STR-377

# Development and Implementation Support Programme for Nuclear Verification 2014–2015

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IAEA
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# Foreword

An effective non-proliferation regime, supported by the application of international safeguards, continues to be the key component of global efforts to stem the spread of nuclear weapons. The IAEA's Department of Safeguards performs an indispensable role by providing credible assurances that States are honouring their international treaty obligations, thereby helping to build international confidence. By being able to detect early any misuse of nuclear material or technology, the IAEA can alert the world to potential proliferation activities.

As the IAEA's verification regime is required to meet the challenges of new and innovative nuclear fuel cycle processes and an increasing number of safeguarded facilities around the world, it remains reliant on appropriate methods and technologies to support safeguards implementation. To that end, Member State Support Programmes (MSSPs) continue to supplement the Agency's regular budget with much needed additional funding, services, research, development and the provision of experts. Recognizing that resources are not expected to increase to match an expanding workload, the Department of Safeguards initiated long-range planning in 2008 to ensure the most effective use of its resources and to enhance its readiness to cope with emerging and future changes to the international nuclear environment.

Through the application of systematic methodologies, the Department of Safeguards developed its first long-term strategic plan, covering the period 2012-2023. The plan supports internal decision-making on needs, programmatic priorities and the allocation of resources. It also called for the development of an accompanying research and development (R&D) plan, covering the same period, to outline the Department's R&D directions, to identify needed long-term capabilities, and to set milestones and priorities. *The Long-Term R&D Plan 2012-2023* was published in January 2013.

The publication and distribution of this document, *Development and Implementation Support Programme for Nuclear Verification 2014-2015*, is linked to the Department's long-term strategic plan through the *Long-Term R&D Plan 2012 – 2023*. It provides MSSPs, other IAEA Member States, the R&D community and stakeholders with a comprehensive and coherent framework for resource planning and for the identification of appropriate solutions to existing and future safeguards challenges. It also provides a basis by which the Department can monitor progress towards its strategic objectives.

I sincerely hope that readers will find this new document to be an effective tool in helping to ensure that the IAEA deploys the appropriate methods and is equipped with the appropriate instruments to meet future challenges and to continue to conduct its work effectively.

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# Introduction to the Development and Implementation Support Programme for Nuclear Verification, 2014–2015

It is the purpose of this biennial document, *Development and Implementation Support Programme for Nuclear Verification, 2014-2015* to inform the inspectorate, Member States and other contributing organizations and stakeholders about the IAEA Department of Safeguard's short-term development objectives, its projects and its plans to support the implementation of safeguards in a manner which is effective, efficient and encourages innovation and excellence.

Required resources to implement the D&IS programme come from the Department of Safeguards itself, Member State Support Programmes (MSSPs) and from other extra-budgetary contributions. The programme's implementation would not be possible without the transfer of technology, funds and expertise through the MSSP mechanism. The biennial programme illustrates the scope and diversity of the Department's activities and provides a better understanding of where assistance is required to meet current and emerging safeguards needs.

## D&IS PROGRAMME OBJECTIVES

The D&IS Programme aims to meet both shorter-term needs and those that are part of longer-term R&D planning. This programme is driven by Departmentally-identified strategic needs, which are assessed against basic scientific information, advances in States' technology and research, IAEA experience associated with specific safeguards implementation, and operating conditions.

With the production of the *Long Term R&D Plan 2012–2023 in January 2013*, the Department of Safeguards completed the framework for the implementation of a structured and coherent strategic planning process to address existing and expected needs and challenges. The plan identified the *capabilities* that the Department of Safeguards needs to achieve its strategic objectives and key *milestones* towards achieving those capabilities. The process provides a firm basis for long-term R&D planning, covering a 12-year period, and the short-term, through the biennial D&IS programme. Long-term directions and strategies flow through to tasks and projects.

The Department is further integrating the D&IS programme with the *Long-Term R&D Plan 2012–2023* in two stages: the first, already completed for the 2014–2015 biennium, introduces the milestones from that plan and links each task to a capability or milestone; and the second, to be completed for the 2016–2017 biennium, will look at restructuring the programme to make the projects fully coherent with the long-term capabilities needed, thus fully aligning the D&IS programme's objectives with the *Long-Term R&D Plan 2012–2023* and the strategic planning framework.

Within the suite of strategic planning documents, particularly the *Long-Term R&D Plan 2012-2023*, effort has been made to avoid the retention of 'distinct work silos', according to divisions. The aim has been to establish a more cohesive, cross-divisional approach to planning. By incorporating the 13 capabilities identified in the *Long-Term R&D Plan 2012-2023* into the D&IS Programme for the 2016–2017 biennium, the process will achieve full alignment with the Department's strategic planning, and will address the same overarching themes running throughout long- and short-term planning documents.

At the task level, tasks will be grouped together under the milestones defined in the long-term R&D plan. A 'milestone owner' will be responsible for all those tasks under that milestone. The 'milestone owner' may also oversee specific tasks associated with his/her expertise. For example, all milestones associated with technical support will fall under an appropriate technical division's 'milestone owner'. This important aspect retains the strength of the divisional based project structure of the 2012–2013 D&IS programme, while facilitating the cross-divisional capabilities outlined in the long-term R&D plan.

Through implementation of this process, the IAEA's Department of Safeguards is well-placed to undertake a 'top-down' needs analysis and a 'bottom-up' identification and selection of the most appropriate verification and detection technologies and approaches available to support future safeguards implementation. The Department of Safeguards has prepared its D&IS Programme for 2014–2015 to further integrate its strategic focus areas, define key achievement targets and prioritize activities in the context of the Department's total work portfolio. Emphasis was put on the full integration of the D&IS programme into the strategic planning framework, ensuring consistency between the long-, medium- and short-term activities.

The D&IS Programme's objective is to define and describe development and implementation support planned for the 2014–2015 biennium, to establish well-constructed plans and targets that will help achieve the long-term goals for R&D supporting the implementation of the Departmental strategies identified in the Department's *Long-Term Strategic Plan, 2012–2023*. The D&IS programme has been prepared in accordance with the Departmental *Long-Term Strategic Plan, 2012–20231*, the *IAEA Medium-Term Strategy, 2012–2017*[2,] and the Departmental *Long-Term R&D Plan, 2012–2023*.

## DEPARTMENTAL STRATEGIC PLANNING FRAMEWORK

In 2008, the Deputy Director General, Head of the Department of Safeguards, launched the Long-Range Strategic Planning Project. The methodology for long-range strategic planning in the Department of Safeguards was approved for implementation in October 2008. That methodology was then applied to develop the Department's first long-term strategic plan covering a 12-year period 2012–2023. This plan was approved for implementation in August 2010. The project provides the Department of Safeguards with a comprehensive and coherent planning framework, covering the long term strategic plan over the next 12 years, the medium-term strategy over six years and the short-term D&IS programme over two years.

This strategic planning process resulted, among other things, in a number of documents:

- The *Long-Term Strategic Plan, 2012–2023* identifies the following three Departmental strategic objectives:

  1. *Deter the proliferation of nuclear weapons, by detecting early the misuse of nuclear material or technology, and by providing credible assurances that States are honouring their safeguards obligations.*

  2. *Contribute to nuclear arms control and disarmament, by responding to requests for verification and other technical assistance associated with related agreements and arrangements.*

  3. *Continually improve and optimize departmental operations and capabilities to effectively carry out the IAEA's verification mission.*

  The document also provides the strategic context and issues facing the Department of Safeguards regarding programmatic priorities and the allocation of limited resources, enabling the Department to focus its efforts and resources where they are most needed.

- The verification chapter of the *IAEA Medium Term Strategy (MTS)* was developed, based on input taken directly from the Long-Term Strategic Plan.
- The *Long-Term R&D Plan, 2012–2023* supports the implementation of relevant strategies of the long-term strategic plan, providing long-term directions for R&D that should be pursued over 12 years, and activities to be implemented through 'Projects' within the plan's first six years.

The *Long-Term R&D Plan 2012-2023* sets out the *capabilities* that the Department of Safeguards needs in the long-term to achieve its strategic objectives and the key *milestones* that are required to be met towards achieving

[1] A summary of the IAEA Department of Safeguards *Long-Term Strategic Plan, 2012-2023, is available at http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf).*

[2] GOV/2010/66 dated 26 November 2010.

those capabilities. These are technical capabilities for which Member State R&D support is or may be needed. Each capability is then broken down into more detailed key milestones, for which Member State R&D support is often required. The perceived urgency for each milestone is defined as high (H), medium (M) or low (L).

In this edition of the D&IS programme, particular emphasis has been placed on aligning existing and planned short-term tasks, which form the foundation of many Departmental projects, to the capabilities and milestones within the long-term R&D plan. D&IS tasks which mainly aim at implementation support activities are linked to identified capabilities, while the development related tasks are linked to the more detailed milestones. Thus, Departmental requirements from the long-term R&D plan flow through to the short-term biennial D&IS programme, further guiding MSSPs with planning and prioritization of support to the Department.

## D&IS PROGRAMME SCOPE

The D&IS programme addresses safeguards development and implementation activities. Funding is derived from MSSPs, the IAEA's regular budget and other extra-budgetary contributions. The programme's development and implementation activities aim at:

- *Continual improvement* with efforts addressing improvements to the efficiency and effectiveness of the Department's processes, equipment/systems, tools, concepts and approaches, and information acquisition, analysis and evaluation capabilities. The Department's quality management system is included in the overall process to serve as the formal mechanism to drive improvement;
- *Sustainability and technology enhancement* with efforts that focus on the Department's need to sustain core capabilities and technologies. These include the development of new equipment and the modification, or replacement, of obsolete equipment and systems. Training programme implementation is included in the overall process to sustain and advance knowledge, skills and abilities of the Department's staff;
- *New capabilities* which have been identified through the Department's strategic planning processes, and which address emerging and future needs. Efforts also include the evaluation of Member State technology proposals that address safeguards applications and the exploration of the practical applications for novel technologies and analytical capabilities. The programme's goal here is to strive to advance the state-of-the-art in nuclear safeguards technologies that are needed in support of safeguards implementation.

## D&IS PROGRAMME DEVELOPMENT AND APPROVAL

Coordination of D&IS activities, including the administration of the MSSPs, is carried out by the Department's Division of Concepts and Planning. For the 2014–2015 biennium, the Department of Safeguards has identified 22 D&IS projects. The projects and their respective managers are listed on page vi.

The current edition of the D&IS programme also includes a new feature where each project identifies the long-term R&D capability or milestone it is addressing, and the key targets that are planned towards achieving each. These targets are specific and measurable and will be used to judge progress towards the longer-term capabilities and milestones.

## PROGRAMME AND PROJECT MANAGEMENT

The execution of the programme is performed through activities planned within each of the 22 D&IS project plans that are described in the main body of this document. For activities involving MSSPs, the work is performed through Support Programme tasks. Each task has an IAEA and MSSP representative assigned to oversee the work.

## PROJECT PLAN STRUCTURE

Each project is described in terms of:

- An introduction, describing the scope of the project, and it's main aim in supporting the *Long-Term Strategic Plan, 2012–2023*;
- An overview (executive summary) presenting:
  - how the project fits into the Department's wider programme,
  - the rationale underlying the project area, mentioning current state-of-the-art, recent achievements, unresolved issues and the project's major challenges in the years to come,
  - recent achievements and next steps,
  - references to active MSSP tasks, and
  - applicable cross-references to other related Departmental projects;
- Capabilities, milestones and key achievement targets in the 2014–2015 biennium:
  - capabilities that have been identified by the Department in the *Long Term R&D Plan 2012–2023* as being needed in the long-term to ensure the IAEA's ability to meet a current or emerging safeguards implementation need;
  - milestones that have been prioritized by the Department and which are addressed by an appropriate project manager to be met within a targeted timeframe; and
  - key achievement targets that detail deliverables, constraints, tasks, activities, timescales and funding sources;
- Proposed and newly planned MSSP task proposals; and
- If applicable, planned development activities supported through the regular budget.

The project plan structure aims to present the reader with a clear view of all the current and planned work to be performed within the project and the reasons for any changes to previous planning. Tables within the project plan summarize the tasks that were active at the time the plan was published. However, task officers share task status reports with the MSSPs on a regular basis.

## REPORTING AND REVIEW

Regular meetings with individual Member States (convened annually or semi-annually, depending on the MSSP's arrangements with the IAEA) are held to review the status of their Support Programmes and progress on specific tasks. A biennial meeting is also held with all MSSP coordinators to discuss the overall programme and other issues of general interest to the MSSPs.

A report on the completed biennium is produced for MSSPs and other stakeholders, highlighting specific project objectives, overall progress, task statuses and key achievements. A report on the R&D Programme for Nuclear Verification 2012–2013 will be provided during 2014.

When a task is completed, an application report is prepared by the task officer or project manager and submitted to the Member States involved, as well as other stakeholders and interested parties, summarizing the task objectives, if and how they were met, key achievements, the impact the activity had on IAEA safeguards, and any follow-up activities.

## ADMINISTRATION OF MEMBER STATE SUPPORT PROGRAMME TASKS

Existing MSSP tasks and new task proposals are included within the activities of each project. These tasks are administered by the Department's Support Programmes Coordination Team (SPCT) in the Section for Strategic Planning and External Coordination, Division of Concepts and Planning, together with MSSP coordinators. The appointed MSSP coordinator is the IAEA's main point-of-contact with each Member State concerning D&IS projects.

## THE FUTURE

The IAEA's Department of Safeguards will continue to rely on MSSP resources to provide the necessary technology, funds and expertise to meet its research, development and implementation support needs.

With respect to the management of the D&IS programme, the Department intends to pursue its policy of continual improvement. Over the period of the 2014–2015 biennium, the Department will continue to further streamline the top-down planning and implementation process of the D&IS activities, and demonstrate the full integration of the Departmental long-range strategic planning framework. D&IS project plans will continue to address Departmental needs identified in the *Long-Term Strategic Plan 2012–2023*, and the Long-Term R&D Plan 2012–2023, while taking into account specific safeguards implementation needs, scientific and technological state-of-the-art, and challenges facing each individual project. The D&IS Programme will also continue to include a prioritization process.

## MEMBER STATE SUPPORT PROGRAMMES

A list of all Member State Support Programmes is shown on the following page.

# List of Member State Support Programmes

Argentina (ARG SP)

Australia (AUL SP)

Belgium (BEL SP)

Brazil (BRZ SP)

Canada (CAN SP)

China, People's Republic of (CPR SP)

Czech Republic (CZ SP)

European Commission (EC SP)

Finland (FIN SP)

France (FRA SP)

Germany (GER SP)

Hungary (HUN SP)

Japan (JPN SP)

Netherlands (NET SP)

Republic of Korea (ROK SP)

Republic of South Africa (RSA SP)

Russian Federation (RUS SP)

Spain (ESP SP)

Sweden (SWE SP)

United Kingdom (UK SP)

United States of America (USA SP)

# List of D&IS Project Plans and Project Managers 2014–2015

| Project ID | Project Title | Project Manager | Responsible Division | Programme and Budget 2014–2015 |
|---|---|---|---|---|
| SGAS-001 | Destructive Analysis of Nuclear Materials | Steven Balsley | SGAS/NML | 4.1.7.001 |
| SGAS-002 | Environmental Sample Analysis Techniques | Stephan Vogt | SGAS/ESL | 4.1.7.001 |
| SGAS-003 | Analysis Support and NWAL Coordination | Catherine Mansoux | SGAS/CSS | 4.1.7.001 |
| SGCP-003 | Safeguards Approaches | Masato Hori | SGCP/CCA | 4.1.1.001<br>4.3.1.001<br>4.3.3.006 |
| SGCP-101 | Quality Management | Haroldo Barroso | SGCP/CPD | 4.0.0.002<br>4.1.1.002 |
| SGCP-102 | Training | Jean-Maurice Crété | SGCP/CTR | 4.1.1.003<br>4.3.1.004 |
| SGIM-002 | Commercial Satellite Imagery | Karen Steinmaus | SGIM/ISI | 4.1.5.001 |
| SGIM-003 | Information Analysis | Matthew Ferguson | SGIM/ISF | 4.1.5.003 |
| SGIM-007 | Evaluation of Data from Environmental Sampling and Destructive Analysis | Diane Fischer | SGIM/IFC | 4.1.7.001<br>4.1.5.004 |
| SGIM-008 | Statistical Analysis | Claude Norman | SGIM/IFC | 4.1.5.002<br>4.1.5.004 |
| SGIS-002 | Information Security and Infrastructure | Scott Partee | SGIS/IS | 4.1.9.001 |
| SGIS-003 | Safeguards Information Systems and System Usability | Gregg Whitaker | SGIS/PS | 4.3.1.002 |
| SGOA-002 | Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX) | Christophe Creusot | SGOA/OA2 | 4.1.6.004<br>4.3.3.001 |
| SGOC-001 | Chernobyl | Sigitas Kurselis | SGOC/OC2 | 4.1.6.004<br>4.3.3.003 |
| SGTS-001 | NDA Techniques | Mikhail Mayorov | SGTS/TND | 4.1.6.001<br>4.3.2.001 |
| SGTS-002 | Techniques and Instruments for Sealing and Containment Verification | Bernard Wishard | SGTS/TSI | 4.1.6.002<br>4.3.2.001 |
| SGTS-003 | Surveillance Techniques | Martin Moeslinger | SGTS/TUS | 4.1.6.002<br>4.3.2.001 |
| SGTS-008 | Instrumentation Technology Foresight | Dimitri Finker | SGTS/TND | 4.3.2.002 |
| SGTS-011 | Unattended Measurement Techniques | Thierry Pochet | SGTS/TUS | 4.1.6.001<br>4.3.2.001 |
| SGTS-013 | Universal NDA Data Acquisition Platform (UNAP) | Kenneth Baird | SGTS/TND | 4.1.6.001<br>4.3.2.001 |
| SGTS-014 | Remote Monitoring and Data Processing Systems | Jim Regula | SGTS/TSI | 4.1.6.004 |
| SGTS-015 | Technologies for Possible New IAEA Verification Tasks | Kenneth Baird | SGTS/TSI | 4.1.6.001<br>4.1.6.002<br>4.1.6.004<br>4.3.2.001<br>4.3.2.002 |

# Overview of the long-term directions, key objectives and key achievement targets

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| SGAS-001 Destructive Analysis of Nuclear Materials | 10.1. Utilise the expanded NWAL, in order to:<br>• Provide external quality control and reference materials<br>• Provide technical expertise<br>(High) | • Complete the characterization of plutonium materials in order to make possible the production of large size dried (LSD) spikes using Japanese plutonium source material. [2015]<br>• Complete the characterization of uranium fuel pellets for the Combined Procedure for Uranium Concentration and Enrichment (COMPUCEA) calibration. [2014]<br>• Conduct a coulometry workshop for training of new plutonium lab staff. [2014] |
| | 10.3. Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples.<br>Improve capability to characterize nuclear material and verify its origin e.g.:<br>• Age determination<br>• Uranium speciation<br>• Analysis of uranium impurities<br>(High) | • Complete additional shipment of plutonium samples to the NWAL. [throughout 2014 and 2015]<br>• Complete the testing of a new alumina pellet system for $UF_6$ collection. [2015]<br>• Implement a new high-active liquid waste treatment technique for the dissolution of refractory particles. [2015] |
| SGAS-002 Environmental Sample Analysis Techniques | 10.1. Utilize the expanded NWAL, in order to:<br>• Provide external quality control and reference materials<br>• Provide technical expertise<br>(High) | • Produce and distribute quality control swipes containing uranium, uranium-plutonium mixtures and plutonium particles. [December 2015] |
| | 10.2. Develop techniques, methods and equipment to detect signatures of nuclear activities in environmental samples including:<br>• Age determination of U and Pu relevant to the origin of nuclear materials<br>• Analysis of impurities relevant to the origin of source materials<br>• Particles morphology for identifying operational processes<br>• Reliably finding smaller particles of interest in an excess of background material<br>(High) | • Implement improved sample preparation method for large geometry- secondary ion mass spectrometer (LG-SIMS). [December 2014]<br>• Validate and apply the laser-ablation (LA) sampling technique to the multi-collector inductively-coupled plasma mass spectrometry (MC-ICP-MS). [December 2014]<br>• Develop and implement techniques for the identification and isolation of single, nuclear material containing particles from swipe samples for instrumental analysis. [December 2015] |
| SGAS-003 Analysis Support and NWAL Coordination | 10.1. Utilise the expanded NWAL, in order to:<br>• Provide external quality control and reference materials.<br>• Provide technical expertise<br>(High) | • Implement the expansion of the NWAL, including completion of on-going qualification of candidate laboratories. [December 2015]<br>• Conduct inter-laboratory comparison exercises and produce new QC reference materials. (December 2015] |
| | 10.3. Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples.<br>(High) | • Deploy the next version of the NML Laboratory Information Management System (AIMS 2.0). [September 2014] |

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| SGCP-003 Safeguards Approaches | 1.2. Prepare additional guidance for the on-going development of State-level safeguards approaches:<br>• The use of State-specific factors<br>• Acquisition path analysis<br>• The specification of options for Headquarters and in-field activities required to meet the technical objectives<br>• The link between the State evaluation process and development of SLAs1 and AIPs2<br>(High) | • Issue the guidance documents for performing APA and developing SLAs and the guidance document for producing AIPs. [2014] |
| | 1.3. Develop additional tools to support the development of State-level safeguards approaches:<br>• The analysis, representation, and prioritization of acquisition paths<br>• The planning of safeguards activities<br>• The assessment of overall safeguards effectiveness<br>• The determination of technical objectives<br>(Medium) | • Develop templates, software tools and reference material to support development of SLAs. [2015] |
| | 1.4. Develop approaches to more fully utilize SRA data and verification findings, where appropriate, to achieve efficiencies.<br>(High) | • Identify approaches which will enable the Agency to assess and more fully utilize the technical capability and verification findings of the SRA. [2015] |
| | 1.5. Develop safeguards guidance for States, including web-based versions, addressing topics such as:<br>• Regulatory authority<br>• Design information<br>• Inspections and complementary access<br>• Imports and exports<br>(High) | • Develop and publish detailed guidance on safeguards implementation practices: on facilitating IAEA verification activities and establishing State infrastructure [2014]<br>• Provide information to the IAEA and undertake collaborative approaches to safeguards implementation. [2015] |
| | 2.3. Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.<br>(Medium) | • Update Physical Model. [2015] |

[1] State-level approaches
[2] Annual implementation plans

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| | 3.1. Develop generic safeguards approaches for:<br>• Pyro-processing plants (Medium)<br>• Other new reprocessing technologies (Low)<br>• Laser enrichment plants (Medium)<br>• Other new enrichment technologies (Low)<br>• Small modular and/or Gen IV reactors (Medium) | • Develop a safeguards approach and supporting measures for a specific pyro-processing facility. Draft a Safeguards Technical Report for safeguarding generic pyro-processing plants. [2015]. |
| | 3.2. Develop tools and techniques to characterize:<br>• Fissile content in metal mixtures containing the actinides Np, Am and Cm during pyro-processing (Medium)<br>• Fuel types for Gen IV reactors containing minor actinides (Low)<br>• Seismic signals in geological repositories (Medium)<br>• Soon-to-be difficult-to-access nuclear material (Medium) | • Hold the annual Experts Group meetings for Application of Safeguards to Geological Repositories (ASTOR) to facilitate development of equipment and technologies for safeguarding geological repositories and encapsulation plants. [2014 and 2015] |
| | 3.4. Develop a mechanism to enable safeguards to be considered early in the facility design process. (Medium) | • Issue safeguards-by-design documents for conversion, fuel fabrication, spent fuel management, enrichment and reprocessing plants. [2014] |
| | 4.1. Consult with Member States with established naval nuclear propulsion programmes for development of future verification arrangements in this area. (High)<br>4.2. Develop concepts, tools, and measures to enable the IAEA to design a verification approach for nuclear material destined for, and returned from, naval propulsion (Medium)<br>4.3. Develop an approach to provide credible assurance that nuclear material being used in naval propulsion is not used for the production of nuclear weapons or other nuclear explosive devices (Medium) | • Consult with Member States with established naval nuclear propulsion programmes to identify challenges and develop possible solutions relevant to development of concepts and tools for development of future verification arrangements in this area. [2015] |
| | 12.1. Assist with Chernobyl, Fukushima and DPRK related activities as requested. (Medium) | • Identify action items and best approaches for effective and efficient safeguards for fuel debris in Fukushima-Daiichi. [2015] |
| SGCP-101 Quality Management | 1.1. Develop safeguards policy, guidelines and processes to more fully implement the State-level concept. (High) | • Develop and implement Safeguards Process Performance Indicators. [On-going]<br>• Prepare and implement the Internal Quality Audit Programme. [On-going]<br>• Implement a new condition report tracking system. [June 2014] |

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| SGCP-102 Training | Capability 1.<br>Ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards | • Develop training courses and curriculum following guidance documents for implementation of the State-level concept. [December 2014] |
| | 13.1. Develop training tools using advanced methods such as virtual reality, immersive learning systems and web-based training:<br>• Develop prototype virtual reality systems, test and evaluate performance<br>• Include immersive learning for all types of fuel cycle facilities<br>• Develop web-based tools for specific safeguards equipment<br>• Develop signal (neutron/gamma) simulators to generate responses from equipment during training<br>(Medium) | • Publish nuclear fuel cycle training manuals. [December 2015]<br>• Include interactive training simulations in further development of the pressurized heavy water reactor virtual environment, including an application guide for trainers. [December 2015]<br>• Improve and implement procedures for training needs analysis. [December 2014] |
| | 13.2. Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility<br>(Medium) | • Develop materials for more interactive sessions for training SSACs on collecting data and reporting. [December 2014]<br>• Develop e-learning modules after feasibility studies. (Priority for States developing nuclear energy). [December 2015] |
| SGIM-002 Commercial Satellite Imagery | 2.3. Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.<br>(Medium) | • Develop and implement SAR-based analytical techniques into workflow. Demonstrate the use of SAR techniques in production within ISI. [December 2015]<br>• Develop and implement methodologies to exploit thermal infra-red satellite data. Successfully demonstrate ISI's ability to process and analyse IR data in production within ISI. [December 2015]<br>• Develop software and present training packages to improve analytical skills in the processing and interpretation of SAR imagery. [December 2014] |
| | 9.1. Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file.<br>(Medium) | • A document outlining the framework for the digital delivery of spatial data will be submitted to ISI by the University of Bonn. [January 2014].<br>• Develop and evaluate the submission process of the Additional Protocol 2.a.iii in a digital format compatible with the GES. [on-going through December 2015] |
| SGIM-003 Information Analysis | 2.1. Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.<br>(Medium) | • Integrate open source information collections within established information management systems, such as the Geospatial Exploitation System. (SGIM-02) [On-going]<br>• Identify, test and develop information management technologies that may provide visualization of large and disparate datasets with input from open sources, inspection data, environmental sampling results, etc. [December 2015] |

