16TH INTERNATIONAL CONFERENCE ON MANAGEMENT
OF LARGE-SCALE SYSTEM DEVELOPMENT (MLSD'2023)

The 16th International Conference on Management of Large-Scale System Development (MLSD'2023) was held on September 26–28, 2023. This conference is organized annually by the Trapeznikov Institute of Control Sciences, the Russian Academy of Sciences (ICS RAS), with the support of the IEEE Russia Section.

The MLSD'2023 program included one plenary session and 16 sections in the following areas.

Section 1. Management problems of large-scale system development, including multinational corporations, state holdings, and state corporations.

Section 2. Methods and tools for managing investment projects and programs.

Section 3. Management of development of a digital economy. Design offices both situational and expected analytical centers, institutes of development of large-scale systems.

Section 4. Simulation and optimization in the problems of development management of large-scale systems.

Section 5. Nonlinear processes and computing methods in the problems of management of large-scale systems.

Section 6. Management of development of banking and financial systems.

Section 7. Management of fuel, power, infrastructure, and other systems.

Section 8. Management of transport systems.

Section 9. Managing the development of aerospace and other large-scale organizational-technical complexes.

Section 10. Managing the development of regional, urban, and municipal systems.

Section 11. Management of objects of nuclear power and other objects of increased danger.

Section 12. Information support and software management systems for large-scale production.

Section 13. Methodology, methods, software, and algorithmic support of intellectual processing of large volumes of information.

Section 14. Monitoring in the management of large-scale systems.

Section 15. Management of large-scale systems advancement in healthcare, medico-biological systems, and technologies.
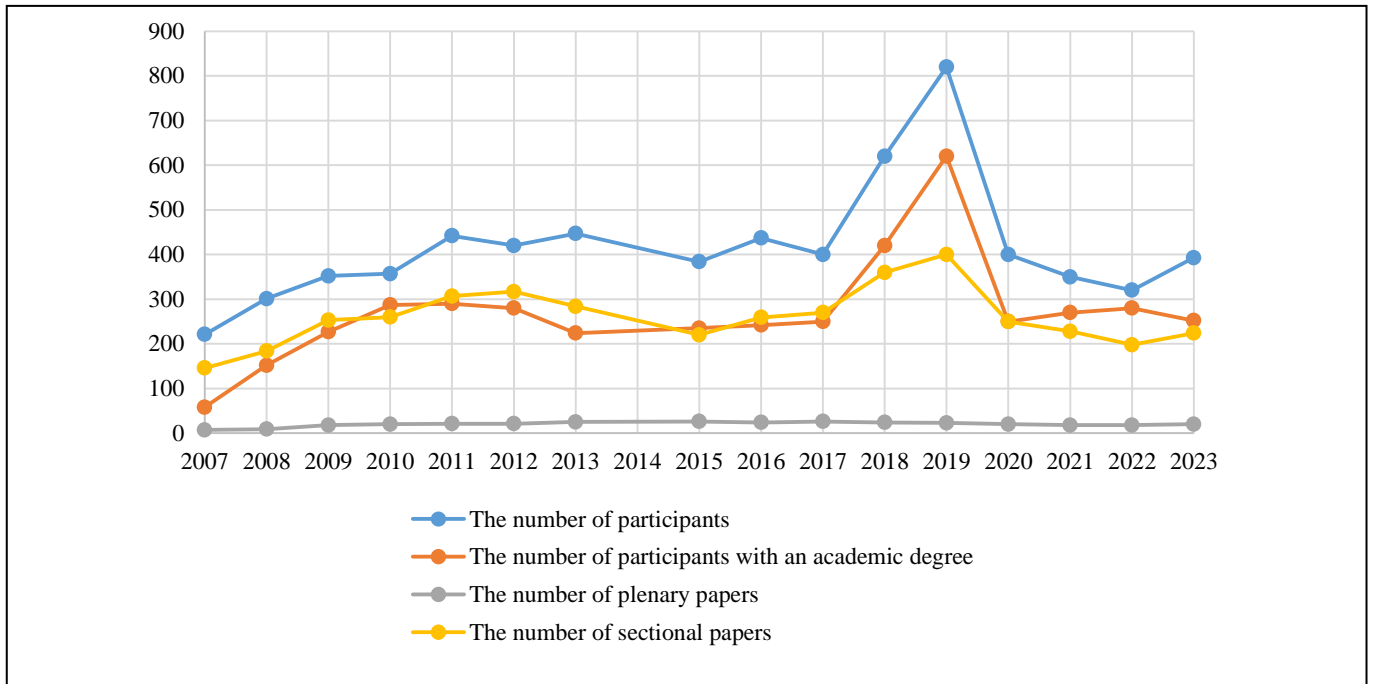
Section 16. Managing the development of social systems.

