Life cycle of the project of creation and operation of the megascience facility

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Abstract. In order to create, ensure the functioning and effective use of the megascience-project, it is necessary to have a holistic view of the concept of "megascience", the basic processes and constraints that accompany this activity and the project life cycle. For this purpose an analysis of the life cycles of various megaprojects was carried out, and as a result of the analysis, the main stages characteristic of all the projects reviewed were identified. Also considered are approaches to the implementation of these stages and a list of possible restrictions and risks is defined. Based on the data obtained, a model for creating a megaproject on the territory of the Russian Federation is proposed, in particular, it is planned to apply the obtained result in the process of creating the International Center for Neutron Research based on the PIK high-flux research reactor. The reported study was funded by RFBR according to the research project № 18-29-15015.

1. Introduction

At present, projects of the mega-science class are being implemented in the Russian Federation aimed at achieving fundamentally new frontiers in basic science and creating new opportunities for international scientific and technical cooperation in promising research areas [1]. The implementation of mega-science projects in Russia concentrates resources on priority research areas, and promotes the organization of new high-tech industries. They, in turn, create additional highly qualified jobs in high-tech industries. Entire scientific clusters are formed around such megaprojects, which gives impetus to the development of both fundamental knowledge and technology.

The term megascience defines projects that have no analogues in the world, within the framework of which work is carried out on international world-class research programs using the capabilities of individual groups of scientists from different countries. Financing the creation and operation of such projects goes beyond the capabilities of individual organizations and even countries, and they form the basis of the global research infrastructure.

As a result of the analysis of world experience in the development of megascience projects, the Ministry of Education and Science of the Russian Federation submitted to the Government of the Russian Federation a list of criteria for classifying Russian research facilities as international scientific mega-projects, which was approved by the Government Commission on High Technologies and Innovations on July 5, 2011 [2]. Such projects include Russian research facilities that meet the following criteria:
The research facility allows you to solve large-scale scientific problems; the expected scientific results obtained only with its use open up new opportunities in the development of world science and the creation of breakthrough technologies that have no analogues.

The installation significantly exceeds in parameters the closest analogue, the expected period of preservation of uniqueness is at least 10 years.

The intention to participate in the creation (content) of the installation was expressed by foreign states.

The creation and operation of the installation is carried out on the basis of an international agreement.

The presence of a positive international examination of the project.

The availability of technical, economic and financial justification for the project.

The presence in the Russian Federation of internationally recognized scientific schools.

The estimated cost of participation of the Russian Federation in the creation and / or maintenance of the installation over 5 years exceeds 1.5 billion rubles, the share of financial participation of the Russian Federation corresponds to world practice for such installations.

The participation of Russian organizations in the construction and operation of foreign megascience facilities provides an opportunity for a long time to obtain new unique knowledge about the structure and properties of matter, and also provides an additional impetus for the creation of the latest large-scale plants in the Russian Federation, such as new accelerators, reactors, x-ray lasers, tokamaks, radiation monitoring and registration systems. The creation of large research infrastructures in the Russian Federation will ensure Russia's leading position in the global research market and, undoubtedly, contribute to the innovative development of the Russian economy.

The criteria for determining large research infrastructures on which international scientific megaprojects or international megascience projects are implemented above are fully satisfied by 5 foreign:

- European Organization for Nuclear Research - CERN (Geneva, Switzerland);
- European source of synchrotron radiation - ESRF (Grenoble, France);
- European X-ray free electron laser - European XFEL (Hamburg, Germany);
- European Center for the Study of Ions and Antiprotons - FAIR (Darmstadt, Germany);
- International Experimental Thermonuclear Reactor - ITER (Cadarache, France)

and 4 large research infrastructures created on the territory of the Russian Federation according to Protocol No. 8 [3] of the meeting of the interdepartmental working group in the direction “Research Infrastructure” of the Presidential Council on Science and Education of May 21, 2014:

- International Center for Neutron Research on the basis of the PIK reactor - ICSTI PIK (Gatchina, Leningrad region);
- Ion Collider based nuklotr at the NICA (Dubna, Moscow about the blasts);
- Source of synchrotron radiation of generation 4+ (Novosibirsk region);
- Russian-Italian project of the Ignitor tokamak (Troitsk, Moscow).