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| | 2.3. Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization. (Medium) | • Develop a scientific and technical literature monitoring system grounded in professional bibliometry and semantic searching. [December 2015]<br>• In conjunction with SGCP-102 develop and implement specific analytic training courses to maintain analytic competence across the Department. Examples include, advanced open source information collection and analysis courses, procurement and trade analysis workshops, advanced analytical techniques training, etc. [On-going] |
| | 2.4. Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions. (Medium) | • Test, and implement, the Rapid News Service to monitor news and streamline information management processes. [July 2014]<br>• Implement entity extraction software to interface between large unstructured datasets and analytical software platforms. [July 2014] |
| SGIM-007 Evaluation of Data from Environmental Sampling and Destructive Analysis | 2.2. Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools. (High) | • Accept final delivery of MSTAR+ enrichment code. [2014]<br>• Obtain analytical results and metadata from Springfields uranium ore concentrates (UOC) samples.[2015]<br>• Accept and implement stand-alone version of multivariate analysis software (DAVE) for evaluating impurity signatures in uranium. [2015] |
| SGIM-008 Statistical Analysis | 2.5. Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results. (Medium) | • Update technical documentation on sampling plans and related procedures and upgraded sampling plan code. [2015]<br>• Prepare consolidated documentation on current random inspection schemes and methodologies for evaluating their results, including procedures for their practical implementation. [2015] |
| SGIS-002 Information Security and Infrastructure | 8.1. Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol and an electronic State file containing all safeguards-relevant information about each State (High) | • Increase detection of incidents by building security operations capabilities by:<br>- Enhancing the tools in use for security event detection and improving processes surrounding them<br>- Developing systems that analyse roles, classification, and capabilities of the Department IT systems and detect anomalous behaviours.<br>• Join The Forum of Incident Response and Security Teams Organization.<br>• Deploy comprehensive endpoint protection. [2015]<br>• Evaluate and implement automated security testing tools. [2015]<br>• Update security policies, procedures, standards, and guidelines with ISO 27000 in conjunction with the IAEA's Central Security Coordinator. [2015] |
| | 9.3. Deploy secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices (Medium) | • Deploy secure communication and mobile productivity for staff in the field. [2015] |
| | 9.4. Ensure the Department's ability to recover from an IT failure (High) | • Develop and implement an updated disaster recovery programme in alignment with the IAEA's Central Security Coordinator's initiative for business continuity. [2015] |

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| SGIS-003 Safeguards Information Systems and System Usability | 8.1. Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State. (High) | • Complete the migration of mainframe data to ISE (2014) and continue the integration of non-mainframe data to ISE (2015), including documents stored in Live Link and State File directories. [2015]<br>• Align IT capabilities with new Safeguards business processes in support of the State Level Concept by enhancing the usability of information systems with modern software and analytical tools in an integrated and collaborative working environment. [2015] |
| | 9.1. Enhance field activity data and report management capabilities. (High) | • Enhance existing capabilities to support field activity data and reporting management involving secure communications, mobile devices, and offline functionality. [2015]<br>• Develop new capabilities to support field activity data and reporting management, involving an electronic inspection data package (eIDP), design information, additional protocol data and the transmission of state supplied data. [2015] |
| SGOA-002 Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX) | 5.3. Develop improved tools and techniques to enable real time flow measurements of nuclear material, including $UF_6$ at enrichment facilities and plutonium at reprocessing facilities. (Medium) | • Depending on Japan's provision of an updated J-MOX construction and commissioning schedule:<br>- Develop a safeguards approach for J-MOX, based on the basic elements agreed with Japan, and start the preparation of procedures for implementation<br>- Design, test and install safeguards equipment (NDA, C/S) that provide high quality, independent and reliable results<br>- Design, test and implement an integrated data collection and evaluation software for J-MOX, using synergies with the RRP Information System<br>- Establish and implement DIE/DIV procedures that assure that the facility is constructed and will operate as declared, while ensuring that the safezguards approach remains adequate and robust. Carry out DIE/DIV activities from construction to MOX commissioning phases. |
| SGOC-001 Chernobyl | 12.1. Assist with Chernobyl, Fukushima and DPRK related activities as requested. (Medium) | • Develop approaches, instruments and associated methods and install relevant equipment to maintain continuity of knowledge of safeguarded nuclear material. [The following activities will begin in 2015]:<br>- During transfer from ISF-1 to ISF-2 and from ISF-2 to dry storage<br>- During processing in ISF-2<br>- In dry storage<br>- In NSC |

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| SGTS-001 NDA Techniques | 2.2. Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools. (High) | • Establish a reference library with a collection of non-radiation signatures of metallic alloys, inorganic and organic compounds, specific to the nuclear fuel cycle. (NFC) [December 2015] |
| | 2.6. Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations. (High) | • Select, evaluate, customize and authorize commercial off-the shelf equipment for detection of non-radiation signatures of the NFC. [December 2015] |
| | 5.4. Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding storage/transport containers at all points in their life- cycle (Medium) | • Authorization of the Dual-Slab Verification Detector. [July 2015] |
| | 5.5. Develop methods to verify fresh fuel in shipping containers without opening the containers (Medium) | • Re-engineer the Inspector Multichannel Analyser (IMCA) software package based on the GENIE-2000 package currently embedded in the IMCA software to incorporate the functions of other stand-alone gamma spectra analysis software ;<br>• Ensure the sustainability and maintenance of software for plutonium-isotopics and uranium enrichment to determine nuclear characteristics ;<br>• Development algorithms for isotopic analysis of uranium and plutonium samples using medium resolution gamma-spectrometry (with LaBr3, CZT detectors) for the improved attribute test capability. [December 2015] |
| | 5.6. Develop improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition (Medium) | • Develop the methodology for the on-site bias defect analysis of uranium or thorium ore concentrates, $UF_6$ and impure and dirty scrap materials using the Combined Procedure for Uranium Concentration and Enrichment Assay. (COMPUCEA) ;<br>• Develop and manufacture a compact tomographic gamma scanner. [December 2015] |
| | 5.7. Develop more sensitive and less intrusive alternatives to existing instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage. (High) | • Develop an improved technique for irradiated fuel attribute test ;<br>• Evaluate a prototype tomographic spent-fuel detector system. [May 2014] |
| | 5.8. Develop alternative instruments, for instance based on liquid scintillators, to improve performance in neutron coincidence counting techniques applied to various types of fissile material. (Medium) | • Develop a prototype liquid scintillator-based coincidence counter ;<br>• Evaluate and select a fast neutron detector for neutron coincidence counting applications. [December 2015] |

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| | 6.2. Develop neutron counting systems reducing the use of 3He or offering equivalent functional and technical alternatives (Medium) | • Evaluate Boron-10 hybrid proportional counters for neutron coincidence counters ;<br>• Develop the next generation Cherenkov viewing device (CVD) ;<br>• Authorize a hand-held pressure differential device for the purpose of` measuring liquid levels in tanks at reprocessing facilities. [May 2014] |
| SGTS-002 Techniques and Instrument for Sealing and Containment Verification | 5.4. Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle. (High) | • Field test the low-cost sea. [December 2014]<br>• Deploy the LMCV to replace one component of dual containment and surveillance (C/S). [December 2015] |
| | Capability 6.<br>Ability to acquire and deploy safeguards equipment that is sustainable, tandardized and modular, with increased use of commercial off-the-shelf products | • Assess and evaluate glass seal prototypes as potential replacements for the metal E-Cap seal, which is a 50 year old design. [January 2015]<br>• Deploy the iReader for multiple seal types to decrease equipment carried by Inspectors in the field. [December 2015]<br>• Deploy UIT based on smart card technology to store certificates and private keys securely. [December 2015]<br>• Integrate high-security RFID tags into one or several types of passive seals; develop management systems and readers for these tags; conduct a field test; and evaluate results. [December 2015] |
| SGTS-003 Surveillance Techniques | 5.1. Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of plutonium (Pu) separation) (Medium) | • Conduct a series of field tests to benchmark the applicability of the 3DLR technology as an alternative for traditional containment verification or sealing measures. A related report will be presented. [June 2015] |
| | 5.3. Develop improved tools and techniques to enable real-time flow measurements of nuclear material, including uranium hexafluoride ($UF_6$) at enrichment facilities and Pu at reprocessing facilities (Medium) | • L2IS is currently authorized for use at the Rokkasho enrichment plant. The technology's applicability will be assessed for other enrichment plants and for facilities handling bulk nuclear material. A related assessment report will be presented. [December 2014] |
| | 7.2: Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements (High) | • Complete a addition to the NGSS camera, to support operator-owned analogue cameras including a related security vulnerability assessment. [September 2015] |
| SGTS-008 Instrumentation Technology Foresight | 12.2. Develop and implement a technology foresight horizon scanning process for external, potentially relevant research and development (R&D) fields. (High) | • Establish and document a sustainable process for the implementation of technology foresight covering technologies that focus on the instrumentation applicable to safeguards field and laboratory activities. [2014]<br>• Issue and distribute a quarterly Technology Preliminary Evaluation Report on potential emerging technologies to the Department of Safeguards. [Quarterly release, on-going]<br>• Conduct and present a comparative exploration of new technologies for SG inspectors, including indoor positioning, portable mass spectrometry, material identification instrumentation, and micro seismic monitoring. [Dec. 2015] |

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| SGTS-011 Unattended Measurement Techniques | Capability 5.<br>Ability to deploy equipment at facilities to meet safeguards requirements. | • Deploy and implement required safeguards instruments and systems in the field. |
| | 5.1. Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation) (Low) | • Improve, evaluate and test upgraded solution monitoring software. [2014] |
| | 5.2. Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities (High) | • Complete the viability study of the UCVS at an enrichment facility. [2015] |
| | 5.3. Develop improved tools and techniques to enable real time flow measurements of nuclear material, including $UF_6$ at enrichment facilities and Pu at reprocessing facilities. (Medium) | • Field test OLEM prototypes at an enrichment facility. [2014] |
| | 5.4. Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle (Medium) | • Complete the authorization of the MUD2. [Oct. 2014] |
| | 5.7. Develop more sensitive and less intrusive alternatives to existing instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage. (High) | • Conduct a quantitative assessment of the viability of passive gamma-ray emission tomography for high-fidelity verification of fuel assembly integrity. [January 2015] |
| | Capability 6.<br>Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products. | • Develop, provide evaluate, upgrade, deploy Departmentally-needed instruments and systems. |
| SGTS-013 Universal NDA Data Acquisition Platform (UNAP) | Capability 5.<br>Ability to deploy equipment at facilities to meet safeguards requirements. | • Conduct performance characterization of the UNAP; e.g., data, reliability, and performance analysis. [May 2014]<br>• Perform a field evaluation of UNAP prototypes, at one or more facilities, in cooperation with Member States. [December 2015]. |
| | Capability 6.<br>Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products | • Conduct a comprehensive review, validation, and where necessary, revision of the requirements and specifications for procurement of production units. [July 2014] |

| Project | Capability, or Milestone, associated with project (Milestone Urgency) | Key Achievement Targets for 2014–15 [Target completion date] |
|---|---|---|
| SGTS-014 Remote Monitoring and Data Processing Systems | 2.4. Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions (Medium) | • In partnership with Euratom contractors, modify the existing CRISP application to make it IAEA specific. [December 2015]<br>• Add new surveillance and electronic seal modules to CRISP. [December 2015] |
| | 6.1. Implement an improved cost/benefit assessment methodology for the design and operation of safeguards equipment (Medium) | • Install RAINSTORM, with standardize basic transfer and authentication methods, on all new equipment. [December 2015] |
| | 7.1. Develop minimally intrusive techniques that are both secure and authenticated to enable the use of operator's systems, instruments and process monitoring for cost-effective safeguards implementation (High) | • Install advanced wireless options, Ethernet extenders, etc. at several facilities where the existing communication infrastructure is inadequate for Safeguards needs, and retire all analogue modem systems. [2014] |
| | 7.2: Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements (High) | • Continue to assess, implement and upgrade communications, where required, to ensure the most secure and cost- effective communication links between locations in the field facility and IAEA offices. [December 2015] |
| SGTS-015 Technologies for Possible New IAEA Verification Tasks | 11.1. Develop options and approaches for possible future mandates as required or requested (e.g., fissile material cut off treaty, arms control) that respect sensitive and proprietary information (High) | • Develop and build prototype instrumentation to maintain CoK of PMDA fuel as it is shipped from fuel fabrication facilities to a PMDA designated reactor.<br>• Develop conceptual designs of NDA systems, including associated data acquisition, to confirm irradiation levels of spend designated fuel in PMDA LWR and FNR reactors. |

# Projects

# SGAS-001

## Destructive Analysis for Nuclear Materials

### Project Manager: Steven D. Balsley — Division: SGAS

### 1. Introduction

Project SGAS-001 aims to develop and implement new or strengthened processes supporting laboratory practices in the Analytical Services Division (SGAS) related to the destructive analysis of nuclear material samples. This pertains particularly to the Nuclear Material Laboratory (NML), including the On-Site Laboratory Team (OSL Team) in Japan. This project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

The NML, including the OSL Team in Japan, has the main responsibility for the processing, analysis and result reporting of nuclear material samples for the Department of Safeguards. It is the mandate of SGAS management to improve analysis quality continuously, to reduce radioactive waste at the laboratories and to operate its laboratories in accordance with established safety and security guidelines. The special nature of nuclear laboratory operations requires that the SGAS-001 project manager stays informed about technological advancements, training opportunities and other prospective research and development opportunities.

The SGAS-001 project addresses the development, implementation, and enhancement of processes for destructive analysis of nuclear material samples. This project supports the *Long-Term R&D Plan, 2012–2023*, particularly with regard to achieving Capability 10 (*ability to provide analytical services through the NWAL to support foreseen future verification requirements*). More specifically, the project focuses on the development and implementation of techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples (Milestone 10.3) and to contribute to the utilization of the expanded Network of Analytical Laboratories (NWAL) (Milestone 10.1). Destructive analysis of nuclear material samples is the backbone of the Agency's efforts to verify the declared nuclear material inventories in bulk handling facilities. Therefore, Project SGAS-001 intends to enhance the NML and OSL Team effectiveness by continuing to explore and develop analytical techniques and capabilities that meet the Department's current and projected needs for the analysis of nuclear material samples. In particular, technological improvements will be sought that allow the NML and the OSL Team to process, measure and report results from a variety of nuclear material samples in a timely manner. The SGAS-001 project is closely related to, and coordinated with projects SGAS-003 "Analysis Support and NWAL Coordination" and SGIM-007 "Evaluation of Data from Environmental Sampling and Destructive Analysis".

Within the current scope of the project, nearly all of the requested support has been, or is being addressed. The most important need that arose during the 2012-2013 biennium was the disposition of about 60 g of legacy plutonium in solution form. At the time of signing of this document, more than 30 g has been solidified for long-term storage stability, and the first shipment of material was made in 2013.

During the last two years, significant achievements were obtained in the development of instruments supporting the independent determination of plutonium for certification of internal laboratory standards in NML, for the quantification of measurement uncertainty following the Guide to the Expression of Uncertainty in Measurement (GUM) of the Bureau International des Poids et Mesures (BIPM), which is the standard being

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

adopted across many analytical laboratories, and for the improvement of the hybrid k-edge densitometry (HKED) measurement system used in Rokkasho Japan by the OSL Team.

As chemical and analytical instrumentation advancements are realized, SGAS-001 shall seek to explore the feasibility of these improvements for implementation in the NML and the On-Site Laboratory. Clear movement towards more emphasis on chemical and physical attribution factors in nuclear material may dictate new task proposals from SGAS-001, as possible advancements toward the reduction of radioactive waste.

End-users are Departmental analysts who receive and evaluate analytical data produced by the laboratories, Divisions of Operations and ultimately the Department of Safeguards when it comes to drawing safeguards conclusions.

In the 2014-2015 biennium, the SGAS-001 project will:

- Improve technological foundations through expert contributions and provision of instrumentation;
- Improve analytical competency through training;
- Improve laboratory proficiency through inter-laboratory sample exchanges (also see SGAS-003).

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute directly to the long-term attainment of Capability 10 (*ability to provide analytical services through the NWAL to support foreseen future verification requirements*) in general, and specifically to meeting the near-term attainment of Milestones 10.1 and 10.3 identified in the *Long-Term R&D Plan 2012-2023* and captured in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| **10** | Ability to provide analytical services through the NWAL to support foreseen future verification requirements. | 10.1. Utilise the expanded NWAL, in order to:<br>• Provide external quality control and reference materials<br>• Provide technical expertise<br>• *Complete the characterization of plutonium materials in order to make possible the production of large size dried (LSD) spikes using Japanese plutonium source material [to be completed in 2015]*<br>• *Complete the characterization of uranium fuel pellets for COMPUCEA[1] calibration [to be completed in 2014]*<br>• *Conduct a coulometry workshop for training of new plutonium lab staff [to be completed in 2014]* | H |
| | | 10.3. Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples.<br>Improve capability to characterize nuclear material and verify its origin e.g.:<br>- Age determination<br>- Uranium speciation<br>- Analysis of uranium impurities<br>• *Complete additional shipment of plutonium samples to the NWAL [throughout 2014 and 2015]*<br>• *Complete the testing of a new alumina pellet system for UF6 collection [to be completed in 2015]*<br>• *Implement a new high-active liquid waste treatment technique for the dissolution of refractory particles [to be completed in 2015]* | H |

## 4. Activities

Funding and resources for most of the project's D&IS activities are provided by Member State Support Programmes (MSSPs), which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources.

***Capability 10: Ability to provide analytical services through the NWAL to support foreseen future verification requirements.***

- A number of implementation tasks are used to channel on-going analytical support and technical expertise provided by partner laboratories. Tasks EC A 01391 and JPN A 01345 provide technical support to the On-Site Laboratory in Rokkasho in the form of expert assistance with HKED and reference materials. These two tasks are of an on-going nature. Task JPN A 01963 is the subject task of providing technical consultancy to the NML in mass spectrometry and radiometry. Under task FRA B 01492, the French Support Programme offered training for NML staff on plutonium glove box safety and handling techniques. This training took place at the MELOX training facility in June 2013.

***Milestone 10.1: Utilise the expanded NWAL, in order to:***
- ***Provide external quality control and reference materials***
- ***Provide technical expertise***

- In-house produced measurement standards play an important role in the quality control of analytical results, and for use as chemical tracers that allow the determination of amount contents of uranium and plutonium in inspection samples. In some cases certified reference materials (CRMs) are used to produce secondary measurement standards, such as large-size dried spikes (LSD spikes), for determination of uranium and plutonium content in spent nuclear fuel samples. Nuclear CRMs for this purpose are difficult to produce and less obtainable as existing stocks are depleted. One approach to reduce the use of CRM plutonium in LSD spikes is the substitution of reference materials (RMs) from indigenous stock material that is proven to be sufficiently homogeneous and stable with reference to specified properties, and that is established to be fit for its intended use in measurement or in examination of nominal properties. By means of task JPN A 01795, the NML will characterize plutonium from a Japanese mixed oxide (MOX) material with the goal of producing a reference value for plutonium content and isotopic composition so that the material may eventually be used in Japan for the production of LSD spikes. The success of this task will greatly reduce the consumption of CRM plutonium, which can then be conserved for more important uses in the future. A second approach is to rethink the entire approach of the LSD spike, both in terms of its size and composition, but also in its chemical and mechanical properties. Tasks EC A 1606 and EC A 1806 endeavour to look into new ways of optimizing the solid spike approach, and to facilitate an exchange of samples between NML and the Institute for Reference Materials and Measurements for crosschecking of measurement results.
- COMPUCEA (Combined Procedure for Uranium Concentration and Enrichment Assay) is used for analytical measurements in support of Safeguards inspections during accountancy verification campaigns in low-enriched uranium fuel fabrication plants. The analyses are provided directly onsite with transportable equipment. They involve the determination of the uranium elemental content and of the $^{235}U$ enrichment in samples (uranium oxide pellets and powders). Through task JNT A 01877 (BRZ) the NML will complete the characterization of two batches of different-enrichment fuel pellets from Brazil that will be used in the field as calibration standards for COMPUCEA. The success of this task will reduce the amount of CRM uranium.
- Controlled potential coulometry is a first-principle plutonium measurement technique used in the NML to verify independently the plutonium content of in-house produced reference materials. Coulometry has no analytical commonality with the other major plutonium content measurement method used in NML, isotope dilution mass spectrometry, and is therefore very important for identification of measurement bias. Through Task USA A 1049, the NML will host a coulometry workshop that is intended to refresh already-experienced staff, but also to introduce the topic to new NML staff as well as external staff from the European Commission, which is exploring the setting up of a similar system.

***Milestone 10.3: Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples. Improve capability to characterize nuclear material and verify its origin e.g.:***

- ***Age determination***
- ***U speciation***
- ***Analysis of U impurities***

- A key activity under this milestone is the transfer of approximately 60 g of plutonium to the Chalk River Laboratory for analysis, which will provide the NML with valuable analytical confirmation of the composition of the material, and will help reduce the inventory of plutonium held in the Seibersdorf fissile materials storage (CAN A 01938). The first Type A shipment of material was realized in June 2013, and the task will endeavour to achieve complementary shipments in 2014. However due to shipping restrictions and high costs, shipments may take from three to five years to complete. The NML is more than 50% complete with the solidification of the solution-based plutonium, which will facilitate safe storage in Seibersdorf until the transports can be organized and executed.
- During safeguard inspections at enrichment plants, $UF_6$ samples are taken from process lines and/or cylinders to verify the uranium enrichment and assay conformity with design/operator declarations. A Hoke tube type is normally used for $UF_6$ sampling. The samples collected are under fluorine gas and according to the transport regulations, are classified as "Dangerous Goods, Corrosive Class 8 and Radioactive Class 7". In order to simplify the shipment, and consequently to reduce cost, a new method, based on the ABACC3-Cristallini Method, has been developed for enrichment determination of the sampled $UF_6$. This method uses alumina pellets that absorb and hydrolyze $UF_6$ directly during the sampling. Just a small amount of uranium is captured and the sample ready for shipping is at the atmospheric pressure. Upon receipt at the analytical laboratory, the uranium retained in the alumina pellets can be removed with distilled water without any effort. In order to implement this new sampling method, Argentina, Brazil, ABACC and the IAEA Department of Safeguards decided to contribute together under the Development and Implementation Support Programme. Two independent tasks were initiated: ARG A 01769 as initiator of the method was involved in all validation procedure while BRZ A 01764 will contribute by supplying $UF_6$ and testing the sampling, which is expected to be completed in 2015. These tasks will also provide an enhancement of the cooperation between NML and Brazilian and Argentinian laboratories.
- A significant challenge faced by the OSL Team in Rokkasho is the correct determination of plutonium in high-active liquid waste (HALW) samples from the Rokkasho Reprocessing Plant. The aim of a joint French and European Commission task (JNT A 01946) is to develop a non-destructive method for determining the plutonium content of HALW samples which contain a considerable amount of solid particles. Within the framework of the task, the Institute of Transuranium Elements is developing a method based on X-ray fluorescence (XRF) technique, already available at Rokkasho as part of the hot-cell Hybrid-KED setup. The success of this joint task will allow the IAEA to independently measure and evaluate the plutonium in HALW samples, which can reach up to several percent of the total sample content. The task request 09/OAT-002 for support in this area is pending with the United States Support Programme.
- The HKED systems at the OSL are the workhorse analytical systems for uranium and plutonium determination from spent fuel dissolver solutions from the Rokkasho Reprocessing Plant. Although these systems are wellcharacterized and in routine use for this purpose, they are capable of a wider range of analysis, including neptunium determination. Through USA A 1369, the OSL plans to enhance the HKED capability at the OSL in the coming two years in order to strengthen the verification capability of the OSL. The realization of HKED at the Oak Ridge National Laboratory was recently announced, significantly expanding the field of users of this instrumentation. Through Task proposal 09/OAT-001, the OSL hopes to take advantage of the knowledge and experience gained at Oak Ridge.

[3] Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 10.1. | EC | A 01806 | Verification of Mixed U-Pu Spikes | On-going |
| 10. | JPN | A 01345 | Technical Support for the Joint IAEA/Japan On-site Analytical Laboratory at the Rokkasho Reprocessing Plant (JU-01) | On-going |
| 10. | JPN | A 01963 | Consultancy on Analytical Chemistry | March 2014 |
| 10.1. | BRZ | JNT A 01877 | Standard Pellets for In-the-Field DA Calibration | December 2014 |
| 10.3. | EC | JNT A 01946 | Analysis of HALW-Samples Containing Particles | December 2015 |
| | FRA | | | December 2015 |
| 10. | EC | A 01391 | Support for the Rokkasho On-Site Analytical Laboratory | On-going task |
| 10. | FRA | B 01492 | Training for NML Staff on Plutonium Glove Box Safety and Handling Techniques | Training completed in June 2013 |
| 10.1. | JPN | A 01795 | Characterization of Japanese LSD Spikes (JC-22) | On-going |
| 10.3. | ARG | A 01769 | $UF_6$ Sampling Method Using Alumina | December 2015 |
| | BRZ | A 01764 | | December 2015 |
| 10.3. | CAN | A 01938 | Safeguards Samples for Characterization | December 2015 |
| 10.1. | EC | A 01606 | Study on Optimization of a New LSD Spike | On-going |
| 10.1. | USA | A 01049 | Controlled Potential Coulometry of 3-5 mg Pu with SRL Coulometer (A218) | On-going |
| 10.3. | USA | A 01369 | Enhanced ANM Capability for HKED Software at SAL (A.250.02) | December 2015 |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 10.1. | 09/OAT-001 | Support for HKED Hardware and Software Testing and Training | Outstanding with USA. |
| 10.3. | 09/OAT-002 | Analysis of HALW-Samples Containing Particles | Outstanding with USA. Accepted by EC and FRA |

## 4.2. In-house Development Activities

No in-house development activities are planned in this biennium for SGAS-001.

# SGAS-002

## Environmental Sample Analysis Techniques

### Project Manager: Stephan Vogt

### Division: SGAS

### 1. Introduction

Project SGAS-002 aims to develop and implement advanced analytical methods and quality control materials for the analysis of environmental samples within the Department of Safeguards. The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

This project addresses the development of new and enhanced forensic analytical methods for environmental samples in order to detect undeclared nuclear material and activities. All aspects of environmental sample processing are affected by the development of: improved sampling equipment and procedures, more sensitive screening methods and more accurate bulk and particle analysis methods, better data evaluation methods and uncertainty estimation and quality control materials to check the performance of analytical laboratories. The ultimate goal is to provide information to the Department for drawing conclusions about the absence of undeclared nuclear material and activities.

The project supports the IAEA *Long-Term R&D Plan 2012-2023*, in particular with regards to Capability 10 (see Table 1) by strengthening the Agency's competence with early detection of the possible misuse of nuclear material and/or technology, and by supporting the goal of strengthening the Agency's analytical capabilities at the Safeguards Analytical Laboratories (SAL). The SGAS-002 project is closely related to and coordinated with projects SGAS-003 "Analysis Support and NWAL Coordination" and SGIM-007 "Evaluation of Data from Environmental Sampling and Destructive Analysis".

