**Ministry of Science and Higher Education
of the Russian Federation**

2022

ANNUAL REPORT

**St. Petersburg Federal Research Center
of the Russian Academy of Sciences**

**St. Petersburg
2022**

Ministry of Science and Higher Education
of the Russian Federation

ST. PETERSBURG FEDERAL RESEARCH CENTER
OF THE RUSSIAN ACADEMY OF SCIENCES
(SPC RAS)

ANNUAL REPORT

2022

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GENERAL INFORMATION

St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS) is established in accordance with the orders of The Ministry of Science and Higher Education of the Russian Federation of December 18, 2019 No. 1399 and of July 08, 2020 No. 768 (information about the organization is entered in the Unified State Register of Legal Entities (USRLE) by the Federal Tax Service on July 17, 2020 No. 2207803466891) through the reorganization of Federal State Institution of Science "St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences" (SPIIRAS) in a form of joining:

The Federal State Research Institution "North-West Research Institute of Agricultural Economics and Rural Development" (IAERD);

The Federal State Research Institution "North-West Centre of Interdisciplinary Researches of Problems of Food Maintenance" (N-W CIRPFM);

The Federal State Institution of Science "St. Petersburg Scientific Research Centre for Ecological Safety of the Russian Academy of Sciences" (SRCES RAS);

The Federal State Institution of Science "Institute of Limnology of the Russian Academy of Sciences" (IL RAS);

The Federal State Research Institution "Novgorod Scientific Research Agriculture Institute" (NSRAI – Branch of SPC RAS).

According to the Charter the SPC RAS (the SPIIRAS successor) was founded as Leningrad Research Computer Center of the USSR Academy of Sciences by the Decree of the Council of Ministers of the USSR of December 19, 1977 No. 2643-p and the Decision of the Presidium of the USSR Academy of Sciences of January 19, 1978 No. 194.

The scientific and methodological management of the SPC RAS activities is performed by RAS through: Department of Nanotechnologies and Information Technologies of RAS, Department of Earth Sciences of RAS, Department of Agricultural Sciences of RAS).

SPC RAS is headed by the Director: Andrey L. Ronzhin, Doctor of Technical Sciences, Professor, Professor of RAS, appointed by the Order of The Ministry of Science and Higher Education of the Russian Federation of July 18, 2018 No. 20-3/114 п-о

based on the Minutes of the labor collective General Meeting of March 23, 2018.
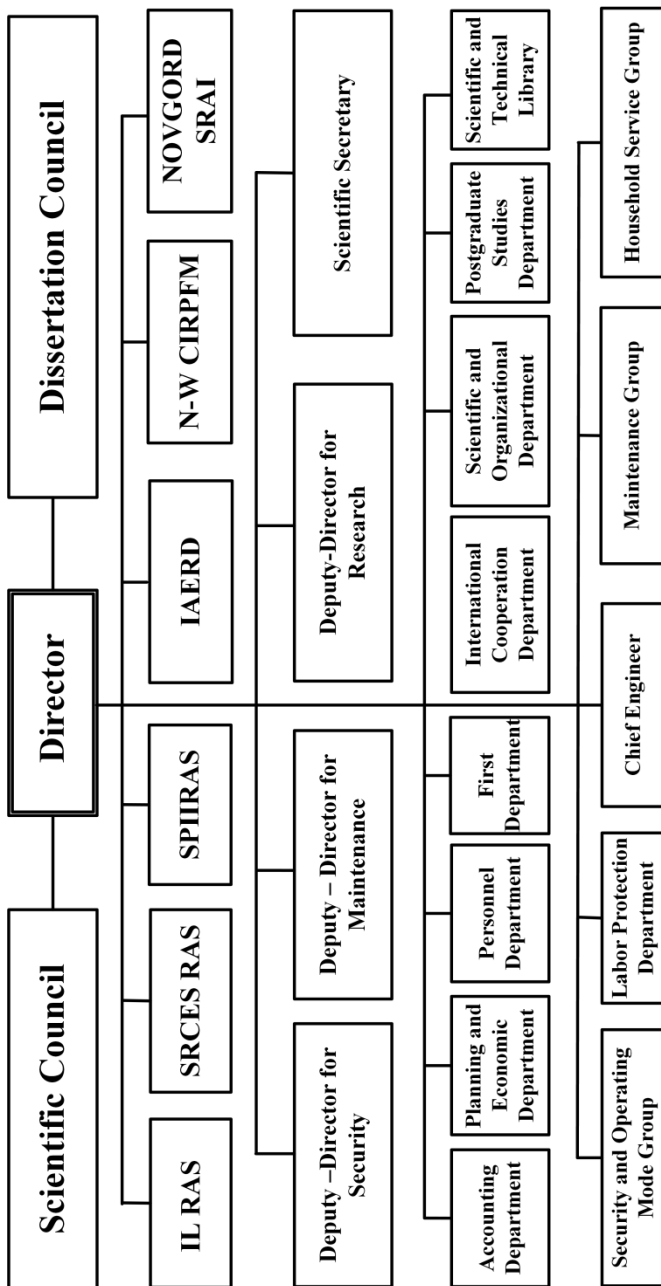
The Scientific Secretary of SPC RAS is Alexandra A. Zaitseva, Candidate of Technical Sciences.

The Deputy Director for Research is Sergey V. Kuleshov, Doctor of Technical Sciences.

The purpose and subject of SPC RAS activities are basic, exploratory and applied research aimed at acquiring new knowledge in computer science and automation, management methods and information and communication technologies, environmental safety, environmental protection, food security, economy and organization of the agro-industrial complex, contributing to its technological, economic and social development, implementation of scientific advancements and best practices, training of highly qualified professionals.

SPC RAS takes the experience and the heritage of united scientific organizations and successfully continues research aimed a developing and implementing strategic digital technologies and robotic systems designed to increase the efficiency of managing processes responsible for the socio-economic development of the North-West region of Russia, as well as ensuring security and enhancing the citizens' life quality.

Digitalization, ecology, agriculture form the core scientific research topics of the Center and correspond in importance to global trends. The institutes and centers involved in the SPC RAS establishing have a unique scientific groundworks, as well as human resources to implement the tasks of food, environmental and information security.

Scientific Council — **Director** — **Dissertation Council**

Director:
- IL RAS
- SRCES RAS
- SPIIRAS
- IAERD
- N-W CIRPFM
- NOVGORD SRAI

- Deputy –Director for Security
- Deputy – Director for Maintenance
- Deputy-Director for Research
- Scientific Secretary

Deputy-Director for Research:
- International Cooperation Department
- Scientific and Organizational Department
- Postgraduate Studies Department
- Scientific and Technical Library

- Accounting Department
- Planning and Economic Department
- Personnel Department
- First Department

- Chief Engineer

Chief Engineer:
- Security and Operating Mode Group
- Labor Protection Department
- Maintenance Group
- Household Service Group

Research activity

Basic, exploratory and applied research and developments are done in the following areas in accordance with the SPC RAS Charter:

– fundamentals of information society development and the digital economy in Russia;

– fundamentals of complex modeling, automation of proactive monitoring and management of information processes in complex (info-, bio-, eco-, agro-, cogni-, socio-, geo-, aviation-space and transport) systems;

– fundamental and technological basics of artificial intelligence, big data, development of intelligent integrated decision support systems, multi-modal user interfaces in human-machine and robotic complexes;

– basic and technological foundations of artificial intelligence, big data, development of intelligent integrated decision support systems, multimodal users' interfaces in human-machine and robotic complexes;

– fundamentals and technological basics of information and cyber security, post-quantum cryptosystems;

– fundamentals of rational use of the territories' agricultural resources potential, conservation and reproduction of biological diversity of agricultural animals and crops to ensure food and environmental security of the Russian Federation;

– fundamental and technological basics for optimization of reclamation systems, construction and reconstruction of reclamation facilities that ensure the preservation of natural resources potential and increase the productivity of agro-landscapes;

– fundamentals and technological models aimed at effective management of the agroecosystems' production process based on adaptation, environment formation and biologization;

– fundamental and technological basics at cultivating economically expedient agricultural crops in order to create highly productive agro-phytocenoses;

– fundamental and applied technological basics of agricultural production that meet the needs of various population groups in a balanced high-quality agricultural raw materials for high-quality food supplies production;

–   fundamental and applied basics of rational environmental management in the Arctic zone of the Russian Federation, given the first priority to production and consumption of locally produced food stuffs with a high level of environmental and biological safety;
–   fundamentals of innovative and investment development of agricultural sectors and enterprises;
–   fundamentals of integrative processes development in regional agro-industrial complexes;
–   fundamentals of rural territories development, land relations and land use in the economy agrarian sector;
–   fundamental ecology-economic and legal problems for ecological safety ensuring;
–   fundamentals of ecosystem health assessment and maintenance, methods for their state diagnostics and prompt warning an occurrence of threats to ecological safety;
–   fundamental and applied basics of transformation and migration of ecotoxicants in the environment;
–   basic and applied research of life cycles of natural and economic systems and objects of past environmental damage, methods and processes of rehabilitation of disturbed and polluted ecosystems and man-made landscapes, waste management systems;
–   basic research on the origin, evolution, functioning, sustainability, and lakes restoration in different physical and geographical zones;
–   development of the theory of eutrophication and pollution of internal water basins, formation of their water quality and scientific forecast of these processes based on long-term studies, accounting for natural, climatic and anthropogenic factors;
–   research fundamentals for assessing and forecasting trends in the natural resource potential of the Russian Lake Fund, its protection and rational use, accounting for the socio-economic regions' development;
–   basic and applied complex research of Lake Ladoga – the Neva river – the Gulf of Finland system as a geostrategic water object.

Within the Government Order approved by The Ministry of Science and Higher Education of the Russian Federation in 2022 SPC RAS worked on 17 State Budget tasks:

- Theoretical and technological basics of the digital transformation of society and the Russian economy (SPIIRAS).
- Development of basic theory and technology to analyse non-structured data and multimodal users' interaction, intelligent support for targeted collective behavior of participants in human-machine communities (SPIIRAS).
- Methodology and technologies of multi-criteria proactive life cycle management of available and prospective integrated state and commercial information management and telecommunication systems and networks (SPIIRAS).
- Theory of interaction between groups of heterogeneous robotic tools executing joint tasks via biosimilar self-learning systems for intelligent processing of large volumes of fuzzy information (SPIIRAS).
- Theoretical and technological basics for operational processing of large flows of heterogeneous data in socio-cyberphysical systems (SPIIRAS).
- Fundamental basics and practical applications of cybersecurity methods in critical infrastructures and development of post-quantum cryptosystems (SPIIRAS).
- Fundamental basics for development of the agro-industrial complex on the digital transformation of production and economic relations, refinment of spatial development, institutional environment and land relations in the North-West of the Russian Federation (IAERD).
- Development of basic, methodological and technological fundamentals for increasing agricultural production in the North-West and in the Arctic zone of the Russian Federation, ensuring food and environmental safety of the regions (N-W CIRPFM).
- Development of scientific basics for technological modernization of agricultural production in the Novgorod region, aimed at ensuring environmental and food security (Novgorod Research Agriculture Institute).
- Identification of new and insufficiently studied natural and anthropogenic ecotoxicants in environmental objects, study of their transformation mechanisms and impact on biota (SRCES RAS).

–   Study of the regularities of transformation against the cumulative technogenic background of natural and economic systems of the Gulf of Finland basin (SRCES RAS).
–   Ecological and economic and legal mechanism for minimizing transboundary environmental pollutions in the Baltic Sea region through the method of prevented environmental damage (SRCES RAS).
–   Scientific basics for assessing the ecosystems' health in the North-West of Russia and preventing threats to environmental safety (SRCES RAS).
–   Complex assessing of the ecosystems' dynamics of Lake Ladoga and its basin reservoirs under the impact of natural and anthropogenic factors (IL RAS).
–   Innovative approaches to the use and management of water ecosystem resources (IL RAS).
–   Development of complex methods for exploring and evaluating the characteristics of solid particles in the nanoscale size range in water bodies with different degrees of anthropogenic load (IL RAS).
–   Patterns of lakes' distribution across Eurasia and assessment of their water resources (IL RAS).

Research done in 2022 on 110 projects included: 19 projects – on the grants of the Russian Science Foundation, 21 – on the grants of Russsian Foundation for Basic Research; 6 – on the projects of Federal target programs and programs of the Russian ministries and services; 4 – on the project of MIC; 48 – on the projects of industrial enterprises; 10 – on the contracts with international partners.

The following organizations acted as customers: FSUE "State Research Institute of Applied Problems" (SRIAP); "SRI SS named after A.A. Maximov" – branch of FSUE "Khrunichev State Research and Production Space Center"; "Ecosystem" LLC; Kaliningrad State Technical University; RC Module; "R&D CIT "PETROCOMETA" JSC; ITMO University; "HUAWEI TECHNOLOGIES Co. LTD"; Festo SE & Co. KG; Hendrikson&Ko; "ACM Decisions" LLC; "Transoil" LLC; "SIRIUS" LLC; "Novbiotech" LLC; "Green City" JSC; Immanuel Kant Baltic Federal University (IKBFU); Leningrad Region FSI "Vyborg Animal Disease Control Station"; "Element" JSC; "SDB Orion" JSC; Dorodnicyn Computing Centre of the RAS (CC RAS); "Surgutneftegas" PJSC;

"RUFILMS INNIVATION" LLC; St. Petersburg State University (SPBU); Lobachevsky State University of Nizhni Novgorod – National Research University (UNN); "Innovative Technologies in Machin-building (ITM)" LLC; REMSTROY LLC; FSUE "CNIIHM"; "ITM Geyser" JSC; Environmental Management Agency; SPE GEOFIZIKA-COSMOS JSC; Institute for Analytical Instrumentation RAS (IAI RAS); "bcc" LLC; "SPRUT" LLC; "EMS-engineering" LLC; Secretariat of the IPA CIS Council; SGUE "SF Mineral" and other.

In 2022, 241 of the Center professionals attended 213 conferences, published over 830 scholarly articles, including:
– 78 publications indexed in the WoS system (of them 75 articles in professional journals, including 22 articles in Q1 journals);
– 282 publications indexed in the Scopus system (of them 161 articles in professional journals, including 50 articles in Q1 journals);
– 490 publications indexed in the RSCI system (of them 198 articles in professional journals included in the Higher Attestation Commission list, and 99 – in journals included in RSCI).

Some results of the SPC RAS intellectual activity in the year of 2022: 5 patents for inventions, 7 patents for utility models, 4 certificates of state registration of Databases and 29 certificates of state registration of computer programs.

