Form № 21

APPROVED BY

JINR Vice Director

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"_____" _____ 2019 _

SCIENTIFIC AND TECHNICAL JUSTIFICATION FOR OPENING A NEW THEME

OR FOR EXTENDING THEME

to be included in the

TOPICAL PLAN FOR JINR RESEARCH FOR 2020–2023 гг.

Theme code 05--6--1118--2014/2019 **Laboratory** LIT

Department _____

Research area: Networking, Computing, Computational Physics

Theme title: JINR information and computing infrastructure

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Abstract:

The theme goal is the development of the JINR network, information and computing infrastructure for the research and production activities of the Institute and its Member States on the basis of state-of-the-art information technologies in accordance with the Seven-Year Plan for the development of JINR. The major direction within the theme is the development of the JINR LIT Multifunctional Information and Computing Complex (MICC) presented as **the Project**. The implementation of the MICC project in 2017-2019 laid foundation for its further development and evolution taking into account new requirements to the computing infrastructure for JINR scientific research based on modern information technologies according to the Seven-Year Plan for the development of JINR for 2017-2023. The rapid development of information technologies and new user requirements stimulate the development of all MICC components and platforms. Multi-functionality, high reliability and availability in a 24x7 mode, scalability and high performance, a reliable data storage system, information security and a customized software environment for different user groups are the main requirements, which the MICC should meet as a modern scientific computing complex.

To fulfill these requirements it is necessary to provide a high-speed telecommunication and network infrastructure as well as a reliable engineering infrastructure.

The MICC project prolongation is aimed at the modernization and development of major hardware and software components of the computing complex, the creation of a state-of-the-art software platform in order to develop methods and algorithms of machine/deep learning (ML/DL) for the solution of a wide range of tasks. The MICC project extension presupposes the work in the following directions:

1. Development and improvement of the JINR telecommunication and network infrastructure.
2. Stage-by-stage modernization of the JINR MICC engineering infrastructure.
3. Modernization and development of the IT-infrastructure of the NICA project.
4. Extension of the performance and capacity of storage systems of the Tier1 data processing center for the CMS experiment.
5. Modernization and development of the resources being part of the Tier-2/CICC integral component, which provides support for the experiments using the grid environment and cooperating with physical groups in JINR as well as for non-grid JINR users and its Member States (MPD/NICA, BESIII, LRB, FLNR, DLNP, BLTP, FLNP, VBLHEP).
6. Extension of the cloud component in order to enlarge a range of services provided to users as well as to create an integrated cloud environment for experiments of JINR (NICA, ALICE, BESIII, NOvA, Daya Bay, JUNO, etc.) and its Member States using the containerization technology.
7. Enlargement of the HybriLIT heterogeneous platform with the GOVORUN supercomputer.
8. Significant extension of resources of the MICC components to meet requirements of neutrino experiments.
9. Development of a unified system for computing resource management aimed at big data processing.
10. Development of a unified data management system for all MICC components (JINR Data Lake).

The other key objectives of the theme are:

- **Information and software environment for the research and production activities of JINR.**
- **Development of the system for training and retraining IT-specialists on the basis of the JINR MICC and its educational components.**

<u>Work stages in frames of the project and the theme</u>

Project of the MICC development

I. Development of the network infrastructure

First years of the MICC project implementation laid foundation for the further development of the JINR network infrastructure, in particular, the projects related to increasing the bandwidth of the Moscow-JINR telecommunication channel to 100 Gbps, installing and configuring the equipment of the Institute backup computing network to 2 x 100 Gbps and the distributed computing cluster network between JINR facilities to 400 Gbps were carried out.

The following main directions can be defined in the implementation of the development of the JINR network infrastructure.

1. Development of external telecommunication channels.

The solution of this task is related to scalability, reliability and fault tolerance of data transmission means and will consist of several successive stages:

- continuation of the modernization of the existing channel-forming telecommunication equipment and 100 Gbps transponders;

— scaling of the Moscow (MGTS-9) telecommunication segment on the MPLS (MultiProtocol Label Switching) and VRF (Virtual Routing Forwarding) technologies;
— optimization of the high-speed data transfer routes with participants of high-energy physics collaborations via the networks GEANT, LHCOPN, LHCONE, etc.

2. Development of the JINR local area network.

The given direction is associated with the development of the Institute inter-laboratory backup network and includes the development of the 100 Gbps segment within the laboratories. Internal laboratory networks should have the same bandwidth as the network channels leading to the laboratories, i.e. 100 Gbps. To carry out this task, it is necessary to replenish central switches with 100 Gbps interfaces. It is supposed to purchase the network inter-laboratory equipment at the expense of the laboratories.

