Grand challenges and S&T responses: a case from Russian S&T Foresight 2030

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S&T Foresight in Russian S&T and Innovation policy: a historical overview

1996 – 1997: Initiation of Foresight Projects in Russia (HSE)

Rapid growth of future-oriented research in S&T areas

Need for systematic approach
S&T Foresight for Russian S&T and innovation policy: possible options for the future

- Evidence-based analysis
- Integration of quantitative and qualitative methods
- Prioritizing
- Communication
- Involving stakeholders
- Integration to policy

Policy mix

Grand Challenges and Grand Responses
Demand for new skills
Multidisciplinary and multicultural research
Changing National Innovation System

Enhancing Infrastructure, networks

New instruments for S&T policy
New economy
New consumers' behavior
Changing society

S&T Foresight
National S&T Foresight: databases and experts networks

Database of experts: more than 10 000

Industry experts
Integrators
Scientist

Regional innovation clusters
Industrial and regional associations
Technological platforms

Web portals and sites
www.prog2030.hse.ru

Seminars, conferences, work groups

Universities engaged in S&T Foresight 2030

Members of Government Academies of Science
CEO of leading companies
Members of High Technologies and Innovation Commission
Members of industrial work groups and councils at relevant ministries
Developers of industrial strategies
Members of leading industrial and academic institutes
Experts with the highest citation index

All largest research centers and universities

Number of respondents
- 0 - 4
- 5 - 12
- 13 - 39
- 40 - 73
- ~ 200
- more than 800

Industry
40 regions

International expert networks
International Advisory Board on Foresight (HSE)
Building sustainable expert networks: Foresight centres at universities

ICT
(St. Petersburg NRU of Information Technologies, Mechanics and Optics)

NANO
(Moscow Institute of Physics and Technology)

BIO
(Siberian State Medical University)

ENERGY
(National Research Nuclear University MEPhI)

USE OF NATURE
(Moscow State University)

TRANSPORT & AEROSPACE
(Russian State University of Aviation Technology)

Coordinator (HSE)

Universities
Business
Industrial Science
Academic Science
Foreign experts
State representatives

Virtual network
3rd cycle: application-driven S&T Foresight

Global trends and challenges of S&T development

Scenarios of long-term S&T development

Choice of points of efforts’ application

External factors

Alternatives

Roadmaps for priorities realisation

System of priorities

Perspective market segments

Innovative products and services

New technological solutions

R&D

S&T

Products

Markets

Highest importance and S&T potential
3rd S&T Foresight cycle: major components

S&T Foresight 2030

- Macroeconomic trends
- S&T resources (R&D organizations, fixed assets, human resources)
- Roadmaps for sectors and S&T priority areas
- Global and national factors of long-term development
- Strategies for innovation development of sectors
- Recommendations on government policy in the field of S&T and innovation
S&T Foresight: two groups of results

**Priority areas**
- Energy and energy efficiency
- ICT
- Biotechnologies, Medicine and health
- New materials and nanotechnology
- Transport and space systems
- Rational use of natural resources

**Key challenges until 2030**

**Technologies and technological solutions → contribution to responses**

**Description format**

1. Leading countries, Russian teams
2. Management solutions (policies)
3. Time of emergence and application
4. Financial resources
5. Infrastructure solutions
6. Required competencies
Global trends analysis scheme

- Primary literature database
  - Forecasts
  - Foresights
  - Strategies
  - Research fronts
  - More than 600

- Extended list of trends and S&T areas
  - Criteria system

- List of expert panels
  - Criteria system
  - More than 1500
  - Citation index
  - Co-nomination
  - Patents

- Validation of extended list of trends and S&T areas
  - Test for consistence

- Tools for communication with experts
  - Surveys
  - Basic questionnaire
  - Expert panels
  - Work groups
  - Seminars

- Analysis of results
  - Final validation

- Analytical reports
  - Dissemination

- Special questionnaire
  - Survey at http://surveys.foresight.hse.ru

- Combination of qualitative and quantitative methods
Grand Challenges: from broad scope to specific issues

1. Energy security / vulnerability
2. Diseases / health and well being
3. Sustainability and climate change
4. Ageing & other demographic tensions
5. Food security / diet & culture
6. Globalisation vs. Localisation
7. Social cohesion and diversity
8. Technological security, hazard & risk
9. Behavioural change, lifestyles
10. Innovation, knowledge & technology
11. Work-Life balance and mental health
12. Science / technology impacts & ethics
13. Crime, justice, corruption, transparency
14. Governance, democracy, citizenship
15. Coexistence & conflicts
16. Social pathologies & ethics
17. Social exclusion, poverty, affluence
18. Economic prosperity & dynamics
19. Urban and rural dynamics
20. Education standards / investments
21. Water security / vulnerability

