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in the Laboratory to Laboratory Nuclear Materials  
Protection, Control and Accounting (MPC&A) Program**

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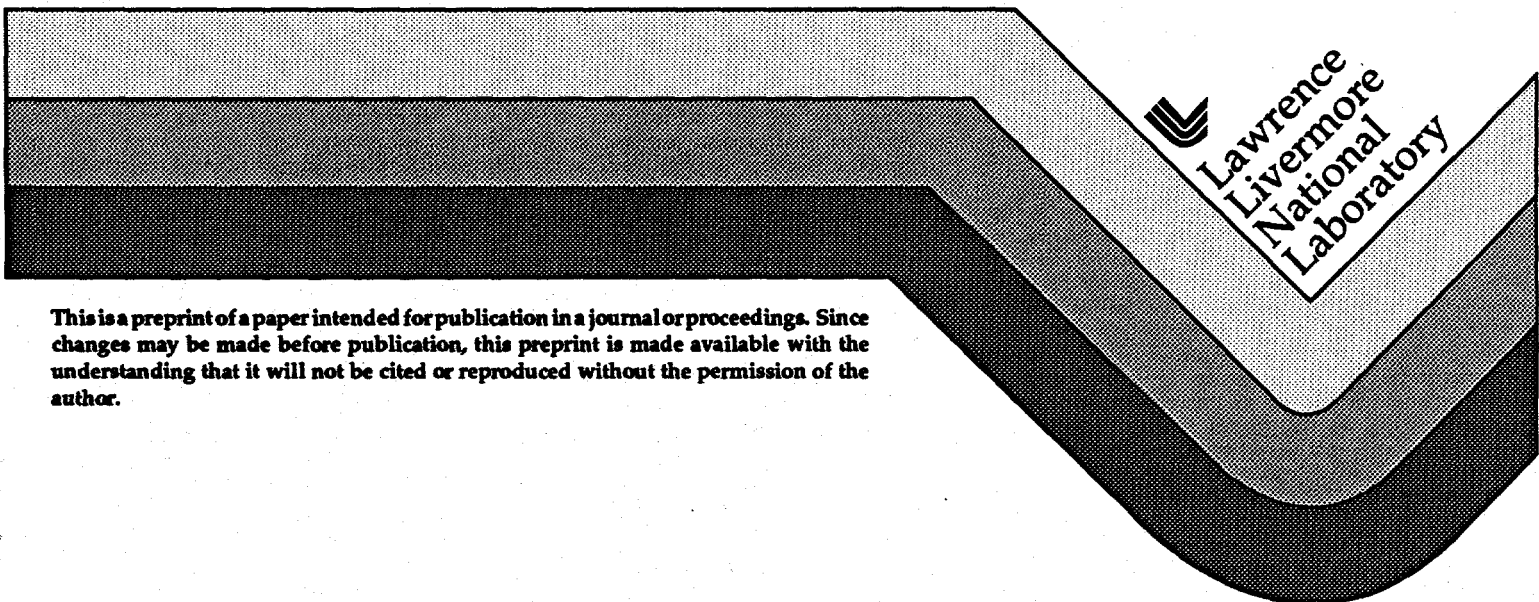
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# ROLE OF LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL) IN THE LABORATORY TO LABORATORY NUCLEAR MATERIALS PROTECTION, CONTROL AND ACCOUNTING (MPC&A) PROGRAM\*

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## Abstract

The Lawrence Livermore National Laboratory (LLNL) is participating in a US Department of Energy sponsored multi-laboratory cooperative effort with the Russian Federation nuclear institutes to reduce risks of nuclear weapons proliferation by strengthening systems of nuclear materials protection, control, and accounting in both countries. This program is called the Laboratory-to-Laboratory Nuclear Materials Protection, Control, and Accounting (MPC&A) Program and it is designed to complement other US-Russian MPC&A programs such as the government-to-government (Nunn-Lugar) programs. LLNL's role in this program has been to collaborate with various Russian institutes in several areas. One of these is integrated safeguards and security planning and analysis, including the performing of vulnerability assessments. In the area of radiation measurements LLNL is cooperating with various institutes on gamma-ray measurement and analysis techniques for plutonium and uranium accounting. LLNL is also participating in physical security upgrades including entry control and portals.