3. Development of the network infrastructure of the MICC and the NICA megaproject.

In frames of this direction, the following works are presupposed:

— development of the MICC local network, i.e. transfer to 100 Gbps interfaces;
— development of the communication component of network subsystems of the MICC and the NICA megaproject using the Multisite cluster network technologies at a speed of at least 400 Gbps;
— creation of the network infrastructure for receiving and transmitting data between the BM@N, MPD, SPD facilities and on/off-line clusters. The given direction presupposes laying new optical networks between DLNP and VBLHEP sites as well as ensuring maximum reliability and fault tolerance of this network.

Increasing the performance of the network segment of the MICC/Tier2 system will allow speeding up access to data stored in the databases of the LHC experiments.

4. Development of the LIT laboratory network.

The given direction related to the modernization of the LIT local network presupposes the installation of a new network equipment in the 134 building with support of network technologies 100 Gbps Ethernet.

The planned increase in the bandwidth of the external telecommunication channels, the JINR backup and local network is shown in Table 1.

Table 1.

	2020	**2021**	**2022**	**2023**
External Channel	2 x 100 Gbps	4 x 100 Gbps	4 x 100 Gbps	6 x 100 Gbps
Backup Network	2 x 100 Gbps	2 x 100 Gbps	2 x 100 Gbps	2 x 100 Gbps
MultiSite Cluster	4 x 100 Gbps	4 x 100 Gbps	8 x 100 Gbps	8 x 100 Gbps

It is noteworthy that the increase in the bandwidth of external and internal telecommunication channels above the plan will be defined by the needs of network-connected facilities, including the needs of the NICA megaproject, and elaborated due to the financial support from the budgets of experiments, joint grants and other sources.

Network services.

One more important direction is the development of network services supporting the network operation such as:

— Network services (NOC Cluster) of e-mail, name management (DNS), data caching (Proxy), resource management (IPDB), authorization (Radius, Tacacs, Kerberos), monitoring (NMIS);
— Service of Single Sign-On (SSO);
— Information security system;
— System of testing of users for the knowledge of the operation rules in the JINR computing network, etc.

The development of the project “My account” will be in progress; it will provide users with access to general Institute services and the ability to request computing and information resources required for their professional activity. Some resources can have certain policies for providing them to various categories of users. Upon users’ request, this resource will be provided to them, or users will get information about the rules of its provision.

II. Development of the MICC engineering infrastructure

The MICC engineering infrastructure is designed to ensure the reliable, uninterrupted and fault-tolerant operation of the information and computing system and the network infrastructure. The use of the integrated approach to building the MICC engineering infrastructure allowed one to elaborate algorithms of the equipment operation and interaction of separate systems both in a normal operation mode and in emergencies, which ensured the uninterrupted performance regardless of external factors.

Another integral feature of the engineering infrastructure is its scalability, the possibility of which was defined on the basis of the analysis of computing equipment growth prospects for 3-4 years.

The main task of the next stage of the modernization and development of the MICC engineering infrastructure relies on providing the uninterrupted power supply, air-conditioning and ventilation of all the components of the complex in accordance with the growth of computing powers.

1. Guaranteed power supply.

The guaranteed power supply system (GPSS) created during first years of the MICC project implementation meets the strictest reliability standards imposed on the MICC functioning in a 24x7x365 mode by the 1st class and ensures:

- guaranteed power supply of connected consumers;
- automatic start of the diesel-generator;
- automatic load switching from the major external power supply network to the diesel-generator and backward;
- sending an alarm to the dispatcher’s post in case of an emergency with the DGU equipment.

The further modernization of GPSS should provide all MICC components with the high-quality power supply in conditions of the quality decrease or short-term loss of the main network via uninterruptible power supplies (UPS). In this regard, it is planned to expand the power of uninterruptible power supplies to 2.4 mVA based on eight APC Galaxy 7000, which will fully provide the MICC halls on the 2nd and 4th floors with electricity until 2023.

Together with this, the modernization of distribution panels for the guaranteed power supply and of load distribution sections for own needs of the building will be performed, as well as a power supply system for four air-cooling modules and cabinets for the network and computing equipment of the MICC complex will be created.

The MICC GPSS development plan presupposes:

- Creation of a power supply system for four air-cooling modules and cabinets for the network and computing equipment of the MICC complex;
- Development and installation of the power supply system of the hall on the 4th floor;
- Elaboration of the project and connection of an additional source of power supply from the Dubna HPS (hydroelectric power station) to provide the MICC with the power supply of the first category;
- Completion of the reconstruction of the power supply and control of air handling units;
- Modernization of schemes and backbones for the power supply of the MICC monitoring and control rooms on a new element base.

***2. Climate control system*.**

The MICC existing refrigeration equipment is a complex of interconnected installations of various air and liquid cooling schemes, with the help of which the corresponding temperature regime ensuring the MICC functioning in a 24x7x365 mode is created. The development and modernization of the climate control system will rely on novel technological solutions applied in modern computing centers to create a required microclimate inside the building and should satisfy the needs of the development of all MICC components.

