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O. B. Zachko,
orcid.org/0000-0002-3208-9826,
D. O. Chalyy,
orcid.org/0000-0002-7136-6582,
D. S. Kobylkin,
orcid.org/0000-0002-2848-3572

Lviv State University of Life Safety, Lviv, Ukraine, e-mail:
dmytrokobylkin@gmail.com

MODELS OF TECHNICAL SYSTEMS MANAGEMENT FOR THE FOREST FIRE PREVENTION

Today, in Ukraine and in the world, despite the rapid development of science and technology, there is a problem of developing as well as improving and adapting information, organizational and technical systems capable of preventing forest fires. The object of the study is the process of identification and formation the parameters of safety-oriented management of technical systems of forest fire prevention.

Purpose. To develop new approaches to the safety-oriented project management of technical systems of forest fire prevention, and their modeling, based on the principles of system analysis.

Methodology. Using the general scientific principles and fundamental provisions of the project management methodology, including system analysis, modeling tools, proactive and reactive management mechanisms, we form a triad of creating the concept of designing a portfolio of technical systems for environmental protection against forest fires.

Findings. A conceptual triad of model-scheme of formation of the portfolio of projects of technical systems for protection of environment from forest fires is presented. A cybernetic model of the “black box” for decision making management during the implementation of the project of the technical system of forest fire prevention is adapted; the impact of factors that may occur under the influence of turbulent internal and external environment on the project is described. A safety-oriented model of project management of the technical system of forest fire prevention is developed, which is characterized by the presence of sub-phases of the life cycle, which are critical places of the project, have their own time frame of operation and resource consumption.

Originality. The model of safety-oriented project management of the technical system of forest fire prevention is developed and subphases in the basic phases of the project life cycle are identified. The developed models are adapted for use in different countries because they are formed in accordance with international standards for project, programs and portfolio of projects management P2M, PmBok, PRINCE2, AGILE, KANBAN.

Practical value. It is possible to use the obtained results in the practical activities of project, operational and management teams of authorities, emergency services and managers in the formation of national projects to prevent forest fires.

Keywords: *technical system, project management, safety-oriented management, forest fire, information system*

Introduction. Today in Ukraine and the world, despite the rapid development of science and technology and advanced technologies an urgent issue remains the development of new as well as improvement and adaptation of existing information, organizational and technical systems capable of preventing forest fires.

This is confirmed by statistical data on the growth of their number, scale and negative consequences, in particular the main factors of their occurrence are anthropogenic and man-made human impact, which accounts for 94 % of all fires in ecosystems, and a derivative factor – global climate change: high temperatures, overheating, which can lead to spontaneous combustion of peatlands, prolonged absence of rain, strong and gusty winds that accelerate the spread of fire, thunderstorms, and so on. In addition to large scales, forest fires are characterized by a significant number of deaths and the specifics of firefighting operations, depending on the geographical location, landscape, staff readiness, external factors (radiation background in Ukraine) (Table 1).

Today in different countries of the world different scientific and practical approaches, technical systems as to moni-

toring of the environment condition are used. Some countries at the state level implement projects for satellite monitoring, sounding and video recording of fires at the initial stages of their occurrence in their territories and border areas with high risk, initiate and implement projects of civilian monitoring institutions.

The countries of the European Union also use the capabilities of the European Civil Protection Mechanism. In Ukraine, despite the existing implementation of state and public monitoring projects, civil protection system reform, there is no comprehensive project approach to management projects, programs and portfolio of projects of implementation of the technical systems for forest fire prevention, in particular in the context of safety-oriented management of such projects. As a result, it causes large-scale losses to the ecosystems of countries and their economies, the death of people.

Thus, the study on planning, implementation and project management of technical systems capable of preventing forest fires remains relevant today, which is achieved by conducting theoretical and methodological research and using the fundamental provisions of project management methodology, in particular: system analysis method, modeling tools, proactive management mechanism and others.

