



13TH INTERNATIONAL CONFERENCE ON MANAGEMENT OF LARGE-SCALE SYSTEM DEVELOPMENT (MLSD'2020)

The 13th International Conference on Management of Large-Scale System Development took place on September 28–30, 2020. The event's organizer was Trapeznikov Institute of Control Sciences, Russian Academy of Sciences (ICS RAS), Moscow, supported by the IEEE Russia Section. Due to the special COVID-2019 pandemic conditions, the conference sessions were held online. With the virtual format, there was no interruption in regular publications and the presentation of new scientific results at the conference organized annually.

MLSD'2020 was attended by 400 participants from different institutions of the Russian Academy of Sciences, Russian universities, management and commercial organizations, and foreign research institutions (France, Norway, Burma, Vietnam, Belarus, and Kazakhstan). Note that 144 papers were included in the conference proceedings.¹

Traditionally, on the first day of the conference, a plenary session was dedicated to fundamental research into the theoretical and methodological platform for strategic management of large-scale system development, with the presence of all conference participants. The following papers of leading scientists were presented at the plenary session of MLSD'2020:

- “Research principles in the theory of control of organizational and technical systems” by *D.A. Novikov*. The paper examined the epistemological principles of the theory. The author identified the principles of rationality, coordination, and decomposition, which reflect the specifics of organizational and technical systems as controlled objects with a complex structure (logical, causal, process, etc.). Such systems include active elements (subjects with active behavior), and their lifecycles should be coordinated.

- “Management of large-scale system development in new conditions” by *A.D. Tsvirkun*. The pa-

per considered a comprehensive analysis methodology and tools for managing the development of large-scale systems intended for solving strategic tasks and management problems in Russia, particularly in emergency conditions.

- “A multilevel system for modeling regional budget revenues in the coronavirus crisis conditions” by *O.I. Dranko*. The paper proposed express modeling of regional budget revenues depending on the crisis depth. A set of support measures for organizations was considered, and their effect on budget revenues was studied.

- “New forms of public-private partnership in Russia's scientific and technological development” by *V.G. Varnavskii*. Particular attention was paid to large-scale projects. The foreign experience of implementing the concept of public-private partnership was presented, and Russia's regulatory and legal base that appeared in recent years was analyzed. According to the author's conclusion, public-private partnership has significant potential for Russia's scientific and technological development.

- “Towards a platform for managing the infrastructural development of a large-scale region in extreme climatic and geographical conditions” by *V.V. Tsyganov*. The paper proposed a theoretical and methodological platform for strategic management of the infrastructural development of a large-scale region in extreme climatic and geographical conditions. Several platform elements were designed: organizational systems and mechanisms for managing infrastructural development, a cost-effect decision methodology for resource exploitation and the spatial development of territories, and a scenario-based simulation model for the development of transport infrastructure during the evolution of the regional socio-economic system.

- “Scenario analysis of the problems of ensuring public security in digitalization conditions” by *V.V. Kulba, A.B. Shelkov, I.V. Chernov, and L.V. Bogatyreva*. The paper considered the problems of increasing the efficiency of public security management processes and the transformation of legislative regula-

¹ Materialy 13-oi Mezhdunarodnoi konferentsii “Upravlenie razvitiem krupnomasshtabnykh sistem” (Proceedings of 13th International Conference on Management of Large-Scale System Development (MLSD'2020), September 28–30, 2020, Moscow, Tsvirkun, A.D., Ed., Moscow: Trapeznikov Institute of Control Sciences, 2020. (In Russian.)



tion and law enforcement systems in a developed information society. A multigraph model was constructed, and the feasibility of creating a single investigative authority was studied using scenario analysis based on the model.

- “New analysis assessment and control methods for complex power systems based on spectral and structural analysis” by *I.B. Yadykin and A.B. Iskakov*. The paper discussed new stability assessment and control methods for large-scale power systems within project no. 19-19-00673 supported by the Russian Science Foundation. The main theoretical result of the project is the development of a new concept of Lyapunov modal analysis (LMA), which combines two approaches to assess the stability of dynamical systems: selective modal analysis and spectral factorizations of Lyapunov functions.