During 2022 the Center contributed to the organization of 11 international scientific conferences, proceedings of 4 of them are indexed in the international databases WoS/Scopus.

The Center employs over 450 staff membes, including: 5 Honored Scientists of the Russian Federation, 3 Academicians of the Russian Academy of Sciences, 3 Corresponding members of the Russian Academy of Sciences, 2 Professors of the Russian Academy of Sciences, 56 doctors of sciences and 111 candidates of sciences.

Educational activity

SPC RAS has a right to maintain education activities as stipulated by the programs for training research as well as scientific and pedagogical personnel in postgraduate and continuous education according to a perpetual license (registration number L035-00115-78/00096292 dated 02.09.2020) issued by the Federal Service for Supervision of Education and Science and also has a perpetual state accreditation for education

activities in the areas of training and scientific specialities of graduate students:

Directions of training:

09.06.01 Computer Science and Engineering:

- direction "System analysis, control and information processing, statistics";
- direction "Mathematic- and software of computers, computer complexes and computer networks";

10.06.01 Information Security:

- direction "Methods and systems of information security, information assurance";

38.06.01 Economics:

- direction "Economics and national economy management":
  - o training profile – economy, organization and management of industries, complexes – agro-industrial complex and agriculture;
  - o training profile – regional economy.

Group of scientific specialities 2.3. Information technologies and telecommunications (by scientific specialities):

- 2.3.1. System analysis, control and information processing, statistics
- 2.3.5. Mathematic- and software of computers, computer complexes and computer networks
- 2.3.6. Methods and systems of information security, information assurance

Group of scientific specialities 5.2. Economics (by scientific speciality):

- 5.2.3. Regional and branch economics.

As of December 31, 2022, the post - graduate course counts 45 post graduate students.

Doctoral dissertation Council functions in specialities: 2.3.1. System analysis, control and information processing, statistics; 2.3.5. Mathematic- and software of computers, computer complexes and computer networks; 2.3.6. Methods and systems of information security, information assurance. In 2022 seven candidate theses in technical sciences have been defended.

SPC RAS administers five basic departments in the leading St. Petersburg universities as well as three joint research laboratories:

- Research Automation at *The St. Petersburg State Electrical Engineering University, established in 1979.*
- Distributed Intelligent Automation Systems at *The St. Petersburg State Polytechnic University, established in 2009.*
- Information Security at *The St. Petersburg State University of Transport Communications, established in 2010.*
- Information Systems and Technologies in Economics at *The St. Petersburg University of Economics, established in 2017.*
- Information Technologies in Logistics at *The St. Petersburg School of Economics and Management NRU HSE, established in 2018.*
  Laboratories:
- R&D Laboratory of Information Technologies in Transport Systems, Power Engineering, Automation and Modeling Systems *at Mari State Technical University, established in 2012.*
- Virtual Joint Laboratory at *The Military Teaching and Research Center of the RF Air Force "Military Air Force Academy", Voronezh, established in 2015.*
- Joint Research Laboratory for Robotic Systems' Design and Programming at *The St. Petersburg State University of Aerospace Instrumentation, establis*hed in 2016.

Sessions of the city seminar on "Informatics and Automation" at the Scientific Council for Informatization of St. Petersburg are regularly held by the Center under the leadership of Corresponding Member of RAS Yusupov, R.M. and Professor Osipov, V.Yu.

At the Center the SPIIRAS History Museum is established and maintained; the presented exhibits show the main directions of computer technologies development over preceding years. The history of Museum collection is inextricably linked with the history of establishing in 1974 the Computer Engineering Department at the Joffe Physical and Technical Institute (further LRCC, LIIAN, SPIIRAN and SPC RAS). The Center occupies the building that used to be the Carl May School premises with the current museum of the same name. Among the Carl May School alumni: 40 members of the Russian Academy of Sciences and the Academy of Fine Arts, 156 Full Professors, two ministers, seven governors, four members of the State Council, twenty generals and admirals, three Heroes of Socialist Labor, two pilot-cosmonauts (G.M. Grechko and A.I. Borisenko).

Using the Museums' factual database the SPC RAS staff members run enlightenment and educational activities at the secondary and higher schools of St. Petersburg promoting, at that, the best scientific, pedagogic, cultural and ethical traditions of the Russian education and science.

Publication activity

SPC RAS is a developer of an electronic editorial platform that provides automation of routine operations of publishers and editorial offices of scientific journals, transparency of the editorial process, generation of citation statistics and import/export of data to global indexes and aggregators of scientific information. In 2022, the platform hosted 4 journals: "Information and Control systems"; "Bulletin of Plant Protection", "Intelligent Technologies in Transport", "Informatics and Automation". SPC RAS co-founder of the journal "Izvestiya Russkogo Geograficheskogo Obshchestva".

Scientific Journal "Informatics and Automation"

Print media and online media – The journal "Informatics and Automation" (Proceedings of SPIIRAS) has been published since 2002, since 2016 is in the international database Scopus (CiteScoreTracker 2021: 2,1; SJR: 0,15), in the List of the Higher Attestation Commission since 2011, in RSCI since 2018, ISSN: 2713-3192, E-ISSN: 2713-3206. Subscription Index (Catalogue "Post of Russia"): P5513. Languages: Russian, English. Publication Frequency: 6 issues a year.

The journal main categories:
– Mathematical Modeling and Applied Mathematics.
– Artificial Intelligence, Data and Knowledge Engineering.
– Digital Information and Telecommunication Technologies.
– Robotics, Automation and Control Systems.
– Information Security.

In accordance with the nomenclature of scientific specialities approved by the Ministry of Education and Science of the Russian Federation through the order of February 24, 2021, No. 118 the journal publishes articles on the following specialties:

1.1.4. Probability theory and mathematical statistics (physical and mathematical sciences),

2.3.1. System analysis, management and information processing (technical sciences),

2.3.2. Computing systems and their elements (technical sciences),

2.3.5. Mathematical and software support of computer systems, complexes and computer networks (technical sciences),

2.3.6. Methods and systems of information protection, information security (technical sciences).

In the rating of the RSCI for 2022: the journal ranks 28th in the overall rating; 1st places on the topic "Automation. Computer Engineering"; "Cybernetics"; "Mathematics".

Full-text versions of the articles are available on the journal's website: http://ia.spcras.ru.

Profile of the journal Informatics and Automation in Scopus: https://www.scopus.com/sourceid/21100793186.

Scientific journal "Russian Geographical Society News"

Print media and electronic media – Journal "Izvestiya Russkogo Geograficheskogo Obshchestva" is published since 1865, in the List of the Higher Attestation Commission (VAK), indexed in the core of RSCI, ISSN: 2079-9705, E-ISSN: 2079-9713. Language: Russian. Publication frequency: 6 issues a year. The journal publishes articles on the speciality: 39.00.00 Geography.

The journal articles are available on the website of the Russian Geographical Society: https://www.rgo.ru/ru/obshchestvo/periodicheskie-izdaniya-rgo/zhurnal-izvestiya-rgo.

Conferences organized in 2022

– XVII All-Russian Scientific and Practical Conference "Prospective Systems and Management Tasks", April 4-8, 2022, Dombaj (Russia), *(Yusupov, R.M., Ronzhin, A.L.)*

– III All-Russian Conference attended by young scientists "Advanced Tendencies in Development of Chemical Technology, Industrial Ecology and Ecological Safety", April 7-8, 2022, St. Petersburg (Russia), *(Tronin, A.A.)*

– Second International Conference on Agriculture Digitalization and Organic Production (ADOP – 2022), June 06-08, 2022, St. Petersburg (Russia), http://adop.nw.ru. (Scopus, Springer, SIST, Q4) (*Kostyaev, A.I., Surovtsev, V.N., Ronzhin, A.L.)*

- VIII Interregional Theoretical and Practical Conference: "Advanced Lines of Development in National Information Technologies", September 20-24, 2022, Sevastopol, Crimea (Russia), http://pnroit.code-bit.com, *(Yusupov, R.M., Kasatkin, V.V.)*
  - 6th Conference "Information Technologies in Control" (ITC-2022) within the 15-th Russian Multiconference on Control Problems (RMCCP-2022), October 04-06, 2022 St. Petersburg (Russia), https://itc.etu.ru/2022/ru/, *(Yusupov, R.M., Fedorchenko, L.N.)*
  - XVIII St. Petersburg International Conference "Regional Informatics (RI-2022)", October 04-06, 2022, St. Petersburg (Russia), http://spoisu.ru, (*Yusupov, R.M, Kasatkin, V.V.*)
  - 8th International Scientific and Practical Conference "Technological Perspective: New Markets and Points of Economic Growth" (Technoperspective 2022), November 10-11, 2022, St. Petersburg (Russia), http://technoperspective.org/, *(Kuleshov, S.V.)*
  - 24-th International Conference "Speech and Computer" (SPECOM-2022), November 14-16, 2022, Gurugram (India), https://www.specom.co.in/, (Scopus, Springer LNCS/LNAI Q2, in a list of top conferences Research.com*) (Karpov, A.A.*)
- IV International conference "Piotrowski's Readings in Language Engineering and Applied Linguistics", November 22, 2022, St. Petersburg (Russia) (*Ronzhin, A.L.)*
- VII International Conference "Interactive Collaborative Robotics" (ICR-2022), December 16-18, 2022, Fuzhou, Jiangxi. (China), (Scopus, Springer LNCS/LNAI, Q3) (*Ronzhin, A.L.*)

Conferences to be organized in 2023
- XVIII All-Russian Scientific and Practical Conference "Prospective Systems and Management Tasks", April 3-7, 2023, Dombaj, Karachay-Cherkess Republic (Russia), https://psct.ru/, *(Yusupov, R.M., Ronzhin, A.L.*)
- Third International Conference on Agriculture Digitalization and Organic Production **(**ADOP – 2023), June 05-07, 2023, St. Petersburg (Russia), http://adop.nw.ru, (Scopus, Springer, SIST, Q4). (*Kostyaev, A.I., Surovtsev, V.N., Ronzhin, A.L.)*
- Seventh International Theoretical and Practical Conference "Simulation and Complex Modeling in Marine Technology and

Maritime Transport Systems" (SCM MTMTS-2023) withint the International Marine Defence Show "IMDS 2023", June 22, 2023, St. Petersburg, Kronstadt (Russia), https://www.fleet-expo.ru/, http://simulation.su/, *(Yusupov, R.M., Sokolov, B.V.)*

- 10-th Interdisciplinary Workshop "Analysis of Spoken Russian" AP3-2023, June 29-30, 2023, St. Petersburg (Russia), https://phonetics.spbu.ru/novosti/12-q-seminar-ar3.html, (*Karpov, A.A.*)
- IX Interregional Theoretical and Practical Conference: "Advanced Lines of Development in National Information Technologies", September 19-23, 2023, Sevastopol, Crimea (Russia), http://pnroit.code-bit.com, (RSCI), *(Yusupov, R.M., Sokolov, B.V., Kasatkin, V.V.)*
- 7th International Scientific Conference "Intelligent Information Technologies in Engineering and Production" (IITI'23), September 25-30, 2023, St. Petersburg (Russia), http://rgups.ru:85/frontend, (*Ronzhin, A.L., Kotenko, I.V.)*
- 11th All-Russian Theoretical and Practical Conference: "Simulation. Theory and Practice" (IMMOD-2023), October 18-20, 22, 2023, Kazan (Russia) http://simulation.su/static/ru-immod-2023.html (RSCI), (*Ronzhin, A.L., Yusupov, R.M., Sokolov, B.V.)*
- XIII St. Petersburg Interregional Conference "Information Security of the Russian Regions (ISRR-2023)", October 25-27, 2023, St. Petersburg (Russia), http://spoisu.ru/conf/ibrr2023 (RSCI) *(Yusupov, R.M., Sokolov, B.V., Kasatkin, V.V.)*
- 25-th International Conference "Speech and Computer" (SPECOM-2023), October, 2023, https://specom.nw.ru/ (Scopus, Springer LNCS/LNAI, Q2), (*Karpov, A.A.)*
- VIII International Conference "Interactive Collaborative Robotics" (ICR-2023), October, 2023, http://icr.nw.ru/ (Scopus, Springer LNCS/LNAI, Q2) (*Ronzhin, A.L.*)

International cooperation

In 2022 the engagements with international research community were continued by strengthening the existing interactions and international scientific cooperation through international contracts, agreements, grants, the R&D contacts, information exchange. Also certain personal communications continued, in St. Petersburg at the premises of SPC RAS were received a group of HUAWEI Technologies Co. Ltd (4 persons); one

young scientist from China; two young scientists from Syrian Arab Republic; one young scientists from Republic of Kazakhstan; one representative of the German comnapy GEA Farm Technologies RUS. Fourteen specialists of the Center took business trips to attend international events in Argentina, India, Republic of Belarus, Republic of Kazakhstan, Malta, Norway, Serbia, Turkey, Republic of Uzbekistan, and Finland. Totally 141 international events and events with international involvement were attended by SPC RAS staff members in person and on-line.

Professional contacts were maintained with the following institutions:

– University of Informatics and Radioelectronics (Republic of Belarus);
– Institute of Experimental Botany of the National Academy of Sciences of Belarus (Republic of Belarus);
– Joint Institute of Computer Science Problems of the National Academy of Sciences of Belarus (Republic of Belarus);
– Bulgarian Academy of Sciences (Bulgaria);
– Center for Environmental Research of the Hungarian Academy of Sciences (Hungary);
– Danube Research Institute (Hungary);
– Budapest University of Technology and Economics (BME) (Hungary);
– Academy of Cryptography (Vietnam);
– Institute of Information Technologies, VAST (Vietnam);
– Helenic Mediterranean University (Greece);
– Dresden University of Technology (Germany);
– Leipzig University of Telecommunications (Germany);
– University of Rostock (Germany);
– Ulm University (Germany);
– University of Cologne, Institute for Geology and Mineralogy (Germany);
– Festo SE & Co. KG (Germany);
– Centre for Water Resources Development and Management (CWRDM), Kerala (India);
– Karnataka Environment Research Foundation (KERF), Bangalore, (India);
– Almaty University of Energy and Communications (Kazakhstan);
– L.N. Gumilyov Eurasian National University (ENU) (Kazakhstan);
– KATU named after S. Seifullin (Kazakhstan);
– A. Baitursynov Kostanay Regional University (Kazakhstan);

– Astana International University (AIU) (Kazakhstan);
– Cyprus University of Technology (Cyprus);
– Wenzhou University (WZU) (China);
– Liaoning University (China);
– HUAWEI TECHNOLOGIES Co. Ltd (China);
– Harbin Polytechnic Institute (China);
– Mexican National Autonomous University – UNAM (Mexico);
– Institute of Mathematics and Informatics of the Academy of Sciences of Moldova (Moldova);
– Institute of Geography and Geoecology of the Mongolian Academy of Sciences (Mongolia);
– University of Novi Sad (Serbia);
– Ford Motor Company (USA);
– Center for Arctic Research at the University of Northern Iowa (USA);
– Erzurum Technical University (Turkey);
– Istambul Aydin University (Turkey);
– Open Innovations Association FRUCT (Finland);
– Paul Sabatier University (Toulouse III) (France);
– Blekinge Institute of Technology (Sweden);
– Swedish Institute of Agricultural Sciences (Ultuna, Sweden);
– Riga Technical University (Latvia);
– Tallinn University of Technology (Estonia);
– Hendrikson&Ko (Estonia).

