National Research Computer Network of Russia: Regulatory Status and Plans for the Development of Regional Telecommunications Infrastructure in 2021-2024

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Abstract

The contribution is dedicated to the development plans of National Research Computer Network of Russia (NIKS) for the period 2021-2024 in the framework of the National project "Science and Universities". The emphasis in the work is done on the current regulatory status of the NIKS project, discussion of significant aspects of the management procedure and the Concept and the roadmap for the functioning and development approved by the line Ministry. The special attention is paid to the main directions of the modernization of the NIKS backbone telecommunications infrastructure and significant expanding territorial accessibility within Russia. Key features of the existing infrastructure, areas of regional development of NIKS, including the Siberian and the Far Eastern Federal Districts, are presented and discussed.

Keywords 1

National research computer network, NIKS, national research and education network, NREN, regulatory status, national project, management procedure, telecommunications infrastructure, regional development

1. Introduction

The term National Research and Education Network (NREN) has long and firmly entered the lexicon of the world research and education (R&E) community. The goals, tasks and main functions of such networks at all stages of development sought to meet the constantly increasing level of information and communications technology (ICT) development, changing external conditions and the real needs of the field of R&E, in many components outstripping the development of networks of commercial telecommunications operators [1-4].

The current level of technological development of NREN and its individual architectural components in a particular country can be considered in the context of the state of the fields of science, education and technology in general. Leading NRENs act as a backbone infrastructure and service platform for large research projects, in the implementation of which modern ICT tools are used intensively. The integrated infrastructure of world NRENs aimed at solving the problems of high-speed transmission, processing and storage of avalanche-like growing volumes of scientific data.

In Russia, the functions of NREN are performed by National Research Computer Network (NIKS, https://niks.su) [5-7] created in 2019 on the assignment of the Ministry of Science and Higher

Education of the Russian Federation (further – the Ministry) by Joint Supercomputer Center of the Russian Academy of Sciences (JSCC RAS). The infrastructure and service basis of the united network was made up of two largest sectoral networks of the country at the time of creation, namely Federal university computer network RUNNet [8, 9] and network of the Russian Academy of Sciences RASNet.

In 2021, the management procedure [10], the Concept and the roadmap for the functioning and development of NIKS for 2021-2024 [11] were approved by the Ministry. The functions of the administrator and operator of NIKS are assigned to JSCC RAS. It is important to emphasize that for the first time in the 25-year history of the existence of separate R&E networks in Russia, the status of NREN is officially assigned to a united federal-scale network. NIKS is included in the National project "Science and Universities" as one of the key projects with the consolidation of the main areas of work, indicators and characteristics of the result.

2. Regulatory status of NIKS and aspects of the management procedure

Unified National project in the field of higher education and science for 2021-2030 "Science and Universities" consists of four Federal projects, among which the project "Development of infrastructure for scientific research and training". The results of this Federal project include the implementation of the development of NIKS in the interests of R&E organizations of Russia, including with the aim of offering access to advanced scientific infrastructure of collective use (supercomputer centers, centers for collective use, unique scientific facilities, digital collections, data banks) by increasing the capacity of the network backbone, territorial accessibility and a set of services.

As the characteristics of the result of the Federal project, it has been determined that NIKS will provide R&E organizations of the country with opportunities to carry out research and development in priority areas of research and technological progress, to participate in large local and international research projects based on the use of a sustainable and up-to-date sectoral information and telecommunications network, integrated into the infrastructure of world NRENs.

In 2021-2024, the development of the backbone infrastructure of the network will be carried out with an increase in bandwidth in the main segments up to 200 Gbps, an expansion of the geography of the location of network access nodes throughout the territory of Russia and an expansion of the range of demanding R&E services.

On the basis of NIKS, the following main tasks will be solved:
- integration of existing and emerging supercomputer centers (SCC), unique scientific facilities of R&E centers, world-class research centers and centers for collective use;
- organization of stable high-speed telecommunication connectivity of R&E organizations; deployment of a digital environment for interaction and development of promising technological solutions;
- ensuring the use of ICT in education, including for access to electronic educational resources, provision of distance learning technologies, R&E mobility;
- organization of effective interaction with major international research centers and projects through cooperation with the world's leading NRENs and network consortia;
- ensuring compliance with information security requirements aimed, inter alia, at the stable and secure functioning of the Russian segment of the Internet.

