Skolkovo Tech
Research Investment Strategy

4 October 2012

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www.skolkovotech.ru

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Skolkovo Institute of Science and Technology

Skolkovo Tech's Mission

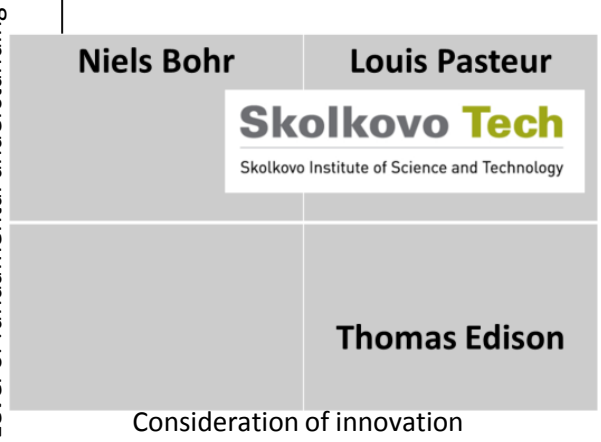
- To have educational, scholarly and economic impact in the Russian Federation and around the world;
- By educating leading graduate students and conducting research programs to address key challenges in science, technology, engineering and innovation;
- Using a fusion of exceptional talent in a new university at Skolkovo.

Research Programs

Goal: Create research programs to address pressing needs of members of society and society as a whole, which build upon fundamental science and technology, yet are guided by a consideration of innovation

Strategy: Create at least 15 Centers for Research, Education and Innovation (CREI):

- International collaborative efforts partnering SkolTech with both international and Russian institutes (Universities and RAS)
- Concentrated excellence in one of the 5 strategic themes, solving real problems in IT, Energy, Biomedicine, Space and Nuclear
- Build capacity at SkolTech and attract top talent
- Integrate education and accelerate innovation