Table 1

Large-scale forest fires by the number of fatalities

Date	Country	Scale	Number of victims
10. 1871	United States of America	500 thousand hectares	1500 people
08.1997–03.1998	Indonesia	2 million hectares	240 people
07– 08. 2007	Greece	270 thousand hectares	84 people
02–03.2009	Australia	450 thousand hectares	173 people
10.12.2010	Israel	5 thousand hectares	44 people
07.2018	Greece	271 thousand hectares	102 people
04–05. 2020	Ukraine (Chornobyl Exclusion Zone)	47 thousand hectares	–

Literature review. The study on the processes of implementation of scientific and practical approaches in the process of formation and management of technical systems and processes of forest fire prevention in Ukraine and the world is a comprehensive study.

Therefore, for a qualitative analysis of existing scientific works by Ukrainian and foreign scientists, we have divided the works into two segments:

1) study on forest fires, their prevention, evaluation and response to them;

2) research on processes of formation, realization of organizational and technical systems in the process of management of projects, programs and portfolios of projects with application of information technologies.

The first segment includes research by scientists Parks S. A., Holsinger L. M., Miller C., Nelson C. R., Baggett L. S., Bird B. J., Silva S. S., Fearnside P. M., Graça P. M., Calviño-Cancela M., Chas-Amil M. L., García-Martínez E. D.

In particular, the theory of functioning of the mechanism of self-regulation of forest fires is described and an assessment of the ability of forest fires to create barriers has been developed [1]. An assessment of the longevity of the regulatory effect of the probability of recurrence of forest fires has been developed [2].

Quantitative assessment of forest fire variants in the conditions of forecasted climate change and features of formation of the structural network of forest fire response system are presented [3]. Factors are described that stimulate forest fires and their impact on the economy, long-term solutions to the need to shift the focus from firefighting to prevention are presented, and a number of fire prevention policies are proposed [4].

In [5] the processes of dynamics change and the reasons of their occurrence are investigated. The processes of forest fire development and their changes under the influence of various factors and the influence of topography on the occurrence of forest fires are described [6].

A quantitative analysis of the impact of forest fires on ecosystems has been carried out [7]. A study on technical means and methods for fighting forest fires is conducted and their features are described [8].

The second segment includes research by scientists Corona P., Ascoli D., Barbati A., Bovio G., Akay A. E., Karaş I. R., Kahraman I., Bushuyev S. D., Bushuev D. A., Bushuyeva N. S., Kozyr B. Yu., Verenysh O., Chernov S. K., Kononenko I., Aghaee A., Lutsenko S., Hnatushenka V. V., Hnatushenka Vik. V., Mozgovyi D. K., Vasiliev V. V., Rach V., Rak Yu. P., Rossoshanska O., Medvedieva O., Yevdokymova A., Sakella-

riou S., Tampekis S., Samara F., Sfougaris A., Christopoulou O., Vasiliev M. I., Movchan I. O., Koval O. M.; it gave results in the field of project-oriented approach, management and development of complex organizational and technical systems.

The integrated processes of forest fire prevention and application of GIS technologies in the process of determining the location and number of rescue units for their elimination have been studied [9]. Features of the integrated process of forest fire management, risk assessment and means of forest fire prevention are presented [10]. The process of development of satellite image processing technology is described, which provides increase in reliability and efficiency of forest area determination according to the data of multispectral low and medium spatial resolution satellite imagery [11].

Features of application of information technologies for developing the competences of project management on the basis of world tendencies are described [12].

The organizational maturity of projects is investigated, in particular the success of realization of programs and portfolio of projects [13]. The process of algorithmization of simplification the solutions for discrete problems of optimization of the projects is described [14]. The application of the method for synthesis of project management methodology with fuzzy input data is investigated [15].

The process of system modeling of development of the innovative project-oriented enterprises is described [16]. A review of the application of the decision support system in the process of forest fire prevention is performed [17]. The processes of optimization of projects of fire extinguishing systems in timber warehouses and features of mixing their ecological risk are studied [18].