The further development of the climate control system is connected with the creation of a centralized cooling system with dry (for the winter period) and wet (for the summer period) cooling towers in the 134 LIT JINR building with a capacity of up to 1.8 mW and a possibility of extension up to 3 mW. The implementation of the MICC climate control system will ensure the connection of the refrigeration equipment of any type and principle of operation, including energy-efficient cooling systems with free cooling, which, with proper design and setup, allow increasing the energy efficiency of the computing complex and reducing costs of energy supply.

To satisfy the growing needs of all MICC components, it is planned:

— to introduce a centralized system for cooling and ventilation of the machine halls on the 2nd and 4th floors;
— to create climate control systems with cold, warm and hot corridors in the hall of the 2nd floor;
— to install external cooling towers and organize a two-circuit cooling system;
— to install four new modules in the machine hall of the 2nd floor;
— to expand the hot water cooling system of the GOVORUN supercomputer to 600 kW.

The planned extension of power consumption and cooling supply is shown in Table 2.

Table 2.

	2020	**2021**	**2022**	**2023**
Power consumption	500 kVA	600 kVA	800 kVA	1000 kVA
Cooling system	300 kW	500 kW	650 kW	800 kW

The modernization of the fire safety complex, the automated system of dispatching and management of the engineering infrastructure is also planned in 2020-2023.

III. Off-line NICA cluster within MICC

The computing for the NICA megaproject should provide data acquisition from detectors and data transmission for processing and analysis. To perform the given tasks, computing has certain requirements including requirements to the network infrastructure, computing architectures, storage systems as well as appropriate software of the system and for data processing and analysis. Developed computing models should take into account the trends in the development of network solutions, computing architectures and IT-solutions, which allow combining supercomputer (heterogeneous), grid and cloud technologies and creating distributed, software-configured HPC platforms on its basis.

One of the uppermost components of the NICA computing complex is the computer network combining clusters and servers inside clusters into a unified computing infrastructure of the complex.

The distributed information and computing cluster of the NICA complex in its basic configuration should provide the processing and storage of up to 10 petabytes of data per year. The complex consists of territorially distributed on-line and three off-line clusters (Off-line cluster 216, Off-line cluster «NICA center», LIT Off-line cluster). Thus, as all large-scale centers of experimental data processing and storage, the computing complex is territorially distributed and combines all the components located in VBLHEP and DLNP in a unified high-speed local multi-site computer network with 4 x 100 Gbps.

The network equipment of the central telecommunication node, i.e. the core of the switching and routing system of on-line and off-line clusters, is located in two JINR sites and implemented on four multifunctional switches Cisco Nexus 9504 with the full-mesh topology for maximum reliability and performance.

The main task of the LIT off-line cluster is the creation of a two-level (disk-tape) storage system for NICA experiments, as after the first stage of these experiments, significant storage volumes will be required (from 2,5 PB to 70 PB per year).

One of the key components of the computer unit of the project “NICA Complex” is a cluster file system. At present, several cluster file systems are used, namely GPFS, Lustre, dCache, Ceph, EOS, GlusterFS, etc. The most appropriate one for on-line and off-line clusters is the EOS file system. EOS is a distributed, parallel, linearly scalable file system with the opportunity to protect it from failures.

Special attention is paid to novel perspective directions in creating distributed data storages (Data Lake), integrating Big data and supercomputer technologies, methods of machine learning.

The implementation of various computing models of the NICA megaproject requires confirmation of the model’s performance, i.e. meeting the requirements for temporal characteristics of data acquisition from detectors with their subsequent transfer to processing, analysis and storage, as well as the requirements for the effectiveness of modeling and processing of events in the experiment. For these purposes, it is necessary to carry out tests in a real software and hardware environment, which should contain all required components. The GOVORUN supercomputer, commissioned in LIT, can become such an environment; it contains the latest computing resources and data storage resources including the ultrafast data storage system, which provides a high speed of data acquisition up to hundreds of gigabytes per second with the possibility of a linear extension of performance and capacity of the system.

Table 3 illustrates the data on the main subsystems of the NICA complex (event size, transmission rate and total data volume per day) used to calculate the major characteristics of the computing unit of the NICA complex.

Table 3.

Subsystems of the NICA complex	Data acquisition rate (GB/s)	Event generation rate (kHz)	Size of the event (MB)	Total size of events per second (GB/s)	Average data transfer rate (Gb/s)	Data volume per 24 hours (TB/24 hours)
Accelerators						
2019 - 2020	0,5				0,1	4
>2020	1,5				0,3	10
BM@N						
2019-2020		30	0,5	15	20	100
>2020		50	0,7	35	100	300
MPD						
2021-2022		0,1	1	0,1	10	200
>2022		6	2	12	100	600
SPD						
>2023		50	0.5	25	100	1000

IV. Information and computing environment for neutrino experiments with the JINR participation

To effectively use resources of the information and computing environment of neutrino experiments, in which JINR employees participate, a decision on the creation of a unified neutrino

information and computing platform (environment) based on the MICC resources was made by the directorate of LIT and DLNP.