MLSD conferences are intended to discuss research in the theory and applications of computer control and management for developing large-scale manufacturing, transport, energy, financial, and social systems. Leading scientists from academia, research institutes, universities, and governmental and commercial organizations are invited to participate in the conference. The statistics of MLSD conferences are presented in the figure below. Three hundred ninety-three participants attended MLSD'2023.

The original proceedings of MLSD'2023 (20 plenary and 224 sectional papers) have been published in Russian and indexed by the RSCI. One hundred fifty-five papers have been extended and published electronically in English in the IEEE *Xplore* digital repository[1] (Scopus indexing).

The main problem-thematic vector of contributions at MLSD'2023 was determined by plenary papers devoted to new formal statements for the strategic management problems of large-scale system development in modern conditions of increased sanctions pressure as well as the approaches, principles, and technologies to solve them.

The tone was set by the plenary paper of Dr. Sci. (Eng.), Prof. *A.D. Tsvirkun* (ICS RAS), "Problems of Managing the Development of Large-Scale Systems in Modern Conditions." He posed the problem of developing methodological foundations to form an integral planning model for the long-term growth trends of the national economy in the current unfavorable geopolitical situation. The author's approach is to plan the macroeconomic development of Russia's large-scale systems that form the gross domestic product, national income, aggregate demand, aggregate supply, general price level, unemployment rate, interest rate, currency exchange rate, state budget, and the balance

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[1] https://ieeexplore.ieee.org/xpl/conhome/10303766/proceeding

of payments. The plenary paper introduced a set of models for analyzing and selecting development scenarios for Russia and a digital platform for managing the development of large-scale production and transport systems.

A.D. Tsvirkun's main conclusions and recommendations are as follows. State programs and large business projects should be implemented after thorough elaboration in the RAS and the Institute of Applied Economic Research (RANEPA). It is necessary to develop a project (topic) and create the Association of Management of Large-Scale System Development (the Center of Competencies), uniting experts in the most important areas of the management of large-scale system development, including investment, information technology, and creation of a digital environment for investment planning. This project aims to design a complex analysis methodology and management tools for large-scale system development for solving strategic tasks and problems in order to manage large-scale production and transport projects in Russia, including emergency conditions. It is advisable to maintain relations with similar international organizations and conferences, as well as hold seminars and schools for experts and young scientists on topical issues arising in the management of large-scale system development.

The energy sector is basic for the Russian economy. Its sustainable development and reliable operation largely determine national security. Academician of the RAS *S.P. Filippov* and Cand. Sci. (Econ.) *F.V. Veselov* (The Energy Research Institute RAS) reflected this problem in the paper "Features and Means of Forming Technological Forecasts of Energy Sector in Modern Conditions." The authors described the future technological image of the energy sector meeting heterogeneous requirements, including the availability and reliability of energy supply, technological independence, and the global competitiveness of energy production. In addition, the significant role of environmental and climatic requirements due to the decarbonization of the economy was emphasized.

