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## Overview of the II International Conference on Applied Physics, Information Technologies and Engineering — APITECH-II 2020

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# Overview of the II International Conference on Applied Physics, Information Technologies and Engineering – APITECH-II 2020

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**Abstract.** The overview describes the main directions and results of the II International Conference APITECH-II 2020 held in Krasnoyarsk from September 25 to October 4, 2020. It gives the details about the participants and the proceedings.

The Volume contains Proceedings of the II International Conference on Applied Physics, Information Technologies and Engineering (APITECH-II 2020) which was held at the Krasnoyarsk Science and Technology City Hall in Krasnoyarsk, Russian Federation from September 25 to October 4, 2020. Additionally, the volume includes the best reports accepted and presented at the XXVIII All-Russian workshop "Neuroinformatics, its applications and data analysis" (September 25-27, 2020) and the XXIII All-Russian workshop "Modeling of nonequilibrium systems-2020" (October 2-4, 2020), which took place in the Federal Research Center «Krasnoyarsk Scientific Center of the Siberian Branch of the Russian Academy of Sciences» at the Institute of Computational Modeling of the Siberian Branch of the Russian Academy of Sciences (ICM SB RAS).

The purpose of these scientific events is to share the results and prospects of the achievements in fields of application of modern methods of applied physics and information technologies in high-tech production, in aerospace, energy, chemical, oil and gas engineering industries, in economics and organization of engineering production; and in modern areas of research of complex technical and information systems.

The International Conference on Applied Physics, Information Technologies and Engineering (APITECH-II 2020) was jointly organised by the International and Russian Union of Scientific and Engineering Associations (Moscow, Russia), Federal Research Center "Krasnoyarsk Science Center of the Siberian Branch of the Russian Academy of Sciences" and Krasnoyarsk Science and Technology City Hall.

The main partner organisations in preparing and organising the Conference in Krasnoyarsk as well as of the previous scientific events [1-10] were: JSC “ISS-Reshetnev Company” and Institute of Space and Information Technologies of Siberian Federal University.

The program of the Conference consisted of keynote and plenary talks and numerous presentations.



The Program Committee and Editorial Board included prominent professors and scientists from the Russian Academy of Sciences, University of Maribor (Slovenia), Tashkent University of Information Technologies (Uzbekistan), Baku State University (Azerbaijan), Ruhr University in Bochum (Germany), Liaoning Normal University (China), Siberian Federal University (Russia), Reshetnev Siberian State University of Science and Technology (Russia), Voronezh State Technical University (Russia) as well as specialists from Russian and foreign leading industrial enterprises.

The international scope of the Conference was confirmed by the participation of representatives from 19 countries besides Russia (Azerbaijan, Ukraine, Peru, Latvia, Poland, Kazakhstan, Vietnam, Belarus, Japan, China, France, Uzbekistan, Iraq, Tajikistan, India, Kyrgyzstan, Switzerland, Bulgaria, Jordan):