The research and contractual works were done on orders by the Secretariat of the CIS Interparliamentary Assembly; Festo SE & Co. KG (Germany); Swedish University of Agricultural Sciences at Ultuna (Sweden); Huawei Technologies Co. Ltd (China); Hendrikson&Ko (Estonia) and other; totally on ten agreements and contracts including four from Chinese enterprises.

Expeditions

In 2022 SPC RAS researchers took part in 39 expeditions, including:
– 2 expeditions to collect biological material at the reindeer herding farms of the Taimyr (Dolgano-Nenets) Municipal District on the right bank of the Yenisey, Yamalo-Nenets Autonomous District;
– 1 expedition to Bolshoe Shchuchie Lake, Salekhard, Yamalo-Nenets Autonomous District;

- 4 Ladoga expeditions to RS "Ecologist" and "Poseidon";
- 17 expeditions to Lake Ladoga and water bodies of its basin;
- 1 expedition to river basin Irtysh;
- 2 expeditions to collect samples of water, phyto- and zooplankton in the water area of LLC "Transneft – Port", Primorsk city;
- 10 field trips to the Limnological station on the lake. Krasnoe (Karelian Isthmus, Leningrad region);
- 1 expedition to the Rybinsk reservoir, Yaroslavl region, village Borok;
- 1 expedition for sampling the aquatic invertebrates to Naroch lakes, village Naroch, Republic of Belarus.

In 2022, over 50 one-day trips were made to various districts of St. Petersburg, the Leningrad Region and Karelia, including the Luga and Priozersky districts, Pushkin, the village of Morozov, Kingisepp, the water area of Lake Lakhtinsky Spill, the mouth of the Syas River, and other.

Monographs

1. Supply Network Dynamics and Control. Springer Nature Switzerland AG 2022. Springer Series in Supply Chain Management. Dolgui, A., Ivanov, D., Sokolov, B. (Eds.). 2022. vol. 20. 210 p. ISBN 978-3-031-09178-0, ISSN 2365-6395. DOI: https://doi.org/10.1007/978-3-031-09179-7. (Scopus)

2. Laskin, M.B. Non-traditional Economic and Mathematical Models in Real Estate ValuationPproblems. SPb, 2022. 260 p. ISBN 978-5-6048093-1-0.

3. Polyak, Yu.M., Sukharevich, V.I., Polyak, M.S. Cyanobacteria and their Metabolites. SPb: Nestor–History, 2022. 328 p. ISBN: 978-5-4469-1975-8.

Conferences proceedings

Speech and Computer. 24th International Conference, SPECOM 2022, Gurugram, India, November 14-16, 2022, Proceedings. Springer Nature Switzerland AG.S.R. M. Prasanna, A. Karpov, K. Samudravijaya, S.S. Agrawal (Eds.): LNCS. 2022. vol. 13721. 720 p. ISBN 978-3-031-20979-6, ISSN. 0302-9743, URL: https://link.springer.com/book/10.1007/978-3-031-20980-2

Interactive Collaborative Robotics. 7th International Conference, ICR 2022, Fuzhou, China, December 16-18, 2022, Proceedings. Springer Nature Switzerland AG 2022. Andrey Ronzhin,

Roman Meshcheryakov, Zhen Xiantong (Eds.): LNCS/LNAI. 2022. vol. 13719. 298 p. ISBN 978-3-031-23608-2, ISSN 0302-9743, URL: https://link.springer.com/book/10.1007/978-3-031-23609-9

Agriculture Digitalization and Organic Production. Proceedings of the Second International Conference, ADOP 2022, St. Petersburg, Russia, June 06–08, 2022. Springer Singapore. Andrey Ronzhin, Alexander Kostyaev (Eds.): SIST. 2022. vol. 331. 459 p. ISBN 978-981-19-7779-4, ISSN 2190-3018. URL: https://link.springer.com/book/10.1007/978-981-19-7780-0

Prospective Systems and Management Tasks. Materials of the XVII All-Russian Scientific and Practical Conference, and the XIII Youth school-workshop. Publishing House: IP Maruk, M.R., 2022. 451 p. ISBN: 978-5-6047666-3-7. URL: https://www.elibrary.ru/item.asp?id=49327291

Modern Tendencies in Developing Chemical, Technology, Industrial Ecology and Environmental Safety. Materials of the III All-Russian scientific and practical conference with the young scientists' involvement. Publishing House: St. Petersburg State University of Industrial Technologies and Design, 2022. 357 p. ISBN: 978-5-91646-296-8. URL: https://www.elibrary.ru/item.asp?id=49291281

Information Technologies in Control (ITC 2022). Materials of the 6th All-Russian Conference within the 15th Russian Multi-conference on Control Problems (MCPU-2022). Publishing House: "Concern "Central Research Institute "Electropribor" (St. Petersburg)."JSC Concern CRI Elektropribor, (St. Petersburg). 2022. 294 p. ISBN: 978-5-91995-088-2. URL: https://www.elibrary.ru/item.asp?id=50210934

Regional Informatics (RI-2022). Materials of the XVIII St. Petersburg International Conference. Publishing House: Regional Public Organization "St. Petersburg Society for Informatics, Computer Technology, Communication and Control Systems" (St. Petersburg). 2022, 626 p. ISBN: 978-5-00182-047-5. URL: https://www.elibrary.ru/item.asp?id=49977019

SPIIRAS – Structural Division of SPC RAS

St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences was founded according to the Decree of the Council of Ministers of the USSR of December 19, 1977 and to the Decision of the Presidium of the USSR Academy of Sciences of January 19, 1978 as Leningrad Research Computer Center (LRCC) of the USSR Academy of Sciences based on the Department of Computer Science of Ioffe Physical and technical Institute.

Based on the Leningrad Research Computer Center (LRCC) was established one of the first global information and computer networks in the country, that is, AcademNet "North –West". In 1985 LRCC was transformed into the Leningrad Institute for Informatics and Automation of the USSR Academy of Sciences.

In 1992 the Leningrad Institute for Informatics and Automation of the USSR Academy of Sciences was renamed to St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences (SPIIRAS) since the historic name of St. Petersburg had been returned to the city of Leningrad.

In compliance with the Russian Fedetion Government Order dated December 30, 2013 No. 2591-p the Institute was turned over to the management of the Federal Agency for Scientific Organizations. By by the Order of the Russian Federation Government of June 27, 2018 No. 1293-p the Institute is transferred to The Ministry of Science and Higher Education of the Russian Federation management.

In accordance with Order of The Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 SPIIRAS acquired a status of SPC RAS structural department.

SPIIRAS does research in informatics, automation and robotics, information and telecoppmunication technologies.

Doctor of Technical Sciences Professor Osipov, Vasily Yu. is the Intitute Director.

Corresponding Member of RAS, Honored Scientist of the Russian Federation, Winner of the RF Government Prize, Doctor of Technical Sciences Professor Yusupov, Rafael M., is the Leader of SPIIRAS Research Direction.

Candidate of Military Sciences, Silla, Evgeny P., is the Institute Scientific Secretary.

Members of the Russian Academy of Sciences in the Institute team

Yusupov, Rafael M., Corresponding Member of RAS, Honored Scientist of the Russian Federation, Winner of the RF Government Prize, Leader of SPIIRAS Research Direction, Doctor of Technical Sciences Professor – scientific basics of computer science, informatization problems of society and regions, information and National Security, models' qualimetry, yusupov@iias.spb.su.

Professor Yusupov, Rafael M. also is Honorary Academician of Tatarstan Academy of Sciences, Emeritus Professor of A.F. Mozhaysky Military Space Academy, Honorary Doctor of Petrozavodsk State University and of St. Petersburg University of Management Technologies and Economics; expert of RAS, President of the National Simulation Society, Deputy Chair of the Scientific Council for Informatization of St. Petersburg , Co-chair of the Coordinating Council of the Partnership for the Information Society Development in the North-West of Russia, Member of the Scientific Councils of the Russian Academy of Sciences: "Scientific Telecommunications and Information Infrastructure", "High-performance Computer Systems, Scientific Telecommunications and Information Infrastructure" and the one on the theory of Controlled Processes and Automation; member Member of the International Academy of Navigation and Traffic Management and many other scientific organizations He actively contributes to evaluation and propagation of scientific knowledge being the Chairman of the SPC RAS Dissertation Council, the founder and the head of the scientific school "Informatization and Forming the Information Society", the Head of basic department – Research Automation at SPb Electrotechnical University "LETI", and participating in the work of editorial boards of over twenty national and international scientific journals, like: "Informatics and Automation (Proceedings of SPIIRAS)" (editor-in-chief); "Economics and Management", "Mechatronics, Automation, Control", "Robotics and Technical Cybernetics", "Problems of Information Security, Computer systems", "Journal of Intelligent Control" (USA), "Cybernetics and Information Technologies" (Bulgaria) and through arranging for topicality and chairing over a dozen regular national and international events.

Laboratory of Applied Informatics and Problems of Information Society

Head of Laboratory: Geyda, Alexander S., Chief Researcher, Doctor of Technical Sciences, Associate Profesor, geida@iias.spb.su.

New Research Results

1. Conceptual and mathematical models of the use of information technologies have been developed that allow for solving a set of problems in designing and improving information technologies as appropriate mathematical problems.Mathematical models reflect the patterns of manifestation of causal and consequential relationships between information and subsequent actions. Models are constructed by the method of sequential creation: diagrams of sequences of actions and possibilities of using information, graph-theoretic models based on these diagrams, parameterized graph-theoretic models based on them, functional probability-theoretic models, and finally, probabilistic and entropy measures describing possible changes in the functioning of the system implemented when using the information acquired in changing conditions. The models are created in a form of hierarchical graphs for implementing the chains of states caused by chains of actions using information. In a result of such models' use, it becomes possible to solve a number of problems of improving the information technologies' use. Also, due to the constructed models, prospects are opening up for creating new digital technologies based on mathematical models of obtaining and using information at the functioning of systems of various types.

2. A methodology has been developed for constructing a computational model aimed at analyzing the development of the phenomena of collapses of aquatic biological resources under quota-regulated exploitation, with due account for the choice of a decision-making strategy on changing the impact based on statistical data and adjusting the previous experience in expert management.

3. An approach to managing the complexity of problems solved by the operator of an ergatic system is proposed. This approach is based on the application of the principle of biofeedback (biofeedback) and can be used in the construction of simulators designed to train operators of complex ergatic systems. The place and role (in the construction of such simulators) of assessing the current functional state of the operator to improve the effectiveness of the learning process are substantiated. Initial

version of the game environment (simulator) has been developed, and a description of the stimulus material, naturally ordered by the complexity degree, is given. Primary measurement experiments were carried out to assess the operator's response rate. A hierarchy of models has been constructed (starting with models of simple Poisson processes and ending with models of non-ordinary non-stationary ones), both allowing for describing the process of generating stimulus material and analyzing data obtained during measurement experiments.

Laboratory for Theoretical and Interdisciplinary Computer Sciences

Head of Laboratory: Abramov, Maxim V., Senior Researcher, Candidate of Technical Sciences, mva@dscs.pro.

New Research Results

1. New method has been developed for identifying the state of clinical deterioration and predicting its changes as a result of the development of the corresponding conditions, based on the unification of values of the RR and QT intervals out of a set of patients' ECG, allowing to obtain a statistically significant value in determining the patient group: with a successful outcome or with a fatal outcome as a result of the development of multiple organ failure syndrome, acute cardiac insufficiency or cerebral edema (https://ecg.dscs.pro).

2. Classification of text posts of social network users in accordance with the previously proposed methodology is automated by the Russian-language BERT (Hubert) model and a fully connected neural network completed above it, which lays the foundation for creating a system for assessing the severity of psychological characteristics of social network users (https://sea.dscs.pro).

3. Prototype application based on the Django web framework has been developed that solves the problem of automated extraction, preprocessing, unification and presentation of data, a new tool for automating the visualization of the social graph of VK users with a display of their interaction metrics has been developed and implemented in the prototype, a mini-application has been developed and launched in VK to collect data on mental characteristics users, over 460 new users visit the application daily (https://sea.dscs.pro).

4. Due to application of a hybrid Bayesian network of trust, the dimension of the parametric space in the task of assessing the intensity of risky behavior based on incomplete and inaccurate data on behavior episodes was reduced, at that, through data on the publication of posts in online media and synthetic data, the vine underlying such a network was quantified for various types of behavior (https://leapp.dscs.pro).

5. Prototype of a system aimed at improving the process of high school students choosing profession and educational programs based on their personal characteristics, interests and skills has been realized, a survey has been developed and a data set containing information about the personal characteristics of the users, information published by them in VK and data on the direction of training have been collected; primary data analysis has been performed (https://vk.com/services?w=app7794698_203437876).

Laboratory of Computer Aided Integrated Systems

Head of Laboratory: Smirnov, Alexander V., Doctor of Technical Sciences, Professor, Honored Scientists of the Russian Federation, smir@iias.spb.su.

New Research Results

1. Method of retrospective (post-hoc) ontology-oriented explanation of the results received by using deep neural networks has been developed, different from the known ones by the use of a number of discovered patterns between the position of concepts in ontology and internal representations generated in hidden layers of the neural network. The application of the method will improve the interpretability of results received with the help of deep neural networks, and expand the scope of their applicability for tasks where the explainability of predictions turns out critical.

2. Ontological model for forming the human-machine groups characterized by purposeful collective behavior has been developed, that represents knowledge about the characteristics of a human-machine group, its potential participants, purposeful collective behavior, context, initiator, features of group forming and allows for organizing context-oriented interaction of people and computing resources in order to let them join such a group.

3. Theoretical and technological basics of intellectual decision support based on the use of generalized patterns of behavior identified through their life models in the digital environment and allowing users to be typified using ontological classification based on knowledge about their personal and behavioral characteristics as decision makers have been developed. The received results are intended for a use in decision support systems to recommend solutions based on users' behavior stereotypes.

