

National Research University Higher School of Economics

Global competitiveness program

Strategic academic unit

**MATHEMATICS, COMPUTER SCIENCE AND INFORMATION
TECHNOLOGY: SCALABLE MATHEMATICAL METHODS**

Description

Moscow, 2016

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1. STRATEGIC ACADEMIC UNIT “MATHEMATICS, COMPUTER SCIENCE AND INFORMATION TECHNOLOGY: SCALABLE MATHEMATICAL METHODS”

1.1 Project summary

Goal: to build an ongoing research cycle and educational trajectory “from fundamental mathematics via computer science to applications in information technologies and contemporary engineering” that will produce scholars, practitioners and researchers highly competitive at the national and international markets.

Main Objectives:

- Breakthrough research in the top globally evolving fields of study: algebraic geometry and mathematical physics, data analysis and machine learning, mathematical and computer modelling;
- Supporting research in the following interdisciplinary fields: number theory, representation theory and dynamical systems, mathematical logic and theoretical computer science, mathematical methods of optimization and stochastics, system and software engineering;
- Development of mathematical tools and computer technologies for use in social science, economics and humanities;
- Development of English-taught Master’s programs in mathematics and software engineering, implementation of educational programs in partnership with leading Russian and international research centers in fundamental mathematics and data science;
- Regular adjustment of educational programs’ curricula and teaching methods based on professional demands and the requirements of the IT labor market.

Main Anticipated Deliverables:

- New research areas: biological and medical informatics, neuromathematics, use of machine learning methods in social and humanitarian studies, operating systems and compilation technologies;
- World-class results in the study of the geometry of algebraic varieties in collaboration with Steklov Mathematical Institute; in data analysis with applications of the processing of experimental evidence produced by the Large Hadron Collider; in the area of information retrieval, computer vision and recommendation systems in partnership with Yandex;
- Practice-oriented model for educational programs based on the integrated interaction system “faculties – research laboratories – academic institutes – high-tech companies”, implemented in coordination with Yandex, the Institute for Information Transmission Problems (Kharkevich Institute) and the Institute for System Programming. This model, on the one hand, will ensure that recent academic achievements and technological solutions are used in the study process. On the other hand, the model facilitates the transfer of technologies developed by STRA-U project groups and laboratories to the open market, with support from partner companies (Yandex, JetBrains, CROC, etc.);
- Bachelor’s and Master’s programs with an enhanced interdisciplinary component, such as Applied Mathematics and Informatics with exclusive concentrations in deep learning, neural networks, image and video analysis;
- Elective tracks at the undergraduate-master level and master-doctoral level, designed for students from different fields of study; for students of HSE doctoral schools in mathematics,

computer science and technical sciences, a thesis topic should be related to STRA-U's current research or applied projects;

- The University's international academic reputation has been evidenced by its entering the Top-150 in the QS Subject Ranking for "Mathematics", the Top-300 in the QS Subject Ranking for "Computer Science & Information Systems" and the Top-200 in the ARWU Ranking for "Mathematics".

Summary of STRA-U's Role and Contribution to the University's Development and Achievement of the Goals and Target Indicators Set by the Global Competitiveness Program

STRA-U has already gained leading positions in the global market of research in fundamental mathematics and has demonstrated a high level of publications and citations in algebraic geometry, representation theory and mathematical physics, working closely with A. Y. Okunkov, the Fields Medal winner, and leading international scholars including F. A. Bogomolov, V. A. Vasiliev, B. L. Feigin, and A. V. Marshakov. In addition, STRA-U acts as a gate for university-industry technology transfer via HSE partner companies.

STRA-U offers undergraduate programs that were recognized by a commission of Fields Medal winners as being among the Top 100 best programs in the world in fundamental mathematics. STRA-U attracts talented prospective students – winners and awardees of the final stage of the All-Russian Olympiad of School Students and other high-profile competitions, thereby contributing to the high average of Unified State Exam scores from HSE students.

In 2015, STRA-U Mathematics ranked 400+ (ranks 6th in Russia) in the QS Subject Rankings for "Mathematics" and "Computer Science & Information Systems" has a good chance to break into the Top 400 in 2016.

1.2 Project Fact-sheet

Key STRA-U Subdivisions and Associated Units

1. Faculty of Mathematics (<https://math.hse.ru/en/>);
2. Faculty of Computer Science (<https://cs.hse.ru/en/>);
3. Moscow Institute of Electronics and Mathematics (MIEM, https://miem.hse.ru/about_en/);
4. International Laboratory of Algebraic Geometry and its Applications (<https://ag.hse.ru/en/>);
5. International Laboratory of Representation Theory and Mathematical Physics (<https://mf.hse.ru/en/>);
6. International Laboratory of Theoretical Computer Science (<https://cs.hse.ru/en/big-data/tcs-lab/>);
7. International Laboratory for Intelligent Systems and Structural Analysis (<https://cs.hse.ru/en/ai/issa/>);
8. Laboratory of Process Aware Information Systems (<https://pais.hse.ru/en/>);
9. Laboratory of Methods for Big Data Analysis (<https://cs.hse.ru/en/lambda/>);
10. Laboratory of Mathematical Methods in Natural Sciences.

Partners: International Laboratory of Algorithms and Technologies for Network Analysis (headed by Panos M. Pardalos) (<https://nnov.hse.ru/en/latna/>).

STRA-U Research Adviser: Yuri Nesterov, full professor of Computer Science, Catholic University of Louvain (UCL), Belgium, and Professor and Researcher at the HSE Faculty of Computer Science, Doctor of Sciences, (<https://www.hse.ru/en/org/persons/150293981>).

STRA-U Academic Leader: Ivan Arzhantsev, Dean of the HSE Faculty of Computer Science, Doctor of Sciences (<https://www.hse.ru/en/staff/arjanstev>).

Key Educational Programs and Their Development

STRA-U is responsible for 15 Bachelor's programs (2347 students, including 102 international students) and 15 Master's programs (521 students, including 54 international students).

STRA-U's partnership and close collaboration with external organizations is a distinctive feature of STRA-U's educational programs. STRA-U partners with both academic institutes in fundamental mathematics and large IT companies. Experts from external organizations are involved in the development of programs and the teaching process, and students participate in research projects and do internships at partner companies.

1. Programs in fundamental mathematics are delivered in partnership with the Steklov Mathematical Institute, Lebedev Physical Institute, Kharkevich Institute, Leiden University, University of Tokyo, University of Luxembourg and Osaka University. Students take part in research projects on algebraic geometry, representation theory, mathematical physics and theoretical computer science.

The undergraduate program in Mathematics (Academic Supervisor: Professor S.M. Khoroshkin, Doctor of Sciences) includes courses in fundamental mathematics and its application in physics, economics and computer science. The program offers a broad variety of elective courses and individually-designed study plans; the program attracts the best applicants in Russia. In 2015, 3 winners and 4 awardees at the final stage of the All-Russian Olympiad of Secondary School Students in Mathematics and 2 winners and 1 awardee in Physics were enrolled in the program. The passing score in 2015 was 260 out of 300. After graduation, some students choose to continue their studies at leading international universities including MIT (3 undergraduate students entered MIT in 2015), CalTech, and ETH Zurich, while others immediately enter the workforce, taking jobs at the Central Bank of the Russian Federation, Bank of Moscow, Otkritie Bank, AT Consulting, SIBUR Holding, KMPG, and other organizations.

The Master's program in Mathematics is delivered in English under the supervision of Professor Y.S. Ilyashenko, Doctor of Sciences. The program trains two kinds of specialists: prospective researchers in the field of mathematics and other exact sciences and prospective experts in knowledge-intensive applications.