- Academia Internacional de Ingeniería, República del Perú
- Azerbaijan Military Academy named after Heydar Aliyev
- Sumgait state university, Azerbaijan
- Belarusian State Technological University, Minsk, Republic of Belarus
- Donetsk National Technical University, Donetsk, Ukraine
- Vietnam Maritime University, Hai Phong, Vietnam
- Fergana branch of Tashkent University of Information Technologies named after Mukhammad al-Khwarizmi, Fergana, Uzbekistan
- Harbin Institute of Technology, Harbin, China
- INSA Rouen, St Etienne du Rouvray, France
- Karshi branch of Tashkent University of information technologies named after Mukhammad al-Khwarizmi, Karshi, Uzbekistan
- Kyrgyz State Technical University named after I. Razzakov, Bishkek, Kyrgyzstan
- Ministry of Education and Training, Vietnam
- Navoi State Mining Institute, Navoi, Uzbekistan
- Niigata University, Niigata, Japan
- Riga Eastern Clinical University Hospital Riga, Latvia
- Riga Technical University, Riga, Latvia
- Samarkand branch of Tashkent University of information technologies named after Mukhammad al-Khwarizmi, Samarkand, Uzbekistan
- Satbayev University, Kazakhstan
- Jordan University of Science and Technology, Jordan
- Tashkent State Technical University, Tashkent, Uzbekistan
- The Tajik state university of finance and economics, Dushanbe, The Republic of Tajikistan
- Ukraine Federal State Budgetary Educational Institution of Higher Education
- Ukraine Zhytomyr Agrotechnical College
- University of Baghdad, Baghdad, Iraq
- University of Lille, Lille, France
- Vietnam Naval Technical Institute, Hai Phong City, Vietnam
- Warsaw University of Life Sciences, Warsaw, Poland
- Wuhan Textile University, China
- College of Informatics and Computer Engineering, Dushanbe, The Republic of Tajikistan
- China Aviation Industry General Aircraft Zhejiang Institute Co., Ltd, China
- Tiruvannamalai (Anna University, Chennai), Tamilnadu, India
- Donbass National Academy of Civil Engineering and Architecture, Ukraine
- Donetsk National University, Donetsk, DPR, Ukraine
- Institute of Polymers, Department of Materials, ETH Zurich, Switzerland
- National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
- School of Mechanical Engineering, Vietnam Maritime University, Hai Phong, Vietnam
- Technical University-Sofia, Bulgaria
- Samarkand State Medical institute, Uzbekistan
- Karaganda Technical University, Kazakhstan
- Karaganda Economic University of Kazpotrebooyuz, Kazakhstan
- Arunai Engineering College, India
- Baishev University, Aktobe, Kazakhstan
- University of Al-Qadisiyah, Diwaniyah, Iraq

The participants from Russia represented more than 200 universities, scientific institutes and organisations, industrial enterprises from more than 40 regions of the Russian Federation:

- "PROMED" The limited liability company, Penza
- "Tehosnastka ltd"
- "V. V. Dokuchaev Soil Science Institute, Moscow
- A.I. Kryzhanovski Krasnoyarsk Regional Clinical Oncology Hospital
- ABC Solutions
- Academic University, Russian Academy of Sciences, St. Petersburg
- Academy named after Professor N.E. Zhukovsky and Yu.A. Gagarin, Voronezh
- Agat Organization, Moscow
- All-Russian Research Institute for Hydraulic Engineering and Land Reclamation (VNIIGiM)
- All-Russian Scientific Research Institute of Soybean, Blagoveschensk
- Altai State University, Barnaul
- Anapa Zonal Experimental Station of Viticulture and Wine-making
- Arctic state agrotechnological university, Yakutsk
- Aviaavtomatika named after V. Tarasov Joint-Stock Company, Kursk
- Azov-Black Sea Engineering Institute – branch of FSBEI HE «Don State Agrarian University» in Zernograd
- Bauman Moscow State Technical University
- Belgorod National Research University
- Belgorod State Agrarian University named after V. Ya. Gorin
- Belgorod State Technological University V. G. Shukhov
- Biysk Technological Institute (branch) of Altai State Technical University named after I.I. Polzunov
- Blokhin' National Medical Research Center of Oncology of the Ministry of Health of the Russian Federation, Moscow
- Branch JSC Rosenergoatom Novovoronezh Nuclear Power Plant, Voronezh
- Branch of LUKOIL-Engineering VolgogradNIPImorneft, Volgograd
- Branch of the Ufa State Petroleum Technological University in Sterlitamak
- Bratsk State University
- Bryansk State Technical University
- Central branch of the Russian state university of justice, Moscow
- Chechen State University, Grozny
- Chuvash State Agrarian University, Cheboksary
- Chuvash state university named after Ilya Nikolayevich Ulyanov, Cheboksary
- Company group "Technoserv", Moscow
- Control Systems LLC, Krasnoyarsk
- Cultural and sports complex "NORD" LLC "Gazprom transgaz Yugorsk"
- Dagestan State Technical University, Makhachkala
- Department Federal State Budgetary Educational Institution of Higher Education «Saint Petersburg State University of Architecture and Civil Engineering»
- Department of Aircraft Engines, Reshetnev Siberian State University of Science and Technology, Krasnoyarsk
- Department of Applied Mathematics, Orenburg State University, Orenburg
- Department of Biomedical Engineering, Southwest State University, Kursk
- Department of Electrotechnical Complexes and Systems, Department of Electrotechnology and Electrical Engineering, Polytechnic Institute
- Department of Information Technologies, Siberian Federal University, Krasnoyarsk
- Department of Physics and Information Systems, Kuban State University, Krasnodar
- Department of System Analysis and Operation Research, Reshetnev Siberian State University of Science and Technology, Krasnoyarsk
- Derzhavin Tambov State University
- Dmitry Mendeleev University of Chemical Technology of Russia
- Don State Technical University
- Far Eastern State Transport University, Khabarovsk
- Federal State Budgetary Military Educational Institution of Higher Education «The Mozhaisky Military Space