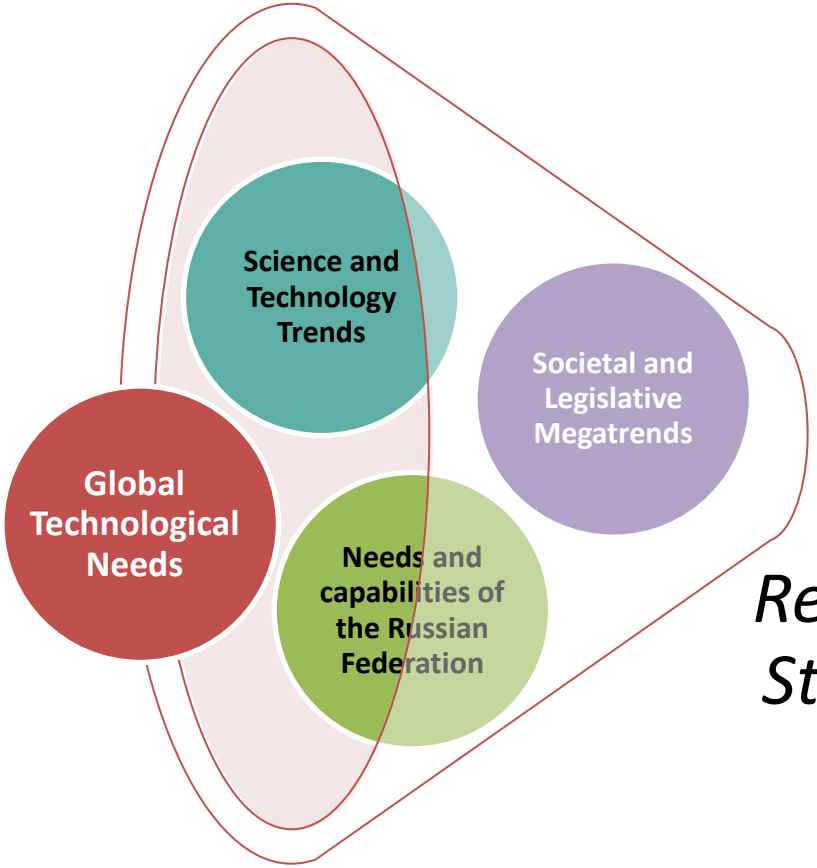
Each center funded at 6-12 MUSD/year

The Skolkovo Tech Research Strategy

- Research strategy should address the most promising research directions for Skolkovo Tech to live up to our mission:
  - To expand the frontiers of science and technology while making a strong impact on the Russian economy.
- The strategy is the result of several months of collecting and analyzing inputs on trends in the following areas
  - Technology and science,
  - Market needs, and
  - Legislation and societal changes.
- The strategy is a living document
  - As we receive further input, this document will be updated.

Sources of Input to Skolkovo Tech Research Strategy

Which Areas Formed the Basis for the Skolkovo Tech Research Strategy?



Research Strategy

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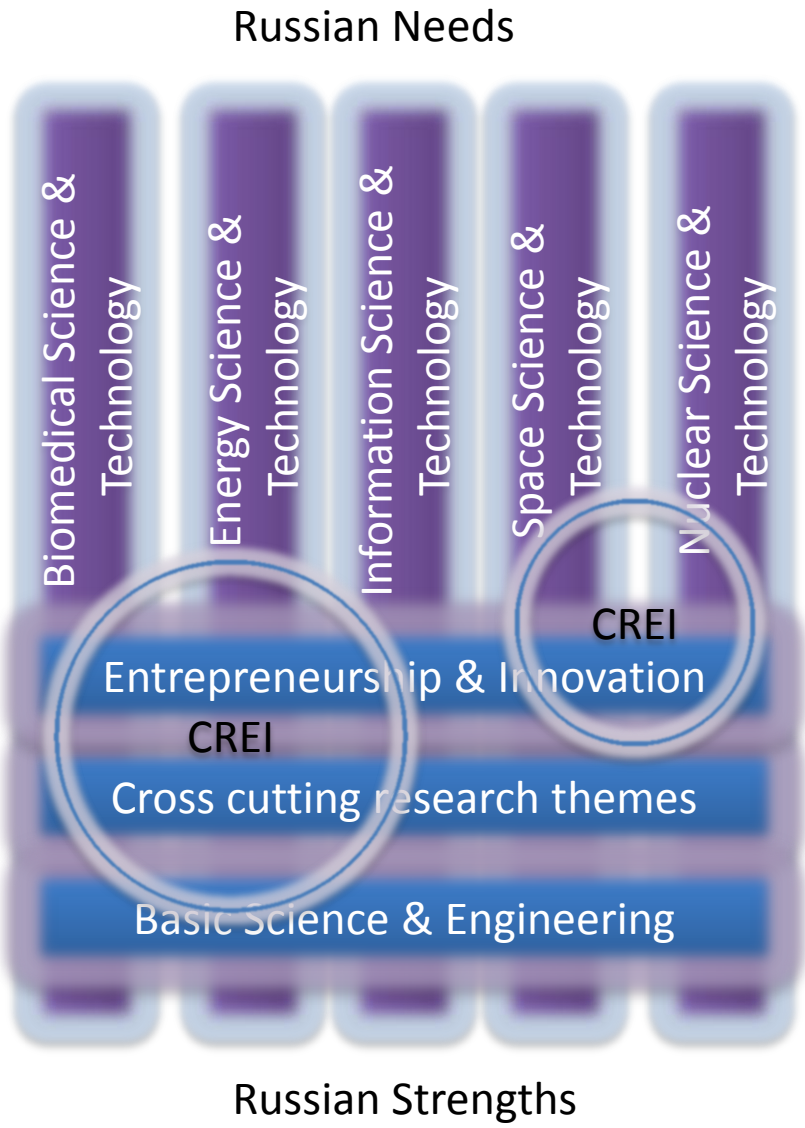
- Biomedical Science & Technology
- Space Science & Technology
- Nuclear Science & Technology
- Energy Science & Technology
- Information Science & Technology

