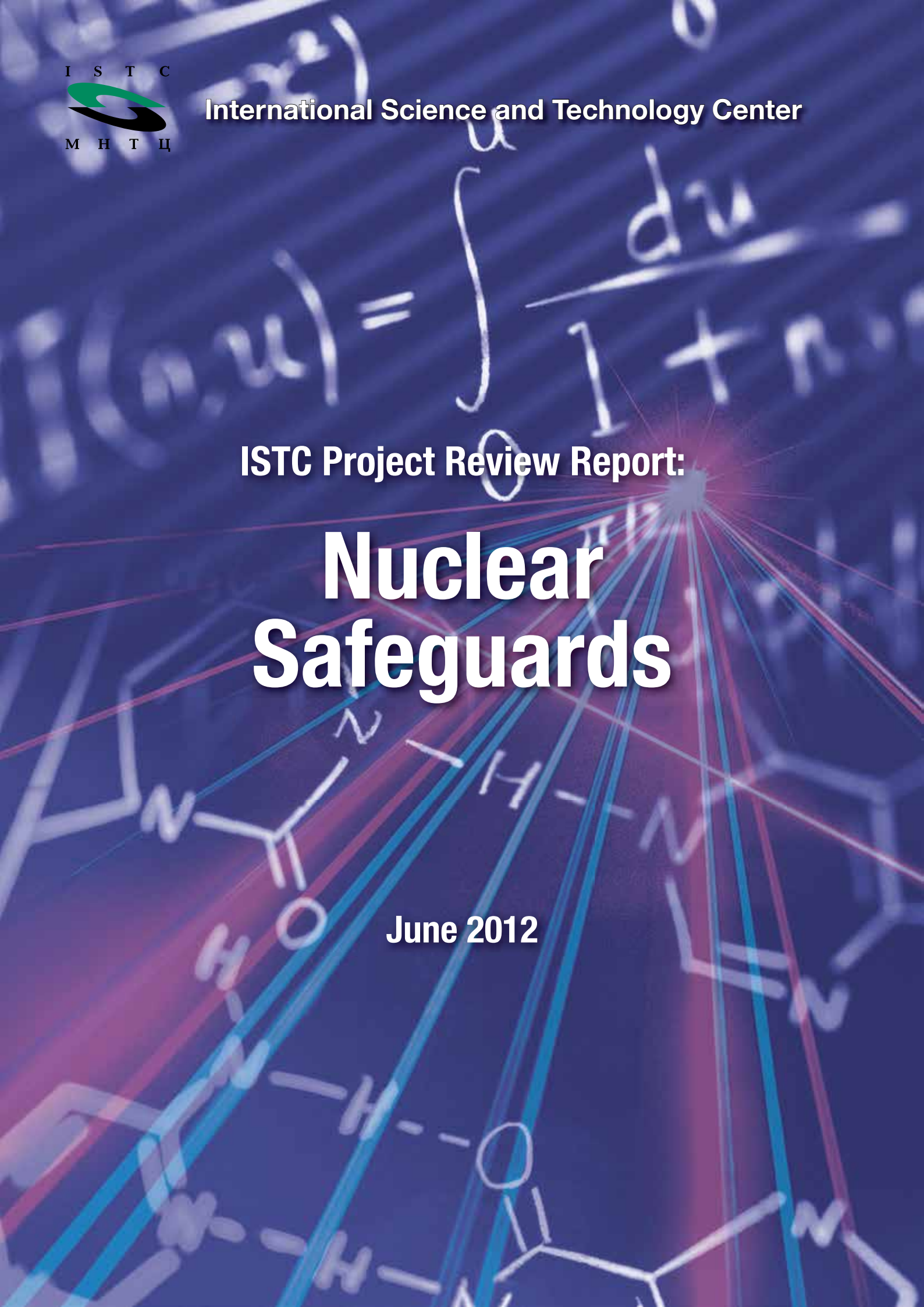

International Science and Technology Center

ISTC Project Review Report:

# Nuclear Safeguards

June 2012

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# ISTC Project Review Report:

# Nuclear Safeguards

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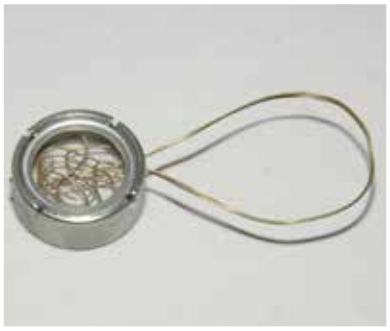


# Contents

# EXECUTIVE SUMMARY

Following the approval by the ISTC Governing Board (GB53) of a program to review the results of completed ISTC projects in identified scientific areas, the Review Panel responsible for the sector of nuclear safeguards, safety, security and related issues considered 16 projects which were chosen and evaluated following the procedures outlined in the Operational Guide applicable to the different reviews.

The Results of the evaluation were quite positive with 4 projects rated A (all objectives being met), 6 projects rated A/B (most objectives being met) and 6 projects rated B (all project objectives being partially met). The significant convergence of the ratings given by the different Panel members should be noted. Among the factors which led to the high ratings, one should emphasize the very favorable overall opinion on the cost efficiency of the work performed; value for money was demonstrated and a large majority of foreign collaborators were satisfied with the conduct and outcome of the projects in which they were involved.

The report on nuclear safeguards has been published by ISTC. The publication can be downloaded from the ISTC website: www.istc.ru or can be ordered via e-mail to Mrs Elena Zaitseva of ISTC: zaitseva@istc.ru.

# INTRODUCTION

The ISTC began work as an international organization in 1994. More than seventeen years after the center opened its doors, the ISTC Governing Board (GB53) approved a program to review the results of completed ISTC projects per identified scientific area. This intergovernmental organization involves 39 nations and is in charge of cooperative science with a nonproliferation aspect. Work takes place on the basis of the ISTC Agreement of 1992 and subsequent ISTC Governing Board decisions and implementation guidelines.

During the years of activities, the ISTC has supported more than 2,750 civilian-oriented projects, which have involved more than 90,000 scientists, engineers, and other technical personnel leading to more than 300 patents and numerous publications in prestigious international journals. The funding parties have contributed more than 850 million USD in support of ISTC projects. There was also an additional 170 million USD in supplemental (support) programs. The research institutes and laboratories participating in ISTC projects have provided substantial in-kind resources. Thousands of collaborators from countries around the globe have played a role in ISTC projects and participated in ISTC conferences and workshops.

The topics of the reviews will include, but not be limited to nuclear safeguards, safety, security and related issues; nuclear reactor technology development; technologies to support oil and gas research; and research to support energy requirements (e.g. renewable energy, energy storage, energy transmission) as well as research in the medicinal field.

An Operational guide was made outlining the procedures and approach to be applied to this ISTC review of the results of the work of ISTC. Annex 1 contains a Project Review Process Flow Chart which provides a summarized overview of the steps taken to review the projects in this sector.

This report describes the results of the review of ISTC projects in the sector of nuclear safeguards, safety, security and related issues.

# APPROACH

## THE REVIEW PANEL

A review panel was established to review the results of the ISTC projects in the sector of nuclear safeguards, safety, security and related issues. The panel and chairperson were selected by the Secretariat in close consultation with the sponsoring parties/partners of each review. This panel was chaired by Prof. Jean-Pierre Contzen, Chairman, von Karman Institute for Fluid Dynamics and SAC member. Dr. Yuri Malakhov of ISTC acted as the Secretariat.

The other participants in the panel were:

- Dr. Didier Haas, Senior Adviser for Nuclear Safety and Security to the Director General of JRC, Chairman of the Belgian Nuclear Society;
- Dr. Marc Humphery, the Team Leader of the Safeguards Technology Development Program, Office of Nuclear Safeguards and Security within DOE/NNSA's Office of Defense Nuclear Nonproliferation, USA;
- Prof. Yusuke Kuno, Deputy Director & Prime Scientist, PhD, Department of Science and Technology for Nuclear Material Management, Japan Atomic Energy Agency (JAEA), Professor (appointed), University of Tokyo, Nuclear Non-proliferation Research Laboratory, Department of Nuclear Engineering and Management School of Engineering;
- Dr. Gennady Maximovitch Pshakin, FEI (IPPE), Obninsk, Russia;
- Dr. Kevin Veal, Acting Director of the Office of Nuclear Safeguards and Security within DOE/NNSA's Office of Defense Nuclear Nonproliferation, USA.

