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**Aleksander Śladkowski
Tofiq Babayev (Eds.)**



**5th International Conference on
Problems of Logistics, Management
and Operation in the East-West
Transport Corridor**

Book of Abstracts

May 18-21, 2026
Baku, Azerbaijan



**Aleksander Sladkowski
Tofiq Babayev (Eds.)**

**5th International Conference on
Problems of Logistics, Management and
Operation in the East-West Transport
Corridor (PLMO 2026)**

Abstracts

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About the Conference

The East-West Transport Corridor is an integral part of the ancient Silk Road and an initiative that requires the development of new mechanisms for regional economic partnership. It stimulates the economic prosperity, cultural exchange and communication between of the member countries. Moreover, it serves as a tool to promote peace and create sustainable development.

Being an integral part of the “One Belt One Road” concept, the East-West Corridor is aimed at improving trade routes, transport and economic corridors and creating new trade routes. The East-West Corridor is also considered to be the shortest trade route that connects Europe and China.

The main goal of the 5th International Conference on Problems of Logistics, Management and Operation in the East-West Transport Corridor is to bring together researchers and relevant representatives from the public, private sector, universities and international organizations to discuss scientific and practical issues such as, problems in the transportation of goods through different transportation methods. Taking into consideration the achievements of 4th Industrial Revolution, the introduction of digital technologies and digital economy could tackle the problem.

The conference this year is dedicated to the 75th anniversary of the distinguished scientist of Azerbaijan,

Doctor of Physical and Mathematical Sciences, Honored Teacher of Azerbaijan, Corresponding Member of the Azerbaijan National Academy of Sciences, Head of the Laboratory at the Institute of Mathematics, Professor Kamil Aida-zade.

Professor Kamil Aida-zade's Anniversary

Prof. Kamil Rajab oglu Aida-zade was born on December 23, 1950 in Qusar District. He graduated from the Azerbaijan State University in 1972, obtained the degrees of Candidate of Sciences in Physics and Mathematics in 1978, Doctor of Physics and Mathematics in 1989, the title of Professor in 1992, and was elected a Corresponding Member of ANAS in 2014.



After starting his professional life as a laboratory assistant at the Institute of Cybernetics in 1972, K. Aida-zade worked as a junior researcher, then as head of sector at the Computing Center of the Azerbaijan State University in 1974-77, as head of sector at the Institute of Cybernetics in 1977-79, as head of sector, the head of department, Deputy Director for Science at “Neftgazavtomat” SPC in 1979-94, chaired the Department of Applied Mathematics at ASOIU in 2004-2016, and the Department of Informatics at BSU in 2016-2018. He has been Head of Laboratory at the Institute of Control Systems of ANAS since 1995. Since 2026, he has been working as the head of the Decision-Making Methods and Applications Laboratory at the Institute of Mathematics. He also works as a professor at

the Department of Information Technologies and Systems at Azerbaijan University of Architecture and Construction.

K. Aida-zade developed various methods for solving various optimal control problems: conditional, unconditional, multi-criteria, global optimization, with lumped and distributed parameters. Under his direction, intelligent computer systems were developed for recognizing and understanding the text of speech and manuscripts the Azerbaijani language.

In 1981-1998, K. Aida-zade was the scientific supervisor of the work on the development of control systems of Urengoy and Yamburg gas condensate fields, dispatch operational control system of Aztransgaz PA. The "Control system of Yamburg gas field" project developed under his direction and with the involvement of leading Russian and Ukrainian scientific research centers won the competition announced by the Ministry of Gas Industry of the USSR in 1988 and was commercialized.

K. Aida-zade was a member of the Expert Council of the Higher Attestation Commission under the President of the Republic of Azerbaijan (1993-2001), the Dissertation Council of the Institute of Cybernetics (2001-2008). He has been a member of the Board of Directors of the State Examination Center since 2016. He is an expert of EU international scientific research programs.

K. Aida-zade is the author of 700 research articles (500 of them published abroad, 103 in Web of Science, 115 in Scopus database) and 3 books. 5 Doctors of Sciences and 22 Doctors of Philosophy defended their theses with him as

their advisor. His team has been awarded prizes and grants (CRDF, INTAS, EIF) in more than 10 competitions.

He is a member of editorial board of 9 journals, of which 5 are international. He is one of the Deputy Editors-in-Chief of International Journal of Computational Intelligence and a member of the editorial board of Ege University Journal of the Faculty of Science. He has been a reviewer of a Germany-based international mathematics journal since the 1980s. He is one of the associate editors of the journals: "Applied Mathematics and Fundamental Informatics", TWMS "Pure and Applied Mathematics", "Proceedings of Institute of Applied Mathematics", "Proceedings of the Institute of Mathematics and mechanics", "Informatics and control problems". Since 2016, he has been on the editorial board of the monthly journal "Abituriyent," published by the State Examination Center (SEC), which provides textbooks across all subjects to assist university and school entrance exam candidates.

He is also a member of the program and/or organizing committees of a number of international conferences on: "Optimization and applications" (OPTIMA-2008-2026), Problems of Cybernetics and Informatics (PCI-2006-2025), Management and control in solving engineering problems (MaCoSEP-2025), Information technologies and their applications (ITTA-2024,2026), Interactive Collaborative Robotics (ICR-2023-2026), Control and Optimization with Industrial Applications (COIA-2005-2026), Problems of Logistics, Management and Operation in the East-West Transport Corridor (PLMO-2021-2026), Mathematical

Optimization Theory and Operations Research (MOTOR-2023-2026), Information Technologies and Technical Means of Control (ICCT-2016-2025), Applied Mathematics and Fundamental Informatics (PMFI-2018-2026), Differential Equations and Their Applications (2018-2025), Mathematics, Its Applications and Mathematical Education (MPME-2014-2023), The 4th Congress of the Turkic World Mathematical Society (TWMS-2012), Current Problems of Modern Mathematics, Computer Science and Mechanics – II, Information-innovation Technologies: Integration of Science, Education and Business.

He was awarded diplomas of the Ministry of Instrument-Making of the former USSR in 1985, 1988, 2001, diplomas of the Ministry of Communications and Information Technologies of the Republic of Azerbaijan in 2007 and 2011 for high scientific achievements, and with certificates of merit of ANAS.

In 2011, K. Aida-zade was awarded the title of Honored Teacher.

The organizers and participants of the PLMO 2026 conference congratulate the outstanding scientist, Doctor of Mathematical Sciences, Corresponding Member of ANAS, Professor Kamil Aida-zade on his 75th birthday and wish him good health and further scientific achievements!

Plenary

Kamil Aida-zade

Optimization and Control Problems in Complex Hydrocarbon Pipeline Transportation Networks

Institute of Mathematics, Baku, Azerbaijan

Azerbaijan University of Architecture and Construction,
Baku, Azerbaijan

Abstract: The presentation will consider the following problem formulations arising in the control of hydrocarbon transportation in pipeline networks with complex looped structures:

- 1) Hydraulic calculation of raw material flow in pipeline systems with complex structures under both steady-state and transient flow regimes.
- 2) Determination of hydraulic resistance coefficients for linear sections of the pipeline network under steady-state and transient flow conditions.
- 3) Detection of sections and locations of raw material leaks in steady-state and transient operating modes.
- 4) Operational planning of steady-state operating modes for sources and consumers of raw materials, taking into account the pipeline transportation network.
- 5) Optimal control of transient operating modes in the pipeline transportation network.
- 6) Calculation of the work performed during the transportation of raw materials in a pipeline network with a complex structure.

The paper will describe numerical methods for solving

these problems, and for some of them, results of numerical experiments will be presented.

Tamaz Natriashvili, Revaz Kavtaradze, Giorgi Chilashvili
The Influence of Working Fluid Turbulence on the Efficiency and Environmental Performance of Traditional Diesel Engines Converted to Natural Gas and Hydrogen with Forced Ignition

Rafael Dvali Institute of Machine Mechanics, Georgia

Abstract: A key challenge in modern transport engine manufacturing is converting a vast fleet of vehicles to alternative fuels that decarbonize combustion products. This paper examines the potential for minimizing NO_x and noise emissions, as well as improving the performance of production diesel engines converted to gas engines. Three converted diesel engine configurations are considered: natural gas, spark-ignition hydrogen, and gas-ignition diesel engines. The study utilizes a 3D mathematical model of in-cylinder processes based on fundamental Navier-Stokes equations. The mathematical model is implemented using a numerical control volume method. The experimental portion of the study (engine performance indexing, piston surface temperature measurements, and NO_x emission measurements) was primarily aimed at verifying the mathematical modeling results. The conducted research revealed that the kinetic energy of Turbulence (KET) of the working fluid is a factor determining both environmental performance (NO_x

emissions, engine noise) and efficiency (changes in pressure and heat release rate in the combustion chamber, heat loss into the wall). Clearly, by adjusting KET, the environmental and efficiency performance of an engine converted to alternative fuels can be significantly improved. Specific examples are provided to support this assertion.

Keywords: Diesel, conversion, natural gas, hydrogen, forced ignition, 3D mathematical modeling, kinetic energy of Turbulence, model verification, minimization of nitrogen oxides.

Sections

A.T. Harunov, Kh.V. Aliguliyeva

Innovative Renewable Energy Technologies as a Driver of Sustainable Economic Development: Opportunities for Solar Energy Integration in Azerbaijan

Sumgayit State University, Sumgayit, Azerbaijan

Azerbaijan State Oil and Industry University, Baku, Azerbaijan

Baku State University, Baku, Azerbaijan

Abstract: The aim of this study is to comprehensively analyze the current state, development dynamics, and economic impacts of Azerbaijan's renewable energy sector within the context of the global energy transition. Within the framework of the research, structural changes in renewable energy sources over the period 2018–2025 were assessed based on statistical data, with particular emphasis on the growth trends of solar and wind energy. At the same time, Azerbaijan's position in regional and global rankings was examined comparatively, revealing that the country's share of renewable energy remains below the global average. From a methodological perspective, the study employs econometric time series analysis, the Levelized Cost of Energy (LCOE) model, and the Revealed Comparative Advantage (RCA) and Relative Trade Advantage (RTA) indices, which measure international trade competitiveness. The LCOE results indicate that solar and wind energy are economically

competitive, while hybrid energy systems, in particular, provide a more balanced and efficient production model. In addition, innovative technologies such as Floating Photovoltaics (FPV) and Building-Integrated Photovoltaics (BIPV) are identified as having significant potential to enhance energy efficiency in the long term. The findings of the analysis demonstrate that the development of the renewable energy sector has a positive impact on Azerbaijan's macroeconomic indicators. In particular, meeting domestic energy demand through alternative sources creates favorable conditions for expanding natural gas exports and generating additional economic value. The positive dynamics of the RCA and RTA indices confirm the strengthening of the country's competitive advantage in electricity exports. The study also highlights the importance of the "green energy zone" concept for regional development and substantiates the strategic role of the Karabakh and Eastern Zangezur regions in this direction. Furthermore, the necessity of implementing energy storage systems, smart grids, and optimal management mechanisms for the large-scale integration of renewable energy sources is emphasized. In conclusion, the study determines that the formation of Azerbaijan's renewable energy strategy based on the integration of technological innovation, economic efficiency, and institutional development is of critical importance for strengthening the country's energy security and ensuring a competitive position in the global green energy market.

Ababil Nagiyeva, Sakit Verdiyev, Kenan Abdullayev

Spatial Domain Image Steganography Methods for Secure Information Exchange in Digital Transport and Logistics Systems: A Survey and Comparative Analysis

Azerbaijan Technological University, Azerbaijan

Abstract: Steganography and steganalysis are two parallel development directions of data Steganography is the art of transmitting a secret message in an electronic carrier of information without causing suspicion concerning the presence of hidden information of a third party. An integral part of steganography is steganalysis aimed at detecting hidden messages in the information carriers. In this paper we focused on image steganography methods in spatial domain. This article provides state of the art survey and analysis of steganography and steganalysis methods mainly covering the fundamental concepts of steganography systems and its basic operations and evaluation criteria, the progress of digital image steganography and steganalysis methods. In the same time enhanced description and analysis of last recent years of proposed interpolation methods are investigated. On the base of investigated scientific papers, basic principles and recommendations concerning improvement quality of cover image for secret message embedding by using interpolation methods are defined In addition, the paper highlights potential applications of image steganography in emerging domains such as intelligent transportation systems and digital logistics, where secure data exchange between vehicles, infrastructure, and monitoring systems

is becoming increasingly important. The survey also reviews recent studies that explore the use of steganography techniques for enhancing information security in transportation and logistics environments.

Keywords: Steganography system; data hiding; spatial domain; interpolation; steganalysis; Intelligent Transportation Systems (ITS); digital logistics; information security.

Afet Asgerova

Application of Innovative Technical and Technological Solutions in Various Types of Transport

Azerbaijan Technological University, Ganja, Azerbaijan

Abstract: The use of various types of vehicles, whether in the transportation of goods, in the transportation of passengers, or in the use of personal vehicles, is known to be a waste of time, to prevent damage to goods or to ensure that passengers reach the required place at any time, as well as to cause environmental pollution, emission of harmful gases, and fuel consumption in the transportation of goods. In this regard, the application of innovative technical and technological solutions in various types of transport is inevitable and is considered a topical issue. Considering the relevance of harmful gases in the air - especially the environment, high fuel consumption in transport systems, accidents, etc. factors, the application of innovative technical and technological solutions in various types of transport recommended by us is aimed at increasing the capabilities of various types of transport

vehicles. The application of innovative solutions makes a significant contribution to increasing competitiveness in the transport sector, improving service quality and ensuring sustainable development, as well as to the development of the transport sector.

Keywords: Innovation, digitalization, technological solutions, green vehicles, sustainable development, innovation, intellectual, automation, safety, efficiency.

Agil Huseynov, Svetlana Ahmadova, Sevinj Javadova, Aysel Huseynzade

Analysis of Improvement Process of Intellectuality of Systematical Designing Process of Technical Systems

Sumgayit State University, Sumgayit, Azerbaijan

Abstract: The present research is deal with the automated designing procedures of technical systems with complex structures and analyses the available ways for improvement of intellectuality of automated designing systems. In this respect, herein are specified the key subjects of the systematical designing stages of technical systems and are applied the algorithms of their fulfillment. Generally, the possibility of utilization of data base and artificial intellectual elements are under the research in order to realize the designing procedures of the conceptual design-ing stage which demands creative approach. Meanwhile, the article is deals with the application tasks of designing process of data base and herein, the conceptual model of designing procedures are under the formation.

Keywords: Automated designing system, systematical designing, conceptual model, unified model, data base.

Ahmet Talha Bektaş, Chingiz Hajiyev

Adaptive Iterative Least Squares Estimation for GPS-Based Navigation of Small Satellites Under Variable Visibility Conditions

Istanbul Technical University, Istanbul, Türkiye

Istanbul Gelisim University, Istanbul, Türkiye

Abstract: Global Navigation Satellite System (GNSS)-based navigation is the primary method for autonomous orbit determination of Low Earth Orbit (LEO) satellites. However, the highly dynamic space environment introduces challenges such as frequent satellite visibility changes due to Earth occultation, antenna field-of-view limitations, and variable signal strength. This paper proposes an adaptive Iterative Least Squares (ILS) framework to address the effects of highly variable GPS satellite visibility for small LEO satellites. The method employs a high-fidelity orbital dynamics model based on Cowell's formulation, including J2–J4 Earth gravitational perturbations, atmospheric drag modeled using NRLMSISE-00, and third-body perturbations. A three-stage visibility filtering process is implemented, incorporating geometric occultation checks, antenna pattern constraints using Patch-Excited-Cup (PEC) antenna characteristics, and link-budget-based C/N0 thresholding. A realistic measurement noise model is implemented by scaling pseudorange variance as a

function of the instantaneous carrier-to-noise density ratio. The estimator utilizes QR decomposition to enhance numerical stability and adopts a warm-start strategy to improve convergence performance. Simulation results using the STSAT-3 reference satellite indicate high-precision positioning, achieving an RMSE of 2.00 m with eight or more visible satellites. Furthermore, the estimator demonstrates robustness during severe visibility degradation ($4 \leq n < 6$), maintaining an RMSE of 3.72 m despite poor geometric conditions.

Keywords: GPS navigation LEO satellites Iterative Least Squares Variable Visibility Noise Modeling Orbit determination.

Akan Guven, Chingiz Hajiyeu

Robust Controller for B-747 Aircraft Fault-Tolerant Flight Control System

Istanbul Technical University, Istanbul, Türkiye

Istanbul Gelisim University, Istanbul, Türkiye

Abstract: Aircraft control surface loss of effectiveness is occurred on the ailerons and the lateral dynamics of Boeing-747 aircraft are affected. The magnitude of this fault is estimated via Two-Stage Kalman filter. To compensate the impact of the fault, a robust controller is designed. The flight dynamic model of Boeing-747 aircraft is simulated in a steady state flight during the fault. The condition of the aircraft was stable till the aileron is teared %50. To compensate the impact of the fault, a robust controller is designed.as linear matrix inequalities. The

main contribution of this work is that the passive controller keeps the aircraft stable under a fault domain. Robust stabilization is formed by regarding the fault as parametric uncertainty. The LMI technique become a common solution to these types of faults which is an optimization problem includes constraints to emphasize robustness.

Keywords: Robust Control, Fault-Tolerant Control, Fault Detection, Actuator/Control Surface Fault Estimation, Lateral State Estimation, Electronic Flight Control System, Two-stage Kalman Filter, State Space Model, Passive control, Linear Matrix Inequality.

Aleksandr Adadurov, Aleksandr Ivanov

Cascade Mathematical Model of Damage Accumulation in Freight Wagon Running Gear Under Multiple Wheel Flats

Emperor Alexander I Saint Petersburg State Transport University, Saint Petersburg, Russia

Abstract: Current condemnation criteria in Russia define rejection thresholds for a single wheel flat on a freight wagon axle and do not account for the synergistic effect of two or more simultaneous defects on the same bogie. This paper presents the problem formulation and architecture of a cascade damage accumulation model covering three critical running gear components — the cassette-type axle box bearing, the primary suspension spring set, and the bogie side frame — under the action of $N \geq 2$ wheel flats. The model integrates five complementary methods:

nonlinear contact mechanics following Zhai's law for impact force generation with N-flat superposition; multibody dynamic simulation (MBS) of the bogie (17 degrees of freedom); fatigue life calculation for the cassette bearing using the Ioannides–Harris model with a temperature-dependent lubricant viscosity modifier; nonlinear spring mechanics with a coil-clash detector and Miner's rule; and finite element stress analysis of the side frame verified against the Goodman diagram. The key physical finding is that two wheel flats with angular offset $\Delta\varphi \neq \pi$ produce an asymmetric twisting moment on the bogie frame and increase the equivalent bearing load nonlinearly, with the load growing proportionally to N raised to the power $10/3$. The proposed residual life function $L_r(N, d, v, T, L)$ is intended for validation against trackside hot-box detector (CTSM) data along the Saint Petersburg–Chita route (9,288 km), accounting for the temperature gradient as an independent physical degradation factor.

Keywords: Wheel flat, cassette axle box bearing, bogie side frame, fatigue damage accumulation, multibody dynamics (MBS), Ioannides–Harris model, residual life, hot-box detector (CTSM), Trans-Siberian Railway, freight wagon.

Ali Aliyev, Vagif Hasanov

Limitations of Dynamic Positioning Systems. A Safety-Critical Perspective for Maritime Navigation

Azerbaijan State Marine Academy, Baku, Azerbaijan

Azerbaijan Technical University, Baku, Azerbaijan

Abstract: Dynamic Positioning (DP) systems are now central to offshore vessel operations that require precise station-keeping without anchoring, including subsea construction, diving support, cable laying, and offshore energy support. Their operational value is undeniable, yet long experience at sea shows that technical sophistication does not remove all risk. In practice, loss of position may still develop through weaknesses in sensor integrity, position-reference performance, propulsion and power availability, software behaviour, environmental loading, or operator response. This paper examines those weaknesses from a safety-critical standpoint. Instead of treating DP as a purely technical control problem, the study approaches it as a socio-technical system in which sensing, computation, actuation, environmental disturbance, and human judgment are closely interdependent. The discussion is based on academic literature, industry guidance, and a real-world diving-support incident that demonstrates how multiple deficiencies may align under operational pressure. The paper argues that safer DP operations require more than duplicated hardware, they also require stronger fault detection, more credible reference validation, improved operator support, more realistic simulator training, and robust cyber protection.

Keywords: Dynamic positioning, offshore vessels, maritime safety, redundancy, position reference systems, sensor fusion, operator support, resilience, cybersecurity, fault tolerance.

Ali Namazov, Liudmila Guzikova, Zahid Mamedov, Eldar Asadov, Allahkhah Hadi

Innovative Activities of Russian Oil and Gas Companies Aimed at Decarbonization

Peter the Great Saint-Petersburg Polytechnic University,
Saint-Petersburg, Russian Federation

St. Petersburg Branch of the Financial University under
the Government of the Russian Federation

Azerbaijan State University of Economics, Baku,
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Institute of Mathematics, St. Petersburg State University,
St. Petersburg, Russian Federation

Abstract: The article is devoted to one of the urgent issues of the global climate agenda related to the preservation of the fundamental conditions of human existence - the fight against atmospheric pollution and the increase in its carbon dioxide content. The work is based on an analysis of key provisions related to decarbonization goals, organizational, managerial and technological aspects of innovation activities aimed at reducing CO₂ emissions. The positive and negative features of the global and Russian approach to decarbonization are noted. The directions of innovation activity relevant for Russian companies in the oil and gas sector in the light of the global climate agenda, environmental protection, social responsibility and national interests in the modern geopolitical space are considered. The practical experience of innovations of the largest companies in the

industry aimed at decarbonization is described. The problems of companies' innovation activities are identified due to the difficulties in attracting investments for innovative projects, especially in conditions of market instability and oil prices, as well as a lack of economic incentives to replace traditional energy with alternative energy. Recommendations are formulated on promising areas of innovation that ensure decarbonization through the beneficial use of associated petroleum gas, and a systematic change in the structure of the energy balance over the strategic horizon.

Keywords: Innovation, decarbonization, oil and gas industry, technologies for capturing and using carbon dioxide, the use of associated petroleum gas, low-carbon fuels, renewable energy sources, green transformation.

Aliagha Gasimov, Sevar Mammadova, Elman Ibishov

Innovation as a Catalyst for Transport Sector

Development: Evidence from Azerbaijan

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Azerbaijan

Abstract: The main objective of this study is to provide an econometric assessment of the impact of innovations on the development of the transport sector in the Republic of Azerbaijan. To this end, theoretical approaches regarding the influence of innovations on the transport sector have been examined. The literature review reveals that innovations contribute positively to the development of the transport sector through various channels, including

increased efficiency in freight transportation, reduction of operational costs, and mitigation of environmental problems. The transport sector plays a significant role in both the global and national economy by exerting direct and indirect effects. In recent years, the increased attention of the state to this sector has stimulated its development. In order to determine the impact of innovations on the development of the transport sector in Azerbaijan, two estimations were conducted using the FMOLS method. Due to the lack of sufficient statistical data on innovations, re-search and development (R&D) expenditures—representing the creation and advancement of innovations—were used as a proxy variable. The indicators employed in the econometric models cover the period 2005–2024 and were obtained from the database of the State Statistical Committee of Azerbaijan. The econometric results indicate that, in the long run, R&D expenditure will have a positive effect on profit growth and value added in the transport sector. Although there has been a substantial increase in R&D expenditures in Azerbaijan over the years, a comparative analysis with other countries reveals existing shortcomings. It is believed that the implementation of appropriate measures in this direction can further enhance R&D expenditure in the country. The necessary diagnostic tests conducted for the applied econometric models confirm their adequacy.

Keywords: Transport Sector, Innovations, Research and

Development (R&D) Expenditures, Econometric Models, Fully Modified Ordinary Least Squares (FMOLS) Method.

Alihuseyn Haziyeu, Akif Ismayilov, Vagif Hasanov

Influence of Heat Source Parameters and Heat Transfer Intensification Methods on the Performance of Shipboard Freshwater Generators

Azerbaijan State Marine Academy, Baku, Azerbaijan
Azerbaijan Technical University, Baku, Azerbaijan

Abstract: Improving energy efficiency and reducing fuel consumption remain primary technical challenges in maritime transport. This study evaluates the thermodynamic performance of shipboard vacuum freshwater generators utilizing the main engine's jacket cooling water as a heat source. Particular attention is given to the effect of heating medium parameters, namely temperature and mass flow rate, on the daily distillate production.

Calculations based on operational datasets demonstrate that increasing the inlet temperature from 75 °C to 85 °C significantly raises the logarithmic mean temperature difference, thereby boosting daily fresh-water production from 21.36 to 38.16 tons. However, temperatures exceeding 82 °C exponentially accelerate scale deposition on the outer surfaces of the heat ex-changer tubes, leading to a rapid decline in the overall heat transfer coefficient.

To address this operational limitation, the study introduces and analyzes new technical solutions for marine transport: the application of passive (internally corrugated tubes) and active (low-frequency pulsation)

heat transfer intensification methods. These modifications structurally and hydrodynamically improve heat exchange without requiring an increase in the thermal load of the main engine. The obtained results can be applied in the optimization of shipboard freshwater generation systems, allowing an increase in productivity while maintaining stable operation and reducing the negative effects of fouling.

Keywords: freshwater generator, tubular heat exchanger, waste heat recovery, heat transfer intensification, internally corrugated tubes, low-frequency pulsation, maritime transport.

Aliya Imangazieva

Robust Decentralized Multi-Channel Control System with Time Delay

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Abstract: The task is to synthesize a robust multi-channel decentralized control system with delay under the influence of external uncontrollable perturbations. Decentralized robust control for such a system is defined as the task of constructing r local control blocks, for the functioning of which only their measured outputs and inputs are used, while cross-couplings between agents must be compensated. In this case, the required quality of transient processes in local agents of the plant is specified by equations of local reference models. To solve the problem, each agent of the system uses an auxiliary loop

method based on the principle of dynamic compensation: a generalized perturbation signal is isolated and then suppressed using an auxiliary loop and two observers with a high gain coefficient. The structure of the synthesized system is such that the isolated perturbation signal contains information not only about the parametric uncertainty of the plant model, but also about the delay and external perturbations acting on each agent individually. The Lyapunov function method is used to prove stability. A numerical example of a system consisting of three agents is considered, illustrating the algorithm's performance for the required dynamic accuracy. The control system is simulated in the Simulink Matlab package. The simulation results confirmed the theoretical conclusions and demonstrated the effectiveness of the control system, taking into account delays in conditions of parametric uncertainty and external uncontrollable perturbations.