Under the sanctions, it is of great interest to manage the development of Russia's production infrastructure according to the concept of fast-growing organizations and industries. In his paper "Fast-Growing Organizations in Russia: Growth versus Sustainability," Dr. Sci. (Eng.) *O.I. Dranko* analyzed the prospects for practical implementation of this concept. The author developed a technology for evaluating fast-growing segments of the economy based on organizations' statistical data and financial statements. Fast-growing industries were defined by the average annual growth rates exceeding those for the entire economy. Fast-growing organizations were defined by the average annual growth rate of more than 50% per year in current prices. About 2000 fast-growing organizations in Russia with revenues of more than 1 billion rubles were identified. The total revenue of the sample of fast-growing organizations in 2022 was about 20 trillion rubles. The analysis demonstrated the contribution of fast-growing organizations to the growth of the Russian economy under various development scenarios. The big data processing methods applied by the author quickly decompose information from the macro level (the GDP of the country) to the

revenues of individual organizations. However, for the sample of fast-growing organizations, the calculations revealed an increase in the debt burden compared to the complete list of organizations. They did not reveal changes in current liquidity. Therefore, the class of fast-growing organizations can be attributed to organizations with higher but not critical financial risks. The studies showed the average factual values of risk indicators and can be used to formulate the risk management problem under fast growth.

An interesting aspect of the consequences of the sanctions policy was mentioned by Dr. Sci. (Econ.) *O.S. Sukharev* (the Institute of Economics RAS) in his paper "Industrial Development of Russia: Analysis of Prospects." The author defined sanctions pressure as force majeure circumstances generating crises in the system of large-scale management, including its content, speed, the efficiency and accuracy of decisions, and non-standard institutional constraints. In such circumstances, forecast assessments become inadequate. According to the conclusions, it is necessary to analyze industrial development at the sectoral and system-wide levels, including assessing the impact of macroeconomic instruments. He considered industry to be a large-scale multi-sector system with branching and significant links (the industrial base of the economy) that requires a special methodology of macroeconomic analysis and system management. The main outcome of the paper is the fundamental possibility to relax the blow to the Russian economy provoked by the decline in net exports due to the reduction in sales of raw material components and to deploy new productions and technologies based on the closed cycle principle, which is used in innovation systems to ensure technological sovereignty.

An essential problem in the new theory of managing the development of large-scale systems in force-majeure circumstances is the organization of purposeful (targeted) activity. This problem was considered in the paper "Control of the Purposeful Process of Complex Systems Design" by Corresponding Member of the RAS *A.F. Rezchikov* (ICS RAS), Cand. Sci. (Eng.) *E.V. Kushnikova* and *O.V. Kushnikov* (Saratov State Technical University), and Dr. Sci. (Eng.) *A.S. Bogomolov* (Federal Research Center Saratov Scientific Center RAS). The authors represented the achievement of design objectives as a controlled process and defined its input and output coordinates invariant to the activity's nature, duration, and scale. When achieving design objectives, the values of the input coordinates of this process are repeatedly changed by the decision maker, which may cause significant deviations from the desired results. The paper proposed a problem statement for determining the perturbations of the control coordinates without deviations from the planned results.

In the paper "Hierarchical Games in Deep Learning," Cand. Sci. (Phys.–Math.) *M.A. Gorelov* and Dr. Sci. (Eng.) *F.I. Ereshko* (Federal Research Center "Computer Science and Control" RAS) demonstrated a formal tool to uniformly generate and consider different statements of deep learning and strategic planning problems. In deep learning, it is topical to find weight coefficients under uncertain factors affecting the entire network, and the game-theoretic approach provides an apparatus to write solution algorithms in various enumeration schemes in the state space or gradient algorithms. In strategic planning, the weight parameters of convolutions are usually given by industrial processes, and the most relevant problems are to form activation functions (in this interpretation, for the players' strategy) and the interaction graph, i.e., the architecture of an artificial neural network.

The main results of this work are models of hierarchical systems in the multistep case, with different degrees of awareness of the Principal and subsystems. The authors investigated control procedures for the system of players in a peculiar architecture of links, characteristic of artificial neural networks. In addition, the problem of calculating the Principal's maximum guaranteed result was formulated, a fundamentally new problem for hierarchical games.