4. Approach to remote monitoring of a driver's fatigue based on mobile video measurements (using modern computer vision technologies) and analysis of eye movement strategy (using the Pupil Labs Invisible eye tracker) is proposed. The approach allows for evaluating such parameters of a driver as: number of inhales/exhales, heartbeat, degree of tilt and rotation of the head, openness / closeness of eyes and mouth, and body movements, as well as for identifying the relationship between the numerical characteristics of the glance and the degree of fatigue of the driver.

5. Approach to solving a cooperative game for forming a coalition of participants at hospitalization in a complex epidemiological situation based on a genetic algorithm is proposed. The approach peculiarity is the cost function of evaluating the effectiveness of the hospitalization process based on the selected strategies of its participants, with account for socially-oriented factors. A genetic algorithm is proposed in which the proposed efficiency evaluation function is used as a function of the fitness of the population, and the chromosomes of individuals are determined by a set of selected strategies of participants in the hospitalization process.

Laboratory of Speech and Multimodal Interfaces

Head of Laboratory: Karpov, Alexey A., Chief Researcher, Doctor of Technical Sciences, Profesor, karpov@iias.spb.su.

New Research Results

1. New mathematical and software for a mobile audiovisual recognition system of the most commonly used Russian-language control speech commands of drivers to multimedia and navigation systems under natural driving conditions hindered by the presence of dynamic acoustic noises, active head turns, changes in body position, distance to recording devices, changing lighting conditions, characterized by parallel processing of bimodal speech information based on an integrated deep neural network that combines neural network models of audio- and video modality, thus, allowing to achieve over 90% accuracy in recognition of several dozen speech commands of drivers under full-scale conditions in the speaker-dependent mode.

2. New mathematical and software has been developed for automatic recognition of protective masks' types (6 types) on people's faces by audio and video information, based on the application and integration of modern pre-trained convolutional neural networks (PANN and ResNet), data augmentation methods (SpecAugment, Mixup, Insert and Mosaic) and the Yolov5 object detector, in which the combination of audio and video information occurs at a late level of hypotheses by weighing predictions; the developed method surpassed the methods based on a single modality in terms of efficiency (accuracy, completeness and F-measures).

3. New approach and an integral neural network model for automatic speech reading on the lips of the speaker is proposed, based on the integration of modern methods for visual speech recognition, methods of augmentation of visual data, training of deep neural networks, including 3D CNN and bidirectional BiLSTM models; the model allowed for achieving the best accuracy of speech recognition (known in the scientific literature on the date of publication), both for Russian-language speech and for English-language speech (on the audio-visual speech corpus LRW).

4. New methods of extracting the acoustic, linguistic and visual signs, as well as data augmentation for automatic recognition of human affective states based on independent calculation and combination of expert and neural network signs are proposed and investigated; in a result

of experimental studies, the proposed methods of feature extraction surpassed the basic expert signs in terms of efficiency (accuracy, completeness and F-measures), the developed augmentation methods led to significant increase of the amount of training data for improving the effectiveness of recognition methods.

5. New ensemble model for determining aggression in speech is proposed, and consists of random forest methods and majority voting; the model, when trained on three sets of acoustic expert signs calculated using the openSMILE software toolkit and normalized by the MinMaxScaler method, allowed to obtain a result at the level of the best known analogues.

6. Original approach to multimodal and multitask analysis of the levels of engagement and emotions (intensity and valence) of participants of the group virtual communication is proposed; the approach allows to simultaneously analyze video and audio data of interlocutors and make probabilistic predictions in parallel on the involvement and emotions of teleconferences' participants.

Laboratory of Research Automation

Head of Laboratory: Kuleshov, Sergei V., Chief Researcher, Doctor of Technical Sciences, Profesor of RAS, kuleshov@iias.spb.su.
New Research Results

1.   Set-theoretic model and algorithm for forming the core of documents have been developed, different in the use of a displacing principle that only supports the availability of relevant documents in the database, and provide Internet search for information not furnished by a priori information necessary for keyword search, like, information about new scientific directions, new technologies, novelties in the product markets, as well as reduces the time for forming the document samples in the conditions of external resource constraints of data storage systems.

2.   Method of multi-purpose processing of news' flows, that uses recurrent neural networks with logical organization of layers and continuous learning, is proposed, based on the development of associative processing of text information in streaming recurrent neural networks with controlled elements; the method provides operational selection, recognition, recovery, prediction and synthesis of news based on deep associative continuous processing of links between text elements, as wel as scalability of intelligent systems of a new generation for processing and forecasting various types of information with a volume increase in news flows.

3.   New method and models of substantiation of programs (scenarios) of epidemiological informing of the population in cities connected by passenger flows of different intensity are proposed, that implement an analysis of accumulated data on the state of public health of the population, economy and business, features of the epidemic development in connected cities and possible counteraction measures, allowing to account for the impact of information activities on the development of epidemics and economic losses, providing support decision-making on combating epidemics, this increases the efficiency of managerial decision-making and reduces the risk of erroneous application of secondary information impacts.

4.   The architecture and implementation of a distributed virtual machine have been developed, that incoprporate a description of a minimum set of instructions sufficient for building distributed systems, designed to create distributed interactive applications, information systems, as well as to arrange for communication between robotic complexes in swarm scenarios of their application.

Laboratory of Computer Security Problems

Head of Laboratory: Kotenko, Igor V., Doctor of Technical Sciences, Profesor, ivkote@comsec.spb.ru.

New Research Results

1.   Methods, models, techniques and algorithms for operational analysis and risk management of information security have been developed based on analytical processing of large arrays of heterogeneous data that regard cybersecurity events in the interests of assessing the state, decision support and incident investigation. The developed methods differ in calculating the level of risk based on data on attacks and anomalies detected during a joint analysis of network traffic and event logs, and using the estimates obtained to predict the development of cyber attacks, accounting for the stage of the attack where the detected attacking action belongs. The developed model-algorithmic part of the approach includes a model of the analyzed cyber-physical system, an attack model, a model of damage distribution in the analyzed system, as well as methods for their construction based on the analysis of event logs and network traffic data, and algorithms for calculating the risk level. The data acquired will serve as an input for the cybersecurity decision-making component.

2.   Decision-making method for the protection of critical resources has been developed, characterized by the allocation of decision-making levels depending on the available time, the possibility of automatic implementation of protection measures and access rights necessary for the implementation of protection measures, on the one hand, and the allocation of proactive and reactive decision-making depending on the attack, on the other hand; and by the developed algorithm for selecting the optimal set of protective measures using the results of detection of attacks and anomalies and risk analysis. The model-algorithmic part of the method has been developed; it includes a protective measure model and a hierarchical decision-making model, as well as a methodology and algorithm for choosing the protective measures based on multi-criteria optimization.

3.   Model-methodological apparatus has been developed for designing physical security systems based on microcontrollers protected against cyber-physical attacks, including an extensible hierarchical relational model of the domain based on sets and a set of algorithms for designing such systems. Also, a design methodology was developed that

combines a set of algorithms and an extensible hierarchical model into a single automated approach with minimal operator involvement. In addition, a software implementation of the model-methodological apparatus was presented, that confirms the correctness of the results received based on the design of a secure system of mobile robots for perimeter monitoring.

4. Model-methodological apparatus for automated analysis of data security and privacy in smartphone-based systems has been developed. The developed solution works on the principle of a white box and is designed to help developers to evaluate and improve their products. The distinctive features of the system are the ability to work under the incomplete data conditions, as well as accounting for the specifics of monitoring systems for drivers of vehicles that are built based on smartphones.

5. Model has been developed to classify the vulnerabilities of the interfaces of the "smart city" transport infrastructure. This model allows for identifying the components of the "smart city" transport infrastructure, the options for interactions between them and their semantic orientation based on the use of the categorical division apparatus. Thus, eight classes of components were identified that can interact in pairs with each other, what led to 64 classes of interactions. Semantic orientation has increased the number of classes to 128. Interface vulnerabilities, in turn, are associated with each of 128 interaction classes.

6. Approach to classification of textual information in social networks with active learning has been developed. The purpose of the approach is to detect unwanted information in the publications of the VK social network. The key feature of the approach is the constant increase in size of the training data set, at that; the learning process takes place while the operator is working. This approach is designed to reduce the burden on information security specialists by automating the routine tasks.

7. Methodology has been developed to form the interaction interfaces for solving specific information security tasks, that is based on a model of human-computer interfaces and a model of their vulnerabilities, as well as algorithms for calculating vulnerability indicators and assessing the overall level of security, and allows for evaluating the human-computer interface in terms of security and usability after taking countermeasures, thereby helping to form a better secured interface. An experimental stand has been developed that implements the developed interface models and the developed interaction algorithms, using the developed methodology to

form the interaction interfaces to solve specific information security problems. Experimental and expert evaluation of the developed interface models, interaction algorithms and methods of interface forming based upon the developed evaluation algorithm was performed. The assessment showed that requirements for efficiency and resource consumption are met. The expert evaluation determined what values of vulnerability indicators should be used when calculating the vulnerability of the interface. Scientific and technical proposals for the practical implementation of the results developed in research have been formed.

8.   Method has been developed for setting a hidden discrete logarithm problem on commutative algebras, characterized by a doubled verification equation and allowing the implementation of blind signature protocols based on the computational difficulty of this problem, that are of potential interest as post-quantum primitives.

9.   Approach to developing an anomaly detection system in the Internet of Things based on federated learning and the architecture of a federative learning system for detecting anomalies in the Internet of Things have been developed, within whose framework the SOViA architecture based on FO has been developed. The key differences of the developed Sofia are the availability of functions related to the organization of distributed training of analytical models, aggregation of local models and distribution of a global analytical model to interacting clients.

10.   Method for the anomalies detecting based on the transformation of network data into images with grayscale gradations has been developed. This transformation of the source data allows for training analytical models that possess a higher level of resistance to the detection of previously unknown objects that were not present in the training sample.

Laboratory of Autonomous Robotic Systems

Head of Laboratory: Saveliev, Anton I., Senior Researcher, Candidate of Technical Sciences, saveliev@iias.spb.su.
New Research Results

1. Event-oriented model for managing the data flows of the ground-based robotic means has been developed, characterized by the use of an ontological representation of information about embedded devices and allowing to reduce the computational load on the central control device by preprocessing data at the computers of sensor and executive devices, for example, while solving the problem of cargo transportation up to 41.8%.

2. Algorithm has been developed for replacing the power supply of a ground-based autonomous robotic vehicle (ARV) by a group of small mobile robots, that allows for adjusting the orientation of the manipulator actuators at operating on inhomogeneous surfaces, reducing the displacement error to 4 mm along all three axes when installing the battery, what reduces the number of iterations and leads to a reduction in ARV downtime by up to 30%.

3. Algorithm has been developed for planning the trajectories of terrain coverage when solving problems of aeromonitoring by unmanned aerial vehicles (UAVs) of multicopter type, characterized by the application of principles of optimal direction of sweep and forming a constant orientation of UAV, reducing the number of maneuvers, flight time up to 30%, electricity consumption up to 19%.

4. Method of spot irrigation and fertilization using a group of autonomous heterogeneous robotic ground and air vehicles over large agricultural lands has been developed, including identification, grouping and prioritization of potential fertilization zones based on analysis of the dynamics of changes in the values of the Normalized Difference Vegetation Index (NDVI) index in the areaof study, providing the possibility of replacing the battery of two UAVs types and replenishment of solution tanks in the areas of operations.

5. Approach to automated monitoring of plant growth at a vertical farm using groups of multicopter-type unmanned aerial vehicles (UAVs) has been developed, characterized by the use of ArUco markers to identify racks and each container with plants during UAV movement and plant photofixation, providing tracking of plants' development dynamics with an accuracy of up to 96%.

Laboratory of Big Data Technologies of Socio Cyber Physical Systems

Head of Laboratory: Levonevsky, Dmitry K., Senior Researcher, Candidate of Technical Sciences, levonevskij.d@iias.spb.su.

New Research Results

1. To solve the problem of automatic face recognition of people, who use individual protection means like medical mask, an approach is proposed based on the methods for generating synthetic images of partially hidden faces and the ArcFace face recognition model. A strategy forming the training data sets is proposed and a number of recognition models are developed. Experiments show that neural network models, retrained on datasets in which the volume of artificially synthesized images is 40-60%, demonstrate higher values of the recognition accuracy index, over 87% according to the quantitative metric AAc (Average accuracy). The use of the proposed approach allows to significantly improve the quality of recognition of partially hidden faces.

2. Models and methods have been developed that allow for timely detection and prediction of safety incidents occurring, say, at the operation of escalators and threating the passengers' life and health, like fallings, pinching of body parts, equipment failure, etc. The process of identifying the safety incidents on the escalator is based on complex processing of data acquired from video surveillance cameras, technological microphones and various sensors. For data processing, a neural network model is proposed, that consists of two identical recurrent neural networks for forming a data and forecasting model, and a control unit. The method of complex data processing includes the stages of assessing the probability of occurrence of an event and clarifying information about it.

3. Models developed for the regular and emergency scenarios of medical cyberphysical systems's functioning regardin the cases when patients are at home, in hospitals and other inpatient institutions, as well as models for storing and processing data on events in medical cyberphysical systems. A generalized architecture of a medical cyberphysical system is proposed. Implementation of the proposed solutions will provide an opportunity for medical professionals to faster receive and evaluate information, which in turn will lead to an improvement in the quality of medical services provided.

4. Method for detecting objects on a single image, that contains samples of objects of interest and the processed image is proposed. For this

purpose, a model of ordering image data is proposed, the problem of approximation of a non-hierarchical sequence of optimal piecewise constant approximations of the image is formulated by a hierarchical sequence of suboptimal approximations, described by a convex sequence of values of the total quadratic error. To minimize it, here proposed a modernization of the classical Ward methods, separation/fusion, as well as the K-means method, and their joint application. An efficient computational version of the clustering model is achieved in terms of a developed network data structure that supports reversible calculations with sets of pixels through dynamic Slator-Taryan trees and cyclic graphs.

5.　　Technique has been developed for determining the relevance of brightness indices values to classes of underlying surfaces on multispectral aerial photographs of the Earth's surface. The methodology is based on procedures for identifying the statistically significant differences in data samples and consideres various characteristics of the data, including heteroskedasticity, non-compliance with the normal distribution law, uneven samples. Experiments on a sample of Agricultural Vision Dataset aerial photographs showed statistically significant differences ($p < 0.01$) in the NDVI index values for six out of nine classes represented in the sample. The application of the technique allows for statistical substantiating the correspondence in ranges of index values for various classes of underlying surfaces, that can be used to form relevant samples of images of the Earth's surface, as well as to classify surface types.

