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Russian Nanotechnology 2020

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Motivation

The overall goal of the project was to develop a methodology for the **NNFP** or **National Nanotechnology Foresight Program** and to outline the global and national trends in nano-science and nanotechnology. Analytical studies were designed to feed the development of the Russian Nanotech Initiative and to provide inputs to Delphi-survey and scenario development processes.

Catching-up with Global 'Nano' Development

This project might be considered the first stage on the way to setting up the **NNFP** or **National Nanotech Foresight Program** in Russia. It can also be considered the analytical background for the Russian Nanotech Initiative. The point of departure was the recognition that Russia needed to assess its future from the global perspective, to identify strategic research areas for the next 15-20 years in order to support the competitiveness of the Russian economy and to respond to future social needs and to strengthen future-oriented cross-disciplinary activity inviting all stakeholders to discuss about the future challenges, benefits and threats.

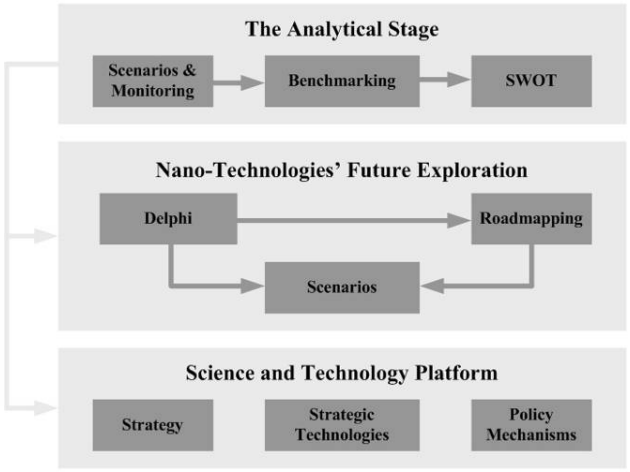
The project consisted of four parts:

- The methodological background for the development of the NNFP was the key objective of the project. The methodology was designed to provide a **dialogue between different stakeholders** and users of innovation to respond to the specific characteristics of nanotechnology. These were two key objectives of the methodological part of the project.
- The second part of the project was focused on the **global R+D trends** and on the analyses of the National Nanotech Initiatives around the world. The main task of this part of the project was to learn more from the experience of other countries.
- In the third part the future **nano-market trends** were outlined to provide the guidance for the public and private sector in terms of "What kind of niches of the world market are expected to flourish" and "What sectors of economy might be a significant consumers of nano-innovations in the future". Not only did the project focus on the macro-nano-domains – nano-materials, nano-electronic, nano-energy, nano-bio - but also on the future markets of the very precise nano-fields – nano-fibres, nano-powder, and the like.
- The fourth part of the project deals with Russian issues. The specific objectives of this part of the project were: to map Russian R+D capacity, to identify and to map Russian nanotech companies, to analyze governmental and private sector initiatives and to outline **strength and weakness of Russia** based on the points above.

Using 'Nano' Breakthroughs for Various Sectors of Russian Economy

Nanotechnology is an emerging, disruptive technology in an early and exploratory creative stage. This is a fast developing multidisciplinary S+T domain, which is expected to change all sectors of the economy, social needs and precondition the emergency of new markets. As a new emerging field its areas of application remain not well defined but it is already clear that the same scientific breakthroughs might be used in different sectors of the economy. The consequences - both beneficial and adverse - of technological innovations' implementation are not well explored; neither are the impacts of nanotech on other S+T domains. In addition, social values and cultural issues will have a special impact on nanotechnology development. The methodology was designed to meet these specific characteristics of nanotechnology.

The methodology was based on the combination of the following tools: scanning and monitoring - S&M, benchmarking, SWOT, Delphi, Scenarios, Technological Roadmapping.



S&M plays a special role for the analytical part and for the NNFP as a whole. It should be designed to feed the program and to provide inputs to all methods and tools. Based on this assumption the general and specific indicators for the S&M were formulated in the project.

Delphi plays a key role for the exploration and assessment of coming technologies. Its methodology comprises the inclusion of the corporations, academia, governmental officials and innovations' users given the fact that cultural and social issues are of considerable importance to the nanotechnology evolution. These four groups of actors have different knowledge and interests concerning the future of nanotech. Accordingly, it was concluded to develop four questionnaires with common technological statements but different characteristics / indicators.