Skolkovo Tech Research Vision

- The Five Research Areas
  - Fuzzy boundaries, overlapping, and interacting
  - Interdisciplinary nature with their own complex research agenda
  - Cross-cutting research themes
    - E.g., advanced materials, computational and data-intensive science and engineering, human engineering and cognition.
  - Dynamic and reconfigurable as new problem domains arise
- Cross-cutting foundation for 21st century research, education, & innovation
  - Research capacity established using CREIs
  - Entrepreneurship and Innovation tied in to all areas
  - Basic science and engineering underlying research
  - Mutually driven research agendas create synergy
- Research infrastructure supporting all
  - 21st century research infrastructure for interdisciplinarity, collaboration with other institutions, economic development



Basic Science and Engineering Science underlying Research

- Basic Science, and Engineering Science are key enablers of research with a consideration of innovation.
  - Create new ideas, understanding, and visions
  - Attract talent
- Skolkovo Tech will build on Basic Science and Engineering Science
  - Small groups of scientists, and engineering scientists at Skolkovo Tech
  - Strong links to other institutions, especially in Russia
- Skolkovo Tech faculty in Science and Engineering Science will be developed
  - Primarily by expressed needs of the CREIs
  - In a few focussed areas (e.g., mathematics) by a specific search

Designation of Topics for CREIs

- The resulting potential topics for CREIs are listed on the following charts.
- Topics that are designated as “high priority,” indicate a strong desire to establish a CREI in that area. Topics not so designated are also of interest, and could be funded if a strong team and proposal are received.
- Cross cutting, industrially motivated, and inter-topic proposals are welcome. Some topics are specifically annotated as “potentially joint with …” to suggest their inter-topic nature
- Topics listed as “defer”, indicate that, while of great interest to SkolTech, these will require further background work before we are prepared to fund such a project
- Some topics are currently the subject of negotiation with potential partners. These are indicated as “Center in negotiation.”

BioMedicine

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Skolkovo Tech Strategy – BioMedicine (1)

- **Computational and systems biology** – profoundly different approaches to study biological systems, including complex data, in order to support both basic, as well as applied research involving discovery of new drugs and drug targets [high priority]
- **Immunology and infectious disease -** in terms of diseases caused by multi-drug resistant bacteria and viral pandemics, the role of microbiome in human health, and organized response to and treatment of disease [high priority, center in negotiation]
- **Gene- and nano-medicine** - impacting the understanding of disease, therapeutics and drug delivery [high priority, center in negotiation]
- **Regenerative medicine -** stem cell research as well as tissue and organ fabrication [high priority, center in negotiation]

Skolkovo Tech Strategy – BioMedicine (2)

- **Neuroscience** - game changing approaches to address major diseases or trauma of the nervous system, especially neuro-degenerative diseases
- **Translational medicine –** stratified medicine and human genotype- phenotype - how to impact clinical outcomes [defer until development of SkolTech strategy for preclinical and clinical testing in Moscow]
- Cross-area research, connections to IT, Energy, Nuclear, and Space (including potentially Energy, the environment, and its impact on agriculture and human health)

Energy

Skolkovo Tech Strategy – Energy (1)

- **Hydrocarbon fuel production and transportation** – how to extract hydrocarbons efficiently from potentially non conventional reservoirs, and with minimum impact on the environment. Extraction in harsh environmental conditions such as the arctic [high priority]
- **Hydrocarbon processing** – how to refine and bring to market gas, petroleum and higher value products, particularly outside of Russia [high priority]
- **Electrical power systems generation and distribution** – how to generate renewable power (particularly with solar and wind), integrate into conventional distribution, condition electricity (at power levels), and distribute effectively. [high priority]
- **Electrical energy storage** – building storage capacity at the grid level [high priority, center under negotiation]