The National project established the indicator of connection to NIKS of leading Russian R&E organizations, which at the end of 2024 should be at least 90%. The indicated percentage refers to the following R&E organizations (accepted criteria for categorization as leading) [7, 12]:

1. Higher education institutions, which, in accordance with the Federal Law "On Education in the Russian Federation" dated December 29, 2012 No. 273-FZ, are authorized to develop and approve independently educational standards for all the levels of higher education;

2. Research organizations and higher education institutions of the 1st category determined in accordance with the Decree of the Government of the Russian Federation dated April 8, 2009 No. 312 "On the assessment and monitoring of the performance of research organizations carrying out research, experimental design and technological work for civil purposes";

3. National research universities;
4. Federal research centers;
5. Universities under the jurisdiction of the Government of the Russian Federation.

The approved management procedure of NIKS [10] defines goals, main tasks, principles of operation and development, features of structure, principles of management, sources of financing for NIKS activities as a united industrial telecommunications network in the R&E sphere of the country.

This document states that NIKS is national information and telecommunications network of the NREN level, which has unique characteristics in comparison with public networks, which is operated in the interests of science and higher education, ensures network connectivity of users and inter-networking with foreign NRENs, provides access of users to the global digital space.

The goals of NIKS in expanded form in comparison with the regulatory documents are [10]:

• providing research institutions and higher education institutions with opportunities to carry out research and development in priority areas of scientific and technological progress, the use of modern ICT in the implementation of educational programs of higher education, participation in large Russian and international R&E projects based on the use of sustainable and meeting up-to-date requirements of the industry information and telecommunications network, integrated into the infrastructure of the world NRENs;

• participation in the formation and maintenance of the functioning of a common R&E information space of Russia [6] in order to effectively use the advanced infrastructure of scientific research, development and innovation being created in the country, including to ensure global accessibility and opportunities for distributed work with big data generated on the MegaScience class facilities, other large unique scientific facilities, SCC and centers for collective use, engineering centers and other forms of R&E cooperation;

• provision of sectoral network connectivity and a set of specialized services for science and higher education [13], implementation of the development of interfaces for managing the network's resources for integration with digital platforms of R&E, including using federated authentication technologies.

The main tasks of NIKS in accordance with the management procedure are:

• organization of high-speed domestic telecommunications connectivity of users on the basis of NIKS;

• providing users with guaranteed quality and high reliability of access to research results, global open data arrays in the sphere of higher education and science, scientific and educational resources and services of NIKS using its own ICT infrastructure and infrastructure of foreign NRENs;

• providing users with opportunities for full participation in global research projects implemented with broad domestic and international cooperation, intensively using the high-speed telecommunications infrastructure of NRENs;

• ensuring the interconnection of Russian organizations involved in storage, processing and analysis of experiments on existing and new facilities of the MegaScience class, improving the access of NIKS users to such facilities;

• formation of a high-speed telecommunications infrastructure for the unification of SCCs into the National Supercomputer Infrastructure [7, 14, 15];

• providing users with infrastructural and service opportunities for the formation of new Russian and international R&E collaborations, expanding interaction and cooperation of research teams in the joint implementation of science-intensive projects;

• providing users with opportunities for controlled remote access to facilities for collective use (centers for collective use, unique scientific facilities) located in research organizations and higher education institutions of the country and the world;

• optimization of the methods of network interaction of organizations involved in fundamental and applied research in priority areas with organizations of the real sector of the economy to increase the share of external users of scientific equipment and transfer of technologies and developments, including in order to solve the tasks of the Strategy of Scientific and Technological Development of the Russian Federation and in the interests of society as a whole;

- partnership with foreign NRENs and international network R&E consortia in order to ensure global international research connectivity;
- creation of conditions for the participation of Russian software manufacturers in the formation NIKS services in the interests of users within the framework of import substitution processes;
- realization of connectivity with commercial providers of public networks and Internet through centralized management in order to obtain significant savings in funds and resources;
- strategic planning, organizational and technical management of international, federal and regional nodes, backbone infrastructure of the NIKS network;
- ensuring the life cycle of software and hardware solutions used in NIKS, their maintenance, modernization of individual elements of NIKS;
- approbation, testing, implementation, maintenance and delivering services in the interests of users [13];
- monitoring the current demand, tracking requisition and forecasting the prospects for the use of NIKS services;
- deployment of a common digital space for interaction and providing users with opportunities for testing, approbation and implementation of promising ICTs;
- providing broad opportunities for the use of ICT in education, including access to electronic educational resources, distance learning systems, implementation of network models of education, delivering access to electronic libraries and digital collections, management systems in higher education institutions and scientific organizations, providing networking opportunities for university campuses, support for the mobility of students and teachers;
- optimization of user costs for services in the field of ICT, including by eliminating duplicate elements, namely network connectivity of individual networks, maintenance of hardware and software resources, as well as by moving from private dedicated use of software to shared use in time-sharing mode;
- delivering communication services for data transmission and access to the Internet.