## 1. Introduction

Several US National Laboratories, which are supported by the US Department of Energy, have undertaken a program of cooperation with Russian institutes in the field of Nuclear Material Protection, Control and Accounting (MPC&A). In addition to Lawrence Livermore National Laboratory (LLNL) these are Los Alamos National Laboratory (LANL), Sandia National Laboratory (SNL), Brookhaven National Laboratory (BNL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest Laboratory (PNL). The objective of the program is to accelerate progress toward a common goal: to reduce the risks of nuclear proliferation by strengthening systems of MPC&A in both countries. These risks include such threats as theft, diversion, and unauthorized possession of nuclear materials. The program is being carried out by Russian institutes and US laboratories mutually developing and implementing a collaborative program for the improvement of nuclear MPC&A systems at Russian facilities.

More specifically the lab-to-lab MPC&A program is attempting to make rapid improvements in the protection, control, and accounting of nuclear material, especially weapons-grade materials such as separated plutonium and highly enriched uranium, by working directly and cooperatively with Russian institutes. LLNL, along with the other US National Laboratories, is contracting directly with the institutes to carry out MPC&A improvements. The US laboratories provide support, technical assistance, and equipment as needed to further the objectives of the program. The Russian institutes are taking the primary responsibility and provide the effort needed to improve their MPC&A system

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based upon their requirements. Our mutual long range goal is for the Russian institutes to institutionalize the improvements by transferring them to other facilities and organizations where we may not be able to go, because of sensitivity or for other reasons.

A great deal of discussion and coordination goes into the decision making process with respect to what projects will be worked on and which Russian institutes and US laboratories will be involved in each of them. Russian institute interests and needs and US laboratory capabilities are discussed during site visits at each others facilities. A US MPC&A Steering Committee made up of representatives of the participating laboratories discusses priorities and agrees on lead and supporting US laboratory assignments. Priorities are then established by a Joint US Russian Steering Committee made up of Russian institute and US laboratory representatives.

## 2. Overview of LLNL MPC&A Activities

Each US laboratory is focusing on its particular areas of expertise. LLNL's areas of expertise are safeguards and security planning and analysis, particularly the analysis of the insider threat; gamma ray radiation measurements and data analysis; the determination of system requirements, which includes the characterization of the facility and materials, defining the threats and identifying assets; and systems integration including access control systems, communications and the display of information.

LLNL is contracting directly with six different Russian institutes in three major areas of MPC&A. An overview of the areas of LLNL's major collaborations by institute is shown in Table A. In addition LLNL is collaborating in several areas such as portal design and access control, with other institutes under contracts held by other DOE Laboratories.

	Russian institutes
Integrated Safeguards and Security Planning and Analysis	Kurchatov, Eleron, Institute of Physics and Power Engineering (IPPE), VNIITF (Chelyabinsk-70), VNIIEF (Arzamas-16)
Radiation Measurements	Kurchatov, IPPE, VNIITF, VNIIEF, Institute of Inorganic Materials, (Bochvar/VNIINM)
Site Characterization and Conceptual Design	VNIITF

Table A - LLNL MPC&A Activities

The remainder of this paper will describe the ongoing and planned collaborations in each of the major areas.

## 3. Integrated Safeguards and Security Planning and Analysis

The first major area called "Integrated Safeguards and Security Planning and Analysis" involves the sharing of US vulnerability assessment techniques and includes a two week workshop to be given at several Russian institutes.

Vulnerability assessment (VA) is an analytical process that is used to evaluate risks and to determine cost-effective protection improvements using defined threats and the characteristics of the facility being evaluated. LLNL has developed vulnerability assessment tools in use throughout the U.S. Department of Energy complex for the insider threat and for cost-benefit analysis of physical protection upgrades. These tools evaluate Materials Protection, Control & Accounting (MPC&A) systems against both abrupt theft scenarios

and protracted theft scenarios (scenarios in which the adversary attempts to accumulate a goal quantity of material by making several thefts of smaller amounts of material over time). Evaluating these systems requires using probabilities to estimate detection and assessment capabilities of the physical protection, and mathematical formulas and optimization techniques to determine worst-case adversary scenarios and paths. Sandia National Laboratories (SNL) has developed complementary vulnerability assessment tools for the outsider threat, and is participating with LLNL in this Laboratory-to-Laboratory effort.