## THE REVIEW PROCESS

The review process of the results of the work of ISTC includes the following steps:

- Identification of the scientific areas to be reviewed;
- Procedure of the selection of relevant projects per selected scientific area including selection criteria;
- Preparation of a draft review report per selected scientific area;
- Discussion and adoption of the report by the Review Panel and by the ISTC Governing Board;
- Publication and dissemination of the report.

The approach applied to the selection of projects in this particular scientific sector was based on a first selection performed by US Department of Energy (DOE) experts using the criteria defined in section 2.2 of the Operational Guide. These criteria are:

- Funded projects that started after 1 January 2001 and are now technically completed;
- Projects with financial support of more than 150,000 USD (with the exception of project extensions).

Subsequently, the Chairman and the Secretary conducted an analysis of this first list and proposed an updated list which basically corresponded to the highest priorities of the US DOE list with the addition of several projects, i.e., projects 1919, 2033, 2978 and 3831, which at the time of their ex ante evaluation by the ISTC Scientific Advisory Committee (SAC) were highly recommended for funding. Some projects on the updated list, i.e., projects 614, 698 and 3831 were below the threshold set up in the Operational Guide of 150,000 USD but were considered as relevant for this review. Equally, some projects with starting dates earlier than 1 January 2001 were kept for their relevance when considering later projects in the same specific field. On the contrary, three projects were deleted from the initial list having been approved but not executed.

This updated list of 16 projects in total was approved and became the basis of the Panel's work. It should be noted that all the projects under consideration originate from the Russian Federation.

Annex 2 provides the list of projects reviewed for this sector. It contains the most relevant project information (i.e., number, title, lead institute, foreign collaborators, funding, project duration and period of work).

Twelve out of the 16 projects were retained for oral presentation; only 6 of them were actually presented, the others were dropped due to the absence of project managers reporting to the Panel. The Panel was disappointed that these presentations were never made.

The Panel thanks those who made the effort to come and make presentations: Mikhail Syrunin from VNIIEF, Sarov for projects 215 and 963; Evgeny Petrov from VNIIA, Moscow for project 1954; Vladimir Podgornov from VNIITF, Snezhinsk for project 772; Alexei Kondrashenko and Anton Blikov from VNIIEF, Sarov for project 3831; and Boris Ryazanov from FEI, Obninsk for project 1356. They provided excellent summaries and responded fully to the questions raised by Panel members. In addition, the presentation allowed for the discussion of follow-on work that had been undertaken following the formal completion of each project; this provided additional information and context that allowed the Panel to better judge the overall impact of each project.

## THE SCORING SYSTEM

An evaluation scoring system was used by the panel to provide an independent review of the selected sector projects. This scoring system is based on a developed evaluation system by the Scientific Advisory Committee (SAC) of ISTC. The final technical report, the project assessment sheet, and the foreign collaborators approvals/ assessments were the main sources of information for the completion of the evaluation sheets (see Annex 3). Oral presentations provided additional information which was considered quite useful but the Panel members, in the final discussion on the outcome of their review, agreed that they did not introduce a negative bias for those projects which had only written information available.

All selected projects for written and oral review were evaluated on the basis of the following criteria:

1) Accomplishment of major tasks of the project, to include, degree of fulfillment of project work, achievement of final objectives and cost efficiency of the project;
2) Contributions to the scientific field in question;
3) Impact of the results of the project, i.e., did it lead to further applied research, commercialization of new technologies, innovation in existing technologies or patents;
4) Dissemination of project results, to include number of publications in internationally recognized journals number of publications in national journals and presentations at international conferences;
5) Collaboration network between CIS institutes;
6) Partnership and collaboration with foreign institutes.

Within each criterion, the averaging of ratings given to each criteron was left to each Panel member as well as his averaging leading to his overall rating. The overall score for each reviewer may not be in accord with mathematical average since certain criteria may have been weighted more heavily depending on the reviewer's views.