The management procedure enforces that the general administration of NIKS is carried out by the Ministry. In order to ensure the functioning, technological development, fulfillment of the requirements of the legislation of Russia on information, information technologies and on the protection of information and scientific and methodological support, the Ministry determines the administrator of NIKS.

The collegial governing body of NIKS is the Council of the Ministry for Digital Development and Information Technologies. The Presidium of the Council has the right to entrust the implementation of the Council's functions to a specially created working group. Expert support of NIKS activities in accordance with the functions assigned to the RAS by Federal Law No. 253-FZ dated September 27, 2013 is provided by the RAS Council "High-performance systems, scientific telecommunications and information infrastructure". It is assumed that the management of NIKS should be carried out taking into account the best world practices and specific domestic features.

As users of infrastructure and services of NIKS in a broad sense are considered:
- research organizations, higher education institutions of Russia, including operators of centers for collective use, unique scientific facilities, SCCs and other objects of scientific infrastructure of collective use, basic organizations of the MegaScience class facilities;
- organizations – participants of world-class research centers, world-class R&E centers, competence centers of the National Technology Initiative, technology transfer centers;
- the RAS and branch academies of sciences;
- other organizations subordinated to the Ministry;
- organizations conducting research activities and subordinated federal executive bodies;
- organizations of the real sector of the economy engaged in scientific and technological activities, innovation incubators and others.

The principal possibility, conditions, procedure for connecting organizations to NIKS and receiving services are determined by the administrator on the basis of the Concept of functioning and the Action plan ("roadmap") for the implementation of the functioning and development of NIKS [11], as well as the technical requirements of the organization.

The roadmap worked out by JSCC RAS includes the following key sections:
1. The development of the NIKS infrastructure.
2. Information security assurance.
3. International interaction of NIKS.
4. Legal support for the functioning and development of NIKS.
5. Activities to involve Russian R&E community in digital transformation processes.

Some activities and main directions of work on the development of the NIKS infrastructure will be presented and discussed in the next section. Substantive discussion of the remaining sections listed is beyond the scope of the paper.

3. The main directions of the development of NIKS infrastructure: 2021-2024

3.1. Features of the structure and the development of the NIKS telecommunications infrastructure

At the moment NIKS has points of presence in 37 regions of the country, directly providing telecommunications services to more than 150 state higher education institutions, scientific and research organizations [5-7, 12]. NIKS unites information and telecommunication networks of users on the base of up-to-date network technologies, unified network IP-address space and the provision of ICT services.