The Master's program in Mathematics and Mathematical Physics supervised by Professor I.M. Krichever, Doctor of Sciences, includes a block of courses in physics in addition to a broad selection of courses in mathematics. This enables students to acquire in-depth knowledge of fundamental models of contemporary theoretical physics and gives them an opportunity to seek employment at leading research centers in Russia and abroad.

2. Some programs in applied mathematics and informatics have been developed and are delivered in cooperation with Yandex. Students are engaged in research projects in machine learning, data analysis and theoretical computer sciences. Student project work is supervised by experts from Yandex, JetBrains, EMC and other partner companies.

The undergraduate program in Applied Mathematics and Informatics, supervised by Associate Professor A.S. Konushin, Candidate of Sciences (PhD), is modeled after the leading programs in computer science offered at the Swiss Federal Institute of Technology of Lausanne, Switzerland, and Stanford University, USA. Thirteen to fifteen winners and awardees at the final stage of the All-Russian Olympiad of School Students are admitted to the program every year. The passing score in 2015 was 281 out of 300. The program focuses on training researchers, researchers in engineering and software developers.

The Master's program in Data Sciences, supervised by professor S.O. Kuznetsov, Doctor of Sciences, is delivered in partnership with Kharkevich Institute, Skoltech, and Yandex School of Data Analysis. The program is devoted to Big Data processing and trains data-scientists who are in high demand on the global market today. Students in the program have the option of participating in academic mobility programs and spending a semester at Blaise Pascal University, Dresden University of Technology or Texas University in Brownsvill and receiving fully transferable credits.

An English-taught double-degree undergraduate program in computer sciences with the University of London is being developed and the first students will be enrolled in 2017.

3. Programs in software engineering sciences are delivered in partnership with the Institute for System Programming, Eindhoven University of Technology, IBM, Luxoft and Kaspersky Lab. Students are involved in research projects in compilation technologies, software verification, modelling and process mining in information systems.

The undergraduate program in Software Engineering is aimed to train the best technical specialists, highly qualified software developers and software architects, quality assurance managers for software products and software development. The passing score in 2015 was 278 out of 300.

The Master's program in System and Software Engineering is delivered in English and trains specialists in the industrial production of software. A separate program track is devoted to the design and development of mobile applications, from the fundamental principles of design to the practical aspects of the mobile product promotion. A new Master's program in system programming in cooperation with the Institute for System Programming is scheduled to launch in 2017.

4. Educational programs through the HSE Moscow Institute of Electronics and Mathematics in applied mathematics and modelling are delivered in partnership with Dorodnicyn Computing Center, Trapeznikov Institute of Control Sciences, Space Research Institute, Keldysh Institute of Applied Mathematics. Students participate in research projects in mathematical and computer modelling.

The undergraduate program in Applied Mathematics trains specialists who can tackle a wide range of tasks in the field of IT and contemporary engineering. Graduates have excellent career prospects working for multinational companies (Microsoft, Oracle, SAP, etc.).

The Master's program in Mathematical Methods of Modelling and Computer Technologies, supervised by Professor M.V. Karasev, Doctor of Sciences, develops interdisciplinary competencies in mathematics and its applications in promising technological areas: supercomputer clusters, distributed computations, complex networks and statistical systems, diffusion waves and phase transitions. In 2015, Professor V.V. Stegailov, a senior lecturer in the program, received the Russian Presidential Award for Young Scientists in the Field of Science and Innovation.

In partnership with innovative companies and startups, Kharkevich Institute initiated two Master's programs. Students enrolled in this program take part in research projects in machine learning, data mining and its applications.

In 2015, the first students were enrolled in the Mathematical Optimization Methods and Stochastic Systems program, supervised by professor V.G. Spokoyny, Candidate of Sciences (PhD). The program is implemented in partnership with the Laboratory of Structural Data Analysis Methods in Predictive Modeling (PreMoLab) and Skoltech. Fourier University, Humboldt University and Airbus, Autodesk, and Huawei are among the program's international partners. The program is designed to train researchers and analysts in the field of applied mathematics and mathematical modeling with an in-depth study of mathematical statistics, stochastic analysis and discrete mathematics, as well as specialists in methods of optimization. Students are involved in applied projects, including the traffic optimization project, implemented by the HSE Institute of Transport Economics and Transport Policy.

Drawing on the success of this project, a Master's program in Data Mining in Biology and Medicine will be launched in 2016 under the supervision of Professor M.S. Gelfand, Doctor of Sciences. Program partners include Belozersky Institute of Physico-Chemical Biology MSU, Vavilov Institute of General Genetics, Shemyakin - Ovchinnikov Institute of Bioorganic Chemistry, Moscow School of Bioinformatics, and Litech, Knomics, Atlas, Biomed Group, and iBinom companies. The program aims to train specialists in bioinformatics who will be able to develop computation methods and apply them to solving tasks in various areas of biology and medicine. The key advantage of this program is that it offers interdisciplinary education with in-depth knowledge of both mathematical tools and biological systems. Bioinformatics is extremely popular among undergraduate students at Russian universities; however, only 5 programs are currently being delivered throughout the whole country.

Key Research Projects and Their Development

The Faculty of Mathematics brought together a unique research team of leading mathematicians from all over the world. Their research projects are closely linked with cross disciplinary studies, which is the essential in modern mathematics. For example, 13 out of 21 plenary speakers invited to the International Congress of Mathematicians (Seoul, 2014) work in geometry, representation theory, dynamical systems, mathematical physics and number theory. Russia was represented only by four section speakers, and three of them are involved in STRA-U's research projects.

The Faculty of Computer Science was created with strong involvement from Yandex, and it is an example of full-scale collaboration between a university and a company, which is rare for Russia. Since 2015, a research team from the Laboratory of Methods for Big Data Analysis has participated in the LHCb experiment (one of the four experiments conducted at the Large Hadron Collider). Personnel from academic institutes and developers from the leading IT companies are engaged in teaching at the faculty.

Established in 1962, MIEM (Moscow Institute of Electronics and Mathematics) merged with HSE in 2012. Several MIEM research schools in various fields of applied mathematics, IT and engineering have become legendary. Some of the most prominent scholars work at MIEM, including academician V.P. Maslov, one of the leading experts in mathematical physics, and A.S. Holevo, an expert in quantum informatics and the winner of the 2016 Claude E. Shannon Award, alongside other outstanding experts.

The integration of these three university divisions within the framework of the unified Strategic Academic Unit will produce a substantial synergistic effect.

Key research projects:

1. *Algebraic Geometry, Representation Theory and Mathematical Physics*. This project is dedicated to the development of Russian mathematics and groundbreaking research projects in fields that have already proved to be the bellwethers of the Moscow mathematical school as well as globally: algebraic geometry, differential geometry, complex geometry, representation theory, mathematical physics, number theory and dynamical systems.

Project supervisors: Alexander Kuznetsov, Head of the HSE International Laboratory of Algebraic Geometry and its Applications, Leading Researcher at the Steklov Mathematical Institute, winner of the European Mathematical Society Prize 2008 and Russian Presidential Award for Young Scholars in the Field of Science and Innovation (2009) and Boris Feigin, head of the International Laboratory of Representation Theory and Mathematical Physics, professor at the HSE Faculty of Mathematics.

The International Laboratory of Algebraic Geometry and its Applications (<https://ag.hse.ru/en/>), established in 2010 under the supervision of F.A. Bogomolov, professor at the Courant Institute of Mathematical Sciences (New York, USA), and International Laboratory of Representation Theory and Mathematical Physics, established in 2014 under the supervision of A.Y. Okunkov, Fields Medal Winner and professor at the Columbia University (New York, USA), are the key structural units in this project.

The project aims to achieve a number of specific targets, including the study of the interrelation between categorical joins and homological projective duality with application to building new examples of homologically projectively dual manifolds and creating new interrelations between derived categories; the study of minimal compactifications of basic affine varieties and building new examples of compactifications of affine varieties with application to higher dimensional Fano varieties, etc. The project is implemented in partnership with the Steklov Mathematical Institute.