- Academy» of the Ministry of Defense of the Russian Federation, Saint-Petersburg
- Financial University under the Government of the Russian Federation, Moscow
  - GAZ Metallokomplekt LLC, Taganrog
  - Government of the Krasnoyarsk region
  - Grozny State Oil Technical University named after academician M. D. Millionshchikov
  - Gubkin Russian State University of Oil and Gas (National Research University), Moscow
  - INCONTROL LLC, Moscow
  - Institute for Electrophysics and Electric Power RAS, Saint-Petersburg
  - Institute of Mineralogy of Southern-Urals Federal Research Center of Mineralogy and Geoecology of Ural Branch of RAS, Miass, Chelyabinsk Region
  - Institute of Astronomy of the Russian Academy of Sciences, Moscow
  - Institute of Chemistry and Chemical Technology SB RAS
  - Institute of Computational Modelling of SB RAS, Krasnoyarsk
  - Institute of Control Sciences named by V.A. Trapeznikov of Russian Academy of Sciences
  - Institute of Design and Technological Informatics of the Russian Academy of Sciences, Moscow
  - Institute of engineering and technology, Katanov Khakas State University, Abakan
  - Institute of Engineering Science, Russian Academy of Sciences, Moscow
  - Institute of market problems of the Russian Academy of Sciences, Moscow
  - Institute of Mathematics and Informatics MPSU, Moscow
  - Institute of Mechanical Engineering A.A. Blagonravova RAS, Moscow
  - Institute of Solar-Terrestrial Physics of Siberian Branch of Russian Academy of Sciences, Irkutsk
  - Integrated Management Systems Certification Body “YUG-TEST” LLC, Rostov on Don
  - Interregional public institution «Institute of Engineering Physics», Moscow reg., Serpukhov
  - IPG Photonics Corporation, Fryazino
  - Irkutsk National Research Technical University
  - Irkutsk State Transport University
  - Irkutsk State University
  - ITMO University, Saint Petersburg
  - Izhevsk State Technical University named after Kalashnikov
  - Joint Stock Company “Scientific and Production Association named after S.A. Lavochkin”, Khimki
  - JSC "Special Design Bureau of the Moscow Energy Institute"
  - JSC “Academician M F Reshetnev Information satellite systems”, Zheleznogorsk, Krasnoyarsk region
  - JSC Federal Scientific and Production Centre «Titan - Barricady», Volgograd
  - K.G. Razumovsky Moscow State University of Technologies and Management, Moscow
  - Kabardino-Balkarian state agricultural university named after V.M. Kokov, Nalchik
  - Kalashnikov Izhevsk State Technical University, Izhevsk
  - Kaliningrad Branch of the Federal Research Center “Computer Science and Control” of the Russian Academy of Sciences
  - Kaluga branch of the Moscow State Technical University named after N.E. Bauman
  - Kaluga State University named after K.E. Tsiolkovsky
  - Kazan Federal University
  - Kazan National Research Technical University. A.N. Tupolev - KAI
  - Kazan State Agrarian University
  - Kazan State Power Engineering University
  - Kirensky Institute of Physics (FRC KSC SB RAS), Krasnoyarsk
  - Kotelnikov Institute of Radio Engineering and Electronics Russian Academy of Sciences, Fryazino
  - Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations
  - Krasnoyarsk Science Center of the Siberian Branch of the Russian Academy of Sciences
  - Krasnoyarsk State Agrarian University
  - Kuban State Agrarian University named after I.T. Trubilin
  - Kurgan State University
  - Kuzbass College of Architecture, Construction and Digital Technologies, Novokuznetsk
  - Lipetsk State Technical University