Models of safety management in development of projects related to complex organizational and technical systems are described [19]. The critical parameters of discrete-event modeling of the products of infrastructure projects at the planning stage are studied [20].

However, the works of the above scientists, on the one hand, do not describe the concept of forming forest fire prevention projects using the tools of technical means and systems. On the other hand, there is no project-oriented approach to the project formation process, where the main purpose of research was the process of prevention and elimination of forest fires, rather than the implementation of anti-crisis set of technical measures to prevent their occurrence, which requires the use of safety-oriented project management methodology, programs and portfolio of projects, in particular at the planning stage.

Object of the study. The process of identification and formation of parameters of safety-oriented management of technical systems for forest fire prevention.

Subject of the study. Management models of technical systems for forest fire prevention.

Purpose. Carrying out the research and development of models of managing the technical systems of prevention of the occurrence of forest fires. To achieve these goals we formed the following tasks: based on general scientific principles and fundamental provisions of project management methodology, including system analysis, modeling tools, mechanisms of proactive and reactive management to conceptualize the triad of project portfolio of technical systems for environmental protection against forest fires, to conduct system structuring, to describe the process of management decisions in the implementation of the technical system project and to develop a model of safety-oriented project management of the technical system of forest fire prevention, to explore the process of interaction of project elements, its life cycle.

Methods. The technical process of managing natural emergencies, which include forest fires, in modern conditions is characterized by the presence of many factors that affect the success of the project, among which the human factor is not always decisive.

In particular, the complexity and scale of the fire, uncertainty in the process of involving project teams in managing the emergency response process, the dynamics and nature of their behavior, which complicates the process of managing a project, program or portfolio of technical system projects at different stages.

Thus, taking into account the above and on the basis of a systematic approach, we formed a conceptual triad of model-scheme of forming a portfolio of projects of technical systems for environmental protection against forest fires (Fig. 1).

The model scheme is formed of three interconnected blocks of the system, where the first block is a hierarchically structured set of basic elements of the natural environment of the technical system project (ecosystem, forest, flora, fauna, which in turn takes into account all subelements, including water bodies, atmosphere, soils, and others).

The second block is a block of project and technical management, which is filled with the basic elements of project management methodology, programs and portfolio of projects.

The third block describes the projected level of development of forest fires according to their scale and operational teams to respond and manage them. The formation of the project portfolio is carried out on the basis of possible manifestations of forest fires in different conceptually dependent planes.

The concept of management of the technical systems of environmental protection against forest fires provides consid-

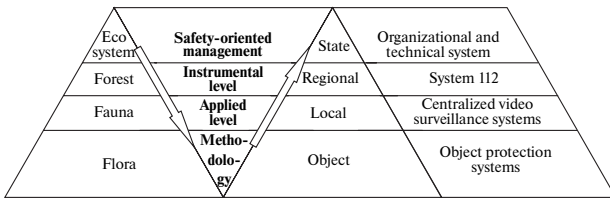


Fig. 1. Conceptual triad of model-scheme of formation of the portfolio of projects of technical systems for protection of environment from forest fires

eration in the project portfolio of a set of the following cases of technical systems:

- a project of technical system of forest fire prevention;
- a project of technical system of operative reaction to forest fire;
- a project of technical system of fire extinguishing;
- a project of technical system of forest fund restoration (Fig. 2).

The formalized structural model of the technical system of forest fire prevention can be represented in the form of a tuple

$$St = \langle Sp; So; Se; Sr \rangle, \quad (1)$$

where St is technical systems of environmental protection against forest fires; Sp – project of forest fire prevention; So – project of operative reaction to forest fire; Se – project of fire extinguishing; Sr – project of forest fund restoration.

Development of projects is possible by the Ministry of Energy and Environmental Protection, the Ministry of Internal Affairs, the USSCP.

The financial resources of projects can be both funds from the state and regional budgets, and grants, if necessary, credit loans. The priority of project implementation and their scale directly depends on the level of safety of each of the regions. The level of safety of the region is determined by the method of total ranks, with the calculation of safety indices, based on the processing of regional parameters, the presence of forests and fire statistics in them, climatic conditions, terrain, remoteness from settlements, availability of special equipment, population within the territory of the region, the presence of critical infrastructure, and others.