- “The use of existing managerial innovations is enough for breakthrough development and recession reversal” by *V.A. Irikov*. The practical proposals outlined in the paper are a response to the initiative of the President of the Russian Federation for breakthrough development and the goals set by him in the Presidential Address to the Federal Assembly on March 1, 2018. As a result, the implementation of the described breakthrough technologies of the third generation will accelerate by 1.5-2 times the achievement of the socio-economic targets indicated in the Budget Law for 2018–2020 and will even double the increase in the rates of social and economic growth in the next 2–3 years.

- “Prospects for coordinating technological development with national projects” by *N.I. Komkov*. The paper focused on increasing the requirements to the competitiveness of domestic innovative solutions and technologies: diversifying technological potential throughout the entire technological cycle, reducing costs and economic losses at all stages and technological redistributions, coordinating the potential, quality, and interests of all links of technological chains, etc.

- “New functions for designing supervisory control systems of nuclear power plants” by *A.G. Poletykin*. The paper proposed adding modern computer technology-based functions into the upper level of the industrial process control system of new-generation nuclear power plants (NPPs). The list of functions, their placement at NPPs, required personnel, and implementation methods were considered. In addition, the issues of ergonomics and cybersecurity were discussed.

- “Structural dynamics and macroeconomic policy in Russia” by *O.S. Sukharev*. As shown in the paper, the structural policy is an indispensable way to create a new growth model for the Russian economy;

it reduces to institutional changes balancing the profitability of the transactional, raw material, and manufacturing sectors. The research methodology was structural analysis and the pairwise correlation method to determine the contribution of macroeconomic tools to the growth rates of Russia’s GDP components and their effect on GDP on the time interval under consideration.

The program of MLSD’2020 covered 234 papers distributed in the following sections:

Section 1. Problems of managing 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. Managing the development of a digital economy. Design offices, situational and prediction and analytical centers, institutes of large-scale system development.

Section 4. Simulation and optimization in problems of managing large-scale system development.

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

Section 6. Managing the 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 nuclear power objects and other objects of increased danger.

Section 12. Infoware and software for management systems of large-scale production.

Section 13. Methodology, methods, software, and knoware for big data processing and intelligent analysis.

Section 14. Monitoring in managing the development of large-scale systems.

Section 15. Managing the development of large-scale health systems, biomedical systems, and technologies.

Section 16.1 Managing the development of socio-economic networks.

Section 16.2 Mechanisms for managing the development of socio-economic systems.

The sections were conducted on the second and third days of the conference. Of major interest is to

group the sections papers by the relevant problems of managing large-scale system development. Among them, we will identify seven areas described below.

Industrial and commercial use of resources (energy, transport, production, etc.) requires optimal **investment** in their development. The following papers presented interesting solutions for the problems of this area:

- “Methods to model and optimize the choice of investment decisions” by *V.K. Akinfiev and A.D. Tsvirkun*. The authors considered models for selecting a portfolio of projects for industrial companies with a complex asset structure based on a simulation and optimization approach. In addition, portfolio selection by maximizing the market value of a holding company was described.

- “Assessing the effectiveness of large-scale investment projects in various conditions” by *V.N. Livshits, I.A. Mironova, T.I. Tishchenko, and M.P. Frolova*. The paper proposed an unconventional model for assessing the social effectiveness of a large-scale infrastructural project to maximize the investor’s capital at the end of the calculation period, considering the scenarios of an efficient use (reinvestment) of the capital formed from the project profit and loss of profits.

- “The role of investment projects for large-scale systems in crisis conditions and a minimax approach to implement them” by *E.V. Popova*. As shown by the author, minimax strategy, property strategy, reform methodology, target models, and value drivers are effective tools to revise large projects and programs.