Dr. Sci. (Econ.), Corresponding Member of the RAS *V.I. Suslov* and his colleagues *Yu.S. Ershov* (the Institute of Economics and Industrial Engineering, Siberian Branch RAS) and Cand. Sci. (Econ.) *N.M. Ibragimov* (Novosibirsk State University) presented the paper "Interregional Models in the Study of Spatial Economy of Russia." The authors introduced an original method of studying the Russian economy from a spatial perspective based on the principle of sequential detailing of the object (from point to space). In addition, they described a model-software complex replacing the optimization interregional inter-industry model with modified search algorithms for equilibrium and the system core within the spatial "input-output" model. This approach generates forecasting information using not only the national, sectoral, and regional retrospective trends but also the commissioning dates and capacities of individual large enterprises.

The paper by Dr. Sci. (Econ.) *V.G. Varnavskii* (ICS RAS) "Using Input-Output Tables for Assessment Structural Changes in the Russian Transport Sector" was devoted to a methodological approach to studies describing structural shifts in international

production linkages and foreign trade at the level of products and sectors. The author considered an indicator of an exporting country engaged in the importing country's production (the so-called production participation index proposed by him previously) and global input-output models to assess multiplicative economic effects and the involvement of countries, sectors, and products in global value chains. The paper provided an algorithm for analyzing key aspects of structural changes in the Russian transport sector in 2000–2018 based on the Inter-country Input-Output Tables (ICIO) for 2021. According to the conclusions, the integration of the Russian transport sector into global value chains has approached the optimal level.

The same topic was touched on by Dr. Sci. (Eng.) *V.V. Tsyganov* (ICS RAS) in his plenary paper "From a Complex of Models to a Platform for Strategic Management on Transport Infrastructure." The author proceeded from the assumption that the socio-economic development of Russia under sanctions is impossible without advanced transport infrastructure development in new and promising directions of traffic flows. The accelerated changes, scale, number, and complexity of transport infrastructure links determine the relevance of a strategic management platform project to be scientifically justified and implemented. V.V. Tsyganov described the objectives, tasks, principles, and main processes for the strategic management platform of transport infrastructure as well as the processes of coordinating strategic documents by the objectives, tasks, timing of activities, and the amount of resources required. A central mechanism of this platform is a simulation complex for the consequences of management decisions using artificial intelligence technologies and mathematical analysis methods. Note that the approach under consideration has been tested for strategic sustainable operation planning of the Russian economic complex, including Siberia, the Far East, and the Arctic zone of Russia. The formal apparatus to implement this project was illustrated by the mathematical modeling and forecasting of the consequences of one-time adjustments of transport infrastructure as one example.

Dr. Sci. (Eng.) *V.K. Akinfiev* (ICS RAS) presented the paper "The Choice of Optimal Options for the Development of Transport Corridors in the Context of the Reorientation of Export Flows of Russian Companies." He considered the problem of choosing the optimal option for developing transport infrastructure under sanctions and the closure of some export markets for industrial companies from Russia. The development of transport corridors will allow companies to reorient their export flows to other markets without

losing financial stability. The problem under consideration was stated as a dynamic production and transportation problem with mixed variables and the choice of options for developing transport infrastructure. The solution of this problem yields the optimal options for developing transport infrastructure and the optimal production and supply volumes of companies considering the capacity dynamics of export markets and other constraints under different initial data scenarios and assumptions.

The paper "Theory and Practice of Decision-Making in the Implementation of Large-Scale Transport Projects" by Dr. Sci. (Econ.) *V.N. Livschits*, Cand. Sci. (Econ.) *I.A. Mironova*, Cand. Sci. (Econ.) *T.I. Tishchenko*, and Cand. Sci. (Econ.) *M.P. Frolova* (Federal Research Center "Computer Science and Control" RAS) was devoted to an approach to implementing a large-scale transport project. Its socio-economic efficiency was assessed in accordance with the federal and regional regulatory legal acts of Russia.