At present and over the next several years, the following neutrino scientific experiments with the JINR participation require storage resources and computing powers: Baikal-GVD, JUNO, NOvA.

1. Baikal-GVD

The Baikal-GVD experiment uses the JINR cloud infrastructure resources for performing calculations as well as for data storage.

According to the experiment program, it is planned to increase the amount of cloud resources by 300 CPU cores, 3000 GB of RAM and 200 TB of disk space per year. The total expected amount of resources of the experiment by year is presented in Table 4.

Table 4.

	2020	**2021**	**2022**	**2023**
Total number of cores	684	984	1284	1584
Total RAM volume, TB	6.75	9.75	12.75	15.75
Disk space, TB	400	600	800	1000

2. JUNO

In frames of the JUNO experiment, after the launch of the installation, primary data in the amount of 2 PB/year are expected. The experiment is scheduled for 20 years. Accordingly, the total amount of raw data at the end of the JUNO operation is estimated at 40 PB, which will be permanently stored on tape drives.

In frames of the JUNO collaboration, it was agreed that raw data would be stored at least in two data centers, namely one in China (IHEP) and one in Europe. It is planned to use the LHCONE infrastructure for transmission. It is expected to store one full copy of raw data in the JINR MICC.

Apart from raw data stored on tape drives, it is necessary to provide disk storage used in data processing. The estimated volumes by data type are presented in Table 5.

Table 5.

	Required volume, TB		
Data type	Permanent part	For every year	Total (for 20 years)
Reconstruction from raw data		10	200
Calibration data		1	20
MC simulation		150	3000
Data analysis	100		100
Total	100	161	3500

The needs of the JUNO experiment in computing resources are estimated at 12000 CPU cores, which will be used for uninterrupted raw data processing and modeling as well as for analysis. The JINR preliminary contribution to the end of the experiment is estimated at 4000 CPU cores. The total expected amount of the experiment resources by year is shown in Table 6.

Table 6.

	2020	**2021**	**2022**	**2023**
Total number of cores	2096	3096	4096	5096

Total RAM volume, TB	32.5	48.5	64.5	80.5
Disk space, PB	1.13	1.63	2.13	2.63
Capacity of tape storage, PB	0	4	6	8
Disk space for tape storage cache, PB	0	0.4	0.6	0.8

3. NOvA

For several years the NOvA experiment has successfully used the JINR cloud infrastructure resources for calculations as well as for data dCache-based storage.

The local group of the experiment plans to increase the amount of cloud resources by 120 CPU cores, 640 GB of RAM and 100 TB of disk space per year. The total expected amount of resources of the experiment by year is presented in Table 7.

Table 7.

	2020	**2021**	**2022**	**2023**
Total number of cores	660	780	900	1030
Total RAM volume, TB	3.14	3.78	4.42	5.06
Disk space, TB	388	488	588	688

V. Development of the MICC grid component Tier1 of the CMS experiment and the MICC integral component Tier2/CICC

The grid center resources of the JINR MICC are part of the global grid infrastructure WLCG (Worldwide LHC Computing Grid), developed for the LHC experiments. JINR LIT actively participates in the WLCG global project, which aims at providing distributed computing resources for annual data processing, storage and analysis. About 30 PB of raw data is acquired by the LHC experiments, the volume of processed data is significantly higher. The work on the use of the grid infrastructure in frames on the WLCG project is carried out in cooperation with the collaborations such as CMS, ATLAS, ALICE and major international centers, which operate as Tier1 centers of the CMS experiment (CH-CERN, DE-KIT, ES-PIC, FR-CCIN2P3, IT-INFN-CNAF, US-FNAL-CMS) and as Tier2 grid centers located in more than 170 computing centers of 42 countries worldwide. Since the beginning of 2015, a full-scale WLCG Tier1 site for the CMS experiment at the LHC has been operating in JINR LIT. The importance of developing, upgrading and expanding the computing performance and data storage systems of the center is dictated by the research program of the CMS experiment, in which JINR physicists take an active part in frames of the RDMS CMS collaboration.

In terms of hardware, a linear increase in the characteristics of Tier1, Tier2/CICC is planned in accordance with the figures in the Seven-Year Plan for the JINR development in the direction “Information technologies”. The fulfillment of the seven-year plan figures will ensure the required level of resources for all LHC collaborations at Tier1 and Tier2 in JINR due to the planned Run3 at the LHC.

In frames of the project implementation it is planned to increase the information storage capacity on the EOS system, which was put into operation at the beginning of 2019. This system should become the major one for all MICC components, and later for all JINR computing resources.

The development of the data storage system on robot tape libraries is also planned. In 2020-2021 it is planned to create a tape library for the NICA experiments and other user groups. In this regard, the update of the existing tape library IBM TS3500 to the TS4500 with an increase in its capacity up to 30-40 PB is planned in 2022-2023.