The improvement of analytical methods and techniques for the analysis of environmental samples will provide the Department of Safeguards with high-quality information to aid in the drawing of safeguards conclusions, especially about the presence or absence of undeclared nuclear materials and activities. Detection of uranium or plutonium, either in the whole sample (so-called bulk analysis), or in the form of micrometre-sized particles, allows early detection of materials, such as highly-enriched uranium (HEU), or activities such as separation of plutonium, which might be indicators of an undeclared nuclear activity. The probability of detecting an undeclared activity, or the presence of an undeclared material, is based on the release scenario and amount of material released, and on the probability of an inspector collecting this signature on an environmental sample some distance away either in space or time. Lower detection limits for elements of interest such as uranium, plutonium or fission and activation products will translate into earlier and more reliable detection of undeclared material and activities.

Challenges to be addressed in the 2014 – 2015 bienneim include the achievement of a below-femtogram detection capability for plutonium in swipe samples, the attainment of more reliable results for finding and measuring uranium or plutonium particles, in the presence of an excess of background material by scanning electron microscopy (SEM), or secondary ion mass spectrometry (SIMS) techniques, improvement in the sensitivity of screening methods, such as gamma or X-ray fluorescence spectrometry for the detection and localization of traces of nuclear material on swipe samples, and the development and production of quality control materials to assess the performance of analytical laboratories that measure environmental samples, thus improving the

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*).

reliability of their data and the robustness of the resulting safeguards conclusions. In addition, new analytical techniques are being developed continually and the Agency must keep abreast of such developments. One such method is laser-ablation combined with inductively-coupled plasma mass spectrometry (LA-ICP-MS) for the measurement of large numbers of particles and the isotopic analysis of uranium or plutonium -containing particles that can be identified by other methods, such as SEM.

The structuring of this project is based on identifying needs from the *Long-Term R&D Plan 2012-2023*, and through discussion with the safeguards data evaluators, inspectors and outside experts. From such discussions, priorities for new developments in forensic analysis methods, or improvements in existing techniques, are derived along with the required measures of performance. This information is then turned into task proposals for Member State Support Programmes (MSSPs) or assigned to IAEA staff as part of their duties funded under the Regular Budget. New instrumentation is procured from regular budget or extra-budgetary sources and laboratory facilities to house them are provided. Training of IAEA staff is also carried out under the MSSP's or other means in order to continue to improve the quality of measurements at SAL. All developments carried out at SAL through the MSSPs or regular budget are communicated and transferred to the Network of Analytical Laboratories (NWAL) for the benefit of the entire environmental sampling implementation.

End-users are Departmental analysts who receive and evaluate analytical data produced by the laboratory, Divisions of Operations and ultimately the Department of Safeguards when it comes to drawing safeguards conclusions.

In the 2014-2015 biennium, the SGAS-002 project will:

- Produce and distribute quality control swipes containing uranium, uranium-plutonium mixtures and plutonium particles;
- Implement improved sample preparation method for large geometry-secondary ion mass spectrometer (LG-SIMS);
- Validate and apply the laser-ablation (LA) sampling technique to the multi-collector inductively-coupled plasma mass spectrometry (MC-ICP-MS);
- Develop and implement techniques for the identification and isolation of single, nuclear material containing particles from swipe samples for instrumental analysis.

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will directly contribute to the long-term attainment of Capability 10 (*ability to provide analytical services through the NWAL to support foreseen future verification requirements*) in general, and specifically to meeting the near-term attainment of the Milestones 10.1 and 10.2 identified in the *Long-Term R&D Plan 2012-2023* and captured in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| **10** | Ability to provide analytical services through the NWAL to support foreseen future verification requirements | 10.1. Utilize the expanded NWAL, in order to:<br>• Provide external quality control and reference materials<br>• Provide technical expertise<br><br>• *Produce and distribute quality control swipes containing uranium, uranium-plutonium mixtures and plutonium particles December 2015* | H |

| Capability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| | | 10.2. Develop techniques, methods and equipment to detect signatures of nuclear activities in environmental samples including:<br>• Age determination of U and Pu relevant to the origin of nuclear materials<br>• Analysis of impurities relevant to the origin of source materials<br>• Particles morphology for identifying operational processes<br>• Reliably finding smaller particles of interest in an excess of background material<br>- *Implement improved sample preparation method for large geometry- secondary ion mass spectrometer (LG-SIMS) December 2014*<br>- *Validate and apply the laser-ablation (LA) sampling technique to the multi-collector inductively-coupled plasma mass spectrometry (MC-ICP-MS) December 2014*<br>- *Develop and implement techniques for the identification and isolation of single, nuclear material containing particles from swipe samples for instrumental analysis December 2015* | H |

## Activities

Funding and resources for most of the project's D&IS activities are provided by MSSPs, which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources.

This project concentrates on chemical and isotopic analysis of environmental samples, the instrumentation procedures and methods used to obtain information, and the means by which the quality of such information is assessed. The project's long-term direction will be to continue to make improvements in the accuracy, sensitivity and reliability of techniques that provide information of safeguards relevance in the search for undeclared nuclear materials and activities.

***Milestone 10.1: Utilize the expanded NWAL, in order to:***
- ***Provide external quality control and reference materials***
- ***Provide technical expertise***

Development and production of quality control materials, to improve the reliability of analytical data reported by SAL and the NWAL, is the key objective of the activities under Milestone 10.1.

The IAEA's Environmental Sample Laboratory (ESL) has a limited number of particle standards, which have been used in the production of quality control swipes in the past. New particle standards are required for the quality control of the analytical process and quality control of the performance of the NWAL. The Agency will continue to specify such materials, as the need arises, and collaborate with Member State laboratories in their production.

Task FIN A 1543 "Production of Particles for Quality Control of Environmental Analysis" has previously produced several batches of uranium, plutonium, and mixed uranium and plutonium containing particles, which have been transferred to the IAEA for further characterization and use in preparing quality control (QC) swipes. This task is currently on 'stand-by' and the Finnish experts have been consulted to re-join the collaborative efforts. Additional batches of particles could be produced, as needed, from certified starting solutions that will be provided by the IAEA.

Task GER A1961 "Production of Particle Reference Materials (C.45)" involves the testing of a vibrating orifice aerosol generator for more precise control of tparticle size and composition. Initially, uranium particles of various enrichment levels will be produced, further characterized and used for production of QC materials. These materials will be used mainly for instrument calibration, method validation and general process control.

If successful, this technology will be transferred to ESL where additional batches of particles will be produced, as needed.

Task EC A 1966 "Production of Particle Reference Materials" mainly supports characterization and certification of uranium, plutonium, and uranium-plutonium mixture particles as reference materials by the Institute for Reference Materials and Measurement (IRMM) in Geel, Belgium. These particle reference materials could be used for instrument calibration and method validation.

***Milestone 10.2: Develop techniques, methods and equipment to detect signatures of nuclear activities in environmental samples including:***

- ***Age determination of U and Pu relevant to the origin of nuclear materials***
- ***Analysis of impurities relevant to the origin of source materials***
- ***Particles morphology for identifying operational processes***
- ***Reliably finding smaller particles of interest in an excess of background material***

The development and implementation of methods and techniques to detect signatures of undeclared nuclear materials and activities in environmental samples is the first key objective of the activities under Milestone 10.2.

The ESL has implemented a number of highly sophisticated methods for the analysis of environmental samples. A scanning electron microscope (SEM), with energy-dispersive X-ray (EDX) and wavelength-dispersive X-ray (WDX) spectrometers, has been acquired and is being put into operation for automated searching and detection of particles containing uranium or plutonium. An MC-ICP-MS has been installed for the bulk analysis of environmental swipe samples with detection limits up to one order of magnitude lower compared to the previous generation of ICP-MS. A large-geometry secondary ion mass spectrometer has been acquired and installed in the ESL building for the detection and isotopic analysis of uranium-containing particles from environmental samples. Sensitive methods of radiometric screening of samples using gamma and X-ray fluorescence spectrometry have been implemented, thus giving rapid and sensitive information in a non-destructive way before samples are submitted for detailed analysis at SAL or the NWAL. The key objectives of this project are: to improve all the above methods in order to reduce the detection limits for plutonium by bulk analysis to the sub-femtogram range per sample; to improve the sensitivity and accuracy of particle analysis data provided by SEM/EDX, SEM/WDX and LG-SIMS; to develop age-dating methods for plutonium and uranium particles and to improve the sensitivity and timeliness of screening methods.

The task EC B 1752, "Training on Mass Spectrometry and Other Analytical Techniques". The task's title was changed from "Mass Spectrometry Training" at the April 2013 European Commission (EC) annual support programme meeting. The on-going activities will continue for the foreseeable future in collaboration with the (IRMM) that has expertise in highly accurate and precise thermal ionization mass spectrometry (TIMS) and the Institute for Transuranium Elements (ITU) in Karlsruhe, Germany, that has expertise in TIMS, ICP-MS and SIMS, including LG-SIMS.

Under task FRA A 1565, "Technical Support for ICP-MS Measurements", IAEA staff will be trained at a French laboratory of the Comissariat à l'Energie Atomique et aux Energies Alternatives (CEA) in the highly sensitive measurement of uranium and plutonium by ICP-MS.

Task USA A 1081 "Support to SAL (A.223)" will continue to be used in 2014 – 2015 to train new IAEA staff from the ESL in techniques appropriate to clean-room laboratories and for the selective and efficient separation of uranium, plutonium, and americium from environmental samples.

Task JPN 1845 "Sample Preparation for Particle Analysis" involves the development of improved methods of sample preparation for LG-SIMS analysis. Various methods will be tested to improve the efficiency and cleanliness of planchet preparation and the results will be transferred to IAEA staff for implementation.

Task USA A 1909 "Sample Preparation for Particle Analysis (A.289)" involves development of new methods of sample preparation for LG-SIMS analysis. A prototype for sample preparation using electrostatic precipitation

of particles from environmental swipes was developed and transferred to the ESL. The instrument is currently being tested for its efficiency and effectiveness.

ESL staff are actively involved in developing and implementing techniques and methods to identify uranium and plutonium containing particles, so-called particles of interest (POI), in a matrix of non-nuclear material (Internal Activity #1). To differentiate POI from the non-nuclear matrix, methods such as alpha-radiography and fission tracks will be used. Both methods require that particles are spread over a plastic tracketch film and fixed in their position in a layer of solution, e.g. collodion. Tracketching of the film, after either passive exposure to particles comprising plutonium (alpha-tracks) or after active irradiation with thermal neutrons to induce fission of $^{235}U$ (fission tracks), will reveal plutonium and uranium- containing particles. These can then be removed selectively by cutting the area of interest around the particle using the laser micro-dissection (LMD) system and transferred for instrumental analysis using mass spectrometry.

Task JPN A 1679 "Age Determination of Uranium and Plutonium Particles (JPN JC-21)" is for the development of methods to measure radioactive decay products as a means of determining the age of a material since its last chemical purification. Such methods exist for larger samples (milligram amounts), but it is challenging to apply such methods to individual particles (in picogram to nanogram amounts). The age-dating of plutonium particles using $^{241}Am$ in-growth has been demonstrated, but the age-dating of uranium -particles using $^{230}Th$ or $^{231}Pa$ in-growth requires extreme sensitivity and is not yet possible. Presently, activities are focused on the improvement of the accuracy and precision of plutonium agedating and viable schemes for uranium particle measurements.

Task RUS A 1652 "Age Determination of Uranium and Plutonium Particles" is for the development of methods to measure radioactive decay products as a means of determining the age of a material since its last chemical purification.

Development of laboratory tools in support of environmental sampling implementation and enhancement of the ESL's capabilities is the second key objective of the activities under Milestone 10.2.

The analysis of bulk samples at the sub-femtogram level will be facilitated by the recently installed multi-collector ICP-MS in the ESL. Further development in the chemical separation of the sample and in the maintenance of the cleanliness in the laboratory areas, reagents and labware are needed to take full advantage of the instrument's sensitivity. The production of certified swipe sampling kits has been installed in new rooms in the Clean Laboratory Extension CLE building, providing redundancy and higher cleanliness for this essential activity. Laser ablation ICP-MS will be tested for its sensitivity and ability to provide unique information about particles in a sample including both nuclear (uranium, and/on plutonium) and non-nuclear particles. Improved screening of environmental samples will be accomplished with a re-designed X-ray fluorescence instrument, or by using laser induced breakdown spectroscopy (LIBS).

Task UK A 1776 "Evaluation of Ultra-High Sensitivity Secondary Ion Mass Spectrometry for Environmental Samples" will continue during the initial phase of routine LG-SIMS operations. The collaboration with the United Kingdom's LG-SIMS facility and SIMS experts will aim at improving measurement protocols, data reduction and reporting of LG-SIMS data for safeguards purposes.

Task RUS A 1957 and SWE A 1928 "Support for Large-Geometry Secondary Ion Mass Spectrometry for Analysis of Environmental Samples" complement the previous task UK A 1776. They provide for the collaboration with the Russian LG-SIMS facility at the Laboratory for micro-analysis and the Swedish LG-SIMS facility and its experts. The objective of these tasks is to improve measurement protocols, data reduction, and reporting of LG-SIMS data for safeguards purposes in cooperation with their SIMS experts.

Task GER A 1835 "Feasibility Study of a Pre-screening System Based on Laser Induced Breakdown Spectroscopy (LIBS) for Environmental Samples at the IAEA-SAL (C.41)" involves collaboration with a German laboratory to develop and deliver a prototype screening device to ESL for the detection of isotopically-altered uranium in swipe samples. This would enhance the IAEA's ability to design detailed analysis schemes for samples and would streamline the handling at the selected laboratory (ESL or NWAL).

A femtosecond laser ablation system for the analysis of individual particles using the MC-ICP-MS instrument has been procured in 2011 and funded through extra-budgetary contribution from Germany. The instrument will be delivered to ESL in late 2013. ESL staff will be responsible for the installation, testing and routine operation of this instrument.

A LMD system is being procured for sample preparation of micrometre-sized particles prior to their analysis using mass spectrometry and/or an electron microscope with EDX and WDX spectrometers.

### 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 10. | USA | A 01081 | Support to SAL (A.223) | December 2014 |
| 10.1. | EC | A 01966 | Production of Particle Reference Materials (GER (C.45)) | December 2014 |
| | GER | A 01961 | | December 2014 |
| 10.1. | FIN | A 1543 | Production of Particles for Quality Control of Environmental Analysis | On stand-by |
| 10.2. | FRA | A 01565 | Technical Support for ICP MS Measurements | December 2015 |
| 10.2. | EC | B 01752 | Training on Mass Spectrometry and Other Analytical Techniques | December 2014 |
| 10.2. | GER | A 01835 | Feasibility Study of a Pre-screening System Based on Laser Induced Breakdown Spectroscopy (LIBS) for Environmental Samples at IAEA - SAL (GER (C.41)) | December 2014 |
| 10.2. | JPN | A 01679 | Age Determination of Uranium and Plutonium Particles (JC-21) | December 2015 |
| | RUS | A 01652 | | December 2015 |
| 10.2. | JPN | A 01845 | Sample Preparation for Particle Analysis (JPN (JC-24), USA (A.289)) | December 2015 |
| | USA | A 01909 | | December 2014 |
| 10.2. | RUS | A 01957 | Support for Large-Geometry Secondary Ion Mass Spectrometry for Analysis of Environmental Samples | December 2015 |
| | SWE | A 01928 | | April 2015 |
| 10.2. | UK | A 01776 | Evaluation of Ultra-High Sensitivity Secondary Ion Mass Spectrometry for Environmental Samples (B1(v)) | December 2014 |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 10.2. | 10/ESL-001 | Sample Preparation for Particle Analysis | Outstanding with UK |

## 3.2. In-house Development Activities

*Table 4. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 10.1. | 1 | Identification of Particles of Interest in non-nuclear material matrix | Developing of techniques to identify uranium and plutonium containing particles, so-called POI, in a matrix of non-nuclear material. | December 2015 |

# SGAS-003

## Analysis Support and NWAL Coordination

### Project Manager: Catherine Mansoux — Division: SGAS

### 1. Introduction

Project SGAS-003 aims to develop and implement new or strengthened processes for analysis support and coordination of the IAEA Network of Analytical Laboratories (NWAL) for Safeguards. The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

The IAEA collects nuclear material (NM) and environmental samples during safeguards inspections in order to verify the correctness and completeness of declarations made by Member States on their nuclear activities. NM samples are shipped directly to Seibersdorf, Austria, where the Nuclear Material Laboratory (NML) performs analyses to support the material balance evaluations used to verify Member State declarations of nuclear material holdings. Environmental samples, which focus on the detection of undeclared nuclear materials and activities, are typically delivered to IAEA Headquarters in Vienna. After processing, these are sent for analysis by members of the NWAL. NM samples are primarily analysed to support material balance evaluations to verify Member State declarations of NM holdings, while environmental samples focus on the detection of undeclared nuclear materials and activities. Environmental samples are generally analysed by two complementary analytical methodologies, referred to as bulk and particle analysis. Bulk analysis is performed on the whole sample and determines the total amount of uranium and plutonium as well as their average isotopic composition in the sample. Particle analysis techniques are used to measure the uranium and plutonium isotopic composition of individual particles.

Project SGAS-003 addresses the development, implementation, and enhancement of processes for analysis support and coordination of the NWAL. This project supports the *Long-Term R&D Plan, 2012–2023*, particularly with regard to achieving Capability 10 (*ability to provide analytical services through the NWAL to support foreseen future verification requirements*). More specifically, the project focuses on the utilisation of the expanded NWAL (Milestone 10.1). It also contributes indirectly to achieving Milestone 10.3 (*develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples*). The desirable goal is smooth performance of routine analytical operations, within agreed timeliness and quality targets. The SGAS-003 project is closely related to, and coordinated with projects SGAS-001 "Destructive Analysis for Nuclear Materials", SGAS-002 "Environmental Sample Analysis Techniques" and SGIM-007 "Evaluation of Data from Environmental Sampling and Destructive Analysis".

The NWAL has grown and evolved over time to meet the requirements of the Department of Safeguards and the safeguards analytical community more broadly. Presently, the NWAL consists of the IAEA Safeguards Analytical Laboratories[3] and 20 other qualified laboratories of the Member States and the European Commission. In 2012, the University of Western Australia (UWA) and the Korean Atomic Energy Research Institute (KAERI) in Republic of Korea were qualified for particle and bulk analysis of environmental samples, respectively. In 2013, the IAEA took a step towards expanding the NWAL capacity for conducting NM analysis for accountancy purposes.

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1 http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

2 As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*).

3 The Safeguards Analytical Laboratories (SAL) are composed of the Environmental Sampling Laboratory and Nuclear Material Laboratory at Seibersdorf, Austria, which includes IAEA staff stationed at the On-Site Laboratory in Rokkasho, Japan.

A NM round-robin, using certified reference materials, was conceived and executed in order to make a quality assessment of analytical results. Candidate laboratories for NM analysis qualification were invited to participate. Another inter-laboratory comparison (round-robin) exercise was organized and finalized in 2012 to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to impurity analyses. Improvements have been achieved regarding delays in the receipt, distribution, and analysis of environmental sampling (ES) results as compared to the previous biennium. The past trend of deteriorating timeliness figures has been reversed and the situation has been gradually and constantly improving, due to a collaborative effort between IAEA and its NWAL partners.

End-users are Departmental analysts who receive and evaluate analytical data produced by the NWAL members, Divisions of Operations and ultimately the Department of Safeguards when it comes to drawing safeguards conclusions. During NWAL technical meetings (TMs) or consultant group meetings (CGMs), the community of experts, from all NWAL members, reviews the state-of-the-art for analytical practices, shares information on method improvements towards better quality of safeguards sample analyses, and revises technical objectives for performance monitoring of analytical services.

Various challenges remain to be addressed. Due to the high sample load distributed throughout the NWAL, streamlining of sample distribution among NWAL members and maintaining timeliness of reporting continue to require permanent attention from the IAEA and its partners. Efforts will also continue to monitor and control analytical performance in terms of timeliness and quality and to further strengthen the NWAL quality control programme. In this regard, continued Member State Support Programme (MSSP) support for proficiency testing of NWAL performance and provision of highly specialized certified reference materials remain essential. Finally, new capabilities such as fingerprinting and forensic analysis are under exploration in response to emerging demands. The improvement of existing methods or development of new analytical methods for destructive analysis (DA) of nuclear material and environmental sample analysis are addressed by the projects SGAS-001 and SGAS-002, respectively.

In the 2014-2015 biennium, the SGAS-003 project will:

- Implement the expansion of the NWAL, including completion of on-going qualification of candidate laboratories (December 2015);
- Conduct inter-laboratory comparison exercises and produce new quality control (QC) reference materials (December 2015);
- Deploy the next version of the nuclear material laboratory (NML) Laboratory Information Management System (AIMS 2.0) (September 2014).

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute directly to the long-term attainment of Capability 10 in general, and specifically to meeting the near-term attainment of the Milestones 10.1 and 10.3 identified in the *Long-Term R&D Plan 2012-2023* and captured in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Cap-ability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| **10** | Ability to provide analytical services through the NWAL to support foreseen future verification requirements. | 10.1. Utilise the expanded NWAL, in order to:<br>• Provide external quality control and reference materials.<br>• Provide technical expertise<br>- *Implement the expansion of the NWAL, including completion of on-going qualification of candidate laboratories: December 2015;*<br>- *Conduct inter-laboratory comparison exercises and produce new QC reference materials. December 2015.* | H |
| | | 10.3. Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples.<br>- *Deploy the next version of the NML Laboratory Information Management System (AIMS 2.0). September 2014* | H |

## 4. Activities

Funding and resources for most of the project's development and implementation support activities are provided by MSSPs, which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources.

***Milestone 10.1: Utilise the expanded NWAL, in order to:***
- ***Provide external quality control and reference materials.***
- ***Provide technical expertise.***

The objectives for the NWAL are:

- To supplement the safeguards sample analysis capacity of the IAEA's own Safeguards Analytical Laboratories (SAL);
- To complement the analytical methods performed by SAL;
- To provide external duplication of analysis for selected safeguards samples;
- To provide external quality control (QC) for analysis of safeguards samples;
- To provide certified reference material (CRM) for analytical QC, calibration and uncertainty quantification;
- To provide specialized analytical services that include cutting-edge or costly, specialized techniques that are not routinely requested by safeguards inspectors or data evaluators;
- To provide a network of experts in the analysis of safeguards samples; and
- To provide back-up capacity in the event that SAL is temporarily unable to provide analytical services.

A number of MSSP tasks aim to qualify new laboratories to expand NWAL capabilities and capacities.

- Qualification of Laboratories for Environmental Sample (ES) Analysis:

In the field of ES analysis, provision of additional capacity for particle analysis by fission-track-thermal ionization mass spectrometry (FT-TIMS) and large geometry-secondary ion mass spectrometry (LG-SIMS) is welcome. Based on the current level of analytical requests, there is limited need for additional capacity for bulk analysis beyond the current candidate laboratories.

Tasks ARG A 1154, CPR A 1725 and ROK A 1765, "Qualification of Environmental Network Laboratories", aim to qualify new candidate laboratories under the respective MSSP. Task ARG A 1154 is on stand-by, resulting from the decision to initiate qualification for analysis of heavy water samples (see task ARG A 1906 below). The China Institute of Atomic Energy (CIAE), in the People's Republic of China, is undergoing qualification for particle analysis. KAERI, in the Republic of Korea, received its qualification for bulk analysis in December 2012 and is in the early stage of qualification for particle analysis. These three tasks are expected to be completed at the end of 2014.

Task AUL A 1857 "Qualification of the IAEA's Network of Analytical Laboratories (NWAL) for Particle Analysis of Environmental Samples" was established to qualify the SIMS laboratory at the UWA for particle analysis. Since October 2012, the UWA has been qualified for LG-SIMS particle analysis and an active NWAL member, completing the task. In the 2014-2105 biennium, LG-SIMS particle analysis support will be provided within the framework of Task AUL A 0859 "Analytical Services for Environmental Sampling".

Task CZ A 1631 "Qualification of Environmental Network Laboratories for Bulk Analysis" is the subject task to qualify the laboratory at Nuclear Research Institute Rez plc (UJV Řež) for bulk analysis. The future of this task is pending a decision regarding an exploratory cooperation of UJV Řež with SAL in the area of FT-TIMS. The task will be extended until the end of 2014.

Task HUN A 1834 "Qualification of the IAEA's Network of Analytical Laboratories (NWAL) for Analysis of Environmental Samples and Nuclear Materials" is the subject task to qualify the Centre for Energy Research of the Hungarian Academy of Sciences (MTA) in Budapest for bulk analysis of environmental samples. This task is extended to be completed before the end of 2014.

- Qualification of Laboratories for Nuclear Material Analysis for Accountancy Purposes:

In 2013, the IAEA took a step towards expanding the NWAL capacity for NM analysis for accountancy purposes. Five candidate laboratories participated in a NM round-robin, using certified reference materials, in order to make a first assessment of the quality of analytical results. The NM round-robin was concluded by a TM, held on 26-28 June 2013, which recommended that a second NM round-robin be organized in 2015. It is foreseen that the NWAL component for NM analysis will consist of two groups of laboratories. A core group of laboratories will be able to receive, prepare, and process the safeguards samples for analysis. This group of laboratories will therefore be able to provide QC for the entire measurement process, including sample preparation. A supplementary group will receive samples that have undergone chemical preparation at SAL and are ready for measurement. As such, this second group of laboratories will be able to provide quality control for the final measurement systems only.

Tasks BEL A 1758, FRA A 1479 "Qualification of the IAEA's Network of Analytical Laboratories (NWAL) for Analysis of Nuclear Materials" are the subject tasks to qualify the Studiecentrum voor Kernenergie – Centre d'Etude de l'Energie Nucléaire (SCK-CEN) in Belgium and the Laboratoire d'Analyses Nucléaires Isotopiques et Elémentaires of the Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA-LANIE) in France for NM analysis. Similarly, tasks CAN A 1950, NET A 1974, and USA A 1956 "Qualification of a Laboratory for the IAEA's Network of Analytical Laboratories (NWAL) for Destructive Analysis of Nuclear Materials" are the subject tasks to qualify the Atomic Energy of Canada, Limited (AECL) laboratory at Chalk River in Canada, the Nuclear Research and Consultancy Group (NRG-Petten) in the Netherlands, and the Savannah River Site (SRS) in the USA, respectively, for NM analysis.

Tasks CZ A 1516 and RUS A 1514 "External Quality Control of Analytical Services" are the subject tasks to host contributions from UJV Řež and the Khlopin Radium Institute (KRI) in the Russian Federation, respectively, to the NWAL QC programme for NM analysis, in view of their re-activation as NWAL members.