2. *Mathematical Methods in Theoretical Computer Science* project fosters research in the field of theoretical computer science and related areas of mathematical logic: algorithmic information theory and algorithmic randomness, algorithmic statistics, provability logic and its application to arithmetic theories analysis, logical verification of communications protocol, logic means of representation and processing of data and knowledge.

Supervisors: Lev Beklemishev, Leading Research Fellow at the Steklov Mathematical Institute, Yandex professor at the HSE Faculty of Mathematics, Associate Member of the Russian Academy of Sciences (2006) and Nikolay Vereshchagin, professor at the HSE Faculty of Computer Science, member of the Academia Europaea: Informatics (2014).

International Laboratory for Intelligent Systems and Structural Analysis (leading research fellow - Andre Scedrov, Professor of Mathematics at the University of Pennsylvania) and International Laboratory of Theoretical Computer Science (<https://cs.hse.ru/en/big-data/tcs-lab/>, leading international research fellow - Vladimir Gurvich, professor at Rutgers University, USA) are involved in project activities.

The principal subject of research in the algorithmic information theory is the size of the most concise description of finite objects. This theory will soon be extrapolated to algorithms with limitations on computational resources (time and memory).

Another current objective is the study of provability logics and their application to the analysis of the first and the second order arithmetic theories. The project also includes the development and systematization of positive provability logics, specifically positive modal logic applications to the database theory and ontology languages.

3. *Machine Learning and Data Mining with Applications in Information Technology, High Energy Physics, Biology, Medicine and Neuroscience.* This project aims to develop data analysis methods with practical applications, including information retrieval, computer vision, biological, chemical and medical informatics, recommendation systems and computational linguistics.

Supervisors: Sergei Kuznetsov, Head of the School of Data Analysis and Artificial Intelligence under the Faculty of Computer Science and Andrey Ustyuzhanin, Head of the HSE Laboratory of Methods for Big Data Analysis, supervisor of joint projects with Yandex company and CERN.

The Bayesian methods team headed by Dmitry Vetrov works on integrating modern instruments of probabilistic modelling into learning algorithms of deep neural networks. A specific example of the projected application of the team's activities is the compactification of neural network layers for use in mobile resources. One other promising area is the application of machine learning methods to high energy physics. HSE 2014-2015 research projects analyzing the results of experiments conducted at the Large Hadron Collider showed that a 40-60% increase in efficiency at various stages of data processing is quite possible. Specific tasks of the project include designing a cell phone-based system for data processing to be used for observing ultra-high energy space particles (A.E. Ustyuzhanin, D.A. Derkach). This technology could help to save the funds allocated for construction of costly observatories. Both project tracks are implemented in partnership with Skoltech and Yandex.

New projects dedicated to life sciences, the development of new methods in bioinformatics (M.S. Gelfand), mathematical neurobiology (A.E. Osadchy, B.S. Gutkin), medical informatics (S.O. Kuznetsov, O.S. Pyanykh), neurotechnologies (A.E. Osadchy, M. Feura) and cognitive technologies (T.Savada, I.S. Utochkin) are scheduled to be launched. HSE's partners in these projects will include the Kharkevich Institute, Moscow Bioinformatic School and HSE Center for Cognition & Decision Making.

4. *Process Mining: Modelling and Analysis of Information Systems Based on Their Real Behavior.* This project aims to develop new approaches to increasing the efficiency, reliability and safety of modern information systems, based on the event log records that reflect real behavior of systems and their users. This project deals with Process Mining, which is a new and rapidly growing area of knowledge.

Supervisors: Wil van der Aalst, full professor of Information Systems at the Eindhoven University of Technology (Netherlands), HSE Distinguished Professor, member of the Academy of Europe: Informatics and Irina Lomazova, Head of the HSE Laboratory of Process-Aware Information Systems.

The HSE Laboratory of Process-Aware Information Systems was initiated by Professor Wil van der Aalst, the creator of process mining. HSE is a current member of the IEEE SIC Task Force on Process Mining (<http://www.win.tue.nl/ieeetfpm/doku.php?id=shared:org:hse>), an international collaboration group that is comprised of leading academic and industrial centers. The examples of process mining practical applications include business process management systems (BPM), workflow management systems (WFM), enterprise resource planning systems

(ERP) and case handling systems. The project's goal is to develop new methods to analyze and design such systems. In process mining, comprehensive software products are created based on the LEGO principle – when a new method is introduced, a new plug-in is created and then incorporated into the complex. A module to adapt the existing model to real business processes, when there is no exact match between the model and process parameters, is being developed.

5. *Mathematical and Computer Modelling*. This project deals with current issues in two interrelated areas: developing new mathematical methods for multi-scale modelling technologies and technical systems management at the macro level.

Supervisors: Mikhail Karasev, Head of the HSE Mathematical Methods in Natural Science Laboratory and Lev Shchur, Head of Information and Communication Facilities and Systems Joint Department with RAS Computing Center named after A.A. Dorodnitsyn.

HSE partners in this project include the National University of Science and Technology MISiS, Irkutsk National Research Technical University, Space Research Institute of the Russian Academy of Sciences, Central Research Institute for Machine-building TSNIIMASH, Research and Manufacturing Association named after Lavochkin.

The integrated approach allows to significantly expand the range of project tasks - from atomic scale materials design, quantum informatics and bioinformatics to macro-level modelling and management of technical systems and processes. The project is dedicated to optimizing design concepts (including aerospace technology) for spaceflight dynamics, space missions trajectory plans, biomechanical systems modelling and artificial implants design for bone tissue.

Information on the connections between research and educational programs is available in section Key educational programs and their development of this passport.

Key External Parties Who Benefit from STRA-U Activities

The list of key employers for STRA-U's graduates and STRA-U's partners in fundamental and applied research includes the Institutes of the Russian Academy of Sciences (Steklov Mathematical Institute, Kharkevich Institute, Institute for Systems Analysis, Institute for System Programming and others), leading Russian and international companies (Yandex, co-organizer of HSE Faculty of Computer Science, Facebook, Google, Microsoft, IBM, ABBYY, Croc company and others), commercial banks (Sberbank, VTB 24, Alfa Bank, Otkritie Bank, etc.), telecommunication companies (Rostelecom, Beeline, MTS, Megafon, etc.), and IT units of state authorities.

STRA-U infrastructure

1) CUDA computing cluster and CiaraNexus high-performance cluster. CUDA parallel computing platform provides a range of extensions for the C and C++ languages that allow to express the data parallelism and the tasks parallelism at the small and large structural units level.

2) Equipment set of the Laboratory for High-Performance Hardware and Software Systems and Local Area Networks main functions include design, prototyping, and control of radio-technical and info-telecommunication devices and systems. This equipment allows to process the video data, images (compressing, decoding, and others), and address the comprehensive issues, such as the updating of the topographic maps, oil spills monitoring, hazardous natural phenomena monitoring.

3) The laboratory and research package for solving practice-oriented educational and scientific and technological tasks based on the space technologies is designed for education and research in mathematical support, numerical models, and reliable on-board software of the real systems.

4) 3D Scanning and Printing Hardware and Software Package. 3D computer modelling is one the main stages of prototyping. The mathematical model can be obtained virtually in any 3D model computer modelling software tool that can further export to the STL format. The quick prototyping technologies allow to build both complicated models, and the separate nodes consisting of the parts movable in relation to each other. The quick prototyping with 3D printers is the layer-by-layer building of the physical structure of the object based on the developed mathematical 3D model.

5) 3D Visualisation and Computer Graphics Laboratory Package allows to conduct the laboratory and research projects of various level of complexity, from the detailed design of the radio-electronic equipment housings with their further conversion to the virtual space of the laboratory, to the complicated internal representation of the integrated circuit layers.