The Russian organization that provides scientific guidance and coordination of Russian participation in five international projects of the mega-science class is the National Research Center “Kurchatov Institute”. NRC “Kurchatov Institute” is also the responsible organization for the implementation of three international projects of the mega-science class in the territory of the Russian Federation: ICNR PIK, a source of synchrotron radiation of generation 4+ and the Ignitor tokamak. In the project of creating the Russian-Italian tokamak, Ignitor, along with the NRC “Kurchatov Institute”, is responsible for the implementation of the project by the Russian Federation is the State Atomic Energy Corporation “Rosatom”. The Joint Organization for Nuclear Research (JINR) is the responsible organization for the implementation of the Ionic Collider project based on the NICA Nuclotron.

The aim of this work is the formation of the main stages of the implementation of mega-science projects based on the analysis of world experience and the creation of large international research infrastructures. The resulting Roadmap for the development of megascience projects can be applied by
project participants for the effective consistent implementation of projects to create large research infrastructures in the Russian Federation.

2. Development of a scientific program and technological concept of the project

The initial stage or “phase 0” of creating a large research infrastructure involves the development of the following basic elements that form the foundation of the project (often presented in the form of a document – the White Book):

- the general scientific program - “scientific case”, which includes the expected results that will be achieved in the framework of the project;
- the technological concept of the installation is the “feasibility study”, which demonstrates the basic technological solutions for creating a large research infrastructure;
- the partnership at the national level - the creation of a national collaboration of research and educational organizations for the implementation of the project.

The presented three initial stages are fundamental in the implementation of the project and becomes the trigger for subsequent work.

Creating of general scientific program means a description of the chain from the initial scientific idea(s) to the implementation of a research experimental program with scientific results. In accordance with the criteria for classifying Russian research facilities as international scientific megaprojects, the expected scientific results should open up new opportunities in the development of world science. Scientific issues should include answers to the global challenges facing humanity in order to improve the quality of life and obtain new fundamental knowledge through comprehensive multidisciplinary research of a world level [4].

The general scientific program is developed by the parent organization – the author of the initial scientific idea(s) and presented at conferences, scientific seminars, scientific readings in order to obtain expert opinion of the scientific community in specific areas of scientific research. In a number of cases, at this initial stage, expert reviews of the scientific program at the national level were obtained. As the example we can consider the creation of a large MAX IV synchrotron research infrastructure in Lund (Sweden), where as part of Phase 0 a detailed design project for the facility was prepared – “Detailed Design Report (DDR)”, which includes a common scientific program and technological concept installation and received a positive expert opinion. In general, the result of the development of a common scientific program should be a positive conclusion of the national scientific community in specific areas of scientific research on the feasibility and interest in the implementation of the project.

The technological concept of the installation is a technological solution for creating a large research infrastructure with the aim of practical implementation of the initial scientific idea(s) and the expected scientific results. In this concept, the initial estimate and the schedule of the necessary work to create the installation is presented. Similar to the general scientific program, the technological concept is presented to the scientific and engineering community in order to obtain a positive conclusion.

Subject to the positive conclusions of the scientific and engineering communities at the national level, a partnership is formed to participate in the project of research and educational organizations. For this purpose, at this stage, the following legal documents may be prepared:

- “Letter of intent (LoI)”, confirming interest in participating in the project of national research and educational organizations;
- “Memorandum of Understanding (MoU)”, which defines the interest and, in some cases, the areas of responsibility of national research and educational organizations with participation in the implementation of the project.

Thus, upon completion of the initial stage - phase 0 - a core is formed, consisting of the lead organization and national project participants, for the implementation of the next stage - the development of a “Conceptual Design Report (CDR)” of the large research facility.
3. Development of a conceptual design report (CDR) of a large research facility

The conceptual design report of the project is a key document in light of the adoption of further decisions on the financing and implementation of the project. The development of a conceptual design report is carried out at the expense of the parent organization with the possibility of attracting funding for scientific foundations for the implementation of individual research projects. National organizations – partners participating in the project, with the possible involvement of their funds, also take part in the development of the CDR. As a rule, the development of a conceptual design report takes a period of time from one to two years.