It is foreseen that most of the above tasks will be extended until the end of 2015 to accommodate participation of the laboratories to the second IAEA NM round-robin exercise.

Task GER A 1960 "Qualification of a Lab for the IAEA's Network of Analytical Labs (NWAL) for Destructive Analysis of Nuclear Materials" is the subject task to qualify Forschungzentrum Jülich (FZJ) in Germany for nuclear material analyses as part of the NWAL. Qualification in this case is in the preliminary stage.

- Qualification of Laboratories for Heavy Water Analysis:

  Task ARG A 1906 "NWAL Qualification for Heavy Water Laboratory" aims to qualify an Autoridad Regulatoria Nuclear (ARN) laboratory as a second NWAL member to perform analysis of heavy water tritiated samples. It is foreseen that this task will be extended to the end of 2014.

- Provision of external QC for analysis of safeguards samples:

  Assuring quality of analytical results through external means (i.e., quality assurance measures beyond internal means prescribed by the specific laboratory's quality management system) is an important tool in maintaining high performance of analytical services across the entire NWAL. This need is of an on-going nature. Some laboratory proficiency testing and inter-comparison programmes are well established, though the specific nature of nuclear material and environmental samples, as well as samples used for fingerprinting/forensics, necessitate new developments in this area.

  Tasks EC A 0267 and FRA A 1100, "Analytical Quality Control Services" focus on proficiency testing of laboratory performance through the distribution of well-characterized materials from the Institute for Reference Materials and Measurements (IRMM, part of the European Commission Joint Research Centre in Geel, Belgium) and the Commission d'Établissement des Méthodes d'Analyse (CETAMA) in France, respectively. Whereas IRMM administers the Nuclear Signatures Inter-laboratory Measurement Evaluation Programme (NUSIMEP) and Regular European Inter-laboratory Measurement Evaluation Programme (REIMEP), CETAMA has various materials (plutonium, uranium, impurities) under the Étude de la Qualité des Résultats d'Analyse dans l'Industrie Nucléaire (EQRAIN) programme. The Department has expressed its need for a CETAMA-organized round-robin on spectral evolution for determination of uranium to plutonium ratios by X-ray fluorescence (XRF), which would be of particular interest for the IAEA On-Site Laboratory in Rokkasho, Japan. Both tasks are of an on-going nature and will be extended until the end of 2015.

  Task USA A 1497 "Analytical Quality Control – Participation of SAL in NBL Safeguards Measurement Evaluation (SME) Programme (A.264)" provides for the IAEA Nuclear Material Laboratory to participate in the SME inter-comparison programme administered by the New Brunswick Laboratory (NBL). The task is of an on-going nature and will be extended until the end of 2015.

  Following the 2013 IAEA NM round-robin exercise and the recommendations of the TM held on 26-28 June 2013, the IAEA plans to organize a second NM round-robin in 2015 (Planned Internal Activity #1).

  An inter-laboratory comparison (round-robin) exercise was organized by SGAS, in cooperation with SGIM, and conducted during 2011/2012 to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to impurity analysis. This exercise served: to identify the analytical capabilities of the participating laboratories and assess the different analytical procedures (i.e., what is current state-of-the-practice); to identify between-laboratory differences and their potential causes; to identify chemical elements that are problematic and/or difficult to analyse with established analytical techniques; to review the associated measurement uncertainties as reported by the laboratories; and to assign consensus values to the two materials for future use for quality control in analysis of impurities in uranium materials. SGAS staff selected samples for the round-robin exercise, performed all necessary analyses, evaluated results submitted by participating laboratories

and issued a final report. SGAS intends to plan a follow-up exercise in the future (Planned Internal Activity #2).

The next bi-annual TM on bulk analysis of environmental samples will take place in November 2014, in coordination with SGIM. It will gather NWAL members with the objective to review the operation of the analytical services provided and to discuss the experience collected in analysing environmental samples, new developments and instrumentation, and related research plans. This edition will also cover gamma spectrometry and other NDA techniques used in the NWAL. A gamma spectrometry round-robin exercise will take place in 2014 (Planned Internal Activity #3). Following a recommendation of the 2012 TM on bulk analysis, the US Department of Energy coordinated in 2013 a bulk analysis inter-laboratory comparison exercise. Results will be reported in October 2013. Organization of a new bulk analysis inter-laboratory comparison exercise in 2015 will be considered (Planned Internal Activity #4).

The bi-annual TM on *Particle Analysis of Environmental Samples for Safeguards* took place in November 2013. It included a session on particle QC reference materials and a LG-SIMS workshop. A following TM in ES particle analysis will be scheduled in 2015 in coordination with SGIM.

s Figure 1. CRM 126-A, Plutonium metal assay CRM used to produce large-size dried (LSD) spikes.

- <u>Provision of certified reference materials (CRMs) for analytical QC:</u>

The availability of highly specialized CRMs is the cornerstone of analytical QC. They are necessary for proper instrument calibration, traceability to the International Organization for Standardization (ISO) standards, measurement control and uncertainty quantification.

The following tasks serve to provide special reference materials for quality assurance of analytical performance as well as special source materials for production of secondary reference materials, mostly large-size dried (LSD) spikes, for the IAEA Nuclear Material Laboratory:

Tasks EC A 0318, FRA A 1101, RUS A 0491, "Special Reference and Source Materials for DA" provide such materials from IRMM, CETAMA and KRI, respectively. These tasks are of on-going nature and will be extended until the end of 2015. In particular, RUS A 0491 will be exploited to certify 20 g of high-enriched uranium $U_3O_8$ for use in the NML as a quality control standard and for the production of LSD spikes.

Task USA A 1496 "Traceability of DA Measurements – Provision of NBL Certified Reference Materials (A.263)" provides well-characterized reference materials from NBL. The task is of on-going nature and will be extended until the end of 2015.

Task USA A 0909 "Separation of Plutonium Isotopes for the Production of High Purity Spike Reference Materials (A.202)" aims to provide Plutonium isotopes for subsequent separation of $^{244}$Pu as a secondary reference material as high purity spike. The task is expected to be completed in 2014.

There will be a continuing need for uranium materials with high precision minor isotope composition, plutonium materials with high precision isotopic composition, and production of uranium-plutonium LSD spikes. In addition, there is a growing need for new reference materials to meet evolving safeguards requirements: reference materials for trace element characterization of uranium, environmental reference materials, especially for particle analysis, reference materials for material age-dating techniques, heavy water reference materials, and others as safeguards needs evolve. Of particular importance is the provision of highly specialized, certified reference materials, suitable for forensics-type analysis (New Task Proposal #1).

A TM on Reference Materials for Destructive Analysis in the Nuclear Fuel Cycle will be organized in September 2014. The meeting will aim to verify the range of nuclear CRMs in use throughout the industry and by safeguards laboratories. It will also review the availability of the most essential nuclear CRMs, identify potential gaps and prioritize needs. Recommendations are expected to be produced to facilitate the near and medium-term supply and development of nuclear CRMs.

In addition, the provision of QC materials to cover specific needs for quality control swipes containing uranium, plutonium and mixed uranium/plutonium particles also constitutes a key achievement target of project plan SGAS-002 under Milestone 10.1 and is detailed in SGAS-002 project plan.

**Capability 10: Ability to provide analytical services through the NWAL to support foreseen future verification requirements**

A number of implementation tasks are used to channel the continuous support provided by MSSPs in the field of analytical services. These tasks are of an on-going nature and will be extended until the end of 2015.

Task AUL A 0859, "Analytical Services for Environmental Sampling", deals with specialized aspects of employing accelerator mass spectrometry (AMS) at the Australian Nuclear Science and Technology Organization (ANSTO) for the bulk analysis of environmental swipe samples. The task will also be used to host UWA support for ES particle analysis by LG-SIMS.

Tasks RUS X 1515 and UK X 1045 "Analysis of Environmental Samples Supplied by IAEA" aim to support requests for bulk analyses at KRI and particle analyses at the Laboratory for Microparticle Analysis (LMA) in the Russian Federation, as well as particle analyses at the Atomic Weapons Establishment (AWE) in the United Kingdom, respectively.

Task UK C 1742 "Implementation Support to SGAS" offers the framework for provision of *ad hoc* implementation support, in the form of individual requests. The task aims to facilitate communication and technical exchanges between experts from the UK and the Safeguards analytical laboratories.

To cover the costs of NWAL analyses, the IAEA pays a fixed amount for each type of sample and analysis. Tasks EC X 1969 and FRA X 1941 offer the administrative vehicles to account for supplementary funds made available by the EC and French Support Programmes to cover the costs of analysis of safeguards samples.

[s] Figure 2. Type A containers for shipment of liquid and solid samples

***Milestone 10.3: Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples.***

- Development of new software constituting the Laboratory Information Management System (LIMS) of the IAEA Nuclear Material Laboratory:

  The upgrade of the LIMS, used by the NML for its daily operations, has been necessary and is contributing directly to the NML mission, delivering quality and timely analytical results to the safeguards data evaluators. This development work is supported by tasks USA D 1523 and USA D 1934.

  Task USA D 1523 "Software Development Support: LIMS for the SAL (D.156)" successfully implemented re-engineering and transition of the LIMS to a modern platform and delivery of version 1.0 of the Advanced Information Management System (AIMS) software on time and within budget. This task will be completed in 2014.

  Task USA D 01934 "AIMS 2.0 Development Project" aims to provide the next release of software constituting the NML LIMS, with additional functionalities and enhancement of the existing ones. This task will enable the system to be ported to .NET[4] to guarantee long-term maintainability and to accommodate reference material integration, advanced report management and versioning, bar code integration and automated result incorporation. Furthermore, consolidation of the system and database architecture is being accomplished. The task has been progressing as planned and is expected to be completed in September 2014.

[4] The .NET Framework is a software framework developed by Microsoft. It was selected by SGIS as the standard platform for software development in the Department of Safeguards. It provides interoperability across several programming languages. Programs written for the .NET Framework execute in a software environment, known as the Common Language Runtime (CLR), an application virtual machine that provides services such as security, memory management, and exception handling. The .NET Framework is constituted by the CLR itself and a foundation of components (class library) providing user interface, data access, database connectivity, cryptography, web application development, numeric algorithms, and network communications.[4]

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 10.1. | ARG | A 01154 | Qualification of Environmental Network Laboratories | Task on stand-by |
| | CPR | A 01725 | | December 2014 |
| | ROK | A 01765 | | December 2014 |
| 10.1. | ARG | A 01906 | NWAL Qualification for Heavy Water Laboratory | December 2014 |
| 10.1. | AUL | A 01857 | Qualification of the IAEA's Network of Analytical Laboratories (NWAL) for Particle Analysis of Environmental Samples | Work completed[5] |
| 10.1. | BEL | A 01758 | Qualification of the IAEA's Network of Analytical Laboratories (NWAL) for Analysis of Nuclear Materials | December 2015 |
| | FRA | A 01479 | | December 2015 |
| 10.1. | CZ | A 01631 | Qualification of Environmental Network Laboratories for Bulk Analysis | December 2014 |
| 10. | EC | X 01969 | Analysis of Environmental and Nuclear Samples Supplied by IAEA | On-going task |
| 10.1. | FRA | A 01100 | Analytical Quality Control Services | On-going task |
| 10. | FRA | X 01941 | Support for Environmental Sampling and Destructive Analysis | On-going task |
| 10.1. | HUN | A 01834 | Qualification of the IAEA's Network of Analytical Laboratories (NWAL) for Analysis of Environmental Samples and Nuclear Materials | December 2014 |
| 10. | RUS | X 01515 | Analysis of Environmental Samples Supplied by IAEA (UK A5(b)) | On-going task |
| | UK | X 01045 | | On-going task |
| 10. | UK | C 01742 | Implementation Support to SGAS (B1(t)) | On-going task |
| 10.1. | USA | A 01496 | Traceability of DA Measurements – Provision of NBL Certified Reference Materials (A.263) | On-going task |
| 10.1. | USA | A 01497 | Analytical Quality Control – Participation of SAL in NBL SME Programme (A.264) | On-going task |
| 10.1. | CAN | A 01950 | Qualification of a Laboratory for the IAEA's Network of Analytical Laboratories (NWAL) for Destructive Analysis of Nuclear Materials (USA (A.293), GER (C.43)) | December 2015 |
| | NET | A 01974 | | December 2015 |
| | USA | A 01956 | | December 2015 |
| | GER | A 01960 | | December 2015 |
| 10. | AUL | A 00859 | Analytical Services for Environmental Sampling | On-going task |
| 10.1. | CZ | A 01516 | External Quality Control of Analytical Services | December 2015 |
| | RUS | A 01514 | | December 2015 |
| 10.1. | EC | A 00267 | Analytical Quality Control Services | On-going task |
| 10.1. | EC | A 00318 | Special Reference and Source Materials for DA (MT10a) | On-going task |
| 10.1. | FRA | A 01101 | Special Reference and Source Materials for DA | On-going task |
| 10.1. | RUS | A 00491 | Special Reference and Source Material for Destructive Analyses (A25) | On-going task |

[5] In the 2014-2105 biennium, LG-SIMS particle analysis support will be provided within the framework of Task AUL A 0859 "Analytical Services for Environmental Sampling".

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 10.1. | USA | A 00909 | Separation of Plutonium Isotopes for the Production of High Purity Spike Reference Materials (A202) | December 2014 |
| 10.3. | USA | D 01523 | Software Development Support : LIMS for the SAL (D.156) | To be completed in 2014 |
| 10.3. | USA | D 01934 | AIMS 2.0 Development Project (D.156.04) | September 2014 |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 10.1. | New Task Proposal #1 | Provision of certified reference materials suitable for forensics-type analysis | To be submitted in 2014 |

*Table 4. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 10.1. | 1 | IAEA NM round-robin exercise | Inter-laboratory comparison exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to NMA analysis. | December 2015 |
| 10.1. | 2 | IAEA impurity round-robin exercise | Inter-laboratory comparison exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to impurity analysis. | December 2015 |
| 10.1. | 3 | Gamma spectrometry round-robin exercise | Inter-laboratory comparison exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to gamma spectrometry. | December 2014 |
| 10.1. | 4 | Bulk analysis round-robin exercise | Inter-laboratory comparison exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to bulk analysis of environmental samples. | December 2015 |

# SGCP-003

## Safeguards Approaches

### Project Manager: Masato Hori — Division: SGCP

### 1. Introduction

This section of the document describes the Department's plans to further elaborate and develop safeguards concepts and approaches for the period 2014–2015. Project SGCP-003 will serve to help fully implement the State-level concept (SLC). This project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

Project SGCP-003 addresses the development, demonstration, implementation, and enhancement of safeguards concepts and approaches. This includes development of safeguards policy, guidelines and processes to more fully implement the State-level concept. The project supports the *Long-Term R&D Plan, 2012–2023,* particularly with regard to achieving Capabilities 1, 2, 3, 4, 11 and 12 (see Table 1 for full capability descriptions).

Over recent years, progress has been made in the development of methodologies supporting new safeguards approaches for specific facility types and general improvements made regarding the overall effectiveness and efficiency of safeguards implementation. As part of this project, there has been an on-going effort by the Department of Safeguards to prepare guidance towards safeguards implementation that is oriented more towards a 'State as a whole' approach.

Toward this end, valuable contributions related to the development and testing of innovative safeguards concepts, guidelines and approaches have already been provided by Member States through the Member State Support Programmes (MSSPs). These contributions continue to be essential to the project's ability to meet Department expectations.

End-users are primarily inspection divisions carrying out safeguards activities.

In the 2014-2015 biennium, the project will:

- Develop guides for performing acquisition path analysis (APA), developing State-level approaches (SLAs) and developing annual implementation plans (AIPs) (December 2014);
- Develop approaches to more fully utilize the technical capability of State or regional authorities responsible for safeguards implementation (SRA) and State findings (December 2015);
- Develop detailed guidance on safeguards implementation practices that make safeguards implementation more effective and efficient (December 2015); and
- Update the Physical Model to improve its completeness and usability (December 2015).

### 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute to the long-term attainment of Capability 1 (*ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards*), Capability

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

2 (*increased ability to detect undeclared nuclear material and activities*), Capability 3 (*ability to safeguard new types of facility*), Capability 4 (*ability to provide credible assurances that nuclear material used in non-proscribed military activities, specifically naval propulsion, is not used for the production of nuclear weapons or other nuclear explosive devices*) and Capability 12 (*ability to take on technical challenges and opportunities, and emerging tasks*) in general, and specifically to meeting the near-term attainment of milestones identified in the *Long-Term R&D Plan 2012-2023* as summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Cap-ability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| 1 | Ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards. | 1.2. Prepare additional guidance for the on-going development of State-level safeguards approaches:<br>• The use of State-specific factors<br>• Acquisition path analysis<br>• The specification of options for Headquarters and in-field activities required to meet the technical objectives<br>• The link between the State evaluation process and development of SLAs[1] and AIPs[2]<br>*Issue the guidance documents for performing APA and developing SLAs and the guidance document for producing AIPs* [2014]. | H |
| | | 1.3. Develop additional tools to support the development of State-level safeguards approaches:<br>• The analysis, representation, and prioritization of acquisition paths<br>• The planning of safeguards activities<br>• The assessment of overall safeguards effectiveness<br>• The determination of technical objectives<br>*Develop templates, software tools and reference material to support development of SLAs* [2015]. | M |
| | | 1.4. Develop approaches to more fully utilize SRA data and verification findings, where appropriate, to achieve efficiencies.<br>*Identify approaches which will enable the Agency to assess and more fully utilize the technical capability and verification findings of the SRA* [2015]. | H |
| | | 1.5. Develop safeguards guidance for States, including web-based versions, addressing topics such as:<br>• Regulatory authority<br>• Design information<br>• Inspections and complementary access<br>• Imports and exports<br>*Develop and publish detailed guidance on safeguards implementation practices: on facilitating IAEA verification activities and establishing State infrastructure* [2014]; *provision of information to the IAEA and undertaking collaborative approaches to safeguards implementation* [2015]. | H |
| 2 | Increased ability to detect undeclared nuclear material and activities. | 2.3. Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.<br>*Update Physical Model* [2015]. | M |

| Cap-ability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| 3 | Ability to safeguard new types of facility. | 3.1. Develop generic safeguards approaches for:<br>• Pyro-processing plants<br>• Other new reprocessing technologies<br>• Laser enrichment plants<br>• Other new enrichment technologies<br>• Small modular and/or Gen IV reactors<br>*Develop a safeguards approach and supporting measures for a specific pyro-processing facility. Draft a Safeguards Technical Report for safeguarding generic pyro-processing plants* [2015]. | M<br>L<br>M<br>L<br>M |
| | | 3.2. Develop tools and techniques to characterize:<br>• Fissile content in metal mixtures containing the actinides Np, Am and Cm during pyro-processing<br>• Fuel types for Gen IV reactors containing minor actinides<br>• Seismic signals in geological repositories<br>• Soon-to-be difficult-to-access nuclear material<br>*Hold the annual Experts Group meetings for Application of Safeguards to Geological Repositories (ASTOR) to facilitate development of equipment and technologies for safeguarding geological repositories and encapsulation plants* [2014 and 2015]. | M<br>L<br>M<br>M |
| | | 3.4. Develop a mechanism to enable safeguards to be considered early in the facility design process.<br>*Issue safeguards-by-design documents for conversion, fuel fabrication, spent fuel management, enrichment and reprocessing plants* [2014]. | M |
| 4 | Ability to provide credible assurances that nuclear material used in non-proscribed military activities, specifically naval propulsion, is not used for the production of nuclear weapons or other nuclear explosive devices. | 4.1. Consult with Member States with established naval nuclear propulsion programmes for development of future verification arrangements in this area.<br>4.2. Develop concepts, tools, and measures to enable the IAEA to design a verification approach for nuclear material destined for, and returned from, naval propulsion<br>4.3. Develop an approach to provide credible assurance that nuclear material being used in naval propulsion is not used for the production of nuclear weapons or other nuclear explosive devices<br>*Consult with Member States with established naval nuclear propulsion programmes to identify challenges and develop possible solutions relevant to development of concepts and tools for development of future verification arrangements in this area [2015].* | H<br>M<br>M |
| 12 | Ability to take on technical challenges and opportunities, and emerging tasks. | 12.1. Assist with Chernobyl, Fukushima and DPRK related activities as requested.<br>*Identify action items and best approaches for effective and efficient safeguards for fuel debris in Fukushima-Daiichi* [2015]. | M |

## 4. Activities

In order to achieve the milestones of the project, the following activities have been identified. Many of these activities will be performed by Safeguards Department personnel. However, some assistance will be required from Member State Support Programmes (MSSPs). The activities under this D&IS project will be coordinated with other projects, such as SGCP-102 *Training*, SGIM-003 *Open Source Analysis*, SGIS-001 *Integrated Analysis*, and SGTS-008 *Instrument Technology Foresight*.

***Capability 1: Ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards.***

Tasks AUL 01208 (*Re-Examination of Basic Safeguards Implementation Parameters*), GER 1473 (*Development of Techniques to Estimate the Separative Capacity of R&D Isotope Separation Installation*), JPN 01922 (*Support for Implementation of the State-Level Concept beyond Integrated Safeguards*), and USA 01134 (*Consultant - Services*

*Safeguards Issues*) are currently inactive. However, they remain open as it is anticipated that each shall be used for a specific purpose in the 2014-2015 biennium.

***Milestone 1.2: Prepare additional guidance for the on-going development of State-level safeguards approaches.***

There has been an on-going effort to prepare additional guidance for the development of State-level approaches in order to evolve safeguards implementation by making greater use of 'State as a whole' considerations (Figure 1: Process supporting safeguards implementation). Preliminary guides to perform APA, develop SLAs and produce AIPs have been drafted. During 2014, these guides will be refined and finalized based on feedback from State Evaluation Groups (SEG). The outcomes of the MSSP Joint Task (JNT C 1871 EC, FRA, GER, HUN, UK, USA, Task Proposal 10/CCA-004) pertaining to acquisition path analysis methodologies and software packages will be incorporated, as appropriate, into departmental guides.

***Milestone 1.4: Develop approaches to more fully utilize SRA data and verification findings, where appropriate, to achieve efficiencies.***

Several years of experience gained from safeguards implementation and coordination with SRAs (like EURATOM through the new partnership approach) have provided a solid foundation for developing innovative concepts to make fuller use of the reports and findings of SSACs/RSACs.

Based on the experience, the IAEA will consider how enhanced cooperation could be factored into the development of approaches for evaluating, planning and implementing safeguards.

During the next two years, the IAEA plans to explore ways to assess and more fully utilize the technical capabilities and verification findings of the SRA.

***Milestone 1.3: Develop additional tools to support the development of State-level safeguards approaches:***

A joint MSSP task to support these efforts began in 2011 with the aim of determining which methods could most effectively be applied to acquisition path analysis (APA) and State-level approach development (JNT C 1871 EC, FRA, GER, HUN, UK, USA, Task Proposal 10/CCA-004).

The IAEA is planning to hold a workshop in the first quarter of 2014 to consolidate and share the results of these MSSP activities and Agency's developments with regard to the APA guidance. Based on the workshop proceedings, future steps and activities for tools to support APA will be identified and developed.

***Milestone 1.5: Develop safeguards guidance for States, including web-based versions, addressing topics such as:***

- Establishing State infrastructure to facilitate safeguards implementation, including legislative framework and State authority;
- Provision of information to the IAEA (reports, declarations, design information and import/export information);
- Facilitating and supporting IAEA activities in the field;
- Undertaking a collaborative approach to safeguards implementation;

To facilitate the cooperation between the IAEA and States in safeguards implementation, and to improve States' understanding and performance, the IAEA is preparing a new "Safeguards Implementation Practices" (SIP) series of guides.

The first SIP addresses States' implementation practices to facilitate IAEA verification activities. The second SIP addresses the establishment of State infrastructure to implement safeguards. The third

SIP covers all aspects of providing information to the IAEA. The fourth SIP addresses practices to take collaborative approaches to safeguards implementation. Experts meetings have been held with representatives from States to identify needed input, prepare input, review draft documents and provide feedback. Experts from States are contributing substantially to the development of the implementation practices by sharing their experiences and lessons learned that are relevant to each topic, and by reviewing the drafts and providing feedback (JNT C 1959). The first two SIP Guides were prepared in 2013 for publication in 2014, and the second two documents will be prepared in 2014 for publication in 2015.

***Capability 2: Increased ability to detect undeclared nuclear material and activities.***
***Milestone 2.1 Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.***

The Physical Model serves as a technical resource for IAEA personnel involved in safeguards activities such as State evaluation, acquisition path analysis and State-level approach development, and training. The PM needs to be updated to ensure it remains current and also so that it is well organized and accessible in a manner that facilitates its use. The IAEA will update the Physical Model to improve its completeness and usability.

***Milestone 3.1: Develop generic safeguards approaches for:***

- ***Pyro-processing plants***
- ***Other new reprocessing technologies***
- ***Laser enrichment plants***
- ***Other new enrichment technologies***
- ***Small modular and/or Gen IV reactors***

Task ROK C 1761 started in 2008 to develop a safeguards approach for a model pyro-processing facility. The IAEA has been discussing with Republic of Korea (ROK) the possibility of identifying additional tasks to address specific pyro-processing facilities in ROK.

Task JNT C 01953 was started in 2012 to keep the IAEA informed and involved about safeguards R&D activities related to pyro-processing carried out by a Safeguards and Security Working Group (SSWG) under the ROK/US Joint Fuel Cycle Study (JFCS). This work between ROK and the USA is being performed in close co-operation with various divisions within safeguards (SGAS, SGCP, SGIM, SGTS and SGOA).

Using the outcome of these tasks, the IAEA plans to develop a Department wide approach for safeguarding future pyro-processing facilities. Separate Member State Support Programme tasks (Task Proposal 10/CCA-005, EC C 01917, FRA C 01943, JPN C 01962 and ROK C 01885) have been established with the goal of producing a Safeguards Technical Report (STR) for safeguarding generic pyro-processing plants within the next two years.

***Milestone 3.2: Develop tools and techniques to characterize:***

- ***Fissile content in metal mixtures containing the actinides Np, Am and Cm during pyroprocessing***
- ***Fuel types for Gen IV reactors containing minor actinides***
- ***Seismic signals in geological repositories***

The Experts Group for Application of Safeguards to Geological Repositories (ASTOR) was established as a joint MSSP task (JNT C 1611 BEL, CAN, CZ, EC, FIN, FRA, GER, HUN, NET, ROK, RSA, SWE, USA) to provide recommendations to the IAEA regarding the application of safeguards to geological repositories.

The model safeguards approaches for spent fuel conditioning plants and geological repositories has been discussed at ASTOR meetings. On-going development of the safeguards equipment and

technologies applicable to the facilities such as seismic monitoring, virtual containment and quantitative measurements, will be reviewed and discussed under the framework of ASTOR.