- “Comparative analysis of efficiency criteria for share portfolios under different approaches to form them” by *D.S. Sizykh*. The paper presented a modified version of the Markowitz portfolio optimization model using the stable growth indicator of stock prices. In addition, the efficiency of various portfolio formation approaches was compared on an example of portfolios consisting of the shares of leading IT and telecommunications companies for the period 2015–2020.

- “A mixed investment portfolio with a limited choice of assets” by *A.S. Syrovatkin*. As noted in the paper, modern economic reality is increasingly moving away from classical market regulation. As a result, the concept of a free market becomes less and less applicable, and an opportunity to use it may arise only in narrow market niches. In other cases, in one form or another, there is an external impact breaking the natural balance. The author proposed a method to form and optimize a mixed investment portfolio under

restrictions (the obligation to launch a given share of real projects).

An important tool for managing the development of large-scale systems is **intelligent computer modeling** associated with knowledge acquisition. The following papers were devoted to various aspects of this area:

- “The concept of forming a single information Internet-based space for the scientific and educational resources of a country” by *F.I. Ereshko, V.I. Medennikov, and Yu.A. Flerov*. The authors proposed a methodology for assessing the effectiveness of using scientific and academic information resources on the Internet under the transition to the digital economy and innovative development.

- “Mathematical models and algorithms for the predictive assessment of national security in training situational centers” by *N.V. Yandybaeva, A.F. Rezchikov, E.A. Gorshkov, A.S. Bogomolov, V.A. Kushnikov, and A.D. Tsvirkun*. A mathematical system dynamics-based model was developed to carry out an express analysis of the current state and predict the national security of countries. In addition, an algorithm for using the developed knoware for assessing the national security of countries was presented. Finally, a methodology to train national security specialists in situational centers was demonstrated.

- “Features of managing large-scale cyber-physical municipal water supply systems in different countries” by *N.A. Fomin and R.V. Meshcheryakov*. The paper considered the models of water supply management in cities of different countries: Asia (China and Singapore), the USA, Europe (particularly England), and Russia. Some drawbacks in the management models were identified due to the existing potential threats of water shortage, degradation of water sources, and chemical and biological pollution risks.

- “Assessing the level of digital transformation in Russia’s agricultural sector” by *V.V. Kul’ba and V.I. Medennikov*. The paper introduced a mathematical model of the readiness of Russia’s agricultural sector for digital transformation. In addition, several scenarios for digitalization were calculated, and the corresponding results were presented.

The following papers were devoted to the problem of **sustainable development**:

- “Decision-making in development management systems” by *V.V. Baranov*. The author formulated the fundamentals of feasible and sustainable development management processes in a degrading material and reflexive social environment. Sustainability was related to conflict resolution through sustainable



compromise. The structural configurations of the systems were determined, taking into account the environment values. Finally, a structure, methodology, and constructive tools for development management through the planning cycles of strategic renewal and real management were described.

- “An entropy approach to problems of sustainable regional development” by *A.N. Solomatin*. The paper proposed various ways to fight the growth of entropy. Necessary conditions for sustainable development were formally defined. In addition, the technological, economic, environmental, and management aspects of counteracting the growth of entropy were analyzed in detail.

- “Stable economic dynamics of large-scale systems” by *V.V. Glazunova*. The author introduced the concept of the stable operation of an economy and methods for assessing it. By stability, the author understood the system’s ability to return to the initial state or maintain the trajectory of development under disturbances. If the system cannot return to the previous state or deviates from the given trajectory, it is unstable. For economic systems, the most important ability is maintaining the trajectory of development under exogenous disturbances (the so-called dynamic equilibrium).

Of great interest are original papers expanding the existing knowledge about the control of **nonlinear systems** for industry and cross-industry applications. Among them, we mention the following:

- “Optimal thermodynamic processes for ideal gases” by *A.G. Kushner, V.V. Lychagin, and M.D. Roop*. The problem of optimal control in equilibrium thermodynamics of ideal gases was solved. A thermodynamic process curve maximizing the work functional was found on the Legendre manifold of an ideal gas. Furthermore, constraints on the control parameters were obtained. As shown in the paper, in the case of an ideal gas, the corresponding Hamiltonian system is Louisville integrable, and the controllability of such a system was proved.