Keywords: Robust control, multichannel, decentralized, time delay, auxiliary loop, perturbations.

Altun Balayev, Shahnaz Shahbazova

AI-Generated Media Identification via Neuro-Symbolic Learning and Fuzzy Reasoning: A Conceptual Approach for Cross-Modal Detection

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Azerbaijan

Obuda University, Budapest, Hungary

Abstract: The rapid spread of AI-generated content in the

form of synthetic images and deep-faked videos, as well as artificially-created audio, is a grave danger to the credibility of online information, social credibility, and democratic discourse. The existing detection systems are predominantly founded on entirely data-driven deep learning systems which are uninterpretable and not effective in generalizing new generative architecture. The article furthers a hybrid Neuro-Symbolic (NeSy) model using a fuzzy logic to detect AI-generated media with so much power in various modalities. The neural component is formulated on a multi-modal backbone utilizing Contrastive Language-Image Pre-training (CLIP) besides Convolutional Neural Networks (CNN) in deriving discriminative spectral, spatial, and semantic characteristics. A symbolic reasoning layer, which encodes domain information as logical rules that encode that authenticity clues are represented by, and a fuzzy inference engine, which quantifies the uncertainty of detection by membership functions, represent these characteristics. Conducted tests on the FaceForensics++ and Defactify4 test sets indicate that the suggested architecture can be competitive in terms of accuracy and generate interpretable and confidence-ranked decisions in detection. Our approach addresses three decades-old problems with AI-generated media detection, namely, poor generalization to unseen generative models, lack of explanation in detection, and incapacity to resist the adversarial or compression-based perturbation.

Keywords: AI-generated media detection, neuro-symbolic

learning, fuzzy rea-soning, deepfake detection, CLIP, explainable AI, multi-modal forensics, diffu-sion models.

Amantay Daryn, Gulmira Mukhanova, Tolebay Tokzhan
Transformation of EAEU transport corridors under pressure from sanctions

Satbayev University, Almaty, Kazakhstan

Abstract: Since 2022, sanctions pressure has significantly reshaped the architec-ture of transport corridors across the Eurasian Economic Union (EAEU). Re-strictions on maritime access, financial settlements, insurance mechanisms, and cooperation with international logistics operators have disrupted traditional supply routes and increased operational uncertainty. In response, EAEU member states initiated a large-scale reconfiguration of transport flows, accelerating the development of alternative corridors and multimodal logistics solutions. This pa-per examines the structural transformation of EAEU transport corridors under sanctions pressure, with particular emphasis on the Trans-Caspian International Transport Route (TITR), also known as the Middle Corridor. The study analyzes changes in the geography of cargo flows, the dynamics of freight volumes, infra-structure modernization, and institutional adaptation mechanisms. Special attention is paid to the growing role of Kazakhstan as a transit hub linking China, Central Asia, the Caspian region, and Europe. The findings indicate that sanctions have acted not only as a destabilizing factor but also as a catalyst for corridor diversification, digitalization

of logistics processes, and strengthening of regional connectivity. The expansion of the Trans-Caspian route demonstrates the emergence of a more flexible and geographically diversified logistics architecture within the Eurasian space. The results contribute to understanding long-term trends in corridor development and may support strategic planning for enhancing transport resilience in the EAEU.

Keywords: Eurasian Economic Union; transport corridors; sanctions pressure; Trans-Caspian International Transport Route; Middle Corridor; logistics transformation; multimodal transportation; transit infrastructure; corridor diversification; Eurasian connectivity.

Andrey Rychkov, Majid Abbasov

Metaheuristic Optimization for Cost-Optimal Road Alignment under Terrain-Dependent Construction Costs

St. Petersburg State University, St. Petersburg, Russia

Abstract: The problem of constructing a road between two fixed points with minimal total cost on uneven terrain can be formulated as a variational problem with a nonlocal integral functional. In contrast to classical shortest-path formulations on graphs, the objective depends not only on local transition costs but also on the accumulated length of the already constructed part of the road, which makes direct application of standard graph algorithms insufficient. This paper studies a grid-based

approximation of the road-alignment problem and compares several global optimization strategies, including ant colony optimization, simulated annealing, quantum-annealing-inspired search, and stochastic tunneling. In addition to reporting solution quality on a model example and on a benchmark of randomly generated quadratic cost fields, the paper uses the Wilcoxon signed-rank test to assess whether the observed differences between the strongest methods are statistically significant. The experiments show that simple random walks are not competitive, whereas ant-colony and annealing-based methods produce substantially better solutions. On the main test example, the best result is achieved by quantum annealing combined with stochastic tunneling, while on the broader benchmark the strongest methods remain statistically comparable on the tested instances.

Keywords: Road alignment, Variational calculus, Ant colony optimization, Simulated annealing, Quantum annealing.

Artem Kipin, Akylai Zhumabekova

Deep Learning Model Compression and Optimization for Real-Time Edge Computing in IoT Environments Kyrgyzstan

Abstract: The rapid expansion of Internet of Things (IoT) ecosystems demands efficient deep learning inference on resource-constrained edge devices. This paper presents a hybrid compression framework combining structured pruning, INT8 quantization, and knowledge distillation for

real-time IoT edge computing. Our method achieves up to 12.4× model size reduction and 3.8× inference speedup on ARM Cortex-M devices with less than 0.7% accuracy degradation. The proposed framework introduces three key innovations: (i) a channel importance scoring mechanism based on BatchNorm scaling factors with adaptive threshold selection, (ii) a per-channel asymmetric quantization scheme with KL-divergence based calibration, and (iii) a lightweight self-distillation strategy that eliminates the need for large teacher models. Extensive evaluations on image classification (ImageNet-Edge), human activity recognition (UCI HAR), and acoustic event detection (ESC-50) tasks demonstrate that compressed models maintain > 97% of original FP32 accuracy while reducing energy consumption by 74% and meeting sub-100 ms latency constraints on commercial edge hardware including Raspberry Pi 4, Google Coral, and STM32F7 microcontrollers. The proposed framework is validated through ablation studies, sensitivity analysis, and comparison with state-of-the-art methods including AMC, NetAdapt, and HAQ. Our compressed models achieve 31% smaller model size, 19% lower latency, and 0.7% higher accuracy compared to the best competing method. All code and pre-trained models are publicly available to facilitate reproducibility.

Keywords: Deep learning compression, edge computing, Internet of Things, pruning, quantization, knowledge distillation, real-time inference.

Arzu Safarova

**Growth, Employment and Road Traffic Injuries:
Nonlinear Short-Run Dynamics and Long-Run Stability**

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Abstract: At the first stage of the study, a linear ARDL model was estimated to examine both the long-run and short-run relationships between macroeconomic indicators and road safety. The results confirmed the presence of a long-run coin-tegration relationship between unemployment, GDP per capita, and road traffic injury rates. However, the short-run linear effect of GDP on road traffic injuries appeared to be statistically unstable. Given the theoretical foundations of the Kuznets hypothesis (1955) and the possibility of a structural transformation in the impact of economic growth on road safety, a nonlinear specification of the same variables was subsequently estimated by including a quadratic term of GDP (an inverted U-shaped model). The findings revealed not only a statistically significant long-run negative relationship between unemployment, GDP per capita, and road traffic injuries, but also a short-run nonlinear relationship with GDP. In particular, the results indicate the existence of a turning point (around 2005 in the case of Azerbaijan), after which further economic growth began to contribute to a reduction in road traffic injuries.

Keywords: Road Traffic Accidents (RTAs), ARDL-ECM Model, Inverted U-Shaped Model, GDP per Capita, Unemployment Rate.

Ashraf Balametov, Gulnara Musakhanova, Afaq Salimova,
Tarana Isayeva

**Software for Estimating the Commercial Cost of
Electricity Production to Generate Profit From**

Azerbaijan Scientific-Research and Design-Prospecting
Power Engineering Institute (AzRDPPEİ), Baku,
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Azərişiq" Open Joint Stock Company, Baku, Azerbaijan
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Abstract: Optimizing the operation modes of power systems and power associations is a central focus of operational dispatch services, and their role is significantly increasing in modern conditions with the transition to market-based methods of managing power systems in the electric power industry. When optimizing EPS modes, two main optimization tasks were considered: the most advantageous load distribution between parallel power plants and the selection of the composition of equipment included in the operation. These tasks related to a given point in time and to daily planning of modes. This article examines issues of optimizing the active power mode in a wholesale market environment. By the early 1990s, a large number of large thermal power plants had been built, and unique cascades of hydroelectric power plants had been constructed. High- and ultra-high-voltage overhead lines had been put into operation. The process of creating and developing the Unified Energy

System was underway. An effective centralized dispatch control system was created, ensuring a reliable and economical electricity supply to the national economy. The large-scale development of the electric power industry and the creation of the Unified Energy System (UES) dramatically complicated its management tasks. The UES acquired the properties of a large artificial cybernetic system. To reduce the complexity of calculations, improve information support, and ensure optimal controllability, the entire UES dispatch control structure was built using decomposition methods. The results of simulation calculations for the problem of optimizing the wholesale active power market are presented using the example of the Azerbaijani UES with combined-cycle plants with an efficiency of 53%, modular power plants with an efficiency of 46%, and thermal power plants with an efficiency of 38%.

Keywords: Power system, optimization of the active power mode, Lagrange method, specific fuel consumption, relative increases, cost of electricity production.

Ashraf Balametov, Tarana Isayeva, Eldar Balametov
Optimization of The Power System Mode for Active Power by the Hopfield Neural Network Method
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Azerbaijan State Oil and Industry University Baku, Azerbaijan
AZERCONNECT” LLC, Baku, Azerbaijan

Abstract: Optimization of power system modes is a central issue in the work of operational dispatch services. This article examines the application of Hopfield artificial neural networks to solving the problem of optimal load distribution between thermal power plants in the Azerbaijan Electric Power System. The power system is controlled by changing its state. The main control parameters are the active power of the generator equipment operating at the stations and its output. In a market economy, non-optimal operating conditions for thermal power plants can lead to significant economic damage not only to the power system but also to the national economy as a whole. Solving the optimization problem involves formulating an optimality criterion, adequately representing the object, i.e., constructing a mathematical model, and selecting a solution method. Among the most common approaches to formalizing its solution are the relative increment method, various modifications of gradient methods, and hybrid methods. With a large number of variables, their implementation is significantly complicated by the need to solve high-dimensional nonlinear systems of equations. From this perspective, the use of artificial intelligence (AI) methods, in particular artificial neural networks (ANN), is promising. AI methods do not involve complex algorithmic calculations. The performance of the developed program was verified on a test circuit with three power plants using a Hopfield neural network and compared with the results of a numerical simulation

method. Unlike existing approaches, this article utilized the dependence of active power losses on power plant generation in the form of a verbal description of an artificial neural network, derived from the results of multivariate power flow calculations.

Keywords: Power system, optimization, specific fuel consumption, relative gains, Hopfield neural networks.

Asif Aliyev, Dilavar Karimli, S. M. Pur Riza

Future Trends of Renewable Energy in Azerbaijan

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Institute of Mathematics, Baku, Azerbaijan

Abstract: This study examines the prospects of renewable energy development in Azerbaijan by applying time-series forecasting methods. Considering the country's sustainability goals and international climate commitments, the expansion of renewable energy sources has become increasingly important for ensuring long-term energy security and environmental sustainability. The research analyses historical data from 2007 to 2023, covering major renewable energy sources, including solar, wind, hydropower, and biomass. Using ARMA and ARIMA forecasting models, the study projects a steady and continuous increase in solar energy production through the year 2028. Despite this positive outlook, the overall transition toward renewable energy remains relatively slow. Several challenges contribute to this situation, including financial constraints, infrastructural

limitations, technological barriers, and the need for more comprehensive and supportive policy frameworks. The results of the analysis emphasise the importance of increasing investments in renewable energy projects, strengthening regulatory policies, and encouraging technological innovation. Overall, the findings provide valuable insights and practical implications for policymakers, researchers, and energy sector stakeholders working toward the development of a more sustainable and diversified energy system in Azerbaijan.

Keywords: Azerbaijan, renewable energy, time-series forecasts.

Asif Guliyev, Parviz Mammadov, Valeh Alquluyev, Kamran Shiraliyev, Khazar Najimbayli, Vasif Kerimov

Artificial intelligence (AI) in the optimization of logistics management

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Institute of Mathematics, Baku, Azerbaijan

Abstract: The modern geopolitical and economical issues, the logistics management encompasses the optimization of all activities related to material transportation in external markets with low cost, high security, and reduced transportation time. Logistics management is the key factor in company strategic management, and considering the scarcity of raw materials and global issues, the optimization of all covered activities of logistics is much more required. The optimization activity covers reducing security risk, increasing safety issues, reducing transport

cost and time, continuous training of the logistics team, and the application of modern computer programs and the current last application of artificial intelligence (AI) tools. The AI application is the key step of optimization in logistics in order to avoid all negative impact, especially in today's global issues. The purpose of the study is to define integrated logistics management, logistics problems, and the application of AI tools for the optimization of logistics management for company strategic aim achievement. The applied significance of the study is the definition of all related logistics problems and the application of AI tools for the optimization of management. Scientific innovation of the research is the modern approach, such as integrated logistics management and the definition of advantages and disadvantages of AI application.

Keywords: AI tool, logistics management, inventory management, integrated production planning and control, KAIZEN, AI&ML tool, ILM.

Asif Guliyev, Parviz Mammadov, Valeh Alquluyev, Vasif Kerimov

The Geoeconomic Importance of Zangezur Corridor

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Institute of Mathematics, Baku, Azerbaijan

Abstract: The article defines and analyzes the roles and economic prospects of the Zangezur corridor, one of the important geostrategic projects of the modern era, in the integration of global and regional transport networks. The main goal of the study is to determine how this corridor

will change the economic, and geopolitical landscape of the South Caucasus and its importance as an alternative route for the diversification of transport routes in international freight transportation from Asia to the Middle East and Europe. The Zangezur corridor is located at the intersection of the East-West (Middle Corridor) and North-South transport routes, ensuring the integration of railways and highways into a single network. This corridor shortens the access of the Middle East, China and Central Asian countries to Europe, reduces freight transportation costs, ensures logistics security, and significantly reduces transit time, which is an important element of international freight transportation, as well as increases the economic efficiency of freight transportation. The project not only creates a direct land connection between the Middle East, Asia and Europe, but also connects Azerbaijan and Türkiye, and plays a significant role as a economic catalyst for the exit of all regional countries. The integration of transport networks contributes to ensuring long-term peace, economic growth, and security in the region by increasing economic independence.

Keywords: Zangezur corridor, geoeconomics, transport integration, Middle Corridor, logistics, South Caucasus, transit.

Aygun Jafarova

Ways to Optimize Logistics Services in Tourism

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Abstract: Tourism and logistics are interdependent areas, and the effective operation of tourism depends on an effective logistics system. Transportation organization, supply chain management, information flow integration and risk reduction are the main directions of the tourism-logistics relationship. The application of multimodal transport models, especially the development of infrastructure facilities such as Heydar Aliyev International Airport and Azerbaijan Railways, accelerates the movement of tourists and creates conditions for the expansion of domestic tourism. Supply chain management based on the “Just-in-Time” principle, cooperation with local manufacturers and the application of digital technologies allow for cost reduction and improvement of service quality. Online reservation and information systems, including platforms such as Booking.com, contribute to the automation of logistics processes and increased tourist satisfaction. At the same time, there are difficulties such as lack of infrastructure, seasonal tourist flow, high logistics costs and personnel problems. To overcome these problems, it is important to develop transport and logistics infrastructure, expand digitalization, train professional personnel and apply green logistics principles. As a result, the optimization of logistics services increases the competitiveness of the tourism sector and ensures its sustainable development.

Keywords: Tourism, logistics, transport, service, quality.

Aynura Yahyayeva

Evaluation of the Role of Investments in Enhancing the Competitiveness of the East–West Transport Corridor in the Context of Geo-Economic Changes

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Abstract: Geo-economic changes occurring in the modern global economic system have significantly increased the importance of international transport and logistics routes. The expansion of global trade, the strengthening of interregional economic relations, and the emergence of new transport routes have turned the development of international transport corridors into a strategic priority. In this context, international transit routes developing along the East–West axis play a crucial role in facilitating freight transportation between Asian and European markets and contribute to the efficient organization of global trade flows. The purpose of this study is to evaluate the role of investments in enhancing the competitiveness of international transit transport routes in the context of geo-economic changes. Within the framework of the research, the impact of investments directed toward transport infrastructure, the development of logistics centers, and the implementation of modern transport technologies on the efficiency of international transport systems is analyzed. The findings of the study indicate that investments in transport infrastructure and logistics systems significantly contribute to increasing transit potential, improving the speed and efficiency of cargo transportation, and strengthening interregional economic cooperation. At the same time, the implementation of modern logistics technologies and international investment projects is considered one of the key factors for the long-term development and competitiveness of international transit routes.

Keywords: Geo-economic changes, Investment, International transport routes, Logistics infrastructure, Competitiveness.

Ayshan Mammadova, Seymur Mammadov, Nushaba Hajiyeva

Economic Improvement of Rural Settlements in the Karabakh Economic Region: Main Trends and Development Features

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Abstract: After the 44-day Patriotic War, the reconstruction and redevelopment process initiated in the liberated territories of Karabakh holds strategic significance for the restoration of the social and economic foundations of rural settlements. The destruction caused by the prolonged occupation necessitated the establishment of a modern, sustainable, and diversified model for the rural economy in the region. Reconstruction efforts encompass not only the rehabilitation of residential settlements but also the systematic development of transport, energy, water, and social infrastructures. Government investments, international financial resources, and private sector participation are aimed at ensuring the long-term sustainability of the rural economy. The creation of agro-parks, industrial zones, and clusters facilitates the development of non-agricultural sectors alongside agriculture. Human capital plays a central role in the restoration of the rural economy. Compulsory, voluntary (return), intellectual, and

entrepreneurial migration contribute to the restructuring of the region's socio-economic system. In particular, attracting highly qualified specialists and investors promotes innovation, technological modernization, and increased economic activity. Overall, the reconstruction projects carried out in the Karabakh economic region make a significant contribution to the sustainable development of rural settlements, the phased return of internally displaced persons, and the realization of the region's socio-economic potential.

Keywords: Rural settlement, reconstruction and redevelopment, human capital, sustainable development, regional economy.

Aytan Jafarova

**Digitalization of Transport & Logistics Sector:
Enhancing Tourist Mobility and Destination
Competitiveness in Azerbaijan**

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Abstract: Azerbaijan, located at the crossroads of the East-West Transport Corridor, is undergoing a significant digital transformation in its transport and logistics infrastructure. This study examines how the digitalization of the transport and logistics sector influences tourist mobility and destination competitiveness. Using a secondary data analysis approach based on twelve independent sources, including tourism platforms, official statistics, and policy reports, the study identifies six critical digital mobility gaps. These include a Baku-

regional digital divide, the absence of a unified multimodal platform, navigation barriers, intercity digitalization gaps, a tourism revenue paradox, and fragmentation in the taxi sector. The findings show that, despite progress in urban digital systems, structural weaknesses continue to constrain tourism performance. Drawing on international best practices, the study proposes five evidence-based policy recommendations and highlights the importance of integrated digital transport systems for strengthening tourism competitiveness in Azerbaijan.

Keywords: Digitalization, tourist mobility, destination competitiveness, Azerbaijan, transport logistics, Mobility as a Service (MaaS), multimodal systems.

B.N. Makhutov, Yu.P. Shevelev, R.E. Mamedli

Protection of Electronic Textbooks and Knowledge Control Systems in Distance Learning: Analysis of Approaches and Concept of the "Symbol-Kom" Software-Hardware Solution

Nizhnevartovsk State University, Nizhnevartovsk

Abstract: The article examines the problems of copyright protection and the reliability of knowledge control results in distance learning (DL) systems. A critical analysis of existing formal-legal, software, and software-hardware protection methods is carried out. Based on the authors' many years of development experience, the architecture of the "Symbol-KOM" system is proposed and justified, which uses the principle of having no reference answers in the computer's memory and an external cryptographic

controller. In contrast to earlier publications [1], this paper clarifies the boundaries of the system's "tamper resistance," discusses DL logistics issues, and suggests ways to integrate with modern LMS platforms.

Keywords: Distance learning, electronic textbook protection, software-hardware protection, recognition of ambiguous answers, "Symbol-KOM", knowledge control, trusted execution environment.

Bakhtiyar Namazov, Tofiq Babayev, Nofal Nabiyev

Analysis of the Risks of Damage to Perishable Goods During Transportation from Azerbaijan to Russia

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Institute of Mathematics, Baku, Azerbaijan

Abstract: This article is devoted to the optimization of supply chain management (SCM) for perishable goods transported by road from Azerbaijan to major industrial centers in Russia (Moscow, Saint Petersburg, Yekaterinburg, etc.), the identification of spoilage risks during transit, and the investigation of mitigation strategies. The study analyzes the specific characteristics of the cold chain within the International North-South Transport Corridor (INSTC). Utilizing the Arrhenius equation, a methodology is proposed to calculate the risk of physical damage to cargo due to temperature fluctuations, accompanied by an assessment of associated financial losses. Furthermore, the paper substantiates the effectiveness of implementing the Hub-and-Spoke model and IoT-based monitoring to enhance the resilience of the

logistics network and minimize product losses during border crossings and transit.

Keywords: Supply chains, perishable goods, Azerbaijan-Russia, cold chain, risk management, International North-South Transport Corridor (INSTC).

Bakhtiyar Namazov, Tofiq Babayev, Nofal Nabiyev

Optimization of Cold Chain Logistics for Perishable Agricultural Exports: A Case Study of The Azerbaijan-Russia Trade Corridor

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Institute of Mathematics, Baku, Azerbaijan

Abstract: This study investigates the logistical challenges and biochemical risks associated with the transportation of perishable agricultural products from Azerbaijan to the Russian Federation—a strategic pillar of Azerbaijan's non-oil export sector. Using the Van Arsdel "Time-Temperature-Tolerance" model and the Q10 temperature coefficient rule, the research quantifies potential product losses across different scenarios. Empiric observations indicate that interruptions in "cold chain" infrastructure and regulatory delays at border-crossing points (e.g., Samur-Yaraq Kazmalyar) significantly accelerate microbiological degradation and autolysis. The paper classifies export goods (tomatoes, persimmons, peaches, etc.) based on their transportability index and sensitivity levels. Results suggest that implementing real-time IoT-based monitoring systems and pre-cooling protocols can reduce financial losses by up to 15-20% per shipment.

Keywords: Agricultural exports, logistical risks, cold chain management, post-harvest losses, temperature-controlled logistics, Azerbaijan-Russia trade relations, spoilage kinetics.

Balnur Kubanychova, Samat Osmonov, Al Khan

AI-Enhanced Pedestrian Infrastructure Analysis Using Open Data and Multi-Criteria Methods

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Abstract: Rapid urbanisation and car-oriented planning have led to fragmented pedestrian infrastructure in many cities, particularly in post-Soviet contexts. This paper proposes an AI-enhanced, data-driven methodology for analysing pedestrian infrastructure using exclusively open data sources. The approach integrates multi-criteria analysis (MCA) with Analytic Hierarchy Process (AHP) weighting and introduces a machine learning-based classification model for identifying high-risk and low-quality pedestrian zones. The methodology evaluates three key dimensions: connectivity, safety, and comfort, using OpenStreetMap data, Sentinel-2 imagery, and spatial analysis techniques. A supervised classification approach is applied to categorise urban areas into pedestrian quality levels based on computed indicators. The model supports predictive identification of infrastructure gaps and prioritisation of intervention zones. A pilot case study conducted in Bishkek, Kyrgyz Republic, demonstrates the applicability of the proposed framework in data-scarce

environments. Results reveal significant spatial disparities, with peripheral districts exhibiting substantially lower pedestrian quality compared to the city centre. The integration of AI-based classification enhances the diagnostic capability of the framework, enabling scalable and reproducible urban analysis. The main contribution of this study is the combination of open data, multi-criteria evaluation, and machine learning techniques into a unified framework for pedestrian infrastructure diagnostics. The proposed approach provides urban planners and policymakers with a practical decision-support tool for improving walkability in rapidly urbanising cities.

Keywords: pedestrian accessibility, walkability, multi-criteria analysis, Analytic Hierarchy Process, OpenStreetMap, spatial analysis, GIS analysis, urban diagnostics, post-Soviet cities, machine learning, artificial intelligence, smart city.

Bayram Ibrahimov, Almaz Aliyeva, Ulvi Rafizade

Research Control Systems for the State Multiservice Telecommunication Networks Based on the Concept Logistics Systems

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Mingechaur State University, Mingachevir, Azerbaijan
Azerbaijan Technological University, Ganja, Azerbaijan

Abstract: The key components of state management systems for multiservice tel-ecommunication networks have been analyzed based on the concept of logistics and

transport systems constructed in accordance with the NGN and FN concepts, using a family end-to-end digital technologies and taking into account the recommendations of ITU-T, Y.1542, and Y.3001, and their performance quality criteria have been selected. The aim of the work is to study state management systems of multiservice telecommunication networks based on a logistics approach. In the study, a general problem formulation is developed for selecting efficiency criteria, probabilistic-temporal characteristics, and reliability of the functioning of state management systems for multiservice networks, which are substantiated within the framework of the efficiency of a unified information space and based on methods of shared resource management. Based on the research, a new approach is proposed, by means of which a method for calculating multiservice telecommunication networks is constructed on the basis of the logistics systems concept, taking into account the behavior of self-similar traffic in the provision of multimedia services. The operational scheme of the investigated telecommunication network segment based on the concept of logistics systems using software-defined networking technology is considered, and a structural time diagram of 4G traffic aggregation using voice long term evolution technology is presented. Based on the calculation methods, analytical expressions are obtained that make it possible to evaluate the indicators of probabilistic-temporal characteristics of networks, quality of service, and quality of experience for self-similar

traffic.

Keywords: Software-Defined Networking, OpenFlow Protocol, Application Programming Interface, Self-Similar Traffic, Logistics Systems, Performance Quality, Network Resource.

