

Risk insurance of cosmic projects in Russian Federation

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Abstract— Modern space activities in Russia are the most promising areas of economic development for the near future. The issues of ensuring the safety of insurance for the risks of space projects are extremely relevant, since the space industry is a dangerous type of human activity that has many cosmic risks and is associated with the potential for damage to the life and health of people engaged in space activities. That is why it is necessary to pay more attention to the system of domestic insurance of risks of the space industry, as well as individual projects from various adverse events. To solve this problem, the system of domestic insurance of space projects risks of the Russian Federation was analyzed. The advantages and disadvantages of this insurance system were revealed, the main stages of insurance organization were examined, and the methodology of risk management of the space project was analyzed. Also, the tasks of improving the domestic system for insurance of space projects risks were formulated, and measures were proposed to ensure these tasks. Results of the study allow improving the system of space risks insurance, reducing the expenses of the state budget of space projects risks organization.

Keywords— *space risk, space activities, insurance of space projects.*

I. INTRODUCTION

The space activities of states and the implementation of international space projects are directly related to the exploitation of space devices. In the theory of space law, space activity is an activity that always presents a high danger to surrounding people, and the space device is the source of this danger.

It is known that the implementation of space programs is a very expensive activity. And this concerns not only the size of financial investments, but also those financial losses that can occur at every stage of the space project implementation. There is no guarantee that an emergency situation will not have such a consequence that the amount of funds required to liquidate it will be comparable or even exceed the cost of implementing a space project [1].

As noted above, in the exploration of outer space, there is always a risk, which consists in the possibility of significant damage to the life and health of people engaged in space activities, for instance, cosmonauts and space infrastructure maintenance personnel. Also, there is danger of cosmic risk, to the environment as a whole [2].

The modern domestic system of risks insurance of space projects has been at the stage of formation for a long time. The

damage caused by the space device is important for all participants in space activities. So, the study of the space projects insurance system is relevant. After all, the insurance system allows one to provide protection, compensate material and financial losses in the event of unfavorable events, and also gives the possibility to continue working on the exploitation of space devices and improve infrastructure and rocket and space equipment.

It is known that insurance as a method of managing space risks began to be used only in the 1990s. Only after the beginning of market reforms there were prerequisites for the development of space insurance. There are a few insurance companies-leaders, such as: Ingosstrakh, SOGAZ, Military Insurance Company, Russian Insurance Center, Megaruss [3].

II. SYSTEM OF SPACE PROJECTS RISKS INSURANCE IN USA

To study the insurance system, let us take as an example the foreign system of insurance of risks of space projects of the USA. This system of insurance protection develops a risk management plan at the stage of business planning of the space project, in which special attention is directed to the organization of insurance protection [4]. Also, the American insurance system strictly specifies sanctions (this condition is necessary in order to avoid failure to meet the terms and conditions of the project). All costs included in the insurance of risks of space projects are included in the structure of the price of space devices. The basis for determining the insurance value includes the cost of the space device itself, the cost of deducing and the costs of launching [5]. In the orbital operation of space devices, the risks insurance of space projects is carried out mainly for a period of 1 year. In addition, an obligatory condition of this insurance protection is to carry out insurance of facilities and equipment of the launch complex, which are federal property of the US government, for the amount of about 80 million dollars.

The United States insures all breaks and stops of the implementation of the space program for the launch of the space device. The US government acts *de facto* as the insurer of its commercial operators in the case if third party claims against them in accordance with the international obligations of the United States, both within the limits of their insured amount and in the event that the amount of the third-party claim exceeds the insured amount. It is known that most American insurance companies that provide services for the launch of space devices agree among themselves on self-insurance launches because of the huge number of rates of insurance organizations. In the United States, according to the scheme for guaranteeing the re-launch of a space device, a customer who pays a certain percentage for the launch period will be able to re-launch the spacecraft free of charge in case of failure [6].