The Panel agreed that criteria 3 related to impact was particularly important within the framework of this review exercise, which is clearly more than just a financial and scientific audit. Panel members felt that some elements were requiring further investigation before completing their report, notably the issue of patents and publications. In

several cases, the criterion related to the collaboration network between CIS institutes was not strictly relevant: in general, ISTC projects should be used to increase the networking between institutions inside the CIS, which suffered in the distant past from excessive compartementalization in the nuclear sector. However, some projects were conducted in very large research entities such as Sarov where existing competencies range from pure science to manufacturing of components, making networking superfluous. This aspect has been taken into account in the scores of criterion 5.

During its discussions, the Panel clearly noted that it should take into account the elapsed time since the projects were undertaken, in particular for the earliest projects. This is notable in two respects: first, science evolves rather quickly and the science used in some early projects could appear now obsolete, or at least routine, while it was cutting-edge science at the time of the conduct of the project; second, there has been an evolution in the nature of the projects conducted within the ISTC framework, gradually shifting the emphasis from science to applications; this evolution has to be taken into account while considering criterion 3 (impact).

The Panel noted also that the funding of the projects was around or below 400,000 USD, except in the specific case of project 1606 which involved the design of a significant experimental facility. Considering the limited sums of money involved, one can only expect results which constitute building blocks of a larger knowledge base; it is on the validity and relevance of these buiding blocks that the Panel based its judgment.

## RESULTS OF REVIEWED PROJECTS

Annex 4 gives a table summarizing the nuclear safeguards project scores, indicating for each of the 16 projects the overall score given by each of the 6 Panel Members as well as the consensus score of the Panel. This consensus score which is based on the straight averaging of the 6 scores has been the subject of a further discussion by the Panel in case of balance between two options. Out of the 16 projects, 4 were rated A, 6 rated A/B, and 6 rated B (A means that all objectives have been met, A/B corresponds to most objectives being met and B means all project objectives partially met).

The table shows the noticeable convergence of the ratings of the different Panel Members in spite of their own specific backgrounds.

Some projects gave rise to specific comments:

- Project 1356: one of the projects with the highest rating from all reviewers; one should look at the extension of the application of the results outside Russia.
- Project 1954: one of the projects which received significant follow-up in Russian facilities and enjoyed instrumentation development, e.g. the VESTA-K system. It would be interesting to look at subsequent developments

Considering the factors which led to the scores of each reviewer, one should note that there was a very favorable overall opinion on the cost efficiency of the work performed; value for money was demonstrated and even if there were in some cases slippages in project implementation, they did not have a significant impact on the completion of the work.

The reviewers also appreciated the role of the foreign collaborators who contributed effectively to the progress of the projects, ensuring effective networking, one of the fundamental objectives of ISTC projects. Contacts with several foreign collaborators indicated, with one exception, their own satisfaction about the conduct and outcome of the projects with which they were involved.

Concerning international publications, only 4 out of the 16 projects (projects 215, 772, 1606 and 2978) led to articles or contributions to proceedings at international level. Patents were filed in the case of 6 out of the 16 projects (projects 679, 772, 963, 1919, 2033 and 2188) which is a positive feature although the filings were at the Russian national level.

## CONCLUSIONS

The Panel considers that the results of review are quite positive with high scores for all the projects submitted to its examination. A consensus among Panel members was easy to reach as convergent views emerged from the discussions. The Panel wishes to emphasize the following conclusions and recommendations:

- ISTC-funded projects in the field of nuclear safeguards, safety, and security triggered developments of techniques which were relevant to the peaceful use of nuclear energy and to non-proliferation.
- ISTC-funded projects helped keep essential scientific know-how within the Russian Federation and, particularly in the field of nuclear safeguards, promoted new developments which enhanced the quality of operational systems.
- As the results of ISTC-funded projects led mainly to applications within the Russian internal market, there is a potential for extending these applications at the international level, notably through the IAEA; this should be further exploited.
- The available language skills of the scientists involved in ISTC funded projects has constituted an obstacle for publishing results internationally; the same applies to IPRs' protection at international level. The impact of such obstacle should be mitigated by appropriate measures.