Chingiz Nasirov

Enhancing Offshore Pipeline Reliability Through Electromagnetic Vibration Damping

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Abstract: As offshore energy infrastructure continues to expand into deeper waters and harsher environments, ensuring the safe and uninterrupted transport of hydrocarbons and other energy resources has become a critical engineering challenge. Among the various factors influencing pipeline integrity, vibration induced by ocean currents, wave action, and operational loads plays a significant role in compromising structural stability and fatigue life. To mitigate these dynamic effects, specialized vibration control devices are commonly implemented. However, conventional vibration mitigation solutions often exhibit limited performance under variable loading conditions or require frequent inspection and maintenance. This paper proposes an innovative approach to improving the reliability of offshore pipeline systems using electromagnetic vibration damping. The concept of a device that utilizes magnetic repulsion forces to create a contactless damping effect is to reduce dynamic loads

without physical wear of components. The operating principles, design features, and expected operational benefits of the proposed solution are discussed. An evaluation was performed to assess the potential effectiveness of electromagnetic damping and enhance the operational lifespan of offshore pipeline systems. The findings suggest that this approach has the potential to enhance both structural reliability and operational safety, while also representing a promising innovative solution for future offshore energy transport infrastructure.

Keywords: Damper, riser, vibration, offshore, electromagnetic damping.

Dmytro Krytskyi, Alina Artemova, Elvira Kaidan, Artem Chekhovskoi

Review of Methods for Recognizing Small and Camouflaged Objects Under Various Shooting Conditions

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Abstract: Detecting small and camouflaged objects under difficult observation conditions remains one of the most challenging problems for modern computer vision and remote sensing systems. The visual similarity between objects and background, low contrast, variable illumination, and adverse weather conditions significantly degrade the performance of both human observers and automated recognition algorithms. These challenges become even more pronounced in unmanned aerial

vehicle-based observation systems, where limitations in onboard computational resources, data transmission bandwidth, and sensor payload must be taken into account. This paper analyzes contemporary approaches to small and camouflaged object detection with consideration of sensor technologies, observation conditions, and algorithmic strategies. Methods based on classical visual features, anomaly detection techniques, and deep learning models are examined, along with approaches utilizing multispectral and hyperspectral data and multi-sensor information fusion. Particular attention is given to the influence of external factors such as illumination changes, atmospheric effects, noise, and image compression on detection performance. The analysis indicates that no single approach provides stable performance across all scenarios, while hybrid and context-adaptive solutions that jointly consider environmental conditions and sensor system constraints demonstrate the greatest potential for improving detection reliability.

Keywords: object detection; camouflage; computer vision; sensor systems; unmanned aerial vehicles.

Durdane Selimova

Digitalization and Management in the Development of Transport Corridors with in the East-West Transport Corridor

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Abstract: The development of international transport

corridors plays a significant role in strengthening regional economic cooperation, logistics efficiency, and sustainable development. In the modern global economy, digitalization and effective management approaches have become essential tools for improving the performance of transport and logistics systems. The East–West Transport Corridor is considered one of the most important routes connecting Asia and Europe, creating new opportunities for trade, transportation, and regional integration. The aim of this research is to analyze the role of digitalization and modern management approaches in improving the efficiency of transport corridors within the East–West transport network. The study examines the implementation of digital technologies in logistics management, including smart transport systems, digital platforms, real-time data management, and automated logistics processes. These technologies help optimize cargo transportation, improve transparency, reduce operational costs, and strengthen coordination between different stakeholders. The research is based on a literature review and conceptual analysis of digital transformation processes in transport corridor management. The findings indicate that the integration of digital technologies with effective management strategies significantly increases the operational efficiency and competitiveness of international transport corridors. Moreover, digitalization contributes to sustainable logistics development and enhances the strategic importance of the East–West Transport Corridor in the

regional and global transport system.

Keywords: Digitalization, Management, Logistics Management, Transport Corridors, East–West Corridor, Digital Logistics.

Dursun Mustafayeva

Impact of the Middle Corridor Project on The Geopolitical Positions of Türkiye and Kazakhstan

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Abstract: The Middle Corridor (Trans-Caspian International Transport Route) strengthens the geopolitical positions of Türkiye and Kazakhstan by diversifying trade and transit links between Asia and Europe. For Türkiye, this corridor allows it to expand its influence in the Caucasus and Central Asia and to increase its diplomatic influence with regional powers such as Russia, China, and the European Union in the fields of energy and transit. For Kazakhstan, the corridor creates a significant transit hub, reducing its dependence on routes through Russia and strengthening the country's economic independence and leadership role in Central Asia. This study has assessed the corridor's strategic impact by conducting a comparative analysis of existing transit volumes and trade flows. Initial results indicate that the Middle Corridor has the potential to increase transit volumes away from Russian routes by approximately 15-20%, strengthening opportunities for regional cooperation and attracting investment. Beyond its

economic impacts, the corridor contributes to regional stability, altering the local power balance by ensuring reliable and diversified trade and energy flows. However, the sustainability of these benefits depends on the maintenance of infrastructure investments, diplomatic balance, and regional security. Consequently, the Middle Corridor is both an economic transit project and a strategic instrument that strengthens the geopolitical position of Türkiye and Kazakhstan in Eurasia.

Keywords: Middle Corridor, Eurasian transit, Türkiye, Kazakhstan, Regional projects.

Elshan Hashimov, Aziz Talibov, Bayram Ibrahimov, Islam Islamov, Ramil Akhundov, Kostiantyn Dergachov

Optimal Location of Logistics Centers in Azerbaijan Using a Hybrid Network-Based Multi-Criteria Approach

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National Defense University, Baku, Azerbaijan

National Aerospace University H.E. Zhukovsky "Kharkiv Aviation Institute", Kharkiv, Ukraine

Abstract: This study addresses the problem of rational placement of logistics centers in the Republic of Azerbaijan through the lens of network based multi criteria optimization. The transport infrastructure is formalized as a graph model comprising a set of nodes and links, while the potential locations of logistics centers (candidate sites) are selected according to criteria of

access to major corridors, functional accessibility, and infrastructure compatibility. The proposed hybrid mathematical model combines network-based optimization with a mixed integer linear programming (MILP) framework. The model incorporates total financial costs, capacity constraints, and regulatory driver work regime requirements. The objective function is constructed by integrating shortest path distances to different facility types using normalized weight coefficients, and the optimal solution is determined by a minimization criterion over a discrete set of candidates. Scenario based digital evaluation reveals significant variation in the objective function across candidate sites and shows that the optimal location decision depends on the proximity balance across facility types. In addition, a sensitivity analysis conducted by varying the weight coefficients within a controlled interval makes it possible to assess the response of the optimal site to changes in priorities, thereby substantiating the advantage of a scenario dependent optimal approach in planning. The proposed methodological framework supports decision making at the strategic planning stage through quantitative comparison and can also be considered as an application-oriented tool for the phased development of logistics infrastructure at the regional level.

Keywords: Logistics center, optimal location, network model, graph theory, multi-criteria optimization, weighting coefficients, sensitivity analysis, scenario-based

approach, decision support, hybrid model, mixed-integer linear programming (MILP), capacity constraint.

Elshan Orujov

Strategy for the Diversification of the Non-Oil Sector and Its Reflection in Regional Trade and Logistics Policy

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Baku Business University, Baku Azerbaijan.

Abstract: The diversification of the non-oil sector has become a strategic priority for resource-dependent economies seeking sustainable growth, macroeconomic stability, and resilience to external shocks. Heavy reliance on hydrocarbon exports often generates structural imbalances, including vulnerability to commodity price volatility, limited innovation capacity, and regional development disparities. This paper examines the strategic foundations of non-oil sector diversification and analyzes how such strategies are reflected in regional trade and logistics policy. The study explores theoretical perspectives on economic diversification, structural transformation, and trade competitiveness, linking them to practical policy tools such as infrastructure modernization, transport corridor development, export promotion, and digital logistics systems. Particular attention is given to the integration of regional supply chains and the development of transit potential as mechanisms to stimulate non-oil industries. The findings suggest that effective diversification requires coordinated

industrial, trade, and logistics policies supported by institutional reform and investment in human capital. Regional logistics integration plays a critical role in enhancing export capacity and ensuring long-term economic sustainability.

Keywords: Structural transformation, regional trade policy, logistics infrastructure, transport corridors, supply chain integration.

Enise Kara, Emrullah Sonuç

Solving the Set-Union Knapsack Problem using Simulated Annealing

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Abstract: The Set-Union Knapsack Problem (SUKP) is a variant of the classical knapsack problem, and finding its solution is difficult due to its complex depend-ency structures. Specifically, associating items with multiple subsets expands the solution space, rendering the problem NP-hard. Metaheuristic algorithms are effective and applicable alternatives for solving such structures, thanks to their ability to explore large, complex solution spaces. This study adapts and evaluates the Simulated Annealing (SA) algorithm for solving the SUKP. Each solution is represented by a binary vector indicating the subset selection status. Neighboring solutions are generated by flipping the inclusion status of a randomly selected subset (bit-flip). When capacity constraints are violated, the solution is restored to feasibility through a

repair and improvement process based on the efficiency ratios of the items. The proposed algorithm was developed in Python and tested on various SUKP instances. For each instance, the algorithm was independently run 30 times, and statistical measures including the best, average, and worst values, the median, and the standard deviation were computed. The experimental findings suggest that the proposed SA-based method produces effective, stable solutions and is competitive in terms of accuracy and stability, demonstrating its applicability to similar combinatorial optimization problems.

Keywords: Set-Union Knapsack Problem, Metaheuristic Algorithms, Simulated Annealing, Combinatorial Optimization, NP-hard.

Esmira Mehbaliyeva

Modeling of Heterogeneous Server Systems of a Smart City in an Uncertain Environment

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Abstract: The research object of this paper is the enhancement of a smart city's heterogeneous server (SC) network using fuzzy network theory (FNT). A comparative analysis of existing resource management methods for heterogeneous network platforms applicable in smart cities has been conducted. The feasibility of using fuzzy optimization methods for more efficient implementation of heterogeneous SC server networks has been justified. Based on heterogeneous data streams obtained from

information-measurement flows generated by machine vision systems and sensor networks in transportation and energy supply, a general architecture of Shusha smart city's server infrastructure for a heterogeneous network platform has been proposed. The use of the FNT model enables higher operational performance of Shusha's heterogeneous server network under uncertain conditions. To substantiate this, a staged fuzzy modeling method was proposed that takes into account time-varying energy loads influenced by external meteorological parameters and potential failures. Unlike traditional deterministic and stochastic optimization methods, the proposed fuzzy optimization approach allows for more comprehensive experimental studies under conditions of external uncertainties, network energy supply, operational reliability, and criticality of Shusha smart city network platform parameters. The obtained results demonstrate that fuzzy optimization of the heterogeneous network in Shusha's server infrastructure ensures reliable and uninterrupted operation of heterogeneous server networks under incomplete information conditions, enhances system resilience to failures, and reduces the average query processing time by approximately 30% compared to conventional approaches. The proposed method confirms both the effectiveness and practical applicability for the design and operation of Shusha smart city's heterogeneous server infrastructure.

Keywords: Heterogeneous server networks, fuzzy set theory, smart city, Shusha city.

F.Kh.R Ahmadzada

Current Status of Theoretical-Methodological Bases of Warehouse Logistics and Inventory Management

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The article examines the modern theoretical and methodological foundations of warehouse logistics and inventory management, and analyzes the possibilities of applying queueing systems and GPSS (General Purpose Simulation System) models in this field. The purpose of the research is to identify scientific and methodological approaches for optimizing warehouse processes, improving service levels, and increasing the efficiency of inventory turnover. The study concludes that GPSS modeling and queueing theory provide important analytical capabilities for analyzing the behavior of complex logistics systems, simulating congestion and queue problems, as well as managing inventory levels. In addition, we also emphasize that simulation modeling with digital technologies should be included in Logistics 4.0. There is particular attention to the role of stochastic modeling in dealing with uncertainties in warehouse systems. We also look at the impact of service rate, capacity and system load on system performance measures including waiting time, queue size and system utilization. The results of the simulation experiments suggest that warehouse systems are sensitive to changes

in service rates. This study also shows that resource allocation needs to be balanced. The results of the study demonstrate that using queueing theory and GPSS modeling together with other strategies to make decisions can very effectively inform decision making, manage risks and improve logistics systems to be able to adapt to the changes in the marketplace.

Keywords: warehouse logistics, inventory management, queueing system, GPSS, simulation models, Logistics 4.0.

Farhad Miezayev

Application of Artificial Intelligence in Freight Transportation: World Experience and Prospects for Azerbaijan

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Abstract: This article systematically investigates theoretical and practical aspects of artificial intelligence technology applications in the freight transportation sector. The research analyzes world experience while assessing the prospects for integrating these experiences into Azerbaijan's transport-logistics system. Global research shows that artificial intelligence enables significant results in route optimization, predictive maintenance, fleet management, and warehouse operations automation. The experience of international companies such as UPS, FedEx, and Amazon confirms that AI-based systems reduce operational costs, increase transport efficiency, and minimize carbon emissions.

Considering Azerbaijan's strategic position in international transport corridors, the article proposes a phased development model for AI implementation. Development directions for increasing transit potential are particularly substantiated in the context of regional projects such as the Middle Corridor and Zangezur Corridor. Research results show that phased and systematic implementation of artificial intelligence technologies can strengthen Azerbaijan's position as a regional transport hub while increasing the competitiveness of the logistics sector.

Keywords: artificial intelligence, freight transport, logistics, route optimization, Azerbaijan, Middle Corridor, TRIPP, digital transformation.

Farid Aghababazade, Jamal Hajiyev

Mechanisms of Optimizing the Strategic Development of Human Capital in the Corporate Management System

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Abstract: The function of human capital in guaranteeing the sustainable development of businesses with a corporate structure is strategically significant in the context of the contemporary global economy. The primary institutional process that creates the organization's long-term competitive advantage is human resource management. The optimization of the strategic development of human capital in the corporate

governance system thus emerges as a pressing scientific and practical issue. The study's primary goal is to pinpoint the current issues with human capital management in corporate structures and provide scientific evidence for practical solutions that maximize its strategic growth. The research employed conceptual modeling, institutional analysis, comparative analysis, and systematic analysis.

Keywords: Human capital, corporate governance, strategic development, HRM, optimization mechanisms.

Fuad Dashdamirov, Turan Verdiyev, Ulvi Javad, Royal Allahverdiyev, Mammad Mammadov

Creation of a Digital Twin of the Transportation Network of Provincial Cities: The Case of Azerbaijan
Azerbaijan Technical University, Baku, Azerbaijan

Abstract: The article presents the sequence for creating a digital twin using computer modeling in order to evaluate and improve the transportation network of provincial cities. The results of surveys and monitoring conducted to study the transport network in the cities of the Republic of Azerbaijan were analyzed, and the features of the organization of traffic in cities were shown. The advantages of creating a digital twin using the PTV VISSIM program in small towns were noted, and examples of digital twinning were shown through a network model covering the transport infrastructure of cities. The method of constructing heat maps corresponding to the current changes in transport and pedestrian flows in cities of the

created model is explained. As a result of simulation tests conducted on the transport network in the PTV VISSIM program, it was possible to determine the transport and pedestrian delays at intersections, streets, bus routes, parking zones, and the amount of harmful gases emitted into the environment.

Keywords: Provincial cities, digital twin, transportation network, simulation, in-tersection, delay.

G. Aliyeva, R. Huseynova

Studying the Human Body Cooling Effect Due to Wind

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Azerbaijan Architectural and Construction University,
Baku, Azerbaijan

Abstract: Wind plays a significant role in human thermal comfort and body temperature regulation. This article examines how moving air influences heat loss from the human body, the physiological mechanisms involved, and the environmental and practical implications of wind-induced cooling, commonly referred to as the wind chill effect. A mathematical approach is employed to determine the conditions under which the cooling effect reaches its maximum. Special attention is given to the integral influence of wind over time, considering scenarios in which air temperature increases from a minimum to a maximum value while wind speed varies within defined limits. The results show that the strongest cooling effect occurs when an inverse relationship exists between air

temperature and wind speed, leading to maximum average integral wind chill. The findings contribute to a better understanding of human thermal responses in cold and windy environments and can be applied in fields such as occupational safety, aviation, outdoor operations. Taking into account the effect of headwind on the surface temperature of human body parts, particularly the human face, the problem of determining the optimal relationship between air temperature and wind speed $[V]$, at which the human body surface cooling temperature reaches its maximum, is investigated. It is shown that by imposing a certain constraint on the total wind speed over a certain time interval during which the air temperature increases from $T_{air.min}$ to $T_{air.max}$, the maximum average integral value of wind-induced body temperature cooling is achieved with an inverse relationship between T_{air} and V_s .

Keywords: Keywords: cooling effect, body temperature, wind speed, air temperature, optimization.

Galib Huseynov, Aysel Eminova

The role of technological advances in optimizing the performance of sustainable transport networks (natural monopolies)

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Abstract: Natural monopolies in transport networks are sustainable due to large capital costs and high economies of scale, where one provider operates more efficiently than several providers. Of course, with the presence of one

network in society, the costs of transporting energy are lower than with the presence of several networks, however, the tariffs that network users have to pay may still be high, which is due to the monopolistic behavior of the network operator. Technological advances have the potential to disrupt traditional natural monopolies by introducing new alternatives or enabling market fragmentation. The aim of the study is to analyze the revolutionary changes in the functioning of natural monopolies due to technological advances, from the implementation of smart grids to intelligent transport systems and digitalization. The results of the study show that by harnessing the power of technology, natural monopolies can increase resilience, efficiency and customer satisfaction, and ultimately build a stronger foundation for these important areas. The results also show that numerous developments are on the horizon that will shape the future of infrastructure for natural monopolies, from smart grids and renewable energy to intelligent transport systems.

Keywords: Natural monopoly, transportation networks, technological advances, infrastructure, competition, innovation.

Grzegorz Wojnar, Michał Juzek

An Attempt to Reduce the Peak-To-Peak Value of the Toothed Gear Vibration by Using a Flexible Mounting of The Rolling Bearings of the Gear Shafts

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Abstract: An important direction in gear transmission research is to reduce the vibration of its components. This work attempts to reduce, in particular, the peak-to-peak value of toothed gear vibration by using a flexible mounting of the rolling bearings of the gear shafts. In this case, one of the advantages of the involute tooth profile was utilized: changing the axis distance does not change the direction of the intertooth force. For the lower analyzed pinion speed of 1500 RPM, the reduction in the peak-to-peak value of vibration accelerations of the sleeve in which the gear shaft bearing was mounted occurred only at the low values of the analyzed loads. However, for the higher analyzed pinion speed of 3000 RPM, the reduction in the peak-to-peak value of vibration accelerations of the sleeve in which the gear shaft bearing was mounted occurred across the entire range of 10 gear loads from 0 to 65 Nm. At this rotational speed in all these load cases the root mean square (RMS) value was also reduced.

Keywords: Toothed Gear, Vibration, Reduction, Bearing, Flexible Mounting.

Gulbes Rustamova, Almas Hamidova

The Role of Customs Tariff Mechanisms and Logistics Infrastructure in the Efficient Use of Export Potential
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Abstract: In terms of increasing the country's export potential, not only customs tariff regulation is of decisive importance, but also the development of efficient logistics

systems in this process. The development and improvement of the customs system is a continuously dynamic process. Problems related to the activities of this field and changes in the mechanisms for providing customs services necessitate new consistent scientific, theoretical, methodological and other applied research in rapidly changing economic conditions. The purpose of the study is to determine the relationship between customs tariff regulation and key categories such as customs administration and customs policy in order to better understand the essence of customs tariff regulation. The study makes it possible to analyze the experience of international trade statistics and identifying the main directions of improving the methodology of customs statistics on foreign trade. The results of the study show that funds entering the budget through the customs system constitute an important component of the state financial system, and the growth observed in this area is directly related to the increase in economic activity. In this regard, it may be appropriate to increase the role of customs duties and other fiscal instruments in the future, ensure more transparent and efficient management of import-export operations, widely implement digital customs systems, strengthen risk-based control mechanisms, and develop logistics infrastructure.

Keywords: Globalization, Foreign economic activity, Customs tariffs, Logistics infrastructure, Customs statistics, Digital customs system.

Gunay Rzaeva, Leyla Nasirova, Xalil Aliyev

On a Solution to an Integro-Differential Equation of Vibrations of Mechanical Systems with Viscoelastic Properties

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Abstract: This paper investigates the solution of an integro-differential equation describing the vibrations of a viscoelastic mechanical system with arbitrary hereditary (relaxation) functions. Such systems are widely encountered in engineering applications where material behavior depends on time and past states. The governing equation is derived from the classical model of longitudinal vibrations of an elastic rod by incorporating a hereditary operator that reflects rheological properties of the material. To solve the problem, the Fourier method is applied to reduce the boundary value problem to a system of ordinary integro-differential equations with respect to time. The Laplace integral transform is then employed to convert the problem into an algebraic form, which enables the construction of the solution as a convergent series. The first term of this series coincides with the approximate solution obtained by the classical averaging method, while the inclusion of higher-order terms provides improved accuracy of the solution. The proposed approach allows one to analyze the influence of viscoelastic properties on the dynamic behavior of the system, particularly the damping characteristics of vibrations. It is shown that the presence of hereditary effects leads to exponential decay of oscillations, and the

damping coefficient can be explicitly determined. The developed method is applicable to a wide class of viscoelastic systems and can be extended to more complex boundary conditions and geometries.

Keywords: Viscoelasticity, integro-differential equation, vibration analysis, hereditary functions, relaxation kernel, Laplace transform, Fourier method, averaging method, damping and rheology.

Gunay Valiyeva

Behavioral Biases in Circular Economy-Integrated Supply Chain Design: A Dual-Layer Framework for Reverse Logistics Optimization

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Abstract: We propose a novel dual-layer framework that integrates behavioral economics with circular economy (CE)-driven supply chain design, explicitly addressing biases in consumer recycling decisions and firm-level reverse logistics optimization. Traditional models often assume rational actors, yet real-world decisions are influenced by psychological factors; hence, our approach embeds Prospect Theory for loss-averse firm investments and the Theory of Planned Behavior (TPB) for consumer recycling intentions into a unified optimization system. The behavioral layer dynamically adjusts return-rate predictions using TPB-derived consumer intent, while firms optimize facility locations under loss aversion, altering conventional cost-minimization thresholds. Moreover, the framework incorporates organizational

culture parameters, such as inter-firm trust, as constraints to reflect observed collaboration patterns. Methodologically, we combine federated learning for privacy-preserving behavioral data aggregation with quantum-inspired annealing to solve non-convex firm utility problems efficiently. Unlike existing CE supply chain network design (SCND) models, our framework captures asymmetric risk preferences in firms and adaptively routes return flows based on real-time consumer psychology. The proposed system is validated through a case study, demonstrating improved alignment between theoretical predictions and empirical decision-making. This work bridges a critical gap in CE literature by formalizing how behavioral biases shape reverse logistics, offering actionable insights for policymakers and firms aiming to enhance CE adoption.

Keywords: Circular economy, consumer recycling decisions, TPB-derived consumer intent, CE supply chain network design (SCND) models, collaboration patterns.

Gunel Novruzova

Architecture and Applications of Artificial Intelligence Systems in Logistics

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Abstract: In the context of the digital transformation of the economy, the use of artificial intelligence technologies is becoming a key factor in improving the efficiency of logistics systems. Modern logistics processes are

characterized by large volumes of data, high dynamism, and complex decision-making, making the use of intelligent information systems particularly relevant. This article examines the architectural principles of building artificial intelligence systems used in logistics. The key components of such systems include data collection and storage modules, information processing and analysis systems, machine learning algorithms, and intelligent decision support mechanisms. The use of modern information technologies, including big data, cloud computing, and predictive analytics methods, enables the creation of effective solutions for managing logistics processes. Particular attention is paid to the practical applications of artificial intelligence in logistics. These include optimization of transport routes, intelligent inventory management, demand forecasting, automation of warehouse operations, and supply chain management. The use of artificial intelligence algorithms helps improve forecasting accuracy, reduce operating costs, and enhance customer service. The article also examines the key challenges of implementing intelligent systems in logistics infrastructure. These include the high cost of implementing these technologies, the need for integration with existing information systems, ensuring data security, and training qualified specialists in artificial intelligence and information technology. Thus, the implementation of architectural solutions based on artificial intelligence systems opens up new opportunities for improving the efficiency and sustainability of logistics processes and

plays a vital role in the development of modern transport and logistics systems.

Keywords: Artificial intelligence, logistics, intelligent systems architecture Supply Chains, Forecasting and Optimization, Prescriptive Analytics, Process.

Gunel Zeynalova, Aziz Talibov

Economic-Mathematical Modeling of Military Logistics Center (MLC) Location Under Troop Redeployment

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Military Scientific Research Institute, Baku, Azerbaijan

Abstract: This study proposes a cost-oriented methodological approach to the economic justification of locating military logistics centers (the Center) under conditions of troop redeployment. The main objective is to compare alternative locations based on initial capital investments and annual operating costs, as well as to justify the use of the average annual service cost per unit of equipment as an alternative to traditional profitability indicators in a military context. Within the scope of the research, capital expenditures required for establishing the Center are systematized, including costs related to real estate, transport vehicles, energy supply, water and sewage systems, fuel infrastructure, maintenance equipment, and security systems. Operating costs are mathematically modeled and include components such as the transportation of spare parts, the movement of mobile repair teams, equipment evacuation, depreciation, and labor expenses. The model considers the geographical

location of the Center – particularly its distance to transport hubs and the military units it serves – as a key economic variable. The results demonstrate that the geographical positioning of the Center has a direct impact on transportation costs and the efficiency of maintenance operations. Therefore, the selection of the most suitable location should be based not only on absolute cost indicators but also on relative service cost metrics. The proposed approach enables the comparison of different organizational scenarios in military logistics, supports informed resource allocation, and enhances decision-making by integrating economic considerations with security and environmental factors.

Keywords: Military logistics, logistics center, capital investment, operating costs, military-economic indicators, maintenance and repair, depreciation, transport infrastructure.

Hajar Huseynzade

Analysis of the State and Development Prospects of Digitalization of Railway Transport in Azerbaijan

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Abstract: This article analyzes the current state of digitalization in Azerbaijan's railway transport. The results of the implementation of digital technologies in the field of passenger and cargo transportation are shown. It also highlights the work being done to implement IT innovations at Azerbaijan Railways and their significance. Prospects for increasing the level of digital competencies

of employees of Azerbaijan Railways are presented.