III. DISADVANTAGES OF THE RUSSIAN INSURANCE SYSTEM

To analyze the Russian system of insurance of risks of space projects, the shortcomings of this type of insurance are considered. The most significant shortcoming is the lack of trust funds of state-owned enterprises to provide insurance for the risks of space projects. In the domestic insurance system there is no perfect normative legal framework for insurance. The level of confidence in the reliability of indicators of domestic products of rocket and space equipment from the foreign

insurance market is low. Systemic risks insurance of the domestic insurance system space projects is also absent. The main insurance organizations are Avicos and Russian Insurance Center (RCC).

Despite the sufficient number of deficiencies in this insurance system, there are positive features in it, for example, interest and support from the Federal Executive Bodies. There is a significant growth of insured space projects. Stable relationships between participants in the insurance market, banking and credit organizations.

IV. THE PROCESS OF SPACE PROJECTS RISKS INSURANCE IN RUSSIAN FEDERATION

This process involves several consecutive stages:

1. selection of the coordinator of the pool of insurers, taking into account the insurance conditions, which is selected by the lead contractor of the project of the parent domestic insurance organization;
2. selection of an international broker which is necessary to provide advisory services to a Russian insurer (selected by the lead contractor);
3. pre-insurance examination of the space project by an international broker and a leading domestic insurance company;
4. development of a program for insurance of risks of space projects;
5. organization of the pool by the leading domestic insurance organization from domestic insurance organizations for co-insurance and reinsurance of the risks of the space project;
6. development, approval and conclusion of insurance contracts between the main contractor (participants) of the space project, the main domestic insurance company, domestic co-insurers and reinsurers, the international broker and international reinsurers [7];
7. placement by international broker of reinsurance contracts for the risks of a space project in the international insurance market;
8. accompanying the international broker and the head domestic insurance company to perform insurance contracts: service of the policyholder after the conclusion of the insurance contract; execution of obligations by insurers [8].

Figure 1 shows the structure of space devices risks.

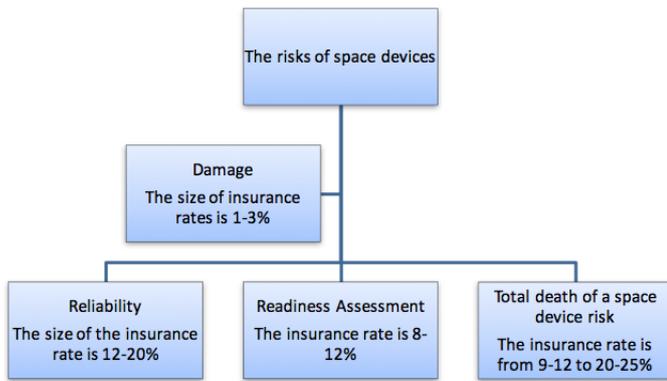


Fig. 1. Structure of space devices risks

The stage of operation of space rockets consists of the transportation of elements of space rockets, their launch and storage, as well as the functioning of orbital ships. The risks of damage to space devices are inherent in the storage phase. The value of insurance rates is 1-3% of the starting amount. The fundamental factor in the risk assessment is the reliability of the withdrawal means. The insurance rate is 12-20%. The main factor of a space device is the reliability and the qualitative implementation of the previous phases of launch. When assessing the readiness of the device, the insurance rate is 8-12%. The risk associated with the total death of a space device ranges from 9-12 to 20-25%. The insurance of a space device in orbit provides protection against partial or complete failures of space object equipment. The rates of insurance premiums in this case are set at a rate of 3-10% [9].

V. THE TASKS OF IMPROVING THE RUSSIAN SYSTEM FOR INSURANCE OF SPACE PROJECTS RISKS

Analyzing the above-mentioned facts, there are the following tasks, such as:

- increase in the degree of state regulation and the administration organization of the insurance system;
- establishment of parity relations with foreign insurance (reinsurance) organizations;
- formation of long-term mutually advantageous relations between insurers and insureds, strengthening of partner relations and organization of mutual exchange of experience between insurance companies;
- increasing the activity of potential insurers.

In order to ensure these objectives, it is necessary to compile a set of organizational and technical measures which includes:

- forming a mutual insurance society to ensure mandatory insurance of risks;
- formation of an insurance pool to ensure voluntary risk insurance;
- formation of an insurance analytical center (information and methodical support of the system) [10].