Table 8 illustrates the planned amount of resources by year.

Table 8.

	2020	2021	2022	2023
Tier1 CPU, kHS06	200	240	300	350
Tier1 disk, PB	8.8	10.88	13.1	16.1
Tier1 MSS, PB	25	30	35	42
Tier2 CPU, kHS06	110	130	150	170
Tier2 disk, PB	4.3	4.6	4.7	5
EOS ALICE, PB	1.2	1.4	1.8	2
EOS MICC, PB	10	30	50	60
MSS/MICC, PB	10	20	30	40

A transfer to new software, in particular, to new batch processing systems and job schedulers, i.e. HTCondor and Slurm, will be carried out on the MICC Tier1 and Tier2/CICC computing components. A unified system of access to software CVMFS will be further developed. CVMFS is regarded as a unified universal system of access to different software installed on one server and available on all interactive and computing machines of the MICC and JINR.

VI. Development of the JINR cloud infrastructure

As the resource base of the JINR cloud develops, its computing resources and storage disk space are planned to be provided to individual JINR users as well as to various scientific projects, for which JINR has certain obligations. A significant increase in the demand for cloud resources is expected from neutrino experiments (NOvA, JUNO, Daya Bay, Baikal-GVD, etc.). The transition of users of the mentioned above experiments to the use of centralized cloud resources will eliminate the need for local scientific groups to independently support computing resources and data storages, and they will be able to fully concentrate on their research.

Table 9 shows the approximate amount of resources that are planned to be purchased on the budget of the Laboratory of Information Technologies by the end of each year.

Table 9.

	2020	2021	2022	2023
Total number of cores	2000	2400	2800	3200
Total RAM volume, TB	10	12	14	16
Disk space capacity, PB	1.5	2	2.5	3

VII. Extension of the HybriLIT heterogeneous platform including the GOVORUN supercomputer

The development of the HybriLIT heterogeneous platform will be carried out both in terms of expanding computing resources of the GOVORUN supercomputer and in terms of developing the services deployed on the platform.

The first direction is related to the increasing demands of JINR users, particularly in the field of theoretical studies within quantum chromodynamics on lattices, and the satisfaction of user requests from the JINR Member States as well as the growing involvement of the supercomputer into the implementation of the leading JINR projects, namely the NICA megaproject and the neutrino program. Expanding the computing power of the supercomputer will be performed both by increasing the number of nodes of the CPU-component implemented on the basis of liquid cooling and by increasing the number of graphics accelerators of calculations from Nvidia, taking into account the development of computing architectures. The total increase in the performance of the CPU- and GPU-components will amount to 90 Tflops for double-precision operations per year. The planned increase in the performance of the GOVORUN supercomputer by components is presented in Table 10.

Table 10.

HybriLIT heterogeneous platform. GOVORUN supercomputer.	**2020**	**2021**	**2022**	**2023**
Performance of the CPU-component (Tflops, for double-precision operations)	260	320	380	450
Performance of the GPU-component (Tflops, for double-precision operations)	330	360	390	420
Total performance of the supercomputer (Tflops, for double-precision operations)	590	680	770	870

The second direction is associated with the development of software and information services providing to users of the heterogeneous platform. In particular, it is planned:

— to develop an ecosystem for tasks of ML/DL and big data analysis, which is primarily aimed at solving problems of fast recognition of multiple tracks in particle physics experiments, including the NICA megaproject and neutrino experiments;

— to develop the HLIT-VDI service designed for calculations in frames of the packages of applied programs with a developed graphics interface such as Maple, Mathematica, Matlab, COMSOL Multiphysics, FLUKA, etc., which are actively used by the Institute Laboratories;

— to introduce and develop the service “My account”, providing users with information on the system operation, the statistics on the use of the platform resources for all components, etc., as well as the opportunity to create requests on solving different types of problems appearing during the work.

VIII. Data storage system (JINR Data Lake)

The uppermost direction in the MICC development plan is the modernization of data storage systems. In 2020-2023 a significant increase in the amount of information is expected, which is needed to be stored and processed and the volumes of which were not entirely clear when forming the Seven-Year Plan for the development of JINR for 2017-2023. At the same time, it is very difficult to evaluate the requirements to storage systems due to the evolution of data and processing models. However, the following requirements should be met:

- to provide a sufficient resource for storage and fast access to the information during processing;
- to provide a constantly expanding resource for long-term data storage. The volume and speed of its enlargement should be balanced with the flow of information for long-term storage;
- to provide the ability to use a data management system that automates the processes of interaction with storage systems;
- to automate support for the storage system to optimize and minimize costs.

One of the options for developing Tier1 and Tier2 storages is to consolidate and import local installations of WLCG sites into a “Data Lake”; such projects are already under development and testing in WLCG. It does not mean that a constant expansion of the resources of certain WLCG sites is not needed, but it may smooth an unsteady increase in resources of various organizations.