Department of prototyping the robotic and embedded systems

Head of Department: Dashevsky, Vladimir. P., Senior Researcher, Candidate of Technical Sciences, vladimir.dashevsky@gmail.com.

New Research Results

1. Within the cooperation with "SIRIUS" LLC, a SCANNER software package has been developed runned by Astra Linux Special Edition 1.6 OS, intended to collect and display information about the current state of equipment that ensures the operation of a distributed infrastructure: power supply networks of cabinets with telecommunication equipment, access control systems, control systems for special-purpose telephone lines, etc.

2. Within the cooperation with "SIRIUS" LLC, a family of multichannel communication controllers of the CSR-48 and CSR-16 facility for 48 and 16 RS 485/RS 232 ports has been developed based upon the SMARC system modules. The controllers allow for scaling the control networks based on modbus/TCP, modbus/RTU protocols, and organizing tunneling of protocols built on interfaces RS-485 and RS-232, via TCP/IP based networks. CSR 48 and CSR 16 can function both independently and as part of the SCANNER complex.

3. Within the internal cooperation between divisions of SPC RAS, R&D was carried out as aimed at developing a device to combat cyanobacterial blooming in small reservoirs, done under the leadership of V.N. Rybakin. The developed device, consisting of a power supply unit, a pump generator unit and a radiator unit, was installed in the Matrossky Pond of the St. Petersburg Victory Park and within two months demonstrated a 16-fold decrease in the concentration of cyanobacteria compared to the Captain's Pond used as a reference. A distinctive feature of the project is the underwater placement of the device blocks in the center of the reservoir, which ensures their hidden installation and protection from theft and a large coverage of the water area by the device's emitters.

4. Within the framework of cooperation with "Ravelin" LLC, a GateNano access controller has been developed based on SMARC system modules. The controller operates runned by the built-in Linux OS, the application software is implemented in Python. The multi-level architecture allows for developing and maintaining several external APIs in one controller for the implementation and collaboration of access control systems of several generations. Linux OS system tools provide secure connections

and work in both private and public networks. This controller is fully hardware compatible with the ProxWay PW-400 access controller, whose production was discontinued because of the the component base aging.

     5.   As part of further cooperation with "Ravelin" LLC, the development of a new SMARC module based on the RK3188 processor of the Chinese company Rockchip has started. The novelty of this project lies in the fact that the new processor module does not contain components developed by companies from unfriendly countries, including secondary semiconductor components. So, the cost of the module is reduced, the availability of components is not subjected to sanctions from governments of unfriendly countries.

     6.   As part of improving the technological capabilities of prototyping the new devices, a CNC machine tool for automated threading and countersinking of holes has been developed. Unlike classic machines with a spindle, a powerful stepper motor is used as the drive of the working body in the new machine tool, that allows for rotating the tool synchronously with the feed, thus, ensuring a constant thread pitch. The machine tool was designed and assembled in a record time of 2.5 months. The actuator is integrated with the CNC processing unit of the serial 4-coordinate machine tool, reconfigured to the threading mode. The use of a standard G-code for creating CNC programs allowed to adapt the threading and countersinking modes to the technological features of the tool, such as variable countersink feed rate depending on the load, threading with the tap feed back for chip breaking.

Laboratory of Information Technologies in System Analysis and Modeling

Head of Laboratory: Sokolov, Boris V., Chief Researcher, Doctor of Technical Sciences, Professor, Honored Scientist of the Russian Federation, twice a Winner of the Government of the Russian Federation Prize in Science and Technology, sokolov@iias.spb.su.

New Research Results

1.   Methodology has been formed for the synthesis of special model-algorithmic and software for proactive management of life-cycle (LC) for information and control telecommunication systems and networks (ICTSN), based on two new applied theories developed by R&D performers: the theory of proactive (anticipatory) management of LC for complex technical objects (CTO), as well as on its complementary theory of multi-criteria evaluation and selection of the best preferrable models and polymodel complexes (PMCs) describing the CTO functioning requirements to the appearance of SMAPS are formulated and justified, the content of one out of the main requirements for existing and prospective ICTSN is described in detail, namely, the requirement to ensure their interoperability (functional compatibility) at various stages of the life cycle.

2.   Proposals have been developed and substantiated in accordance with the basic requirements to special model-algorithmic support for solving problems of autonomous configuration management and reconfiguration of onboard systems of spacecraft (SC) in conditions of planned operation and emergency situations based on a fuzzy-possibilistic approach and multi-agent technologies. Models of special model-algorithmic software have been developed to solve the problems of configuration management and reconfiguration of spacecraft onboard systems in conditions of scheduled operation and emergency situations based on a fuzzy-possibilistic approach and multi-agent technologies, as well as the tasks of planning the transmission and processing of information at the SC distributed network based on multi-agent technologies.

3.   New system-management interpretation and appropriate methodological and model-algorithmic support for solving problems of multi-criteria structural and functional synthesis of technologies and programs to integrate the heterogeneous distributed information resources,

including remote sensing data used in proactive monitoring and management of the development of the territories of the Russian Federation and the Republic of Belarus, have been developed. The architecture and a set of software tools for automating the integration of data received from different types of Earth remote sensing spacecrafts have been scientifically substantiated and practically implemented. The implementation of the results of the development allows for at least 2 times increasing the operativity at solving the tasks of information support for managing the development of territories using heterogeneous data.

4. Set of generalized properties for a complex object is proposed and justified, applicable to objects of different purposes, as well as to those of different nature (artificial and natural), thus, allowing to analyze the properties of the technical part of the system and the human operator interacting with it from a single position. A method of linking metrics of different levels of generality based on the logical-linguistic analysis of the corresponding concepts has been developed. The formalization of finding connections between concepts increases the reliability of the tree of properties for a complex object as compared with the heuristic approach.

5. Methodology for solving the problem of proactive management of grass fodder grass production has been developed. The tasks of synthesis of systems of proactive management of the grass fodder grass production are formulated and justified. The main feature of such systems is that due to constant parametric and structural dynamics, an appropriate adaptation for models and algorithms of proactive control is required. A formal setting for the studied problems of synthesis of proactive control systems is proposed.

6. Methodology of analysis and object-oriented generalization of meteorological data to identify trends of changes in the main climatic indicators of the Arctic regions in the process of global warming with the determination of trends of changes in factors, dynamics of correlations, restoration of data arriving from mainland stations that have ceased their funvtioning, generalization of meteorological data by constructing bioclimatic fields. The methodology was used to analyze the climatic situation and construct bioclimatic fields of the reindeer habitat over the territory of Taimyr and the North of Evenkia as based on the data received from a network of weather stations in the interval from 1970 to 2020.

7. Extension for the technology of the fuzzy-probabilistic approach to representing the complex of weakly formalized objects with

memory is proposed. The extension consists in the introduction of feedback on the object state variable, the introduction of memory to ensure the stability of the computational process, with justification of the possibility of procedures with fuzzy input data. The result is a transition from describing a model of a complex poorly formalized object in the form of a reflex (combinatorial) function to describing an object in the state space.

8. Scientific and methodological basics and model-algorithmic support for automating the tasks of multi-criteria planning of reconfiguration of complex multi-mode objects with a reconfigurable structure have been developed, that are different in considering both a given and an unknown cyclogram for the implementation of their functioning modes, destructive influences and limited resources. Based on the received results, proposals have been formed for the modernization of the control technology for the reconfiguration of the motion control system for the small spacecraft (SS) in the interests of increasing its reliability, survivability, and active life.

9. Combined models and algorithms of complex proactive planning of the development for complex technical objects based on the use of digital "twins" have been developed. On a constructive new model-algorithmic basis, multi-criteria streaming, resource and target coordination of providing and auxiliary operations was simultaneously carried out, based on the involvement of results acquired in the interdisciplinary field of system knowledge.

10. Conceptual provisions on ensuring the interoperability of automated control systems (ACS) with complex technical objects (CTO) are proposed and substantiated. It is established that the functional compatibility of ACS CTO can be ensured on the basis of expert intermediary subsystems implemented in a form of semantic mediators that define a single interpreted terminological space of data and knowledge in such systems based on ontologies.

11. Models, methods and technical proposals have been developed to improve the efficiency of air radio telecommunication systems functioning in the interests of controlling the manned and unmanned aerial vehicles (UAVs) of special purpose aviation. The formed reserve can be used to give a strat to R&D within the state order, the customer for which can be the VKS as part of the MOD of the Russian Federation.

Intelligent Systems Laboratory

Head of Laboratory: Iskanderov, Yury M., Head of Laboratory, Doctor of Technical Sciences, Professor, Academician of the Russian Transport Academy, iskanderov_y_m@mail.ru.
New Research Results

1. Main directions in application of the latest information technologies in supply chains within the developed concept of the industrial Internet of Things (IIoT) are determined. The target focus of informatization in transport and technological processes in supply chains is formulated as the devepment of effective management systems for functional (business) processes based on intelligent information technologies implementing the principles of proactive management and integrated logistics, focused on solving problems of cooperative decision-making in a distributed environment using mobile agents. To organize such interaction in the new supply management structure, it is proposed to implement a single model platform of the "digital supply network" ("digital supply network").

2. Methodology for identifying the state of information security of cyberphysical systems (CPS) based on multidimensional data received from CPS monitoring systems, that uses a combination of various models and machine learning algorithms over separate subsamples, has been developed. The methodology is based on the calculation of qualitative indicators and the selection of the best models on local sample segments. Identification of changes in data and time sequences allows for forming the samples where data have different properties (for example, variance, sample fraction, data span, etc.). Segmentation based on the algorithm for finding points of trend change in a time series and analytical information is presented. Using the example of real dataset data, experimental values of the loss function for various classifiers on individual segments and the entire sample were received.

3. New hybrid models of stationary objects of transport systems (TS) have been developed based on methods of simulation modeling and data mining, considering the characteristic and hidden factors of their behavior. The application of the developed models permits to make substantiated decisions in the interests of optimizing the functioning of TS as a whole.

IAERD – Structural Division of SPC RAS

Institute of Agricultural Economics and Rural Development (IAERD) started out as the Research Institute for Economics and Organization of Agricultural Production for the RSFSR non-Chernozem zone under the VASHNIL Department for the RSFSR non-Chernozem zone, in accordance with the Decree of the RSFSR Council of Ministers dated September 14, 1977 No. 483 and the Order of the VASHNIL Department for the RSFSR non-Chernozem zone dated September 27, 1977 No. 120.

In compliance to the Decree of the President of the Russian Federation "About the Russian Academy of Agricultural Sciences" dated January 30, 1992 No. 84 the united Russian Academy of Agricultural Sciences was established based on the Russian Academy of Agricultural Sciences and the All-Union Academy of Agricultural Sciences, and the Research Institute for Economics and Organization of Agricultural Production in the Russian Federation non-Chernozem zone was transferred to its management.

In accordance with the Order of the Russian Academy of Agricultural Sciences dated January 28, 1998 No. 14 the Research Institute for Economics and Organization of Agricultural Production in the Russian Federation non-Chernozem zone was renamed to the North-West Research Institute of Economics and Organization of Agriculture.

Based on the Federal Law "On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation" of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p NWRIEOA was turned over to the management of the Federal Agency for Scientific Organizations.

By the Decree of the Russian Federation President of May 15, 2018 No. 215: "On the structure of Federal Executive Authorities" and by the Order of the Russian Government of June 27, 2018 No. 1293-p NWRIEOA is transferred to The Ministry of Science and Higher Education of the Russian Federation management.

According to the Order of the Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 NWRIEOA was renaimed into IAERD and received a status of the SPC RAS structural didision.

IAERD does basic, exploratory and applied research aimed at increasing the efficiency of scientific support of the Russian Federation in matters of economic, food and environmental safety. The research is inbtended for obtaining new knowledge in the rational use of agricultural resources of the of Russian North-West, the economy of the agro-industrial complex, innovative and investment development of agricultural sectors that contribute to technological, economic, social and human development, as well as sustainable development of rural areas of the non-Chernozem zone of Russia.

Leading Researcher Candidate of Economic Sciences, Associate Professor Dibirov, Abusupyan A (does research in economics and organization of agricultural enterprises, processes of cooperation and integration into the agro-industrial complex, management systems of integrated associations, mechanisms of rural development) is the Institute Head, szniesh@gmail.com; dibirov.a@spcras.ru.

Senior Researcher, Candidate of Economic Sciences Dzhabrailova, Bariyat S. (does research in models of state regulation of the agricultural land market with due account for rental potential of the regions of the North-West of the Russian Federation) is the Institute Scientific Scretary; barsa70@list.ru.

Members of the Russian Academy of Sciences in the Institute team

Kostyaev, Alexander I., Academician of the Russian Academy of Sciences, Chief Researcher, Doctor of Economics, Doctor of Geography, Professor – theory and methodology of regional agro-economic research, theory of rural development; galekos46@gmail.com.

Nikonova, Galina N., Corresponding Member of the Russian Academy of Sciences, Chief Researcher, Doctor of Economics, Professor – economics and management of the National economy, agrarian relations, institutional foundations and organizational and economic mechanism of sustainable rural development, state regulation of the land market, galekos@yandex.ru.

New Research Results

1. Forms and patterns for differentiation of spatial development of agro-industrial production and rural areas at the macro-, meso- and micro levels are organized; empirical verification of patterns for differentiation of spatial development at the macrolevel is performed, trends of spatial transformation of the agricultural sector of the Northwest economy at the mesolevel are specified; proposals for the development of

local rural areas based on local communities are given; spatial transformation parameters in regard to differentiation of rural settlement are determined; the directions of spatial differentiation of digitalization of rural territories of the North-West are established, with due consideration of foreign experience.

2. Chain of interrelations between the dynamics of demand for agricultural products, the dynamics of acreage and the competitiveness of agribusiness in the regions, depending on their rental potential is determined. The dependence on the value of rental potential is revealed: the dynamics of gross value added production and the number of rural population, the structure of rural settlements according to their population and distribution of rural population in them; it is established that because of small-scale population, 88.5% of rural settlements of the North-Western Federal District will remain without digitalization by 2030. Taking into account the peculiarities of the North-West, it is proposed to include in the digitalization program along with rural settlements counting 100 to 500 people, the ones counting 50-100 people, and in some cases those counting even less than 50 residents.