Each project is developed on the basis of a single monotemplate of the project – a structured project plan, but for each region it will take into account its regional characteristics. First of all, the projects will be implemented in regions of increased danger of possible forest fires. Given the significant resource costs, their implementation in Ukraine, they all need to be implemented in a complex to ensure the safety of the country. It is not possible to implement only forest fire prevention, suppression and response projects and not to implement forest restoration projects.

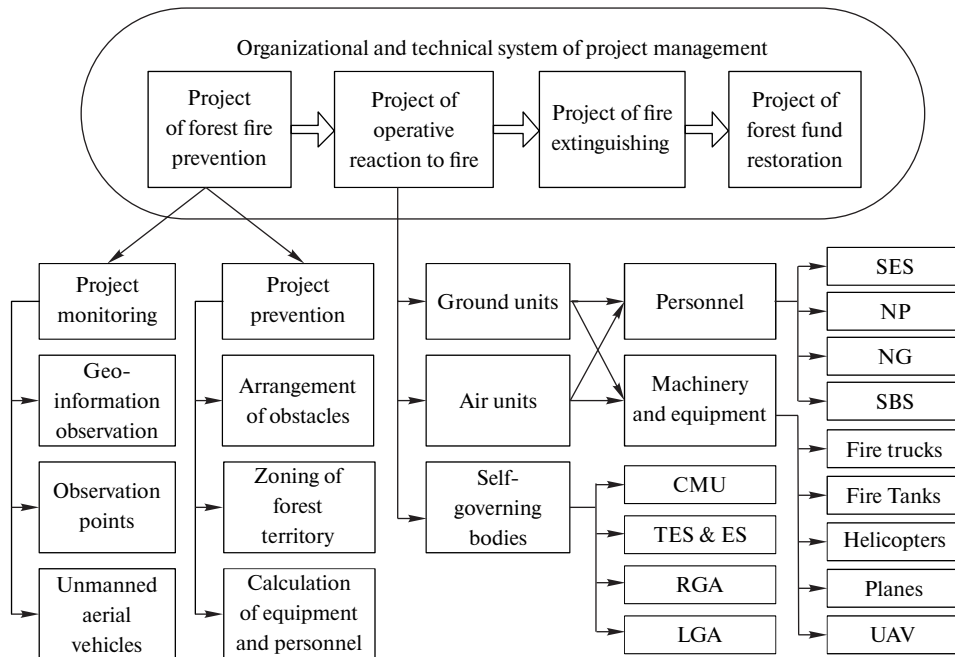


Fig. 2. Structural model of the technical system of forest fires prevention:

SES – State Emergency Service of Ukraine; MIA – Ministry of Internal Affairs; IPMA – International Project Management Association; NP – national police; TES&ES – commission of technogenic and ecological safety and emergency situations; NG – National Guard; RSA – regional state administrations; LSA – local state administrations; SBG – State Border Guard Service; USSCP – unified state system of civil protection; GIASES – government information and analytical system on emergency situations; UAV – unmanned aerial vehicles

Due to global trends, even the most developed countries are not always able to cope with monitoring and responding to forest fires, so they are forced to involve additional forces and resources, so forest restoration projects are an important element of the structural capacity of the forest fire prevention system.

Unlike the existing legal documents, which describe the general algorithms of action in emergencies and firefighting measures, the block of the forest fire prevention project provides for the implementation of a clearly structured set of measures for monitoring and prevention of fires, taking into account the regions of implementation, being planned and implemented basing on project-oriented approach and safety-oriented management.

Developers and managers of project units are regional project teams, which include representatives of relevant structures and managers who plan and implement the whole set of projects, taking into account existing algorithms and regulations and standards.

Given the multifactorial and constant change in dynamics and multi-vector development of forest fires, non-standard conditions of technical system functioning are formed in which operational teams do not cope with operative management decisions, which in turn requires application of project approach and safety-oriented management to prevention process at the project planning stage of technical system.