Taking into account the forecast of volume changes for storages of WLCG, NICA and other virtual organizations, the implementation of the following works is planned:

— to expand storage capacities for the CMS experiment up to 20-30 PB on tapes and 15-20 PB on disks by 2023;

— to increase the storage capacity for ALICE in 1,5-2 times;

— to replace dCache Tier2/CICC with EOS/MICC and transfer the data of WLCG virtual organizations, NICA, JUNO, BES, etc., as well as local users and user groups into EOS/MICC, which will reduce costs and efforts to support large data storages at LIT and JINR;

— to extent the Tier2 storage up to 4-5 PB by 2023.

The planned increase in the MICC storage capacities is presented in Table 11.

Table 11.

Name	Volume of disk pools, PB	To what extent the expansion will be, PB	Volume of tapes, PB	To what extent the expansion will be, PB
T1 Buffer	1	2-3	8	40
T1 DISK	8.3	15-20	-	
T2	2	7	-	
T2/CICC	0.14	Transfer in EOS/MICC	-	
EOS/MICC	4	60		
NICA tapes	0		0	30
Cloud	1.0	2.5	-	-
HybriLIT	0.05	0.5	-	-

Apart from expanding the storage system resources, it is planned:

- to constantly develop software during the planning period;
- to constantly support dCache and transfer to new versions of Enstore;
- to fully authorize access to storages in frames of JINR including the NICA storage at VBLHEP;
- to introduce EOS/MICC into WLCG as an opportunistic data storage.

IX. Development of the MICC unified resource management system

At present, the MICC consists of various computing and data storage resources. A natural heterogeneity of the given systems complicates the process of their effective operation. The concept of operation in this context includes the use of resources by users, support, monitoring and resource management by LIT.

The main objectives of a unified resource management system are:

- to provide the ability to process large amounts of data;
- to provide the possibility to organize massive computing tasks;
- to optimize the efficiency of the use of computing and storage resources;
- to effectively monitor the resource loading;
- to consolidate the accounting for the use of resources;
- to provide a unified interface of access to resources.

A unified resource management system is multicomponent. Some of the components, such as management systems of tasks, jobs and data, information systems, authentication and authorization systems, are autonomous systems, which can be used separately. The other components, such as a monitoring system, an accounting system, a management service for configurations of working nodes and servers, a service of deployment of applied software, are auxiliary. The creation of a unified resource management system of the JINR MICC does not presuppose the development of all components “from scatch”; it implies the integration and, if necessary, the refinement of the existing systems. The implementation and development of the unified management system will significantly increase the efficiency of the MICC resources.

X. Development of a unified data flow management system

Dozens of physical experiments are conducted at JINR, each of which creates and supports its own computing infrastructure or uses the existing IT-infrastructure of JINR and its Member States. LIT provides experiments with a wide range of IT-services for computing: computing powers,

services of storage, authentication and authorization, etc.; it plans to ensure a unified user and software interface to computing and storage resources, but it does not offer ready-made solutions for the organization of the processing model. Along with this, it is planned to develop and implement a unified data flow management system, which should provide:

- the ability to ensure an isolated interface for each experiment;
- the possibility to form a chain of data processing in accordance with the experiment computing model;
- processing on available computing resources.

The system consists of:

- an interface for the formation of jobs, chains and groups of jobs;
- a database for storing job definitions;
- a job generation system based on certain parameters, the preparation of input data through the data management system of the MICC unified resource management system, the selection of suitable computing resources, sending jobs to the load management system of the MICC unified resource management system and ensuring control over their implementation.

A unified data processing management system will simplify the process of launching the processing of data from new experiments, optimize the use of existing computing resources and ensure a cardinally new level of service. For LIT such a system will allow increasing the efficiency of the use of computing resources due to a better forecast of data flows.

XI. Development of the monitoring systems of MICC LIT JINR

The MICC further development is determined by the development of the level of services it provides. To maintain the level of quality of the provided services, an organization of functional and service monitoring is required. The present project encompasses the further development of the monitoring system and its expansion to an information and analytics system of monitoring, the diagnosis of system components and the determination of emergencies. In case of malfunctions, the elaborated system should retain all the information necessary to identify an emergency.
In frames of the monitoring system development, it is planned:

— to add the parameters of the JINR LIT external engineering infrastructure, including the following components: diesel generators, cooling towers, external elements of the cooling system, into the monitoring system;
— to incorporate new nodes of the computing infrastructure of Tier1, Tier2, CICC, the GOVORUN supercomputer and the MICC storage system elements in the monitoring system;
— to develop additional tools for analysis and visualization based on Graphana;
— to create an algorithm to ensure the fault tolerance of the main node of the monitoring system;
— to develop new technological approaches for monitoring, analysis and optimization of distributed computer systems of data processing for large-scale scientific experiments based on the Big Data technology;
— to create the JINR MICC intelligent monitoring in frames of the complex operation in the WLCG distributed environment (in particular, the Tier2 and CMS Tier1 infrastructures), which will allow detecting and predicting problems in the operation of basic services, equipment and engineering systems.