3. Based on the analysis and generalization of the results of quantitative studies of domestic and foreign authors on the results of the introduction of digital technologies in agricultural production and their effectiveness, it is shown that 1) a significant and reliable economic effect of the introduction of digital technologies has not yet been identified; 2) the impact of digital technologies on the greening of agricultural production is also ambiguous – digital technologies can support the changes already taking place in this process or, conversely, contribute to the further industrialization of agriculture, the growth of production and increase the burden on the environment; 3) the most common approaches to evaluating the effectiveness of digital technologies are: Technical Efficiency Analysis and calculation of savings of separatel cost elements, and the most common data source are actual implementation data for a specific technology and/or crop.

4. Scientific foundations of the digital transformation of the development of dairy farming and the production of fodder from perennial grasses in the North-West of Russia with the use of digital technologies for the effective adaptation of agricultural production to local conditions, changes in the external and internal environment have been developed. The general structure of the digital monitoring, control and predicative analysis system, designed for automatic collection and formation of a database in

order to increase the efficiency and sustainability of production, are developed.

5.   Role and prospects of the digital transformation of the agro-industrial complex at the levels of organization and management are substantiated: the digital transformation of the agro-industrial complex is the transformation of production (as well as exchange and consumption) in the agro-industrial complex due to the increasingly widespread quantitative and qualitative use of computer devices and systems, including robots, the Internet, cloud technologies, artificial intelligence; 12 hierarchical levels of transformation are specified, from biological processes and the workplace to state regulatory and management bodies, the place and prospects of digital transformation are presented in a form of specific tasks to be automated, as well as the principles of cooperative and integration development of the agroindustrial complex based on digital transformation, the whose application allows to put state and industry regulation of digital transformation on a scientifically verified planned and controlled basis, ensuring its economic and social efficiency.

6.   By the example of the livestock industry, a scheme for end-to-end integration of supply chain data into the agro-industrial complex using the platform capabilities of the domestic 1C: ERP program at all stages of the food supply chain, incorpotaing: data on purchased fodder, on agricultural land, cultivated forage crops and their nutritional value, environmental friendliness, as well as animal health, animals' keeping conditions, production and quality of products, procedures of processing products, packaging and tracking of the delivery chain; this form of integration generates a chain database at all stages of value creation, thus, opening up new opportunities for transparency and ensuring traceability of product movement, calculations of production costs for each link, control of cash flows and economic efficiency through the production chain from the farm to the end consumer.

7.   Based on the analysis of the features and characteristics of the modern institutional environment for the development of the North-West agro-industrial complex, the influence of its individual elements is determined, including the insufficient development of the processes of digitalization of land relations, thus, causing the preservation of existing problems in the land use, including the disposal of agricultural land from the reproduction process in the agricultural sector. Using the concept of value as a scientific approach, principles and directions for improving the current institutional environment of land relations have been developed,

including: the fullest use of the territories'potential, involvement in the partnership of the state and business, consistency and priority of the strategies being implemented. Based on the above, goals, objectives and assessments of the prospects for the implementation of a system of measures to return unused land to circulation in the regions of the North-Western Federal District were formulated.

N-W CIRPFEM – Separate Structional Division of SPC RAS

North-West Centre of Interdisciplinary Researches of Problems of Food Maintenance (N-W CIRPFM – SPC RAS) is the legal successor of the VASHNIL Department for the non-Chernozem zone of the RSFSR, established by the Decree of The Central Committee of the Communist Party of the Soviet Union and Council of Ministers of the USSR of March 20, 1974 No. 206.

By the Decree of the RSFSR Council of Ministers dated April 3, 1990 No. 107, the VASHNIL Department for the non-Chernozem zone of the RSFSR was transformed in the Regional Department of the Russian Academy of Agricultural Sciences for the non-Chernozem zone of the Russian Federation. In compliance to the Decree of the President of the Russian Federation "About the Russian Academy of Agricultural Sciences" dated January 30, 1992 No. 84 the united Russian Academy of Agricultural Sciences was established based on the Russian Academy of Agricultural Sciences and the All-Union Academy of Agricultural Sciences, and N-W CIRPFM was transferred to its management.

Due to liquidation of the Regional Branch of the Russian Agricultural Academy for the non-Chernozem zone of the Russian Federation, and by the Order of the Russian Agricultural Academy dated January 04, 1996 No. 29 was established the North-West Scientific Center of the Russian Agricultural Academy. In compliance to the Order of the Russian Agricultural Academy dated November 16, 2001 No. 85 the North-Western Scientific Center of the Russian Agricultural Academy was transformed into the State Research Institution: North-West Scientific-Methodical Center of the Russian Agricultural Academy. According to the Order of the Russian Agricultural Academy dated June 23, 2009 No. 81 the State Research Institution: North-West Scientific-Methodical Center of the Russian Agricultural Academy was converted into the State Research Institution: North-West Regional Scientific Center of the Russian Academy of Agricultural Sciences.

Based on the Order of the Federal Agency for Scientific Organizations dated December 15, 2014 No. 1320, the State Research Institution: North-West Regional Scientific Center of the Russian Academy of Agricultural Sciences was renamed to the Federal State Research Institution: "North-West Center for Interdisciplinary Researches of Food Maintenance".

In compliance with the Federal Law "On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation" of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p N-W CIRPFM was turned over to the management of the Federal Agency for Scientific Organizations.

By the Decree of the Russian Federation President of May 15, 2018 No. 215: "On the structure of Federal Executive Authorities" and by the Order of the Russian Government of June 27, 2018 No. 1293-p N-W CIRPFM is transferred to The Ministry of Science and Higher Education of the Russian Federation management.

According to the Order of the Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 N-W CIRPFM received a status of the SPC RAS separate structural didision.

N-W CIRPFM – SPC RAS does basic, exploratory and applied research in the field of food security, with due account for the developing and mastering innovative technologies for the production, storage and processing of environmentally safe agricultural products.

Candidate of Technical Sciences Yury A. Tyukalov is the Center Director.

Candidate of Agricultural Sciences Danilova, Tatyana A. is the Center Scientific Secretary.

Members of the Russian Academy of Sciences in the Center team

Zabrodin, Vasiliy A., Academician of the Russian Academy of Sciences, Chief Researcher, Doctor of Biological Sciences, Professor – Arctic zone of the Russian Federation, branches of traditional nature management, epizootic and epidemiological welfare, reindeer diseases: diagnosis and treatment, improved technologies of reindeer husbandry, szentr@bk.ru.

Layshev, Kasim A., Academician of the Russian Academy of Sciences, Chief Researcher, Doctor of Veterinary Sciences, Professor – Arctic zone of the Russian Federation, branches of traditional nature management, epizootic and epidemiological welfare, reindeer husbandry, improved technologies of reindeer husbandry, improved technologies of reindeer husbandry, problems of rational nature management and environmental safety of the Arctic, layshev@mail.ru.

Ivanov, Alexey I., Corresponding Member the Russian Academy of Sciences, Chief Researcher, Doctor of Agricultural Sciences – general agriculture, land reclamation, agrochemistry and agro-soil science in part of soil fertility management and the production process of agricultural crops, ivanovai2009@yandex.ru.

Department of Agriculture and Crop Production

Head of Department: Arkhipov, Mikhail V., Chief Researcher, Doctor of Biological Sciences, Professor, winner of the USSR Council of Ministers Prize, maikl.arh1pov@yandex.ru.

New Researh Results

Fundamental, methodological and technological bases for increasing agricultural production in the North-West of the Russian Federation, based on acquiring new knowledge in the field of food and environmental safety that concerns the agronomic and economic assessment of means for fertility reproduction and carbon neutral technologies for secondary development of overgrown fallow lands, the comprehensive assessment of technological characteristics of grain in order to develop a methodology for selecting economically valuable seed material from lots of grain with various technological indicators, as well as an assessment of the impact degree of foliar top dressing with potassium iodide solution on the yield and quality of potatoes on soils of various cultivation, a selection of the best effective bacterial preparation against pathogens of scab, late blight and rhizoctoniosis in order to develop new biological measures to protect potatoes.

Department of Animal Husbandry and Environmental Management of the Arctic

Head of Department: Layshev, Kasim A., Chief Researcher, Doctor of Veterinary Sciences, Professor, Academician of the Russian Academy of Sciences, layshev@mail.ru.

New Researh Results

Fundamental, methodological and technological bases for increasing agricultural production in the Arctic zone of the Russian Federation, based on receiving new knowledge in the area of food and environmental safety in regard to the most important hereditary factors that determine the meat productivity indicators of northern domestic reindeers in selection and breeding work and assessing the influence of phenotypic indicators (live weight, body size and physique indices) in northern reindeers as phenogenetic markers in selection for meat productivity.

Novgorod SRAI – Branch of SPC RAS

The Novgorod Research Institute of Agriculture (NSRAI) was established as the Novgorod Regional Integrated Agricultural Experimental Station in accordance with the Decree of the Council of Ministers of the USSR dated January 30, 1950 and the Order of the Ministry of Agriculture of the USSR dated February 08, 1950 No. 237.

"Novgorod SRAI" is the legal successor of the Novgorod Research and Design – Technological Institute of Agriculture, formed in accordance with the Decree of the USSR State Agricultural Committee of August 19, 1988 No. 63 and the Order of the VASHhNIL Department for the non-Chernozem zone of the RSFSR of September 19, 1988 No. 127.

In compliance to the Decree of the President of the Russian Federation "About the Russian Academy of Agricultural Sciences" dated January 30, 1992 No. 84 and the All-Union Academy of Agricultural Sciences, the unified Russian Academy of Agricultural Sciences was established, and "Novgorod SRAI" was transferred to its management.

Based on the Federal Law "On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation" of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p "Novgorod SRAI" was turned over to the management of the Federal Agency for Scientific Organizations.

By the Decree of the Russian Federation President of May 15, 2018 No. 215: "On the structure of Federal Executive Authorities" and by the Order of the Russian Government of June 27, 2018 No. 1293-p "Novgorod SRAI" is transferred to The Ministry of Science and Higher Education of the Russian Federation management.

In accordance with the Order of The Ministry of Science and Higher Education of the Russian Federation of December 18, 2019 No. 1399 "Novgorod SRAI" became a branch of St. Petersburg Federal Research Center of the Russian Academy of Sciences.

The Novgorod Research Institute does basic and applied research in the technological, economic, and social development of the agro-industrial complex of the Novgorod region and the Russian Federation as a whole.

Candidate of Agricultural Sciences Zhukova, Maria Yu., is the Branch Director.

New Research Results

1. There have been developed scientific basics for technological modernization of agricultural production in the Novgorod region, ecological principles of natural resource management and identification of the best adapted annual fodder crops introduced lately.

2. Based on the implementation of introduced annual crops the ecological principles of natural resource management have been developed, that allow for increasing the species diversity of forage crops, for enhancing the soil fertility, for reducing the ecological burden on the environment, for excluding stressful periods in the feed and raw materials conveyor and under conditions of a dry year, assuring a receipt in the second half of the growing season and prior to the frosts the collection of green mass from 20-25 t/ha (millet) up to 40-45 t/ha (sorghum).

3. Methods are developed for using organic feed additives in animal husbandry, the positive effect of using fulvic acid obtained from lake sapropel in the diets of young animals has been determined, its effect on the digestibility of nutrients in diets, hematological blood parameters, productivity has been studied, the optimal dose of fulvic acid feeding in this age period has been determined. The use of fulvic acid in the diet of young animals allowed for increasing the absorption of nutrients from the diet, for improving blood biochemical parameters, for enhancing productivity by 49.8 – 55.6%.

4. New knowledge in the formation of ecological regimes on reclamation systems of closed and open drainage is acquired under the conditions of a dry growing season, when the designs of runoff hollows provided a more favorable water-air regime as compared with the designs of closed drainage, that led to an increase in the yield of the perennial grasses' hay by an average of 0.6 t/ha.

5. Technological foundations for restoration and construction of reclamation systems have been developed, that are based on the use of runoff hollows structures in combination with surface profiling and cavity-free drainage using the acquired knowledge of forming the environmental regimes at reclamation systems.

1. It was set that the use of microbiological fertilizers Azotovite and Phosphatovite in improved feed crop rotations doubled along with mineral fertilizers based on the planned yield increased the production of agricultural products: vico-oat mixture per green mass by 7.5 and 8.3 tons/ha; grains of oz. rye - by 1.7 and vico-oat mixture by 1.3 t/ha compared to background 1 and allowed to produce a thousand feed units of products for farm animals with low specific energy consumption – less than 2.4 GJ.

CRCES RAS – Separate Structural Division of SPC RAS

Scientific Research Center for Ecological Safety of the Russian Academy of Sciences (SRCES RAS) was established as an Institute of the USSR Academy of Sciences based on the Decree of the Presidium of the USSR Academy of Sciences of March 19, 1991 No. 74 and the Decree of the Presidium of the Leningrad Scientific Center of the USSR Academy of Sciences of April 2, 1991 No. 01-78; in accordance with the Decree of the Presidium of the Russian Academy of Sciences of December 18, 2007 No. 274 renamed to the Institution of the Russian Academy of Sciences St. Petersburg Scientific Research Center for Ecological Safety of the Russian Academy of Sciences.Based on the Decree of the Presidium of the Russian Academy of Sciences dated December 13, 2011 No. 262, the name of SRCES RAS was changed to the Federal State Institution of Science St. Petersburg Scientific Research Center for Ecological Safety of the Russian Academy of Sciences.In compliance with the Federal Law "On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation" of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p SRCES RAS was turned over to the management of the Federal Agency for Scientific Organizations. By the Decree of the Russian Federation President of May 15, 2018 No. 215: "On the structure of Federal Executive Authorities" and by the Order of the Russian Government of June 27, 2018 No. 1293-p SRCES RAS is transferred to The Ministry of Science and Higher Education of the Russian Federation management**.** According to the Order of the Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 CRCES RAS received a status of the SPC RAS separate structural didision.

CRCES RAS – SPC RAS does basic and applied research in environmental safety.

Doctor of Geological and Mineralogical Sciences Tronin Andrey A. is the Center Drector.

Candidate of Legal Sciences Kodolova, Alyona V. is the Center Acting Deputy Director for Research.

Manvelova, Alexandra B. is the Center Acting Scientific Secretary.

Laboratory for Bioelectronic Methods of Geoecological Monitoring

Head of Laboratory: Kholodkevich, Sergey V., Chief Researcher, Doctor of Technical Sciences, Academic Title – Senior Researcher, kholodkevich@mail.ru.

New Researh Results

1. New approach is proposed for rapid assessment of differences in the functional state of freshwater bivalves *Dreissena polymorpha* and *Unio pictorum* based on a comparison between the changes' dynamics of heart beat in the water of the examined natural reservoir after 30 minutes of exposure to air and after 60 minutes of exposure to water with increased salinity (10 g/l).