6) Intellectual Control Systems and Robotics Laboratory Package includes the robotics platforms, sets of the sensors structural elements, executive elements, service systems, and micro-controllers that allow to build and study the various executive mechanisms and autonomous systems with the artificial intelligence elements; and allows to expand the scope of scientific research in the dynamic control systems and artificial intelligence.

7) Laser Technologies Laboratory equipment allows to automate the 3D images creation process, create the real-time laser projections, use the laser projections technique for targeting systems of the unmanned aerial vehicles (drones), and others.

8) NvidiaTesla computing cluster (kindly provided by Yandex).

9) IBM CloudOrchestrator-based cloud infrastructure and 2 servers (kindly provided by EC-Leasing).

Current STRA-U Personnel Composition

Average number of academic personnel *per year* – 317, average age of academic personnel – 51, share of academic personnel holding an academic title – 86%, information on the key academic personnel is listed in sections Key research projects and their development, STRA-U's structure and management system of this passport.

Academic Personnel Development: see section 2.5.

STRA-U Structure and Management System

Mathematics, computer science and information technology fall into the first category of HSE STRA-U's. Information on STRA-U's structure, planned organizational changes, autonomy level, and governing bodies' functions is contained in sections 2.1, 2.2 and 2.6.

STRA-U's Governing Board includes the heads of key STRA-U units:

1. Yuri Nesterov (STRA-U's Academic Supervisor)

<https://www.hse.ru/en/org/persons/150293981>;

2. Ivan Arzhantsev (STRA-U's Head, Dean of HSE Faculty of Computer Sciences)

<https://www.hse.ru/en/staff/arjanstev>;

3. Alexander Tikhonov (Director and Academic Supervisor of MIEM HSE)
<https://www.hse.ru/en/org/persons/47632635>;
4. Vladlen Timorin (Dean of HSE Faculty of Mathematics)
<https://www.hse.ru/en/staff/vtimorin>;
5. Sergei Lando (Tenured Professor at the HSE Faculty of Mathematics)
<https://www.hse.ru/en/org/persons/311971>;
6. Sergei Obiedkov (Deputy Dean for Research and International Relations at the HSE Faculty of Computer Science) <https://www.hse.ru/en/staff/obiedkov>;
7. Sergei Aksenov (Deputy Dean for Research at MIEM HSE)
<https://www.hse.ru/en/staff/aksenov>.

STRA-U International Expert Committee:

1. Pierre Deligne
<https://www.ias.edu/people/faculty-and-emeriti/deligne>
Professor at the Institute for Advanced Study, Princeton, USA, Abel Prize Laureate 2013;
2. Tetsuji Miwa
http://www.aps.org/programs/honors/prizes/prizerecipient.cfm?first_nm=Tetsuji&last_nm=Miw a&year=2013
Full Professor at the Department of Mathematics of Kyoto University, Japan;
3. Nikita Nekrasov
<http://scgp.stonybrook.edu/people/faculty/bios/nikita-nekrasov>
Professor of the Stony Brook University, New York, USA;
4. Sergey Fomin
<http://dept.math.lsa.umich.edu/people/facultyDetail.php?uniqname=fomin>
Professor at the Department of Mathematics of the University of Michigan, USA.

1.3 Performance Indicators of Strategic Academic Unit

№	Indicator	2015 actual	2016 plan	2020 plan
1.	Position in broad field (specific subject) rankings (ARWU, THE, QS) as university KPI for which the STRA-U is valuable (according to the “roadmap” of the relevant university)			
1.1.	QS «Mathematics» by faculty	-		101-150
1.2.	QS «Computer Science» by subject	-		251-300
1.3.	ARWU «Mathematics» by subject	-		151-200
2.	Number of publications in the Web of Science per one faculty member of the STRA-U	1,48	1,68	3,25
3.	Number of publications in Scopus per one faculty member of the STRA-U	2,56	3,14	4,98
4.	Average citation index per one faculty member of the STRA-U calculated on the basis of the total number of publications indexed by the Web of Science	3,62	4,50	12,62
5.	Average citation index per one faculty member of the STRA-U calculated on the basis of the total number of publications indexed by Scopus	5,81	7,23	16,58
6.	Percentage of international faculty in the STRA-U’s team including Russian citizens with PhDs from foreign universities	10,1%	10,7%	14,8%
7.	Percentage of international students enrolled in higher education degree programs provided by the STRA-U (including CIS students)	5,4%	6,0%	15,7%
8.	Average Unified State Examination (USE) grade for students enrolled in full-time federal funded Bachelor and Specialist-level programs delivered by the STRA-U ¹	86,5	no less than 85	no less than 85
9.	Percentage of the STRA-U’s income from non-budgetary (non-government) sources	12%	no less than 15%	no less than 24%

¹ The actual value of indicator could be adjusted depending on changes in the scaling system of Federal Education and Science Supervision Agency in the relevant year. Besides, HSE undertakes to remain in TOP-5 Russian Universities for the quality of admissions.

1.4 Quantitative characteristics of the STRA-U's development

№	Indicator	2015 actual	2016 plan	2020 plan
1.	Number of higher education degree programs with international professional or public accreditation delivered by the STRA-U	2	2	4
2.	Number of higher education degree programs delivered by the STRA-U entirely in a foreign language	2	2	3
3.	Number of higher education dual degree programs delivered by the STRA-U	0	0	1
4.	Percentage of the STRA-U's students involved in R&D of this unit and enrolled in higher education degree programs provided by this unit, among the total number of students enrolled in the STRA-U's higher education degree programs	14,39%	15%	15%
5.	Percentage of the STRA-U's students enrolled in higher education degree programs among the total number of students enrolled in higher education degree programs of the relevant university	16%	17%	20%
5a.	Same for Bachelor-level programs (Specialist-level)	18%	20%	23%
5b.	Same for Master's programs	10%	11%	12%
5c.	Same for Ph.D. programs	24%	24%	24%
6.	Percentage of the STRA-U's faculty members who authored publications indexed by Scopus or the Web of Science among the total number of faculty of the STRA-U	64%	67%	80%
7.	Percentage of the STRA-U's employees among the total number of employees of the relevant university	8,1%	8,1%	8,1%
8.	Number of intellectual deliverables/intellectual products (IP) created by the STRA-U's employees	14,00	16,00	20,00
9.	Source-Normalized Impact per Paper (SNIP) of journals indexed in Scopus where the articles authored by the STRA-U's faculty members were published in the reporting year	1,003	1,05	1,25

1.5 Financial Model

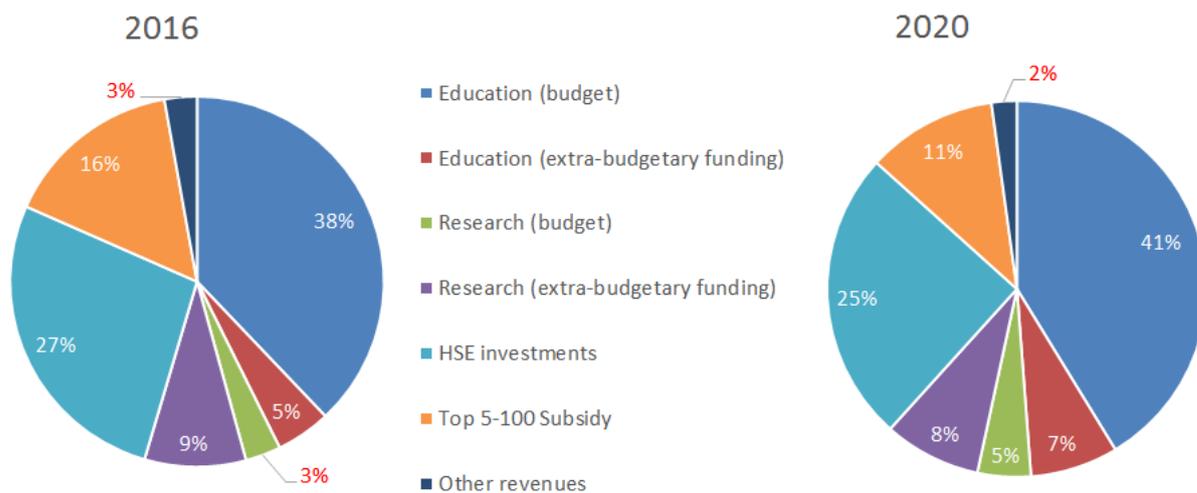
STRA-U budgets are managed by the university and heads of participating units; they are financed from the following three sources:

1. Government-funded education and research projects. STRA-U's contribution to the government projects in 2016-20 is expected to be about 21 % for educational services and 4 % for research. STRA-U units' KPIs include economic efficiency indicators of educational programs.