Obviously, insurance in the framework of a mutual insurance society is the most promising method of risks

insurance of space projects in the implementation of space activities (the risk of death of participants and workers in space activities, the risk of liability for obligations that may arise due to damage to life, health or property of third parties) which unites the Federal bodies of executive power in the field of space activities.

If we consider the insurance system from the point of methodology, then insurance can be called as a system of measures to create a monetary fund from the contributions of its participants. This system allows to the damages caused by adverse events, such as a natural disaster or any accident. Also, amounts of money are paid in the case of an adverse event.

It is important to know the difference between the insurance and the reservation. Insurance is redistributed between the participants (directly between the insurer and the insured). In the reservation the reduction in the degree of adverse event is achieved by creating reserves for which the necessary additional costs of money are required.

VI. METHODOLOGICAL TYPES OF INSURANCE

At present, the following methodological types of insurance are used in insuring major risks of space projects.

1. Mutual insurance. This type of insurance is that all participants involved in the implementation of the space project are directly interested in its success. At the same time, possible damage can occur with the realization of cosmic risk with any of them. Proceeding from this, in terms of value space risk is limited by the cost of the space project and the insurance rate itself takes into account the degree of participation in its coverage.
2. Commercial insurance. In this insurance, there is mandatory commercial (in some cases, state) insurance organization that deals with insurance or reinsurance of space risks. The insurance organizations bear the responsibility of full compensation for damage or partial, which is caused to the insured as a result of the insured event at the expense of insurance premiums.
3. Reinsurance. In this type of insurance, reinsurance is a system of economic relations in which the insurer that has accepted the risk insurance transfers it to other insurers under certain conditions to ensure the sustainability of insurance operations and create a balanced insurance portfolio [11].

The tasks are set, the solution of which is directed to the appropriate methodical support of the activities of insurance organizations, which are as follows:

1. determination of insurance premiums which are determined during the analysis of the distribution of the magnitude of possible damage;
2. initial distribution of funds and their redistribution;
3. definition of the system of payments.

On the one hand, insurance is a means of protecting the activities of economic entities. On the other hand, it refers to commercial activities that are directly related to the investment

of temporarily idle funds in non-production facilities, shares of enterprises, and bank deposits.

It is known that major risks of production and environmental character are transferred to reinsurance to reinsurance organizations (sometimes to the international market). The complexity of such a system is due to the harmonization of foreign and Russian insurance rules.

To date, according to the results of the conducted studies, it is known that the Russian insurance organization is unable to provide for itself the insurance of all insurance operations peculiar to space activities, so it is necessary to use reinsurance. The essence of reinsurance lies in the fact that an insurance company that has concluded an agreement on the protection of the insured's property interests risks at the expense of its own available funds (leaving at the same time a certain portion of the risk and the corresponding part of the insurance premium) [12]. Part of the risk uncovered by insurance is transferred to other insurers (reinsurers) on agreed terms. These reinsurers, to whom the insurance contract was transferred, must be liable under this agreement for the stipulated share of the insurance premium.

The basis of resource support for the activities of insurance organizations is own funds, which are introduced by the Federal Service for Supervision of Insurance Activities. They include:

- paid-up authorized capital;
- extra capital;
- reserve capital;
- undistributed profit of the previous years and the reporting year;
- accumulation fund;
- consumption fund, reduced by the amount of intangible assets and uncovered losses [13].

Formation of own capital has two sources. The first source is due to profits, and the second source is due to the contributions of the founders. These own funds are usually called "free reserves" or "solvency reserves", since they do not depend on any external obligations. For the purposes of ensuring solvency, the amount of free reserves should be the larger the larger the volume of operations of the insurance organization.

In the event that for any type of insurance there is the activity termination, the insurer has two ways out: a complete waiver of this type of insurance (ie immediately) or a partial waiver of this type of insurance (that is, gradually).

The first case concerns the situation when contributions for this type of insurance no longer arrive, despite the fact that liability exists and these requirements continue to apply.

In the second case, there is a gradual decrease in the volume of insurance premiums and the reduction in claims is slower, but in such circumstances, in any case, the time will come when the contributions cease to arrive, the insurer will remain liable and the possibility of claims will exist.