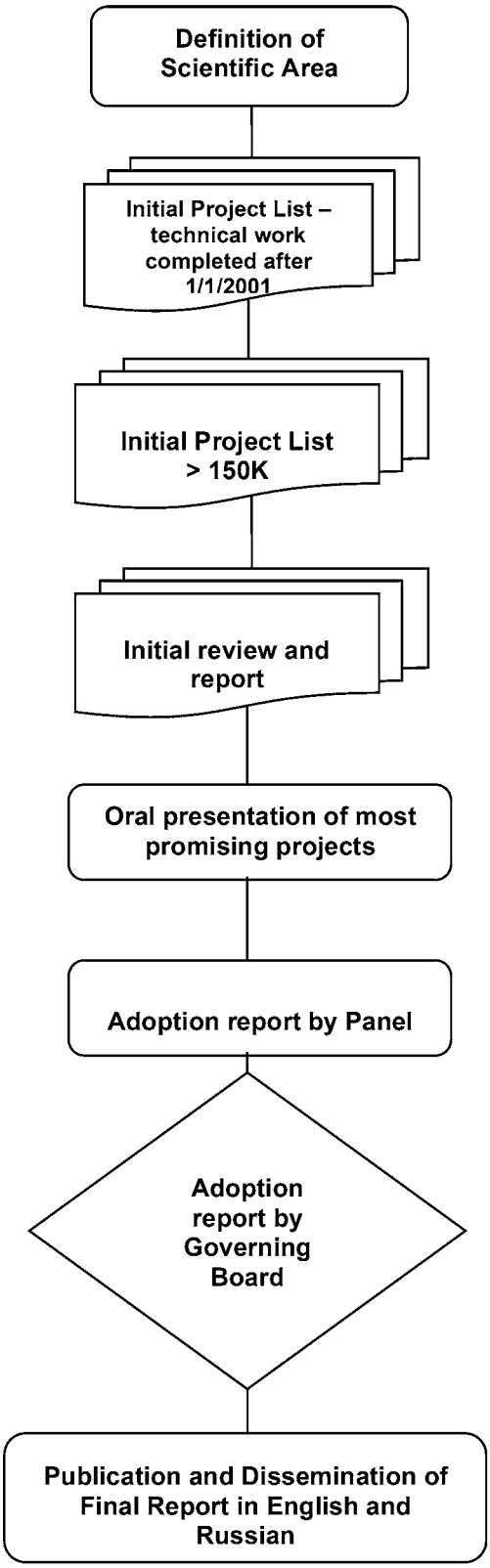
## RECOMMENDATIONS

Furthermore, the Panel considers that this exercise has proven its usefulness; it only regrets that the same type of review has not been performed earlier and in a systematic way. It recommends that the exercise be carried out in the same sector for projects from other CIS countries and Georgia. Following this pilot phase, it could also be extended to others scientific areas such as Homeland Security/ Counter Terrorism, Severe Nuclear Accidents, Environmental Remediation, and Post-Fukushima-related activities.

The Panel thanks the ISTC Executive Director and his staff for the support provided to its work.

# ANNEXES

## ANNEX 1. ISTC PROJECT REVIEW PROCESS FLOW CHART



# Annex 2. Projects Reviewed

This annex provides a list of projects reviewed for this sector, with relevant project information (i.e., number, title, lead institute, foreign collaborators, funding, project duration and period of work).