The objective of this project is for U.S. and Russian personnel to share their safeguards and security vulnerability assessment techniques and approaches, to obtain some early results by actually applying them to facilities and to study and analyze changes which need to be made to the analytic tools and procedures to facilitate their use in Russia. It is anticipated that there will be a continuous process of improving the techniques and applying them to increasing numbers of Russian nuclear facilities.

Tasks vary for different institutes but generally include a report on the institute's philosophy and methodologies for addressing insider and outsider threats to nuclear materials, including a description of any quantitative assessment techniques used, a two week workshop on US methods of implementing integrated safeguards and security planning and analysis including vulnerability assessment (VA) tools and techniques given by a joint team of presenters from LLNL and SNL, and an application of the techniques to determine the probabilistic risks of potential targets to the various assumed potential threats at an actual facility.

Future collaboration could involve the development of modifications and additions needed to adapt existing safeguards and security analysis tools and methodologies for maximum benefit in Russia and the dissemination of information and techniques developed for this effort to other Russian nuclear facilities. Needed upgrades and weaknesses identified as a result of the assessments would be considered for additional Laboratory-to-Laboratory tasks.

LLNL has signed contracts with Kurchatov Institute (KI) and Eleron, both located in Moscow, and the workshops are scheduled there in May and June of 1995 respectively. Contracts are in the final stages with VNIITF (Chelyabinsk-70) in Chelyabinsk, VNIIEF (Arzamas-16), in Nizhney Novgorod and the Institute of Physics and Power Engineering, (IPPE) in Obninsk.

#### **4. Radiation Measurements**

One of the sub areas under, "Radiation Measurements" involves the testing and evaluation of gamma-ray measurement and data-analysis techniques for determining uranium enrichment and plutonium isotopics. LLNL and various Russian institutes are investigating the application of gamma-ray measurement and data-analysis techniques for nondestructive assay (NDA) of uranium and plutonium materials at the institutes. The objective of this work is to improve the nuclear material accountability of the various Russian institutes by assisting them with nuclear material measurements.

LLNL has developed gamma-ray measurement procedures with high-resolution germanium detectors and spectral data-analysis techniques for nondestructive assay (NDA) of plutonium and uranium that are in use throughout the DOE complex for MC&A. LLNL approaches to the analysis of plutonium and uranium gamma-ray spectral data for the determination of their relative isotopic abundance are unique. These analysis techniques have been implemented in an analysis program called MGA (Multiple Group Analysis) for relative plutonium isotopic abundance, which is in use by IAEA inspectors. Similar analysis techniques have been implemented for the determination of U235 enrichment in uranium samples.

The objective of the work at the Kurchatov Institute is to measure the relative isotopic abundances of uranium and plutonium materials stored at, and shipped to and from the

Central Storage Facility for nuclear material accountability purposes using gamma-ray data analysis programs developed by LLNL and Ray Gunnink. The Kurchatov Institute will report on the performance, i.e. precision and accuracy, of these programs on the uranium and plutonium materials shipped from, received at, and stored in the Central Storage Facility. The Kurchatov Institute will develop a measurement plan to establish the performance parameters for the various types of uranium and plutonium materials that can be measured easily by gamma-ray spectrometry at the Central Storage Facility. Gamma-ray measurement and data-analysis techniques will be evaluated for applicability to the measurement of categories of materials that may include: metal, oxide, fresh fuel assemblies, process scrap, etc.

Work is about to begin with IPPE to evaluate and report on the applicability of using MGA and MGAU to measure isotopics non destructively for nuclear materials accounting and/or to confirm the consistency of results from these measurement and data-analysis techniques with accounting information for a variety of chemical and physical forms found in fuel pellets used in two critical assemblies, known as BFS-1 and BFS-2.

Future plans would be for IPPE to implement these techniques routinely in accountability measurements of plutonium and highly-enriched uranium in the BFS facilities.

Discussions are also underway with the Institute of Inorganic Materials for evaluation of US gamma-ray measurement methods for plutonium isotopics and uranium enrichment.

Another of the sub areas under, "Radiation Measurements" involves the production of a nuclear material signature and identification instrument. LLNL has developed a variety of nuclear material signature characterization tools that encompass a variety of approaches. Development activities focused on understanding the applicability and limitations of various instrumental approaches. Examples of LLNL approaches include hand-held devices that are based on commercially available instruments, and methodologies to allow variability in plutonium age, and neutron output variability from low-A impurities. High throughput measurement approaches will be considered because of the volume of Russian containers.