- “Singular control for enhanced oil recovery in natural oil reservoirs” by *A.V. Samokhin, A.V. Akhmetzyanov, and E.I. Krupina*. The paper considered sawtooth waves with periodic shock fronts generated in wellbores. The approach proposed by the authors allows predicting the dynamics of phase transitions adequately and optimizing oil production control.

- “Identification of integrated ranking mechanisms as an optimization problem” by *V.N. Burkov, N.A. Korgin, and V.A. Sergeev*. The authors demonstrated that with the single-coded transformation of

mechanisms, the identification of any integrated ranking mechanism reduces to an optimization problem, and a wide range of methods apply to it. The proposed approach was illustrated by several examples of identification or approximation of learning sets generated by several Boolean functions.

- “Stabilization of a two-rotor electromechanical system based on the principle of decomposition” by *A.S. Antipov, S.A. Krasnova, and S.V. Pivneva*. The paper considered a two-rotor electromechanical system as a plant under parametric uncertainties and cross-links between the rotors. A block design procedure was developed for nonlinear local links and discontinuous controls stabilizing the angular positions under the design constraints. Finally, the simulation results were presented.

Robotics and related computer simulation technologies are of constant interest. In this area, note the following papers:

- “Cybernetics systems: algorithmization in the problems of the primary assessment of objects in a complex unmanned aerial vehicle” by *S.S. Semenov, A.V. Poltavskii, and E.Yu. Rusyaeva*. The paper suggested an approach to substantiating the utility function for obtaining initial estimates of the performance criteria of complex technical systems in the form of an information model considering the consistency of expert judgments.

- “Some methods to classify and recognize targets in modeling the target environment of unmanned aerial vehicles” by *V.Tr. Nguyen, Ch. A. Bui, F.F. Pashchenko, A.F. Pashchenko, and Yu.I. Kudinov*. The paper addressed the issues of modeling unmanned aerial vehicles under multifactor uncertainties. Approaches to the selection of target tasks were proposed. An algorithm for classifying air targets based on dimensional features and an algorithm for classifying air targets based on moment invariants of images were developed. These algorithms can be used for object image recognition and statistical decision-making on target tasks.

- “Estimating the derivatives of reference signals in a control system for UAVs” by *Yu.G. Kokun’ko and S.A. Krasnova*. The authors developed a procedure for designing a dynamic feedback control under which the center of mass of an unmanned aerial vehicle will track a given trajectory invariantly with respect to exogenous disturbances with a desired accuracy under incomplete information about the state variables and the derivatives of the reference signals. In addition, the simulation results were provided.

- “Design and prototype of a six-legged walking machine” by *V.A. Danilov and V.I. Goncharenko*.

The paper presented a mathematical model of a walking hexapod robot. The model provides visual information about its spatial movements and can be used to develop control algorithms.

- “Development of a flight simulator in the conditions of UAV group control” by *P.M. Trefilov, M.V. Mamchenko, and K.A. Kulagin*. The authors described a generalized process of creating a virtual simulator with an integrated geographic information system for simulating flight tasks of unmanned aerial vehicles. The simulator can be used to create flight tasks for single UAVs and their groups and export data on completed missions for performing real flights.

- “Logical control of a gantry robot based on regular grammars in the presence of non-stationary obstacles in the working area” by *O.S. Tkacheva, A.V. Utkin, and M.S. Vinogradova*. The paper was devoted to designing logical control of a gantry robot facing non-stationary obstacles in the working area. For a two-link gantry robot, a gripper motion control model was constructed based on a hybrid automaton with a finite set of states. The logic control algorithm was tested using numerical simulation methods.