An investment project was defined as a justification of economic feasibility, the volume and timing of capital investments, as well as a description of practical actions to implement investments (a business plan). Planned and draft decisions were divided into three categories as follows:

• small, which have no appreciable effect on the structural characteristics of the country's economy, individual sectors, or individual regions, as well as do not affect the prices of essential resources, inflation rates, bank interest rates, currency exchange rates, etc.;

• large-scale, which may significantly affect the above characteristics (e.g., exploitation of new coal deposits may affect the price of coal on the national and world markets);

• global, which may fundamentally change the structure of the national economy and affect the indicators of socio-economic development of a country (or even several countries).

The authors considered the problems of assessing the socio-economic efficiency of a large-scale investment project to develop a transport infrastructure network. An approach based on a vector criterion was proposed. It reflects the properties of investment projects and expands the range of information available to the decision-maker.

Currently, online platforms for communication and opinion exchange are becoming an information resource to support decision-making when managing the development of large-scale systems. Examples include government websites for public interaction,

Internet projects for informing the public and involving citizens in the discussions of legal and regulatory documents, and social media, where users themselves create the content. Social media can play a special role in force majeure circumstances. This topic was covered in the plenary paper "The Impact of Online Social Network Algorithms on User Opinion Formation" by Dr. Sci. (Eng.) *D.A. Gubanov* and Dr. Sci. (Phys.–Math.) *A.G. Chkhartishvili* (ICS RAS). The authors considered the formation model of information cascades in which the agents' opinions (concerning some issue) are not observed whereas the observable actions of agents reflect their opinions only partially. The actions performed by agents (writing comments) influence the opinions of agents acting subsequently, thus forming an information cascade of opinions and actions. According to computational experiments, such a cascade is significantly affected by the algorithm showing previous actions to the network agent: in reverse chronological order, in descending order of likes, or first the comments with a given position. This is especially true when agents read a few comments (perhaps due to their cognitive constraints). Therefore, relatively simple changes in the algorithms of an online social network may exert an indirect but decisive impact on the opinions and preferences of network users (in the final analysis, on their actions).

The paper "Modernizing the Solution of Practical Problems and Methods of Program-Target Planning and Management of Breakthrough Development" by Cand. Sci. (Econ.) *D.R. Gonchar* (Federal Research Center "Computer Science and Control" RAS) and Dr. Sci. (Eng.) *V.A. Irikov* (ICS RAS) discussed the issues of implementing the initiative of the President of the Russian Federation on Russia's transition to breakthrough development. The authors proposed a set of tools and technologies tested both on pilots and on small and medium series of controlled objects. Even in the difficult conditions of new challenges, their implementation will solve the previously considered untreatable problems (mainly due to the system approach, modernization, and the identification and mobilization of new opportunities unutilized so far).

Dr. Sci. (Eng.) *V.V. Kul'ba* (ICS RAS) and Dr. Sci. (Eng.) *V.I. Medennikov* (Federal Research Center "Computer Science and Control" RAS) presented the paper "Management of Scientific Agricultural Digital Ecosystems Based on Ecosystem Classification." They proposed a classification of ecosystems and developed a scientific digital ecosystem. This ecosystem provides a digital tool for collecting, accumulating, and using scientific knowledge and for measuring the state of the most essential ecosystems in nature (agricultural ecosystems).

The paper "Soft Dependencies between Projects in Program Management" by Dr. Sci. (Eng.) *V.N. Burkov*, Dr. Sci. (Eng.) *I.V. Burkova*, and Dr. Sci. (Eng.) *A.V. Shchepkin* (ICS RAS) was devoted to program management problems under soft dependencies between projects. Implementing soft dependencies reduces the time or costs of the next project. The following problem was stated and solved: determine the set of executable soft dependencies under given conditions. The paper considered the problem of finding the minimum program duration under soft dependencies between projects. An algorithm for determining the critical path was proposed.