Source: iKnowfuture, the Millennium Project
Specific challenges for Life Science

- Changing of the key world market players
- Growth of the global demand for food
- Accelerated development of the Arctic and Antarctic → growing demand for extreme medicine
- Creation of electronic analogues of sense organs (biosensors)
- Increase in cancer diseases and cancer mortality
- Increase in cardiovascular mortality
- Increase in chronic obstructive pulmonary diseases
- Changing role of healthcare sys
National S&T Foresight: scientific areas of emerging technologies

**Biotechnology**
- Bioelectrodynamics and X-ray medicine
- Aquabioculture
- Forest biotechnologies
- Industrial biotechnologies
- Agribiotechnologies
- Developing methodologies for biotech research
- Technologies, prototypes, and stands for developing promising transport and space systems
- Development of integrated transport environment

**Medicine and health**
- Human genome description for prophylactic and personalised medicine
- Biomedical cellular technologies
- Human proteomics
- Biodegradable and composite medical materials
- Molecular diagnostics for prophylactic and personalised medicine
- Exploration, development, and research of promising drug candidates by assigning molecular pharmacological targets

**Transport and space systems**
- Promising technologies for environment monitoring and assessment, and forecasting of natural and anthropogenic emergencies
- Exploration and utilisation of oceanic, Arctic, and Antarctic resources

**Information and telecommunication systems**
- Computer architectures and systems
- Algorithms and software
- Telecommunication technologies
- Predictive modelling, techniques, and tools for developing and maintaining promising systems
- Information processing technologies
- Information security
- Component base, electronic devices, robotics

**Energy efficiency and power saving**
- Efficient use of power
- Intelligent energy systems of the future
- Modelling promising energy technologies and systems

**Environment management**
- Environment preservation and safety technologies
- Exploration, prospecting, and integrated use of mineral and hydrocarbon resources

**New materials and nanotechnology**
- Functional materials
- Computer modelling of materials and processes
- Materials diagnostics
- Hybrid materials and convergent technologies

**Environment and conservation technologies**
- Promising energy technologies
- New materials and catalysts for power engineering of the future

**Construction materials**

**Information security**
- Information processing technologies
- Information security
- Component base, electronic devices, robotics
- Predictive modelling, techniques, and tools for developing and maintaining promising systems
Basic questionnaire: example for “Life science”

**World Foresights and Forecasts (F&F)**
- Seven Revolutions
- The Top Trends That Will Shape the 21st Century Enterprise
- IKnowFutures
- The Millennium Project
- Global technology revolution 2020
- OECD forecasts
- UNIDO projects
- World Economic Forum
- World Health Organization

**Questionnaire**
- Block 1. Global trends
- Block 2. Russian challenges and opportunities
- Block 3. S&T areas

**Russian F&F, Other strategic docs**
- State program “Development of S&T till 2020”
- Three cycles of national S&T Foresight 2030
- Forecast for medicine 2030
- Russian Delphi 2025
- Critical technologies
- Technology platforms
- Strategy 2020
- Bio 2020
- Medicine 2020

**Global trends influence on Russia and visa-versa**

**Top-10 crucial challenges and opportunities**

**Survey**

**Integration to global networks and chains**

**Barriers for S&T areas**

**Expert networks**
On-line survey: example for S&T area «Rational use of natural resources»

Please, tick 7 the most important trends from 38 mentioned below

- Экологизация экономики и увеличение роста в развитии стратегии
- Введение юридически обязывающих ограничений на выбросы углекислого газа после 2012 года
- Введение торговых ограничений в сфере углеродного протекционизма
- Рост мирового спроса на продукты питания
- Истощение запасов некоторых стратегических минеральных ресурсов (нефть, фосфориты, редкие металлы)
- Рост нефтегазодобычи на шельфе, ускоренное освоение Арктики
- Рост добычи нефти из нефтегазовых песков и горючих сланцев
- Сокращение доступности пресной воды и увеличение конкуренции за воду в трансграничных речных бассейнах
- Увеличение затрат на охрану окружающей среды
- Увеличение доли городского населения (рост потребления энергии, воды и др. ресурсов, производства отходов)

Please, assess trend influence on Russia

- Экономические тренды (15)
- Технологические тренды (15)
- Научные тренды (4)

Please, indicate specific Russian problems for this S&T area

Значительные объемы накопления отходов производства и потребления, включая накопленный экологический ущерб

Нарастание негативных воздействий из-за изменений климата, включая региональные изменения и экстремальные климатические события

Недостаточная эффективность существующей системы мониторинга и минимизации последствий природных и техногенных катастроф для населения, инфраструктуры и окружающей среды

Отсутствие рынка экологических услуг

Оцените значимость

- низкая
- средняя
- высокая
- очень высокая

В какой из указанных временных периодов проблема или окно возможностей может проявиться в наибольшей степени? (будет иметь максимальных эффект)

- До 2015 г.
- 2016 - 2020 гг.
- 2021 - 2030 гг.
- После 2030 г.