Based on analysis of CDR of successful international megascience projects on the territory of the Russian Federation and the European Union, the optimum content of the Conceptual design report should include following sections:

- Introduction;
- Scientific basis of the project;
- Technological and technical basis of the installation;
- Energy and engineering infrastructure of the complex;
- Control systems and systems for collecting and processing large amounts of data;
- Safety analysis and risk analysis;
- Estimation of cost and schedule;
- Executive Summary.

Section Introduction is actually a justification that includes goals, objectives and expected scientific results as a result of the project. This section provides a historical overview, including, in accordance with criterion 7 of classifying Russian research facilities as international scientific megaprojects, describing internationally recognized domestic scientific schools in the current field of research. It is advisable to analyze the current situation in the world with respect to the chosen field of research, including a long-term forecast for the development of large research infrastructures in this field. One of the results of this analysis is the demonstration, in accordance with criterion 2, of the fact that the facility created within the framework of the project significantly exceeds the closest global analogue in terms of parameters with preserving uniqueness for at least 10 years.

Sections Scientific basis of the project and Technological and technical basis of the installation are the results of comprehensive research work. The scientific basis of the project contains a detailed description of global scientific problems and methods for their solution. Modern large research infrastructures are aimed at conducting interdisciplinary research involving the competencies of scientists working in various fundamental and applied scientific fields. Interdisciplinary integrated approaches to solving global problems should be clearly and thoroughly reflected in this section. It is also appropriate in this section the description of the experimental workstations for research on specific scientific problems.

Technological and technical fundamentals of the installation contain a detailed description of the units and structures of the installation, including innovative technological solutions that will be used to create them. In most cases in this section appears Program for Engineering Research and Development (R&D Program) to create basic installation elements.

The result of the sections Scientific basis of the project and Technological and technical fundamentals of the installation is a demonstration of unambiguous compliance with criterion 1 of classifying Russian research facilities as international scientific mega-projects: “The research facility allows solving large-scale scientific problems; the expected scientific results obtained only with its use open up new opportunities in the development of world science and the creation of breakthrough technologies that have no analogues.”

Section Energy and engineering infrastructure of the complex describes the auxiliary systems of the research infrastructure, including the power supply system, cooling system, air conditioning and ventilation system, vacuum system, radiation safety system and other systems necessary for the operation of the installation. In some cases, an Infrastructure Development Program is provided, including a description of the necessary work and a requirement for labor resources.
The description of Systems of control and systems for collecting and processing large amounts of data in most cases shall be made in a separate section and includes the entire IT component of the project, from control systems directly to plant components to an information center with systems for collecting large amounts of experimental data and processing results, including the creation of distributed data centers.

The Safety Analysis and Risk Analysis section is important and necessary in terms of compliance with Federal laws and codes, as well as state standards. Safety analysis includes an analysis of the security personnel, population and environment, fluidized bed, analysis of the socio-economic environment of the surrounding area, the analysis of radiation safety, including compliance with the regulatory framework in the field of operation of the radiation-hazardous installations, activation analysis and radiation protection, the elimination of management analysis radioactive waste and analysis of the decommissioning of the installation and disposal of radioactive components. In this section, it is advisable to prescribe a schedule for obtaining the necessary licenses.

The implementation of mega-science projects is closely related to the issues of solving the problems of analysis and risk management. To a large extent, the successful implementation of the project as a whole depends on how effectively it is possible to identify, block and reduce the likelihood of risks at this stage and ensure the implementation of the risk management program. The main risk categories when creating an international megascience project are the following:

- political risks;
- economic risks;
- achievement of the main goal of the project;
- technological and technical risks;
- risks implementation of a research program;
- risks associated with the safety of personnel, the public and the environment.

At the same time, it must be borne in mind that all these categories of risks can appear at any stage of the project life cycle. The basic result for risk analysis should be a summary of the methods of countering risks of each category and to assess the probability of the respective scenarios.

The Estimation of cost and schedule includes expert estimates of the cost of research and development work necessary for the development of a technical design report (terms of reference, design assignment) of the installation, the main and auxiliary elements of the installation and infrastructure, experimental stations and the data center, human resources, as well as a calendar schedule of work including the development of a technical design project, construction and installation work on the installation and preparation of the infrastructure up to commissioning, including experimental stations. The cost of participation of the Russian Federation in the creation and / or maintenance of the facility for 5 years in accordance with criterion 8 of classifying Russian research facilities as international scientific megaprojects should exceed 1.5 billion rubles. It should be noted that the summary cost tables and the schedule of this section are the basis of the Roadmap for the development of the project, which presents the technical, economic and financial justification of the project (in accordance with criterion 6 for classifying Russian research facilities as international scientific megaprojects), necessary for further submission to the authorities executive power.