2. Funding from **external sources** (extra-budgetary revenues) derived from fee-based educational services, research and expert review projects in the interests of the government and corporate clients, donations and other special purpose contributions. The share of the STRA-U's extra-budgetary revenues is expected to be no less than 24 % in 2020. Funding from external sources is one of the KPIs of the STRA-U's units heads.

3. **HSE special purpose funds** provided to STRA-U units for development (academic development funds, centralized HSE programs such as the Academic Fund, the Fund of Educational Innovations, etc., acquisition of special research and laboratory equipment, inviting international academic personnel, etc., including funds of the subsidy under Global Competitiveness Program).

Planned STRA-U's structure and revenues dynamics:



$\Sigma = 0,9$ billion rubles

$\Sigma = 1,2$ billion rubles

The growth in the STRA-U's revenues in the period of up to 2020 will be achieved thanks to the increase in the number of students in fee-based programs and the development of new continuing education programs, including the special personnel training by order of HSE partners, such as Rosatom, Roanano, Space Rocket "Energy" Corporation, Vympelcom, MTS, Megafon, Sberbank, VTB-24, Moscow Metro.

In the next 3-5 years, the revenues from mass online-courses are expected to grow consistently both on international platforms and in Russia – in line with the development of the National Open Education Platform. The STRA-U is planning to launch online courses in such fields as contemporary algebra and discrete mathematics, representation theory and mathematical physics, modelling and development of mobile applications.

Increase in the STRA-U revenues derived from research will be accompanied by the changes in revenue structure – the share of project work in partnership with the leading Russian and international companies (for example, Yandex, Microsoft, IBM, SAS, Samsung, EMC, ZyXEL, Vega Concern, Khrunichev State Space Science and Production Center, Research Institute of Space Instrument-Building, Gazprom-Space Systems) is expected to grow.

STRA-U units will continue to actively participate in research grant programs of Russian funds, primarily in such fields as algebraic geometry, representation theory and mathematical physics, theory of algorithms, computation and formal analysis of concepts, neural networks and in-depth learning, biological and medical informatics, information systems and analysis of business-processes. In case of improvements in the international market situation, the revenues from participation in international research grant programs are also expected to go up.

Total increase in the STRA-U's revenues in 2020 versus 2016 will be no less than 300 mln rubles. As compared with the funds received by the STRA-U under Global Competitiveness Program, the anticipated growth of income will exceed 180 %.

STRA-U expenditures include personnel salaries (68-72%) and other operating expenses (teaching and research process, academic mobility, acquisition of information, etc.).

General and administrative expenses are centrally managed by HSE. All facilities, dormitories, IT infrastructure and administrative services are provided by the university.

The STRA-U's financial stability is achieved through the combination of revenues from all types of its operations and HSE investments – through centralized academic development instruments (programs and projects). HSE is ready to provide additional resources to the STRA-U by reallocating HSE's centralized funds if necessary.

1.6 Schedule (Roadmap) for controlled changes

No.	Objective	Year				
		2016	2017	2018	2019	2020
1. Organizational changes						
1.1.	Mathematics, Computer Science and Information Technology (MACSIT) STRA-U organizational structure has been established, including the team, management, collegiate and executive management bodies	X				
1.2.	Project teams have been set up, and required information and material resources for their operations have been defined	X	X	X	X	X
1.3.	The number of international laboratories is growing	X	X		X	
1.4.	New members have joined the International Expert Committee	X		X		X
1.5.	International expert review of the research outcomes of the Faculty of Computer Sciences to mark the Faculty's 5 th anniversary				X	
2. Required changes and results of the educational activities						
2.1.	Launching the Master's program in Data Analysis in Biology and Medicine in academic year 2016-2017	X				
2.2.	Agreements with new international partners for double-degree programs	X	X	X	X	X
2.3.	Student academic mobility programs, student exchange programs	X	X	X	X	X
2.4.	The following English-taught online-courses have been developed for Coursera <ul style="list-style-type: none"> • Galois Theory (E. Amerik) • Modular Forms (V. Gritsenko) • General Relativity Theory (E. Akhmedov) • Formal Concept Theory (S. Ob'edkov) 	X	X	X	X	X

2.5.	The following Russian-taught online-courses have been developed for Coursera <ul style="list-style-type: none"> • Introduction into machine learning (K. Vorontsov) • Development and design of mobile applications (D. Aleksandrov) 	X	X	X	X	X
2.6.	Promotion of the Master's programs on the global market, arranging international students' admission to programs in Mathematics and System and Program Engineering	X	X	X	X	X
2.7.	Professors from the best centers in the field, experts from the real sector of economy have been invited to deliver courses in the Master's programs	X	X	X	X	X
2.8.	ABET international accreditation (Accreditation Board for Engineering and Technology) of the undergraduate program in Program Engineering and the Master's program in System and Program Engineering		X	X		
2.9.	Lectures, seminars, training sessions in the STRA-U-specific fields, delivered by international teachers as online courses in the framework of the Master's programs	X	X	X	X	X
2.10.	Outbound academic mobility for faculty members	X	X	X	X	X
2.11.	Continuing professional development in the STRA-U-specific fields for civil servants employed by government authorities, Russian and international graduates	X	X	X	X	X
3. Changes and outcomes of research and science and technology activities						
3.1.	Implementing applied projects in key academic fields	X	X	X	X	X
3.2.	International recruitment of scholars on a competitive basis	X	X	X	X	X
3.3.	Engaging students in research projects implemented by STRA-U	X	X	X	X	X
3.4.	Outgoing academic mobility programs for researchers	X	X	X	X	X
3.5.	Special continuing education programs for researchers, including lectures, master classes and seminars with participation of leading international scholars	X	X	X	X	X
3.6.	Hosting large international conferences bringing together international scholars and experts in the STRA-U-specific topical areas	X	X	X	X	X
3.7.	STRA-U-related trimesters in basic mathematics and theoretical informatics with participation of international lecturers, and students		X	X	X	X

3.8.	Holding summer schools and off-site seminars, including the Summer School in Algebra and Geometry, Summer School in Machine Learning in High Energy Physics and Summer School in mobile applications, and some other events	X	X	X	X	X
3.9.	Supporting rankings of the Moscow Mathematical Journal in Scopus	X	X	X	X	X
3.10.	The Moscow Mathematical Journal is in Q1 in Scopus and maintains the highest SJR among Russian mathematical journals	X	X	X	X	X
3.11.	Publication and promotion of monographs of foreign authors in English, edited by the STRA-U personnel (Springer publishing company)		X	X	X	X
3.12.	Regular expert review of the STRA-U's research outcomes by the International Advisory Board		X		X	
3.13.	Developing research infrastructure through the acquisition of modern databases, essential STRA-U research projects	X	X	X	X	X
3.14.	Research projects competition for young scholars from other universities and research organizations			X	X	X
4. General changes and results, including at the University's level						
4.1.	Facilitating the HSE achievement of leading positions in education and research at the regional and global level, evidenced by the promotion in the QS global rankings and the QS global rankings in Mathematics, Informatics and Information Technologies	X	X	X	X	X
4.2.	Reducing HSE dependence on the state budget-based financing				X	X

2. TRANSFORMING THE UNIVERSITY BY ESTABLISHING THE BREAKTHROUGH AREAS ACROSS STRATEGIC ACADEMIC UNITS

2.1 Organizational Transformation of the University

HSE is in the process of systemic transformations, first launched by the university in 2010, and aims to create centers of excellence and to disseminate the experiences of these centers throughout the university.