Keywords: Railway transport, digitalization, digital technologies, digital control systems, digitalization of the railway system.

Hasan Huseynov, Shahnaz Shahbazova, Amir Mosavi

Uncertainty-Aware Fuzzy Neural Networks for Explainable Risk Scoring in Real-Time Payment Transactions

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Obuda University, Budapest, Hungary

Abstract: UA-FNN integrates an ANFIS-inspired fuzzification and rule-firing pipeline with a two-layer LSTM consequent network to extract temporal patterns, Monte Carlo Dropout to estimate epistemic uncertainty, and a new Fuzzy-SHAP post-processor which transforms SHAP DeepExplainer attributions into Gaussian membership-function-weighted linguistic tokens. The results of each inference pass are a calibrated risk score, a predictive uncertainty band sigma, a routing action, and a list of languages risk factors in order of rank meeting the requirements of an adverse-action explanation. On three benchmark data sets, the IEEE-CIS Fraud Detection dataset (590,540 transactions), ULB Credit Card Fraud (284,807 transactions), and synthetic PaySim (6.36 million transactions), UA-FNN with AUC-ROC of 0.971, 0.983, and 0.977 and F1-scores The Expected Calibration Error (ECE = 0.031) is 65% lower than the MC-Dropout

DNN baseline. The need of the LSTM consequent and Gaussian membership functions is proved in a systematic ablation study of eight architectural variants. Experiments on uncertainty routing demonstrate that transactions characterized by high uncertainty with 17.5% of total volume have a rate of fraud 20-32 times greater than transactions with low uncertainty, making predictive uncertainty a first-class risk management predictive. All findings are confirmed using DeLong pairwise AUC and Wilcoxon signed-rank tests with $p < 0.01$.

Keywords: Uncertainty-aware machine learning; fuzzy neural networks; ANFIS; Monte Carlo Dropout; SHAP.

Heybatulla Ahmadov, Aytaj Mustafayeva

Hybrid Simulation and AI-Based Adaptive Traffic Management in Corridors

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National Aviation Academy, Baku, Azerbaijan

Abstract: The operation of transport corridors necessitates increasingly complex management mechanisms due to rising cargo volumes, intensified transit frequency, uncertainties, and operational risks. The acceleration of global trade flows and the burgeoning competition among international transport routes mandate a re-evaluation of existing management approaches. As traditional traffic management models rely primarily on static planning, they are unable to respond adequately to real-time changes, unforeseen delays, and peak loads. Consequently, this paper proposes a hybrid

simulation model and an Artificial Intelligence (AI)-based decision support mechanism for the adaptive management of flows along transport corridors. The proposed approach integrates discrete-event and agent-based simulation models with machine learning algorithms, enabling the modeling of the transport system's dynamic behavior in high fidelity to real-world conditions. The AI module facilitates the forecasting of traffic density, delay probabilities, and risks, while simultaneously supporting the selection of optimal management decisions. Scenario analyses demonstrate that the adaptive approach enhances flow efficiency, minimizes delays, and significantly improves the overall resilience of the system.

Keywords: Transport Corridors, Artificial Intelligence (AI), Simulation Models, Logistics, Traffic Flow Management.

Heybatulla Ahmedov, Bala Aga Karimov, Natavan Gojayeva
Digital Multimodal Transport by Rail in Azerbaijan's Logistics System: The Strategic Significance of the Middle Corridor

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National Aviation Academy, Baku, Azerbaijan.

Abstract: Against the backdrop of accelerating globalization, the expansion of international trade volumes, and the intensification of transport and logistics flows between Europe and Asia, the establishment of efficient, flexible, and competitive logistics systems has become a strategic priority for transit countries. In this

context, the Trans-Caspian International Transport Route (the Middle Corridor) plays a pivotal role as an alternative East–West transport linkage, enhancing countries’ capacities in international trade and transit. The aim of this study is to evaluate the role of rail transport in Azerbaijan’s logistics system within digital multimodal transport chains, to scientifically analyze its impact on the transit potential of the Middle Corridor, and to determine the effects of the application of digital technologies on the efficiency, transparency, and in-ternational competitiveness of transport processes. The research was conducted on the basis of synthetic-analytical methods, a systematic literature review, as well as statistics derived from digital monitoring data and electronic document circulation. Within the analytical framework, the impact of real-time monitoring technologies equipped with GPS and IoT sensors, electronic documents (e-CMR, e-TIR), and digital coordination platforms on operational efficiency, security, and time optimization in transit transport was assessed. Empirical findings indicate that increasing the level of digital integration enhances the operational efficiency of transport processes, reduces time losses within the logistics chain, and strengthens compliance with international standards. The im-plementation of electronic document management and real-time monitoring sys-tems contributes to the expansion of Azerbaijan’s transit potential and provides a strategic impetus for the development of the non-oil sector, particularly in export and transport services.

Furthermore, the adoption of digital solutions reinforces the coordination of international cooperation, facilitating optimized information exchange and operational synchronization within regional and global logistics networks, notably along the TRACECA and Trans-Caspian corridors. Furthermore, the implementation of digital multimodal transport systems not only enhances resource efficiency but also supports environmental sustainability. Through optimal route selection and the monitoring of energy consumption, it becomes possible to reduce operational costs and minimize carbon emissions. Ultimately, the systematic adoption of digital multimodal transport models ensures network efficiency, transparency, and competitive advantages, thereby significantly strengthening the position of Azerbaijan's economy within the global logistics system.

Keywords: Middle Corridor; digital logistics; multimodal transport; rail transport; Azerbaijan's transit corridors; digitalization of transport operations.

Hijran Kocharli, Aliyeva Sadagat, Chichak Najafova
Opportunities for Optimizing Transport and Logistics Processes in the East-West Transport Corridor in the Context of The Development of Digital Logistics Platforms

Sumgait State University, Sumgait, Azerbaijan

Abstract: The rapid development of digital technologies has significantly transformed modern logistics systems and international transport networks. Digital logistics

platforms have become an important tool for improving the efficiency, transparency and coordination of transport and logistics processes. These platforms integrate information flows, transport management systems and supply chain operations, enabling more effective planning and control of logistics activities. The East–West transport corridor plays a crucial role in connecting Asian and European markets and facilitating international trade flows. However, the increasing volume of freight transportation and the complexity of logistics operations require the introduction of innovative digital solutions. In this context, the development of digital logistics platforms creates new opportunities for optimizing transport and logistics processes along the corridor. The purpose of this study is to examine the role of digital logistics platforms in optimizing transport and logistics processes within the East–West transport corridor. The research analyzes the impact of digitalization on logistics coordination, information exchange and supply chain integration. Special attention is given to digital tools such as electronic data interchange, intelligent transport systems and digital supply chain management platforms. The results of the study indicate that the implementation of digital logistics platforms significantly improves operational efficiency, reduces transportation time and enhances the transparency of logistics operations. The findings also demonstrate that digital transformation plays an important role in strengthening the competitiveness and sustainability of international transport corridors.

Keywords: Digital logistics platforms, Transport corridor, East–West transport corridor, Logistics optimization, Digital transformation.

I.H.Mammadova

Study of the Effect of Plagiogranite Powder on the Properties of Ceramic Materials Using Mathematical Modeling

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Abstract: In the presented article, the effect of ultradisperse plagiogranite powder on the compressive strength and average density, which are considered the main properties of ceramic materials, was studied through mathematical modeling. Mathematical models were obtained using the least squares method. The coefficients of the regression equations were determined using mathematical models obtained by the least squares method. The choice of this method depends on the problem statement, the quantity of parameters, the amount of parameters, and the number of parameters. Therefore, functional and positional constraints affecting the process were first selected. The clay content (x_1 , %) and plagiogranite content (x_2 , %) were chosen as positional constraints. The average density of the clay (y_2 , g/cm³) was adopted as the functional constraint, and the compressive strength limit of the material was adopted as the objective function. The main goal is to examine the dependencies that ensure the maximum compressive

strength of a ceramic material. To solve the problem posed, the technological process of producing ceramic material must first be investigated. Later, mathematical models were built. As a result of the reports, regression equations were determined. Fisher's exact test was used to assess the validity of the regression equations using the formula. As a result of the reports conducted, the optimal composition and the maximum value of the compressive strength limit of the material were determined.

Keywords: ceramic material, plagiogranite, clay, strength limit, average density, mathematical model, optimal composition, parameter, least squares method.

Ibrahim Hasanli

Transforming the Trans-Caspian Middle Corridor Transport Network: The Structural Role of the Zangezur Corridor

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Abstract: The Trans-Caspian International Transport Route (TITR), commonly known as the Middle Corridor, has rapidly gained strategic importance as global supply chains seek reliable alternatives to traditional Eurasian transport routes. Geopolitical tensions, disruptions in maritime trade, and structural weaknesses in existing land corridors have intensified interest in resilient multimodal logistics networks connecting Asia and Europe. However, despite its growing role, the Middle Corridor remains constrained by infrastructural and topological bottlenecks, particularly in its western segment between the Caspian

Sea and the Turkish border. This study examines the potential structural impact of the proposed Zangezur Corridor as a new logistical link within this segment. Using concepts from transport network theory and graph-theoretical modeling, the corridor is analyzed as a system of nodes and edges. Scenario-based modeling compares the existing linear network with a transformed network containing an additional southern route. The results suggest that integrating the Zangezur Corridor could significantly increase network redundancy, redistribute traffic flows, and reduce congestion. Under moderate assumptions, effective corridor capacity could increase by 15–20%, while average transit times between the Caspian region and eastern Türkiye could decline by 10–15%. The structural resilience of the network improves substantially as the system evolves from a single-route chain into a parallel routing architecture. Beyond operational improvements, the study evaluates economic, environmental, and strategic implications, and provides policy recommendations for regional stakeholders. The findings highlight the importance of network topology in large-scale infrastructure systems and demonstrate how targeted investments can transform the efficiency and resilience of international trade corridors.

Keywords: Middle Corridor, Zangezur Corridor, Transport network, Network topology, Corridor resilience, Graph theory, Scenario analysis, Intermodal logistics, Eurasian connectivity, Infrastructure planning.

Ilgar Mamedov, Ramile Teymurshahova

On Integral Inequalities Associated with the Hamiltonian Function Obtained by Numerical Methods in the Terminal Control Problem

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Sumgait State University, Sumgait Azerbaijan

Baku State University, Baku, Azerbaijan

Abstract: One of the most pressing areas of modern transport logistics is the optimization of terminal control processes. Terminal control mathematically models issues of efficient organization of freight and passenger transportation, minimizing transportation costs or maximizing logistics revenue, and optimal route selection. The key scientific innovation of this work is the construction of an integral equation for the terminal control problem, which includes both the main and adjoint problems. The Fibonacci method, a numerical method for studying trajectories, is applied, and new integral inequalities related to the Hamiltonian function are obtained. This non-classical approach is one of the important steps taken toward developing a theory of for optimality necessary conditions in the field of optimal control and optimization.

Keywords: Terminal control, optimal control, Hamiltonian function, maximum principle, integral inequalities.

Ilgar Safarli, Sevinj Hadiyeva, Ilaha Safarli

Mathematical Modeling of Transportation Problems

Related to Freight Movements

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Abstract: This paper, prepared for conference presentation, examines mathematical models used to optimize transportation processes within logistics systems. Planning the movement of goods from production points to consumption points plays a crucial role in ensuring economic efficiency. The study analyzes the mathematical structure of the transportation problem, its solution methods, and major fields of application. It is demonstrated that mathematical modeling enables the minimization of transport costs and the optimal allocation of available resources in logistics systems.

Keywords: Freight transportation, logistics, transportation problem, mathematical modeling, optimization methods.

Ilya Galaktionov, Vladimir Toporovsky

Comparison of Mie and Henyey-Greenstein Phase Functions for the Aerosol Analysis in Free Space Optics Communications

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Abstract: It is known that the aerosol scattering along with the atmospheric turbulence are a major obstacle for laser beam free space propagation. Research of this phenomenon is necessary for communication tasks and vehicles links. Forward-scattering angular distribution of energy differs significantly between the Mie and Henyey-

Greenstein phase functions. The Mie phase function scatters radiation into a forward cone of about 60° , whereas the Henyey–Greenstein phase function does so into a cone of approximately 10° . In cases of multiple scattering — such as in long free space paths — this difference may not critically affect the final result, and computational speed becomes more important, making the Henyey–Greenstein phase function preferable. However, for low-order scattering or intermediate scattering regimes, such discrepancies can be significant. In these cases, the Mie phase function is preferred, as it describes the angular distribution of scattered radiation most accurately and rigorously for scattering by spherical particles. In this study, both models were implemented, and software was developed for visualizing the scattering diagrams (phase functions) of monochromatic visible-range laser radiation scattered by spherical dielectric particles. A comparative analysis of the angular characteristics of the Mie and Henyey–Greenstein phase functions is presented.

Keywords: Scattering medium, phase function, scattering diagram, Mie scattering, Henyey-Greenstein phase function.

Irada Shirinzade

Study of the Influence of Chemical Composition on the Properties of Clay-Dolomite Composite Materials Using Mathematical Modeling

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Abstract: It is known that there are a number of parameters in the production of building materials whose measurement requires specialized equipment or is time-consuming. Using indirect measurement methods, it is possible to determine the dependence of construction and technical properties on the chemical composition of the material. Knowing the chemical composition of the resulting material allows one to predict its strength and average density in advance, reducing the time and number of experiments required to produce clay-dolomite composite materials of the required quality. The effect of the ratio of basic to acidic oxides ($RO/SiO_2, x$) on the average density and mechanical strength of the resulting clay-dolomite composite materials was studied. We also obtained the parameters of a hyperbolic model for the dependence of the strength of clay-dolomite composite materials on the ratio of basic to acidic oxides (RO/SiO_2). To determine the parameters of the power-law dependence of the strength of the resulting clay-dolomite composite materials on the ratio of basic to acidic oxides (RO/SiO_2), we also used the least-squares method. The resulting regression equations allow us to establish the relationship between the chemical composition and the physical and mechanical properties. Analysis of the resulting models showed that, among the models considered above, the parabolic dependence most accurately demonstrates the relationship between

(RO/SiO_2) and the average density of clay-dolomite composite materials -

$y_1 = 1.76395 + 0.046945 * x - 0.02167 * x^2$. It was also established that there is a parabolic relationship between the strength of clay-dolomite composite materials and their chemical composition.

Keywords: Clay-dolomite composite materials, relationship between chemical composition and physical and mechanical properties, least squares method.

Islam Islamov, Ramil Akhundov, Elshan Hashimov, Ismail Bogrekci, Pinar Demircioglu

Design and Numerical Simulation of a High-Gain Microstrip Monopole Antenna for Satellite Communication Systems

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Azerbaijan Technical University, Baku, Azerbaijan

National Defense University, Baku, Azerbaijan

Aydin Adnan Menderes University (ADU), Aydin, Türkiye

Abstract: This paper presents the numerical simulation and design of a high-gain microwave monopole microstrip antenna intended for satellite communications. The motivation for this study arises from the increasing demand for compact, low-profile, and cost-effective antenna solutions capable of providing enhanced radiation performance for modern satellite communication terminals. The proposed antenna configuration is based on a monopole microstrip radiator

printed on a dielectric substrate with a modified ground-plane structure aimed at improving radiation directivity and gain. Full-wave electromagnetic simulations, based on the numerical solution of Maxwell's equations, are employed to investigate the effects of the antenna geometry and substrate parameters on key performance characteristics, including impedance matching, operational bandwidth, radiation patterns, and gain. A systematic parametric optimization procedure is carried out to achieve optimal antenna performance within the target microwave frequency band. Simulation results demonstrate that the optimized antenna exhibits improved impedance matching, stable radiation characteristics across the operating band, and a significant enhancement in peak gain compared with conventional monopole microstrip antennas. Additionally, the proposed design shows reduced back-lobe radiation and improved front-to-back ratio, which are critical parameters for satellite communication applications. The obtained results confirm the feasibility of the proposed high-gain monopole microstrip antenna for use in compact satellite communication systems, including mobile, airborne, and ground-based terminals, and highlight its potential for integration into advanced microwave and millimeter-wave satellite links.

Keywords: Microstrip Monopole Antenna, Satellite Communication Systems, Slot Integration, Optimization; Microwave, Substrate.

Ismayil Amirli

The Role of Logistics infrastructure in Improving Brand Management Strategies in the Retail Sector of Azerbaijan

Sumgait State University, Sumgait, Azerbaijan

Abstract: The processes of globalization and the expansion of international trade have essentially increased the necessity of logistics infrastructure. The East-West Transport Corridor, connecting Europe and Asia, provides new opportunities for trade development and strengthens the position of transit countries such as Azerbaijan within the regional economic system. Accordingly, the efficient organization of logistics system and supply chains is a key factor in the enhancement of brand management strategies in the retail sector. This study aims to explore the role of logistics infrastructure and transport corridors in improving brand management strategies in Azerbaijan's retail trade. The article examines the theoretical aspect of brand management in retailing and analyzes how logistics efficiency, product availability, delivery speed, and supply chain reliability influence brand image and loyalty. Special attention is given to innovative and digital logistics solutions, including electronic customs systems and modern supply chain management tools, and their role in supporting retail brand development. Using analytical and comparative methods, the research indicates that effective logistics infrastructure strengthens brand competitiveness and ensures continuous product availability in the market. The

findings may help retail companies in Azerbaijan to develop and refine more effective brand management strategies.

Keywords: Logistics infrastructure, retail trade, brand management strategy, East-West transport corridor, digital logistics.

Jakub Donski-Lesiuk

A Logistics Approach to the Effective Use of the Trans-Caspian International Transport Route: A Perspective from Poland

University of Lodz, Institute of Logistics and Informatics, Lodz, Poland

Abstract: The Middle Corridor's transport potential is influenced by various factors, with cost considerations being a primary concern. However, cost isn't the sole factor determining the specific route's utilization. Achieving various objectives (financial, political, efficiency-related, etc.) requires accounting for variables that differ by region, country, and market. This article addresses the issue of optimizing the route to and from eastern Eurasia via Georgia and Azerbaijan from Poland's perspective. Poland has access to efficient logistics channels, but for geopolitical reasons, it is interested in strengthening and intensifying operations in this important alternative transport corridor. The article is based on research questions, and the answers are presented on the basis of a literature review.

Keywords: The Caspian-Caucasus Corridor from Poland's

perspective; Logistics support for trans-Eurasian transport; Geopolitical factors influencing logistics processes.

Jamila Asadova, Ali Talibov

Comparative Evaluation and Adaptation of Deep Learning Algorithms for Azerbaijani Vehicle License Plate Recognition

Azerbaijan University of Architecture and Construction,
Baku, Azerbaijan

Institute of Mathematics, Baku, Azerbaijan

Baku State University Baku, Azerbaijan

Abstract: This paper presents the results of a study, comparison, and adaptation of various Automatic Number Plate Recognition (ANPR) models for application within the context of Azerbaijan, emphasizing their performance in accurately capturing plates at vehicle entry and exit points. It highlights the strengths, limitations, and real-world applications, particularly in parking management. The integration of deep learning techniques, YOLO variants and OCR enhances recognition accuracy, robustness, and efficiency, supporting smart city initiatives and urban transportation systems. This study aims to evaluate and compare various segmentation and OCR methods for processing visual data to accurately identify license plates within the specific context of Azerbaijan's vehicle formats.

Keywords: Deep learning, YOLO, RCNN, License Plate

Recognition, Python, Computer vision, Optical Character Recognition.

K.N Shirinzade

Opportunities and the Potential of Azerbaijan's Logistics Infrastructure in the "Silk Road" Project

Khazar University, Baku, Azerbaijan

Abstract: The purpose of this study is to study the level of readiness of Azerbaijan's logistics infrastructure for the "Silk Road" project and compare its competitiveness with other alternative routes based on price and time (time spent on delivering cargo from the first destination to the final destination) factors, and to identify recommended steps to be able to offer competitive services. During the study, extensive use was made of research in this area by reputable international financial institutions such as the World Bank, the Asian Development Bank, the European Bank for Reconstruction and Development, as well as information published by the State Statistics Committee, the Baku International Trade Port, and "Azerbaijan State Railways" CJSC. The first section of the document contains information on the proposed transport corridors under the Silk Road Project and the East-West transport corridor, on which Azerbaijan is located, the development of trade, logistics and economic opportunities of this project in Azerbaijan, and calculations on the role of improving the quality of logistics in the likely increase in GDP and welfare. The second section of the study provides information on the initiatives and infrastructure

implemented by Azerbaijan within the framework of the Silk Road project (Baku-Tbilisi-Kars railway, Baku International Trade Port, etc.). The third section compares the goals set in the Strategic Road Map adopted in 2016 for the development of logistics infrastructure until 2020 and the current statistical situation. The final section presents the main results of the study and proposals for the development of logistics capabilities.

Keywords: Land Silk Road, Logistics infrastructure, Baku, free trade, seaport, transportation.

Khayala Ibrahimova, Sabina Naghiyeva, Afsana Gulieva
Cybersecurity Challenges in Digital Logistics Systems of the East-West Transport Corridor

Baku Engineering University, Khirdalan, Azerbaijan

Abstract: This article analyzes cybersecurity challenges arising in digital logistics systems operating within the framework of the East–West Transport Corridor. In recent years, the widespread adoption of IoT technologies, cloud-based plat-forms, and real-time data exchange systems in the logistics sector has significantly enhanced operational efficiency, transparency, and managerial flexibility. However, the increasing reliance on digital infrastructure has simultaneously ren-dered these systems more vulnerable to diverse and increasingly sophisticated cyber threats. In particular, ransomware attacks, data breaches, supply chain at-tacks, DDoS attacks, and intrusions targeting industrial control systems pose se-rious risks to the resilience and uninterrupted operation of logistics

infrastructure. This study identifies key challenges, including the disparity in cybersecurity maturity levels among countries participating in the East–West Corridor, the absence of unified security standards, the continued use of legacy systems, and risks associated with cross-border data exchange. The article systematically analyzes existing vulnerabilities and evaluates their potential impact on operational continuity, data integrity, confidentiality, and overall economic stability. Furthermore, a comprehensive security framework is proposed, integrating Zero Trust architecture, AI-based anomaly detection systems, SIEM integration, blockchain-based tracking mechanisms, and internationally coordinated cybersecurity strategies. The findings indicate that without the implementation of a unified, multi-layered, and proactive approach, ensuring the long-term security and resilience of digital logistics systems will not be feasible.

Keywords: Cybersecurity, Digital Logistics Systems, East-West Transport Corridor, Supply Chain Security, Internet of Things (IoT) Security, Ransomware Attacks, SCADA and Industrial Control Systems Security, Zero Trust Architecture, Security Information and Event Management (SIEM), Cross-border Data Security.

Khurshudov Dursun, Hunbataliyev Elmar, Nuraliyev Jamalladdin, Mikayilov Seymur

IoT and Artificial Intelligence-Based Monitoring and Risk-Based Control of Harmful Gases in Smart House

Areas

Azerbaijan University of Architecture and Construction,
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Azerbaijan Technical University, Baku, Azerbaijan

Abstract: This study investigates the problem of insufficient safety-oriented control of Indoor Air Quality (IAQ) within Smart House environments and pro-poses an IoT- and Artificial Intelligence-based system for monitoring harmful gases. In smart homes, comfort-oriented functions (heating, lighting, energy management) typically dominate, while real-time monitoring of gases such as CO, CO₂, NO₂, SO₂, as well as risk factors in basements and technical zones including radon (Rn), hydrogen sulfide (H₂S), and methane (CH₄), often remains limited. The proposed A IoT approach employs a multi-point sensor network to collect measurements across different zones, performs filtering and validation at the gateway level, and determines operational modes (“Normal – Warning – Hazard”) through anomaly/peak detection and risk index calculation. For CO and H₂S, instantaneous variation and peak criteria are applied, whereas for radon, a 24-hour average and trend-based assessment are utilized. In hazard mode, Smart House actuators activate ventilation systems, control valves, trigger alarms, and, when necessary, switch equipment to a safe operating state. As a result, the system extends the Smart House concept from a comfort-centered approach to a risk-based intelligent control model that ensures health protection and life safety.

Keywords: Smart House, Internet of Things (IoT), Artificial Intelligence (AI), Indoor Air Quality (IAQ), harmful gases, carbon monoxide (CO), carbon dioxide (CO₂), sensor network, risk index, adaptive ventilation control.

Konul Aliyeva, Arzu Mammadova

On a Numerical Method for Solving Some Optimization Problems in Transport Logistics

Sumgayit State University, Sumgait, Azerbaijan

Baku Business University, Baku, Azerbaijan

Abstract: This research explores the application of effective mathematical modeling and numerical methods for cost minimization, one of the most pressing challenges in modern transport logistics. The primary objective of the paper is to develop a modified iterative gradient method to enhance decision-making speed and reduce computational complexity in large-scale logistics networks. Alongside the linear structure of the classical transportation problem, the study analyzes non-linear cost functions frequently encountered in real-world scenarios. The paper proposes a hybrid application of the Method of Potentials and the Conditional Gradient (Frank-Wolfe) algorithm. To verify the theoretical propositions, a specific numerical example was calculated and simulated within a Python programming environment. The results indicate that the proposed numerical method demonstrates 25-30% faster convergence on large datasets compared to traditional Simplex-type algorithms.

This approach offers practical applications in the strategic planning of logistics centers, route optimization, and the reduction of fuel consumption. The study concludes that integrating high-speed numerical algorithms into digital logistics platforms significantly improves the overall efficiency of supply chain management and provides a robust framework for handling complex logistical constraints.

Keywords: Transport logistics, optimization problems, numerical methods, gradient descent, linear programming, cost minimization, mathematical modeling, algorithmic efficiency, supply chain management.