Telecommunications infrastructure of NIKS (see Figure 1**Figure 1Figure 1Figure 1Figure 1Figure 1Figure 1Ошибка! Источник ссылки не найден.**) subdivides into backbone infrastructure and access infrastructure [5]. The transport basis of the backbone infrastructure is the core network, which ensures backbone connectivity between all the federal districts and individual regions located in them, as well as with foreign NRENs and R&E network consortia. The operation of the core network is provided by domestic (federal and regional) and foreign communication nodes of NIKS (together called backbone nodes). The backbone infrastructure unites the backbone nodes and communication channels between them, forming the core network.
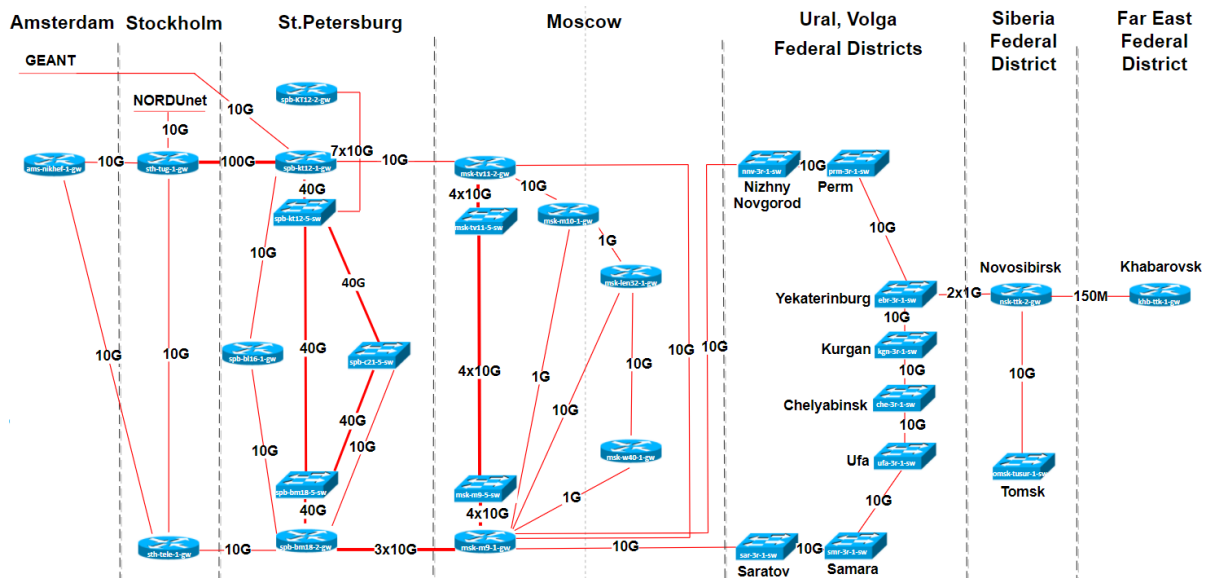

Figure 1: High-level design of the NIKS network architecture as of the end of 2020

Federal communication nodes are key elements of the NIKS network, they are integrated within the cities of location (currently in Moscow and Saint Petersburg) using fiber-optic communication lines that have an extensive infrastructure and ensure the full redundancy. Federal nodes located in different cities today and in the future development will be connected by high-speed trunk channels with a total bandwidth corresponding to the actual needs of the R&E sphere, and determined by the

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current indicators of the development of data transmission technologies. The nodes between Moscow and Saint Petersburg are connected now by four channels (4×10 Gbps), organized on the basis of physically independent links.

Federal nodes communicate with regional nodes, access nodes, research and sectoral networks of other Federal departments, networks of telecommunications operators, Internet exchange points, as well as with public networks and the Internet. Regional nodes are created in large cities of the country, which are leading R&E centers, and they are equipped communication nodes used to connect users located in the region (or in neighboring regions) to the backbone infrastructure. The regional nodes are located now in the following cities: Nizhny Novgorod, Perm, Yekaterinburg, Kurgan, Chelyabinsk, Ufa, Samara, Saratov, Novosibirsk, Tomsk and Khabarovsk.

The basic backbone routers currently used in NIKS are Juniper MX480 and Cisco 7606 (the latter in the course of modernization will be replaced by more modern devices). The ring transport infrastructure in the European part of Russia with a bandwidth of 10 Gbps (see Figure 1) is built on the basis of the Cisco Catalyst 4500x switches. Cisco Catalyst 3550, 3560, and 4500 network switches with 1 and 10 Gbps ports are used as access equipment as part of most regional communication nodes.

The access infrastructure is a set of communication channels and network equipment located at the access nodes, which provide constant highly reliable user access to the NIKS backbone infrastructure. Access nodes are traditionally located in the server rooms of end-users, at technological sites for network interaction of telecommunications operators, at own telecommunications nodes of operators and in data processing centers.

NIKS connectivity with foreign NRENs and public networks, including the global Internet, is carried out through federal and foreign nodes of NIKS (using redundant high-speed trunk communication channels), resource capabilities of NRENs and network consortia, high-level service providers ("uplinks") and key international technological sites for interaction of telecommunications operators. Today, the European R&E network consortium GÉANT, the R&E network consortium of Nordic countries (NORDUnet) and several Tier-1 operators (including Lumen Technologies, TeliaSonera and Cogent Communications) are the key foreign partners of NIKS. The foreign nodes are located now at the sites of NORDUnet (Stockholm), Nikhef (Amsterdam) and IT Center for Science of Finland (CSC, Helsinki).