XII. Provision of information security

The tendency of threats to information security revealed the need for creating a new class of information security systems. In this regard, it is necessary to elaborate solutions allowing one to form and ensure information security policies for the work of IT-administrators, audits and users of JINR corporate information systems. The given solutions should help to follow IT-security

requirements protecting private personal data. Currently, the JINR information security system is built on the Intrusion Detection Systems (IDS) technology. Due to the growing number of threads to information security, the system needs to be upgraded. To increase the efficiency of the system it is planned:

- to introduce a system service for the analysis of DPI data packages using a specialized gateway;
- to adapt the 6-tier structure of information security control at JINR diversified to:

1) available public network,
2) networks of computing complexes such as Tier-1, Tier-2, MICC, NICA,
3) JINR Management network,
4) access control network,
5) networks of research physical installations,
6) particularly important networks (IBR, NICA, etc.).

Functional capabilities of the upgraded security system should include the following components:

— centralized access control in real time;
— account management (including on target devices);
— providing a single entry point in the system Single Sign-On (SSO);
— activity tracking and record of sessions (such as RDP, SSH, Telnet, VNC, etc.);
— generating statistics and reports on user actions.

Information and software environment for the research and production activities of JINR

One of the major goals of the theme is the implementation and development of the JINR corporate information system (CIS). In frames of this direction, support and further development of the following information services and systems will be provided:

— 1C:ERP providing the solution to the problems of accounting and management accounting, payroll, personnel records;
— ADB2, a management accounting system;
— electronic document system EDS “Dubna”;
— information search system (ISS) providing various reports on personnel and financial information;
— “Document Base”, a system of electronic signing, storage and search of documents of the JINR main office administration as well as documents of MES&CC (Management of Economic Services and Capital Construction) and PLS (Procurement and Logistics Service);
— Personal Information System (PIN), a system for storing and managing data on the results of research activities of JINR employees.

The development of information systems and services will be performed taking into account the requests of end users and the recommendations of the coordination group on the development of databases, electronic document management and information security, with the concept of the cloud SaaS platform of a unified administrative and business information system.

It is also planned to develop a personnel information and analytics system for recording the participation of JINR employees in projects and themes.

In frames of the development of CIS, the work on upgrading the information system JINR Document Server (JDS) based on the Invenio JOIN2 (Just anOther INvenio INstance) platform will be in progress. In particular, it is planned:

— to unify metadata formats;
— to update the software platform on a regular basis;
— to develop the project technical documentation;
— to develop the functionality of the JOIN2 software platform: participation in the back-end and front-end development;

— to support the collections Authorities.

In frames of this direction, it is also planned to maintain and develop the JINRLIB program libraries, including the filling with parallel implementations of programs to perform calculations on hybrid computing architectures, the creation of interfaces in C/C++, Python for the programs developed earlier in FORTRAN to allow launching them on modern computing architectures.

Development of the system for training and retraining IT-specialists on the basis of the JINR MICC and its educational components

This section of the theme is aimed at creating a system for training and retraining IT-specialists based on the MICC cloud, heterogeneous and grid infrastructures. In particular, the education and testing polygon of the HybriLIT platform is used for training students, post-graduate students and young scientists in parallel programming technologies to develop programs allowing to perform calculations on hybrid computing architectures, in modern tools for development, debugging and profiling of parallel applications, tools and frameworks for solving problems of machine and deep learning, data analysis, as well as in the usage of specialized software packages for solving problems that require massive parallel calculations in physics, biophysics, etc.

Special attention in training courses will be given to the directions of IT-specialists' training for solving tasks related to data processing and analysis for experiments of megascience projects including the NICA project.

In the framework of this theme section, the organization and realization of the following training courses are planned:

— regular courses on modern IT-technologies both for the Institute staff and students and young scientists from the JINR Member States in frames of practices organized by the UC (JINR University Centre);
— special courses from leading software developers;
— special courses and seminars in frames of conferences and schools organized by JINR;
— special courses organized in the JINR Member States in frames of international cooperation programs.

Results expected upon completion of the theme:

1. Project of the MICC development:

— development of the MICC network and information and computing infrastructure to provide the implementation of the Seven-Year Plan for the development of JINR with necessary means of state-of-the-art information technologies, as well as creation of a unified space of the JINR existing resources: computing, information and data storage ones;
— development of external and local network infrastructures providing the possibility of data exchange between the Institute subdivisions, the JINR Member States and international organizations cooperating with JINR; creation of a network infrastructure for acquiring and transmitting data between the facilities BM@N, MPD, SPD and on/off-line clusters of the NICA megaproject; maintenance and development of general network services such as e-Mail, name management (DNS), data caching (Proxy), resource management (IPDB), monitoring (NMIS), Service of Single Sign-On (SSO), Information security system;
— modernization and development of the MICC engineering infrastructure including uninterruptible power supply systems, air-conditioning and ventilation systems, of the fire safety complex to ensure all components of the Complex in accordance with the increase in computing powers and data storage volumes;
— creation of the off-line cluster based on the MICC in frames of the development of computing for the NICA megaproject providing data acquisition from detectors and data transmission for processing and analysis and satisfying all the requirements to the network infrastructure, computing architectures, storage systems as well as appropriate software;