- LLC VVST, Podolsk
- Maikop State Technological University
- Mari State University, Yoshkar-Ola
- Marine Hydrophysical Institute, Russian Academy of Sciences», Sevastopol
- Maritime State University named after G.I. Nevelskoy, Vladivostok
- MATTEST Engineering bureau of Individual Entrepreneur Eliseev Vladimir Vasilyevich, Voronezh
- Mechanical Engineering Research Institute of the Russian Academy of Sciences, Moscow
- Michurinsk State Agrarian University
- Military Innovative Technopolis “ERA” (VIT ERA), Anapa
- Moscow Aviation Institute (National Research University)
- Moscow Institute of Physics and Technology (State University)
- Moscow Polytechnic University
- Moscow State Humanities and Economics University, Moscow
- Moscow State University
- Moscow State University of Civil Engineering, Moscow
- Moscow State University of Geodesy and Cartography (MIIGAiK)
- Moscow State University of Humanities and Economics
- Moscow State University of Technology "STANKIN"
- MOU “Engineering Physics Institute” (MOU IIF), Serpukhov
- N.N. Krasovskii Institute of Mathematics and Mechanics of the Ural Branch of the Russian Academy of Sciences
- National Park «Buzuluk Bor», Koltubanovsky
- National Research Nuclear University MEPhI
- National Research Tomsk State University (NR TSU)
- National Research University "Moscow Power Engineering Institute"
- National University of Science and Technology "MISIS", Moscow
- Nizhnekamsk Chemical Technology Institute (Branch) of Kazan National Research Technological University
- Nizhny Novgorod Lobachevsky State University
- Nizhny Novgorod State Agricultural Academy
- North Caucasus Federal University, Stavropol
- North-Eastern Federal University named after M. K. Ammosov, Yakutsk
- Nosov Magnitogorsk State Technical University
- Novosibirsk State Agrarian University
- Novosibirsk State Technical University
- OGUZ Irkutsk Regional Hospital
- Omsk State Agrarian University named after P. A. Stolypin
- Orel State University named after I.S. Turgenev
- Orenburg State University
- Pacific National University, Khabarovsk
- Penza State University
- People Friendship University of Russia, Moscow
- Peter the Great St. Petersburg Polytechnic University
- Platov South Russian State Polytechnic University (NPI), Novochoerkassk
- Polzunov Altai State Technical University, Barnaul
- Povolzhskiy State University of Telecommunications and Informatics, Samara
- ProjectMarket LLC
- Pskov State University, Pskov
- Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of the Russian Academy of Sciences (IZMIRAN), Saint-Petersburg
- Research and Design Institute of design information, automation and communication on railway transport, Moscow
- Research Institute of Federal Penitentiary Service, Moscow
- Research Institute of the Federal Penitentiary Service of the Russian Federation, Moscow
- Research Scientist of Research Center No.1 of the Research Institute of the Federal Penitentiary Service, Moscow
- Reshetnev Siberian State University of Science and Technology, Krasnoyarsk
- Rosseti Tyumen, Surgut
- Russian Economic University named after G.V. Plekhanov
- Russian Scientific and Technological Center of Information on Standardization, Metrology and Assessment of Compliance