Konul Aliyeva, Khatire Babayeva

**Analysis of Methods, Models and Algorithms of
Mathematical Modeling Used in Logistics Research**

Sumgayit State University, Sumgait, Azerbaijan

Sumgayit secondary school № 26, Sumgait, Azerbaijan

Abstract: This article investigates the scientific foundations and application areas of mathematical models, methods, and algorithms used in logistics systems. The research analyzes static, dynamic, stochastic, and simulation models developed to improve the efficiency of logistics processes. Several optimization and metaheuristic algorithms (Simplex, Genetic Algorithm, Particle Swarm Optimization, Ant Colony Optimization, etc.) are examined comparatively to demonstrate their effectiveness in transportation planning, inventory management, production scheduling, and digital logistics

systems. Through simulation and hybrid modeling, the behavior of logistics systems under real world uncertainties has been explored, enabling evaluation of risks and system performance. The study results indicate that mathematical modeling can provide up to 20% cost reduction and 15% improvement in service level. Future research directions include the integration of Artificial Intelligence, Digital Twins, Blockchain technologies, and Green Logistics models to enhance smart and sustainable logistics solutions.

Keywords: Mathematical modeling, logistics, optimization algorithms, metaheuristics, simulation, artificial intelligence, supply chain management.

Konul Gasanova

Logistics in the Metallurgical Industry

Azerbaijan Technological University, Ganja, Azerbaijan

Abstract: The metallurgical industry is one of the most logistics-intensive sectors of heavy industry. Efficient management of material flows—from raw material procurement to final product distribution—directly affects production continuity, cost optimization, export performance, and international competitiveness. This paper analyzes the structural components of metallurgical logistics, identifies major infrastructural and operational challenges, and evaluates the role of digitalization, multimodal transportation, and quality management systems in improving logistics performance, with particular focus on Azerbaijan.

Keywords: Metallurgical logistics, supply chain management, industrial transportation, multimodal transport, infrastructure, digitalization, quality management.

Leyla Muradkhanli

Emergency Vehicle Detection and Traffic Control Using Computer Vision and Deep Learning

Baku Higher Oil School, Baku, Azerbaijan

Institute of Mathematics, Baku, Azerbaijan

Abstract: Efficient emergency response is a critical requirement in modern urban transportation systems. However, conventional traffic control mechanisms are static and unable to adapt to real-time situations, leading to unnecessary delays for emergency vehicles. This project presents a real-time intelligent traffic control system that integrates computer vision and deep learning for automatic detection of emergency vehicles. A YOLOv8-based object detection model processes live video streams from traffic surveillance cameras and identifies priority vehicles such as ambulances, fire trucks, and police vehicles. Upon detection, an intelligent decision module dynamically modifies traffic signal states to ensure uninterrupted movement of emergency vehicles. The system operates without requiring any modifications to vehicles, making it cost-effective and scalable for smart city deployment. Experimental evaluation demonstrates high detection accuracy, low inference latency, and stable real-time performance under varying traffic conditions.

Keywords: Computer Vision, Traffic Control, Emergency Vehicle Detection, Adaptive Control, Deep Learning.

Logman Abdullayev, Samira Seyidova Gulshan,
Huseynzade

Financial Information Management and Transit Efficiency in the East–West Transport Corridor

Sumgayit State University, Sumgayit, Azerbaijan

Abstract: The East–West transport corridor has become one of the most important transport routes connecting Asia and Europe and plays a significant role in the development of international logistics systems and global trade networks. The rapid growth of international trade and the increasing volume of cargo transportation have significantly increased the importance of efficient logistics management within this corridor. In this context, the effective management of financial information has emerged as a key factor for improving logistics efficiency and ensuring the sustainability of transit transportation operations. The purpose of this study is to analyze the role of financial information management in logistics activities within the East–West transport corridor and to evaluate the efficiency of transit operations. The research focuses on the relationship between logistics cost management, financial performance indicators and operational efficiency in logistics systems. The findings of the study demonstrate that effective financial information management contributes to improved logistics performance, enhanced cost control and better managerial

decision-making in logistics systems. The results also indicate that integrating financial analysis with logistics management can significantly improve the economic efficiency of transit transportation and support the development of international logistics corridors.

Keywords: East–West transport corridor, logistics management, financial information systems, transit transportation, logistics efficiency, international logistics.

Logman Abdullayev, Samira Seyidova, Gulshan Huseynzade

Financial Information Management and Transit Efficiency in the East–West Transport Corridor

Sumgait State University, Sumgait, Azerbaijan

Abstract: The East–West transport corridor has become one of the most important transport routes connecting Asia and Europe and plays a significant role in the development of international logistics systems and global trade networks. The rapid growth of international trade and the increasing volume of cargo transportation have significantly increased the importance of efficient logistics management within this corridor. In this context, the effective management of financial information has emerged as a key factor for improving logistics efficiency and ensuring the sustainability of transit transportation operations. The purpose of this study is to analyze the role of financial information management in logistics activities within the East–West transport corridor and to evaluate the efficiency of transit operations. The research focuses

on the relationship between logistics cost management, financial performance indicators and operational efficiency in logistics systems. The findings of the study demonstrate that effective financial information management contributes to improved logistics performance, enhanced cost control and better managerial decision-making in logistics systems. The results also indicate that integrating financial analysis with logistics management can significantly improve the economic efficiency of transit transportation and support the development of international logistics corridors.

Keywords: East–West transport corridor, Logistics management, Financial information systems, Transit transportation, Logistics efficiency, International logistics.

Mail Tagiyev, Khadija Aliyeva, Aida Mammedzade, İlahə Abdullayeva

Extruded $\text{Bi}_{0.85}\text{Sb}_{0.15}$ Solid Solution–Based Environmentally Benign Thermoelectric Energy Converters

Azerbaijan State University of Economics, Baku, Azerbaijan

Azerbaijan State University of Architecture and Construction, Baku, Azerbaijan

Institute of Physics, Baku, Azerbaijan

Institute of Molecular Biology and Biotechnology, Baku, Azerbaijan

Abstract: The thermo- and magnetothermoelectric properties of thermoelements and electronic coolers

based on extruded samples of n-type $\text{Bi}_{0.85}\text{Sb}_{0.15}$ and p-type $\text{Bi}_2\text{Te}_3\text{-Sb}_2\text{Te}_3$, thermoelements based on single crystals of n-type $\text{Bi}_{0.85}\text{Sb}_{0.15}$ and p-type $\text{Bi}_2\text{Te}_3\text{-Sb}_2\text{Te}_3$, as well as n-type $\text{Bi}_2\text{Te}_3\text{-Bi}_2\text{Se}_3$ and p-type $\text{Bi}_2\text{Te}_3\text{-Sb}_2\text{Te}_3$, were investigated in the temperature range of approximately 80–300 K. The results of the study suggest that extruded samples of the $\text{Bi}_{0.85}\text{Sb}_{0.15}$ solid solution can be effectively used as the n-leg of a thermoelement, especially in low-temperature stages of multistage thermoelectric coolers. A hybrid electronic cooler consisting of two blocks was fabricated and investigated. The first block is a four-stage cooler operating on the basis of the Peltier effect, while the second low-temperature block is a single-stage thermoelement operating on the Peltier effect in a magnetic field. When the low-temperature block is used as a magnetothermoelectric cooler, the best material for the n-leg of this block is a single crystal of $\text{Bi}_{0.85}\text{Sb}_{0.15}$. Although the temperature difference (ΔT) of extruded samples is 5 K lower than that of single-crystal samples, the high mechanical strength of the extruded material makes it highly advantageous for use as the n-leg of a magnetothermoelectric stage. This is particularly important considering that thermoelectric coolers and devices based on them are subjected to various mechanical and climatic influences during operation. The thermoelectric and hybrid coolers manufactured and investigated using the developed extruded material successfully passed all types of climatic and mechanical

tests required for devices of this class, and can be used in aerospace instruments for cooling various electronic devices.

Keywords: thermoelements, extrusion, energy converts, conductivity, solid solution.

Malahat Huseynova, Aida Tagiyeva

Development Prospects of the East–West International Transport Corridor in the Context of Green Logistics and Sustainable Transport Principles

Sumgait State University, Sumgait, Azerbaijan

Abstract: The development of sustainable logistics systems has become one of the main priorities in modern international transport networks. Rapid globalization and the growth of international trade have significantly increased freight transportation volumes, which in turn has intensified environmental challenges such as greenhouse gas emissions, fuel consumption and environmental pollution. In this context, the concept of green logistics has emerged as an important approach to improving the environmental sustainability of transport systems. The East–West international transport corridor plays a strategic role in connecting Asian and European markets and supporting international trade flows. However, the development of this corridor requires the integration of sustainable transport principles and environmentally friendly logistics solutions. The purpose of this study is to analyze the development prospects of the East–West transport corridor within the framework of

green logistics and sustainable transport principles. The re-search focuses on the role of multimodal transport systems, environmentally friendly logistics technologies and digital logistics management solutions in improving the efficiency of international transport corridors. The results of the study show that the implementation of green logistics strategies can significantly reduce environmental impacts while improving the economic efficiency of logistics operations. The findings also indicate that the development of sustainable transport infrastructure and modern logistics technologies plays an important role in the long-term development of international transport corridors.

Keywords: Green logistics, Sustainable transport, East–West transport corridor, International logistics, Environmental sustainability.

Malik Guliyev

Adaptive Urban Planning of Coastal Territories Under Caspian Sea Fluctuations: Physarum-Inspired Logistics Zonation of the Port of Baku

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Baku, Azerbaijan

Abstract: This paper proposes a digital urban planning model adapted for planning logistics areas located in the coastal zones of the Caspian Sea. A biomimetic algorithm inspired by the behavior of the slime mold *Physarum polycephalum* is considered. The study is necessary due to the rapid decline of the Caspian Sea level (more than 2.14

m between 2006 and 2024), with further declines predicted. A "flexible pulsating zoning" model has been developed within the Industry 4.0 paradigm. This model adapts the distribution of all logistics zones, such as access roads, warehouses, and container terminals, to dynamically changing hydrological conditions. From a mathematical perspective, this study presents the possibility of considering a modified model of the Physarum tubular network. In this model, dynamic obstacles are represented by flooding and shallowing, and the conductivity of network components is compatible with throughput. The risk zone is the operation of the Baku International Sea Trade Port (Alat), a logistics hub of the Trans-Caspian International Transport Route (Middle Corridor). The Alat port area demonstrates the potential to increase the resilience of logistics supply chains by 18–27% under various water level fluctuations. This approach enables the integration of bioinspired computational methods into the digital infrastructure for transport corridor management. This study will provide practical insights into adapting urban planning strategies for coastal logistics hubs.

Keywords: Physarum Polycephalum, Adaptive Zonation, Caspian Sea, Port of Baku, Industry 4.0, Digital Twin, Biomimetic Algorithm.

Malika Baizakova, Kadyralieva Nuraiym, Al Khan
Deep Reinforcement Learning for Adaptive Speech Intervention Sequencing in Children with Autism

Spectrum Disorder

INAI, Bishkek, Kyrgyzstan

Abstract: Autism Spectrum Disorder (ASD) is associated with significant speech and communication impairments that require highly individualised therapeutic intervention. Traditional speech therapy protocols apply fixed, clinician-designed exercise sequences that fail to adapt dynamically to each child's real-time performance. This paper presents DRL-AST, a Deep Reinforcement Learning framework for adaptive speech intervention sequencing in children with ASD aged 3–8. The framework models the therapy process as a Markov Decision Process in which a Proximal Policy Optimisation agent learns to select the next speech task from a structured action space based on a continuous state representation of the child's session performance. We evaluate DRL-AST against three baselines — random sequencing, rule-based sequencing, and a supervised learning scheduler — on a simulated therapy environment parameterised from clinical data of 312 children. DRL-AST achieves a cumulative reward 41.3% higher than the best baseline, reduces mean session error rate from 34.6% to 18.2%, and improves phoneme production accuracy by 22.7 percentage points over 20 simulated sessions. Ablation studies confirm that the reward shaping component contributes 14.8% of the total performance gain. The framework provides a principled, algorithmically grounded approach to personalised speech therapy and offers a blueprint for RL-driven intervention systems in neurodevelopmental care.

Keywords: Deep Reinforcement Learning, Autism Spectrum Disorder, Speech Therapy, Proximal Policy Optimisation, Adaptive Intervention, Markov Decision Process, Personalised Learning, Child Health.

Matanat Akhmedova, Galiba Mammadova, Khayale Mammadova

Strategic Planning and Logistics Coordination in the Management of Technoparks

Azerbaijan Technological University, Ganja, Azerbaijan

Abstract: Technoparks play a crucial role in promoting innovation, supporting high-technology industries, and enhancing regional economic competitiveness. Effective strategic planning and logistics coordination are essential components of technopark management, ensuring efficient resource allocation, infrastructure utilization, and sustainable development. This article examines the theoretical and practical aspects of integrating strategic planning with logistics coordination in technoparks. The study highlights the importance of aligning long-term development goals with logistics processes, including material flows, information exchange, and infrastructure management. Particular attention is given to the role of digital technologies, analytical information systems, and data-driven decision-making tools in improving coordination and operational efficiency. Strategic planning enables technopark management to identify priorities, optimize logistics networks, and respond effectively to dynamic market and technological changes. At the same

time, efficient logistics coordination contributes to reducing operational costs, improving service quality, and strengthening collaboration between resident companies and external stakeholders. The research emphasizes that the integration of strategic planning and logistics coordination enhances the overall performance, adaptability, and competitiveness of technoparks. The findings demonstrate that modern technoparks require flexible management models based on innovation, digitalization, and systemic coordination. The proposed approaches can be applied to improve technopark management systems, support innovation ecosystems, and ensure sustainable economic development in the context of global technological transformation and increasing logistics complexity.

Keywords: Technopark management, strategic planning, logistics coordination, innovation infrastructure, supply chain management, operational efficiency.

Mehriban Yadulla Y.

Azerbaijan's Role in the North-West Transport Corridor: Logistics Development and Regional Connectivity

Baku Business University, Baku Azerbaijan

Abstract: International transport corridors have become essential instruments for enhancing global trade, strengthening regional integration, and ensuring sustainable economic development. The North-West Transport Corridor is gaining increasing importance as a

multimodal route linking Europe and Asia through efficient logistics networks. Within this framework, Azerbaijan plays a strategic role due to its geographical position at the crossroads of major Eurasian trade routes. The country's investments in transport infrastructure, including the Baku International Sea Trade Port and the Baku–Tbilisi–Kars railway, have significantly increased its transit potential and contributed to improved regional connectivity. Moreover, the adoption of digital technologies and smart logistics solutions in line with the Fourth Industrial Revolution can enhance transparency, reduce operational costs, and optimize supply chain performance along the corridor. This abstract emphasizes Azerbaijan's contribution to the development of the North-West Transport Corridor and highlights its economic, technological, and geopolitical significance for regional cooperation and sustainable logistics systems.

Keywords: Azerbaijan, North-West Transport Corridor, logistics, multimodal transport, regional connectivity, digitalization, sustainable development.

Melih Eşiyok, Okan Uluturk, Berke Bekar, Israfil Isakhli, Efendi Nasiboglu

Detection of the Braess Paradox in Signalized Road Networks via Traffic Flow Simulation

Dokuz Eylül University, Izmir, Türkiye

Abstract: Braess's paradox is an observation stating that adding one or more roads to a road network can slow down the overall flow of traffic. This paradox was first

discovered by Arthur Pigou in 1920 and later named after the German mathematician Dietrich Braess in 1968. This research was conducted to examine urban traffic congestion in the Buca district of Izmir, to investigate the observability of Braess's Paradox with real-world data, and to develop simulation-based solutions. The study collected traffic data from 758 strategic points using the TomTom Traffic API and calculated congestion, density, and weight scores. The collected data was analyzed using geographic heat maps and speed analyses. High congestion density and low speeds were observed in the northern regions of the district. The SUMO (Simulation of Urban Mobility) software was used for intersection management. The data was used to test different strategies for lane management, left-turn restrictions, and green wave signalization optimization. The results show that data-driven interventions and microsimulation-supported planning can reduce the average travel time in the region.

Mir Ramin Yunusov

Assessment of Natural Disaster Risks in Transport Networks: Mathematical Analysis and Simulation of Deep Learning Models

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Baku Engineering University, Khirdalan, Azerbaijan

Abstract: Against the backdrop of global climate change, along with the increasing frequency and intensity of extreme meteorological events, ensuring the resilience of

transport infrastructure—considered a critical geostrategic issue in the modern era—is regarded as a highly topical subject. The presented scientific re-search is designed to assess natural disaster risks (landslides, floods, extreme temperatures, and severe meteorological events) within the existing transport networks on the Azerbaijani segment of the East-West Transport Corridor. The study proposes a complex hybrid deep learning framework that radically differs from traditional linear and statistical models by integrating Spatio-Temporal Graph Convolutional Networks (STGCN), Long Short-Term Memory (LSTM) algorithms, and Fuzzy Logic mechanisms. This formulated model conducts an in-depth analysis of network topology and cascading failure dynamics based on complex mathematical graph theory. Within the framework of the study, the structural vulnerability of the infrastructure to natural disasters was quantified using the Fuzzy Comprehensive Evaluation (FCE) method, while the economic and logistical significance of the road segments was simulated through graph betweenness centrality measures and dynamic flow equations. Based on advanced global research from the past fifteen years, this hybrid approach provides optimized computer coding and algorithmic solutions (e.g., IPW - Independent Path Weight) for automated traffic rerouting, the isolation of cascading effects, and network recovery during a disaster. The final results prove that the proposed knowledge-driven hybrid STGCN model demonstrates significantly higher predictive accuracy in forecasting spatio-temporal

traffic flow under extreme weather conditions and in preventing network collapses compared to traditional machine learning models.

Keywords: Transport, natural disaster risks, deep learning, cascading failures, re-silience metrics, fuzzy logic, mathematical simulation.

Mustafa Eminov, Rana Amirova, Gunel Babanli

Transition from Digital Logic to Artificial Intelligence and Fuzzy Logic Models in Logistics Decision Systems

Azerbaijan Technical University, Baku, Azerbaijan

Abstract: Modern logistics systems require intelligent decision-making mechanisms to manage uncertainty, optimize resource allocation, and ensure timely delivery of orders. Traditional digital logic models based on Boolean functions provide a simple framework for modeling logistics decisions; however, they fail to capture the dynamic and uncertain nature of real supply chain environments. This study proposes a transition from a digital Boolean decision model to an artificial intelligence-based framework using fuzzy logic and spherical fuzzy sets. The model evaluates order urgency, resource availability, and route feasibility. Boolean decision rules are analyzed using partial derivatives to determine system sensitivity and are then extended using fuzzy logic to represent uncertainty. A spherical fuzzy optimization approach improves flexibility and adaptability. Simulation results show that the AI-based model provides smoother decision surfaces and better optimization performance

compared to the digital model.

Keywords: Artificial Intelligence, Fuzzy Logic, Spherical Fuzzy Sets, Logistics Decision Systems, Supply Chain Optimization, Boolean Logic, Decision-Making Models, Route Optimization, Resource Allocation.

N.T. Kurbanov, U.S. Aliyeva

Study of Vibrations of Cylindrical Shells with Rheological Properties

Sumgait State University, Sumgait, Azerbaijan

Abstract: Using the Laplace integral transform and small parameter methods, the solution to the Volterra integro-differential equation with a convolution kernel is constructed as a series whose first term coincides with the solution to this equation obtained by the well-known averaging method. The solution is investigated under periodic loading, and it is found that at resonance, the amplitude of forced oscillations remains finite, while the amplitude of free oscillations decays over time.

Keywords: Integro-differential equation, image, original, kernel, rheology, resonance, amplitude, convolution of functions, Laplace transform.

Nabi Kurbanov, Vusala Babajanova, Kamala Agamaliyeva, Konul Abdullayeva

Investigation of the Vibrations of a Viscoelastic Beam with Hinged Ends

Azerbaijan

Abstract: It is known that with advances in engineering

techniques, solving vibration problems of systems has become increasingly important. Therefore, only on the basis of vibration theory can practically significant problems—such as the vibrations of rods, beams, bridges, and foundations under random external forces—be fully understood. Using this theory, the optimal proportions of structures can be determined, taking into account the rheological properties of the construction materials. Many problems concerning the vibrations of rods, beams, and plates are of great importance in structural mechanics and lead to higher-order Volterra integro-differential equations. This work studies the initial-boundary value problem for the equation of forced.

Keywords: viscoelastic beam, rod, rheological properties, Laplace transform, integro-differential equation, averaging method, flexural transverse vibrations.

Nabi Kurbanov, Vusala Babajanova, Kamala Agamaliyeva,
Konul Abdullayeva

Studying Forced Vibrations of a Viscoelastic Beam with Built-in Ends

Sumgait State University, Sumgait, Azerbaijan

Abstract: The paper deals with an initial-boundary value problem for an integro-differential equation forced vibrations of a viscoelastic beam with built-in ends. Such a fourth-order linear Volterra type integro-differential equation with a convolution kernel in the form of a describes transverse bending vibrations of a homogeneous viscoelastic beam when exposed to an

external force in the absence of rotational movement under bending. The problem is solved for arbitrary hereditary functions using the method of separation of variables and the Laplace transforms. The solution is constructed as series in terms of the system of eigenfunctions of a one-dimensional spectral problem, which forms an orthogonal and complete system. The solution to the problem is initially found in the absence of an external force and homogeneous boundary conditions, and then the general case is considered in the presence of an external force. In both cases, the solution to the problem is constructed in the form of a converging series the first term of which coincides with the solution of this equation, obtained by the known averaging method, and taking into account subsequent members provide amendments to these solutions.

Keywords: Built-in beam, forced vibrations, initial and boundary conditions, spectral problem, viscoelasticity, kernel, relaxation function, rheological properties, analytic solution, convolution of functions.

Nahid Jafari, Bruno G. Kamdem

A Differential Game of Profit-Sharing in Multinational Transport Corridors: Strategic Interactions between Governments and Transportation Firms

School of Business, Farmingdale, NY

Abstract: The escalating tensions in the Middle East, coupled with the persistent risk of disruption in the Strait of Hormuz, have intensified concerns about the economic

resilience of multinational energy corridors. This paper addresses these challenges by modeling the strategic inter-action between sovereign governments and transportation carriers as a stochastic differential game within a “Triple-Cost” framework. The latter includes infrastructure maintenance, distance-based tolls, and geopolitical risk. Using a geometric mean-reverting process to capture commodity price volatility, we solve the Hamilton-Jacobi-Isaacs (HJI) equations to characterize a Feedback Nash Equilibrium. Our findings reveal that the optimal fiscal policy follows a bang-bang control structure, where the government’s shift from a high-tax regime to a low-tax incentive is governed by a critical switching threshold (\hat{x}). Notably, increased geopolitical instability, modeled as a higher probability of maritime disruption, exponentially raises this threshold, inducing a “policy lock-in” that compels carriers to impose peak risk surcharges. By integrating stochastic price dynamics and geopolitical risk into a unified payoff framework, this study offers a rigorous analytical lens for assessing the strategic stability and operational viability of global energy corridors amid heightened regional and global uncertainty.

Keywords: Global Supply Chains Geopolitics Nash equilibrium.

Naila Musaeva, Telman Aliev

Technologies for Determining the Most Vulnerable Elements of a Bridge Structure

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Abstract: The study addresses the problem of identifying the most vulnerable elements of a bridge structure subjected to climatic and traffic loads during operation. It is shown that existing monitoring systems fail to effectively detect and track the development of defects in their initial, latent stage; they also lack the capability to prioritize repairs based on the severity of malfunctions when multiple issues occur simultaneously. The authors demonstrate that when defects appear in the structural elements of a bridge, sensor output signals represent an additive mixture of useful components and noise. However, existing monitoring systems do not analyze noise as a carrier of diagnostic information during signal processing. We propose algorithms for calculating the correlation coefficient between the useful signal and the noise as an informative indicator of malfunction occurrence. Furthermore, algorithms are proposed for calculating the probability of the noise falling outside prescribed regulatory intervals. Algorithms are developed for determining the dynamics of malfunction and defect progression at the initial stage by calculating these probabilities over different time periods. Algorithms are proposed for assessing the significance of each structural component of a bridge individually, alongside a technology for identifying the most critical elements across the entire bridge. It is shown that the use of these

developed algorithms and technologies enables the prioritization of repair work when multiple malfunctions occur simultaneously, thereby preventing accidents.

Keywords: noise, useful signals, noise characteristics, bridge, vulnerable structural elements, priority repair.

Najaf Mammadzada, Jabir Mammadov

Zero-Day Vulnerabilities: Detection, Impact and Response in Society 5.0 Critical Systems

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Abstract: As Society 5.0 integrates cyberspace and physical space to solve social problems, the reliance on interconnected software systems reaches unprecedented levels. This hyper-connectivity introduces severe risks from zero-day vulnerabilities—security flaws unknown to the vendor and for which no patch exists. This paper analyzes the lifecycle of zero-day exploits and their potential impact on the critical infrastructure underpinning Society 5.0, such as autonomous transportation, smart grids, and healthcare networks. We explore advanced detection mechanisms, including behavioral analysis and AI-driven anomaly detection, that move beyond traditional signature-based methods. Furthermore, we propose a comprehensive response framework that emphasizes rapid containment, forensic analysis, and coordinated disclosure. By examining case studies like Stuxnet and Log4Shell, we highlight the cascading effects of zero-day attacks. Finally, we project the future of vulnerability management towards 2026,

predicting the rise of automated patching systems and the challenges posed by quantum computing to current encryption standards.

Keywords: Zero-Day Vulnerabilities, Exploit Detection, Threat Intelligence, So-ciety 5.0, Critical Infrastructure, Patch Management.

Najaf Mammadzada, Oghuz Mammadov

Enhancement of Adaptive Digital Forensics and Cyber Incident Response Mechanisms in Critical Infrastructure Facilities

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Abstract: The convergence of Operational Technology (OT) and traditional IT networks has exposed critical infrastructure facilities to sophisticated cyber threats that standard forensic methodologies fail to address effectively. Legacy industrial control systems (ICS), characterized by proprietary protocols, high availability requirements, and severe resource constraints, cannot support the invasive data acquisition techniques used in corporate IT environments. This paper presents the Adaptive Forensic and Response Framework (AFRF), a novel, tool-centric approach designed specifically for SCADA and ICS environments. By in-tegrating open-source industry-standard tools— specifically Zeek for passive network monitoring, OSQuery for endpoint telemetry, and Volatility for memory forensics—into a unified, context-aware architecture, we demonstrate a method-ology that dynamically adjusts data collection fidelity based on real-

time threat levels. Our research proposes a custom “Forensic Governor” module that orchestrates these tools to minimize operational disruption while ensuring the preservation of legally admissible evidence. We validate this framework through a realistic testbed simulation involving Modbus TCP manipulation and ransomware attacks. Experimental results indicate that our adaptive configuration of Zeek and OS-Query reduces forensic data storage requirements by 95% and CPU overhead on critical PLCs by 40% compared to static full-packet capture methods, while successfully preserving 92% of critical attack artifacts.