In the first stage of transformation, the university established 10 international laboratories lead by the prominent foreign researchers. The development of international laboratories in economic, social, computer, and mathematical sciences has contributed to overcoming the long-term isolation of Russian social and economic sciences and enabled HSE to join the global network-based research market and strengthen the university's position as the center of advanced research in select areas of expertise. As a result of the university concentrating its resources on the development of those areas, the number of research publications in the international databases Web of Science and Scopus has grown five times over the last five years. Globally renowned scientists such as Nobel Laureate Eric Maskin, Fields Medal Winner Andrei Okounkov have joined the university. The number of international laboratories grew to 22 in 2015 and these research centers have enabled the university to integrate the new academic culture into more traditional forms through the creation of faculties and moving further to the next transformation stage.

The second stage in the transformation of the university's organizational model is the transition from highly specialized faculties and academic departments, designed with the primary purpose of teaching, to the model of mega-faculties, or large research and education units conducting research (including multidisciplinary research) and faculty training in broad areas of expertise: economic sciences, social sciences, business and management, humanities, computer and engineering sciences, mathematics, law, communications and design and urban studies. The integration process was completed in 2015 when 21 faculties and division networks were replaced with 10 mega-faculties. The former faculties and academic departments became departments and schools, and mega-faculties were merged with previously independent HSE research units to conduct basic and applied research and focus on expert analytical work and consulting. The new organizational model is currently finalizing its operating mechanisms.

The university merger of interrelated fields of expertise encourages the development of promising research areas at the intersection of sciences and ensures the principle of crossdisciplinary interaction in research and teaching. This contributes to the rapid development of the mega-faculties' educational programs built into the framework of new fast-growing areas of expertise that are implemented by research scientists, key employers, international experts; students become involved in real scientific research projects while still in the training. Such integration is provided by research units, departments and schools within the mega-faculties.

The conversion ensures an integrated approach to mega-faculties-based management and the development of all areas of the university's expertise, including higher education and continuing education, basic and applied research, innovation, expert analytical work and consulting. International laboratories still act as the drivers of research, set standards for other research teams and play an important role in graduate and postgraduate education. Regular evaluation of laboratories' performances by internationally recognized experts constitutes the basis for decision-making on the laboratories' existence. Mega-faculty management is based on the principles of academic self-governance, which is implemented at all levels of decision making.

In 2015, the right to managing independently financial resources and the responsibility for achieving planned results (KPIs for the mega-faculties' deans are set) were delegated to the mega-faculties. This significantly simplified the decision-making process, allowed more specific considerations on account of individual disciplines and enhanced their development. Currently, almost 50% of resources from the university-wide academic development fund (scholarships for

academic mobility of faculty members, researchers and students, conferences, etc.) are managed by the mega-faculties. The mega-faculties' academic development funds are competitively distributed in accordance with the decision of mega-faculties' governing bodies, composed of researchers and instructors. The mega-faculties' academic and financial autonomy will be further increased; resources will be managed and decisions made based on KPIs.

The university is currently in the third stage of its transformation: HSE continues to improve the mega-faculties and establish better conditions for their development through the individual research and education units under these new interdisciplinary centers of excellence. The centers use the mega-faculties' infrastructure, human and other resources and have become growth points for promising areas where the university intends to enter the global market. Successes have been achieved in some subject areas as evidenced by high quality publications in the leading journals (See sections below).

2.2 Strategic Academic Units

The mega-faculties and research units (including international laboratories) are used to establish large areas of expertise with interdisciplinary connections: Strategic Academic Units (STRA-U). There are two types of STRA-U – international consortia and centers of excellence, which are currently being formed based on the following criteria:

- 1) Research must be consistent with the global research agenda and international research networks;
- 2) Research must be relevant to Russia's geopolitical interests and/or sectoral priorities;
- 3) STRA-U must serve as expert analytical centers for the development of public policy in the economic and social sectors, education, science and technology forecasting and state-building; each STRA-U should make a significant contribution to the development of Russian economy;
- 4) Educational programs are implemented at various levels (undergraduate, specialist, graduate and post-graduate programs).

The first type of STRA-U includes major consortia that address the university's existing core areas. They are recognized internationally (reflected in their international rankings), and have a high capacity for further dynamic development. These consortia are formed from one or more mega-faculties and academic units of the university, which implement educational programs at all levels and their research has been integrated or is capable of being integrated into the global research agenda:

- Economics and Management (QS Economics & Econometrics – 151-200, QS Development Studies – 51-100, QS Social Science & Management – 161²);
- Challenges for Social Development (QS Development Studies – 51-100; QS Sociology – 151-200; QS Social Sciences & Management – 161);
- Mathematics, Computer Science and Information Technology: scalable mathematical methods (QS Mathematics и QS Computer Science & Information Systems – 400+, ranks 6th in Russia);
- Humanities Consortium “Humanus” (QS Philosophy – 151-200, QS Arts & Humanities – 289).

The second type of STRA-U includes centers of excellence: individual structural units that have been created as new growth points in relatively narrow and promising interdisciplinary areas of research and education and are integrated into the global research agenda and implement

² HSE position in QS World University Rankings 2015 (by subject and by industry) are given in brackets. This position has been secured thanks to the contribution of the respective STRA-U.

Master's and doctoral educational programs. In the long run, these units are capable of growing into new research and educational areas:

- Foresight and Science, Technology and Innovation Studies (QS Development Studies – 51-100; QS Social Sciences & Management – 161);
- Cognitive Neuroscience: from Computational Models to Neurotechnology (QS Economics & Econometrics – 151-200; QS Social Science & Management – 161);
- Education and Human Development in changing world (QS Sociology – 151-200; QS Social Science & Management – 161);
- Urban and Transportation policy: guiding urban transformation from industrial to digital age (QS Development Studies – 51-100; QS Social Sciences & Management – 161).

Not included in STRA-U's are key HSE faculties such as World Economy and International Affairs, Law, and Communications, Media and Design, as well as the Department of Foreign Languages, because these units are currently focused mainly on the Russian market.

Strategic Academic Unit Management

Each Strategic Academic Unit is managed by:

- the research adviser, a leading scholar in the STRA-U area, well known by the international academic community, whose main functions are to establish the STRA-U research and education agenda and strategies, help enhance STRA-U leadership within the international academic community and engage STRA-U leading experts in relevant fields;
- the leader, a famous academic and experienced research and/or education administrator whose main functions are to ensure achievement of STRA-U goals, coordinate research and education communication among the divisions within STRA-U and make personnel and financial decisions.