The insurance organization must compulsorily determine the amount of money needed to pay claims for all remaining contracts and the costs of their settlement and compliance of the calculated value to the formed insurance reserves. In the case that the formed reserves are less than the estimated value, the obligatory condition is to determine the sources of financing for the implementation of insurance payments: the organization has sufficient own resources or needs to raise money from outside [14]. In the case that own resources for any circumstances are not available or insufficient, a decision could be made to continue this type of insurance at higher tariffs. In addition, a higher tariffs are noncompetitive, which leads to a reduction in the number of contracts concluded, and a reduction in the number of contracts concluded leads to an increase in the scatter of payments, which in turn leads to an increase in tariffs.

In view of the foregoing, the management of the insurance of risks of space projects requires the methodological support of the solution of the following tasks which are shown in Figure 2.

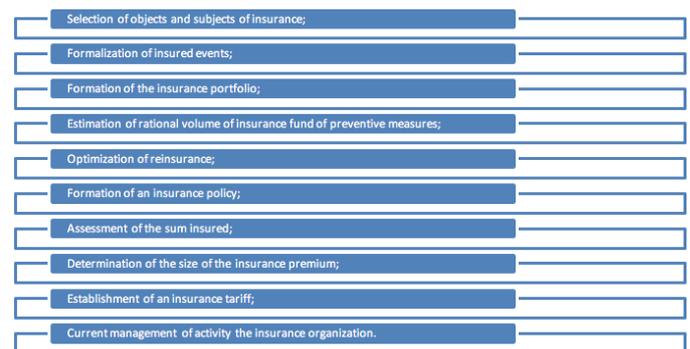


Fig. 2. Tasks necessary for methodological support of space activities

Methods of solving these problems must take into account the specifics of the next stage of the reform of the defense industry complex, primarily the narrowing of the number of organizations participating in activities while strengthening their financial capabilities for insurance of space risks, and, as a consequence, improving the quality and reliability of space techniques.

VII. BASIC METHODS FOR ASSESSING THE INSURANCE RISKS OF SPACE PROJECTS

These methods most often assume the use of special tables, but in some cases, appraisers are forced to do without such help.

The first method of assessing cosmic risk is the percent method. This method consists in calculating the amount by the average indicator which is determined with special tables, taking into account discounts, bonuses and other factors that can be applied at a time. This method is more suitable for the average risks of space projects.

The second method is the method of average values. This method consists in splitting all the risks for a particular object into subgroups. With this distribution, a risk base is formed, which indicates the type of risk, the possibility of the occurrence of a risk event and the approximate amount of covering the damage from a possible risk event. It is taken as the basis of all further calculations. This method of assessing

insurance risks is also suitable for medium risks, which may be related to business activities (theft, fire, etc.) [15].

The method of individual evaluations is the third method. This method is only used when analytical tables cannot give an accurate result when predicting an adverse event. This method is usually applied to new technologies, large-scale unique projects. With this method the risk assessment of space projects is carried out by the insurer subjectively, most often based on personal experience. The method of individual assessments is less accurate than the previous two, but in actuality of technological progress it is practically indispensable.

All of the above methods are not universal and are selected by the insurer on the basis of the features of the insurance object, the list of risks prescribed in the contract and other important factors.

VIII. SPACE RISK MANAGEMENT TOOLS

As noted above, insurance is one of the main instruments of risk management in modern conditions. With the help of insurance it is possible to compensate for damage in the event of an incident during production, any testing of space technology that damages the property of others (physical or legal, etc.). In other words, the insurance of risks of space projects is one of the conditions for guarantees of investments in space projects.

The insurance of space risks is necessary, but the main issue facing the organizations is how to reduce the occurrence of unfavorable risk events and maximize the possibility of operational risk management. A new tool is being developed to reduce adverse events: the testing of space projects in virtual reality.

This test system is a software and hardware complex that performs the following functions (Figure 3):

1. data that describe the state of objects in the real environment;
2. transformation of the state parameters of real environment objects into the parameters of virtual environment objects;
3. change the state of objects in the virtual environment in accordance with the incoming values of the parameters;
4. geometric calculations;
5. visualization of virtual scene objects in real time mode [17].