Keywords: Critical Infrastructure Protection, Digital Forensics, Incident Response, SCADA Security, Zeek, OSQuery, Industrial Control Systems, Adaptive Forensics.

Namig Heydarov, Orkhan Ahmadzadeh, Arif Hasanov,
Adalat Pashayev

**Scientific Foundations of a Video-Camera and
Artificial-Intelligence-Based Proactive Hazard
Detection System for Railways**

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Azerbaijan Railways Closed Joint-Stock Company (ADY
CJSC), Baku, Azerbaijan

Military Research Institute of the National Defense
University, Baku, Azerbaijan

Institute of Mathematics, Baku, Azerbaijan

Abstract: Safety in railway transportation—especially on open track segments, level crossings, station approaches,

and railway sections adjacent to populated areas—depends not only on operating discipline but also on the ability to identify risk in advance. Owing to the large mass of trains, long braking distances, and the limited field of view available to the driver, late detection of hazardous objects on or near the track may lead to severe consequences. This paper proposes a pro-active hazard detection system that combines video cameras, computer vision, and deep-learning-based object detection modules. The study focuses on three technical pillars: real-time object recognition in the railway environment, monocular image-based distance estimation, and computation of a risk index consistent with train dynamics. In the proposed approach, a YOLO-type detector, camera calibration, a perspective projection model, a vanishing point derived from rail geometry, and a safe stopping distance model are integrated within a single system. Simulation-based calculations indicate that, for a train operating in the 80–100 km/h range, reliable detection of an object at a distance of 400–550 m creates a practical window for driver warning and/or automatic braking decisions. The paper concludes that a camera-based hazard detection system enhanced by AI is an economically and technically justified direction for the digital transformation of railway safety when integrated with existing signalling infrastructure.

Keywords: railway safety, computer vision, object detection, monocular distance estimation, YOLO, risk model, camera calibration.

Nubar Guliyeva, Gusniyya Gashimova, Humay Guliyeva
**Intelligent Control of Transit Cargo Flows in the Baku
Logistics Hub of the East–West Transport Corridor**

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Abstract: Efficient management of transit cargo flows is one of the key challenges in modern transport logistics, especially for international transport corridors connecting Asia and Europe. Azerbaijan plays a strategic role in the East–West transport corridor, where the Baku Logistics hub acts as an important multimodal transport node integrating maritime, railway, road and air cargo transportation. In this study, a mathematical model of the transport network of the Baku Logistics hub is proposed for the analysis and optimization of transit cargo flows. The transport system is represented as a directed graph in which nodes correspond to logistics centers and transport hubs, while edges represent transport routes between them. The objective of the model is to determine optimal routes for cargo transportation based on transit time and network conditions. Simulation experiments were conducted in the MATLAB environment to evaluate the behavior of the transport control system under different operational scenarios, including transport delays and infrastructure disruptions. The proposed model can also be used to analyze the stability of transport networks and to evaluate alternative logistics routes under varying operational conditions. The results demonstrate that intelligent control of transport routes allows more

efficient distribution of cargo flows and improves the reliability of transit transportation within the East–West corridor. The proposed approach can be applied to the development of intelligent transport management systems for multimodal logistics networks.

Keywords: transport logistics, graph modeling, intelligent transport systems, cargo flow optimization, multimodal transport, East–West corridor.

Nuray Aliyeva

**Transport Corridors as Drivers of Tourism
Development: The Case of the Zangezur Corridor in
Azerbaijan**

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Azerbaijan

Abstract: The Zangezur Corridor, which was built after the Second Nagorno-Karabakh War in 2020, is vital for transportation and economic connectivity in the region. The establishment of the corridor could create new chances for growth in both the tourism and trade and logistics industries. Building better roads and other transportation infrastructure makes it easier for tourists to get to their destinations and opens up new tourism routes. The aim of this research is to examine the potential impacts of the Zangezur Corridor on the expansion of tourism in Azerbaijan. The research analyzed the theoretical framework on the economic and social benefits of transportation corridors to the tourism industry and

evaluated the possible effects of the Zangezur Corridor on the accessibility of Azerbaijan's tourist hotspots. The corridor's potential to enhance regional tourism, facilitate the development of new tourism routes, and strengthen cross-border tourism collaboration has also been analyzed. The research utilized a literature review and conceptual analysis methodology. The research findings indicate that transportation corridors significantly contribute to the development of the tourism industry, and the completion of the Zangezur Corridor could augment tourism activities in Azerbaijan. But things like regional security, investments in infrastructure, and working together with other countries are some of the most important things that affect how the corridor affects tourism.

Keywords: Zangezur Corridor, tourism development, transportation development, regional connectivity, Azerbaijan tourism.

Olga Kosheleva, Shahnaz Shahbazova, Huseynova Sevil
Iskender, Iskenderov Rehim

Data Privacy in the Age of Big Data: Opportunities and Challenges

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Abstract: In our research, we begin by reviewing big data

and how it has revolutionized the way data is collected, stored, and analyzed, and then highlight the various opportunities that big data provides, including the ability to identify new patterns, trends, and ideas leading to more informed decision-making processes. We explore the value of data privacy and how it helps protect people's rights and freedoms. The paper examines the various types of information that are collected and used in the analysis of large amounts of data, including personal information, and emphasizes the importance of consent and openness in the collection and use of information. In its conclusion, the academic study highlights the value of data privacy in the age of big data and notes that it is a fundamental right that must be preserved. The study highlights the need for group initiatives to protect data privacy involving governments, organizations, and individuals.

Keywords: Data privacy, Big Data, Personal data, Privacy concerns, Privacy protection, GDPR.

Orkhan Hasanli, Heybatulla Ahmadov

The Use of a Method for Selecting the Right Outsourcing Providers in the Logistics Strategies of Enterprises

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Abstract: This article studies the development of a method for selecting the right outsourcing providers in the logistics strategies of enterprises. One of the main

problems faced by enterprises using outsourcing services is ensuring the right provider selection and taking into account technical and economic indicators in this process. The proposed “MI-MA” method involves conducting internal and external assessments. This assessment is based on 6 main criteria: experience, cost, quality, risk, carrying capacity and traceability indicators. Within the frame-work of the study, the evaluation coefficients are analyzed more precisely using fuzzy set theory and objective comparisons are made. The constraint conditions defined for each criterion allow evaluating the effectiveness of providers and determining their suitability. The proposed method creates an optimal choice opportunity for customer enterprises, taking into account the different indicators of providers. The methodology obtained as a result of the study provides enterprises with new approaches to more effectively use the advantages of outsourcing services, reduce costs and improve the quality of work. The approaches in the article are suitable for practical applications and can help enterprises develop outsourcing strategies.

Keywords: logistics, outsourcing, transport logistics, evaluation method, logistics management, outsourcing strategy.

Petro Stetsyuk, Viktor Stovba, Olha Khomiak

On the Uniqueness of the Solution in a Linear Two-Stage Transportation Problem

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Ukraine

Abstract: This paper investigates the relationship between solutions of the linear programming problem and corresponding quadratic optimization problems defined over the set of optimal solutions. It is shown that if the linear programming problem admits a unique optimal solution, then it coincides with the solution of the quadratic problem. However, the converse does not hold in general, which is demonstrated by a counterexample. A simple sufficient condition for non-uniqueness is established based on the comparison of solutions obtained by linear and quadratic formulations. The quadratic problem is further interpreted as a regularization of the linear programming model, allowing one to select a unique canonical solution with minimal Euclidean norm. This approach eliminates ambiguity in the presence of multiple optimal solutions and provides a stable and well-defined representative of the optimal set. The theoretical results are illustrated in the context of the two-stage transportation problem with two-sided constraints on consumer demands and capacities of intermediate nodes, and related applications, where non-uniqueness naturally arises. The proposed framework offers both theoretical insight and practical tools for handling multiple optimal solutions in optimization problems.

Keywords: Two-Stage Transportation Problem, Linear Programming, Quadratic Problem, Optimal Solution Uniqueness.

Piotr F. Borowski

Economic and Ecological Efficiency of Rail, Road and Air Transport in the Management of Forwarding Companies: Analysis of Poland-Azerbaijan Trade

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Khazar University, Baku, Azerbaijan

Abstract: The chapter presents a comparative analysis of three main transport modalities – rail, road, and air – in terms of their economic efficiency and environmental impact in the Poland–Azerbaijan trade corridor. The study is based on trade data from 2020–2025 (including the first half of 2025), analyzing trade turnover, commodity structure, unit transport costs, transit times, and greenhouse gas emissions. The empirical analysis includes the maximum values for each transport mode: rail transport can deliver goods in up to 14 days with a maximum emission of 30 kg CO₂/tkm and a cost of 100 USD/t, road transport in up to 12 days with a maximum emission of 120 kg CO₂/tkm and a cost of 200 USD/t, and air transport in up to 2 days, generating maximum emissions of 600 kg CO₂/tkm at a cost of 1200 USD/t. The study also considers the role of logistics companies operating along this trade route. The empirical analysis is extended with a forecast of trade development and transport demand until 2028, using a linear extrapolation method based on trend analysis. This approach allows for the assessment of both the current efficiency of each transport mode and their potential role in handling increasing freight flows. The results highlight the growing

importance of intermodal solutions and the necessity of implementing strategies to mitigate the environmental impact of transport, which has significant implications for logistics management in the medium term.

Keywords: Transport modalities, CO₂ emissions, freight efficiency, logistics management, transport enterprise performance.

Qayyum Shah, Shaukat Ali Shah

The Analytical Framework of Forced Convective Two-Dimensional MHD Flow of Jeffrey Nanofluid Along with Thermal Radiation and Activation Energy

Pakistan

Abstract: The present communication owns to address the mathematical framework of two-dimensional electrically conductive and thermally radiative Jeffrey nanofluid flow by a curved surface. The interaction of a periodic magnetic field with the suspended nanoparticles and mixed convection are critically important due to its application in a broad spectrum. Buongiorno's model, incorporates the effect of thermophoretic force and Brownian movement, describes the nature of Jeffrey nanofluid. The influence of activation energy, viscous dissipation, and thermal radiation effects are reserved. The dimensionless system of differential equations has been diminished from the modeled equations via transformation framework which is solved analytically versus homotopic algorithm. The stability and convergence analysis has been carried out to optimize

system parameters and accuracy of the system. The effect of physical constraints on flow field, energy, and concentration of nanoparticles are portrayed via plotted graphs and debated.

Keywords: Jeffrey nanofluid, MHD, HAM solution, mixed convection, thermal radiation.

R. Asadova

Method for Determining the Water Cut of Formation Oil at the Sucker Rod Pump Intake

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Abstract: This article addresses a critical socio-technical and engineering challenge: the real-time determination of the water cut of formation fluids in oil wells equipped with sucker rod pumps (SRP). The efficiency of oil field development, particularly in its late stages, is heavily contingent upon the precision and timeliness of monitoring the composition of the extracted fluid. Given the widespread use of water injection for reservoir pressure maintenance, there is a significant increase in the water content of well production. This phenomenon diminishes oil recovery efficiency, escalates energy consumption, increases transportation and processing costs, and accelerates equipment corrosion. A novel method for determining the water cut at the SRP intake is proposed, based on the measurement of operational well parameters: casing and flowline pressure, the dynamic fluid level in the production string, and the pressure and temperature within the annulus. Measurements are

conducted at two distinct points in time with the flowline valve closed, allowing gas to accumulate above the fluid level in the annulus. A calculation algorithm has been developed to determine the water fraction based on these measured parameters and the known densities of oil and water. The method incorporates a mathematical model and an architectural framework for a measurement system comprising pressure, temperature, and level sensors, alongside a computing and display unit. A computational example validated the applicability of the method, yielding a water cut of 45%. Key advantages of the method include: Real-time measurement capability; Elimination of the need for manual laboratory sampling; Simplicity of implementation; Seamless integration into automated oil production management systems.

Keywords: Oil production, formation fluid, water cut, sucker rod pump (SRP), dynamic level, gas-oil ratio, oil production automation.

Rahman Aliyev, Vyacheslav Kuznetsov

Conceptual Design of a Solar-Hydrogen Autonomous Power Unit for Offshore Oil and Gas Infrastructure

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Azerbaijan

Abstract: The offshore oil and gas industry increasingly requires autonomous, reliable, and environmentally sustainable power sources for monitoring, safety, and auxiliary systems in remote marine environments. Conventional solutions, such as diesel generators, battery

systems, or subsea cable connections, involve high operational costs, complex logistics, fuel transport challenges, and environmental risks, including emissions and spills. This paper proposes a conceptual design of a solar–hydrogen autonomous power unit for offshore applications. The system integrates three physically validated processes: solar-driven photo-catalytic hydrogen generation from water, ultrasonic enhancement of reaction kinetics and mass transfer, and hydrogen-based energy conversion through fuel cells or micro-turbines. Ultrasonic activation improves hydrogen evolution by promoting cavitation, enhancing mass transfer, and reducing catalyst deactivation. Seawater is used as the working medium, while solar radiation serves as the primary energy input, minimizing external consumables and maintenance requirements. The feasibility of the concept is justified using literature-reported phenomena, engineering rationale, and fundamental physical principles, without experimental validation at this stage. The proposed system is suitable for autonomous applications such as navigation buoys, pipeline monitoring stations, cathodic protection units and environmental monitoring platforms. Compared to conventional solutions, the system offers zero local emissions, elimination of fuel spill risks, reduced logistical demands and improved compliance with environmental regulations and ESG frameworks. Currently, the concept corresponds to Technology Readiness Level 1–2, with future research focused on laboratory validation and pilot-

scale testing. This approach represents a promising direction for the development of autonomous, low-maintenance, and environmentally safe power systems for offshore oil and gas infrastructure.

Keywords: Solar hydrogen, photocatalysis, ultrasonic enhancement, offshore energy systems, oil and gas infrastructure, autonomous power supply.

Ramin Musaev

The Ethics of Artificial Intelligence and the Ethics of Artificial Intelligence in Medicine and Healthcare, Recommendations of the World Health Organization (WHO).

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Abstract: This article explains the concept of the ethics of artificial intelligence (AI), the ethics of artificial intelligence in medicine and healthcare, and describes the recommendations of the World Health Organization (WHO). It describes the White Paper on Ethics in AI, published in Russia—a detailed and carefully structured overview of the most pressing ethical issues arising in the development of artificial intelligence. It also describes the first WHO global report on artificial intelligence (AI) in healthcare and six guiding principles for the development and use of relevant tools. The article also describes the recommendations on the ethical aspects of artificial intelligence adopted by UNESCO. This article addresses the most pressing socio-ethical issues associated with the development and widespread implementation of

advanced artificial intelligence in the context of global digitalization. It examines the impact of artificial intelligence on economic growth, productivity, and the workforce, as well as the exacerbation and perpetuation of inequality caused by the implementation of AI-based technologies. The article challenges the myth that the implementation of advanced artificial intelligence will lead to the replacement of jobs associated with monotonous and repetitive labor, leaving only creative professions. On the contrary, the need to develop, train, and technically support artificial intelligence leads to the creation of a huge number of ghost jobs with monotonous work, without any contracts or control over labor relations. It also analyzes AI-related discrimination in the labor market and other consequences for individuals and society. The article demonstrates the intertwining of ethical issues and the social consequences of the widespread implementation of advanced artificial intelligence. The growing use of AI in healthcare presents governments, providers, and communities with new opportunities and challenges. We live in extraordinary times—an era when technology is advancing rapidly, and artificial intelligence is no longer science fiction, but a part of our reality. But this technological progress raises an important question: how can we ensure that AI development is safe, fair, and ethical? And by what rules will we live in a society of new technologies? With every step in technological development, we encounter increasingly complex ethical and social questions. Who is

responsible for the decisions made by autonomous systems? Is it even possible to delegate decision-making to AI. Will we lose our jobs. What happens to the privacy of our data. Is AI a black box, and how should we properly communicate with AI systems and with each other.

Keywords: Concept of artificial intelligence (AI) ethics, AI ethics in medicine and healthcare, WHO's first global report on artificial intelligence (AI), data protection, healthcare, artificial intelligence, human rights.

Ramin Musaev

The Concept of Oil Refining and Petrochemical Synthesis and Closed-Loop Economics for Solving Environmental Problems in oil Refining, Petrochemical Synthesis, and Oil and Gas Production

Russian Academy of Sciences, Moscow, Russia

Abstract: This article explores the concepts of oil refining and petrochemical synthesis. It describes the principles of a circular economy, explores its meaning, and explores its role in solving environmental problems in oil refining, petrochemical synthesis, and oil and gas production. Interest in the circular economy (CE) is growing in academia, government, and business. However, the question of what a circular world will look like remains insufficiently studied or even formulated. Scientific research focuses on analyzing circular strategies (C-strategies) within the context of sustainable development, examining the benefits of C-strategies, and the barriers to achieving them. However, C-strategies without a clear

vision of the future can hinder the achievement of goals and the resolution of a number of environmental problems. This article presents visions of a circular future and defines the circular economy. Without these, diverse understandings of the concept are inevitable, leading to the introduction of different metrics for measuring progress toward circular goals. Key findings: The circular economy is an evolving concept, which explains the lack of a unified definition. It should reflect visions of the future, which will form the basis for developing a unified system of metrics for measuring the degree of goal achievement and comparing them internationally. Visions of the future must be interpreted as a process of improvement, as they can be transformed... The concept of oil refining. Oil refining is the processing of crude oil to obtain primary petroleum products. Previously, straight-run distillation was used. Now, more complex processes have been developed and are used. The oil refining process includes: cracking; alkylation; hydrogenation; aromatization; polymerization; synthesis. Straight-run distillation of crude oil is the process of separating it into individual fractions, which differ primarily in boiling point. Petrochemical synthesis is the extraction of substances from petroleum products and hydrocarbons from petroleum and natural gases through chemical processing. Thus, chemical compounds obtained from petroleum are classified as petrochemical products. The aim of this study is to demonstrate how circular economy principles in the oil industry can be used to avoid environmental pollution

and address the issue of sustainable development in a country or region.

Keywords: Concept of oil refining, concept of petrochemical synthesis, oil and gas production, circular economy, sustainable development.

Rashad Mastaliyev, Khayala Alasgarova, Nigar Gafarova
On First-Order Necessary Optimality Conditions for Stochastic Integro-Differential Systems with Memory Effects

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Abstract: This paper investigates an optimal control problem for stochastic systems governed by ordinary nonlinear integro-differential equations. In this class of equations, the limits of integration depend not only on the current time but also on the past trajectory of the process. This feature captures the inherent memory effect of the system and allows for a more accurate and adequate representation of real-world phenomena. At the same time, such dependence significantly complicates the analysis of dynamical systems under uncertainty and necessitates a non-trivial extension of classical deterministic methods. The admissible controls are assumed to belong to the class of piecewise continuous functions. The objective functional is defined in the Mayer

form, and the problem consists in minimizing its mathematical expectation. Under a set of natural and sufficiently general assumptions on the problem data (the control domain is bounded –convex, and open set) first order necessary optimality conditions are derived. In particular, stochastic analog of Pontryagin’s maximum principle, the linearized maximum principle, and Euler type necessary optimality conditions are established. The analysis is based on variational techniques and linearization procedures, employing a refined version of the increment method adapted to the stochastic framework. The proposed approach contributes to the development of optimal control theory for systems with memory and provides a theoretical foundation for applications in stochastic decision-making problems.

Keywords: Stochastic Integro-Differential Equations, Memory Effects in Stochastic Systems, Optimal Control, Stochastic Optimality Conditions, Pontryagin’s Stochastic Maximum Principle, Linearized Stochastic Maximum Principle, Euler Type Stochastic Necessary Condition.

Revaz Kavtaradze, Giorgi Chilashvili, Revaz Giorganishvili, Jemal Javakhishvili, Paata Dolidze

Development of the Automotive Version of an Atomic Hydrogen Generator for Reducing Nitrogen Oxides in Internal Combustion Engine Exhaust Gases

Rafael Dvali Institute of Machine Mechanics, Tbilisi, Georgia

Abstract: We propose a method for neutralizing nitrogen

oxides in exhaust gases using atomic hydrogen, according to which the radical-chain reactions for the reduction of nitrogen oxides proceed actively in the exhaust pipe of the internal combustion engine with the participation of hydrogen atoms, without a heterogeneous catalyst containing precious metals. For the dissociation of hydrogen molecules into atoms directly in the exhaust pipe of the internal combustion engine, a generator of barrier electric-arc discharge (plasmatron) is proposed. The Laboratory tests confirmed the viability of this method for NO_x neutralization and the promise of continuing research in this direction. The article discusses the issues of development of a compact, vehicle-adapted version of an atomic hydrogen generator for reducing nitrogen oxides in internal combustion engine exhaust emissions. In particular, the design of a barrier discharge generator (plasmatron) for producing atomic hydrogen was developed, its dimensions were determined, and materials for the housing and electrode windings were selected. The type and material were selected and an indicator for determining a degree of dissociation of the molecular hydrogen into atoms within the barrier discharge generator was manufactured. An holder design for attaching the indicator to the outlet cross-section of the plasmatron was produced, and the temperature of the hydrogen flow exiting the electric arc discharge zone was measured in the holder. To reduce the recombination period of hydrogen atoms, an ejector was developed and manufactured for reducing excess gas pressure in the

zone, where the atomic hydrogen generator is mounted on the engine outlet pipeline. The degree of dissociation of hydrogen molecules, and consequently the degree of NO_x neutralization, was determined depending on the voltage applied to the plasmatron electrodes. In particular, by increasing the voltage from 4.5 to 7.3 kV, the reduction in NO_x concentration reached 31%.

Keywords: Internal Combustion Engine, dissociation of hydrogen, plasmatro.

Robert Tomanek

Corporate Carbon Footprint Assessment in Urban Public Transport: Methodology and Empirical Results from the Upper Silesian Metropolitan Region (Poland)

University of Economics in Katowice, Katowice, Poland

Abstract: This paper presents a transport-oriented methodology for assessing the Corporate Carbon Footprint (CCF) of urban public transport operators and discusses empirical results from the Upper Silesian Metropolitan Region (Poland) for 2024. The study focuses on the operational dimension of emissions, linking greenhouse gas emissions to transport performance indicators and fleet structure. Emissions were calculated in accordance with the GHG Protocol (Scopes 1 and 2, including selected elements of Scope 3), based on operator-level data on fuel consumption, electricity use, and vehicle activity. The analysed companies delivered nearly 90 million vehicle-kilometres annually, accounting for approximately 75% of metropolitan transport services.

Total identified emissions amounted to approximately 142,000 tonnes of CO₂e, corresponding to an emission intensity of 1.59 kg CO₂e per vehicle-kilometre. The results confirm the dominant contribution of diesel consumption and electricity use to total emissions and demonstrate the relevance of well-to-tank emissions in fuel-intensive transport systems. The analysis highlights the importance of fleet electrification, energy sourcing strategies, and vehicle occupancy in shaping overall carbon intensity. The study demonstrates that carbon footprint assessment can serve as a practical tool supporting strategic transport planning, fleet renewal decisions, and metropolitan-level decarbonisation policies.

Keywords: Corporate Carbon Footprint, Vehicle-Kilometre Emission Intensity, Public Transport.

Rustam Khalilev, Meray Yeraly

The architecture and operational mechanisms of a Unified Integration Platform for a Digital Transport Corridor in the context of Autonomous Freight Vehicles

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Abstract. This article explores the concept of an integration platform (IP) as the technological core of a digital transport corridor (DTC). It examines the requirements for seamless interaction between autonomous freight vehicles (AFVs), roadside units (RSUs), and government regulatory authorities. The article de-scribes

a four-layer platform architecture, V2X communication protocols, and mathematical models for the dynamic control of autonomous transport (ATVs). It describes algorithms for dynamic traffic flow control (“Green” and “Red” corridors) based on V2X, Edge Computing, and distributed ledger technologies (DLT). Global logistics is shifting from a model of physical movement to a model of “information-oriented transportation.” As noted by Bouton et al. (2021), traditional border barriers account for up to 15% of a product’s added value due to transit delays. The implementation of a unified integration platform (UIP) enables the concept of “synchromodality,” where route and mode selection occurs dynamically based on real-time data. Modern international logistics is characterized by high data fragmentation. A single cross-border shipment involves up to 40 different documents processed in disparate IT systems. According to the World Trade Organization, the digitization of trade procedures could increase the growth rate of global trade by 2 percentage points per year. The Digital Corridor Integration Platform is not just a database, but a cyber-physical system that ensures interoperability between vehicles, road infrastructure, and government information systems. The main goal of the UIP is to transition from reactive control (inspection upon arrival) to predictive control (in-transit data verification).

Keywords: Middle Corridor, Digital Corridor, Data collection, Digitalization, Transnationalization.

Rustam Rahimov, Farida Galimova, Diyor Zafarov, Doston Sultonaliyev

Development of Structural Solutions for the Conversion of a Passenger Railcar Body for Baggage Transportation and Loading-Unloading Operations

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Abstract: The paper presents the results of the development and computational-experimental validation of structural solutions for the body of a baggage car created by converting a passenger car. An analysis was conducted of existing structures and technical solutions used in the design of baggage car bodies and the organization of loading and unloading operations. A spatial finite-element model of the body has been developed, allowing for the assessment of the stress-strain state of the load-bearing structure, taking into account the presence of door openings in the side walls and the effects of operational loads. Based on the calculation results, optimal parameters for the door opening and structural solutions for reinforcing its area in the side walls were determined. The adopted solutions provide for door openings measuring 2200×1900 mm with perimeter reinforcement. A comparative analysis of reinforcement options has justified the use of 5P channel sections measuring 50×32×4.4 mm, as well as an optimal thickness for the side wall cladding sheets. The proposed technical solutions ensure the required strength, stiffness, and stability of the car body while reducing the structural steel

consumption. A methodology for experimental testing of a prototype baggage car using strain gauges has been developed. The results of static and dynamic running tests confirmed the accuracy of the design data and the structure's compliance with regulatory requirements. The effectiveness of the proposed technical solutions and their practical applicability in the design of baggage cars based on passenger rolling stock are demonstrated.