— creation of a unified information and computing platform (environment) based on the MICC resources to implement the JINR neutrino program;
— extension of computing resources and data storage systems of the MICC Tier1 grid component, Tier2/CICC in accordance with the figures in the Seven-Year Plan for the JINR development in the direction “Information technologies”, which will ensure the required level of resources for all LHC collaborations at Tier1 and Tier2 in JINR due to the planned Run3 at the LHC;
— transfer to new software, in particular, to new batch processing systems and job schedulers, HTCondor and Slurm, as well as to a unified system of access to software CVMFS;
— expansion of the MICC cloud component in order to enlarge a range of services provided to users, creation of an integrated cloud environment with clouds of the JINR Member States;
— extension of computing resources of the GOVORUN supercomputer to satisfy the needs of JINR users and its Member States in computing resources to solve challenges facing the Institute; provision of users with modern IT-solutions and services in the field of HPC;
— creation of the JINR “Data Lake” based on the MICC storage systems;
— creation and implementation of the MICC unified resource management system optimizing the efficiency of using computing and data storage resources of the Complex;
— development and implementation of a unified data flow management system, which will simplify the process of launching the processing of data from new experiments and optimize the use of existing computing resources due to a better forecast of data flows;
— creation of an information and analytics intelligent system of monitoring with the use of novel technological approaches, including Big data analytics, which allows aggregating information from various levels of the computing center, i.e. engineering infrastructure, network, computing nodes, job launching systems, data storage elements, grid services, etc., which will ensure a high level of the MICC reliability;
— upgrade of the information security system.

2. Maintenance and further development of the JINR integrated corporate information system (CIS) including subsystems of accounting, financial and personnel records, electronic document management, interconnected through a universal data exchange gateway and providing access to reliable management information. Development of the NICA project management information system. Upgrade of the PIN subsystem. Implementation of the system “My account” providing the end user with access to his personal information and simplifying access to JINR CIS. Development of electronic libraries and video portals.
3. Creation of a special polygon based on the MICC and a developed ecosystem for training IT-specialists capable of solving tasks in projects underway at JINR, the projects of a megascience level including the NICA megaproject, the neutrino program, etc.

Participants from JINR

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Participating countries, institutes and organizations

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Azerbaijan	Baku	IP ANAS	Mamedov N.T. + 5 pns.	Collaboration
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		SU	Dimitrov V.	Collaboration
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Georgia	Tbilisi	GTU	Prangishvili A.	Protocol
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		NU	Mazhitov M.I.	Protocol
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		IAP ASM	Baznat M.I.	Protocol
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	Pereslavl-Zalessky	PSI RAS	Abramov S.M.	Collaboration
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	Presov	PU	Stevko R.	Protocol
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Ukraine	Kiev	BITP NASU	Zagorodniy A.G., Zinoviev G.M., Svistunov S.Ya.	Collaboration
	Kharkov	NTUU KPI	Levchuk L.G.	Collaboration
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	Arlington	UTA	De K.	Collaboration
	Batavia	Fermilab	Rosen R., Holtzman B.	Collaboration

Time frame of the theme 2020-2023

Total estimated cost of the theme

№№	Activities	Total cost	Costs per years (thousand USD)			
			1st year	2nd year	3rd year	4th year
1.	Computer communication	110,0	20,0	30,0	30,0	30,0
2.	Travel expenses	535,2	133,8	133,8	133,8	133,8
3.	Materials	640,0	160,0	160,0	160,0	160,0
4.	Equipment	28582,3	6747,0	6990,3	7160,0	7685,0
5.	Payments for agreement-based research	100,0	25,0	25,0	25,0	25,0
6.	Licensed software	1400,0	300,0	300,0	400,0	400,0
7	Construction	1150,0	250,0	300,0	300,0	300,0
	Total	32517,5	7635,8	7939,1	8208,8	8733,8

Other financing sources: targeted funding, grants of plenipotentiaries, grants of RFBR, FTP, RSF, EU, etc.

Cost estimates for the theme

№№ of items	Budget items	Total 2020–2023	Including 2020
1	Funding on grants of RFBR, FTP, RSF, EU, etc.	126,4 k$	63,2 k$
	Total	126,4 k$	63,2 k$

AGREED:

JINR Chief Scientific Secretary

_____ / _____ /

"____" _____ 2019

Head of Planning and Finance Department

_____ / _____ /

"____" _____ 2019

Head of Science Organization Department

_____ / _____ /

"____" _____ 2019

Laboratory Director

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