***Milestone 3.4: Develop a mechanism to enable safeguards to be considered early in the facility design process.***

The concept of safeguards-by-design (SBD) is an approach where international safeguards considerations are fully integrated into the design process of a new nuclear facility.

In 2008, the IAEA enlisted the cooperation of Member States in promoting SBD through the Support Programme structure (Tasks ARG C 1770, BEL C 1746, BRZ C 1767, CAN C 1739. CPR C 1748, EC C 1726, FIN C 1829, FRA C 1792, GER C 1780, JPN C 1738, ROK C 1724, UK C 1755, and USA C 1734). With the help of these Support Programmes, as well as the programmes in other IAEA Departments that inform embarking States about nuclear power, consideration of safeguards is gaining a presence in the designer/operator community as those stakeholders become aware of the legal requirements for safeguards, the equipment installation aspects and the potential to reduce overall nuclear construction project risk.

Supporting the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), the Department of Safeguards provides expertise and guidance for developing and testing a "Proliferation Resistance Assessment Methodology." In addition, coordination with INPRO and the Departments of Nuclear Energy and Technical Cooperation offer other chances to exchange information on safeguards considerations with other stakeholder groups. During the next two years, INPRO will issue a revision to its Nuclear Energy Self Assessment (NESA) tool for use by States interested in the sustainable use of nuclear energy. This tool will help promote early and comprehensive consideration of safeguards in new nuclear facilities by States and vendors.

***Capacity 4: Ability to provide credible assurances that nuclear material used in non-proscribed military activities, specifically naval propulsion, is not used for the production of nuclear weapons or other nuclear explosive devices.***

***Milestone 4.1: Consult with Member States with established naval nuclear propulsion programmes for development of future verification arrangements in this area.***

There is a need in the foreseeable future to assure that nuclear material used in non-proscribed military activities, specifically naval propulsion, is not used for the production of nuclear weapons or other nuclear explosive devices.

To improve the preparedness to apply a verification approach for nuclear material destined for, and removed from naval propulsion, IAEA will consult with Member States with established naval nuclear propulsion programmes to identify challenges and develop possible solutions related to future verification arrangements in this area.

***Capacity 11: Ability to deal with new mandates.***
***Milestone 11.1: Develop options and approaches for possible future mandates as required or requested (e.g. fissile material cut off treaty, arms control) that respect sensitive and proprietary information.***

The Agency has been monitoring general nuclear disarmament discussions and provided technical support to discussions on the verification of the Fissile Material Cut-off Treaty (FMCT).

In accordance with the formal request received from the authorities of USA and the Russian Federation, the Department of Safeguards actively participated in the elaboration of the Russia-US-IAEA agreement defining verification measures to be performed by the IAEA under the U.S.-Russia Plutonium Management and Disposition Agreement (PMDA). This task is coordinated with project SGTS-015 Technologies for new IAEA verification mandates.

During the 2014–2015 period the IAEA, when requested, will contribute to technical studies on the verification of an FMCT and will continue to participate in efforts to develop verification schemes as requested under the PMDA.

***Capacity 12: Ability to take on technical challenges and opportunities, and emerging tasks.***
***Milestone 12.1: Assist with Chernobyl, Fukushima and DPRK related activities as requested.***

The IAEA and Japan has established the Fukushima Task Force (TF) to develop a holistic approach to safeguards implementation at the Fukushima Dai-ichi site (primarily units 1, 2, 3 and 4) due to the exceptional conditions of that site after the March 2011 earthquake and tsunami. This will require measures to maintain knowledge of nuclear material and a detailed characterization plan to allow for the verification of nuclear material, to the extent practical, as part of decontamination and a decommissioning work and to establish nuclear material accountancy during the overall environmental clean-up.

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 1. | AUL | C 01208 | Re-Examination of Basic Safeguards Implementation Parameters | End 2014 |
| 1. | GER | C 01473 | Development of Techniques to Estimate the Separative Capacity of R&D Isotope Separation Installation (A.33) | End 2014 |
| 1. | JPN | C 01922 | Support for Implementation of the State-Level Concept beyond Integrated Safeguards (JA-17) | February 2015 |
| 1. | UK | C 01265 | Conceptual Development Support for Integrated Safeguards (A7(e)) | End 2013 |
| 1. | USA | C 01134 | Consultant - Services Safeguards Issues (Hooper) (F32) | End 2013 |
| 1.2., 1.3. | EC<br>FRA<br>GER<br>HUN<br>RUS<br>UK<br>USA | JNT C 01871 | Acquisition Path Analysis Methodology and Software Package (EC, FRA, GER (B.24), HUN, RUS, UK (A7(k)), USA (C.125)) | End 2014<br>Extension will be discussed at the APA Workshop. |

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 1.5. | AUL<br>BRZ<br>CAN<br>CZ<br>EC<br>FIN<br>FRA<br>GER<br>HUN<br>JPN<br>NET<br>ROK<br>RSA<br>SWE<br>UK<br>USA | JNT C 01959 | Member State Contributions to IAEA Topical Guidance on Safeguards Implementation (AUL, BRZ, CAN, CZ, EC, FIN, FRA, GER, HUN, JPN, NET, ROK, RSA, SWE, UK (A7(I)), USA (C.128)) | End 2015 |
| 3, 3.2. | CAN<br>CZ<br>EC<br>FIN<br>FRA<br>GER<br>HUN<br>NET<br>ROK<br>RSA<br>SWE<br>USA | JNT 01611 | (ASTOR), Group of Experts (BEL, CAN, CZ, EC, FIN, FRA, GER (A.35), HUN, NET, ROK, RSA, SWE, USA (C.118)) | End 2016 |
| 3.1. | EC<br>FRA<br>JPN<br>ROK | C 01917<br>C 01943<br>C 01962<br>C 01885 | Contribution to a Safeguards Technical Report on Pyroprocessing | End 2014 |
| 3.1. | FRA | C 01904 | Consultant - Evaluations Supporting Making the IAEA Safeguards System Fully Information Driven | Stand-by |
| 3.1., 3.2. | ROK<br>USA | JNT C 01953 | Trilateral Safeguards and Security Working Group (SSWG) under the USA/ROK Joint Fuel Cycle Study (JFCS) (ROK, USA (C.127)) | End 2016 |
| 3.1. | ROK | C 01761 | Support for Development of a Safeguards Approach for a Pyro-processing Plant | End 2014 |

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 3.4. | ARG | C 01770 | Guidance for Designers and Operators on Design Features and Measures to Facilitate the Implementation of Safeguards at Future Nuclear Fuel Cycle Facilities (GER (A.43), JPN (JA-15), UK (A7(j)), USA (C.121)) | End 2014 |
| | BEL | C 01746 | | |
| | BRZ | C 01767 | | |
| | CAN | C 01739 | | |
| | CPR | C 01748 | | |
| | EC | C 01726 | | |
| | FIN | C 01829 | | |
| | FRA | C 01792 | | |
| | GER | C 01780 | | |
| | JPN | C 01738 | | |
| | ROK | C 01724 | | |
| | UK | C 01755 | | |
| | USA | C 01734 | | |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 1.2., 1.3. | 10/CCA-004 | Acquisition Path Analysis Methodology and Software Package | Outstanding with BEL. Accepted by EC, FRA, GER, HUN, RUS, UK, and USA. |
| 1.5. | JNT C 1959 | Member State Contributions to IAEA Topical Guidance on Safeguards Implementation | Outstanding with ARG, BEL. Accepted by AUL, BRZ, CAN, CZ, EC, FIN, FRA, GER, HUN, JPN, NET, ROK, RSA, SWE, UK, and USA. |
| 3.1. | 10/CCA-005 | Contribution to a Safeguards Technical Report on Pyro-processing | Outstanding with UK. Accepted by EC, FRA, JPN, and ROK. |
| 3.1. | New task proposal | Field Test of Safeguards Measures and Equipment at Pyro-processing Facilities in ROK | ROK |
| 3.4. | New task proposal | New Safeguards By Design (SBD) task on outreach and workshops using SBD guidance documents | ARG, BEL, BRZ, CAN, CPR, EC, FIN, FRA, GER, JPN, ROK, RSA, UK, and USA. |
| 4. | New task proposal | Investigation on Aspect Relevant to Concept and Tools Development for Nuclear Material used in Naval Propulsion | FRA, RUS, UK and USA |

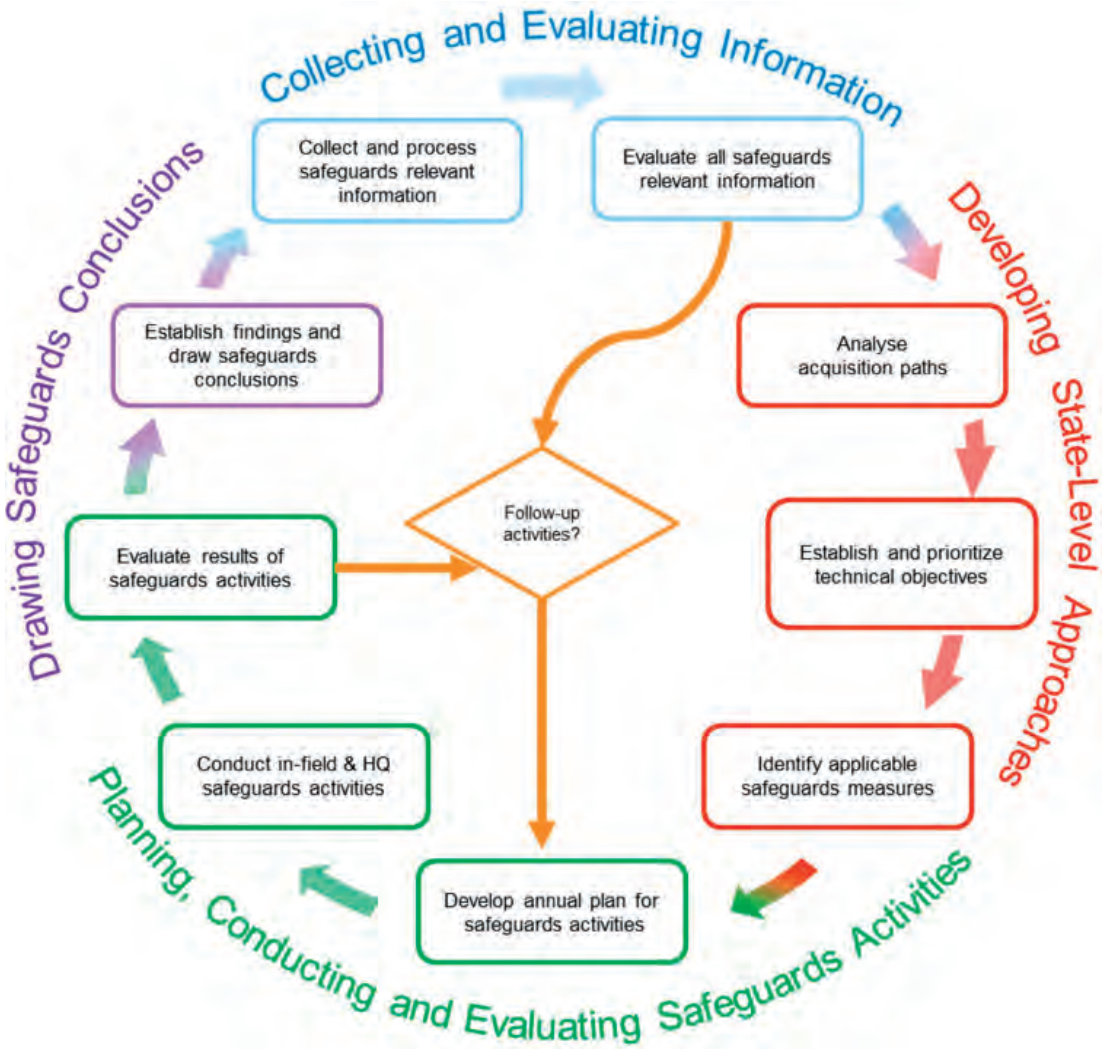
## 4.2. In-house Development Activities

*Table 4. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 1.2. | 1 | Develop and improve the guides to perform APA, develop SLAs and develop annual implementation plans | During 2014, these guides will be refined based on feedback from State Evaluation Groups (SEG). The outcomes of the Member State Support Programme Joint Task (JNT C 1871 EC, FRA, GER, HUN, UK, USA, Task Proposal 10/CCA-004) pertaining to Acquisition Path Analysis Methodologies and Software Packages will be incorporated, as appropriate, into departmental guides | December 2014 |
| 1.4. | 2 | Develop approaches to more fully utilize SRA data and verification findings, where appropriate, to achieve efficiencies | Explore ways in which the Agency may more fully utilize the technical capability and verification findings of the SRA. | December 2015 |
| 2. | 3 | Update Physical Model to improve the completeness and usability | Under take effort to enhance the Physical Model and facilitate its use, with three area of focus:<br>Update Content: bring the information in the Physical Model up to date to include the latest processes and indicators and implement a process through which the Physical Model will continue to be updated as technology develops in the future.<br>Improve Availability: improve the Physical Model structure and make it accessible so that the most up-to-date version can be used by the various databases, systems and uses in the Department that require the information. | December 2015 |
| 12.1. | 4 | Assist with Chernobyl, Fukushima and DPRK related activities as requested. | The IAEA will assess and facilitate applicable safeguards related activities under the Fukushima TF to develop effective and efficient safeguards approach in response to the catastrophic events that occurred at the Fukushima Dai-ichi site. | December 2015 |

*Table 5. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 4.1. | 1 | Consultations with Member States with established naval nuclear propulsion programmes for development of future verification arrangements | Consult with Member States possessing established naval nuclear propulsion programmes to identify challenges and develop possible solutions relevant to development of concept and tools for development of future verification arrangements in this area. | 2015 |




[s] Figure 1: Process supporting safeguards implementation

# SGCP-101

## Quality Management

### Project Manager: Haroldo Barroso Jr — Division: SGCP

### 1. Introduction

Project SGCP-101 aims to develop, implement and enhance processes and methodologies within the scope of the quality management system in compliance with the requirements of the management standard, ISO 9001:2008, within the Department of Safeguards for the period 2014–2015.

The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

As outlined in the Department of Safeguards Quality Policy Statement (see figure 1) the Quality Management System (QMS) provides the framework for accomplishing the objective of drawing soundly-based safeguards conclusions. The QMS, through the implementation of a process-based approach, provides the Department with the necessary tools to measure achievements and progress using relevant and easily-understood indicators and supports the implementation of safeguards by highly and technical competent staff.

The scope of the project includes the development and implementation of a process-based management system that is compliant with ISO 9001:2008. In recent years, the Departmental QMS structure has fully supported the design and development of new processes and activities. Main safeguards processes are being improved in order to support changes in the Department. New and updated process maps and descriptions are under development to reflect the changes.

Safeguards process maps are being used for several purposes in the Department, Supporting the identification of efficiencies and areas for improvement within the scope of safeguards processes and the implementation of the necessary improvements to those processes.

Support was provided to the Department in relation to the new safeguards information management system on two main tasks: design of a system to provide staff with access to safeguards information assets, and the migration of Safeguards data from the mainframe to the new IT environment. These activities will continue also in the 2014-2015 period.

The development of safeguards performance indicators (PIs) is evolving and its implementation will continue in 2014-2015.

The cost calculation methodology is being used also as a decision-making tool for a number of applications within the Department. The effort estimates, used in the cost calculation methodology, have been revised according to the new responsibilities, functions and processes as a result of the changes in the Department. The Corrective Action Report (CAR) system was revised and upgraded to the Condition Report (CR) system. New action-tracking and work-flow software is in development, in partnership with the Safeguards Office of Information and Communication Systems (SGIS).

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

A system to support knowledge retention activities for departing and retiring staff in the Department of Safeguards has been fully established.

A new version of the QMS Document Manager was launched in 2012, providing staff with new resources and tools for access to approved Safeguards documents.

The internal quality audit programme was implemented as anticipated. The Departmental Quality Manager has been assigned as the focal point for Office of Internal Oversight (OIOS) audits and evaluations in the Department of Safeguards.

The end-users of this project range from staff in the Department of Safeguards, the Board of Governors, and States who receive reports on the outcome of the Secretariat's verification and evaluation activities.

Consistent with the scope of Project SGCP-101, this 2014–2015 biennium plan includes both the development of new elements for the management system and the wider implementation and support for the elements developed in 2012-2013.

- The focus of the project over the next biennium 2014-2015 will be on establishing the process-based approach fully within the Department. This involves not only ensuring that processes are adequately defined and have the appropriate documentation, but also implementing measurement systems to monitor process performance and ensuring the Department has the appropriate set of tools and techniques to improve those processes continually. These tools and techniques will be refined as experience is gained in their use.
- The next biennium will be a period of focused improvements as the Department applies the State-level concept to all States with safeguards agreements in force. During the 2014–2015 biennium, the Department will modify existing processes, and develop new ones. As such, the quality management project plan will be adjusted, taking new demands from the Department into consideration.

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute to the long-term attainment of Capability 1 (ability to fully implement the State-level concept for planning, conduct and evaluation of safeguards) in general, and specifically to meeting the near-term attainment of Milestone 1.1 identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Cap-ability | Capability Description | Milestone<br><br>*Key achievement targets for 2014-15:* | Urgency |
|---|---|---|---|
| 1 | Ability to fully implement the State-level concept for planning, conduct and evaluation of safeguards | 1.1. Develop safeguards policy, guidelines and processes to more fully implement the State-level concept.<br>• *Develop and implement Safeguards Process Performance Indicators*<br>• *Prepare and implement the Internal Quality Audit Programme*<br>• *Implement a new condition report tracking system[June 2014]* | H |

## 4. Activities

Activities under this project will contribute directly to achieving Milestone 1.1. Most of the activities will be performed by Safeguards Department staff. Further assistance will be required from Member State Support Programmes for some activities.

*Milestone 1.1: Develop safeguards policy, guidelines and processes to more fully implement the State-level concept*

- **Support to the management review and communication processes**: Activities within Project SGCP-101 will support regular management review, and will communicate the importance of the quality management system to staff, as needed. Regular budget funds and resources are used for these activities, and MSSP support is not envisioned at this time.
- **Monitor the implementation and maturity of the quality management system:** In order to monitor the overall progress in implementing the quality management system, and to help indicate where more effort is required, an assessment is planned for the 2014–2015 biennium. The Department will conduct the assessment of the quality management system's maturity, using ISO 9004:2009 as a reference.
- **Process performance indicators:** The project will develop and implement measurement and analysis systems to provide management with clear identification of trends in Departmental processes, and whether the processes are operating effectively and efficiently. A workshop is planned to support the development activity (CAN C 1978).
- **The Internal Quality Audit (IQA) Programme**: This programme is now an established element of the quality management system, and the audit methodology and capability will be reviewed during the 2014–2015 biennium to better encompass process effectiveness, and to evolve to meet the needs of the Department. The following sub-activities are planned:
  - Audits will be conducted, based on approved plans for 2014 and 2015;
  - The use of other "assessment-like" structures, such as intra-departmental peer reviews and self-assessments, will be reviewed and, if deemed practical, the structures will be developed and implemented.
- **Condition Report (corrective and preventive actions):** The condition report process, which is designed to prevent undesirable events or conditions that have occurred from re-occurring, has been implemented as part of the quality management system. A new Condition Report tracking system is under development to control the implementation of corrective and preventive actions and manage follow-up actions, facilitating the exchange of lessons learned.
- **Documentation and Records Management:** The Department's processes need to have an appropriate set of related documentation (e.g. policies, procedures, forms, etc.). With specific regard to process documentation, the document management system will also continue to be improved and implemented through the following sub-activities:
  - The existing electronic document storage and retrieval system will be further improved based on experience gained;
  - A number of measures will be identified and implemented to ensure that document quality is sustained: ensuring documents have the appropriate information and level of detail; minimizing duplicate or unnecessary documents; ensuring documents are regularly reviewed and kept current; proper metadata are recording; etc.
  - Forms and working papers will be reviewed and updated/redesigned, and electronic forms will be introduced with support from the UK Support Programme ( task UK A 1729 – Technical Manuals and Procedures for SG Instrumentation).
- **Enhance financial transparency and accountability.** The cost calculation model and methodology for calculating safeguards implementation costs, as well as the comparison of costs of safeguards measures, will be validated. It will be modified based on use and experience gained since 2011when the methodology was implemented. This activity is on-going throughout the 2014–2015 biennium, with continued MSSP support (USA F 1808) covering the provision of a consultant to conduct expert periodic reviews of the cost model.

- **SG Processes Mapping.** The SG processes mapping task aims to fulfil internal needs on the availability of detailed information related to the core safeguards processes and the identification of areas for improvement.
- **Knowledge Management:** To ensure that effective knowledge management practices are implemented in the Department, including exchange-of-information enhancement and the establishment of structures facilitating knowledge sharing, Project SGCP-101 activities will focus on the following areas:
  - Project SGCP-101 will continue to implement the knowledge retention program for departing and retiring departmental staff throughout the 2014–2015 biennium. This programme was initiated in the 2010–2011 biennium
  - A knowledge-oriented analysis methodology was applied to the complementary access process in the 2010–2011 biennium (USA X 1892). A similar approach, with possible MSSP support to cover the provision of an expert consultant, could be used to analyse another core process, depending on specific demand from the Department. In this case, a consultant will develop, where appropriate, IT solutions for deficiencies identified during the analysis;
  - Continued provision of support to the IAEA corporate knowledge management project;
  - Establishment of a new procedure in 2014 – 2015 biennium to trigger knowledge management activities one year before staff separation.

### 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 1.1. | CAN | C 1978 | Performance Indicators Workshop | End. 2014 |
| 1.1. | USA | X 1892 | Implementing Departmental "Day to Day" Knowledge Management (KM) Using Practical Experience from a Variety of Experts. | End. 2015 |
| 1.1. | USA | F 1808 | Consultant: Implementing Activity Based Costing (ABC) in the Safeguards Cost Calculation System (F.40) | End 2015 |
| 1.1. | UK | A 1729 | Technical Manuals and Procedures for SG Instrumentation | May 2014 |

### 4.2. In-house Development Activities

The activities listed in table 3 concern the Department's on-going need to maintain and upgrade in-house systems and processes.

*Table 3. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 1.1. | 1 | Implementation Support for the Management System | Implement effectiveness measurements for Safeguards processes, including management review and reporting, key performance indicators, corrective and preventing measures (CARs/CRs), and internal quality audits (IQAs). | On-going activity |
| 1.1. | 2 | Maintain and Enhance Safeguards Documentation and Records Management | Further improve documentation and records management following quality management principles, and upgrade the Safeguards QMS document management system with new features. | On-going activity |

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 1.1. | 3 | Management System Training | Deliver training and advice for quality management tools and techniques. | On-going activity |
| 1.1. | 4 | Developing a Cost Methodology for Safeguards Implementation | Implement and further improve the Safeguards cost methodology. | On-going activity |
| 1.1. | 5 | Support to the Department's Design and Development of New Guidelines and Processes | Review existing Safeguards processes and where necessary design new processes with the support of QM IT tools. This activity aims to ensure that Departmental processes deliver efficient safeguards implementation and adapt to changing environments. | On-going activity |
| 1.1. | 6 | Improved Knowledge Management and Encouragement of Knowledge-sharing. | Further develop the Safeguards Department's knowledge management strategy, and support the Agency's knowledge management activities | On-going activity |

IAEA
International Atomic Energy Agency

Department of Safeguards

# Quality Policy

The international community demands that safeguards conclusions are soundly based; relevant activities, carried out in the field and at Headquarters, must therefore be of the highest quality (effective, timely and efficient). The framework for the Department of Safeguards to accomplish this is the Departmental Quality Management System, which supports the implementation of safeguards by highly trained and technically competent staff.

So as to achieve Departmental objectives in a changing world while maintaining the quality of our work, we will continually strengthen the link between strategies, safeguards implementation and people. In this regard, the ability to measure achievements and progress through relevant and easily-understood indicators will contribute to further improvements.

As everyone's participation is critical to achieve the best outcome, it is vital that managers develop and sustain all staff engagement towards achieving the goals set out in the Departmental policy on quality. Leading by example, communicating expectations, engaging and encouraging staff to maximise their contributions as well as welcoming constructive feedback are managerial skills that are key to meeting the highest quality standards.

Maintaining the highest quality of work within the Department will benefit all of us and further enhance our credibility in the eyes of our stakeholders. This endeavour will succeed through everyone's involvement and commitment at each level and throughout all Divisions and Offices of the Department of Safeguards.

Tero Varjoranta
Deputy Director General
Head of the Department of Safeguards
January 2014

[s] Figure 1: Department of Safeguards Quality Policy Statement, 17 December 2013

# SGCP-102

## Training

### Project Manager: Jean-Maurice Crété — Division: SGCP

### 1. Introduction

Project SGCP-102 aims to develop and implement Training within the Department of Safeguards. The project supports the Department's *Long-Term R&D Plan, 2012–2023*, which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[1], and the key milestones necessary to achieve those capabilities.

### 2. Overview

The rationale underlying the SGCP-102 project is to establish competency profiles for current and future missions and challenges in the area of safeguards, as identified by Departmental long-range strategic planning, and to transfer these competencies to safeguards staff and staff of State Systems of Accounting for and Control of Nuclear Material (SSACs). This is to be achieved through courses built upon a systematic approach to training, emphasizing not only technical competencies but also behavioural competencies, and including an assessment mechanism.

With the developments in safeguards and nuclear fuel cycle related technologies and equipment, the evolution of safeguards implementation focusing on considerations relating to the State as a whole, the expansion of tasks and responsibilities of safeguards staff, particularly inspectors and analysts, training needs have significantly evolved and increased.

In addition, training courses for Member States' staff play an important role in the effectiveness and efficiency of safeguards activities both for Member States and for the IAEA. Reliable SSACs, along with proper administrative, legislative and regulatory systems, are fundamental for States to fulfil their nuclear non-proliferation obligations, while the IAEA greatly benefits from effective and efficient SSACs.

As a result, the safeguards training curriculum needs to be maintained and updated in a continuous and timely process. Three major challenges are:

- Providing safeguards staff with new skills and abilities while maintaining and enhancing existing competencies, particularly in nuclear material accountancy, by taking full advantage of the most advanced training technologies and techniques, as well as best practices accumulated in the Department;

- Offering a balanced training programme to meet the needs of safeguards staff, particularly inspectors and analysts, in the areas of both technical and behavioral competencies; and

- Meeting a very broad range of Member States' needs in establishing and maintaining their SSACs through a relevant set of international, regional and national training courses, taking into account common and specific needs, in particular for States developing nuclear energy.

This is an on-going process, requiring a thorough monitoring of courses' relevance and effectiveness through a robust assessment mechanism and by keeping abreast of latest developments in safeguards-related issues from technical, legal and training methodologies standpoints, through frequent communication and close cooperation with all project stakeholders.

[1] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

As underlined by an Office of Internal Oversight Services (OIOS) programme evaluation report, "Support from Member States has been essential to the safeguards training programme, particularly to host courses involving practical works on nuclear facilities and material. Without this cooperation, safeguards training activities would suffer seriously."