Designing Questionnaires for Each Target Group

The task of **academic researchers** is to evaluate the nanotechnology impact on the development of other S+T domains, their possible negative impact on population health and environment, to outline the likely scientific and technical barriers and to suggest S+T policy mechanisms as well as to estimate the gap - forestalling or tardiness - of Russian R+D in compression to the world leaders. It was purposed that **corporations** should evaluate market demand and barriers, fields of nanotechnology application and the impact of nanotech on the competitiveness of Russian companies as well as to formulate innovation policy mechanisms. The role of **governmental officials** was to estimate public demand, institutional and legislative barriers and to suggest policy mechanisms. At last **potential users** should evaluate future technology in terms of cultural barriers and their importance for the solution of social and environmental issues. This approach provides opportunity to make a comprehensive assessment of nanotech, to accumulate knowledge of different stakeholders and potential users and to link science push and demand pull approaches.

Exchange of Information among Stakeholders

Since nanotechnology is an interdisciplinary and fast developing domain it was decided to couple Delphi with a multidisciplinary brainstorming workshop to outline what kind of scientific breakthroughs with significant impact on economy and social problems' solution could happen in the future. It is expected that this workshop's outputs could serve as one of important inputs to the Delphi questionnaire.

Delphi was developed to provide the dialogue between different stakeholders. For this purposes it was suggested in the second round to send the output of the first round calculated for each group of respondents to the members of four respondents' group. This way each group of respondents could learn the expectations of other groups. Corporations, for example, could learn the expectations of innovations' users, governmental officials and scholars and make corrections in their own judgments.

Developing the Nano Roadmap

Delphi outputs were proposed to be used for the first round of technology prioritization. For this purposes the methodology suggests using the following approaches:

- Orientation on the consensus between different respondent's groups,
- Realization of four stages of technology mapping using the criteria of technology importance (in terms of competitiveness at the world market, contribution to the social and environmental issues solution, impact on the other S+T domains' evolution and importance for the national defence sector) and likelihood,

- Evaluation of possibility of technology implementation in different sectors of economy.

Delphi-survey outputs serve also as the input for the development of **technological roadmaps**. Roadmaps were built for different nano-fields – nano-materials, nano-bio, nano-electronic, nano-energy. It is expected that they will be used by policy-makers and scholars and serve as input for the S+T platform development. The roadmap for different sectors of economy is oriented towards the implementation by corporations and as input for scenarios.

Scenarios: Putting the Building Blocks Together

Scenarios play a special role for the NNFP. They help to explore how nanotech will be perceived in different contexts - geopolitical, economic, social and cultural. The scenario approach is used for fostering a dialogue between different stakeholders. It is considered a powerful tool for the learning process. Information from all building blocks of the NNFP - S&M, benchmarking, SWOT, Delphi and technological roadmaps - is used as input for scenario building.

Special characteristics of the nano-scenario approach were:

- Implementation technological roadmaps - technologies are used as events in scenarios,
- Evaluation of external environment impact on the technological trajectory and adverse impact of technological development on the external environment,
- Delineation of turning points in technological trajectory,
- Analysis of critical uncertainties.

The Science and Technology Platform

COURSES	METHODS and TOOLS
Normative Scenarios	Goal Tree Stakeholder Workshops
Benchmarking SWOT & Scenarios	Morphological Analysis Stakeholder Workshops
Delphi & Scenarios Technology Roadmaps	Stakeholder Workshops
Delphi & Scenarios	Stakeholder Workshops

The outputs of analytical and future studies serve as inputs for the development of the national S+T platform. Fig.2. gives an idea about information sources and methods & tools used for these purposes. The design of NNFP as a dialogue forms also the framework for possible networks and for public-private partnership.

Predominance of Nano-materials in the Russian Nano-sector

The project might be considered the first study providing the mapping of Russian R+D capacity and nano-companies, evaluating public and private sectors' initiatives and challenges.

Sectoral and Regional Concentration

Within the Russian R+D system the project identified 147 R+D organizations in the nano-field, thereby outpacing Asia and North America (see Table 1 below) although some experts understand that some R+D organizations of defence and energy sectors as well as some small research centres were missed due to lack of information. The strong predominance of academic institutes (40%) and universities (30%) is observed as well as their concentration in the Moscow area (more than 50%). The most part of R+D organizations perform in the field of nano-materials (72%) and nano-electronic (18%).