- Russian State Agrarian University - Moscow Timiryazev Agricultural Academy
- Russian State Scientific Center for Robotics and Technical Cybernetics, Saint-Petersburg
- Russian State Social University, Moscow
- Russian Technological University (RTU MIREA), Moscow
- Russian University of Transport, Moscow
- Ryazan State Radio Engineering University
- Ryazan State University
- Saint Petersburg Mining University
- Saint Petersburg State Electrotechnical University
- Saint Petersburg State University of Aerospace Instrumentation
- Saint Petersburg State University of Architecture and Civil Engineering
- Saint-Petersburg State Agrarian University, Pushkin
- Samara State Technical University
- Samara University
- Saratov State Vavilov Agrarian University
- Scientific and Technological Center of Unique Instrumentation of RAS, Moscow
- Scientific Research Institute of System Analysis of the Russian Academy of Sciences, Moscow
- Sevastopol State University, Crimea
- Sholom-Aleichem Priamursky State University, Birobidzhan
- Shternberg State Astronomical Institute of Lomonosov Moscow State University, Moscow Russian Technological University, Moscow
- Siberian Federal Scientific Centre of AgroBioTechnologies of the Russian Academy of Sciences
- Siberian Federal University, Krasnoyarsk
- Siberian Fire and Rescue Academy of Firefighting Service of EMERCOM of Russia, Krasnoyarsk Territory, Zheleznogorsk
- Siberian State Automobile and Highway University (SibADI), Omsk
- Skobelkin' State Scientific Center of Laser Medicine FMBA, Moscow
- South Ural State Agrarian University, Chelyabinsk
- South Ural State University, Chelyabinsk
- South Urals Federal Research Centre of Mineralogy and Geoecology of the UB RAS, Chelyabinsk region, Miass, Ilmen reserve
- Southern Federal University Institute of Nanotechnology, Engineering center of instrument making, radio- and microelectronics, Taganrog
- Southern Federal University, Rostov-on-Don
- Southwest State University, Kursk
- St. Petersburg State Forest Technical University named after S.M. Kirov
- St. Petersburg State University of Architecture and Civil Engineering
- St. Petersburg University
- Stary Oskol Technological Institute named after A.A. Ugarov (branch) NUST MISIS
- State Research Institute of Civil Aviation, Moscow
- State University of Management, Moscow
- Stock Company «Experimental Design Bureau «Electroavtomatika» named after P A Yefimov, Saint Petersburg
- Surgut State University
- Tambov State Technical University
- Technological University, Nizhnekamsk
- The branch of JSC «FGC UES» Krasnoyarsk enterprise MES
- The Federal Siberian Research Clinical Center of FMBA of Russia
- The Institute of Radioelectronics and Information Technologies, Ural Federal University, Yekaterinburg
- The Main Directorate of EMERCOM of Russia for Krasnoyarsk Territory
- Thermal Electrical Systems LLC, Togliatti
- Togliatti State University
- Tomsk State Pedagogical University
- Tomsk State University of Architecture and Building, Tomsk
- Tomsk State University of Control Systems and Radioelectronics
- Trapeznikov Institute of Control Sciences of RAS, Moscow
- Tula State University
- Tuva State University, Kyzyl
- Tver State University
- Tyumen Industrial University
- Udmurt Federal Research Center of the Ural Branch of the Russian Academy of Sciences, Izhevsk
- Udmurt State University, Izhevsk
- Ufa State Aviation Technical University
- Ufa State Petroleum Technological University

- Ulianov Chuvash State University, Cheboksary
- University of the Ministry of Internal Affairs of St. Petersburg
- Ural Federal University;
- V.F. Voino-Yasenetsky Krasnoyarsk State Medical University
- V.I. Vernadsky Crimean Federal University, Simferopol
- Vladimir State University Named After Alexander and Nikolay Stoletovs
- Volgodonsk Engineering Technical Institute - a branch of the Federal State Autonomous Educational Institution of Higher Education National Research Nuclear University "MEPhI"
- Volgograd State Technical University
- Vologda State University
- Voronezh Institute of High Technologies
- Voronezh State Technical University
- Voronezh State University
- Voronezh State University of Forestry and Technologies named after G.F. Morozov
- Vyatka State Agricultural Academy, Kirov
- Yaroslavl State University
- Yuri Gagarin State Technical University of Saratov

The event has offered a platform for bringing together students, postdocs, innovative academics and industrial experts to exchange their ideas and contribute new applied physics and engineering approaches to research mechanical and automation processes in various technological and information systems. Great interest was aroused by the section about applied physics, cybernetics and information technologies, engineering and mechanical science. These directions stimulated lively discussions among researchers as well as industrialists.