The final section Executive Summary, as experience in creating international mega-science projects shows, is in most cases a general document of a conceptual design project for initial submission to national and international expert commissions of various levels. This section, as a rule, includes an important element of educational policy during the implementation of the project. Plans are presented for creating specialized in relevant scientific areas of the project faculties of higher educational institutions, as well as plans for conferences, seminars, lecture cycles, summer schools, internships for students, graduate students and young scientists.

The developed conceptual design project is sent to an independent international commission, created in most cases by the Ministerial bodies, to undergo the review in accordance with criterion 5 of classifying Russian research facilities as international scientific megaprojects. Subject to a positive decision of the international expert commission, the conceptual design project, the roadmap for the
development of the project and the expert opinion are sent to the interdepartmental working group in the direction of the "Research Infrastructure" of the Presidential Council on Science and Education and executive authorities to decide attribution to the international scientific mega-project and project financing.

4. Formation of an international collaboration of project participants

4.1. Declaration of interest
At the final stage of developing a conceptual design report, a pool of foreign research and educational organizations interested in the project is being formed as the potential participants of the project. The declaration of interest in participating in the project can be expressed in one of the following forms:

- “Letter of Intent (LoI)”, confirming interest in participating in the project of foreign research and educational organizations;
- “Memorandum (Letter, Protocol, Agreement) of Understanding (MoU)”, which defines the interest and, in some cases, the areas of responsibility of foreign research and educational organizations with participation in the project;
- “Framework Agreement”, which is an agreement on scientific and technical cooperation between the parent organization and a foreign research organization in a wide range of research areas, including the areas of project research;
- Joint communiqué on joining forces to create a large research infrastructure.

As an explanation of the last paragraph, it will be appropriate to cite as an example the Moscow Communique “International Design Effort for the Future Light Sources” (Moscow Communique), signed by the leaders of four research centers (SIC “Kurchatov Institute”, German synchrotron laboratory - DESY (Deutsches Elektronen-Synchrotron), European source of synchrotron radiation, France - ESRF (European Synchrotron Radiation Facility), Synchrotron radiation source, Japan - SPring 8 (Super Photon ring 8) in Moscow November 18, 2011 ABOUT The new provision of this communiqué is as follows: “The design of a new generation of X-ray ring apparatus requires an analysis of the future needs of the scientific community in the field of photon sciences (scientific justification) with a prospect far beyond 2020. This, in turn, requires an international coordinated effort with the participation of experts in various scientific fields to create a new generation radiation source, including possible and desirable solutions for the creation of new accelerator technologies, as well as on the technological challenges with carrying out the necessary research and development. In November 2011 in Moscow, the undersigned research centers decided to cooperate in this area."

A document with a declaration of interest in participating in the project is sent by foreign research and educational organizations to the relevant state executive bodies. Thus, compliance with criterion 3 of classifying Russian research facilities to international scientific megaprojects about expressing intentions to participate in the creation (content) of the installation of foreign states is achieved.

4.2. Determining the type of large research infrastructure
Upon completion of the conceptual design report, in preparation for the selection of the legal form of the megascience project, it is advisable to determine the type of large research infrastructure.

Four types were selected based on the institutional organization of the work of large research infrastructures. Type 1 includes international organizations whose activities are regulated by specialized agreements and treaties of participating countries. In this case, it is necessary to emphasize the supranational character of the large research infrastructure being created, when geographical localization does not reflect the nature of the infrastructure, and it acts as a separate subject of law. Type 1 includes such research infrastructures as the Joint Institute for Nuclear Research (JINR), the European Organization for Nuclear Research (CERN), the International Thermonuclear Experimental Reactor (ITER).