Implementation of an increasing number of international, regional and national SSAC training courses and workshops, and organization of ISSAS (IAEA SSAC Advisory Service) missions during the following two years also requires strong support from Member States on logistical and technical matters.

In the 2014-2015 biennium, the project will :

- Review tasks and activities with respect to the *Long-Term R&D Plan*, 2012–2023, identifying priorities and appropriate training programmes and techniques, and development of training tools;
- Review, update and complement as necessary training courses on information collection and analysis (December 2014);
- Develop training courses and curriculum following guidance documents for implementation of the State-level concept (December 2014);
- Develop materials for more interactive sessions for training SSACs on collecting data and reporting (December 2014);
- Improve and implement procedures for training needs analysis (December 2014);
- Publish nuclear fuel cycle training manuals (December 2015);
- Include interactive training simulations in further development of the pressurized heavy water reactor virtual environment, including an application guide for trainers (December 2015);
- Develop e-learning modules after feasibility studies (Priority for States developing nuclear energy) (December 2015).

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute indirectly to the long-term attainment of Capability 1 *(Ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards)*, Capability 2 *(Increased ability to detect undeclared nuclear material and activities)*, 3 *(Ability to safeguard new types of facility)* and 13 *(Ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s))*, and specifically to meeting the near-term attainment of milestones identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| 1 | Ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards | Develop training courses and curriculum following guidance documents for implementation of the State-level concept. (December 2014). | |

| Capability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| **13** | Ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s). | 13.1. Develop training tools using advanced methods such as virtual reality, immersive learning systems and web-based training:<br>• Develop prototype virtual reality systems, test and evaluate performance<br>• Include immersive learning for all types of fuel cycle facilities<br>• Develop web-based tools for specific safeguards equipment<br>• Develop signal (neutron/gamma) simulators to generate responses from equipment during training<br>• *Publish nuclear fuel cycle training manuals (December 2015);*<br>• *Include interactive training simulations in further development of the pressurized heavy water reactor virtual environment, including an application guide for trainers (December 2015);*<br>• *Improve and implement procedures for training needs analysis (December 2014).* | M |
| | | 13.2. Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility.<br>• *Develop materials for more interactive sessions for training SSACs on collecting data and reporting (December 2014);*<br>• *Develop e-learning modules after feasibility studies (Priority for States developing nuclear energy) (December 2015).* | M |

## 4. Activities

Funding and resources for most of the project's D&IS activities are provided by Member States Support Programmes (MSSPs), which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources. In order to strengthen the ability of the Training Section to apply the "Systematic Approach to Training" and to make full use of new training technologies and techniques, two key activities will be conducted during the biennium:

- Improve and implement procedures for training needs analysis;
- Train the Trainer program to develop trainer capabilities and ensure trainers are up to date with the latest techniques.

***Capability 1: Ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards.***

- Training courses and curriculum following guidance documents for the implementation of the State-level concept will be developed.

***Capability 2: Increased ability to detect undeclared nuclear material and activities.***

- Training needs are normally addressed by the annual Safeguards Departmental Training Programme. However, some new urgent training needs may emerge, which are not covered by planned training courses. A new course must then be designed at short notice, possibly requiring the support from experts or access to nuclear facilities, laboratories or sites from Member States offering different parts of the nuclear fuel cycle. Tasks FIN B 1949 and UK B 1936 provide this necessary flexibility.
- A comprehensive set of training courses on information collection and analysis has been developed and will be complemented or updated as necessary:
  - Training on Export Control Concepts and Standards from International Perspective, USA B 1800,

is a key course, particularly for country officers and analysts. Training for Information Collection and Analysis for Additional Protocol Verification FRA B 1427 has been extremely useful.

- Training on Proliferation Analysis initiated by the AUL SP was successful. The course is organized on a yearly basis and is open to analysts and inspectors. Long-term support is requested through task AUL B 1828.
- A State Evaluation Strategy seminar was developed on internal resources in 2010. This seminar is now a mandatory seminar for staff members of State Evaluation Groups (Activity #1).
- Training for Open Source Information Collection, SWE B 1838, has been updated to be more interactive and to integrate latest developments in web searching tools and techniques. Long-term support is requested.
- Satellite Imagery Training Courses, CAN B 1483 and SWE B 1373, and Specialist Training for IAEA's Imagery Analysts, USA B 1442 and GER B 1456, managed under SGIM-002 project, should continue. The satellite imagery awareness training course focuses on how to take full advantage of satellite imagery for State evaluation and on-site activities, as an integrated training for inspectors and analysts.
- Analytical skills training is an important component of the training curriculum to support capability 2. It is provided by the USA under voluntary contributions.
- Developing Analytical Skills for Safeguards, UK B 1940, aims to provide staff, especially members of State Evaluation Groups, with required individual and collaborative analytical skills for taking advantage of all available information to perform consistency analysis of declared nuclear capabilities of States, to conduct nuclear material acquisition path analysis, and to prepare relevant information collection and processing plans. It is considered that, in order to administer own the analytical processes it uses, the Department should be able to deliver this training with its own resources in the mid-term.
- The objective of Advanced Training on Nuclear Fuel Cycle Facilities to Assist State Evaluation, UK B 1903, is to enable safeguards staff to analyse advanced nuclear sites in a complete and correct manner by making full use of nuclear fuel cycle related indicators. It allows participants to apply knowledge gained and competencies acquired during the Nuclear Fuel Cycle and Indicators training course in the field.
- A training course has been developed with internal resources to provide analysts and inspectors with the necessary knowledge and skills to effectively use the Palantir Workspace. This training is complemented by Nuclear Trade Analysis – Support and Training, FRA B 1768, to develop skills for performing links analysis (data analysis technique used to evaluate relationships (connections) between nodes).
- During Complementary Access (CA) training courses, emphasis is put on definition of CA technical objectives and identification of location for conducting CAs (see below Workshop on Additional Protocol Activities, FIN B 1422, HUN B 1525, USA B 1415, and EC B 1563).

***Capability 3: Ability to safeguard new types of facility.***

***Milestone 3.3: Develop training to reflect the approaches and equipment for safeguarding new types of facility, including consulting with States developing such facilities to help assess what training is required.***

- The pyroprocessing course, USA B 1669, was conducted for the first time in 2007. The task is to be continued in coordination with the development of a safeguards approach for pyroprocessing research and/or facilities.
- Training course on laser isotope separation technology, FRA B 1506, is planned for 2014 and will be part of the long-term planning, in line with the latest developments in this technology. An additional seminar will be developed internally to ensure staff have a basic understanding of the technology and associated safeguards challenges.

*Capability 13: Ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s).*

- Full scope training on safeguards implementation at all types of fuel cycle facilities and technical training involving nuclear material remain the key factors in the process of training inspectors to perform their tasks. It is only possible through MSSPs hosting courses involving practical work on nuclear facilities and material:
  - Nuclear material verification

The basic training in non-destructive assay (NDA) techniques is conducted in the USA with support provided under USA B 0086. This course is mandatory for newly recruited inspectors. An additional course, EC B 1702, developed in coordination with Los Alamos, was originally organized at JRC-Ispra and is being transferred to ITU Karlsruhe due to relocation of nuclear material between these two sites.

The Spent Fuel Training provided under tasks CAN B 1688, FIN B 1435 and SWE B 1709 remains part of the training programme and will be required on a long-term basis. It is now organized on two sites, one for improved Cerenkov viewing device (ICVD) and one for gamma-neutron measurements for a better teaching process, taking full advantage of available material at each site.

A DCVD Partial Defect Test course (SWE B 1933 and CAN B 1930) has been designed to train inspectors from Operations A and also State inspectors from the Japanese State Authority in support of the removal of spent fuel from the Fukushima reactors.

The Advanced Plutonium Verification Course is conducted in the USA with support provided under USA B 0086 and in Russia under RUS B 1719. It is complemented by Plutonium Diversion Detection, EC B 1750, which aims to provide experienced inspectors in charge of coordinating activities at facilities processing or storing plutonium or highly enriched uranium with an integrated set of analytical concepts and practical tools and techniques. The last offering of the course was in 2008. Discussions are taking place with the EC and the US to revive the course.

A set of half-day seminars provides inspectors and analysts with the necessary background for understanding the mathematical rationale underlying safeguards verification strategies and the analytical treatment of quantitative data. It has been developed using internal resources with the support of SGIM (*Activity #3*).

Nuclear Material Solution Accountancy and Verification Training, EC B 0620, and Training on Laser Range Finder, EC B 1844, remain part of the training programme and will be required on a long-term basis.

With approximately 290 unattended and remote monitoring systems currently installed in the field, Training on Remote and Unattended Monitoring, USA B 1337, includes a generic part and a specific part. The course material is being updated to better reflect the new technologies and to incorporate real data sets in the practical exercises. It will be required on a long-term basis, the Training Section taking on more of the responsibility for delivery of the course.

  - Nuclear activities verification

The Comprehensive Inspection Exercise for light water reactors is supported by CZ B 1431, HUN B 1065 and Slovakia, with BEL B 1433 as backup. These courses have been improved by strengthening the complementary access component. The successful completion of the course is mandatory for newly recruited inspectors, after having completed the Introductory Course on Agency Safeguards (ICAS). Two courses per year will be required on a long-term basis.

An Advanced Comprehensive Inspection Exercise at LWRs and CANDU reactors was successfully organized for the first time in 2010 in The Republic of Korea. It is supported by ROK B 1872 and will be required on a long term basis.

The Comprehensive Inspection Exercise at Bulk Handling Facilities is supported by UK B 1751, ROK B 1895 and SWE B 1328. At least two courses are necessary per year on a long term basis.

Design Information Verification Exercise at Bulk Handling Facilities, UK B 1618, remains part of the training programme and will be required on a long-term basis.

Design Information Verification at Research Reactors, JNT B 1757 USA, BEL, CZ, was given in the USA for the first time in 2009. The course is now organized on a yearly basis at Mol in Belgium and is highly appreciated. Given the sensitivity of the topic, this task will be required on a long-term basis.

Limited Frequency Unannounced Access (LFUA) at enrichment facilities, UK B 1797, GER B 1896 and NET B 1852, will be required on a long-term basis. The course was reviewed in 2012 in order to reinforce the participants' understanding of the process flow of nuclear material at a gas centrifuge enrichment plant (GCEP) and the main safeguards features at such a type of facility. The theoretical knowledge of enrichment technology is provided by USA B 1001, Safeguards Training Course on Enrichment Technology. This course remains part of the training programme and will be required on a long-term basis.

Training in Implementation of Safeguards at Centrifuge Enrichment Plants, RUS B 1053, which was reassessed in 2011 in order to avoid overlaps and gaps with other courses on the same topic, took place in 2012 in Angarsk. It is expected to have this course in the future, including lessons learned from the 2012 pilot course.

The IAEA's requirements for Inspector Training for CANDU Facilities, CAN B 1624, have been revised in order to focus on safeguards considerations for CANDU plants and the fuel monitor system.

Training for inspection activities at JNC-1 site facilities organized jointly with the operator and State inspectors, JPN B 1812, focuses on fuel cycle related activities at JNC-1 and relevant safeguards approaches. It will be required on a long-term basis.

Workshop on Additional Protocol Activities, FIN B 1422, HUN B 1525, USA B 1415, and EC B 1563, designed as full scope training for the implementation of complementary access (CA), is based on realistic scenarios jointly developed by the Department and the MSSPs. It has been expanded to train the inspectors on a wide range of facility types and operational situations. Emphasis is also put on the identification, definition and fulfilment of CA technical objectives. EC B 1563 has been revised with the support of ITU Karlsruhe and focuses on CAs at R&D centres. These courses are key courses of the training programme and will be required on a long-term basis.

Technical Visits to Uranium Mines, CZ B 1526, and Training Course on Nuclear Material Accounting in Action, CZ B 1558, should continue.

The Safeguards for Support Staff Training Course is supported by the Czech Republic and Slovakia with visits to nuclear power plants in both countries. This course is a key component of providing all safeguards staff with the same necessary safeguards culture and knowledge. It will be required on a long-term basis.

With regard to reprocessing plants, Familiarization Visit to La Hague for Reprocessing Plant, FRA B 1562, has been conducted successfully in the previous years and should be kept available. The task JPN B 1897 Training on Reprocessing Activities at a Commercial, Engineering or Laboratory Scale from a Safeguards Standpoint provides joint training on small-scale reprocessing activities. The first course took place in Tokai in 2012 and is offered on a yearly basis.

- To complement hard skills training, training courses to develop soft skills are important components of the training programme:
  - Tasks Enhanced Observational Skills, USA B 1446, and Enhanced Communication Skills, USA B 1245, continue to support training for both new and experienced inspectors. The objective is to review and conduct these two courses using internal resources in the mid-term.
  - Training in and evaluation of the necessary soft skills for safeguards activities is a multi-phase joint project currently supported by FRA B 1708 and FIN B 1699. The first phase completed in 2009 under FRA B 1708 consisted of the identification of necessary and existing soft skills for safeguards activities through interviews and surveys. The second phase will consist in designing training courses filling the gaps identified between necessary and existing soft skills. Support has been requested through task proposal 05/TTR-008.
  - A negotiation skills training course is supported by UK B 1874. Its objective is to train all safeguards staff responsible for negotiating safeguards implementation documents, like subsidiary agreements or facility attachments, or for dealing with State authorities on a routine basis.
  - A writing skills course (four sessions per year) has been developed through regular budget (*Activity #2*). Its objective is to enable safeguards staff to report on their activities in a clear, concise and factual manner.
- A "Train the Trainer" programme will be organized to develop trainer capabilities and ensure trainers are uptodate with latest techniques

***Milestone 13.1: Develop training tools using advanced methods such as virtual reality, immersive learning systems and web-based training:***

- ***Develop prototype virtual reality systems, test and evaluate performance***
- ***Include immersive learning for all types of fuel cycle facilities***
- ***Develop web-based tools for specific safeguards equipment***
- ***Develop signal (neutron/gamma) simulators to generate responses from equipment during training***

- The development of computer-based training or virtual reality training tools is a priority in order to take full advantage of modern techniques. Such developments are crucial to make training courses more readily available through e-learning and more interactive through simulation of activities in computerized models of nuclear facilities. A comprehensive computerized PHWR including safeguards features is being developed with the USA under US B 1912. EC B 1876 aims at training facility officers and safeguards technicians in optimizing surveillance systems. ROK B 1907 offers a computerized model of a bulk handling facility for training inspectors on safeguards at this type of facility. These training tools are being integrated into relevant training courses, such as those offered and supported by ROK B 1872, CAN B1624, UK 1903 and ICAS. These tools will also be made available to staff for self-learning, as appropriate.
- The Revision to Nuclear Fuel Cycle Training Manuals, AUL B 1782, FIN B 1900, UK B 1727, and USA B 1772, will make available a set of seven manuals providing to inspectors and analysts a comprehensive technical background on the various steps of the nuclear fuel cycle. A first document was published on "Fuel Fabrication". "Research Reactors, critical assemblies and accelerator driven neutron sources", "Nuclear power plants" and "Reprocessing" are being finalized. This task is supported by US C 1677, Consultant: Development of Safeguards Documentation.

***Milestone 13.2: Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility.***

Support for Member States, namely SSAC training and ISSAS missions, are funded through different mechanisms, mostly MSSPs, the European Union Joint Action and the Nuclear Security Fund. Partnerships for organization, implementation and delivery of SSAC training courses and workshops, and specific training sets open to the participation of Member States personnel, are the most used tools in this regard:

- Development of an e-learning tool for SSAC Training to assist pre-course assessment of participant knowledge and help define course material. This will complement tasks BRZ B 01811, AUL B 01693 and RUS B01107;
- Assistance to States who are pursuing new nuclear power programmes to understand the major undertakings in safeguards, as explained in the Nuclear Energy (NE) Document, "Milestones in the Development of Nuclear Power Programmes" (Support for Newcomer States pursuing a nuclear power programme FIN B 1939);
- In-Field Training in the Framework of the Safeguards Traineeship Programme provided by the Hungarian Support Programme HUN B 0813 has been extremely important in the process of preparing trainees for future safeguards activities in their national authorities or in the IAEA. This task should continue and support the 2014 Traineeship Programme;
- International SSAC training courses, including for SQP States, organized in the USA, funded by USA voluntary contributions;
- Regional Training Course on SSAC, AUL B 1693, AUL B 1823 and BRZ B 1811;
- Consultations and Support to Member States, FRA B 1447;
- Training Courses for SSAC Personnel, RUS B 1107.

It must be noted that there is a need for ensuring a harmonization mechanism between all stakeholders providing Member States with training to build their capacities for developing nuclear energy or for implementing safeguards in order to support the best use of stakeholder and Member State resources and to ensure consistency in the training material. Several initiatives have already been taken: exchange of lecturers, development of joint training material, sharing of schedules, and development of networks like INSEN (International Nuclear Security Education Network) and APSN (Asian Pacific Safeguards Network).

In addition, the IAEA is working with Member States to prepare a reference textbook on IAEA safeguards, suitable for use in a university course or for self-study, addressing the institutional and technical aspects of IAEA safeguards (Task Proposal 10/CCA-007). The development of this textbook is coordinated with SGCP-003.

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 2. | FIN | B 01949 | Specialized Training and Visits to Nuclear Facilities (UK C1(y)) | On-going |
| | UK | B 01936 | | On-going |
| 3.3., 13. | FRA | B 01506 | Support in Laser Isotopes Separation Technology | On-going |

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 3.3., 13. | USA | B 01669 | Pyroprocessing Training Course (B.102) | On-going |
| 13. | CZ | B 01526 | Technical Visit - Uranium Mines | On-going |
| 2. | FRA | B 01427 | Training for Information Collection and Analysis for Additional Protocol Verification | On-going |
| 13.2. | FRA | B 01447 | Consultations and Support to Member States | On-going |
| 13. | FRA | B 01562 | Familiarization Visit to La Hague for RRP Inspectors | On-going |
| 13.2. | HUN | B 00813 | In-Field Training in the Framework of the Safeguards Traineeship Programme | On-going |
| 13.1. | AUL<br>FIN<br>UK<br>USA | B 01782<br>B 01900<br>B 01727<br>B 01772 | Revision to Nuclear Fuel Cycle Training Manuals (UK (C1(t)), USA (B.104)) | December 2015 |
| 2. | AUL | B 01828 | Proliferation Analysis Workshop | On-going |
| 13. | BEL<br>CZ | B 01433<br>B 01431 | Comprehensive Inspection Exercise at LWRs | On-going<br>On-going |
| 13. | BEL<br>CZ<br>USA | JNT B 01757 | Training Course for Safeguards at Research Reactors (BEL, CZ, USA (B.105)) | On-going<br>On-going<br>On-going |
| 2. | CAN | B 01483 | Satellite Imagery Training Programme | On-going |
| 13. | CAN | B 01624 | Inspector Training for CANDU Facilities | On-going |
| 13. | CAN<br>FIN<br>SWE | B 01688<br>B 01435<br>B 01709 | Spent Fuel Verification Training Course | On-going<br>On-going<br>On-going |
| 13. | CAN<br>SWE | B 01930<br>B 01933 | DCVD Training for Spent Fuel Verification | On-going<br>On-going |
| 13. | CZ | B 01558 | Training Course on Nuclear Material Accounting in Action | On-going |
| 13. | EC | B 00620 | Nuclear Material Solution Accountancy and Verification Training | On-going |
| 2, 13. | EC<br>FIN<br>USA | B 01563<br>B 01422<br>B 01415 | Workshop on Additional Protocol Activities (USA (B.96)) | On-going<br>On-going<br>On-going |
| 13. | EC | B 01702 | NDA Training Course | On-going |
| 13. | EC | B 01750 | Plutonium Diversion Detection | On-going |
| 13. | EC | B 01844 | Training of Safeguards Inspectors on 3DLR (3D Laser Range Finder) | On-going |
| 13.1. | EC<br>USA | B 01876<br>B 01912 | Development of Virtual Reality Tools for Safeguards Training (USA (B.109)) | December 2015 |
| 2, 13. | FIN<br>FRA | B 01699<br>B 01708 | Training and Evaluation of the Necessary Soft Skills for Safeguards Activities | On-going<br>On-going |
| 13.2. | FIN | B 01939 | Support for Newcomer States Pursuing a Nuclear Power Programme | On-going |
| 2. | FRA | B 01768 | Nuclear Trade Analysis - Support and Training | On-going |

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 13. | GER | B 01896 | Limited Frequency Unannounced Access (LFUA) Training (GER (B.25), UK (C1(u))) | On-going |
| | NET | B 01852 | | On-going |
| | UK | B 01797 | | On-going |
| 13. | HUN | B 01065 | Comprehensive Inspection Exercise Training (CIET) | On-going |
| 2, 13. | HUN | B 01525 | Workshop on Additional Protocol (Complementary Access) Activities | On-going |
| 13. | JPN | B 01812 | Training for Inspectors for the JNC-1 Site Facilities (JE-38) | On-going |
| 13. | JPN | B 01897 | Training on Reprocessing Activities at a Commercial, Engineering or Laboratory Scale from a Safeguards Standpoint (JE-43) | On-going |
| 13. | ROK | B 01872 | Advanced Comprehensive Inspection Exercise at CANDU and LWR Facilities | On-going |
| 13. | ROK | B 01895 | Comprehensive Inspection Exercise at Bulk Handling Facilities (UK (C1(r))) | On-going |
| | SWE | B 01328 | | On-going |
| | UK | B 01751 | | |
| 13.1. | ROK | B 01907 | Development of Virtual Training for Bulk Handling Facilities | December 2015 |
| 13. | RUS | B 01053 | Training in Implementation of Safeguards at Uranium Gas Centrifuge Enrichment Plants | On-going |
| 13. | RUS | B 01719 | Training "Advanced Pu Verification Techniques" | On-going |
| 2. | SWE | B 01373 | Satellite Imagery Training Programme | On-going |
| 2. | SWE | B 01838 | Open Source Information Collection Training Course | On-going |
| 13. | UK | B 01618 | Design Information Verification at Bulk Handling Facilities Training Course (C1(c)) | On-going |
| 13. | UK | B 01874 | Negotiation Skills Training Course (C1(v)) | On-going |
| 2. | UK | B 01903 | Advanced Training on NFC Facilities to Assist State Evaluation (C1(w)) | On-going |
| 2. | UK | B 01940 | Developing Analytical Skills for Safeguards (C1(x)) | On-going |
| 13. | USA | B 00086 | Training - IAEA Participation in US Sponsored Courses (B.093) | On-going |
| 13. | USA | B 01001 | Safeguards Training Course : Enrichment Technology (B82) | On-going |
| 13. | USA | B 01245 | Enhanced Communication Skills (B.88) | On-going |
| 13. | USA | B 01337 | Training on Remote and Unattended Monitoring (B.91) | On-going |
| 13. | USA | B 01446 | Enhanced Observation Skills (B.98) | On-going |
| 2. | USA | B 01800 | Training on Export Control Concepts and Standards from International Perspective (B.106) | On-going |
| 13.2. | AUL | B 01693 | Regional Training Course on State Systems of Accounting for and Control of Nuclear Material, Australia | On-going |
| 13.2. | BRZ | B 01811 | Regional Training Course on SSAC, Brazil | On-going |
| 13.2. | RUS | B 01107 | Training Courses for SSAC Personnel | On-going |
| 13. | USA | C 01677 | Consultant: Development of Safeguards Documentation (C.119) | December 2014 |

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 13.2. | AUL<br>EC<br>GER<br>SWE<br>USA | JNT C 01914 | Textbook on International Safeguards (AUL, EC, GER (B.27), SWE, USA (C.126)) | December 2015 |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 2, 13. | 05/TTR-008 | Training and Evaluation of the Necessary Soft Skills for Safeguards Activities | Outstanding with SWE. Accepted by FIN and FRA. |
| 13.2. | 10/CCA-007 | Textbook on International Safeguards | Outstanding with ARG, JPN, ROK, and UK. Accepted by AUL, EC, GER, SWE, and USA. |

## 4.2. In-house Development Activities

*Table 4. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 2. | 1 | State Evaluation Strategy seminar | The seminar consists of stimulating overview lectures and practical exercises, involving introduction and use of the physical model, available and contemporary analytical tools and interactive role-play of two teams simulating developing a State Level Approach, followed by a review and discussion session. | On-going |
| 13. | 2 | Writing skills training course | To provide participants with necessary writing skills as required by their assignments, with priority given to those whose mother tongue is not English. | On-going |
| 13. | 3 | Set of half-day sessions on statistics, export information, accountancy related data processing and other specifics topics. | The three seminar blocks are as follows:<br>CORE: Statistical Concepts for SGs, Measurement Errors and their Propagation, Sampling Plans, Material Balance Evaluation, Understanding Material Balance Reports and In-field Material Balance Evaluation Tools<br>COMPLEMENTARY: Inference and Decision, NDA and DA Databases for Statistical Analysis, Estimation of Measurement Uncertainties, Detection Probabilities of Verification Sampling Plans, Detection probabilities of Random Inspections, Time Series Analysis and Trend Analysis in Material Balance Evaluation.<br>SPECIAL TOPICS: Orders of Magnitude in the Nuclear Fuel Cycle, Accelerators and Proliferation, EXCEL applications for Safeguards, Near Real Time material Accountancy, Shipper Receiver Differences at Reprocessing Plants and Introduction to Game Theory. | On-going |
| 1., 2., 3., 13. | 4 | Providing of lecturers and technical training officers or coordinators. | Support provided by all divisions, particularly Operations Divisions, for the implementation of the training programme. | On-going |

*Table 5. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 1. | 1 | Supporting the implementation of the State-level concept | Develop training courses and curriculum following guidance documents for the implementation of the State-level concept. | December 2014 |
| 13. | 2 | Training on observational and communication skills | Review learning objectives and content of existing courses, update and conduct courses using a more interactive approach | December 2014 |

# SGIM-002

## Commercial Satellite Imagery

**Project Manager: Karen Steinmaus** **Division: SGIM**

### 1. Introduction

Project SGIM-002 aims to develop and implement improved procedures and techniques for using commercial satellite imagery to produce imagery analysis reports and Geographic Information System (GIS) site plans in support of nuclear safeguards for the period 2014–2015. The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

The project supports the *Long-Term R&D Plan, 2012–2023,* particularly with regard to achieving Capabilities 2 and 9 (see Table 1 for full capability descriptions). More specifically, the project focuses on developing methodologies, tools and techniques to increase the IAEA's ability to detect signatures of undeclared nuclear material and activity, and to improve analysis of nuclear fuel cycles, including weaponization (Milestone 2.3). It also seeks to develop updated software tools for use by a State or regional authority responsible for safeguards implementation (SRA) in creating and submitting site maps in additional protocol declarations, supporting the further integration of State declared information within the electronic State file (Milestone 9.1).