Skolkovo Tech Strategy – Energy (2)

- **Energy efficient systems** - how to minimize energy losses and consumption, and development of energy efficient systems
- **Energy and the environment** – understanding and monitoring the impact of sustainable energy production and consumption on the environment (potentially joint with Space)
- Cross-area research, connections to Biomedical, IT, Nuclear, and Space

Information Technologies & Computing

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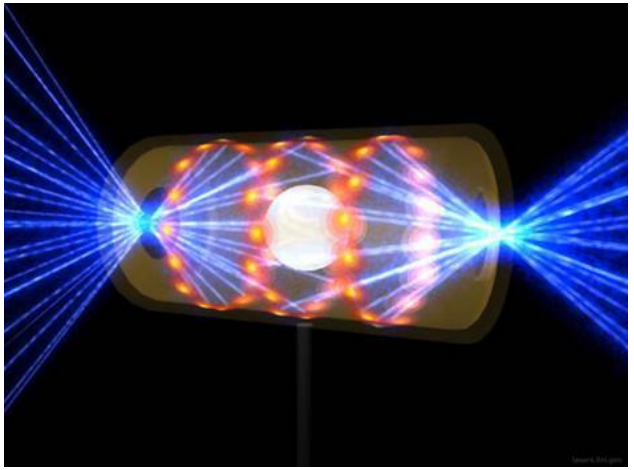
Skolkovo Tech Strategy – IT Computing

- **Machine learning and artificial intelligence** – machine learning as well as computer vision, natural language processing, robotics, intelligent interfaces, HCI, human machine symbiosis, and augmenting human cognition [high priority]
- **Advanced computing systems** – including networking, wireless communications, cryptography and technology for network integration and security, massive data transmission and processing, distributed computing, formal methods, and support for next generation systems [high priority]
- **Big Data** – databases, data mining, data analytics, foundations of information extraction from massive data, scientific, industrial applications. Also includes social networking, crowd computing [high priority]
- Cross-area research, connections to Biomedical, Energy, Nuclear, and Space

Skolkovo Tech Strategy – IT Hardware Technologies

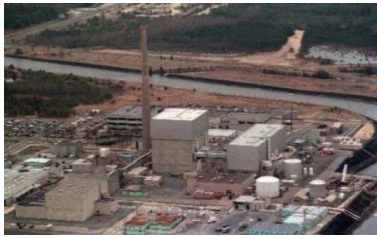
- **Electronics materials and devices** – with emphasis on pushing the limits of silicon and developing systems beyond silicon, including nano-materials and fabrication. Also the development of energy-aware devices, and of devices that can operate in high radiation environments [high priority]
- **Quantum physics/technology** – using quantum approaches to overcome fundamental limits of contemporary devices, and including quantum communication and computing [high priority, ongoing discussions with potential partner]
- **Photonics** – including fast communications and on-chip photonics, capable of attaining new levels of performance for networking and high-bandwidth processing
- Cross-area research, connections to Biomedical, Energy, Nuclear, and Space.

Nuclear and Radiation



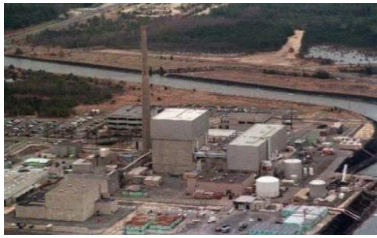
Skolkovo Tech Strategy – Nuclear (1)

- **Nuclear energy safety** (potentially joint with space) – risks reduction and safety systems that include human factors [high priority]
- **Materials for extreme environments** - including the effects of nuclear and radiation environments, high temperature, pressure and extreme chemical conditions [high priority]
- **Non-Energy applications** of nuclear and radiation technologies [high priority]
  - Uses of radiation, particularly for security, but also for medical, agricultural, and others applications
  - Generation and transport of radiation, as well as radiation interaction with matter and beam-beam interaction, and registration, detection, imaging, data acquisition