| Project # | Project title | Leading Institute | Foreign Collaborators | Funding | Project duration | Period of work |
|---|---|---|---|---|---|---|
| 215 | Multipurpose Supercontainer | VNIIEF | Albuquerque, NM, USA (Carbiener K E) Transnucl aire, Paris, France (Malesys P) | $ 300.000 (EU: $ 150.000, US: $ 150.000) | 36 months | 1.11.1995 - 1.11.1998 |
| 614 | Numerical Simulation of Nuclear Fuel Behavior under Accidents and Normal Operations | VNIIEF | Los-Alamos National Laboratory, Los-Alamos, NM, USA (Boyack Brent) | $ 124.000 (US) | 36 months, extended by 3 months | 1.04.1999 - 1.07.2002 |
| 679 | Independent System for Parametric Control (ISPC) of Abnormal Thermomechanical Loadings Produced upon Potentially Dangerous Goods in the Protective Container | VNIIEF | Sandia National Laboratories, Albuquerque, NM, USA (Charles Dennis Croessmann) | $ 300.000 (US) | 30 months, extended by 5 months | 1.11.1995 - 1.11.1998 |
| 698 | Experimental Mock-Up of Accelerators Based Facility for Transmutation of Radioactive Waste and Conversion of Military Plutonium | VNIIEF | CEA / DRN / DER / CEN Cadarache, Cadarache, France; CEA / DSM / DAPNIA/CEN Saclay, Saclay, France; Royal Institute of Technology / Institute of Physics, Stockholm, Sweden (Gudowski Waclaw) | $ 50.000 (EU) | 9 months | 1.07.1998 - 1.06.2001 |
| 772 | Development of Methods for Creation and Registration of Unique Recognizable Optical Images for Nuclear Material Control | VNIIEF | Lawrence Livermore National Laboratory, Livermore, CA, USA (Blasy J) | $ 300.000 (US) | 24 months, extended by 5 months | 1.08.1998 - 1.05.1999 |
| 963 | Development of a Technical Design for DU-shielded Transport Cask with Increased Spent Nuclear Fuel Specific | VNIIEF | Sandia National Laboratories, Albuquerque, NM, USA (Yoshimura R H) | $ 400.000 (US) | 36 months, extended by 12 months | 1.06.1998 - 1.11.2000 |
| 1356 | Development of a Nuclear Materials Control and Accounting System Model for Complex Nuclear Facilities | FEI | Joint Research Centre of European Commission, Ispra, Italy (Brian Hunt) | 378.680 € | 24 months, extended by 3 months | 1.02.2000 - 1.02.2004 |
| 1606 | Experimental Mock-up of Molten Salt Loop of Accelerator-Based Facility for Transmutation of Radioactive Waste and Conversion of Military Plutonium. Stage 2: Experimental Study of Molten Salt Technology for Safe, Low-Waste and Proliferation Resistant Treatment of Radioactive Waste and Plutonium in Accelerator-Driven and Critical Systems | VNIIEF | Risley Warrington, Chesire, UK (Blue Roger); CEA / DRN / DER / CEN Cadarache, Cadarache, France (Salvatores M); CEA / DSM / DAPNIA/ CEN Saclay, Saclay, France (Carre F); EDF / Recherche et Developpement, Moret-sur-Loing, France (Mialon P); European Commission, Brussels, Belgium; Institut f r Kern und Energietechnik, Karlsruhe, Germany (Knebel J U); International Atomic Energy Agency, Vienna, Austia (Stanculescu A); Nuclear Research Institute, Rez, Czechia (Vasa I); Royal Institute of Technology / Nuclear and Reactor Physics, Stockholm, Sweden | 950.000 € | 36 months, extended by 45 months | 1.03.2001 - 1.06.2003 |
| 1831 | Application of Non-Radiation Methods for Nuclear Materials Accounting, Control and Identification | VNIIEF | Pacific Northwest National Laboratory / Battelle, Putting Technology to Work, Richland, WA, USA | $ 294.000 (US) | 24 months | 1.02.2002 - 1.02.2004 |
| 1919 | Tamper Indicating Device Complex Development and Implementation within NM Protection, Control and Accountability System (MPC&A) | VNIIEF | Sandia National Laboratories, Albuquerque, NM, USA (Lockner T) | $ 150.000 (US) | 18 months, extended by 3 months | 1.06.2002 - 1.03.2004 |
| 1954 | Prompt Control and Identification of Uranium and Plutonium in Containers with Applications of a Non-Destructive Method on the Basis of a Russian Portable Rapid Inventory Confirmation System | VNIIA | Lawrence Livermore National Laboratory / University of California, Livermore, CA, USA (Ruhter W D) | $ 220.000 (US) | 24 months, extended by 3 months | 1.02.2002 - 1.06.2004 |
| 2033 | Development of a Fuel Element Diagnostics Technique for the Aperiodic Pulse Reactor BR-1 with the Metallic Core | VNIIEF | Nuclear Reactor Facilities-Development 6431, Sandia Pulse Reactor Facilitiy, Albuquerque, NM, USA (Ford J) | $ 200.000 (US) | 24 months, extended by 6 months | 1.08.2002 - 1.02.2005 |
| 2188 | Development of the Protection Plate Resistant to Unauthorized Effects of Mechanical, Thermal and Chemical Break Means | VNIIEF | Sandia National Laboratories, Albuquerque, NM, USA (Lockner T) | $ 230.000 (US) | 24 months | 1.06.2003 - 1.06.2005 |
| 2405 | Experimental Researches of Nuclear-Physics Characteristics of Materials Essential for the Processes of Weapon Plutonium Utilization and Radioactive Wastes Transmutation | VNIIEF | Los-Alamos National Laboratory, Los-Alamos, NM, USA (Chadwick M B, Rawano T., Prael R E) | $ 200.000 (US) | 24 months | 1.04.2005 - 1.04.2007 |
| 2978 | Digital Technology for the Detection and Control of Fissile Materials in Devices with Pulsed Neutron Sources | VNIIA | Chalk River, ON, Canada (Maykut R); Fraunhofer-INT, Euskirchen, Germany (Koeble T); Oak Ridge National Laboratory / Nuclear Science and Technology Division, Oak Ridge, TN, USA (Pozzi S); UniversitaDegli Studi di Bari / Dipartimento Interatenio di Fisica, Bari, Italy (Marrone S) | $ 219.950 + 165.370 (EU: 165.376, CA: $ 219.950) | 30 months, extended by 5 months | 1.10.2005 - 1.09.2008 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3831 | Development Technology and Experiments at Large-Scale Installation for Heating and Retention of Corium | VNIIEF | AREVA / Areva NP GmbH, Erlangen, Germany )Fischer M, Fargette A); CEA / DEN, Gif-sur-Yvette Cedex, France (Journeau Ch.); EDF, Paris, France (Atkhen K); European Commission / Joint Research Center / Institute for Transuranium Elements, Karlsruhe, Germany (Foit J, Miassoedov A); Gesellschaft für Anlagen und Reaktorsicherheit mbH, Köln, Germany (Spengler C); IRSN, Fontenay aux Roses, France (Cranda M) | 61.535 € | 9 months | 1.05.2009 - 1.02.2010 |