Commercial satellite imagery is an accepted and essential element within the IAEA's safeguards system. High-resolution imagery has demonstrated its value, and is routinely used as a reference source to:

- Aid in in-field and inspection planning;
- Verify the accuracy and completeness of information supplied by Member States;
- Detect changes and monitor activities at NFC-related sites;
- Investigate undeclared activities; and
- Provide analytical input to the State Evaluation process.

In addition, GIS technologies further advance the use of satellite remote sensing and information technologies to generate site plans and store and manage critical information related to sites and facilities.

While SGIM is responsible for geospatial analysis, all Divisions within the Department are end-users of such information.

During the past two years, Project SGIM-002 has overseen the initial deployment of the Geospatial Exploitation System (GES) within the Agency. The GES provides a 3-D geospatial viewer/browser, allowing users to manage the complete cycle of acquisition, analysis and dissemination of product, and has become the repository and knowledge management system for all satellite imagery datasets, imagery analysis reports and site maps. The process of roll-out to inspection divisions began in September 2012, giving inspectors access to satellite imagery data. By September 2013, six State Evaluation Groups had access to the GES. SGIM will seek to enhance the GES in a Phase II project, which foresees an enhanced 2-D interface and connectivity to other

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

Safeguards System Operated Architecture (SOA) based systems that reside within the Integrated Safeguards Environment (ISE).

In the 2014-2015 biennium, the project will:

- Review tasks and activities with respect to the Long-Term R&D Plan, 2012–2023, identifying priorities and appropriate workplans;
- Organize and participate in scientific meetings/workshops/conferences with other organizations, on a periodic basis, in areas of mutual concern (imagery analysis, geospatial data management, etc.) for improved interaction, information and knowledge exchange (December 2015);
- Conduct further research into the processing and analysis of synthetic aperture radar (SAR) and thermal infra-red (IR) satellite imagery, and develop and implement analytical techniques for their wider use within ISI (December 2015);
- Provide specialist training for analysts on image processing and exploitation and allow opportunities for analysts to participate in technical visits to nuclear fuel cycle (NFC) facilities (December 2015);
- Continue to roll-out the GES to Safeguards users, develop further GES capabilities and link to other Safeguards data sources for mutual exploitation of each other's data to support an all-source information analysis environment within the Department of Safeguards (December 2015);
- Seek to enable Member States to provide digital state-declared spatial information using standard, compatible formats, thus allowing IAEA to directly ingest this information into existing and evolving information systems (December 2015).

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute indirectly to the long-term attainment of Capability 2 (increased ability to detect undeclared nuclear material and activities) in general, and specifically to meet the near-term attainment of Milestones 2.3 and 9.1 identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key achievement targets for 2014-15:* | Urgency |
|---|---|---|---|
| **2** | Increased ability to detect undeclared nuclear material and activities. | 2.3. Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.<br>• *Develop and implement SAR-based analytical techniques into workflow. Demonstrate the use of SAR techniques in production within ISI [on-going through December 2015]*<br>• *Develop and implement methodologies to exploit thermal infra-red satellite data. Successfully demonstrate ISI's ability to process and analyse IR data in production within ISI [on-going through December 2015]*<br>• *Develop software and present training packages to improve analytical skills in the processing and interpretation of SAR imagery [December 2014]* | M |

| Capability | Capability Description | Milestone<br><br>*Key achievement targets for 2014-15:* | Urgency |
|---|---|---|---|
| 9 | Ability to communicate secure, authentic information that is fully compatible with ISE between the IAEA, SRAs and inspectors/ equipment in the field. | 9.1. Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file.<br>• *A document outlining the framework for the digital delivery of spatial data will be submitted to ISI by the University of Bonn [January 2014].*<br>• *Develop and evaluate the submission process of the Additional Protocol 2.a.iii in a digital format compatible with the GES [on-going through December 2015]* | M |

## 4. Activities

Funding and resources for most of the project's development and implementation support activities are provided by MSSPs, which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources.

***Capability 2: Increased ability to detect undeclared nuclear material and activities.***

Project SGIM-002 will continue to rely on MSSPs to supply expert individuals to further imagery and geospatial analysis capabilities to meet operational demands. On-going expert assistance will be required in the following areas:

- Imagery analysis (UK D 01794 and USA D 01942 and new tasks 11/ISI-001 and 13/ISI-001);
- Geospatial analysis (FRA D 01296);
- GES administration, support and training (USA D 01870).

***Milestone 2.3: Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.***

- Organize and participate in scientific meetings/workshops/conferences with other organizations on a periodic basis in areas of mutual concern (imagery analysis, geospatial data management, etc.) for improved interaction, information and knowledge exchange. Activities will include the following:

  Attendance at remote-sensing industry events allows staff to stay current with industry developments. Such events include GEOINT, DGI Europe and ESRI annual conferences, using a combination of regular budget and extra-budgetary contributions;

  A follow-on to last year's IAEA workshop (JNT D 01657 JPN) on the use of satellite imagery in support of safeguards verification activities with the organizing body, Japan Aerospace Exploration Agency (JAXA). The meeting will review the workshop's conclusions and recommendations and determine the points of collaboration between JAXA and the IAEA regarding the use of satellite imagery and derived geospatial products.

This will also complement the related work taking place under project SGIM-003 Information Analysis.

- Conduct research into the processing and analysis of high resolution, electro-optical, SAR and thermal IR satellite imagery:
  - Continue an on-going study (SWE D 01706) to develop 3-D models of nuclear facilities using high-resolution optical stereo pairs.

- Continue a project (JNT D 01657 GER) to develop high-resolution digital surface models (DSM) of nuclear facilities.

- Continue an on-going study (JNT D 01657 GER) to develop the use of SAR for safeguards purposes. Research on radar imagery will be conducted in the following three areas and training packages will be prepared for use by Departmental analysts:

  - Ascending/descending image combinations for building outline detection and building height estimation
  - Interferometric SAR/coherent change detection
  - Mining volume change measurements

- Improve analytical skills through training in the use of ENVI[3] software suite during 4th quarter 2013, under the on-going support programme task GER D 01457.

- Initiate a task (12/ISI-002) to investigate the processing and analysis of high-resolution, thermal IR imagery.

- Participate in technical visits to NFC facilities.

  Continue to derive benefit through technical visits to NFC sites/facilities, with the active support of Member States, to further the knowledge and understanding of signatures and observables for analysts (CAN B 01484, GER B 01456, SWE B 01504).

- Provide specialist training for analysts on image processing and exploitation.

  Continue to benefit from expert lectures on imagery analysis of NFC sites/facilities under an on-going support programme task (UK B 01655), and enhance/create additional training materials;

  Receive extensive experience, from subject experts under the on-going support programme task (UK D 01819), on priority tasks and on an ad-hoc basis;

  Benefit from the development of software for radar imagery interpretation and for optical DSM production. The German Aerospace Centre (DLR) will provide a week-long training session on these topics to analysts during January 2014 (JNT D 01657 GER);

  Benefit from training imagery analysts on signatures of industrial facilities at the Vigilance ISR Academy, Eindhoven, Netherlands under the on-going support programme task (NET B 01851).

- Continue to roll-out the Geospatial Exploitation System (GES) to Safeguards users, and develop further GES capabilities.

  Complete roll-out of Phase I to Operations Divisions and establish a GES maintenance contract in 2014;

  Establish a Phase II plan for the design and implementation of GES enhancements. Enhancements will primarily include a new 2D interface that will be a web-based, geobrowser light interface that will provide for better user/system performance. GES Phase II work will support an all-source information analysis environment within the Safeguards Department (to be completed by December 2015).

- Continue to collect satellite imagery from non-standard data sources for priority tasks (UK D 01329). This is a shared resource with analysts concerned with State factors for the procurement of high resolution satellite imagery and open source data collection.

[3] Environment for Visualizing Images

***Milestone 9.1: Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file.***

- Presently, Member States provide site maps as attachments to their Additional Protocol 2a(iii) declarations, mostly in hardcopy format. However, many site operators and SRAs create these site maps digitally using a GIS or Computer Aided Design (CAD) software package. The Department seeks support to enable digital submission of Additional Protocol 2a(iii) declarations. The IAEA will benefit significantly through the provision of digital declaration data. If Member States can provide digital state-declared spatial information using standard, compatible formats, then IAEA can ingest this information into existing and evolving information systems directly. This would improve the IAEA's ability to develop and maintain accurate site maps to support safeguards activities (12/ISI-003) dramatically.

- The University of Bonn (GER D 01313) is undertaking the development of a framework for the digital delivery of spatial data for IAEA as part of the declaration activities of the member states. This task is expected to document the current submission process and outline the potential workflow which would provide geospatial data in a format compatible with ISE.

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 2. | CAN | B 01484 | Specialist Training for IAEA's Imagery Analysts (GER (B.13), USA (D.149)) | On-going |
| | GER | B 01456 | | On-going |
| | SWE | B 01504 | | On-going |
| | USA | B 01442 | | On-going |
| 2. | NET | B 01851 | Training on Satellite Imagery for Safeguards Applications | May 2014 |
| 2. | UK | B 01655 | Consultant: Training on Satellite Imagery Analysis for Safeguards Applications (F1(d)) | On-going |
| 2. | UK | D 01819 | Nuclear Fuel Cycle Specialist Assistance (F1 (f)) | Dec 2014 |
| 2., 2.3., 9.1. | FRA | D 01296 | Commercial Satellite Imagery Analysis and Photo Interpretation Support (GER (A.27), UK (A6(d)) | Dec 2015 |
| | GER | D 01313 | | Dec 2015 |
| | UK | D 01329 | | Dec 2015 |
| 2.3. | AUL<br>CAN<br>FRA<br>GER<br>JPN<br>USA | JNT D 01657 | Signatures of Nuclear Fuel Cycle Related Processes (Satellite Imagery/Space Borne Remote Sensing Data) (AUL, CAN, EC, FRA, GER (B.22), JPN (JB-10), USA (D.173)) | Dec 2015 |
| 2.3. | GER | D 01457 | Software, Hardware and Database Provision for Satellite Imagery Analysis Support (GER (B.14), USA (D.152)) | Dec 2015 |
| | SWE | D 01706 | | Dec 2013 |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 2.3. | 12/ISI-002 | Training and Support on Thermal Infra-Red Commercial Satellite Imagery | Under consideration by ROK |
| 9.1 . | 12/ISI-003 | Digital Declaration Site Maps (DDSM) | Outstanding FIN, and GER.<br>Accepted by CAN. |

## 4.2. In-house Development Activities

*Table 4. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| Capability 2 | 1 | Development of stereo satellite image pair based analysis and visualization techniques | The use of a 3D stereoscopic system with a pair of satellite images is a potential technique for enhancing SGIM's capability to analyse and visualize information from nuclear sites in 3D. There is a need to enhance existing methods and tools, in order to improve understanding, achieve better communication and make more precise analysis of nuclear sites from satellite imagery. These techniques include evaluating novel 3D tools, collecting sophisticated 3D building data from stereo pairs, analysing 3D data such as measuring building heights and modelling and visualizing nuclear sites in 3D. | Dec 2015 |
| Capability 2 | 2 | Provision of training on GES system across Department of Safeguards | Continued expansion of the cohort of GES users through a rolling programme of training sessions for State Evaluation Groups | May 2015 |

*Table 5. Proposed and Planned In-house Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| Capability 2 | 1 | Mobile application for inspectors to review data | Develop a highly secure solution for the dissemination of spatially-aware data for mobile applications to be used for in-field verifications. The solution will take advantage of existing datasets within the IAEA such as satellite imagery and derived products e.g. imagery analysis reports or site plans. The mobile device and application will be compliant with the Integrated Safeguards Environment (ISE) and act as an in-field real-time access point to data and analysis within ISE. | 2016 |
| Capability 2 | 2 | Image data mining | Investigate advances in data mining that specifically focus on the discovery of features in 2D colour and panchromatic satellite imagery datasets. The ability to automatically identify specific imagery features through the mining of large collections of image datasets would significantly assist search and detect types of tasking especially with regard to undeclared facilities. | 2016 |

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| Capability 2 | 3 | Signatures database as an add-on to GES | Build and maintain a common feature library to assist imagery analysts in identifying structures and building types that are common to industrial manufacturing and processing plants associated with supporting the nuclear fuel cycle. | 2015 |
| Capability 2 | 4 | Feature extraction from satellite imagery | Develop methodology and workflow for robust vector feature extraction from existing satellite imagery. The method will use automated algorithms for precise and accurate feature extraction of complex nuclear facilities. | On-going |
| Capability 2 | 5 | Exploiting data from Unmanned Aerial Vehicles (UAVs) | Activities under such a task would be related to gaining knowledge and establishing workflows related to the storing and exploitation of UAV data from commercial or State suppliers over their own territories. A direct application would be analysis of such datasets in support of crisis events (e.g. Fukushima), but other applications such as mapping would also be investigated. | 2017 |
| Capability 2 | 6 | Use of 8-band Multispectral Satellite Imagery | Further consideration will be given to potential uses within SGIM of 8-band imagery for the identification of nuclear fuel cycle structures and activities. | 2014 |

# SGIM-003

## Information Analysis

### Project Manager: Matthew Ferguson — Division: SGIM

### 1. Introduction

Project SGIM-003 aims to develop and implement methodologies and processes, and guide the development of technologies, for the collection, analysis, dissemination and management of open source information within the Department of Safeguards in support of the State evaluation process. The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

The project addresses the development of processes and methodologies that will further enhance the collection and analysis of open source information, including trade and procurement data, within the Department of Safeguards. The project supports the *Long-Term R&D Plan, 2012–2023,* particularly with regard to achieving Capability 2 (see Table 1 for full capability descriptions). More specifically, the project focuses on integrating disparate information sources to detect inconsistences in nuclear programmes and States' declarations (Milestone 2.1).

The collection and analysis of open source information is an essential element in the State evaluation process. Open source information, including trade and procurement data, can provide early indications of potentially undeclared nuclear activities. Analysis of open-source information is used by the Department to support the State evaluation process, in particular to help verify the completeness of State declarations. With the help of Member States, progress has been made during the preceding years to develop proper analytical methodologies in support of safeguards activities.

An effective safeguards system requires the integration of safeguards relevant information from all available sources, including not only States' declarations and information resulting from field activities, but also from open and other sources, such as trade and export control data. Such information must be collected, organized, analysed and disseminated in a timely manner in support of the State evaluation process and other safeguards activities. Information is collected from a wide range of open sources, including international and national news media, commercial databases and government reports, and scientific and technical literature. Activities under this project contribute to the information analysis required to support the evaluation of States' nuclear activities provided in the State Evaluation Reports (SERs) and to support activities in the field, such as complementary access. In addition, the IAEA-wide dissemination of open source highlights on a daily basis maintains on-going awareness of safeguards and non-proliferation developments and issues.

The growing volume of information sources and the diverse forms of information available (text, audio, visual) pose significant challenges. Meeting these challenges requires on-going development and long-term investment in technology and tools that effectively collect relevant information, filter out "noise", and organize valuable information in a clear and accessible manner. This project aims to guide and enhance these aspects of information collection, processing, analysis and dissemination.

While the Division of Information Management (SGIM) is responsible for developing open source processes, all Divisions within the Department are endusers of such information, with a significant portion of the information used, in collaboration with relevant inspection divisions, for the State evaluation process and for support of in-field activities.

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1 http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

2 As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

Most of the funding for information collection and analysis comes from the Department's regular budget. Member State upport Programme (MSSP) support will be requested to focus on specific areas, including the development of analytical methodologies and capabilities, assistance in diversifying sources, and technology and tool development in coordination with Project SGIS-003, Safeguards Information Systems and System Usability.

In the 2014-2015 biennium, the project will:

- Review tasks and activities with respect to the *Long-Term R&D Plan, 2012–2023*[3], identifying priorities and appropriate workplans (December 2013);
- Develop analytic processes and capabilities to maintain the highest standards of analytic rigour (December 2015);
- Diversify information sources to ensure analytic standards and the ability to independently corroborate State supplied information (December 2015);
- Review, develop and guide the implementation of new tools and technologies, e.g. *Palantir*, to streamline the collection and processing of open source information (December 2015);
- Establish or enhance partnerships with Member States willing to voluntarily provide information, using the expertise and knowledge of the IAEA (December 2015).

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute to the long-term attainment of Capability 2 (increased ability to detect undeclared nuclear material and activities) in general, and specifically to meeting the near-term attainment of milestones identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| **2** | Increased ability to detect undeclared nuclear material and activities. | 2.1. Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.<br><br>*Integrate open source information collections within established information management systems, such as the Geospatial Exploitation System (SGIM-02)* [Ongoing]<br><br>*Identify, test and develop information management technologies that may provide visualization of large and disparate datasets with input from open sources, inspection data, environmental sampling results, etc.* [December 2015] | M |
| | | 2.3. Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.<br><br>*Develop a scientific and technical literature monitoring system grounded in professional bibliometry and semantic searching* [December 2015]<br><br>*In conjunction with SGCP-102 develop and implement specific analytic training courses to maintain analytic competence across the Department. Examples include advanced open source information collection and analysis courses, procurement and trade analysis workshops, advanced analytical techniques training, etc.* [Ongoing] | M |

[3] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

| Capability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| | | 2.4. Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.<br><br>*Test, and implement, the Rapid News Service to monitor news and streamline information management processes* [July 2014]<br><br>*Implement entity extraction software to interface between large unstructured datasets and analytical software platforms.* [July 2014] | M |

## 4. Activities

Funding and resources for most of the project's D&IS activities are provided by MSSPs, which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources.

***Capability 2: Increased ability to detect undeclared nuclear material and activities.***

- Indicators of undeclared nuclear activities, or nuclear material, may be observable in open source information collection and analysis. This will continue to be a high priority for the IAEA and requires increased focus on elaborating research strategies and methodologies to detect and analyse efficiently and effectively such indicators through open source information collection and integration with other sources of information available to the IAEA. Given the large quantity of information that must be reviewed, the development of analytical methods and tools is an on-going process. Inputs from specialized technical consultants can also play a role in enhancing the Department's capability to evaluate new technologies and complex issues. Training in information collection and analysis is required to continue.

***Milestone 2.1: Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.***

- In addition to existing sources of information, the IAEA seeks to constantly expand the sources of safeguards relevant information upon which to base its analysis to support the drawing of its safeguards conclusions. This work has been on-going since 2008–2009 with regular budget funding and will be continued in 2014–2015. Member State support requested will include assistance in the identification and evaluation of sources (JPN D 1733, ROK D 1213, RUS D 1414), and possibly a limited number of consultancies in 2014 and 2015 (AUL D 1378, FRA D 1417).
- A continuing aspect for 2014–2015 is an increased emphasis on access to regional scientific and technical information, including additional translations of relevant non-English language information (UK D 1728, UK D 1730) and retrieval of information from new media (BEL D 1478, ROK D 1213, RUS D 1414, RSA D 1489, FRA D 1417).
- Analysis of scientific and technical literature can provide indications of undeclared nuclear activity. To that end, a scientific and technical literature monitoring system will be developed (10/ICA-008), grounded in professional bibliometry and semantic searching (FRA JNT D 1902, USA 1902). It will generate search strategies and methodologies optimized to identify safeguards-relevant articles and to disseminate them to Safeguards staff responsible for their evaluation. Coordination with the IAEA library and INIS will be an integral part of this task.

This will also complement the related work taking place under project SGIM-002 Commercial Satellite Imagery.

***Milestone 2.3: Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.***

- Provision of consultants with extensive experience in open source analysis by Member States (USA D 1126 and FRA D 1417) and, in the future, by the European Commission Joint Research Centre (EC D 1880), allows the Agency to provide a broader and deeper range of high-quality analytical products. In addition, the opportunity to interact with outside experts will enable information analysts to improve their knowledge of analytical approaches and technical issues. Support for visits by experienced open source analysts will therefore continue to be an essential element in developing capabilities in this area.
- Through activities in the past two years, a number of sources for trade and procurement data have been identified and evaluated for use. Support is needed to continue this process, including data to track safeguards relevant shipments (as part of task EC D 1662).
- In order to provide comprehensive, pertinent analysis of Safeguards-relevant information to State evaluation groups, analytical methodologies, tools and techniques must be further developed and refined, with a particular focus on the use of trade and procurement data. Training in support of such analysis (GER B 1560, FRA B 1768) has proven effective in raising the competence levels of analysts, and technological support (CAN D 1623) has streamlined analytic processes.
- Support from Member States to help identifying Patent Classification codes with respect to the Physical Model [is needed?]; respective support from in-house experts has already been provided but not all areas of the Physical Model could be sufficiently covered.

***Milestone 2.4: Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.***

- The European Commission Joint Research Centre (Ispra) has agreed to facilitate the release to the Agency of their Rapid News Service (RNS) tool which works together with the European Media Monitor (EMM) to monitor news and create newsletters, therefore aiding an efficient and less time consuming SGIM Daily Highlights production and related article retrieval (EC D 1880). At present RNS is being used on a trial basis.
- This will also guide the related work taking place under project SGIS-001, Integrated Analysis.

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 2.1. | JPN | D 01733 | Provision of Open Source Information (JPN (JB-11)) | May 2015 |
| | ROK | D 01213 | | Dec 2014 |
| 2.1. | UK | D 01728 | Regional Information Collection Centre-East Asia (A8 (f)) | Apr 2016 |
| 2.1. | UK | D 01730 | Regional Information Collection Centre-Middle East (A8(e)) | Apr 2016 |

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 2.1., 2.3. | AUL | D 01378 | Open Source Information Collection | On-going |
| | BEL | D 01478 | | Dec 2014 |
| | FRA | D 01417 | | Dec 2014 |
| | RSA | D 01489 | | Dec 2014 |
| | RUS | D 01414 | | On standby |
| | SWE | D 01380 | | Dec 2014 |
| 2.3. | AUL | D 01915 | Consultant - Assistance on Information Collection and Analysis | On-going |
| 2.3. | CAN | D 01947 | Maximising the Analytical Capabilities of VITA | Activities pending awaiting awarding of contract in Canada |
| 2.3. | EC | D 01662 | Improving Analysis of Covert Nuclear Trade | Dec 2014 |
| 2.3. | FRA | JNT D 01902 | Scientific and Technical Information Management (FRA, USA (D.200)) | Dec 2014 |
| | USA | | | Dec 2014 |
| 2.3. | GER | B 01560 | Nuclear Trade Analysis Related Support and Training for Trade and Technology Analysis Unit (B.20) | Dec 2014 |
| 2.3. | HUN | D 01919 | Collection and Analysis of Nuclear Trade Related Information to Strengthen Safeguards | Dec 2014 |
| 2.3. | UK | D 01916 | Improving the Analysis of Trade Data for Safeguards Relevant Proliferation Activities (A8(h)) | December 2014 |
| 2.3. | USA | D 01126 | Consultant - Assistance on Information Collection and Information Systems (D.137) | Dec 2014 |
| 2.4. | EC | D 01880 | Collection, Analysis and Dissemination of Open Sources | Dec 2014 |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 2.3. | 10/ICA-008 | Scientific and Technical Information Management | Outstanding with RUS, CAN, and UK. Accepted by FRA and USA. |
| 2.3. | 09/ICA-012 | Improving the Analysis of Trade Data and Non-technical Indicators for Safeguards Relevant Proliferation Activities | Outstanding with AUL. Accepted by UK. |
| 2.3. | New task proposal | Diversifying the sources of nuclear relevant trade data (Open Source Trade Exploration Project, OSTEP) | Under discussion with MS experts from Germany and France, Task Proposal still to be finalized. |

## 4.2. In-house Development Activities

*Table 4. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| Capability 2 | 1 | Research on identification and search strategies for indicators of undeclared activities | Open source information is a potential indicator of undeclared nuclear-related activity in a State. Drawing on in-house expertise and Member State support the Agency is constantly developing and refining its open source search terms. | On-going |
| Milestone 2.1. | 2 | Development of a regular review and alert service for scientific and technical literature | Indicators of undeclared nuclear activities or nuclear material may in some cases be observable via open source scientific and technical information collection, analysis and integration with other IAEA information. There is a need to improve existing methods and tools, in order to improve efficiency and effectiveness in detecting and analyzing such indicators in scientific and technical information. | On-going |
| Milestone 2.3. | 3 | Identification and evaluation of new open source information collection and analysis tools | The increasing volume of open source information requires constant development of the means by which to collect and manage the information. Once collected the information forms part of a broader analytic process that evaluates open source information, including trade and procurement information, commercial satellite imagery, scientific and technical publications, with State declared data and the results of inspection activity, including environmental sample analysis and nuclear material evaluations. In house analytic expertise is complemented with tools to streamline the analytic process. | On-going |
| Milestone 2.2. | 4 | Development of open source search terms and indicators based on the physical model | Relying on in-house expertise and support from nuclear fuel cycle experts in a number of Member States the IAEA is continually developing open source search terms based on the Physical Model to ensure completeness of open source information collections. Member State experts are able to review current search terms and advise refinements to reduce the noise in the collections, allowing analysts to focus on essential information collections.<br><br>Efforts have been underway with in-house experts to identify patent classification codes with relevance to the Physical Model. Support from experts in a number of Member States may be requested complement this effort. | On-going |
| Capability 2 | 5 | Expansion and diversification of open source information sources | The Agency draws its conclusions based on a rigorous comparative analysis of all safeguards-relevant information. Open source information is an important information source used in this comparative analysis and many varied, independent, verified information sources contributes to impartial, unbiased analysis. | On-going |
| 2.3. | 7 | Enhance cooperation where appropriate with international organisations | Explore any information available in other international organizations that would be relevant to the safeguards mandate | On-going |
| 2.3. | 8 | Workshop on Advances in Proliferation Analysis | The fourth workshop with selected Member States contributing to improved analysis of trade data. | Jun 2014 |

# SGIM-007

## Evaluation of Data from Environmental Sampling and Destructive Analysis

**Project Manager: Diane Fischer** **Division: SGIM**

### 1. Introduction

Project SGIM-007 is designed to develop or augment capabilities for assessment of results of environmental sampling (ES) as well as of the enhanced destructive analysis (DA) of nuclear material and other samples collected for nuclear safeguards. The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

This project covers the research and development (R&D) of new capabilities for assessment of results of environmental sampling (ES) as well as of the enhanced destructive analysis (DA) of nuclear material and other samples collected for nuclear safeguards. The SGIM-007 project is closely related to, and coordinated with the three SGAS R&D projects aimed at improving quality and reliability of the laboratory analyses of safeguards samples (*SGAS-001 Destructive Analysis of Nuclear Materials, SGAS-002 Environmental Sample Analysis Techniques and SGAS-003 Sampling Logistics, Analysis Support and NWAL Coordination*). The outcome of the ES and DA evaluations have a major impact on the drawing of sound safeguards conclusions. In view of advances in possible deception scenarios, the Agency will continue to experience challenges in maintaining an effective and efficient safeguards verification system. Therefore, all aspects of the ES and DA planning, implementation and evaluation require continual R&D to improve verification capability and reliability. This includes investigating sampling strategies, processing and evaluation of sample-related information and laboratory analysis results, modelling of nuclear-fuel-cycle processes, as well as quality control of the entire process.