Formally, this process can be represented in the form of a cybernetic model of the "black box" (Fig. 3).

Fig. 3: Fi – a project completion phase (commissioning of the technical system); Fp – a planning phase of the technical system project; Fr – a phase of practical implementation of the technical system project; Fs – a phase of initiation of the project of technical system; Pp – a transitional subphase between the phases of planning and practical implementation of the technical system project; Pr – a transitional subphase between the phases of practical implementation and the phase of project completion (commissioning of the technical system); Ps – a transitional subphase between the phases of initiation and planning of the technical system project; Xi – a set of planned factors affecting the design of the technical system; Xij – a factor of modification of factors influencing the project due to the application of safety-oriented approach to project management of the technical system; Xj – a set of non-staff factors that affect the quality of the technical system project.

The presented model reflects a set of parameters that affect the process of forming a project of a technical system for preventing forest fires in conditions of uncertainty, where:

- $\{Yi\}$ is a set of factors that are taken into account when planning the project of the technical system of forest fire prevention

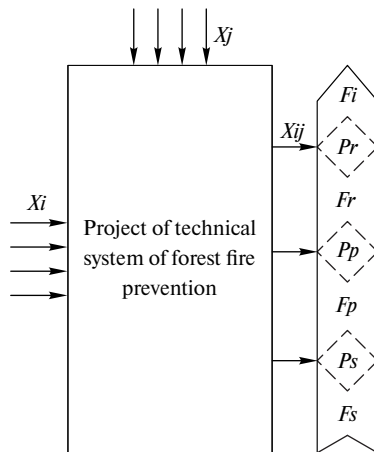


Fig. 3. Cybernetic model of the "black box" when making management decisions for the implementation of the project of the technical system for forest fire prevention

$$\{Yi\} = \{Yi1, Yi2, \dots, Yin+1\}, \text{ at } i = \overline{1, n}; \quad (2)$$

- $\{Yj\}$ is a set of non-staff factors influencing the project of the technical system of forest fire prevention

$$\{Yj\} = \{Yj1, Yj2, \dots, Yjn+1\}, \text{ at } j = \overline{1, n}. \quad (3)$$

Accordingly, the set of management decisions $\{Yij\}$ lies at the intersection of these sets and provides consideration of all possible alternatives (Yij, Yij, \dots, Yij , at $ij = \overline{1, n}$)

$$\begin{aligned} \{R\} &= \{Yi\} \cap \{Yj\} = \\ &= \{Yi1, Yi2, \dots, Yin+1\} \cap \{Yj1, Yj2, \dots, Yjn+1\} = \\ &= \{Yij1, Yij2, \dots, Yijn+1\}. \end{aligned} \quad (4)$$

One of the important features of the project of a technical system of this type is the life cycle. According to the international standardization for project management, programs and portfolios of projects P2M, PmBok, PRINCE2, AGILE, KANBAN, the life cycle is formed of 4 phases: project initiation phases, planning phases, project implementation phases, project completion phases.

$$P = \langle Fs; Fp; Fr; Fi \rangle. \quad (5)$$

In this type of technical system project in the basic phases, transitional subphases are formed, bottlenecks of the project, which receive the greatest risk of load and impact of various planned and unplanned factors that directly affect the success of the project as a whole.

$$P = \begin{cases} Ps \in [Fs; Fp] \\ Pp \in [Fp; Fr] \\ Pr \in [Fr; Fi] \end{cases}. \quad (6)$$

These subphases are transitions between blocks of phases from one to another. They have their own time frame, depending on the mono-templates adapted for each region, according to their parameters, under the direct influence of the turbulent internal and external environment of the project (variable parameters of the mono-template, reactivity and proactivity factors), project participants, regulatory framework and operational management decisions, resource costs.

Based on a comprehensive study on forest fire prevention processes in Ukraine and the world, the use of elements of system analysis and tools of safety-oriented project management, programs and project portfolios of technical systems, we formed a model of safety-oriented project management of technical systems for forest fire prevention (Fig. 4).