The Conference provided the premier interdisciplinary and multidisciplinary forum for researchers, practitioners and educators to present and discuss the most recent innovations, trends, concerns, practical challenges encountered and the solutions adopted in the fields of industrial physics, materials sciences, mechanical and aerospace engineering, information and transport technologies, robotics and cybernetics, data protection in automation systems, chemical, ecological and power engineering, etc.

Although the schedule of the Conference was very tight, there were very vivid discussions among the participants. The program of the Conference consisted of keynote and plenary talks and numerous presentations.

A wide range of engineering and industrial physics problems in various production and technological systems has undergone consideration during the meeting. The programme of the Conference included the following scientific directions:

- Condensed Matter Physics;
- Nanoscience and Nanotechnology;
- Optical Physics, Quantum Electronics and Photonics;
- Engineering and Industrial Physics;
- Instrumentation Metrology and Standards;
- Software Engineering;
- Information Systems;
- Software Reliability and Data Protection;
- Cybernetics, Economics and Organization of Mechanical Engineering Production;
- Mechanical Engineering and Industry 4.0;
- Materials Science, Aerospace Technology and Engineering;
- Power, Chemical and Ecological Engineering;
- Oil and Gas Engineering;
- Neuroinformatics, its applications and data analysis (the XXVIII All-Russian workshop);
- Modeling of nonequilibrium systems (the XXIII All-Russian workshop).

All participants were invited to present their papers in this Volume and all submitted manuscripts went through the independent peer review process. We are very grateful to all reviewers from Russia, China, USA, Slovenia, Germany and Republic of Kazakhstan for their time and highly professional



comments. We deeply believe that their reviews gave opportunity to improve the scientific quality of the presented papers which may be useful for academic, scientific and industrial partners.

More than 700 reports were submitted to the Organizing Committee of the Conferences APITECH-2020, the XXVIII All-Russian workshop "Neuroinformatics, its applications and data analysis" and the XXIII All-Russian workshop "Modeling of nonequilibrium systems-2020". 413 reports were selected for inclusion into this Volume after the review process. All the papers were subjected to rigorous peer-review by conference committee members and international reviewers. The papers were selected based on their quality and relevance to the Conference directions. The proceedings present to the readers the recent advances in the field of applied physics (section 1), cybernetics and IT (section 2), engineering and material science (section 3), instrumentation technology and environmental engineering (section 4). These papers reflect modern industrial physics and engineering approaches in all Conference directions, broaden the researches of the previous Conferences [1-10]. We hope that you enjoy the reading of the papers.

We chose the IOP Journal of Physics: Conference Series to provide all contributors with the opportunity to publish their papers in an international, peer-reviewed journal. This is understood and appreciated by all the participants of our Conference, and therefore this Volume provides an excellent overview of the main topics of our Conference.

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We are grateful to scientists and professors of Siberian Federal University, Saint Petersburg State University of Aerospace Instrumentation, Institute of Computational Modeling of Siberian Branch of Russian Academy of Sciences and Reshetnev Siberian State University for active participation in the Conference.

On behalf of the conference committee and organizers, we would like to thank all the authors who contributed to this Volume as well as to the reviewers, speakers and all the conference participants for their support to APITECH-II 2020.

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### References

- [1] 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **450** 011001
- [2] Kovalev I V, *et al.* 2019 *IOP Conf. Ser.: Earth and Environ. Sci.* **315** 011001
- [3] Kovalev I V, *et al.* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **537** 011001
- [4] Kovalev I V, *et al.* 2019 *J. Phys.: Conf. Ser.* **1399** 011001
- [5] Kovalev I V and Voroshilova A A 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **734** 011001
- [6] Kovalev I V, Pyzhikova N V and Voroshilova A A 2020 *IOP Conf. Ser.: Earth and Environ. Sci.* **421** 011001
- [7] Antokhina Yu A, *et al.* 2020 *J. Phys.: Conf. Ser.* **1515** 011001
- [8] Kovalev I V and Voroshilova A A 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **862** 011001
- [9] Kovalev Igor V *et al.* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **548** 011001
- [10] Kovalev I V *et al.* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **919** 011001