In order to increase the level of global network connectivity, NIKS connects to major Internet exchange points in Russia and abroad (AMS-IX, MSK-IX, SPB-IX, DATA-IX, PITER-IX and NSK-IX; more than 50 Gbps in total for today), participates in direct inter-network traffic exchange with the networks of the largest Russian and foreign telecommunications operators (e.g. Google, MegaFon, Rostelecom, Mail.ru, Selectel, FIORD, Filanco, ER-Telecom; more than 30 connections, more than 200 Gbps in total). On the whole, by the level of network connectivity, NIKS (AS3267) is ranked as the Top10 in Russia (on the background of the largest network operators, such as Rostelecom, Transtelecom, Vimpelcom, RASCOM, MegaFon, MTS, FIORD, Filanco, et al.) and occupies at the moment the 67th place in the world (according to https://asrank.caida.org).

As part of the section of the roadmap concerning the development of the NIKS infrastructure, the following top-level directions of work are announced:

- expanding territorial accessibility of NIKS inside the country;
- increasing the network bandwidth of the NIKS backbone infrastructure;
- connection to NIKS of high-performance SCCs for collective use;
- connection to NIKS of leading research organizations and higher education institutions of Russia [7, 15];
- connection to NIKS of centers for collective use and unique scientific facilities, which have the ability to perform research in remote access mode and located in the leading R&E organizations of Russia;
- ensuring high-speed network connectivity and user access to data centers of unique scientific facilities of the MegaScience class network;
- development and modernization of NREN-level services of NIKS for education, science and technology as part of the following service groups – infrastructure services, basic network services and telematics services, infrastructure monitoring and management services, information technology services and specialized services for R&E [13];

- creation of an environment for unified interaction of high-performance SCCs [16];
- creation of a web-portal of R&E services (in a form of marketplace, see the pilot version on the website https://service.niks.su).

3.2. Regional development of NIKS within Russia

The target user base of NIKS is formed now by R&E organizations of 15 federal executive authorities, while 80% of them are subordinated to the Ministry. The number of higher education institutions among the latter is 79, scientific and research organizations – 63 (including 48 institutes of the RAS). Among NIKS users today are MSU and SPbSU, a number of federal and national research universities (BMSTU, MIPT, MEPHI, MIREA, MAI, MISiS, SPbPU, ITMO, LETI, SPMU, SFU, UNN, TSU, TPU, PSU, SSU, USATU, et al.), large scientific and research centers (including KIAE, and JINR), leading institutes of the RAS (IKI RAS, INASAN, IO RAS, ZIOC RAS, GPI RAS, LPI RAS, Ioffe Institute, et al.). 21 of 34 of the most powerful supercomputer systems of Russia hosted by R&E organizations (from the actual Top50 list, http://top50.supercomputers.ru) are connected to NIKS.

For the next 4 years, a large-scale improvement of the NIKS network infrastructure is planned, the commissioning of new backbone communication nodes and the expansion of the area of presence in Siberia, the Far East and in certain regions of Southern Russia. The plans for the development include the construction of a redundant network backbone with a throughput of 10...100 Gbps, connection of more than 300 research organizations and higher education institutions, integration of SCCs into a single network with the simultaneous modernization of their capacities within the National Supercomputer Infrastructure [14]. The data transmission network will be built on the basis of TCP/IP protocols using MPLS functionality at all the levels and will provide a bandwidth for each connected user of at least 1 Gbps (for large SCCs – up to 10 Gbps). In the plans for the development of the backbone infrastructure, the main emphasis is on creating fault-tolerant ring network topologies.

It is supposed to use the same type of equipment in the network for the formation of modular topologies of communication nodes of various types and capacities, which will allow flexible use of the equipment in the implementation of the plans for the creation and modernization of network sections and help to reduce the cost of purchasing and maintaining. Existing and new communication nodes are classified as federal nodes, regional nodes and access nodes with the calculated minimum characteristics necessary to ensure the design performance of the network.