The developed model combines the existing unit of USS-CP, which in accordance with the state strategy and using the tools of information and technical management system, forms, in accordance with the mission of the program of protection of critical infrastructure and environment, a portfolio of program projects where the basic project is a developed and proposed technical system of forest fire prevention.

$$\begin{aligned} Ss \\ \downarrow \\ Tp \Rightarrow Mp \Rightarrow Pp \Rightarrow St, \\ \uparrow \\ Cp \end{aligned} \quad \begin{array}{c} \text{---} \\ ni \quad ni+1 \quad (ni+1) \rightarrow \infty \\ \text{---} \\ ni \quad ni+1 \quad (ni+1) \rightarrow \infty \\ \text{---} \\ ni \quad ni+1 \quad (ni+1) \rightarrow \infty \\ \text{---} \end{array} \quad (7)$$

where Tp is project management tools (information, technical, organizational systems); St – technical project management system for environmental protection against forest fires; Cp – USSCP; Ss – developed and adopted state strategy; Mp – the mission of the program to protect critical infrastructure and the environment; Pp – program project portfolios; ni – projects included in the program of projects

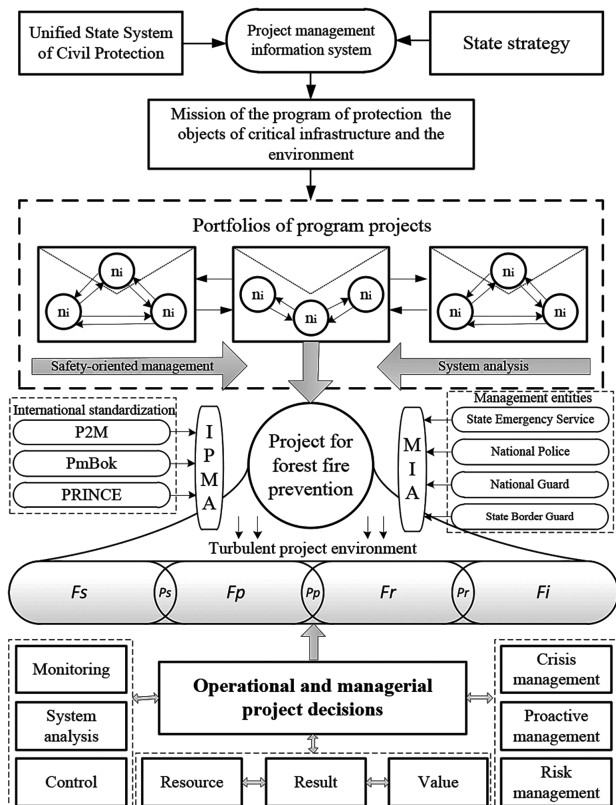


Fig. 4. Model of safety-oriented project management of the technical system for forest fire prevention

for the protection of critical infrastructure and the environment.

Operational and managerial project decisions consist of three control units:

- the first block is monitoring of the current state of the project, analysis of the received data and control of execution of decisions;

- the second block includes resources involved in the implementation of the project of the technical system, the formation and understanding of the desired value of the project product, which form its result;

- the third management unit consists of the use of elements of crisis management, the risk of identification, prevention and management, and the use of elements of proactive management, characterized by clear planning of operational management, otherwise reactive management is determined by unforeseen external circumstances.

$$\begin{array}{c}
 I_s \\
 \Downarrow \\
 St \leftarrow Om \leftarrow \begin{array}{|c|c|c|} \hline Mi & Ai & Ci \\ \hline Ri & Si & Vi \\ \hline Cmi & Pri & Rmi \\ \hline \end{array} \\
 \Uparrow \\
 M_s
 \end{array} \quad (8)$$

where St is a technical project management system for environmental protection from forest fires; I_s – use of international standardization for management of projects, programs and portfolio of projects (P2M; PmBok; PRINCE; AGILE; KANBAN); M_s – project management entities; Om – operational and managerial project decisions; Mi – project monitoring; Ai – project analysis; Ci – project control; Ri – project resources; Si – the result of obtaining the project product; Vi – the value of the project; Cmi – crisis project management; Pri – proactive project management; Rmi – project risk management.