Let us emphasize two thematically close plenary papers: "Development of Control Methods for Nonlinear Processes in Continuous Media" by Dr. Sci. (Phys.–Math.) *A.G. Kushner* (ICS RAS and Moscow State University) and "A Model of the Wave Displacement of Hard-to-Recover Oil Fields Reservoirs by Active Reagents" by Cand. Sci. (Eng.) *A.V. Akhmetzyanov* and Dr. Sci. (Eng.) *A.V. Samokhin* (ICS RAS). These papers give an example of advanced computer modeling tools supporting breakthrough technologies of innovative development at the sectoral level.

In particular, A.G. Kushner presented some results on controlling processes in continuous media. These results refer to many physical processes: thermodynamics, filtration, and motion of media with molecular structure. The unified approach described in the paper is based on the geometric theory of nonlinear differential equations and contact and symplectic geometries. The results have been applied to controlling oil and gas field exploitation processes and phase transition control.

In their plenary paper, A.V. Akhmetzyanov and A.V. Samokhin investigated the effect arising in the production of hard-to-recover oil field reservoirs using active reagents. High-frequency nonlinear wave oscillations accelerate diffusion and increase the oil recovery factor of deposits. The authors showed the results of numerical experiments using a mathematical model of cylindrical waves in the direction of filtration fluid flow; the effectiveness of cyclic wave control actions was demonstrated as well.

The development of domestic advanced software for large-scale industrial processes is of great importance for improving national security. Some results in this sphere were presented in the papers "An Integration Platform for the Operator System (Process Control System)" (Dr. Sci. (Eng.) *A.G. Poletykin*, *N.E. Megazetdinov*, Cand. Sci. (Eng.) *E.F. Jharko*, Cand. Sci. (Phys.–Math.) *V.G. Promyslov*, Cand. Sci. (Eng.) *M.E. Byvaikov*, Cand. Sci. (Eng.) *V.N. Ste-*

panov, Cand. Sci. (Eng.) *A.A. Baibulatov*, Cand. Sci. (Phys.–Math.) *K.V. Semenkov*, and *K.V. Akaf'ev* (ICS RAS)) and "Implementation of Advanced Planning and Scheduling Systems for Oil Refineries, Petrochemical Complexes and Their Associations" (Dr. Sci. (Eng.) *A.S. Khokhlov*, Cand. Sci. (Eng.) *D.Yu. Mishutin*, and Cand. Sci. (Eng.) *E.S. Baulin* (OOO Center for Digital Technologies, Skolkovo)).

This brief overview of the plenary papers demonstrates the active and constructive nature of the concepts, methods, and models of strategic management for developing Russia's large-scale systems under increased sanctions pressure.

The conference results were summarized at the closing session. The chairs of the conference sections underlined the diversity and relevance of the conference problems. Following the established tradition, they also recommended the most interesting papers for publication, in an extended form, in leading peer-reviewed journals of ICS RAS: *Automation and Remote Control*, *Advances in Systems Science and Applications*, *Control Sciences*, and *Large-Scale Systems Control*.

Chair of the Organizing Committee
A.D. Tsvirkun

Deputy Chair of the Organizing Committee
O.I. Dranko

Secretary of the Organizing Committee
I.A. Stepanovskaya

Author information

Tsvirkun, Anatoly Danilovich. Dr. Sci. (Eng.), Trapeznikov Institute of Control Sciences, Russian Academy of Sciences, Moscow, Russia
✉ tsvirkun@ipu.ru

Dranko, Oleg Ivanovich. Dr. Sci. (Eng.), Trapeznikov Institute of Control Sciences, Russian Academy of Sciences, Moscow, Russia
✉ olegdranko@gmail.com
ORCID iD: https://orcid.org/0000-0002-4664-1335

Stepanovskaya, Iraida Aleksandrovna. Cand. Sci. (Eng.), Trapeznikov Institute of Control Sciences, Russian Academy of Sciences, Moscow, Russia
✉ irstepan@ipu.ru
ORCID iD: https://orcid.org/0000-0003-2012-8063

Translated into English by *Alexander Yu. Mazurov*, Cand. Sci. (Phys.–Math.), Trapeznikov Institute of Control Sciences, Russian Academy of Sciences, Moscow, Russia
✉ alexander.mazurov08@gmail.com