The objective of this work is to implement off-the-shelf nuclear material identification technology in Russian institutes with direct-use nuclear materials such as plutonium and highly-enriched uranium, and to assist them with nuclear material measurements to improve their nuclear material accountability. Desirable attributes of the deployed measurement system will be rapid detection and identification of fissile inventory in variable background environments, without opening the storage container. Additionally, identity information will be archived in multiple locations to facilitate shipper/receiver tracking. A large number of storage containers will require rapid processing. This work will focus on the production aspects of a signature logging device to prepare for certification and distribution through the commercial infrastructure in Russia.

VNIIEF has developed a passportization instrument and has made arrangements for commercial distribution of a variant of the device. This device measures both gamma-ray and neutron signatures to identify whatever is in the packing container. The purpose of this work is to create the design documentation for manufacture, build 2-3 units for certification testing and test the units. LLNL, VNIIEF, and other DOE laboratory participants will evaluate design approaches. VNIIEF will develop and document a concept for application, specify requirements for design, and test an instrument, and make the necessary arrangements for hand-off to the Russian manufacturer. The desired utility is that the selected instrument demonstrate a role in the accounting practices necessary for managing the inventory of nuclear material.

LLNL is also discussing a passportization project with VNIITF in which the institute will prepare a survey of existing Russian instruments, algorithms, and applications appropriate for the identification of their unique set of nuclear material, also in storage containers. Included will be a description of the operational nuclear radiation environment in the test cell and storage vault. In addition, VNIITF will describe the nuclear material accounting and control approach or process that depends on the above instruments, or that

they recommend, if any. It is likely that this instrument will be portable to allow inventory checking without movement of material.

IPPE will be evaluating a commercially available instrument for portable and rapid material identification. The instrument is based on a "pocket" sized multi-channel analyzer and a sodium-iodide probe. LLNL has developed software that will be evaluated by IPPE, and modified by them as necessary, to tailor the instrument response or operation to their needs.

Other DOE laboratories such as ORNL, LANL, and BNL similarly have worked in the area of nuclear material characterization and they will be involved as appropriate.

## **5. Site Characterization and Conceptual Design**

LLNL and VNIITF are in the final stages of negotiating three contracts covering facility characterization and MC&A and physical protection system conceptual designs for a facility at VNIITF. The objective of this effort is to provide physical protection and MC&A designs to determine what improvements need to be implemented and to provide immediate fixes to increase short term protection effectiveness.

This effort is coordinated with and depends on parts of a vulnerability assessment effort described under, "Integrated Safeguards and Security Planning and Analysis" above. For example the threat description and vulnerability assessment to guide MC&A and physical protection requirements for the facility are being performed there.

Existing physical protection and MC&A will be evaluated based on the value of the asset, the defined potential threat, and the consequences of loss, damage or sabotage of the asset. Assets which require additional physical protection or MC&A which go beyond the immediate requirements will be identified.

The conceptual designs will employ a modular implementation concept and are expected to become the master plan for the facility MC&A and physical protection systems. Each conceptual design will include a prioritization of tasks (modules) to be implemented to support possible modular implementation. VNIITF and LLNL, along with the other major supporting Laboratories, Los Alamos National Laboratory, (LANL) and Sandia National Laboratory (SNL), will prioritize the items which should be implemented first. Other US national laboratories are also supporting this effort.

This effort supports several goals, as follows: to jointly apply physical protection and MC&A technologies, to develop design and evaluation methodologies, and to implement upgrades for nuclear facilities. In addition the vulnerability assessment described earlier will be revised to show the benefits which would result from the implementation of the integrated MC&A and physical protection conceptual designs. It is anticipated that future efforts will involve more detailed design and implementation of the highest priority and most cost effective MC&A and physical protection improvements.

In summary site characterization and conceptual design efforts will proceed in parallel with the identification of system requirements and a vulnerability assessment. The vulnerability assessment will identify needed upgrades which will be prioritized and considered for implementation. As upgrades are implemented they will be evaluated for implementation at other facilities.

## **6. Conclusion**

The cooperative efforts described between LLNL and the various Russian institutes is either in the early stages of implementation or implementation is about to begin. Discussions and activities thus far indicate that significant progress can be made toward the overall goal of nuclear nonproliferation through this type of collaborative effort.



## 7. References

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