Keywords: Baggage car, car body, body conversion, door opening, structural reinforcement, finite element modeling, strength, stability, static tests, dynamic tests, strain gauging.

Rzayeva Gunay, Aliyev Khalil, Nasirova Leyla

On a Solution to an Integro-Differential Equation of Vibration of Mechanical Systems with Rheological Properties

Azerbaijan

Abstract: The paper studies the solution of an integro-differential equation of vibration of a viscoelastic system for arbitrary hereditary functions. The suggested method allows to construct the solution to equation in the form of a series, the first term of which is the solution of this equation obtained by the averaging method, and taking into account subsequent terms of this series makes it possible to determine more exact solution of the equation. In modern power structures, various materials with rheological properties are most often used. The study of the physical -mechanical properties of these materials

leads to solving a Volterra type partial integro-differential equation.

Keywords: Viscoelastic, original, images, rheology averaging, integro-differential equation.

Saida Beknazarova, Dilnoza Yunusova, Ozoda Abdullayeva
Procedural Texture Synthesis in 3D Reconstruction of Historical Objects and Virtual Environments
TUIT named after Mukhammad al-Khwarazmiy, Tashkent, Uzbekistan

Abstract: This article explores the advantages of procedural texture synthesis in generating high-quality textures for the 3D reconstruction of historical objects and their representation in virtual environments. Particular attention is given to methods for creating unique and realistic textures using fractal structures and space-filling curves such as the Cantor set, Gilbert curve, and Gosper curve. The methodology provides a detailed description of fractal rules, parametric curves, and algorithmic processes involved in texture generation. The research results demonstrate the effectiveness of the proposed approach in achieving high-quality visual effects in reconstruction processes, supported by digital test examples.

Keywords: Procedural texture synthesis, Cantor set, Gilbert curve, Gosper curve, fractal technologies, 3D reconstruction, virtual environment, computer graphics.

Samira Rustamova

Digital Transformation and Sustainable Logistics

Management in the East–West Transport Corridor: Evidence from Azerbaijan

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Abstract: The East–West Transport Corridor has emerged as a critical component of global logistics networks, facilitating trade flows between Asia and Europe and enhancing regional economic integration. Azerbaijan’s strategic geographical location positions it as a key transit country within this corridor, offering significant opportunities for the development of efficient and sustainable logistics systems. This paper investigates the role of digital transformation in improving logistics management and operational performance in Azerbaijan. It examines the application of advanced digital technologies, including data-driven platforms, automated systems, and real-time tracking tools, and evaluates their impact on efficiency, transparency, and sustainability. The study adopts a qualitative and analytical approach based on secondary data from international organizations and policy reports. The findings indicate that digitalization contributes to reduced transit times, lower operational costs, and enhanced coordination among stakeholders. However, challenges such as limited system integration, regulatory inconsistencies, and skills gaps persist. The paper concludes with policy recommendations aimed at strengthening Azerbaijan’s competitiveness and supporting the long-term development of the East–West Transport Corridor.

Keywords: Digital transformation; logistics management; East–West Corridor; Azerbaijan; sustainability; supply chain; smart transport; innovation.

Sanan Asgarov, Farida Alakbarova

Interconnected Risk Dynamics in Air Transportation Systems

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Abstract: Since its inception, the civil aviation industry has been characterized by its sensitivity to geopolitical situations and international economic problems. When these crises occur, industry risks associated with external environmental factors also increase. These risks are not limited to technical and operational problems. They are also amplified by large-scale factors such as geopolitical instability, changes in the energy market, evolving digital threats, and climate change. The purpose of this article is to systematically analyze the main problems that have led to an increase in sectoral risks in civil aviation and to identify possible approaches for managing risks within the framework of crisis management in the aviation sector. The results of the analysis show that geopolitical tensions lead to longer flight routes and increased operational costs. In terms of financial risks, it is possible to see that changes in fuel prices play a key role. On the other hand, with airlines making greater use of modern technologies, a sharp increase in the threat of cyberattacks is being observed. The number of disruptions to flight operations is steadily increasing due to climate change and extreme

weather conditions, one of the most significant problems of the 21st century. Additionally, the risk of a post-pandemic experienced personnel shortage is delaying airlines' recovery plans. Consequently, assessing these risks within a framework of their interplay is crucial for the effective management of risks in the civil aviation sector.

Keywords: Civil aviation, risk management, crisis management, sustainability, post-pandemic period.

Saule Bekzhanova, Daliga Tashmaganbetova

Digital Technologies and Education in Logistics in Kazakhstan: Pathways to Increasing Competitiveness and Technological Readiness

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Abstract: The digital transformation of transport and logistics systems requires not only modernization of infrastructure but also the development of educational models capable of preparing specialists for data-driven logistics environments. In corridor economies such as Kazakhstan, logistics competitiveness depends on the ability to integrate digital technologies into operational processes, including supply chain analytics, simulation modelling, digital twins, and platform-based coordination. However, the effectiveness of digital transformation is limited when educational systems do not provide sufficient competencies for working with advanced logistics technologies. This study proposes a framework for evaluating the digital maturity of logistics education

and its impact on technological readiness. A composite indicator, the Digital Logistics Education Index (DLEI), is introduced to measure the level of digitalization of logistics education based on infrastructure readiness, curriculum digitalization, industry integration, and research activity. Using publicly available international statistics and national data, a pilot empirical assessment of digital readiness and logistics performance in Kazakhstan is conducted. The results indicate significant progress in digital connectivity and digital government development, while logistics performance indicators remain moderate, suggesting the presence of a competence gap. The study proposes a modernization framework for logistics education based on simulation-based learning, digital twin laboratories, and cluster-based cooperation between universities and industry. The pilot calculation shows that the DLEI increased from 0.49 to 0.96 during the period of analysis.

Keywords: Industry 4.0, digital twins; supply chain analytics, logistics performance, digital infrastructure.

Sayyad Agayev, Murad Yusifov, Konul Aghayeva, Aygun Aliyeva

Digital Transformation and Economic Determinants of Freight Transport: An Econometric Analysis of the Logistics System in Azerbaijan

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Azerbaijan University of Architecture and Construction, Baku, Azerbaijan

Abstract: This article explores how the volume of freight transport (CT) in the transport sector of Azerbaijan is influenced by economic and technological indicators and provides a comprehensive analysis of the impact of digital transformation on the efficiency of supply chains. Based on official statistical data for 2005–2024, the study evaluates the dynamics and structural characteristics of the logistics sector using the Ordinary Least Squares (OLS) method, based on 17 observations covering the years 2008–2024. Within the analytical framework, the primary factors affecting freight transport volume are identified through econometric modeling methods, while directions for increasing the efficiency of logistics processes are simultaneously investigated. The research findings indicate that technological, investment, and institutional changes exert a significant influence on the volume of freight transport. The results demonstrate that digitalization has a multifaceted impact on the operation of logistics systems, creating conditions for cost reduction, acceleration of operations, and more efficient use of resources. In particular, the application of digital technologies optimizes information exchange among supply chain participants, enhances the level of coordination, and improves the quality of decision-making processes. Furthermore, digitalization strengthens the

transparency and stability of logistics systems, increasing their resilience to external influences. The proposed econometric model provides a scientifically justified methodological framework for the assessment and improvement of supply chain performance. These approaches hold practical significance both for the formulation of logistics policy at the state level and for operative and strategic decision-making within business structures.

Keywords: Logistics, Freight Transport, Digitalization, Econometric Modeling, Transport Systems.

Sh.S. Huseynzade, E.A. Nasirova, G.Y. Abbasova

The Role of Intelligent Transportation Systems in the Development of Transportation Safety

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Abstract: The article examines the reasons for the emergence of traffic jams, in-frastructure overloading, and increased risks in transport safety, while modern transport systems significantly increase the intensity of people and goods transportation, stimulate economic activity, and contribute significantly to the strengthening of global relations. To solve these problems, the structure of the Intelligent Transport System (ITS) is presented using advanced technological approaches. ITS combines sensors, information technologies, communication networks, automated control, and data analysis to perform real-time monitoring and management of transport

processes. The use of such applications results in accident detection, traffic flow optimization, driver assistance, and provision of technical maintenance during infrastructure forecasting. Studies show that the introduction of such systems in cities and regions has reduced accidents by 20–35% in the first three years, while significantly minimizing operational efficiency, efficiency, and operating costs. ITS technologies are applied in a number of transport modes, including rail, road, air, and sea transport. However, there are difficulties such as system compatibility problems, high financial costs, data confidentiality violations, and human adaptation. This article examines the role of ITS in organizing transport safety, solutions to existing technological issues, application problems, and future prospects, as well as an analytical analysis of artificial intelligence and big data.

Keywords: Intelligent Transportation Systems, Transportation Safety, Traffic Monitoring, Traffic Management, Automated Management, Big Data Analytics.

Shafa Aliyev

Assessment of the Efficiency of the Transport and Logistics System in Azerbaijan in the Context of Global Corridors

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Abstract: As a key transit country along the East-West transport corridor, Azerbaijan has taken extensive measures in recent years to develop and strengthen its transport and logistics system. The volume of freight

moved through global transport corridors crossing Azerbaijan continues to grow and carries strategic importance. In this context, the country is expanding strategic cooperation with many countries. New projects are being implemented to expand the capacity of the Middle Corridor across the Caspian Sea. Azerbaijan is interested in increasing the efficiency of freight transport between Europe and Asia, and this objective is aligned with the regional and international interests of neighboring countries, the European Union, and Southeast Asian countries, especially China. In addition, several other global transport corridors pass through Azerbaijan, including the North-South, North-West, Europe-Caucasus-Asia, and South-West corridors. To make transit freight operations more productive and efficient, the infrastructure of the Alat International Seaport on the Caspian coast is being strengthened. It is also planned to build an airport for air cargo transportation in the coming years. Railway lines and highways passing through Azerbaijan are being modernized in line with international standards. The expected opening of the Zangezur transport corridor may create additional opportunities to increase the efficiency of Azerbaijan's transport and logistics system.

Keywords: Global corridors, transport and logistics system, Azerbaijan's transit potential, East-West transport corridor.

Shafiga Mammadova, Khagani Hebibzade

Synergetic Integration of Bio-Graphene Production in Green Logistics and Medical Rehabilitation Within the "Ekoaz" Biosphere Management Framework

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Abstract: This paper explores the transformative potential of bio-graphene (Bioqrafen) synthesized from agricultural waste (hazelnut, almond, and cotton residues) through advanced flash pyrolysis and pyrogasification processes. Innovative methods of processing biomass resources are proposed to achieve carbon neutrality in global logistics and transport systems. The research focuses on the production of Biohydrogen and high-tech Biographene through pyrogasification of biomass. A bio-energy generation model is analyzed to offset the emissions of internal combustion engines in the modern logistics sector (combine harvesters, tractors, and heavy-duty trucks). Within the context of the "EkoAz" model and the "Green Corridor" strategy of Azerbaijan, we propose a decentralized production system designed to achieve net-zero emissions in regional logistics clusters. The study details the technical integration of bio-pyrogasification reactors with mobile machinery to utilize bio-hydrogen and syngas. Furthermore, the application of bio-graphene is extended to the medical sector, specifically in smart prosthetics and targeted drug delivery systems, emphasizing its superior biocompatibility compared to traditional carbon materials. To satisfy the academic

requirements of the PLMO 2026 conference, a mathematical model based on Fuzzy Logic is introduced to predict the quality parameters (conductivity and strength) of bio-graphene based on varying biomass feedstocks. Additionally, stochastic processes are utilized to calculate the carbon offset efficiency within the logistics chain. The results demonstrate that the "EkoAz" biosphere management model not only provides high-tech carbon materials for space and industrial logistics but also offers a viable roadmap for monetizing carbon removal certificates (CORC).

Keywords: Bio-graphene, flash pyrolysis, green Logistics, EkoAz Model, fuzzy Logic, medical rehabilitation, carbon neutrality, biosphere management, bio-hydrogen, smart prosthetics.

Shahin Guliyev

Development of the Transcaspian International Transport Route “East-West” in the Context of the Strategic Partnership Between Azerbaijan and Kazakhstan

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Abstract: This paper analyzes the strategic partnership between the Republic of Azerbaijan and the Republic of Kazakhstan within the framework of the Trans-Caspian International Transport Route (TITR). The author argues that the success of the "East-West" corridor is built not only on physical infrastructure but also on a high level of political trust and the historical kinship of the two fraternal nations.

Keywords: Azerbaijan, Kazakhstan, Middle Corridor,

TITR, logistics, digitalization, green economy, transport diplomacy

Shahnaz Shahbazova, Amir Mosavi, Kalbiyeva Solmaz,
Feyzullayeva Sevinc

Big Data in Healthcare: Privacy and Security Issues

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Obuda University, Hungary

Azerbaijan University of Architecture and Construction,
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Abstract: The latest achievements in big data security and privacy in the healthcare industry are discussed in this study. Big data has the ability to dramatically revolutionize patient care and improve health outcomes. However, the collection and analysis of massive amounts of sensitive medical data raises serious privacy and security concerns. In order to identify relevant difficulties and potential solutions, this paper undertakes a comprehensive analysis of existing research publications on big data in healthcare, focusing on privacy and security challenges. The authors investigate various cryptographic algorithms, such as AES, RSA, and SHA-256, that can be used to protect healthcare datasets. They also handle issues like as patient privacy, data breaches, and legal and ethical concerns. Furthermore, the paper proposes a framework for storing and sharing data while preserving privacy. It underscores the importance of implementing strong security measures in healthcare organizations to

prevent data breaches and safeguard confidential patient information, all while leveraging big data for research and analysis purposes.

Keywords: healthcare, privacy, security, big data.

Shamama Mammadova, Shahla Ismayilova, Humay Guliyeva, Nubar Guliyeva, Sahila Askerova

Modern Logistics and East-West Corridor

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Abstract: In the context of the global restructuring of logistics chains, Azerbaijan's strategic turn to the East-West markets, the development of national transport corridors is very important. The geographical position of Azerbaijan in Europe determines its potential as a major transit bridge and turns it into an important transport hub of Eurasia. The relevance of the topic is also determined by the need to stimulate the spatial development of regions, economic growth, and adapt to technological challenges such as digitalization and environmental standards. The purpose of the article is to conduct a comparative analysis of the main transport corridors of Azerbaijan - Baku-Tbilisi-Kars (BTK), North-South International Transport Corridor, Zangezur Corridor, South-West Corridor, in order to determine their strategic role, specialization, competitive advantages and contribution to the integration of Azerbaijan into international transport and logistics systems. The subject of the study is the modern international transport corridors of Azerbaijan, their historical evolution,

geographical and economic specialization, regulatory and legal framework, as well as their comparative characteristics in terms of length, delivery time, throughput and geopolitical significance. According to the results of the study, each corridor has its own specialization and strategic purpose.

Keywords: international transport corridor, arteries, infrastructure, pairs, terminal, transit, coordination, synchronization.

Shohrat Aliyeva

Current Status of Agriculture in the Sheki-Zagatala Region, the Role of the Transport-Transit Sector in the Development of the Region's Socio-Economic Infrastructure

Sumgayit State University, Sumgayit, Azerbaijan

Abstract: The Sheki-Zagatala region, considered one of the richest regions in the Republic of Azerbaijan, is located in the northwest of Azerbaijan, on the southern slope of the Greater Caucasus Mountains, encompassing the territories of the Balakan, Gakh, Gabala, Oguz, Zagatala, and Sheki administrative districts. The region's economy is primarily focused on agricultural production, based almost entirely on grain cultivation. The article analyzes the current state of the region's agricultural and transportation sectors, proposes recommendations based on a mathematical-statistical model, and examines the role of grain farming in the region's agricultural development.

Keywords: Transport, logistics services, productivity,

labor costs, sales profitability, agricultural applications, correlation analysis.

T. Natriashvili, M. Chelidze, B. Gitolendia, V. Zviadauri
**Problems of Urban Environmental Pollution Caused
by Transport Noise and Ways to Solve Them**

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University of Georgia; Tbilisi, Georgia

Abstract: The aim of the presented research is to study, using the example of Tbilisi, the increased noise caused by road and railway transport, as well as the ways and methods of reducing it, taking into account the city's narrow streets, densely populated districts, and varied terrain. Modern global experience shows that transport-generated noise occupies a leading position among sources of urban noise in contemporary cities and poses a significant threat to human health. Based on spectral oscillograms, it was determined that one of the main sources of increased noise in the city is vehicle speeds of 60 km/h and above, as well as the use of older vehicles with increased vibration, which remains typical for cities in post-Soviet countries. It is worth noting that the main factors causing noise at high speeds are vehicle tires and road surface quality. Based on the analysis of spectral oscillograms, the causes of noise intensity in railway transport have also been identified, including in metro tunnels and in moving railcars, as well as methods for detecting damaged components and eliminating them. To

improve public health and quality of life, it is essential to apply modern approaches to noise management and, taking into account economic capabilities, to implement European standards in noise regulation policy.

Keywords: Transport, urban environment, vibration, noise, sound, enclosed space, tunnel, reverberation, spectrum.

T.A. Hagverdiyeva, G.R. Bayramova

Planning the Optimal Composition of Alkaline-Mineral Adhesive Mortar Using Information Technology Software

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Abstract: One of the most important tasks facing the construction industry sector is to organize the construction of long-lasting and durable buildings and structures by utilizing the benefits of modern scientific and technological progress and making the right choice of materials. The rapid growth of construction in the 21st century requires the efficient use of construction materials and the economical use of cement which producing is expensive. In the current study, the possibility of using alkaline-mineral adhesives in masonry and plastering works in order to save on Portland cement was studied. The application of an alkaline-mineral adhesive solution based on liquid glass-based Marten pulp (pos) in plastering of brick and stone masonry has been studied. The composition of the resulting adhesive material was

designed according to the compressive strength parameter of the base hardened material. The experimental results were analyzed using a computer program, a mathematical model was constructed taking into account the obtained regression coefficients and the influence of variable factors and optimized using a built-in information technology program. The performance characteristics of the obtained alkaline-mineral adhesive solution were determined.

Keywords: Rapid development, construction materials, concrete, adhesive, alkaline mineral, pulp, sodium oxide, liquid glass, calcium hydroxide, strength, functional properties, technology.

T.A. Hagverdiyeva, K.B. Jamalova

Development of Sustainable Road Concrete Composition Using Production and Consumption Waste Using Mathematical Planning Method

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Abstract: The rapid industrialization of the modern world has necessitated the application of advanced techniques and technologies in the construction materials sector, as well as the organization of the production of higher-quality materials. This has led to an increase in the exploitation of natural resources. In order to effectively use natural resources, real conditions have been created for the application of various wastes in production. The presented work is devoted to the study of the possibilities

of using sand-like chemical industry wastes, which disrupt the ecological balance in modern times and pollute the environment in adverse weather conditions, as well as household wastes containing plastic mass, the disposal of which requires high costs and takes 400–800 years to decompose in natural conditions, in the production of concrete products with a wide range of applications. It was determined that as a result of mechanical processing of this type of waste, sand-like wastes can be used as a mineral additive in the preparation of concrete mixtures by ultrafine grinding. At the same time, it was considered appropriate to use various plastic beverage bottles in the production of fiber concrete as a result of cutting them into fibers and increasing their surface adhesion by mechanical action. Using these components, the composition of fiber concrete was optimized based on the application of the statistical planning of experiments method, and as a result, fiber concrete with the main indicators - an average density of 2400 kg/m^3 and a compressive strength of 48.35 MPa was obtained. The operational parameters of these concretes optimized in terms of composition and properties were studied (compressive strength, flexural strength, crack resistance, dynamic stability, tensile strength during bending, friction index, water resistance) and the possibility of their application in road construction was determined.

Keywords: strength, durable, concrete, waste, modification, ecology, mathematical planning, impact, model.

T.A. Hagverdiyeva, G.M. Hatamkhanova, M.E.Majidov
**Mathematical Planning Method for the Formulation of
High-Quality Concrete Used in The Production of Road
Pavements Using Household Waste**

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In the modern era, preserving ecological balance is one of the most important issues facing civilization. Changing world demography, in addition to requiring greater use of natural resources, leads to air pollution, changes in the natural landscape of land and water, which largely depend on the rapid growth of production and consumption. One of the main causes of environmental pollution in the current era is the increasing amount of plastic waste. Thus, in all types of manufacturing industries, large amounts of various types of plastic materials are used during product packaging, which are then discarded as waste after consumption. The current study studied the application of this type of household waste, which requires a lot of labor and financial resources to dispose of and releases harmful substances into the air, in the production of concrete products by recycling it for more efficient purposes. It has been determined that by crushing thin packaging waste using a simple mechanical grinding method without subjecting it to any chemical or incineration processes, and using it in an amount of only 3% in the concrete composition, it is possible to obtain concrete with 18-20% higher compressive strength under

a specially selected hardening regime. It is intended to prepare roadbeds based on such concretes and use them as abrasion-resistant concretes. The optimal composition and processing temperature of the proposed concrete were determined by the method of mathematical planning of experiments using a computer program.

Keywords: ecological balance, packaging waste, environment, environmental pollution, paving stones, fine-grained concrete, strength, abrasion, polyethylene bag, household waste.

Tahir Alizada, Ulviyya Mammadova, Elkhan Sabziev, Ramil Akhundov, Ana Mammadova, Elvin Rustamov

Conceptual Foundations of an Intelligent Acoustic Diagnostic System for Defect Detection in Railway Axlebox Bearings

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Military Research Institute of the National Defense

University, Baku, Azerbaijan

Azerbaijan University of Architecture and Construction, Baku, Azerbaijan

Abstract: This paper develops the conceptual foundations of an intelligent acoustic diagnostic system for defect detection in railway axlebox bearings. The study addresses the need for early, non-contact, and practically deployable condition monitoring under severe railway noise, including rolling, traction, aerodynamic, and other operational interference. The central methodological premise is that weak defect-related acoustic signatures

become easier to detect when the signal is represented in a hybrid mel-domain form that combines conventional log-mel energy with envelope-sensitive and spectrally enhanced components. Rather than claiming a fully field-validated product, the paper establishes the conceptual, physical, and mathematical basis of such a system, outlines its functional architecture, and explains the role of hybrid time-frequency representation in axlebox-bearing diagnostics. An illustrative pilot computational experiment is included to support the plausibility of the framework and to show that mel-domain acoustic representations can separate healthy and defective bearing states in a multiclass setting. The results support the feasibility of this conceptual direction and justify further development of railway-oriented acoustic diagnostic systems.

Keywords: Conceptual foundations, railway axlebox bearings, acoustic diagnostics, acoustic monitoring, mel-spectrogram, hybrid signal processing, convolutional neural network, fault diagnosis, predictive maintenance.

Tamaz Natriashvili, Revaz Kavtaradze, Lana Shamanauri, Giorgi Chilashvili, Vazha Chagelishvili

Minimization of Nitrogen Oxides in Automotive Internal Combustion Engine Exhaust Emissions

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Abstract: By improving the engine design and optimizing the adjustable parameters of the working process, it is

possible to significantly reduce nitrogen oxide emissions; however, it cannot be ruled out that at certain engine operating modes, NO_x emission levels may considerably exceed the strict standards established by the law, and the additional purification of exhaust gases from nitrogen oxides remains relevant. The article considers the measures applied to neutralize toxic substances in the exhaust gases of gasoline and diesel engines. Based on their analysis, it is shown that it is desirable to replace the existing methods and devices for neutralizing harmful components in exhaust gases with more effective neutralization means. The study of the mechanism of nitrogen oxide neutralization in exhaust gases using existing methods showed that the bond between nitrogen and oxygen atoms can be broken through atomic hydrogen. This is particularly significant for prospective hydrogen-powered internal combustion engines, in which the only legally restricted harmful component in the exhaust gases are nitrogen oxides. It is hypothesized that dissociated atoms obtained by passing hydrogen molecules through an electric discharge arc should be introduced into a reaction with the exhaust gases of the internal combustion engine, which ensures the reduction of nitrogen oxides to environmentally safe nitrogen molecules. Tests conducted on the automobile gasoline engine at a test bench in the internal combustion engine testing laboratory demonstrated that, with the participation of hydrogen atoms in the exhaust pipe of the internal combustion engine, radical-chain reactions for the

reduction of nitrogen oxides proceed actively without a heterogeneous catalyst containing precious metals. The results of bench tests on the neutralization of nitrogen oxides in exhaust gases using atomic hydrogen were analyzed, on the basis of which it was established that the described method for neutralizing nitrogen oxides is viable, and that continued research in this area is promising.

Keywords: Internal Combustion Engine, Nitrogen Oxides, atomic hydrogen.

Tatiana Dudnik, Aleksander Sładkowski

The Growth of Economic Integration Driven by the Development of the Middle Corridor

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Abstract: In conditions of growing political instability worldwide and the declining reliability of traditional logistics routes, the role of the Middle Corridor, which connects China and Europe, has increased significantly. However, despite its growing importance, this relatively new logistics route remains insufficiently studied. This article aims to address this research gap by analyzing the development of the infrastructure of the Middle Eurasian Corridor, with a particular focus on rail and maritime transport, and by assessing the impact of this development on economic integration among the core countries of the route, namely Azerbaijan, Georgia, and Kazakhstan. The relationship between the growth of freight transportation along the Middle Corridor and the

increase in bilateral trade between Kazakhstan and Azerbaijan, Kazakhstan and Georgia, and Azerbaijan and Georgia was examined using second-degree polynomial regression. The results indicate a significant acceleration in the development of the Middle Corridor's infrastructure in recent years. The largest number of infrastructure developments was recorded in 2025, when new seaport terminals were opened, container hubs were established, railway sections were modernized, and dry ports were constructed. Alongside the overall growth of freight traffic along the route, economic integration among the three selected countries strengthened, with a notable correlation identified between these processes.

Keywords: Middle Corridor, Trans-Caspian International Transport Route, BRI, TRACECA.