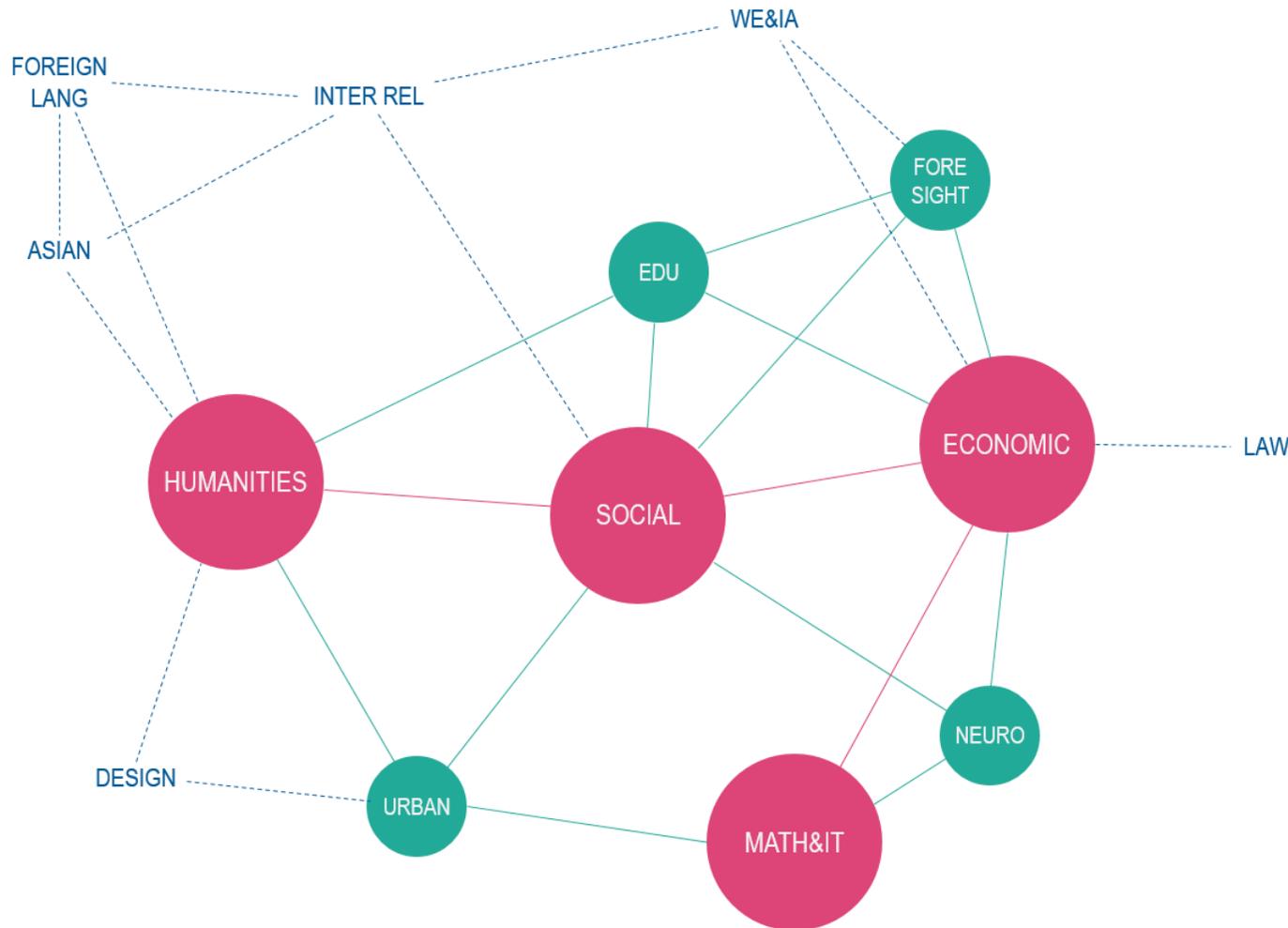
STRA-U is managed by the Management Board, which makes programmatic and resource decisions on each of the STRA-U's tasks delivery and ensures monitoring of STRA-U's tasks delivery.

Some STRA-U's have already established International Expert Committees and others will establish them by the end of 2016. International Expert Committees will conduct external evaluations of STRA-U research and educational activities and provide recommendations regarding STRA-U development strategy. They will also promote international partnerships and the integration of STRA-U researchers in international research networks.

The university's management practices have been tested within the mega-faculties model and have proved to be viable and effective. They will also be used in the next stage of the university development within STRA-U's framework (see more details in respective sections of each STRA-U fact-sheet).

The scheme of interaction between STRA-U's and other units that haven't been integrated as a STRA-U yet is defined in the following figure.

STRATEGIC UNITS INTERACTIONS



StraU's of I type **CONSORTIUMS**

- >**ECONOMIC**< ECONOMICS AND MANAGEMENT >
- >**SOCIAL**< CHALLENGES FOR SOCIAL DEVELOPMENT >
- >**MATH&IT**< MATHEMATICS, COMPUTER SCIENCE AND INFORMATION >
- >**HUMANITIES**< SCHOOLS AND INSTITUTES CONSORTIUM «HUMANUS» >

StraU's of II type **CENTERS OF EXCELLENCE**

- >**FORESIGHT**< FORESIGHT AND SCIENCE, TECHNOLOGY AND INNOVATION STUDIES >
- >**NEURO**< COGNITIVE NEUROSCIENCE: FROM COMPUTATIONAL MODELS TO NEUROTECHNOLOGY >
- >**EDU**< EDUCATION AND HUMAN DEVELOPMENT >
- >**URBAN**< URBAN AND TRANSPORTATION POLICY: GUIDING URBAN >

OTHER UNITS

2.3 Research and innovation activities

Research and science project areas are described in detail in each STRA-U Fact-sheet.

HSE strategy for basic research sets rigorous requirements for research quality, and personnel incentives are aimed at facilitating research in the most cutting-edge areas and topical fields. This has caused a significant growth in the number of quality publications. Articles by HSE faculty and researchers are published in top international journals, including Review of Economics and Statistics, Acta Mathematica, Journal of Personality and Social Psychology, The Lancet, IEEE Transactions on Pattern Analysis and Machine Intelligence, Nature Genetics, Journal of Political Economy, Physical Review Letters, American Economic Review, Behavioral and Brain Sciences, Journal of Materials Processing Technology, Annals of Statistics, Communications in Mathematical Physics.

The university has robust research and innovation cooperation with major Russian and foreign companies and organizations which are not only customers of research and consulting projects but also partners in implementation of customized educational programs of mainstream and continuing education. The demand for the university's research is evidenced by steady growth in R&D total revenues, which is currently almost 40%. HSE has partnership relations with such major companies as Gazprom, Rosatom, Rosneft, Novatek, Gazprom Neft, Alrosa, Norilsk Nickel, Aeroflot, Rosgeologiya, Nissan, Sibur, Gazprombank, Lukoil, Transneft, Yandex and others. HSE is constantly expanding the network of joint departments (currently - 40) established in cooperation with leading research and science centers, global consulting companies, ICT companies, analytical centers, and others.

The university's innovative activities are designed to provide diverse forms of communication with project teams which include undergraduate, graduate and post-graduate students, professors and research scientists. Those activities range from annual competitions of business plans for innovative projects to supporting the start-ups at various stages of maturity. A prominent place in the Russian innovation ecosystem is taken by the HSE's Business Incubator which provides coaching and advisory services to student teams; the Innovation Center which provides organizational support to the spin-off companies, and Prototyping Center that provides an experimental platform for technological projects and boasts state-of-the-art equipment.

According to UBi Global rating, in 2015, HSE Business Incubator ranked 14 among global university business incubators (sole university business incubator in Russia to rank in global Top-25).

2.4 New organizational model for the education process

Establishing mega-faculties through the merger of academic units has enabled the implementation of a university-wide organizational and management model for the education process on the basis of "academic adviser - academic council - student office". In spite of a wide variety of programs, the quality of the education process and outcomes is ensured by general principles incorporated in the unique educational standards aimed at a higher level of complexity.

The implementation of undergraduate programs is based on a model that provides for:

- a limited number of courses (no more than five) to be studied by a student in any given semester, at least half of which are electives;
- a fixed part of the program within which a student works on projects and research papers primarily in actual research departments at the university;
- select clusters of courses (minors) available to all students (20 ECTS in two years);
- independent assessment of students' knowledge of the English language at the end of the second year through the process of international exams, and mandatory study of at least two major courses in English;
- mandatory preliminary thesis defense in English.