Funding Organisations

Russian nano-science is financed from different sources. The Ministry of Science and Education (MSE), the Ministry of Industry and Energy, Ministry of Defence, the Ministry of Public Health, the Russian Academy of Sciences, the Russian Academy of Medical Sciences, and the Russian Foundation of Fundamental Research (RFFR) are the key agencies supporting nano-science. It has to be pointed out that the Ministry of Science and Education plays a special role in supporting civilian R+D of RFFR. It was evaluated that, in 2005, the budget appropriations for nano-science was about $US 220-250 mill. Therefore Russian public investments into nano-science are less than those of the USA, Japan and EU but higher than public investments of many Asia-Pacific and EU countries.

R+D projects are supported in various national and departmental programs: "National Technological Base" (2002-2006); "Ultra-dispersion Nano-materials and Nanotechnologies"; "Nano-electronic of Armed Forces of the RF till 2010"; "Development of R+D Capacity of High School" (2006-2008); "Low-dimensional Quantum Structures"; "Nano-materials and Supra-molecular Systems"; "Physics of Solid Nanostructures"; "R+D in Priority Directions of S+T (critical technologies)".

More Coordination among Agencies Needed

Some regional authorities - in particular in Moscow and Tomsk - also support nano-science as part of regional and municipal programs. However R+D is not coordinated between different departments and federal and regional power structures. One may observe duplication of R+D on the one part, and lack of information about the outputs, on another part. An Interdepartmental Council on Nano-science and Nano-

materials was set up however the coordination of activities still remains a problem.

In 2005 MSE gave special attention to the development of scientific and information infrastructure in the nano-field. There are 36 centres in the Russian Federation where research facilities might be used by public and private sectors - much more than in other countries. In 2005 MSE allocated about €24 million for the purchase of equipment for the centres, however one may observe low demand from management of both public and private sectors for the development of these facilities.

Russia's Weakness: Commercialization

At the beginning of 2006 a National Program of Nano-science Development was launched to focus on resources and to coordinate the upcoming challenges. This program will run till 2015.

On the Russian market the project identified 20 nano-companies - about 80% of them played on the nano-material's market. All companies were classified as SMEs. Most of these were spin-offs. It is assumed that some companies do not represent themselves as 'nano'. Comparing Russia to other countries one observes that Russia is rather strong in terms of R+D capacity but dramatically weak in R+D commercialisation and in the setting up new start-up companies (see Table 1).

Companies in the Market

REGION	Large	Affiliates	SMEs	R+D Orgs
Asia	50	22	51	111
EU	26	2	125	170
North America	41	41	278	107
Russia	N.A.	N.A.	20	142

There are many factors responsible for this situation including historical and cultural ones; however, unequal governmental measures seem to take major responsibility:

- There were no measures to support spin-offs and start-up companies,
- There was a lack of activities to support networks and academia-industry relationships.

The Russian innovation system remains fragmented. There is limited mobility between research institutes and between R+D system and industry. Russian R+D organizations do not have many traditions in the commercialization of research results or in the handling of patents and other IPR issues. The Russian innovation system also suffers from a weak entrepreneurial tradition.

Focus on Comparative Advantage

Nanotechnologies can be regarded as a challenge to foresight methodology, as well as to the economy, R+D and educational systems and to the public at large. The general messages that have come out from the project are that methodology should respond to special characteristics of nanotech, and NNFP should be designed as a dialogue between different stakeholders. Russia should focus on the areas where it has comparative advantages. Further the experts recommended that the Russian Federation should concentrate its resources on specific sectors and sub-sectors, and coordinate its activities between different departments, foster public-private partnerships and strategic thinking.

The main recommendations made to policy-makers were the following:

- To develop measures to support spin-offs and start-ups,
- To support multidisciplinary networks, research teams and institutes as well as academia-industry partnership,
- To set up websites providing researchers and industry with information in nanotechnology and related fields - markets, patents, completed R+D, and the like,
- To support interdisciplinary training and education.

Sources and References

This monograph was prepared on the basis of the '*Nanotechnology Foresight*' project by Nadezhda Gaponenko. The final report of the project will eventually be made available on the web.