Оценка возможностей России

- участвовать маловероятно, в России практически нет коллективов, обладающих соответствующими компетенциями мирового уровня
- участвовать возможно на «паритетных началах», за счет интеграции в мировые цепочки создания стоимости, формирования международных альянсов
- участвовать возможно на «правах лидера» - российские коллективы являются признанными мировыми лидерами в данной тематической области

Если кооперация возможна, то с какими странами? (Укажите)
Grand Challenges for Medicine and Health

Illustrative example

Opportunities

Threats

Source: HSE analytics based on experts estimations
National S&T Foresight: Challenges and windows of opportunities for technologies

### Medicine and health
- Increase of cancer rates
- Proliferation of city diseases
- Lack of organs and tissues for transplanting
- High mortality rate
- Small towns and villages do not have advanced medical facilities nearby
- Inefficient rehabilitation system

#### S&T areas
- Gene and cell therapy
- Drug delivery and localisation systems
- Biocompatible non-degradable materials

### Transport systems
- Stricter environmental requirements
- Increased energy saving requirements
- Safety on transport
- Low energy efficiency and reliability of vehicles
- Inefficient monocentric radial structure of the transportation network

#### S&T areas
- Hybrid automobile engines
- Low-carbon sustainable vehicles
- Intelligent transport networks

### Energy
- Increased global energy consumption
- Exhaustion of cheap conventional energy resources
- Vulnerability of power infrastructure
- Low oil recovery ratio at traditional oilfields
- Low efficiency of gas steam-turbine plants
- High energy waste in the grids

#### S&T areas
- Highly efficient heat and power natural gas based plants
- New technologies for burning organic fuels
- New hydrogen production, storage and consumption technologies
Scientific areas: “white spots” and breakthrough windows

- Functional structure composite materials for dental and maxillofacial implants
- High-temperature and durable turbine buckets
- Human proteome profiling
- Climate and climate change modelling

- Technologies for mathematical modelling and optimisation of next-generation power generating and related installations’ schemes and parameters
- Biotechnological processes for producing industrial and medical bioproducts in plants and animals
- Bio-testing and bio-indication techniques offering increased sensitivity and selectivity
- New distributed computing principles
- Computational systems’ component prototypes
- Materials diagnostics
- Technologies for deep processing of organic fuels

- Detoxication of air and water environments
- Software systems’ prototypes for real-time analysis of complex 3D images and videos
- Tissue equivalents and artificial live human organs
- Techniques to cultivate marine organisms’ cell lines

- Next-generation engineering systems for energy-efficient buildings
- Traffic flows’ and transport systems’ intelligent management systems’ models
- Wireless energy transfer
- Techniques to cultivate marine organisms’ cell lines

“White spots”

World leader
- High-temperature superconductivity
- Chemistry of solids
- Nanosize catalysts and membranes for deep integrated processing of raw materials

State-of-the-art
- Bio
- Medicine
- ICT
- Transport & space
- Use of Nature
- Nano
- Energy
Results: Foresight-based investment decisions (example for nanotechnologies)
S&T Foresight results: optional strategies based on roadmaps

- **Import of technologies**
- **Technical requirements**
- **Price vs quality**
- **Technological chain**
- **Markets**

**R&D** → **Manufacturing** → **Product** → **Market**
Research organizations

- Formulation of basic research plans
- Working out R&D agenda

Research universities

- Developing research agenda
- Developing education programmes
- Participation in joint R&D
S&T Foresight → Innovation

Large firms
- Revelation of challenges and windows of opportunities
- Development of innovation strategies
- Development of technology modernization plans

SMEs
- Comprehension of S&T priorities
- Participation in joint research projects

NIS infrastructure
Funds; Development institutions
- Participation in revising and realization of S&T priorities
- Development of joint R&D agenda, support for strategic initiatives
S&T Foresight → Policy Implementation

- Russian S&T policy framework till 2020
- RF Strategy for innovation development
- Strategy-2020

- Government and federal target programs
- Innovation infrastructure at universities
- Bridging universities and industry
- Establishing international labs at universities

- Strategies for regions and cities development

- Technology platforms
- Corporate innovation development programs
- Clusters development programmes
Thank you for your attention!

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