The combination of all blocks of the model in combination with the use of professional software and mono-templates al-

lows forming and implementing regional projects of technical systems for forest fire prevention.

Approbation of the model was carried out during the preparation of proposals for the formation of scientific and technical policy on issues within the competence of the SES of Ukraine, coordination of research and implementation of best practices, scientific achievements, latest technologies, other fire products in the Department of Emergency Prevention of the State Emergency Service of Ukraine during consideration of the draft state and local programs developed to improve the protection of facilities and territories in case of emergencies, as evidenced by the receipt of the relevant act of implementation.

Results. Theoretical studies on the project management process, programs and portfolio of projects of technical systems for forest fire prevention with the use of international standards, systems analysis, modeling tools, mechanisms of proactive and reactive management allowed forming a conceptual triad of model-scheme of formation of the portfolio of projects of technical systems for protection of the environment from forest fires, adapting a cybernetic model of the “black box” for decision making management during the implementation of the project of the technical system of forest fire prevention, describing the impact of factors on the project that may occur under the influence of turbulent internal and external environment and taking into account project planning, forming a safety-oriented model of project management of the technical system of forest fire prevention, which is characterized by the presence of sub-phases of the life cycle of the project of the technical system, which are critical places of the project, have their own time frame of operation and resource consumption.

The results of the study are of practical and scientific value for the implementation and management of technical systems for forest fire prevention, which are intensified due to climate change, drought, human impact and cause great damage to the environment and people. The models developed during the study are adapted for use in different countries because they are formed in accordance with international standards for management project, programs and portfolio of projects P2M, PRINCE2, PMBok, AGILE, KANBAN.

Conclusions. The topical problem of planning, implementing and managing the project of technical systems of preventing forest fires using the instrumental tools of safety-oriented management is solved.

Originality is to develop a model of safety-oriented project management of the technical system of forest fire prevention and identify subphases in the basic phases of the project life cycle, to adapt the cybernetic model of the “black box” for management decision making during the implementation of technical system project of forest fire prevention, forming its structural and conceptual models.

Practical value of the obtained results is the possibility of using the obtained results in the practical activities of project, operational and management teams of authorities, emergency services and managers in the formation of national projects to prevent forest fires.

Prospects for further research are the need to adapt the developed basic model of safety-oriented management of the technical system of forest fire prevention to the characteristics of different regions, study of time parameters of subphase blocks of the project life cycle and optimization the forces and resources of the project. Development of a methodology for forming a comprehensive program of safety-oriented projects of technical systems, project content management and assessment of the safety level of forest fires on critical infrastructure, safety-oriented systems and possible consequences, creating a methodology for calculating such assessment.

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Моделі управління технічними системами запобігання виникнення лісових пожеж

О. Б. Зачко, Д. О. Чалий, Д. С. Кобилкін

Львівський державний університет безпеки життєдіяльності, м. Львів, Україна, e-mail: dmytrokobylkin@gmail.com

На сьогодні в Україні та світі, попри швидкий розвиток науки й техніки, існує проблема розробки нових, удосконалення та адаптації інформаційних, організаційних і технічних систем, здатних запобігти виникненню лісових пожеж. Об'єктом дослідження обрано процес ідентифікації та формування параметрів безпеко-орієнтованого управління технічними системами запобігання виникнення лісових пожеж.

Мета. Розробка нових підходів до безпеко-орієнтованого управління проектами технічних систем запобігання виникнення лісових пожеж, та їх моделювання на основі принципів системного аналізу.

Методика. Використовуючи загальнонаукові принципи та фундаментальні положення методології управління проектами, зокрема системний аналіз, інструментальні засоби моделювання, механізми проактивного й реактивного управління, сформована тріада концепції створення портфелю проектів технічної системи захисту навколишнього середовища від лісових пожеж.