2. Using the example of groups of freshwater mollusks *Dreissena polymorpha* and *Unio pictorum* from three different lakes of Belarus (Naroch, Myastro and Batorino) with close hydrochemical composition of water, but different trophic status, it is shown that *Dreissena polymorpha* mollusks exhibit higher filtration activity in the most trophic of these lakes, and *Unio pictorum* mollusks, on the contrary, in the least trophic.

3. By method of microbial indication the relative abundance of heterotrophic microbiota in the intestines of Unio pictorum mollusks from the Narva River and from the Dubki monitoring station (Sestroretsk, the Resort district of St. Petersburg), were analyzed with an emphasis on oil-processing organisms and revealed negligible contamination of the studied waters with petroleum products.

4. New biomarker is proposed intended for assessing the ecological state (health) of the coastal waters of the Gulf of Finland of the Baltic Sea and inland freshwater reservoirs– the maximum intensity of aerobic energy exchange (aerobic power) of bivalve mollusks *Dreissena polymorpha* (Pallas, 1771), quantified by the rate of oxygen consumption by mollusks under functional load, and a method for measuring it is developed.

5. Laboratory experiments have shown that the toxic effect of heavy metals (Cd, Cu, Zn) on the functional state of bivalves *Dreissena polymorpha*, estimated by the intensity of aerobic energy exchange, depends on the type of metal, its concentration and duration of exposure. The effect of base metals Cu, Zn is not dose-dependent, unlike Cd.

6. Minimal effective concentration of diclofenac (0.1 mcg/l) in water was detected, that leads to an increase in the energy needs of aquatic animals at a decrease in tolerance to cardiac stress, and at a level close to 1 mcg/l, reproductive function disorders occur (increased embryo mortality).

7. Study of the influence of the mass development of cyanobacteria on the genotoxic properties of natural water, conducted in model ecosystems (microcosms) with different composition of biotic components (zooplankton, amphipods and fish), revealed genotoxic effects at microcystin concentrations below those established by the World Health Organization (WHO) for drinking water. In all experimental variants of exposure, cells with disorders such as polyploidy and mitotic abnormalities associated with damage to the mitotic spindle, including c-mitosis, as well as lagging chromosomes have been found.

8. Combined assessment of bottom sediments from different parts of the Eastern part of the Gulf of Finland was performed by biotesting on the survival of amphipods and on the cardiac activity of bivalves. The good indicativity of both indicators in relation to the potential toxicity of bottom sediments and the importance of using both indicators in combination, since they are sensitive to the effects of various kinds of pollution, was revealed.

Laboratory of Biological methods of Environmental Safety

Head of Laboratory: Kuzikova, Irina L., Leading Researcher, Candidate of Biological Sciences, ilkuzikova@ya.ru.

New Researh Results

1.   For the first time an ability of autochthonous microbiota of different types of water bodies in the North of the Central part of the Russian Federation (Rybinsk reservoir) and the North-West of the Russian Federation (Sestroretsky spill, Lower Suzdal Lake, Lake Ladoga) to destroy highly toxic microcystin-LR (MC-LR) was shown.

2.   Identified MC-LR biodegradation products (tetrapeptide m/z 615, linealized MC-LR m/z 107, MC-LR conjugates with glutathione m/z 1017 and cysteine m/z 1116) indicate the presence of microorganisms in the autochthonous microbiota of the studied objects capable of destroying microcystins both by *mlr* mechanism and by a biochemical pathway involving glutathione. The received results are important for understanding the process of detoxification of water bodies by autochthonous microbiota and can be used to isolate new microcystin-degrading microorganisms.

3.   Bacterial strain capable of MC-LR destroying has been isolated. A new isolated bacterial strain that degrades MC-LR and is identified as *Sphingopyxis sp.* can be used both directly during harmful algal blooms to destroy MC, and in biofilters to remove MC-LR from drinking water.

Laboratory of Remote Methods for Geo-ecological Monitoring and Geoinformatics

Head of Laboratory: Gorny, Victor I., Leading Researcher, Candidate of Geological and Mineralogical Sciences, v.i.gornyy@mail.ru.

New Researh Results

1.   Under the study of urban ecosystems response to climate warming, a technology for satellite mapping the economic losses due to overheating of the urban environment caused by climate warming, developed at the CRCES RAS – SPC RAS, was tested on the example of St. Petersburg. The uneven distribution of economic detriments across the city districts has been revealed. The necessity of economic justification of the problem of five-storey buildings is formulated: renovation with the destruction of intra-blocks green areas and, as a result, increased losses from mortality caused by overheating; major repairs preserving intra-quarterly green areas.

2.   At study of surface air pollution in the cities, it is shown that in Murmansk and other settlements of northern Fennoscandia, an increase in sulfur dioxide content may not only be of a man–made nature, but also be a consequence of natural factors – volcanic explosions in Iceland.

Laboratory of Studying Migration Forms of Ecotoxicants in Environment

Head of Laboratory: Kudryavtseva, Valentina A., Head of Laboratory, Candidate of Chemical Sciences, valenkud@yandex.ru.

New Researh Results

The developed methodological approaches to multiparametric qualitative and quantitative identification of labile forms of heavy metals allow for assessing the cumulative effects of transformation of objects of accumulated environmental harm, to determine the life cycles of ecotoxicants taking into account the phenomena of synergism, antagonism, additivity. Interpretation of environmental monitoring data, considering the previously neglected mechanisms of the impact by objects of accumulated environmental harm, is necessary when preparing regional programs for their elimination.

Laboratory of Full-Scale Ecological and Chemical Research

Head of Laboratory: Zhakovskaya, Zoya A., Leading Researcher, Candidate of Biological Sciences, zazhak@hotmail.com.

New Researh Results

1. For the first time, toxigenic species of cyanobacteria (Microcystis spp.) producing toxins (up to 5 and 9 structural variants of microcystins, respectively) were detected in the reservoirs of the cryolithozone of the North-East of Russia and the largest lake of Kuzbass, Bolshoy Berchikul, that indicates the spread of harmful "blooms" in regions with extreme climatic conditions.

2. For the first time, positive correlations have been established for the Eastern part of the Gulf of Finland between the levels of organic tin compounds (OTC) and a number of characteristics of bottom sediments that affect the accumulation, degradation rates and the possibility of secondary OTC emission. For the first time, the relationship between the content of OTC and the gas saturation of bottom sediments was revealed.

3. Positive correlation has been established between the content of OTC and heavy metal oxides (MnO, Fe2O3) and Br, reflecting the process of sorption and accumulation of organometallic compounds in areas of the increased aeration and formation of ferromanganese nodules in the Gulf of Finland and indicating relatively strong binding and the longest deposition of OTC in them.

4. The negative influence of the constantly expanding anoxic zones in the Gulf of Finland on the degradation processes of accumulated OTC is shown.

5. Neurotoxic properties of hormone-like xenobiotics of alkylphenols, in particular nonylphenol and octylphenol, were detected for the first time, also was established that the studied compounds are weak neurotoxins. A method has been developed for an analysis of alkylphenols by an analytical platform with planar sensors to detect their presence in wastewater contaminated with nonionic synthetic surfactants.

Laboratory of Methods of Rehabilitation of Technogenic Landscapes

Head of Laboratory: Bakina, Lyudmila G., Head of Laboratory, Doctor of Biological Sciences, Associate Professor, bakinalg@mail.ru.
New Researh Results

1.   It is set that the dynamics of the processes of natural biodegradation of oil in podzolic soils obeys the same patterns. However, the quantitative indicators of these processes vary significantly depending on the subtype of soils – podzolic or sod-podzolic.

2.   Experimentally proven through the results of laboratory and field experiments for the studied soils, the relationship between a decrease in the content of petroleum products and an increase in carbon dioxide emissions indicates the microbial nature of oil destruction. It was found out that the most intensive decrease in the concentration of petroleum products in sod-podzolic soil occurs in the first 1.5–3 years of experience, and further the rate of decomposition of oil decreases at all levels of pollution.

3.   Analysis and generalization of multiannual geobotanical descriptions allowed for concluding that podzolic soils differ significantly in the nature and rate of restoration of vegetation cover disturbed by an oil spill. It was found that the most stable is a motley grass and cerial community on sod-podzolic loamy soil, which restores after 4 years. The community of lichen-green moss pine forest on sandy podzolic soil gets recovered far slower. According to the results of studies performed in 2022, 18 years after the oil spill, the total projective coverage of oil-contaminated soils did not exceed 80%.

4.   Laboratory experiments on biotesting revealed that podzolic soils differ significantly on the dynamics of reducing environmental toxicity caused by oil pollution. Established, that at an equal level of oil pollution, sandy podzol compared with sod-podzolic soil was characterized by both a higher degree of toxicity and a lower (3-5 times) rate of its decline.

5.   Different levels of stability of the studied sod-podzolic and podzolic soils under conditions of oil pollution and the peculiarities of their natural recovery processes should considered at environmental rationing, determining the maximum permissible residual concentrations of oil, as well as at developing effective methods of their reclamation.

6.   The indicators of vegetation state, biological activity, functional state of soil microbiocenosis and toxicity used in multiannual field experiments on oil pollution of soils specified their high informative value for judging the health and quality of soils.

Laboratory for Economic Problems of Environmental Safety

Head of Laboratory: Donchenko, Vladislav K., Chief Researcher, Doctor of Economic Sciences, Professor, Honored Scientist of the Russian Federation, Winner of the Academician M.I. Budyko Prize awarded by the Government of St. Petersburg and the St. Petersburg Scientific Center, donvk2020@mail.ru.

New Researh Results

1. Based on the results of an analysis of institutional processes in the countries of the Baltic Sea Region, the EU members, using the example of Sweden, Finland and the Russian Federation, it is shown that currently the theoretical and methodological model of the closed cycle economy has a strategic priority, since it formalizes a transition from the concept of combating environmental pollution to the concept of pollution prevention by using waste as secondary resources in production of secondary certified raw materials and its sale at various markets.

2. Concept of preventive environmental policy is formulated, that systematically combines previously quite autonomously existing mechanisms, tools and procedures for regulating environmental and economic relations in economic and other spheres of activity that practically implement closed-cycle economic models. The concept of preventive environmental policy in 2022 included in the draft Model Law of the CIS member States "On Environmental Safety of the CIS member States. New Edition".

3. According to results of the analysis of legislative ecological and economic regulation of the processes of involvement of secondary resources in the closed cycle economy, it is shown that currently the existing statistical reporting in the EU states and in the Russian Federation does not reflect the volume of sales of secondary materials and energy raw materials, therefore, the creation of a specialized international system of statistical accounting for forming the secondary resources (material and energy) is of particular relevance, the volume of their processing, certification in the form of secondary raw materials and their sales by volume and in monetary terms at various markets.

4. Synthesis method for qualimetric assessment of the ecological capacity of cities and urbanized territories has been developed. It is shown that the levels of ecological capacity within the boundaries of the subjects of territorial division of states are a key indicator of the state of

environmental safety. This indicator is recommended to be used in territorial environmental agreements of territorial public authorities, economic entities, regardless of ownership forms, public associations and citizens.

5. At full-scale ethnogeographic studies in tourist zones, examples of the use of elements of a closed-cycle economy in the territories of indigenous peoples in the Baltic Sea Region are given.

6. Acquired research results were used in the development of draft model laws of the CIS Member States: "On environmental safety of the CIS Member States (new edition)", "On Environmental Damage Assessment", "On Access to Environmental Information (new edition)", "On Environmental Funds".

IL RAS – Separate Structural Division of SPC RAS

In February of 1944, the Presidium of the USSR Academy of Sciences issued an Order on Establishing the All-Union Laboratory of Lake Science within the Department of Geological and Geographical Sciences in Leningrad, the main task assigned was "development of theoretical issues of lake science: origin and history of the development of main types of lakes; study of the lakes' water chemical and thermal balance; lakes' mineral, energy, plant and animal raw materials basis; lakes' influence upon the climate". The founder and ideological inspirer of the Laboratory developmet was an outstanding limnologist G.Yu. Vereshchagin.

Institute of Limnology of the Russian Academy of Sciences (IL RAS) was founded by the Decree of the Presidium of the USSR Academy of Sciences of July 29, 1971 No. 731. Based on the Decree of the President of the RSFSR of November 21, 1991 No. 228 "On the organization of the Russian Academy of Sciences", IL RAS became a part of the Russian Academy of Sciences as the Institute of Limnology of the Russian Academy of Sciences. In compliance with the Decree of the Presidium of the Russian Academy of Sciences dated December 18, 2007, No. 274 IL RAS was renamed to the Institution of the Russian Academy of Sciences: Institute of Limnology RAS. By the decree of the Presidium of the Russian Academy of Sciences dated December 13, 2011 No. 262, IL RAS was renamed into the Federal State Institution of Science: Institute of Limnology of the Russian Academy of Sciences.

In compliance with the Federal Law "On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation" of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p IL RAS was turned over to the management of the Federal Agency for Scientific Organizations. By the Decree of the Russian Federation President of May 15, 2018 No. 215: "On the structure of Federal Executive Authorities" and by the Order of the Russian Government of June 27, 2018 No. 1293-p IL RAS is transferred to the Ministry of Science and Higher Education of the Russian Federation management.

According to the Order of the Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 IL RAS received a status of the SPC RAS separate structural didision.

IL RAS – SPC RAS does basic and applied research in limnology; developing methods intended for in-depth comprehensive study of the structural and functional features of lake ecosystems, restoration of lakes and reservoirs, their use for drinking water supply purposes, fish farming and recreation; solving lakes' monitoring and managing problems as well as tasks of their natural resources' rational use.

Candidate of Biological Sciences Glibko, Oxana Ya. is the Institute Head.

Candidate of Biological Sciences Mitrukova, Galina G. is the Institute Acting Scientific Secretary.

Laboratory of Geography and Hydrology

Head of Laboratory: Naumenko, Mikhail A., Doctor of Geographical Sciences, Professor, m.a.naumenko@mail.ru.

New Researh Results

1. Statistical analysis of vertical temperature profiles in Lake Ladoga, measured over a long period of time from 1897 to 2017, allowed for the first time developing of empirical quantitative relationships between stratification parameters with high determination coefficients. Based on the differences in the physical features of the processes of heating and cooling of the lake surface, dependences that represent the seasonal course of the thermal parameters of Lake Ladoga are found for each of the periods. The rates of change in water temperature and changes in the parameters of the jump layer during the stratification period are estimated. The developed methodological recommendations can be applied to study the thermics of other dimictic lakes.

