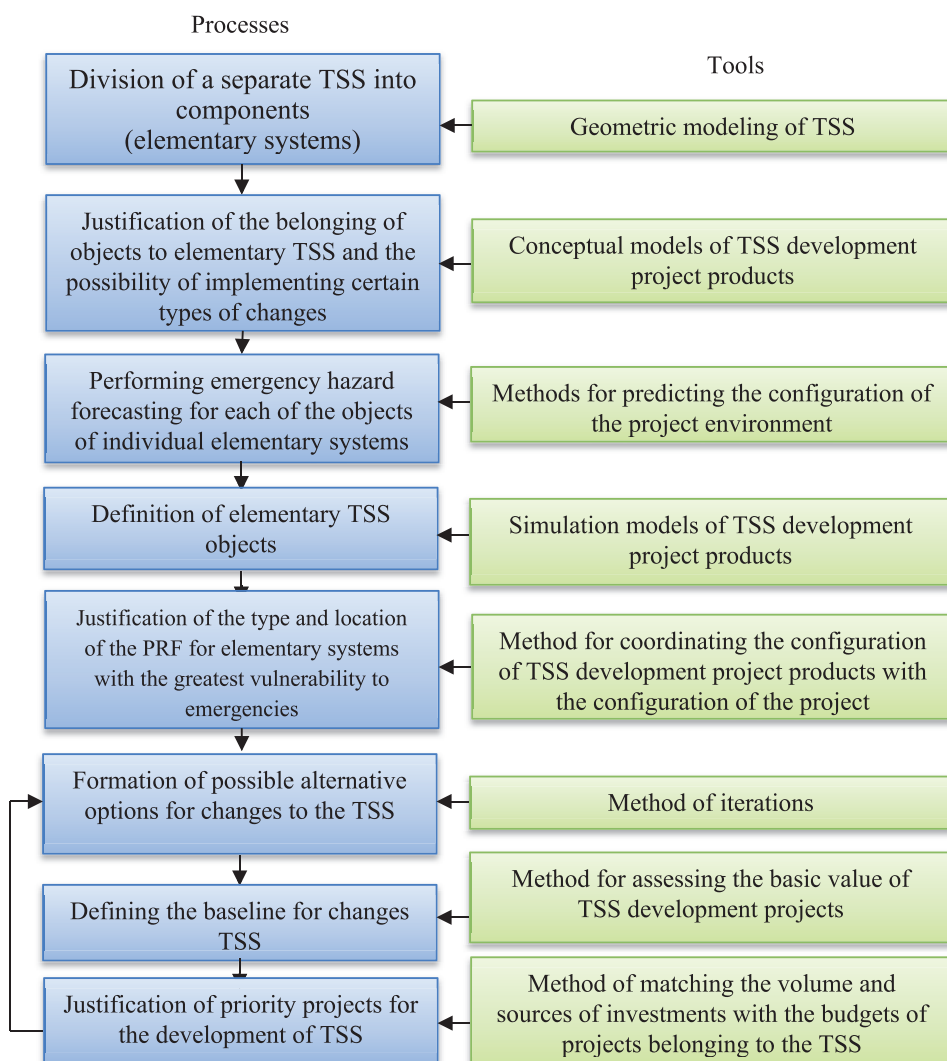


Figure 3. Stages of the method for initiating TSS development projects

A key element of the assessment is the concept of hybrid projects – projects that are periodically repeated or whose products have unique but well-known consumer properties. According to the developed model, the value of safety-oriented systems is a combination of four interrelated types of benefits for stakeholders:

- Basic value: benefits that communities receive directly from the implementation of local projects.
- Additional value: the results of project implementation at the regional level.
- Added value: benefits on a national scale.
- Systemic value: the effect of emergence and synergy that arises from integrated portfolio management and the effective allocation of shared resources.

Quantitative assessment of value is based on the criterion of effectiveness, defined as the ratio of the reduction in probable losses from emergencies (loss of life, property, and natural resources) to the costs of implementing and maintaining fire and rescue units.

Conclusions

A well-founded portfolio-hybrid approach to managing the development of territorial security systems (TSS) facilitates a transition from a fragmented allocation of resources to systematic planning across three hierarchical levels: local, regional and national. This allows security projects to be viewed as complex organisational and technical structures aimed at maximising public value and accounting for the systemic impact on adjacent territories.

The digitalisation of HRM and resource management processes, in particular the implementation of intelligent systems for assessing rescue workers' competencies in accordance with IPMA ICB 4.0 standards and GIS technologies based on OpenStreetMap, creates an objective basis for the rational deployment of units. The use of predictive neural network models enables effective management of volunteer availability, a critical factor in enhancing the security of rural communities in a dynamic project environment.

The findings of the study confirm the value of the widespread implementation of the proposed solutions in post-war reconstruction programmes. Further adaptation of the algorithms to managerial turbulence (BANI environments) and integration with ERP systems will ensure the flexibility of the security portfolio architecture, thereby contributing to the stable development of communities even under critical resource constraints.

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