The implementation of graduate programs is based on the following model:

- no more than 12 courses to be studied by students over two years;
- two professional “core” disciplines (the second disciplines is to be selected by the academic program management and by the students themselves);
- research and independent work must constitute at least 70% of the load;
- opportunity for first-year students to select courses from the general pool of disciplines with broad humanities, social science and economic focus (MagoLego).

HSE’s educational programs are focused on the international market: the share of foreign students is currently 7.5%; 18% of disciplines are taught in English; 15 programs in the current academical year and 20 programs in the new academic year will be fully focused on English-speaking students; 43 (29%) educational programs are implemented in partnership with leading foreign (41) and Russian universities (2). HSE is actively involved in the work of universities’ consortium representing massive on-line courses on Coursera international platform: in 2015, over half a million students from 195 countries, representing 5% of all Coursera students, signed up for 36 HSE’s online courses taught in Russian and English.

2.5 Development of Academic Personnel

Academic personnel development within the new STRA-U framework will be provided by the instruments of academic development and through competitive procedures established in HSE in recent years and described in detail in the Roadmap of the Program for Enhancing HSE Competitiveness of the second stage.

The main instrument for attracting international experts is the international recruitment strategy, which has been in place at HSE since 2010. The ruble devaluation has significantly restricted Russian universities’ capacity to compete as employers in the global academic market; therefore, specialist recruitment on the international market in 2016 will change: most cited scientists in high demand by strategic academic units will be selected through the international recruitment procedure. Foreign researchers will be engaged in scientific projects under short-term contracts and remote work contracts. Particular emphasis will be placed on engaging talented young scientists in international research projects through the postdoctoral research fellow program, which will be enhanced starting from 2016.

Mandatory engagement of faculty members in research and involvement of researchers in the educational process is guaranteed by the single contract with academic personnel implemented by HSE in 2015. Faculty members’ teaching load is alleviated by teaching assistants, who are selected from among the best students and thus get a chance to start their academic career. Personnel rotation and academic faculty selection is performed through creating competitive academic environment - an open competition for academic faculty positions is held annually and attracts many external candidates. The competition procedure involves the multi-stage selection of candidates: evaluation of research, professional level, interviews, and open lectures. The selection is carried out by expert subject committees, mega-faculties’ personnel, and the personnel committee of the HSE Academic Council. The open procedure and similar evaluation criteria for HSE professors and external candidates provide conditions for the selection of the best specialists to be employed by the university on a full-time basis. They meet the university’s requirements focused on the global market: HSE academic faculty was renewed approximately by one third in 2013.

The merit-based personnel selection system is supported by a wide range of incentives that provide for professional development and the opportunity to select the optimum academic path for each faculty member. The instruments include stipends for publications at the international level, contributions to the university’s reputation, teaching courses in English, development of new teaching methods and training courses, individual and collective research and academic mobility scholarships, international partnership development scholarships, comprehensive professional development program which includes internships and PhD

education at foreign universities and academic English courses at Academic Writing Center. All of these procedures are carried out on a competitive basis.

HSE strives to create an English language-driven professional environment and to ensure the smooth integration of international students, faculty members and researchers into the university academic life. HSE has established special administrative units that provide guidance to international students and academic personnel in all aspects of the HSE experience (including medical insurance, social support, etc.). The university has created English language information resources and hires program coordinators with fluent English. In the coming years, the number of administrative personnel with English proficiency will be increased, and international faculty members will receive comprehensive information about what is occurring during their employment at HSE.

HSE's target personnel development model suggests that by 2020 at least 60% of academic personnel will be scientists (included in the global academic networks), about 20% will be the leaders of the Russian professional market, and the remaining 20% will be engaged only in teaching (mostly teaching foreign languages). It is also planned that 90% of full-time HSE faculty members will be able to teach and conduct research in foreign languages.

2.6 Financial sustainability and resource allocation for the establishment and development of Strategic Academic Units

Resources for the Program of Enhancing Competitiveness and the university's financial sustainability in general are secured primarily through revenue from core activities (all types of educational services, research and expert and consulting activities). In aggregate, HSE revenues in 2016³ will exceed 14 billion rubles (\$190M), which is higher than the revenue in 2012 by 44%. The university earns about 40% of the funds or 6 billion rubles per year (\$80M) in the open market: in terms of extra-budgetary revenue, HSE is among top three Russian universities. Global Competiveness Program program funding constitutes only 6.5% to the university's revenue.

In the years leading up to 2020, HSE will increase its overall revenue by 31% compared to 2015, mainly through extra-budgetary income, of which 70% will come from for-profit educational services, and 20% from applied R&D and consulting services. Overall, by the end of the period the share of extra-budgetary income will increase to up to 44%.

Resources for the implementation of the HSE Roadmap will be gathered by combining centralized incentive mechanisms and increasing the financial autonomy of the units. HSE makes target investments of more than a quarter of its income into the university's development projects. The share of funds managed at the level of research and educational units and their consortia is, on average, more than 50%.

The university's financial model is actually replicated within STRA-Us: the units' financial sustainability is achieved through a combination of revenues from all types of activities and diversification of sources of their financing. The tasks of resource allocation to the units within STRA-Us are reflected both in their budget structure, and in the KPI system of their leaders (see Section 2.1).

Key risks for the financial sustainability of the university and its units in the period of up to 2020 are mostly related to negative economic conditions:

- 1) the devaluation of the ruble caused a significant reduction in the competitiveness of Russian universities as employers in the international academic labor market; paying competitive salaries becomes increasingly difficult, especially when trying to maintain fair balance between Russian and foreign academics;

- 2) the devaluation has also resulted in the significant increase of other university costs that depend on currency exchange rates, such as international academic mobility, access to foreign sources of information, purchase of equipment, etc.

³ Excluding state capital investments

3) reduction of Federal Budget expenditures for 2015-2017 significantly restricts the university's income growth potential, both in education and in research.

The key measures taken by HSE to address those risks are:

- cutting operational and administrative costs (in 2016, operational costs were cut by 15%, administrative personnel costs were cut by 10%, etc.);

- reducing full-time employment of foreign personnel in favor of short-term and remote contracts, without compromising the requirements related to cooperation with Russian personnel and publication activity levels;

- stricter internal requirements related to the efficient utilization of resources: allocation of funds for research projects that foster academic personnel allowances; implementation of economic standards for educational programs and personnel schedule and workload; and introducing indicators for attracting external resources into managers' KPI systems;

- reducing (and closing) administrative and research units and educational programs that do not meet academic criteria of productive efficiency (in particular, in 2014-2015, the Master's programs portfolio was optimised, and a number of academic departments were reorganized).

Information on HSE-Moscow total revenues and expenses in 2015-2020 are given in the table below (mln rubles):

	mln rubles		
(excluding state capital investments)	2015	2016	2020
REVENUES	13150	13880	16197
Educational services	7 127	8 228	10 375
State assignment for educational services	4 703	5 352	6 176
Fee-based educational services – Higher education	1 331	1 652	2 311
Fee-based educational services – Continuing education	632	695	1 240
Pre-university education	168	301	386
Subsidy for the scholarship fund	293	228	262
Research and Development	2 577	2 568	3 000
State assignment for research	888	862	1 000
Applied research and development	1 690	1 705	2 000
Other revenues (special purpose subsidies, donations, other revenues)	817	1 102	1 016
Funding under 5-100 Program (special purpose subsidy)	930	930	930
EXPENSES	12 099	12 903	15 304
Program and project expenses	3 109	3 364	3 969
Current operating expenses	7 961	7 920	9 960
Special purpose expenses (scholarships, major repairs, taxes)	1 029	1 293	961
Reserves	283	325	414
BALANCE (end of period)	1 052	977	893