# Annex 3. Evaluation Form for Technical Review of ISTC Projects

| This evaluation form will be completed on the basis of written evaluations:<br>Final Technical Report,<br>Project Assessment Sheet,<br>Foreign collaborators approval/assessment, and the oral presentations to the panel. | |
|---|---|
| Project Attributes | |
| Project Number | |
| Project Title | |
| Leading Institute | |
| Project Manager | |
| Foreign Collaborators | |
| Duration | |
| Total Budget | |
| Funding Parties | |
| ISTC Project Manager | |

| Evaluation of Completed Project | |
|---|---|
| I. Accomplishment of major tasks of the project | |
| Degree of fulfillment of scientific objectives<br>i.e. were the foreseen research objectives fully met, partially met, or not met at all? | (A, B, C)* |
| Degree of fulfillment of other objectives<br>i.e. non-proliferation, human engagement, sustainability. | (A, B, C) |
| Cost efficiency of the project<br>i.e. were the project costs in line with the project activities – was there value for money inside the project? | (A, B, C) |
| Comments | |

| | |
|---|---|
| Average score of I | (A, B, C) |
| II. Contributions to the scientific field (A, B, C)<br>Scientific Results<br>Did the scientific results contribute to the scientific field in question?<br><br>Non-Proliferation Results<br>Did the scientific work contribute to non-proliferation objectives?<br>Other<br>Did the project lead to additional follow-up projects? | |
| Comments | |
| III. Impact (A, B, C)<br>i.e. what was the impact of the results of the project? Did it lead to applied research, commercialization of new technologies, innovation in existing technologies or patents? | |
| Comments | |
| IV. Dissemination of the results | |
| Number of publication in internationally recognized journals (weighted with the impact factor of the journal) | (A, B, C) |
| Number of publication in national journals | (A, B, C) |
| Presentations at the international conferences (weighted with the “impact factor”: invited, oral, poster) | (A, B, C) |
| Comments | |
| Average score of IV | (A, B, C) |
| V. Collaboration network beween CIS Institutes (A, B, C) | |
| VI. Partnership and collaboration with Foreign Institutes (A, B, C) | |
| Final overall evaluation | (A, A/B, B, B/C, C) |
| Assessment of potential for further development and application | |
| * A = all project objectives met;<br>A/B = most project objectives met;<br>B = all project objectives partially met;<br>B/C = most project objectives partially met and<br>C = project objectives not met. | |