2. Based on the firstly created digital model of the Valaam Archipelago with a spatial resolution of 25×25 m, a quantitative assessment of the spatial distribution of depths and bottom slopes was made. Hypsographic and volumetric curves, as well as histograms and spatial correlation functions are constructed, indicating that statistically significant relationships between morphometric parameters exist at distances less than 1.5 km for depths and less than 260 m for bottom slopes. Video photography of the Valaam Island steepest slope revealed its morphometric features and the structure of rocks composing the slope with signs of seismic activity of the territory.

3. Time of termination of the Geiniok junction between Lake Ladoga and the Baltic Sea has been established – 3000-3500 cal. l.n., despite the fact that the first signs of a decrease in runoff through it have already been noted 4500-4000 cal. l.n., and the final establishment of lake sedimentation conditions in the basins of lakes located on the paleoprol route at modern elevations of 14-16 m above sea level, occurred no later than 2700-2500 cal. l.n.

4. According to the diatom analysis' data of bottom sediments of Lake Ladoga, the role of transgressive-regressive stages of the Baltic paleobassins and changes in natural and climatic conditions in the development of the reservoir in the early Holocene was revealed. It was found that during this period, the depth, configuration, sedimentation

conditions, trophic status and duration of the hydrological seasons of Lake Ladoga differed significantly from the modern ones.

5. Results of the studying the current state of the Himalayan lake ecosystems allowed to compare data on a significant area of inaccessible mountain systems, at different absolute elevations and in different landscapes. New palynological data on surface samples of lake sediments from various regions of the Himalayas (India, Nepal, Tibet) the influence of high anthropogenic load on almost all the studied lakes was shown.

Hydrobiology Laboratory

Head of Laboratory: Kurashov, Evgeny A., Leading Researcher, Doctor of Biological Sciences, Professor, Corresponding Member of the Russian Academy of Natural Sciences, evgeny_kurashov@mail.ru.

New Researh Results

1. It is shown that the alien Baikal species Micruropus possolskii Sowinsky, 1915 continue to settle in Lake Ladoga in the South and North-West of the lake with the development of new biotopes and an increase in quantitative indicators of development in the South and North-West of the lake, that means a new large-scale transformation of the littoral zone of Lake Ladoga and its possible spread to Lake Onega and the Neva Bay of the Finnish gulf, entailing a significant transformation of their ecosystems.

2. System of bioindication of lake biotopes based on the analysis of low molecular weight metabolism of aquatic macrophytes has been developed, allowin for an assessment of aquatic ecosystems' stability.

3. Comprehensive studies of the ecosystem of Lake Ladoga and its tributaries performed in 2022 considered the impact conditions of natural and anthropogenic factors, in general, once again confirmed the fact of a fairly prosperous and stable state of the lake, influenced by natural factors of the natural environment; at the same time, the influence of anthropogenic factors, leading to disturbances in the flow of lake hydrobiological processes, is sometimes noticeable in local areas, and reflected in the recorded corresponding changes in hydrobiological characteristics.

4. New results of a comprehensive comparative limnological analysis of the seasonal dynamics of the main characteristics of hydrobiocenoses of aquatic ecosystems of the Nizhne-Vuoxinsk landscape of the Baltic-Ladoga District of the South Taiga subprovincion of the North-West landscape region have been received, and considered on the example of lake-river systems: Lake Naryadnoe – the Syomuzhya River, Lake Gusinoe – Stream Prozrachnyi, Lake Bolotnoye – a channel from Lake Bolotnoye, that are the basis for their monitoring and the basis for making informed decisions on the rational use of these water systems.

Hydrochemistry Laboratory

Head of Laboratory: Ignatieva, Nataliya V., Senior Researcher, Candidate of Geographical Sciences, natali_ignatieva@mail.ru.

New Researh Results

1.   Within the multiannual study of the hydrochemical regime of Lake Ladoga as a whole, the main characteristic features of the spatial distribution of the main components of the chemical composition of water and the presence of a number of trends identified earlier were confirmed. Thus, according to the data of the summer of 2022, the spatial and temporal variability of the content and ratio of the main ions was poorly expressed, however, over the past decades a tendency has evolved to increase the proportion of bicarbonate ion in the main water mass of the lake. In past years, there has been a gradual decrease in the values of the hydrogen pH index, in the summer of 2022 they did not exceed 7.84. The relative content of dissolved oxygen in August 2022 reached or exceeded 100% only at several stations in the Northern and Eastern parts of the Lake, as well as in Petrokrepost Bay. In two cases – in the strait near Pitkyaranta near the pulp and paper mill and in the Sortavala Bay near Sortavala, the concentration of oxigen fell below the maximally permissible value for objects of fishery water use (6 mg/l). Based on the average summer concentration of total phosphorus for the Lake, it was assumed that in 2022 the average concentration over the period of open water could be at the level of 2020-2021, again exceeding the permissible value for the Lake.The average concentration of total organic carbon in the deep-water zones of the Lake in August 2022 increased compared to previous years, because of this, the average concentration for the entire Lake increased. Summer studies of petroleum hydrocarbons have confirmed the presence of an increase in their concentrations observed in all limnic zones of the Lake, including deep-water ones.

2.   Within the multiannual comprehensive studies of the main components of the Lake Krasnoe ecosystem, belonging to the Vuoksa river system, it was found out that under conditions of elevated temperatures and a sharp decrease in the water level in the summer-autumn period of 2022, the greatest development over recent years in the Lake of cyanoprokaryotes, mainly *Plankthotrix agardhii*, an indicator of anthropogenic eutrophication, was noted. As well as in 2021, an increase in the concentration of phosphorus and phytoplankton biomass took place.

The decrease in the level in recent years resulted in an increase of the area of thickets of low-grass macrophytes and alien species. Following the change in plant communities, the structure and quantitative indicators of littoral communities changed.

3. In the period of open water of 2022, comprehensive studies of lake-river systems of the Nizhnevuoksinsky landscape of the Baltic-Ladoga district of the South Taiga subprovincion of the Northwestern Landscape Region (Lake Naryadnoe – the Syomuzhya River, Lake Gusinoe – Stream Prozrachnyi, Lake Bolotnoye – a channel from Lake Bolotnoye), whose various areas are experiencing anthropogenic impact to varying degrees. It has been established that the studied aquatic ecosystems are low-mineralized, that makes them extremely vulnerable to external negative impacts. Due to the large swampiness of the landscape, small shallow lakes and watercourses are characterized by natural acidification of waters.The inflow of substances from private river catchments has a decisive influence on the chemical composition of watercourses flowing from lakes. In all water systems, there was a consistent transformation of all structural and functional characteristics of biological communities (phytoplankton, periphyton, bacterioplankton, zooplankton, protozoan plankton) from lake stations to river stations and further from the upper reaches of the river to the lower reaches. Both the species composition and the productivity of biological communities in all studied lake-river systems indicate the absence of severe pollution, including organic. Due to the low water consumption of rivers, the influence of the studied water systems on the water quality of Lake Ladoga is negligible.

Laboratory of Complex Problems of Limnology

Head of Laboratory: Rybakin, Vladimir N., Senior Researcher, Candidate of Physical and Mathematical Sciences, v.n.rybakin@gmail.com

New Researh Results

1.   All available information related to the formation of the low molecular weight metabolome (LM) of freshwater macrophytes in various plant growth conditions and the formation of an information basis for the practical use of various characteristics of LM has been collected and summarized. It was shown that a high percentage of the relative amount of aromatic hydrocarbons, in particular phenols, as well as aldehydes and the total content of aldehydes and ketones indicates unfavorable living conditions for hydrobionts. The above can be used as an indicator of the contamination of waters with a high content of organic substances.

2.   In accordance with data received during previous studies, the parameters for a programmable ultrasonic device for combating cyanobacterial blooming of small reservoirs have been determined. A mock-up of such a covertly installed ultrasonic device has been produced, and successfully tested on the Matrossky Pond of the St. Petersburg Victory Park. Data on a significant decrease in number of cyanobacteria cells occurring in the reservoir under the influence of low-intensity ultrasound are represented. It is confirmed that this ultrasonic device can be used as a stationary device operating on small reservoirs, as well as as part of a network of several such devices for carrying out work on larger reservoirs. An application for a utility model has been prepared.

3.   For the first time, studies have been run on the effects of an ultrafine suspension of humic sapropel, acquired from lake sapropel via a specially developed technology that includes ultrasound exposure. The possibility of using such an ultrafine suspension to increase the efficiency of such branches of agriculture as crop production, animal husbandry, as well as for the industrial preparation of raw materials for the production of ethyl alcohol is sustansiated.

4.   Modernization of the remote-controlled uninhabited underwater vehicle Limnouscaut was executed, that allowed for extending its technical capabilities in regard to deep-sea research. New results received during its testing run in the deep-water part of Lake Ladoga are presented. A prototype of a mobile bathymetric altimeter with automatic

data binding to GPS coordinates has been produced. A prototype of a mobile magnetometer has been developed and manufactured. An intelligent control and data collection system has been developed for the upgraded DAK-250 dredger that allows for performing bottom sampling in difficult conditions, with high productivity and minimal requirements to the operator.

5. Concept was developed and the method of calculating the transport of sediments of different forms in the river flow was tested based on the analysis of the hydraulic structure of the flow and the velocities of its critical states. New data on the spatial distribution of microplastic particles in the water area of Lake Ladoga, at various horizons of the water column and in bottom sediments have been received. The forms of heavy metals were specified, the role of organic substances in the formation of stable complexes with metal pollutants in samples of bottom sediments from the Rybachy peninsula and from the lakes of Yakutia was evaluated. The analysis of the effect on geochemical parameters is performed. In the areas of trout farms in the Lake Ladoga bottom sediments, a significant impact of anthropogenic impact on the geochemical parameters of bottom sediments was recorded.

Laboratory of Mathematical Modeling Methods

Head of Laboratory: Kondratyev, Sergey A., Chief Researcher, Doctor of Physical and Mathematical Sciences, Honorary Worker of Science and Technology of the Russian Federation, kondratyev@limno.org.ru.

New Researh Results

1. For the first time to assess possible changes in runoff from the Ladoga Lake catchment the scenarios of greenhouse gas emissions into the atmosphere RCP 2.6 and RCP 8.5 were used – the best and worst in terms of environmental impact, respectively. RCP 2.6 requires that carbon dioxide (CO_2) emissions begin to decline and reach zero by 2100. In RCP 8.5, emissions continue to grow throughout the 21st century at the same rate as now. The values of meteorological parameters were calculated using the MPI-ESM-MR climate model (Max Planck Institute, Germany). The ILLM model developed at IL RAS was used as a model for forming the runoff from the Ladoga Lake and the Neva River catchment. It is shown that an increase in air temperature in the RCP8.5 scenario leads to a significant increase in the calculated values of evaporation, what largely compensates for the increase in river flow due to an increase in sedimentation parameters of bottom sediments. In a result, by the end of the 21st century, the runoff is expected to get increased by less than 35% relative to the period 2006-2015. The RCP2.6 scenario gives a decrease in runoff to 11%, since there is practically no increase in air temperature, and precipitation has a slight negative trend. Quantitative assessment of possible changes in runoff from the catchment area of Lake Ladoga and the Neva River create an information basis for planning measures to improve water supply systems in St. Petersburg, settlements of the Leningrad Region and Karelia, as well as planning the development of water transport in the region.

2. Verification of the 3D model of the hydrothermodynamics of Lake Ladoga was carried out according to the data of field and satellite observations. Using a 3D model, the features of the formation of upwelling and downwelling zones in the Lake were studied. The upwelling/downwelling can be caused by the wind impact, long-period waves, as well as long-shore density currents. The deep waters coming to the surface during upwelling differ from the surface ones by a lower temperature, as well as a higher content of nutrients. Areas with sustainable upwelling are biologically more productive and richer in fish as

compared with the surrounding waters, what is of great practical importance. The surface waters that descend during downwelling – denser and with a high content of dissolved oxygen – play an important role in the vertical redistribution of heat and aeration of the deep layers of water masses, that plays an important role in the functioning of aquatic ecosystems. It is established that the 3D model of the hydrodynamics of Lake Ladoga satisfactorily reproduces these phenomena. While determining the spatio-temporal parameters of upwelling/downwelling, the most effective are the 3D modeling methods supplemented by both the results of expedition work and remote sensing methods.

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12.   Certificate of state accreditation of educational activities. Registration No. 3436. Issued by: Federal Service for Supervision of Education and Science. End date: 18.05.2022.

ABBREVIATIONS

ASRT	Academy of Sciences of the Republic of Tatarstan
BSTU	Baltic State Technical University "Voenmeh" D.F. Ustinov
A.F. Mozhaysky's MSA	A.F. Mozhaysky's Military-Space Academy
IAERD	Institute of Agricultural Economics and Rural Development
IL RAS	Institute of Limnology of the Russian Academy of Sciences
Minobrnauki	Ministry of Science and Higher Education of the Russian Federation
SRCES RAS	St. Petersburg Scientific Research Center for Ecological Safety of the Russian Academy of Sciences
Novgorod SRAI	Novgorod Scientific Research Agriculture Institute
NSU	Yaroslav-the-Wise Novgorod State University
DES RAS	Department of Earth Sciences of the Russian Academy of Sciences
DNTIT RAS	Department of Nano Technologies and Information Technologies of the Russian Academy of Sciences
DAS RAS	Department of Agricultural Sciences of the Russian Academy of Sciences
PSTU	St. Petersburg State Transport University
PetrSU	Petrozavodsk State University
BRP	Basic Research Program
RAS	Russian Academy of Sciences
Herzen University	Herzen State Pedagogical University of Russia
SZNIESH	North-West Research Institute Economy and Organization of Agriculture
N-W CIEPFM	North-West Center of Interdisciplinary Researches of Problems of Food Maintenance
Mass media	Mass media
SPSUACE	Saint Petersburg State University of Architecture and Civil Engineering (SPSUACE)
SPSAU	Saint Petersburg State Agrarian University
SPbU	Saint Petersburg State University
SPbMU	St. Petersburg Mining University
SPbSMTU	St. Petersburg State Marine Technical University

PFSPbSMU	First Pavlov State Medical University of St. Petersburg
SPbPU	Peter the Great St. Petersburg Polytechnic University
SUAI	Saint Petersburg State University of Aerospace Instrumentation
SPbUWC	Saint Petersburg Water Communications University
SPbUTME	St. Petersburg University of Management and Economics Technologies
ITMO	ITMO University
LETI	Saint Petersburg Electrotechnical University "LETI"
SPbSC RAS	St. Petersburg Scientific Center of the Russian Academy of Sciences
SPC RAS	St. Petersburg Federal Research Center of the Russian Academy of Sciences
SPIIRAS	St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences
FTP	Federal Target Program

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