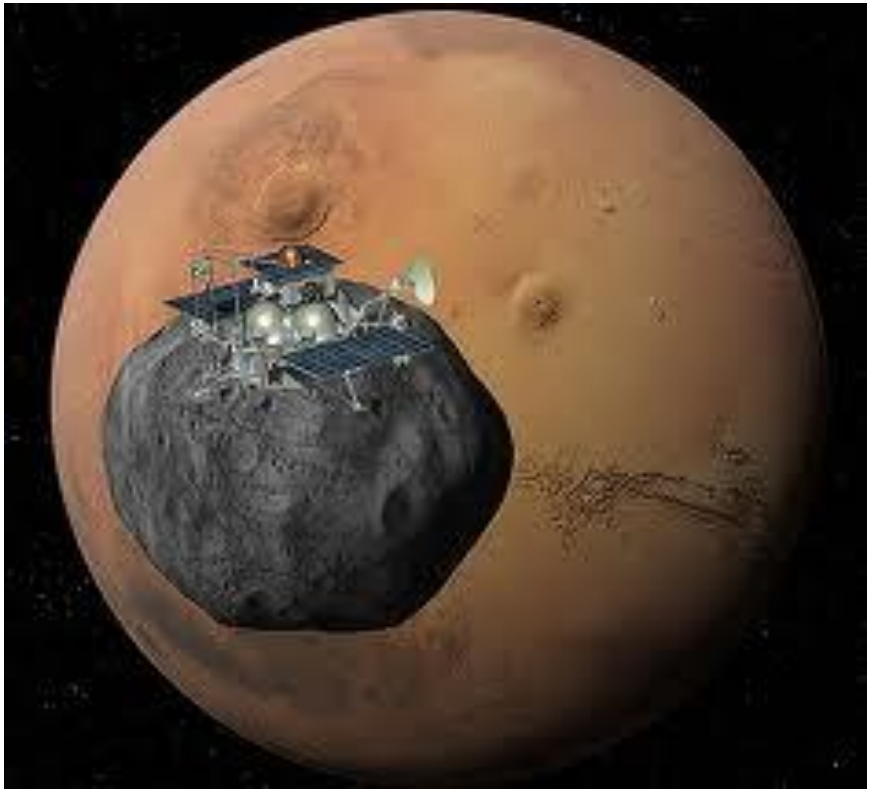


Skolkovo Tech Strategy – Nuclear (2)

- **Human and biological radiation effects** (potentially joint with Space and Biomedicine)
- Cross-area research, connections to IT, Energy, Biomedical, and Space.



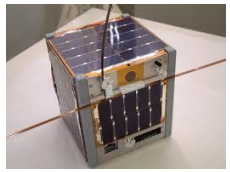
Space



Skolkovo Tech Strategy – Space (1)

- **Supporting humans in long term space exploration** – understanding and designing remediation for the effects of radiation and lack of gravity on humans and other organism. Supporting humans in tasks in spacecraft with autonomy and robotic systems, with emphasis on the use of the ISS as a laboratory (potentially joint with Nuclear [high priority]

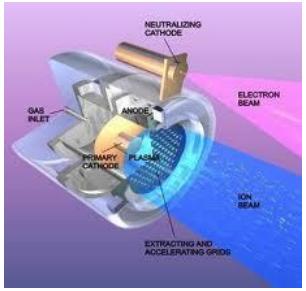
- **Small satellites** – the development and operation of small satellites for scientific, developmental and commercial applications, and the extension of their capability to applications beyond low earth orbit and using multiple spacecraft [high priority]



- **Utilization of space data for communications, positioning, and earth system information collection**. Management, commercial and scientific exploitation of the data generated in space, with particular emphasis on the support of climate science and energy system development (potentially joint with energy or IT) [high priority]