The expected map of the NIKS backbone infrastructure corresponding to the development plan as of the end of 2024 is shown in **Figure 2**Figure 2.
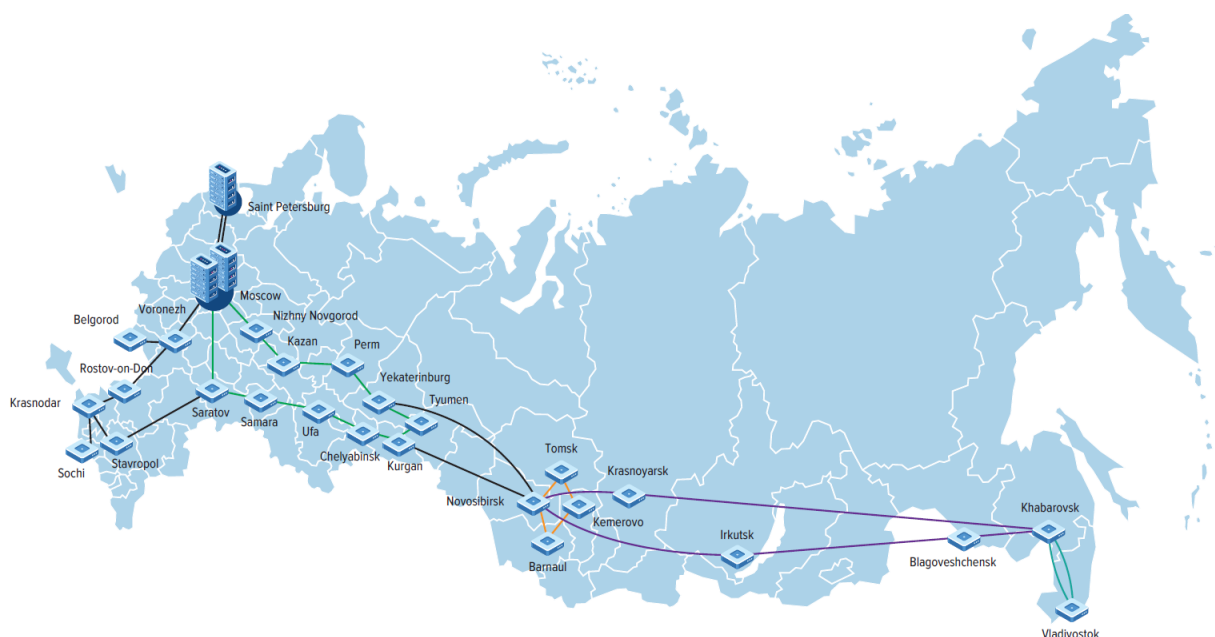
Figure 2: Map of the NIKS backbone infrastructure as of the end of 2024

The expected results of work in the areas of expanding territorial accessibility and increasing the network bandwidth of NIKS include:

- creation of new backbone communication nodes of NIKS in the Siberian, the Far Eastern and the Southern Federal Districts, in cities with the largest presence of leading R&E organizations;
- modernization of individual existing communication nodes of the NIKS backbone network;
- phased creation of new ring and linear segments of the NIKS backbone infrastructure in certain regions of Russia, including the Siberian ring (10 Gbps), the Southern ring (10 Gbps), the Small Siberian ring (1...10 Gbps), segments Khabarovsk – Vladivostok (2×10 Gbps), Voronezh – Belgorod (2×2 Gbps), Krasnodar – Sochi (2×2 Gbps);
- phased modernization and development of existing ring and linear segments of the NIKS backbone infrastructure in certain regions of Russia, including Moscow – Saint Petersburg (2×100 Gbps), the European ring (10 Gbps).

It is worth noting here significant differences in the current level of development of ICT infrastructure of the regions, the degree of competitiveness of the local telecommunications services market, the presence of telecommunications operators at the federal and local levels, the availability of telecommunication sites. Under certain conditions, these aspects can create difficulties in the process of connecting to the network of organizations in the regions. In this regard, special attention will be paid to establishing cooperation with the remaining regional R&E networks and their associations, to which potential users of NIKS are connected now [17, 18].

4. Conclusion

The inclusion of NIKS in the National project "Science and Universities" highlights and consolidates the special role and significance of the project among the priorities of the country's scientific and technological development for the coming periods. Sustainable targeted government support, a significant increase in the volume of financing of work made it possible to form a long-term vision and strategic plan for the development of NIKS, including taking into account the goals and objectives of the national project.

For the first time in a long period, the opportunity presented itself to purposefully overcome the current gap in the level of NIKS development from leading world NRENs, to deliver a state of the art network in support of expanded R&E activities throughout Russia, to implement and to deliver best-in-class network and services, to provide a sustainable and effective collaboration platform for Russian R&E community.

The unified e-Infrastructure for e-Science and e-Education being created that meets the modern level will take into account the rapidly changing needs of organizations in the R&E sphere, not only subordinate to the Ministry of Science and Higher Education of the Russian Federation, but also to other Federal departments, as well as interdepartmental R&E and scientific and technological consortia, broader and interested social and cultural constituency.

5. Acknowledgements

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