Teymur Mammadli, Shahnaz Shahbazova

Analysis of Text Data Processing Algorithm and Methods Based on Machine Learning

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Azerbaijan

Abstract: The rapid growth of digital information has led to an increase in textual data, creating the necessity for efficient methods to process and analyze unstructured information. This paper presents a comprehensive analysis of text data processing algorithms and methods based on machine learning. It begins by examining traditional approaches, including Bag of Words and TF-IDF representations, as well as classical machine learning

algorithms such as Naive Bayes, Logistic Regression, and Support Vector Machines. While these methods are effective for basic tasks, they face limitations in capturing contextual and semantic relationships in language. To address these challenges, the paper explores modern deep learning techniques, including neural networks, Recurrent Neural Networks (RNNs), Long Short-Term Memory (LSTM) networks, and transformer architectures. These models revolutionise Natural Language Processing methods, enabling automatic feature learning, improved handling of sequential data. The study also highlights key applications such as text classification, sentiment analysis, machine translation, and chatbot systems, demonstrating the practical impact of these technologies. Furthermore, the paper discusses current challenges, including data quality, computational requirements, interpretability, and ethical concerns, while outlining future research directions focused on efficient models, explainable AI, and multimodal learning. Overall, the integration of machine learning and deep learning techniques has significantly advanced the field of text data processing, enabling more accurate and scalable solutions for real-world applications.

Keywords: Text Data Processing, Machine Learning, Natural Language Processing, Deep Learning, TF-IDF, Word Embeddings, RNN, LSTM, Transformers.

Timur Ismailov

Houpu: Development Prospects and a Look into the

Future of Green Energy in Azerbaijan

HOUPU GLOBAL CLEAN ENERGY Co. LTD Russia

Tofiq Babayev, Valery Virkovski, Khalida Melikova

Trade and Transport Corridors Digitalization Policies and Activities in the CAREC Region

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eTrade and eLogistics Company (eTLC)

Abstract: The proposed paper includes the retrospective analysis and literature review of trade and transport digitalization policies and activities in the CAREC region since the time of adoption of the coordinated Strategy for Transport and Trade Facilitation. The resulting conclusions of such analysis are aligned with the outcome of the latest OECD and ITF projects dedicated to enhancing the connectivity, sustainability, and resilience of regional freight transport in Central Asia. As for the common TLS digitalization policies and cooperation in CAREC region the analysis of annual reports and plans endorsed by the Transport Sector Coordination Committee (TSCC) as well as the CAREC Mid-Term Review of the Transport-Strategy demonstrate the growing importance of the coordinated development of digital and transport infrastructures in the region. In particular, it was revealed that investments in physical infrastructure might improve regional transport connectivity, but significant soft-infrastructure barriers remained, including still outdated customs procedures and inefficiencies at border crossing points. As such beyond physical infrastructure developments

digitalization should be definitely considered as the strategically important soft component of trade and transport facilitation and become the effective tool for the CAREC corridors development cycle: Transport Corridor > Trade Corridor > Economic Corridor.

Keywords: CAREC, Digital transport corridor, National e-Logistics Systems, Middle Corridor (Trans-Caspian International Transport Route, TITR), Digital trade platforms, Border Crossing Points.

Ulvi Mammadzada

Macroeconomic Forecasting in Oil-Dependent Transit Economies of the East-West Transport Corridor: A Comparative Econometric and Machine Learning Approach

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Abstract: Forecasting macroeconomic indicators in oil-exporting economies is complicated by frequent swings in global energy prices. Azerbaijan and Kazakhstan are representative cases where oil revenues drive fiscal and external balances. Standard linear models struggle to capture the nonlinear dynamics that emerge across different price regimes. This study compares traditional econometric models with machine learning methods, namely Random Forest and Gradient Boosting, and introduces a hybrid regime-switching approach. When Brent falls below the threshold, SARIMA outperforms machine learning alternatives, while during stable periods Random Forest delivers higher accuracy. The hybrid model

achieves the lowest RMSE overall. Diebold–Mariano tests confirm hybrid superiority over SARIMA. The results further show that oil prices affect the two economies through different channels: Kazakhstan responds more directly to price movements, while Azerbaijan adjusts primarily through current account dynamics. Regime-based forecasting models therefore provide more reliable signals than static alternatives.

Keywords: GDP forecasting; machine learning; hybrid regime-switching model; Azerbaijan; Kazakhstan; Middle Corridor; SARIMA; Random Forest.

Ulvi Rafizade, Irada Imanova, Khagan Mammadli

Computer Vision in Laparoscopic Surgery: Integration of Engineering Architecture and Clinical Decision-Making

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Abstract: Laparoscopic surgery, a minimally invasive method utilizing fiber op-tic cameras, is central to the digital transformation of medicine. This article explores computer vision (CV) algorithms for workflow recognition, anatomical segmentation, and ergonomic monitoring. From an engineering perspective, the effectiveness of architectures such as 3D Convolutional Neural Networks (3DCNN), YOLOv9, and U-Net is analyzed for their ability to process spatio-temporal data and identify tissue at a pixel level. From a clinical standpoint,

we discuss how these models prevent iatrogenic bile duct injuries (BDI) by automat-ing the assessment of the Critical View of Safety (CVS).CV also addresses the 74% prevalence of musculoskeletal disorders among surgeons through real-time postural analysis. Our analysis demonstrates that AI systems can distinguish between novices and experts with an F1 score of 0.91 and identify operative steps with up to 85.6% accuracy. This synthesis of clinical and engineering judgment provides a robust framework for improving safety. Integration of vision technologies ensures quantifiable intraoperative precision.

Keywords: Computer Vision, Laparoscopic Surgery, Artificial Intelligence, Critical View of Safety, Explainable AI, Surgeon Ergonomics.

Ulvu Novruzov, Rena Sultanova

Innovation Ecosystems in Logistics: The Strategic Role of Higher Education in Digital Transformation

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Institute of Economics of the Ministry of Science and Education of the Republic of Azerbaijan, Baku, Azerbaijan.

Abstract: This study examines the role of higher education institutions in strengthening innovation ecosystems and their impact on digital transformation in the logistics sector. While existing research primarily focuses on technological aspects, the institutional and ecosystem dimensions remain insufficiently explored. To address this gap, the study develops and empirically tests

an integrated conceptual model linking university support, innovation ecosystem development, digital readiness, perceived usefulness, and implementation intention. A quantitative research design is employed, and data are collected from 258 participants representing logistics, academic, and innovation-related sectors. The analysis is conducted using SPSS, including reliability, correlation, and regression analyses. The findings indicate that perceived usefulness and innovation ecosystem development are the strongest predictors of implementation intention. Digital readiness and university support also have significant positive effects. In addition, university support demonstrates a strong influence on the development of innovation ecosystems, highlighting its indirect role in facilitating digital transformation. The results suggest that digital transformation in logistics is not solely technology-driven but is significantly shaped by ecosystem dynamics and institutional support. The study contributes by offering an ecosystem-based perspective and emphasizing the strategic role of higher education institutions in enhancing digital transformation processes.

Keywords: Digital Transformation, Logistics, Innovation Ecosystem, Higher Education, University Support.

V.T Mammadova

Multi-Criteria Modeling and Optimization of Multimodal Logistics in East-West Corridor

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Abstract: The dynamic development of global trade and

the increasing volume of international freight have enhanced the strategic importance of transport corridors. In this context, the effective design and optimization of multimodal logistics systems for organizing freight transport between Europe and Asia have become essential. This article models the logistics network along the East–West Transport Corridor using a graph-theoretic framework. A multi-criteria optimization model is developed by considering transportation cost, transit time, and logistics risks. These criteria are integrated into a single objective function using weights that reflect their relative importance, enabling the determination of optimal routes. The model results suggest that an optimal route may connect major regional nodes, including China, Central Asia, the Caspian region, the South Caucasus, and Europe. The findings show that multi-criteria optimization improves decision-making accuracy and supports efficient logistics planning, risk management, and resource allocation. The methodology provides both theoretical and practical contributions to the development of logistics networks and enhances the efficiency of international transport systems worldwide through systematic and data-driven approaches in practice.

Keywords: Multimodal logistics, Logistics network optimization, Multi-criteria optimization, Mathematical modeling, Graph theory, East–West Transport Corridor.

Valeh Mustafayev, Konul Allahverdiyeva, Sabina Gurbanova

A Network-Based Model of Transport Vehicle Movement in Petroleum Product Logistics

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Abstract: This study develops a network-based model for transport vehicle movement in petroleum product logistics under market economy conditions. Simulation-based approaches are commonly employed to distribute various types of petroleum products from supply facilities over a specified period in accordance with demand. However, these methods do not adequately address key issues such as route selection under multiple scenarios, minimization of transportation costs across regions, inventory estimation, and the coordination of vehicle movements. Existing inventory management approaches rely on diverse modeling techniques, while logistics algorithms typically assume that different types of petroleum products can be transported by a single vehicle. Furthermore, most simulation models focus on the interaction between oil refineries and oil depots, without fully incorporating the broader distribution network that includes fuel filling stations. In addition, they do not account for the relocation of vehicles between depots and stations across different regions. As a result, the vehicle fleet is not explicitly represented as a parameter in logistics models, despite its direct role in transportation processes. To overcome these limitations, an extended Colored Petri Net-based model for transport vehicle movement in petroleum product logistics is proposed. The model is formally defined using sets of places and

transitions, with input, output, and incidence functions represented in matrix form. The structural properties of the model are analyzed, the sequence of admissible transitions from the initial state is determined, and a rule base describing causal relationships is constructed. In addition, a graph-based representation of vehicle movement is developed.

Keywords: Network model, petroleum product logistics, petroleum products, Colored Petri nets, transport vehicles, oil depots.

Velizara Pencheva, Asen Asenov, Aleksandar Georgiev,
Kremena Mineva

Life Cycle Environmental Assessment of Battery Electric Buses in Medium-Sized European Cities

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Municipal Transport Ruse, Ruse, Bulgaria

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Abstract: In the context of sustainable urban transport, battery electric buses (BEB) are seen as an effective measure to reduce greenhouse gas emissions. This study presents a Life Cycle Assessment of battery-electric buses in the urban public transport systems of medium-sized European cities, with a focus on Global Warming Potential. The analysis covers all stages of the life cycle – bus and battery production, operation and maintenance, and end-of-life and recycling - with the functional unit set to one km from operation. The results show that battery-electric buses significantly reduce greenhouse gas

emissions per kilometre compared to diesel buses, with the effect depending on annual mileage and the carbon intensity of electricity. With a high annual mileage of 60,000 km/year, the emissions of battery-electric buses are reduced to 1.134 kg CO₂eq/km, which is around 40% lower than those of diesel buses. The main contribution to the Global Warming Potential of battery-electric buses comes from the battery production phase, while service emissions remain low and stable. The study confirms that battery-electric buses represent an effective strategy for decarbonising urban transport and improving air quality, especially when used at high intensity and integrated with a low-carbon electricity mix. The results provide a solid basis for investment and policy decisions in sustainable urban passenger transport.

Keywords: Electric buses, public transport, Life Cycle Assessment, life cycle, Global Warming Potential, medium city, Europe, sustainable transport.

Vladimir Toporovsky, Ilya Galaktionov, Oleg Kolesnikov

Methodology for the Optimization of Piezoelectric Wavefront Correctors in Free-Space Optical Communication

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Moscow Polytechnic University, Moscow, Russia

Abstract: This paper introduces a unified methodology for optimizing the parameters of piezoelectric wavefront correctors (bimorph and stacked-actuator) designed to

mitigate the effects of atmospheric turbulence in free-space optical communication systems. The optimization of the deformable mirror characteristics takes into account dynamic and spatial features of atmospheric turbulence, including the Fried parameter and Greenwood frequency. Key achievements encompass the creation of an enhanced simulation model that incorporates critical factors such as actuator geometry, material properties, and element sizes of the wavefront corrector. Addressing these challenges leads to significant enhancement of adaptive optics solution efficiency and reliability, ensuring high-quality data transfer over long distances even under unfavorable atmospheric conditions. The paper presents the methodology for quick estimation of the wavefront corrector performance in the frame of the closed-loop adaptive optical system with estimation of the dynamic and spatial behavior of the devices. The efficiency was analyzed with Strehl ratio and error budget of the closed-loop adaptive optical system is presented.

Keywords: free-space optical communication, adaptive optics, wavefront corrector, Strehl ratio.

Yagub Piriyeu, Bakhtiyar Namazov

Analysis of Traffic-Induced Noise Pollution in Baku: Evaluation of Mitigation Strategies and Urban Acoustic Mapping

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Abstract: This study presents a multi-dimensional analysis of road traffic noise pollution in Baku, Azerbaijan,

addressing the escalating acoustic crisis within high-density urban corridors. Utilizing a synergistic approach that integrates empirical field measurements with advanced numerical simulations in Python, the research evaluates noise propagation dynamics through both horizontal and vertical planes. A significant finding of the study is the quantification of the "Urban Canyon Effect," which results in a non-linear noise peak of approximately 74 dBA between the 4th and 9th floors of residential buildings. To address these challenges, a multi-factor interaction model was developed, analyzing the dependency of sound pressure levels on distance (r) and the surface absorption coefficient (α). Results from 3D surface modeling demonstrate that implementing a "Hybrid Defense" strategy—combining high-absorption acoustic barriers ($\alpha > 0.8$) with multi-layered biological buffers—can achieve a cumulative reduction of up to 22 dBA. Furthermore, the study incorporates a Cost-Benefit Analysis (CBA), revealing that the socio-medical savings from noise mitigation outweigh the initial capital investment within a one-year horizon. Strategic policy recommendations, including dynamic nighttime speed restrictions and mandatory acoustic auditing for the "Baku 2040 General Plan," are proposed to align Azerbaijan's urban framework with the European Union's Environmental Noise Directive (2002/49/EC). The findings provide a robust technical roadmap for transitioning Baku into a sustainable, acoustically optimized metropolitan environment.

Keywords: Noise pollution, Acoustic mapping, Traffic noise, Urban planning, Environmental Noise Directive (END), Acoustic barriers, Baku 2040 General Plan.

Yasaman Abbaszada

Mathematical Modeling and Intelligent Airspace Optimization in the Middle Corridor: The Case of Azerbaijan

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Abstract: This paper examines the role of mathematical modeling and intelligent airspace optimization in strengthening Azerbaijan's position within the Middle Corridor as a strategic aviation bridge between Europe and Asia. The study addresses the growing need for agile, data-driven approaches to air traffic flow management in order to reduce delays, prevent operational bottlenecks, and improve route efficiency in an increasingly dynamic geopolitical and transport environment. Azerbaijan's airspace has become a critical transit platform: in 2025, more than 342,000 flights were handled, of which 76% were transit operations, while in the first half of 2025 alone over 162,500 flights were managed, including 125,600 transit flights. These figures confirm the country's central role in Eurasian air connectivity. The paper proposes a conceptual framework based on optimization methods, machine learning, and predictive traffic analytics to support intelligent routing, adaptive sector management, and more efficient use of airspace resources.

The scientific contribution of the study lies in adapting contemporary AI-assisted air traffic management logic to the operational realities of the Middle Corridor, with Azerbaijan as a practical case of scalable regional application. AI-based ATM tools are increasingly used to improve prediction, decision-making, and the use of scarce airspace resources, which supports the feasibility of this approach.

Keywords: Middle Corridor; Azerbaijan; airspace optimization; mathematical modeling; air traffic flow management; machine learning; artificial intelligence; route efficiency; transit aviation; predictive analytics.

Yegana Ashrafova

A Numerical Scheme for Simulating Fluid Flow in Complex Pipeline Networks

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Abstract: This paper investigates numerical methods for analyzing transient re-gimes of fluid flow in oil pipeline networks with complex structures. The mathematical model of the process is based on a system of hyperbolic type differential equations describing the unsteady motion of a compressible fluid in each linear pipeline section. Special attention is given to the treatment of non-separated boundary conditions arising at connection nodes of the network, which follow from Kirchhoff's

conservation laws. A computational approach based on an implicit finite-difference grid method is proposed. The sweep (Thomas) method is generalized to solve the resulting systems of difference equations for interconnected pipeline segments. Numerical experiments demonstrate the stability and efficiency of the proposed scheme when applied to pipeline systems with multiple branches and loops. The results confirm that the proposed method can be effectively used for modeling transient hydraulic regimes and for improving the reliability of pipeline transport systems.

Keywords: pipeline network, transient flow, hyperbolic equations, grid method, sweep method, numerical simulation.

Yusif Gasimov, Latifa Agamalieva

Mathematical Modeling and Analysis of Freight Transport in the Middle Corridor

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Abstract: The Middle Corridor, also known as the Trans-Caspian International Transport Route (TITR), has become an important international route connecting Asia and Europe through Central Asia, the Caspian region, and the South Caucasus. The growing volume of international trade and freight transportation along this corridor requires efficient logistics management and optimization of transport operations. Mathematical modeling plays a

significant role in analyzing and improving the performance of complex transport systems. This study focuses on the development of a mathematical model for the analysis and optimization of freight transportation in the Middle Corridor. The proposed model considers the structure of the transport network, transportation costs, delivery time, and capacity constraints of different transport modes. Using quantitative methods and optimization techniques, the model aims to determine optimal freight routes and improve the efficiency of cargo movement along the corridor. The research applies mathematical modeling and analytical methods to evaluate transport flows and identify key factors affecting logistics performance. A detailed case study of electronics supply chain from Xi'an to Warsaw demonstrates the practical applicability of the model. The results demonstrate that the application of optimization models can significantly reduce transportation costs and delivery time while increasing the reliability and efficiency of freight transport systems. Furthermore, the model provides a useful analytical tool for decision-makers in logistics planning and transport management. The findings of this study contribute to the development of efficient transport strategies and support the sustainable operation of the Middle Corridor as a vital component of international trade and regional connectivity.

Keywords: Middle Corridor, Freight Transport, Mathematical Modeling, Logistics Optimization, Transport Networks, Multimodal Transport, Trans-Caspian Route.

Zahid Mamedov, Rasim Rasulov, Farida Agayeva, Eldar Asadov

Agile Design Tool Architecture and Its Application in Logistics Systems

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Abstract: The article proposes the architecture of an Adaptive Design Tool (ADT) featuring a modular and open structure. The proposed model integrates a working data and knowledge base, an accumulation subsystem that collects reusable mathematical and graphical models, and a dynamically formed block of standard tools. In addition to internal databases, the architecture provides real-time access to global Internet resources and enables flexible configuration of tools within the design process. The developed architecture enhances the flexibility, scalability, and integration potential of the automated design system (ADS) environment, creating a methodological foundation for the development of distributed and knowledge-based electronic design systems. The proposed adaptive design tool architecture offers significant advantages not only from a technological perspective but also in economic terms. By reducing time and resource consumption in the design process, the system contributes to the optimization

of production costs and the improvement of productivity. Real-time data integration and dynamic configuration capabilities accelerate decision-making processes, thereby increasing the competitiveness of enterprises. Furthermore, the application of the ADT architecture in logistics systems enables more efficient management of transportation and cargo flows. This approach ensures optimal allocation of resources, reduces transportation costs, and positively impacts the expansion of economic linkages. Thus, the proposed model can be considered a comprehensive approach that promotes both technological innovation and increased economic efficiency.

Keywords: Automated design systems, adaptive architecture, management mechanisms, logistics systems, information integration, economic efficiency, green transformation.

Zakir Rustamov, Narmin Rustamova

“Silk Way” – Maritime Logistics

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Baku Shipyard LLC, Baku, Azerbaijan

Abstract: This paper examines the role of transport corridors in Azerbaijan’s economic integration and evaluates options to increase the efficiency of ferry-based intermodal flows along the Caspian segment of the “Silk Way.” Particular attention is given to the strategic relevance of expanding corridor capacity, including the prospective operationalization of the Zangezur corridor

referenced in the 10 November 2020 declaration (Clause 9), as a key regional connectivity objective. The study aims to justify a stepwise approach to improving wagon-container logistics and to quantify the potential productivity gains for Ro-Pax ferries. The methodology combines a review of logistics concepts and sources with an operational analysis of current rail-ferry practices, focusing on payload losses and cycle-time penalties associated with transporting rail wagons that carry “zero” cargo weight and generate inefficient cyclic (time) losses at terminals. A comparative assessment of alternative loading schemes shows that replacing wagon-based transport with direct container carriage and designing an optimized cargo plan aligned with modern logistics technologies can significantly increase the share of commercial cargo and reduce turnaround losses. Under the considered operating assumptions, the productivity of Ro-Pax vessels can be increased by up to four times, supporting higher throughput on emerging corridors.

Keywords: Maritime transport, door-to-door delivery, just-in-time, logistics, transport technology, railway wagons, containers.

Zhao Xue

Pathways to Enhance the Resilience of Azerbaijan's Oil and Gas Supply Chain from the Perspective of East-West Transport Corridors

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Abstract: Against the backdrop of profound adjustments in the global geopolitical landscape and the restructuring of the global energy supply chain, the strategic importance of the Middle Corridor has risen significantly. As a core hub country of this corridor, Azerbaijan's state-owned oil company SOCAR (State Oil Company of the Azerbaijan Republic) is the pillar of the national energy industry, and its oil and gas supply chain resilience directly affects Azerbaijan's national energy security and the operational efficiency of the entire East-West Transport Corridor. Based on the complex network theory and the supply chain resilience analysis framework, this paper constructs an oil and gas supply chain resilience assessment index system by using the time-series data of Azerbaijan from 2000 to 2024, and empirically analyzes the correlation mechanism between SOCAR's corporate performance and the oil and gas supply chain resilience. The study finds that: (1) The rapid development of the East-West Transport Corridor has significantly improved the network connectivity and risk resistance of SOCAR's oil and gas supply chain, with the corridor's freight volume growth and infrastructure upgrading being the core driving factors; (2) SOCAR's operating performance is significantly positively correlated with the supply chain resilience, among which asset turnover has the most prominent contribution to the resilience improvement; (3) Port infrastructure investment and digitalization level play a positive moderating role in the relationship between the East-West Transport Corridor development

and SOCAR's supply chain resilience, and the synergy of the two can effectively amplify the promotion effect of corridor development on resilience. Based on the above findings, this paper proposes a three-dimensional resilience enhancement path of "infrastructure construction-institutional coordination-technology empowerment", which provides a decision-making reference for Azerbaijan and other countries along the East-West Transport Corridor to optimize the oil and gas supply chain management and improve the regional energy supply chain resilience.

Keywords: East-West Transport Corridor; Oil and Gas Supply Chain; Resilience; SOCAR; Azerbaijan; Complex Network Theory; Empirical Analysis.

Zhazira Shermantayeva, Orken Mamyrbayev, Madihan Muhamadyar

IoT-Enabled Intelligent Monitoring and Management System Using AI for Integration of Various Renewable Energy Sources in Local Electric Power Systems of Kazakhstan

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Institute of Information and Computational Technologies, Almaty, Kazakhstan

Abstract: The integration of renewable energy sources (RES) into Kazakhstan's local electric power systems (LEPS) is accelerating, with the RES share reaching 7% in 2025 (total capacity 3.5 GW across 162 facilities). This paper proposes an IoT-enabled intelligent monitoring

system using AI-driven big data analytics and the Markov Synthesis Similarity Based (MSSB) algorithm to address RES intermittency and enhance grid reliability. The system leverages IoT sensors, Smart Grid technologies, and FPGA for real-time processing, achieving up to 12% reduction in energy losses and 95% accuracy in anomaly detection. Pilot implementation in Turkestan's substations reduced technological losses by 10% and improved load factor from 0.67 to 0.76. The proposed approach supports KEGOC's ongoing Smart Grid initiatives, including the expansion of the southern power grid and the development of digital substations. The research was conducted within the framework of the grant-funded project entitled AP32722743 "Development of methods and models for stochastic forecasting and predictive control for the optimal integration of renewable energy sources into the electric power system of the Republic of Kazakhstan based on Smart Grid technologies." This work was supported by grant funding from the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan under project BR24993001, titled "Creation of a Large Language Model (LLM) to support the implementation of the Kazakh language and enhance technological progress."

Keywords: IoT, Smart Grid, Renewable Energy, FPGA, Markov Processes, Similarity Theory.

Zhibek Primova, Gulzat Muktarkanova, Al Khan

A Hybrid Risk-Weighted Blockchain Framework for

Supply Chain Integrity and Automated Tariff Collection

Kyrgyzstan

Abstract: Global supply chains still rely on fragmented documentation and partially digital customs workflows, creating persistent vulnerabilities in origin verification, fraud detection, and tariff collection. This paper proposes a Hybrid Risk-Weighted Framework (HRWF) for blockchain-enabled customs automation that avoids the main weakness of earlier initiatives: attempting to automate every shipment. The study combines a comparative case analysis of TradeLens, Alibaba's Blockchain-as-a-Service, and the UAE Digital Customs Pilot with a discrete-event simulation of 10,000 synthetic cross-border shipments. Three approaches are compared: traditional processing, fully automated blockchain processing, and selective smart contract execution based on a real-time risk score. The hybrid model achieved the strongest overall performance, reaching 98.7% tariff-collection accuracy versus 94.2% for traditional processing and 96.1% for full automation. It also reduced false positives relative to full automation and cut processing time substantially relative to manual procedures. These findings suggest that blockchain is most viable in customs when paired with risk management and human override rather than used as a fully autonomous replacement for regulatory discretion. The main limitation is the use of synthetic rather than live operational data.

Keywords: Blockchain; Supply Chain Integrity; Smart Contracts; Digital Customs; Risk-Weighted Automation.

Zumrud Gahramanova, Shahla Gahramanova

User Perception and Expert Insight in Urban Transport: A Cognitive Analysis of Baku

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Abstract: The growing complexity of urban environments and increasing transport demand highlight the need for analytical approaches that account for human perception and behavior. This study aims to explore the role of cognitive factors in shaping how urban mobility in Baku, Azerbaijan, is perceived and experienced by users. In this context, mobility is considered not only as a physical but also as a cognitive environment in which individuals interpret, evaluate and make decisions based on both objective conditions and subjective experience. The research adopts a qualitative approach, combining a population survey with semi-structured expert interviews. This combination allows for the integration of everyday travel practices with professional perspectives on urban development, providing a more nuanced understanding of mobility processes. The findings point to complex relationships between user perceptions, behavioral patterns and the structural characteristics of urban mobility. At the same time, they suggest the presence of certain gaps between lived experience and planning logic, which may influence how transport solutions are

perceived and used in practice. Overall, the study highlights the importance of incorporating cognitive and participatory approaches into transport planning. Such perspectives can support the development of more adaptive, user-oriented and context-sensitive mobility strategies.

Keywords: Cognitive Urbanism, Urban Transport Systems, Human-centered Transport Planning, Behavioral Analysis, Decision-making in Transport, Survey-based Research, Expert Interviews.

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Abstracts

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