Type 2 includes organizations working on the basis of national legislation with international participation, when each participating country contributes to the project and assumes certain
obligations (primarily on financing, but also on the operation of the large research infrastructure being created) In this case, priority is given to the country in whose territory the infrastructure is being created, and the rights and obligations of the consortium participants are regulated by special agreements, which, as a rule, are multilateral. Type 2 includes research infrastructures such as European XFEL (X-ray Free Electron Laser), Germany, FAIR (Facility for Antiproton and Ion Research), Germany, ESRF, France, ESS-ERIC (European Spallation Source - European Research Infrastructure Consortium), Sweden and others. Separately, it should be noted the case of double regulation, as is the case with the ESS-ERIC infrastructure, whose activities are carried out in accordance with two national laws in the field of science and high technologies - Sweden and Denmark. It seems that such experience can be claimed, in particular, in the creation and development of large research infrastructures by the EAEU and BRICS member countries.

Type 3 includes research infrastructures created as national organizations that have the right to attract foreign participants to their work. In this case, each specific international project is governed by a special agreement (usually bilateral), national legislation takes precedence, and the participation of foreign scientific groups is limited to a specific project (a scientific experiment or a series of technological works) based on the existing research infrastructure. The involved participants within the framework of type 3 infrastructures cannot influence the organization’s policy and act, in practice, as users of the unique scientific equipment provided to them for operation under the international agreement. Type 3 organizations include all major US research laboratories (Brookhaven National Laboratory - BNL, Fermi National Accelerator Laboratory - FermiLab, Oak-Ridge National Laboratory - ORNL, Los Alamos National Laboratory - LANL, Lawrence Berkeley National Laboratory - LBL, National Superconducting Cyclotron Laboratory - NSCL, Thomas Jefferson National Accelerator Facility - Jefferson Lab and others) and Japanese research infrastructures (High Energy Accelerator Research Organization - KEK, Designated National Research and Development Institute - Riken).

Type 4 organizations include large research infrastructures that do not provide for international participation. Such infrastructures include Chinese research centers, research infrastructures in India and others. In the future, however, it is allowed to attract the international scientific community to work at these research facilities, however, the form and timing of this participation remains uncertain. The identification of type 4 seems necessary to emphasize the possibility of the existence of large research infrastructures outside of international scientific cooperation. In this case, it can be a matter of protecting national sovereignty and ensuring national security issues (dual-use work), as well as the hastiness of international participation, when foreign research teams can be involved subsequently. In this case, the most probable transition of a large research infrastructure from 4 to 3 type seems to be most probable.

At the same time, a complete reorganization of the existing large research infrastructure is possible, when a new institutional unit is created on its basis. A vivid example is the creation of the FAIR Center for the Study of Ions and Antiprotons in Germany of type 2 large research infrastructures, which actually absorbed the Helmholtz Center for the Study of Heavy Ions (Gesellschaft für Schwerionenforschung - GSI) of type 3, thereby making the transition from 3 to 2 type of large research infrastructures due to the transition to the creation of an international megascience project involving countries as members of the project consortium.

4.3. Choice of legal form

Currently, there is no single regulated approach regarding the selection of the appropriate legal form of international mega-science projects in the Russian Federation. At the same time, the definition of the typology of a large research infrastructure in accordance with the previous section will greatly assist in its selection.

The most optimal and effective from the point of view of determining the participation of foreign partners for mega-science projects proposed for implementation in the form of creating an international scientific center is the international intergovernmental organization (IMGO). The project
to create at the St. Petersburg Institute of Nuclear Physics - the National Research Center "Kurchatov Institute" (PNPI - Research Center "Kurchatov Institute"), Gatchina, Leningrad Region, the International Center for Neutron Research based on the high-flux research reactor PIK (ICRC PIK) is one type of large research infrastructures and definitely fits into this legal form. At the same time, it is advisable to consider the experience of creating IMSEs in the territory of the Soviet Socialist Republic / Russia using the example of the Joint Institute for Nuclear Research in Dubna, Moscow Region, an ongoing mega-science project called NICA Superconducting Accelerator Complex (Nuclotron based Ion Collider FAceility).

JINR is an intergovernmental international research organization. JINR was created in pursuance of the intergovernmental Agreement “On the Organization of the Joint Institute for Nuclear Research”, signed in 1956 by the authority of the governments of 11 countries. The JINR Charter was prepared by the Institute's Directorate and approved by the governments of the Institute's member states. Currently, JINR operates in accordance with the Federal Law of the Russian Federation dated January 2, 2000 N 39-ФЗ, ratifying the Agreement between the Government of the Russian Federation and the Joint Institute for Nuclear Research on the location and conditions of the Joint Institute for Nuclear Research in the Russian Federation. In accordance with the JINR Statute, the supreme governing body of the Institute is the Committee of Plenipotentiaries of the Governments of the Institute's Member States. Each member of the Institute has one representative on the Committee of Plenipotentiaries. In accordance with the Agreement, JINR is headed by the Director of the Institute and its two deputies, elected by a majority of the Institute's member states.