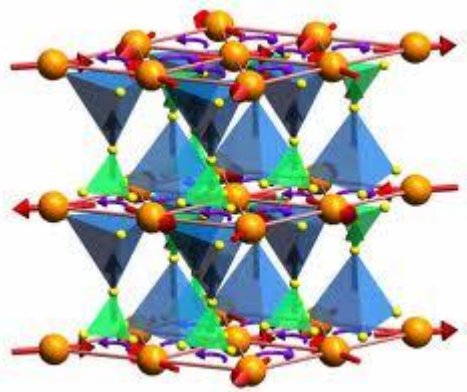
Skolkovo Tech Strategy – Space (2)

- **Lunar and planetary engineering and science**, particularly focusing on the Moon, small bodies and outer planets, addressing lean development of the human exploration of the Moon, and the use of In-situ resources
- **Safety engineering** (potentially joint with Nuclear – see Nuclear)
- **Propulsion**– the improvement of current systems and the development of future in-space propulsion systems (potential joint with nuclear) [defer to joint strategy with Skolkovo Foundation Space cluster]
- Cross-area research, connections to Biomedical, Energy, Nuclear, and IT.



Cross Cutting Research Strategy

- **Advanced materials –** Including materials for structural, biological, and electronic applications, advanced composite materials, including those involved in structures and construction and development of, design and manufacturing with advanced composite fibrous materials [high priority]
- **Computational and data-intensive science & engineering (CDS&E) -** modeling of complex systems, data-intensive methods and analysis, scientific computing and software, tools, data visualization. Uncertainty quantification and verification, computational/applied mathematics, statistics, methods and algorithms for CDS&E [high priority]
- **Human engineering and cognition -** how to design for and with humans, ease of use, social and human factors [high priority]



Industrial Need Driven Strategy

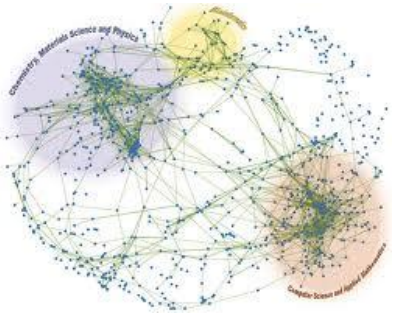
Highlighted here are those topics above that support Skolkovo Tech's strategy to impact Russian industry

- **Composite materials, structures and construction -** development of, design and manufacturing with advanced composite fibrous materials (see also Cross Cutting Research – advanced materials)
- **Oil and gas extraction and refining** - particularly in harsh natural environments (see also Energy – hydrocarbon fuel production and transportation, and hydrocarbon processing)
- **Modeling of complex electrical power networks** (see also Energy - electrical power systems generation and distribution)

Entrepreneurship and Innovation Research Agenda

The Center for Entrepreneurship and Innovation (CEI) will develop a research agenda. The priorities for this upcoming program include:

- **Complex system design -** how to conceive and design highly complex and integrated systems for technical and non-technical aspects
- **Manufacturing and logistics -** including the design and operations of manufacturing systems, supply chains and logistics



Summary of High Priority Investments

- Biomedicine:
  - Computational and systems biology
  - *Immunology and infectious disease*
  - *Gene- and nano-medicine*
  - *Regenerative medicine*
- Energy:
  - Hydrocarbon fuel production and transportation
  - Hydrocarbon processing
  - Electrical power systems generation and distribution
  - *Electrical energy storage*
- Nuclear:
  - Nuclear energy safety
  - Materials for extreme environments
  - Non-energy applications
- IT:
  - Machine learning and AI
  - Advanced computing systems
  - Big Data
  - Electronics materials and device
  - *Quantum physics/technology*
- Space:
  - Supporting humans in long term space exploration
  - Small satellites
  - Utilization of space data
- Cross-cutting:
  - Advanced materials
  - Computational and data-intensive science & engineering
  - Human engineering and cognition

** Topics in italics are under negotiations*

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