Результати. Представлена концептуальна тріада модель-схеми формування портфелю проектів технічних систем захисту навколишнього середовища від лісових пожеж. Адаптована кібернетична модель типу «чорний ящик» для прийняття управлінських рішень при впровадженні проекту технічної системи запобігання виникнення лісових пожеж, описано вплив на проект факторів, що можуть виникнути при впливі внутрішнього та зовнішнього середовища. Сформована безпеко-орієнтована модель управління проектом технічної системи запобігання виникнення лісових пожеж, що відрізняється наявністю підфаз життєвого циклу проекту, які є його

критичними місцями, мають власні часові рамки функціонування й ресурсозатрат.

Наукова новизна. Полягає у розробці моделі безпеко-орієнтованого управління проектом технічної системи запобігання виникнення лісових пожеж та ідентифікації підфаз у базових фазах життєвого циклу проекту. Розроблені моделі є адаптованими до використання у різних країнах, оскільки вони сформовані у відповідності до міжнародних стандартів із управління проектами, програмами та портфелями проектів P2M, PmBok, PRINCE2, AGILE, KANBAN.

Практична значимість. Полягає у можливості використання результатів у практичній діяльності проектних, операційних і управлінських команд органів влади, екстрених служб і менеджерів при формуванні національних проектів запобігання виникнення лісовим пожежам.

Ключові слова: *технічна система, управління проектами, безпеко-орієнтоване управління, лісові пожежі, інформаційна система*

Моделі управління технічними системами предотвращения возникновения лесных пожаров

О. Б. Зачко, Д. А. Чальй, Д. С. Кобылкин

Львовский государственный университет безопасности жизнедеятельности, г. Львов, Украина, e-mail: dmytrokobylykin@gmail.com

На сегодня в Украине и мире, несмотря на быстрое развитие науки и техники, существует проблема разработки новых, совершенствования и адаптации информационных, организационных и технических систем, способных предотвратить возникновение лесных пожаров. Объектом исследования избран процесс идентификации и формирования параметров безопасно-ориентированного управления техническими системами предотвращения возникновения лесных пожаров.

Цель. Разработка новых подходов к безопасно-ориентированному управлению проектами технических систем предотвращения возникновения лесных пожаров и их моделирование на основе принципов системного анализа.

Методика. Используя общенаучные принципы и фундаментальные положения методологии управления проектами, в частности, системный анализ, инструментальные средства моделирования, механизмы проактивного и реактивного управления, сформирована триада концепции создания портфеля проектов технической системы защиты окружающей среды от лесных пожаров.

Результаты. Представлена концептуальная триада модель-схемы формирования портфеля проектов технических систем защиты окружающей среды от лесных пожаров. Адаптирована кибернетическая модель типа «черный ящик» для принятия управленческих решений при внедрении проекта технической системы предотвращения возникновения лесных пожаров, описано влияние на проект факторов, которые могут возникнуть при воздействии внутренней и внешней среды. Сформирована безопасно-ориентированная модель управления проектом технической системы предотвращения возникновения лесных пожаров, отличающаяся наличием подфаз жизненного цикла проекта, которые являются его критическими местами, имеют собственные временные рамки функционирования и ресурсозатрат.

Научная новизна. Заключается в разработке модели безопасно-ориентированного управления проектом технической системы предотвращения возникновения лесных пожаров и идентификации подфаз в базовых фазах жизненного цикла проекта. Разработанные модели адаптированы к использованию в различных странах, поскольку они сформированы в соответствии с международными стандартами по управлению проектами, программами и портфелями проектов P2M, PmBok, PRINCE2, AGILE, KANBAN.

Практическая значимость. Заключается в возможности использования результатов в практической деятельности проектных, операционных и управленческих команд органов власти, экстренных служб и менеджеров при формировании национальных проектов предотвращения возникновения лесных пожаров.

Ключевые слова: *техническая система, управление проектами, безопасно-ориентированное управление, лесные пожары, информационная система*

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