Many studies on cybersecurity analysis and software outlined the key tenets of **risk management**. Among such papers, we mention the following:

- “Analyzing the cybersecurity of a significant object of critical information infrastructure” by *E.A. Sakrutina and A.O. Kalashnikov*. As noted in the paper, for effective risk analysis, it is crucial to identify objects, threats, and vulnerabilities and understand the nature of cyberattacks. Moreover, it is crucial to determine the risk as accurately as possible, identifying its causes, scale, and limitations, and the type of potential threats affecting the object’s goals. In the proposed approach, identifying and managing potential risks was treated as a continuous process of an ordered sequence of events, actions, and decisions (“threats–vulnerabilities–consequences”).

- “Application of cloud service technology to ensure the cybersecurity of an industrial control system” by *A.I. Samoshina, V.G. Promyslov, S.B. Kamesheva, and R.R. Galin*. The paper introduced a mathematical graph theory-based model to describe access relations between the objects and subjects of security policy. Algorithms for traversing the graph vertices were compared to select a suitable method for identifying security zones. Finally, the algorithm for calculating security zones was implemented and added into the omole.ws cloud service.

- “An example of initial data verification for designing the Information base of a nuclear power

plant” by *E.R. Budynkova and A.A. Baibulatov*. A complete code parsing algorithm for the Kraftwerk Kennzeichen system was presented, and all its sectors were studied. In addition, a list of the most common inconsistencies was provided.

- “An arbitration model of information risk management for significant objects of information infrastructure” by *A.O. Kalashnikov and E.V. Anikina*. The paper considered an effective limited resource allocation method for managing information risks of the significant objects of critical information infrastructure based on game-theoretic models (arbitration schemes).

In the theory of managing the development of large-scale systems, of considerable interest is research into methods, models, and tools for **intelligent analysis of big data**. In this area, we highlight the following papers:

- “Digraph clustering methods based on the Laplace matrix and its eigenprojector” by *R.P. Agaev*. The paper was devoted to the topical problem of “meaningful” clustering of oriented networks. As noted by the author, adequate clustering of digraph vertices is impossible when ignoring the direction of graph edges (considering the graph to be undirected).

- “An algorithm for constructing a regression decision tree using additional functions” by *S.A. Saltykov*. The paper examined the problem of constructing accurate and intuitively plausible analytical models clear for the analyst. An algorithm for constructing a regression decision tree with additional functions was presented. Also, a reliability condition for a two-level decision tree was described.

- “Methods for assessing the effectiveness of integrating software and technology solutions into digital platforms” by *D.Yu. Il’in and E.V. Nikul’chev*. In the paper, a digital platform was understood as a technology for acquiring and exchanging information between very many users. The authors developed methods and virtual simulation information infrastructures for assessing the effectiveness of integrating software and technological solutions into digital platforms (on an example of a digital platform for mass research in the education system). The “infrastructure as code” concept reduces the cost of computational experiments on a given technology stack and allows an adequate assessment of a technological solution when technologies are integrated into the stack. Moreover, the infrastructure and operating conditions of the developed digital platform are taken into account. The proposed approach allows assessing the effectiveness of technologies and reducing the cost of computational experiments at the stage of selecting



technologies. In addition, the implementation results were presented to demonstrate the effectiveness of the proposed methods.

The Deputy Chair of the Program Committee, A.D. Tsvirkun, delivered welcoming and concluding remarks for the conference participants. He emphasized the steadily growing scientific potential of the annual conference for 15 years of its history and expressed confidence in future conferences. Moreover, he noted that large-scale systems (corporations, financial and industrial groups) are the locomotive ensuring the competitiveness of the national and transnational economy and supporting them in the global market space. The Government and Science need to undertake the elaboration, renewal, and mutual coordination of general schemes for the development and placement of industries considering the lines of international and regional development. Investment projects should be carried out within a comprehensive long-term cross-sectoral program of the country's socio-economic development and the territorial placement of production. Government programs and large

business projects should be implemented after careful consideration.

Chair of the Organizing Committee
A.D. Tsvirkun

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