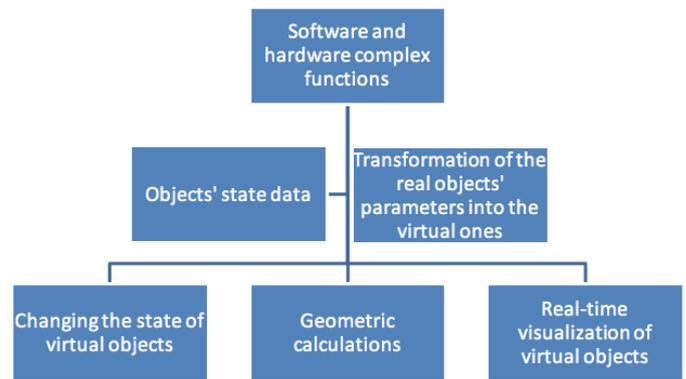


Fig. 3. Software and hardware complex functions

The combination of several virtual reality technologies allows engineers and technicians to create and test devices and processes without the need to physically assemble models and stands. As a result, technical risks are reduced, time and money are saved.

The system is a special software, gloves and glasses, immersed in virtual reality. This equipment allows the engineer to "touch his hands" to a non-existent device, walk along it, disassemble and assemble a virtual aggregate. And all this can be done not alone but with colleagues in the project. In addition, the program allows one to arrange a kind of virtual presentation for the customer, which makes it possible to create a product that best meets the requirements of the customer.

Virtual reality can be used in the development of various space systems, including satellites, reconnaissance vehicles and launch vehicles.

With the help of virtual reality technologies, designers can optimize and test the technological process before launching into production to detect bottlenecks and difficulties in production, even before they actually occur, to ensure the economical use of resources and technologies to avoid major reworking of the project after testing real prototypes. The use of virtual reality technologies makes it possible to examine every process at any time.

At the design stage, the system allows one to check the compatibility of products and assemblies produced or developed at different enterprises in the industry.

Viewing the process of production in virtual reality allows one to justify the correct choice of machines and options for their placement at the stage of preparation of production.

At the stage of preparation of production and production itself, the use of virtual reality determines the possibility of manufacturing and processing on selected machine tools oversized parts, as well as the possibility of their movement in the work area and the territory of production workshops. If these processes are difficult in the virtual reality, then the developers will make changes in the technology and this will avoid difficulties in real production.

Thus, testing a space project in virtual reality, as a tool to reduce space risks, allows one to save financial resources, avoid

harmful effects on the environment and harm the health and lives of people.

Insurance of space risks of projects in the implementation of space activities within the mutual insurance society will be able to increase the number of insured risks and their ability to provide full-fledged financial protection to the Federal space programs; implement a flexible and effective insurance policy; establish the most optimal insurance conditions that would meet all the requirements of participants in space activities and reduce the cost of insurance.

If we take into account the volume of all insurance amounts under contracts for the insurance of risks of space projects (up to 15 billion rubles for each launch) and the complexity of assessing the probability of occurrence of a risk event, which is determined by the specifics of the insurance segment in question, to provide insurance protection, primarily to the risks of death and causing damage to the devices of the rocket and space industry at the stages of launch and operation, it is proposed to form an insurance pool.

State regulation in the formation of the insurance pool will be carried out, first of all, by licensing of insurance companies interested in working in this segment of insurance. Obtaining a license for the implementation of insurance space activities should be the basis for the mandatory entry of this insurance organization into the insurance pool with a certain minimum share of taking on insured risks.

IX. CONCLUSION

Analyzing the system of insurance of risks of space projects of Russia and the USA, it can be concluded that it is necessary to improve the insurance system in our country at all stages of its implementation.

The Russian system of insurance of space risks in the conditions of a market economy is caused, first of all, by the absence of real mechanisms of financial support to enterprises of the rocket and space industry in crisis situations.

In general, these enterprises are legally independent economic entities, so they can determine their financial

policies; on the other hand, this fact deprives them of the state's obligations to determine support in the event of an adverse event.

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