# Annex 4. Summary of Nuclear Safeguards Scores

TOTAL RATINGS

*A = all project review criteria met; A/B = most project review criteria met; B = all project review criteria partially met;

B/C = most project review criteria partially met and C = project review criteria not met.

| Project # | Project title | Reviewer A | Reviewer B | Reviewer C | Reviewer D | Reviewer E | Reviewer F | Consensus Score |
|---|---|---|---|---|---|---|---|---|
| 215 | Multipurpose Supercontainer | B | B | A/B | B | B | A | B |
| 614 | Numerical Simulation of Nuclear Fuel Behavior under Accidents and Normal Operation | B | B | A/B | B | B | A/B | B |
| 679 | Independent System for Parametric Control (ISPC) of Abnormal Thermomechanical Loadings Produced upon Potentially Dangerous Goods in the Protective Container | B | B/C | A | B | B | A/B | B |
| 698 | Experimental Mock-Up of Accelerators-Based Facility for Transmutation of Radioactive Waste and Conversion of Military Plutonium | A | B | A/B | A/B | A/B | A/B | A/B |
| 772 | Development of Methods for Creation and Registration of Unique Recognizable Optical Images for Nuclear Material Control | A | A | A | A/B | A/B | A | A |
| 963 | Development of a Technical Design for DU-shielded Transport Cask with Increased Spent Nuclear Fuel Specific Loading | A/B | A/B | A/B | A/B | A/B | A | A/B |
| 1356 | Development of a Nuclear Materials Control and Accounting System Model for Complex Nuclear Facilities | A | A | A | A/B | A/B | A | A |
| 1606 | Experimental Mock-up of Molten Salt Loop of Accelerator-Based Facility for Transmutation of Radioactive Waste and Conversion of Military Plutonium. Stage 2: Experimental Study of Molten Salt Technology for Safe, Low-Waste and Proliferation Resistant Treatment of Radioactive Waste and Plutonium in Accelerator-Driven and Critical Systems | A | A/B | A/B | A | A | A | A |
| 1831 | Application of Non-Radiation Methods for Nuclear Materials Accounting, Control and Identification | A/B | A/B | A/B | B | B | A | A/B |
| 1919 | Tamper Indicating Device Complex Development and Implementation within NM Protection, Control and Accountability System (MPC&A) | B | B | A/B | A/B | B | A | B |
| 1954 | Development of the Technology for Prompt Control and Identification of Uranium and Plutonium in Containers with Application of a Non-Destructive Method on the Basis of a Russian Portable Rapid Inventory Confirmation System | A/B | A/B | A/B | B | B | A | A/B |
| 2033 | Development of a Fuel Element Diagnostics Technique for the Aperiodic Pulse Reactor BR-1 with the Metallic Core | B | B/C | B | B | B | A | B |
| 2188 | Development of the Protection Plate Resistant to Unauthorized Effects of Mechanical, Thermal and Chemical Break Means | A/B | B | B | A/B | B | A/B | B |
| 2405 | Experimental Researches of Nuclear-Physics Characteristics of Materials Essential for the Processes of Weapon Plutonium Utilization and Radioactive Wastes Transmutation | A/B | B | A/B | A/B | A/B | A | A/B |
| 2978 | Digital Technology for the Detection and Control of Fissile Materials in Devices with Pulsed Neutron Sources | A | A/B | A/B | A | A/B | A | A |
| 3831 | Development and Experiments at Large-Scale Installation for Heating and Retention of Corium | A/B | A/B | A/B | A/B | A/B | A/B | A/B |

## For Notes

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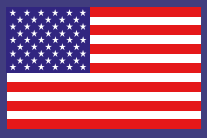

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