Currently, JINR includes 18 member countries of the Institute: the Russian Federation, Azerbaijan, Armenia, Belarus, Bulgaria, Vietnam, Georgia, Kazakhstan, the DPRK, Cuba, Moldova, Mongolia, Poland, Romania, Slovakia, Uzbekistan, Ukraine, the Czech Republic. Another 6 countries are associated members of JINR: Hungary, Germany, Egypt, Italy, Serbia, South Africa. In accordance with the Agreement, each JINR Member State makes annual financial contributions for the maintenance of the institute and for the construction of new research facilities in it, and also participates in the material support of the Institute. The size of the equity participation of the JINR Member States is determined by the Agreement. The sizes of financial participation and in-kind contributions of the associate members of the Institute are determined in accordance with separate agreements on scientific and technical cooperation. In accordance with the Agreement, the size of the shareholding of the JINR Member States is not a factor affecting the degree of participation of a JINR Member State in the scientific activities and management of the Institute (all participants have equal voting rights). A similar approach was implemented when creating the intergovernmental international organization CERN (1 type of large research infrastructures), in contrast to European XFEL and ESRF (2 types of large research infrastructures), where the shareholding of the participating countries determines the degree of influence on scientific and managerial activities.

When creating JINR, the following key stages were completed:

1. At the initiative of the USSR Government, in order to provide promising areas of fundamental physical research and in response to the creation of the CERN international organization in 1954, it was decided to create the Joint Institute for Nuclear Research with the participation of the countries of the socialist camp.

2. Pursuant to this decision, Commissioners from the Governments of 11 countries of the socialist community were appointed. The Commissioners were government officials at the level of Deputy Prime Minister, Minister / Deputy Minister, Chairman of the State Commission.

3. An intergovernmental Agreement “On the Organization of the Joint Institute for Nuclear Research” was developed and signed by Authorized Persons in 1956, including, first of all, the definition of the legal form of JINR in the form of an international intergovernmental organization (IMGO), as well as:
   a) JINR Management Structure;
   b) Financial liabilities (equity participation) of the JINR founding countries;
c) The provision that the size of the share participation of JINR Member States is not a factor affecting the degree of participation of a JINR Member State in scientific activity and the management of the Institute;

4. On the basis of the Agreement, the JINR Statute was prepared by the Directorate and approved by the Governments of the Member States, which determines the procedure for the Institute.

5. In 2000, Federal Law N 39-ФЗ was signed, ratifying the Agreement between the Government of the Russian Federation and JINR, which determines the location and conditions of the Institute's activities on the territory of the Russian Federation.

Next, we consider the main provisions of an international intergovernmental organization. IGOs is an association of states created in accordance with international (public) law and on the basis of an international treaty, in order to carry out cooperation in various fields of activity, including scientific and technical; having an appropriate organizational mechanism, rights and obligations derived from the rights and obligations of states, and autonomous will, the limit of which is determined by member states.

The legal status of IGOs implies the following:

1. Creation in accordance with international (public) law: IGOs activities should be carried out in accordance with generally recognized principles and norms of international law; the IGO charter is subject to registration with the UN Secretariat (Article 102 of the UN Charter);

2. Implementation of cooperation in specific areas of activity: IGO activities should be based on the principles of openness for the participation of all interested states and their equal and mutually beneficial cooperation;

3. The presence of international legal personality: in particular, the right to conclude international agreements and have observers at other international organizations whose activities are consistent with the statutory goals of the IGOs;

4. The presence of legal entity status.

The legal status of the IGOs is determined by the international treaty (intergovernmental agreement), the charter, as well as a separate agreement between the IGOs and the state, the territory of which will be the location of the organization. It is also allowed to apply additional international treaties to the activities of a certain IMGO, for example, the Convention on the Legal Status, Privileges and Immunities of Interstate Economic Organizations operating in certain areas of cooperation, dated December 5, 1980. In addition, IMGO may develop its own internal rules aimed to regulate its activities. The charter of the organization may establish the priority of such rules over the national legislation of the country where the IMGO is located.

International participation in such IGOs can be carried out in several formats:

- based on membership. Membership is determined by international treaty and the charter of IGOs. Member states of the Organization are entitled to participate in the financing of the Institute and have equal rights in the management of the Organization.

- based on bilateral and multilateral agreements on participation in the implementation of individual scientific programs (studies). In this case, the legal basis for the participation of states, international and national research organizations and institutions, individual scientists who are not members of the IGOs in the scientific areas of the IGOs are the above agreements. The agreements establish the scope of joint cooperation, mutual obligations of the parties, etc.

- in observer status. The status of an observer allows you to participate in the established manner in the work of the supreme bodies of the IGOs in order to exchange information, organize cooperation and coordinate activities.

Financing the activities of IGOs, as a rule, is determined by its Charter and financial protocol. The formation of its budget occurs through its own or attracted funds. IGOs funds can come from sources such as membership fees in the corresponding currency (the delivery may include the supply of devices, equipment, materials, the cost of services or work); targeted financing of research projects;
income from business activities; bank loans or loans; funds received under agreements on scientific and technical cooperation; funds from the use of intellectual property and other income.

As the main conclusion, it should be noted that the establishment of the International Scientific Center, according to the type of legal form of JINR or CERN (intergovernmental international organization), provides for the mandatory existence of an intergovernmental agreement between the founding countries of the International Center. Thus, compliance with the remaining criterion 4 of assigning Russian research facilities to international scientific megaprojects on the creation and operation of the facility on the basis of an international agreement is achieved.

Large research infrastructures of type 2, as a rule, carry out their activity in the form of international research centers operating in accordance with national legislation in the form of public limited companies. The international participation of such infrastructures is carried out through the participation of member countries and countries with the status of associate members. The value of contributions of the participating countries is proportional to the number of repurchased shares of the authorized capital of the total project cost.

The governing body of the organization is the Council, including the Chairman of the Council and delegates of member countries. The Council receives recommendations from three committees: the Administrative and Finance Committee (AFC), the Scientific Advisory Committee (NCC) and the Technology Advisory Committee (TAC). The AFC, NCC and TAC include delegates from all member countries, and delegates from the countries of associate members are included in the committees as observers. The Council, as a rule, meets twice a year, decisions on the results of meetings are presented to the Director General. The Office of the Director-General includes the Committees for the distribution of time at experimental research stations, the services of the General Director, as well as the Departments for the operation of the facility and experimental research, support services, a development unit, and a technical infrastructure unit.

It is important to emphasize that when choosing this legal form, the key factor determining the degree of participation in the research programs and management activities of the project is the share of the project member countries. Examples include large research infrastructures with the participation of the Russian Federation as a member: European XFEL and ESRF, operating as public limited companies under German and French law, respectively, as well as the ESS infrastructure, the legal status of which was determined in 2010 in the form of a public limited liability company under Swedish law ESS AB, where 75% of the shares belong to Sweden and 25% to Denmark. Starting October 1, 2015, the legal form was transformed into the ESS-ERIC (European Spallation Source European Research Infrastructure Consortium) in order to facilitate the joint creation and management of the pan-European research infrastructure ESS.

5. Final clauses
The final stage before the start of construction of a megascience installation is the development of a Technical Design Report (TDR). Technical design project includes design assignment:

- capital construction facilities
- all structural elements and installation units;
- energy and engineering infrastructure, including all auxiliary systems;
- data center;
- experimental research stations with a detailed description of the research plan;
- the final calendar schedule of construction right up to commissioning and the detailed cost of all objects of large research infrastructure.

The technical design project is created by the parent organization in partnership with national and foreign research and educational organizations, as well as with national specialized design institutes. The creation of a technical design project usually takes 2 to 5 years, depending on the scale of the research infrastructure. The cost of developing a technical design project, as a rule, is 10% of the total project cost. Upon completion of the technical design project, the construction phase of a large research infrastructure begins, followed by its commissioning.
In conclusion, we express the hope that the material presented will be useful for participants in newly created and new mega-science projects in the Russian Federation. The experience of creating numerous large research infrastructures with international participation demonstrates the greatest efficiency with a clear and consistent implementation of the project with the passage of the above stages.

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