The main areas of the tasks supported by the Member State Support Programmes (MSSPs) for this project are: upgrade of the software tools used for handling and evaluation of sample-related information and all types of analysis results, improvements to the codes simulating physical nuclear-fuel-cycle processes, such as isotope enrichment and reactor irradiation, investigation of signatures of nuclear materials during their chemical processing, assessment of new sampling approaches, provision of expertise, and training in data evaluation otherwise unavailable to the Agency.

Project SGIM-007 supports the *Long-Term R&D Plan, 2012–2023,* particularly with regard to achieving Capability 2 (see Table 1 for full capability description). More specifically, the project focuses on the analysis of environmental sampling and destructive analysis of nuclear material to aid development of isotopic signatures of nuclear fuel cycle activities and processes (Milestone 2.2).

The most recent achievements of the project include: provision of *WIMSD*[3] calculations modelling 46 reactor/fuel irradiation scenarios (UK MSSP); significant progress made in the investigation of trace element behaviour during uranium conversion processes (CAN, EC, and RSA MSSPs); inter-laboratory exercise for comparing elemental impurities analysis capabilities (in-house activity); completion of structural changes to the ES database to accommodate additional and enhanced measurement data (USA MSSP).

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1 http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

2 As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

3 WIMSD: The Winfrith improved multigroup scheme is a deterministic code system for reactor lattice cell calculation on a wide range of reactor geometries.

The end-users are primarily ES data analysts within the Division of Information Management (SGIM) who evaluate and interpret ES and DA data to identify possible undeclared nuclear materials and activities.

Going forward, Project SGIM-007 is focused on the R&D aimed primarily at advancing evaluation of the analysis data through the improvement of enrichment modelling and expansion of the radionuclide inventory libraries of irradiated fuel. The studies of trace element behaviour during uranium concentration and conversion processes will continue, contributing to the population of a reference database of elemental and isotopic signatures of uranium ore concentrates originating from different sources. The capability of conducting multivariate analysis of impurity data is expected to progress significantly with the adaptation of the DAVE[4] software for safeguards data. A long-term challenge concerning ES, is preparing a strategy to adhere to the Department of Safeguards instruction to migrate all Oracle services to Microsoft .Net and SQL server. This will necessitate a major conversion of the ES database and associated applications, reports, and programmes.

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute indirectly to the long-term attainment of Capability 2 *(increase ability to detect undeclared activities)* in general, and specifically to meeting the near-term attainment of Milestone 2.2, identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key achievement targets for 2014-15:* | Urgency |
|---|---|---|---|
| 2 | Increased ability to detect undeclared nuclear material and activities. | 2.2. Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools.<br><br>*Accept final delivery of MSTAR+ enrichment code [to be completed in 2014]*<br><br>*Obtain analytical results and metadata from Springfields* uranium ore concentrates (*UOC) samples[to be completed in 2015]*<br><br>*Accept and implement stand-alone version of multivariate analysis software (DAVE) for evaluating impurity signatures in uranium [to be completed in 2015]* | H |

## 4. Activities

Funding and resources for most of the project's D&IS activities are provided by MSSPs, which continue to play a major role in achieving the project's milestones. Additional activities are supplemented by regular budget sources.

***Milestone 2.2: Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools.***

During the 2014-2015 biennium, Project SGIM-007 will undertake activities that enhance the Department's ES data analysts' ability to evaluate ES data by improving software tools and expanding the reference data libraries for reactor irradiation and uranium elemental signatures. Software related tasks include an upgrade of

[4] DAVE: The Discriminant Analysis Verification Engine (DAVE) is a specialized, multivariate pattern classification application developed at Lawrence Livermore National Laboratory for the purpose of identifying the most probable source of unknown nuclear material based only on the trace element and isotopic concentrations input by the end-user.

the ES database and applications and an enhancement of the MSTAR[5] code that simulates the uranium isotope behaviour in a gaseous centrifuge cascade (USA A 01498). In addition, customized multi-component analysis software will be delivered that will enhance capabilities to evaluate and identify uranium elemental signatures (USA A 01975). Tasks that will improve reference data for various nuclear signatures include the expansion of the library of radionuclide inventory produced during reactor irradiation for multiple reactor designs and fuel configurations (UK A 01853); and the continuing investigation of uranium elemental signatures (EC A 01753, BRZ A 01766, AUL A 01783, RSA A 01790, CAN A 01796, RUS A 01873, EC A01967, UK A 01968 and USA A 01973). Lastly new sampling and analysis approaches will be explored through technical meetings to be held with the network laboratories.

### 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 2.2. | AUL | A 01783 | Experimental Investigation of Behaviour of Trace Elements in Uranium during the Concentration and Conversion Processes (USA: A.292) | Standby |
| | BRZ | A 01766 | | Standby |
| | CAN | A 01796 | | End 2013 |
| | CPR | A 01749 | | Standby |
| | EC | A 01753 | | End 2014 |
| | RSA | A 01790 | | End 2015 |
| | RUS | A 01873 | | End 2015 |
| | USA | A 01948 | | End 2015 |
| 2.2. | EC | A 01967 | Analysis Results and Metadata for the Springfields UOC Sample Collection (UK: A5(j); USA: A.295) | End 2014 |
| | UK | A 01968 | | End 2014 |
| | USA | A 01973 | | October 2014 |
| 2.2. | UK | A 01853 | WIMSD Reactor Calculations (A5(i)) | End 2015 |
| 2.2. | USA | A 01975 | Provision of Stand-Alone Version of DAVE Software for Evaluation of Trace Element and Isotopic Signatures in Uranium Samples (A.297) | June 2014 |
| 2.2. | USA | A 01498 | Environmental Sampling Evaluation Support (A.297) | On-going |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 2.2. | 13/IFC-004 | Expert: Environmental Sampling Database Application Administrator/Developer | submitted 2013, to be considered by SG in 2014 |

[5] MSTAR models multicomponent isotope separation in matched abundance ratio cascades. The model expresses the effective stage separation factor, in terms M*, the arithmetic average of the molecular weight of the key component $M_k$ and the molecular weight of the component whose abundance ratio is matched in the cascade, $M_j$.

## 4.2. 4.2 In-house Development Activities

*Table 4. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 2.2. | 1 | Round-robin exercise on bulk analysis of ES swipe samples | Inter-laboratory exercise to compare laboratory performance of bulk analysis of common samples (ES swipes).<br>Staff costs funded through Regular Budget and organized in cooperation with SGAS. | March 2014 |

*Table 5. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 2.2. | 1 | 2014 Technical Meeting on Bulk Analysis of Environmental Samples | Biennial meeting with network laboratories involved with ES bulk analysis, to discuss current and future developments, and to draft recommendations for future actions.<br>Staff costs funded through Regular Budget and organized in cooperation with SGAS. | November 2014 |
| 2.2. | 2 | Testing of the iDAVE search engine for assessing origin of uranium ore concentrates (UOC) | Staff assessment of iDAVE capabilities for identifying the origin of UOC through the use of known UOC samples.<br>Staff costs funded through Regular Budget. | May 2014 |
| 2.2. | 3 | Round-robin exercise on HRGS analysis of ES swipe samples | Inter-laboratory exercise to compare laboratory performance of HRGS analysis of common samples (QC swipe samples).<br>Staff costs funded through Regular Budget and organized in cooperation with SGAS. | November 2014 |
| 2.2. | 4 | 2015 Technical Meeting on Particle Analysis of Environmental Samples | Biennial meeting with network laboratories involved with ES particle analysis, to discuss current and future developments, and to draft recommendations for future actions.<br>Staff costs funded through Regular Budge and organized in cooperation with SGAS. | November 2015 |
| 2.2. | 5 | 2015 Round-robin exercise on Analysis of Elemental Impurities in Uranium Samples | Inter-laboratory exercise to compare laboratory performance on analysis of trace elements in uranium samples.<br>Staff costs funded through Regular Budget and organized in cooperation with SGAS. | February 2015 |
| 2.2. | 6 | 2015 Technical Meeting on Analysis of Elemental Impurities in Uranium Samples | Second meeting with network laboratories involved with analysis of trace elements in uranium samples, to discuss current and future developments, and to draft recommendations for future actions.<br>Staff costs funded through Regular Budget and organized in cooperation with SGAS. | September 2015 |

# SGIM-008

## Statistical Analysis

### Project Manager: Claude Norman — Division: SGIM

### 1. Introduction

Statistical methodologies contribute to the design of safeguards approaches by proposing effective and efficient random verification methodologies (e.g. sampling plans and random inspection schemes, using modern optimization techniques). Project SGIM-008 supports statistical analysis activities within the Department of Safeguards to provide credible assurance that no nuclear material is diverted from declared facilities through material imbalance (i.e. material unaccounted for (MUF), or falsification of operators' declarations in bulk handling facilities (BHF)). Through the Project's provision of methodologies and tools to facilitate the evaluation of verification data and the optimization of resources, it supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department needs to achieve specific strategic objectives[2], and the key Milestone 2.5.

### 2. Overview

Project SGIM-008 was established to carry out the following activities:

- To review, harmonize and, when appropriate, upgrade existing statistical and probabilistic methodologies applied to safeguards verification approaches and to the evaluation of safeguards data;
- To design new methodologies for the evaluation of verification data from safeguards implementation schemes applied to traditional and innovative nuclear fuel cycle facilities;
- To develop new computerized sampling and evaluation tools for streamlining the sampling and evaluation processes and increasing their detection capabilities; and
- To support the development of optimum random verification schemes.

In addition, the project addresses the enhancement of information analysis and investigates approaches to changing the way the Department evaluates safeguards information in the context of a growing number of nuclear activities and facilities under safeguards, including sensitive and new types of facilities.

The evolution of safeguards concepts over the last decades and the considerable increase in the amount and type of information to be processed and analysed in a context of limited resources, calls for the development and implementation of statistical and probabilistic tools to support effective and efficient verification approaches and evaluation methodologies. In particular, optimized data collection and analysis tools are needed to warrant timely detection of process imbalances in sensitive facilities such as large plutonium bulk handling facilities (BHFs). Substantial progress has been made with the in-house development of complex near real time material accountancy (NRTA) systems. To further optimize their detection capabilities, simulation and sensitivity analysis tools are essential.

The project also encompasses the development and review of probabilistic algorithms and procedures used by the Department to support different sampling and random verification schemes, enhancing them when appropriate, and updating the associated technical documentation. In this context, work covering the review

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

of algorithms to calculate samples sizes for inspection sampling plans has been completed and proposals for upgrading the methodology and the related software tools are in preparation.

Given the growing number of facilities under safeguards, the increasing quantity of data to be processed, and the diversification of the safeguards information obtained from all sources and from new types of facility, the project also investigates innovative methodologies for optimizing the use of inspection resources and supporting conclusions and decisions through intelligent information analysis. The most recent achievements include:

- *General considerations regarding the quantitative design of inspection plans:* For inspection and verification activities, it was shown that one has to distinguish between two kinds of approaches. In the operational approach an inspection plan is built on the basis of a quantitatively defined objective, inspection effort and the use of optimization approaches. In the structural approach, it is built on the basis of specific assumptions about the operator's behaviour and a pre-specified detection probability. It was demonstrated that the use of operational approaches enables analysts to draw conclusions on effectiveness and efficiency of safeguards measures.
- *Optimal planning of random inspections:* The planning of random inspections is often solely based on purely probabilistic considerations. A framework was presented demonstrating how the planning of random inspections could be performed in a strategic manner. It also shows that the quantitative analysis of this problem is mathematically demanding and concrete solutions, as well as effectiveness and efficiency considerations, depend crucially on special modelling assumptions.
- *Strategic considerations of attribute sampling plans:* It was demonstrated how optimal sampling plans have to be built taking inspection resources into account. Furthermore, it was shown how modern computer algebra systems can be used to solve the problem of the optimal sampling plan determination.

The expected project outcomes will also assist the Department if it is requested to take on new verification mandates by enhancing the capabilities of statistical methodologies and tools.

The end-users are staff members of the Safeguards Department who are involved in the statistical analysis of safeguards data, the planning of inspections and the distribution of inspection resources. The investigated and developed methodologies give a unique opportunity to look at daily inspection problems from a more systematic formal point of view. They support decision makers, help to identify optimal random verification schemes and support State-level approaches, annual implementation plans and State evaluation activities.

Going forward, Project SGIM-008 will focus on:

- Updating and consolidating sampling-plan methodologies and procedures, and developing an upgraded sampling plan code;
- Reviewing and harmonizing current random inspection schemes, further developing methodologies to evaluate their results, developing new schemes and drafting the technical documents and procedures related to these processes;
- Reviewing, updating and consolidating the algorithms for the determination of measurement error uncertainties from calibration and paired-data analysis;
- Reviewing, updating and consolidating the statistical methodologies supporting the evaluation of State declarations and safeguards verification results (e.g. the evaluation of MUF, shipper-receiver differences and operator-inspector differences, including the assessment of the quality of the operators measurement and accountancy systems and safeguards verification instruments and analytical methods);
- Investigating the use of advanced mathematical methodologies and computerized tools for safeguards applications, including:
  - exploring the use of game theory approaches to optimize effective and efficient design of verifica-

tion activities and random inspection schemes, and developing methodologies for optimizing the State-level distribution of inspection resources
  - demonstrating the feasibility of intelligent systems, which apply fuzzy logic for analysing non-quantitative data, eliciting analyst conclusions and aggregating them across multiple disparate data sources in order to draw broad State-level conclusions with a measured degree of confidence
  - exploring the application of computer intensive Bayesian approaches to include historical data in the evaluation of safeguards information.
- Developing and optimizing NRTA systems for plutonium BHFs;
- Developing a generic software system capable of simulating the material flows and inventories for mixed oxide (MOX) fuel fabrication plants and configuring it for developing and optimizing material accountancy procedures (particularly NRTA) applied to the Japan MOX fuel fabrication plant (J-MOX) (see also Project SGOA-002).

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, Project SGIM-008 will contribute to the long-term attainment of Capability 2 *(increase ability to detect undeclared activities)* in general, and specifically to meeting the near-term attainment of Milestone 2.5, identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| 2 | Increased ability to detect undeclared nuclear material and activities. | 2.5 Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results.<br>• *Update and consolidate sampling-plan methodologies and procedures, and develop an upgraded sampling plan code taking modern optimization approaches like game theory as well as advanced algorithms for solving combinatorial optimization problems into account. The results of these endeavours will be documented in a technical report. [to be completed in 2015]*<br>• *Review and harmonize current random inspection schemes and methodologies to evaluate their results and develop new schemes. The results including procedures for their practical implementation are drafted in a technical document. [to be completed in 2015]* | M |

## 4. Activities

Funding and resources for most of the project's D&IS activities are provided by MSSPs, which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources.

***Milestone 2.5: Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results.***

To achieve Milestone 2.5, Project SGIM-008 will undertake the following activities in the 2014-2015 biennium:

- *Sampling plan methodologies and tools*: Update the sampling plan technical documentation, including procedures and development of an upgraded sampling plan code. The upgraded sample size algorithms should incorporate features like optimized sampling plans for large gas centrifuge enrichment plants (GCEP), two-stage sampling, and follow-up inspection sample sizes. The two-stage sampling feature is useful when the verification of a stratum can be simplified by clustering items into primary and secondary units. The goal of the follow-up inspection feature is to devise a follow-up inspection sampling plan, in the event that defects are identified in the initial sample. (Supported by USA D 01807 and in-house development activities);

- *Random inspection harmonization:* Review the harmonisation and documentation of random inspection schemes and methodologies for evaluating their results, including procedures for their practical implementation (Supported by in-house development activities and planned MSSP tasks);
- *Algorithms for the determination of measurement error uncertainties:* Review, update and consolidate algorithms for the determination of measurement error uncertainties from calibration and paired-data analysis, including the procedures for their practical implementation (Supported by in-house development activities and planned MSSP tasks);
- *Algorithms for the statistical evaluation of MUF and operator-inspector differences:* Review, update and consolidate the algorithms for the statistical evaluation of MUF and operator-inspector differences, including the procedures for their practical implementation (Supported by in-house development activities and planned MSSP tasks);
- *Develop NRTA systems for plutonium bulk handling facilities:* Develop NRTA systems in line with the requirements for the overall Rokkasho Reprocessing Plant (RRP) and J-MOX projects. A first version of the NRTA system for the RRP is ready for implementation. The NRTA system for J-MOX is currently in the conceptual design phase;
- *Generic software tool to support safeguards implementation at the J-MOX facility:* Configure and implement a generic software tool (developed under UK D 1878) for simulating material flow to support implementation of safeguards at the J-MOX fuel fabrication plant (particularly for designing and optimizing material accountancy and inspection procedures, e.g. NRTA). A draft report and software program were produced and sent to the IAEA under task UK D 1878. The task currently is on hold until mid-2014, and continuation is requested at that time to optimise and document the code package on the basis of the experience gained;
- *Optimization approaches to inspection/verification design:* Investigate approaches based on game theory to design efficient regular inspection schemes and random inspection schemes, and to allocate inspection resources at the State level. (Supported by GER D 01925 and in-house development activities);
- *Demonstration of intelligent decision analysis support in safeguards evaluation:* Demonstrate the feasibility of intelligent systems that apply fuzzy logic for analysing non-quantitative data, facilitating eliciting analyst conclusions, and aggregate analyst conclusion across multiple disparate data sources in order to draw broad State-level conclusions with a measured degree of confidence (BEL D 01927);
- *Demonstration of the applicability of Bayesian approaches to the evaluation of safeguards data:* Explore the use of computer intensive Bayesian methodologies to take historical data into account in the statistical evaluation of safeguards information.

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 2.5. | BEL | D 01927 | Demonstration of Intelligent Decision Analysis Support in Safeguards Evaluation | Stand by |
| 2.5. | GER | D 01925 | Optimization Approaches to Inspection/Verification Design (B.26) | December 2015 |

The IAEA convened a Technical Meeting on *Statistical Methodologies for Safeguards* in October 2013. The meeting produced a working plan which identified the areas of the review, harmonization and upgrade activities of statistical methodologies which could be supported by MSSPs, see Table 3.

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 2.5. | New task proposal | Sampling plan methodologies and tools | Under discussion with MSSP coordinators from Germany and Canada, Task Proposal under preparation |
| 2.5. | New task proposal | Optimization Approaches to Inspection/ Verification Design | |
| 2.5. | New task proposal | Exploring Optimization Approaches for building optimal sampling plans | |
| 2.5. | New task proposal | Demonstration of the applicability of Bayesian approaches to the evaluation of safeguards data. | Under discussion with MSSP coordinator from UK, Task Proposal under preparation. Discussion on potential development topics will be made during the *Scanning the Horizon* workshop. |
| 2.5. | New task proposal | Statistical evaluation of incomplete datasets (missing data) | |

## 4.2. In-house Development Activities

*Table 4. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 2..5. | 1 | Develop Near Real Time Accountancy (NRTA) systems for Plutonium BHFs | The development of NRTA systems is in line with the requirements of the overall RRP and J-MOX projects. A first version of the NRTA system for RRP is ready for implementation. The NRTA system for J-MOX is currently in the conceptual design phase. | December 2015 |
| 2.5. | 2 | Configuration and implementation of the generic software tool for simulating material flow at the J-MOX fuel fabrication plant | Under this activity, a generic software tool (developed under UK D 1878) will be configured and implemented to simulate material flow in support of safeguards implementation at the J-MOX fuel fabrication plant. It will be used in particular to design and optimize material accountancy and inspection procedures, e.g. NRTA).<br>A draft report and software program were produced and sent to the IAEA under task UK D 1878. The task currently is on hold until mid-2014, and continuation of this task is requested at that time to optimise and document the code package on the basis of the experience gained. | December 2015 |

*Table 5. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 2.5. | 2 | Sampling plan methodologies and tools | Update the sampling plan technical documentation, including procedures, and the development of an upgraded sampling plan code. | February 2015 |
| 2.5. | 3 | Random inspection harmonization | Review, harmonize and document random inspection schemes and methodologies for evaluating their results, including the procedures for their practical implementation. | August 2015 |
| 2.5. | 4 | Algorithms for the determination of measurement error uncertainties | Review, update and consolidate the algorithms for the determination of measurement error uncertainties from calibration and paired-data analysis, including the procedures for their practical implementation. | December 2014 |
| 2.5. | 5 | Algorithms for the statistical evaluation of MUF and operator-inspector differences | Review, update and consolidate the algorithms for the statistical evaluation of MUF and operator-inspector differences, including the procedures for their practical implementation. | June 2015 |
| 2.5. | 6 | Optimization Approaches to Inspection/Verification Design | Investigate approaches based on game theory to design efficient regular inspection schemes and random inspection schemes, and to allocate inspection resources at State-level. | April 2015 |
| 2.5. | 7 | Exploring Optimization Approaches for building optimal sampling plans | Demonstrate the use of game theory approaches for efficient routine inspection design, random inspection design and allocation, and for State-level distribution of inspection resources | July 2015 |
| 2.5. | 8 | Demonstration of the applicability of Bayesian approaches to the evaluation of safeguards data. | Demonstrate the use of computer intensive Bayesian methodologies to take historical data into account in the statistical evaluation of safeguards information. | December 2015 |

# SGIS-002

## Information Security and Infrastructure

**Project Manager: M. Scott Partee** **Division: SGIS**

### 1. Introduction

Project SGIS-002 aims to improve information security throughout the Department and focuses on people, processes, technology, software, and infrastructure. The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities. The project also supports numerous initiatives for the modernization of the Safeguards information and communications technologies.

### 2. Overview

The project addresses the development of the information security capabilities within the Department of Safeguards and the IAEA as a whole. The SGIS-002 project plan was prepared with full consideration of the Department's wider programme and its various long-term and medium-term plans. The project supports the *Long-Term R&D Plan, 2012–2023,* particularly in regard to developing Capabilities 8 and 9 (See Table 1). The development and implementation support (D&IS) capabilities the project intends to address are detailed in Section 3.

End users for the project are the users of computing resources within the Department of Safeguards and the primary focus of the projects is to ensure the availability, integrity, and confidentiality of the information of the Department and the IAEA's Member States. The project also plans to include input from and deliver products to, the IAEA in its entirety.

In the 2014-2015 biennium, the project will:

- Increase the information technology (IT) security internal and external incident detection capabilities of the Department through a complementary set of tasks: The acquisition and improvement of incident detection tools, experience in the topic through an expert, and membership of the Forum of Incident Response and Security Teams (December 2014)
- In addition to improving the tools and coordination involved in incident detection, the project will begin implementing an improved security event detection capability too automatically detect anomalous behaviour in Safeguards IT systems.
- Poll out a comprehensive end-point protection solution that enables the implementation of security policy across diverse endpoints such as computers, laptops, smart phones and tablets and increases the event collection and incident detection capabilities in the infrastructure. The project will begin gathering requirements in 2014 and aims to implement a whole house solution in collaboration with Division of Information Technology (MTIT) in the Department of Management by the end of 2015.
- Improve the experience of the mobile workforce by extending the enterprise mobility platform to include content and application management capabilities (March 2014). Additionally, the project will increase the value of the existing mobile platforms by adding functionality such as secure communications and secured access to select resources from mobile devices (January 2015). The project also plans improvements to the ability of staff in the field to communicate with IAEA resources.

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

- Support the standardisation of the IAEA's security management system in accordance with the ISO 27000 series of information security standards (on-going throughout the biennium).
- Develop and demonstrate a highly resilient information processing and data protection capability by extending the computing platforms in use in the Department across multiple active and passive data centres by the end of the biennium.This will meet the Department's disaster recovery milestone and the activities related to building a Safeguards data centre. This activity will be in support of an IAEA-wide business continuity and disaster recovery effort by the IAEA's Central Security Coordinator.

With numerous high priority projects and initiatives taking place throughout the Department, it will prove difficult to obtain the necessary human and financial resources to move the project forward. However, with the right combination of support and prioritization of activities, the goals of the project are imminently achievable and have justifiable value.

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute towards the attainment of Capabilities 8 and 9, in general, and specifically to meeting the near-term attainment Milestones 8.1, 9.3 and 9.4 identified in the *Long-Term R&D Plan* 2012-2023 and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Cap-ability | Capability Description | Milestone<br><br>*Key achievement targets for 2014-15:* | Urgency |
|---|---|---|---|
| 8 | Ability to use safeguards information in a fully integrated, secure environment, maintained and available to all who need it according to their role. | 8.1 Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol and an electronic State file containing all safeguards-relevant information about each State.<br><br>*Increase Detection of Incidents By Building Security Operations Capabilities by:*<br>• *Enhancing the tools in use for security event detection and improving processes surrounding them*<br>• *Developing systems that analyse roles, classification, and capabilities of the Department IT systems and detect anomalous behaviours.*<br>• *Join The Forum of Incident Response and Security Teams Organization*<br>• *Deploy comprehensive Endpoint protection [2015]*<br>• *Evaluate and implement automated security testing tools [2015]*<br>• *Update security policies, procedures, standards, and guidelines with ISO 27000 [2015] in conjunction with the IAEA's Central Security Coordinator* | H |
| 9 | Ability to communicate secure, authentic information that is fully compatible with ISE between the IAEA, SRAs and inspectors/ equipment in the field. | 9.3 Deploy secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices.<br><br>*Deploy secure communication and mobile productivity for staff in the field [2015]* | M |
| | | *9.4 Ensure the Departments ability to recover from an IT failure*<br><br>*Develop and implement an updated disaster recovery programme in alignment with the IAEA's Central Security Coordinator's initiative for business continuity [2015]* | H |

## 4. Activities

Funding and resources for most of the project's D&IS activities are provided by MSSPs, which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources.

***Milestone 8.1: Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol and an electronic State file containing all safeguards-relevant information about each State.***

- **Develop IT Security Operations Centre Capabilities and Enhanced Skills**

During the past four years, the Department has established digital forensics capability. The Safeguards IT Forensics Laboratory, which was built in part by resources and training provided by the Member States, has played an instrumental role in identifying and investigating a number of security incidents, thereby significantly reducing response times and the scope of impact. The services of the Safeguards IT Forensics Laboratory were made available to the entire IAEA and were well-utilized. The forensics and investigative abilities in the Department complement the numerous layers of protection in place throughout the IAEA. The IAEA intends to further improve and optimize its alignment of the various IT security groups and capabilities.

As the threat landscape continually changes due to new technologies, attacker resourcefulness, and the potential of internal threat actors, it is necessary to further augment intrusion detection, monitoring, and detection capabilities for the Safeguards IT operations to maintain and improve its effectiveness. In addition, the support that has been provided by Safeguards IT security staff to the IAEA as a whole has been significant and such inter-departmental requests for Safeguards digital forensic support is increasing.

MSSPs funded an independent assessment of the Safeguards IT security operations, incident response, and investigation capabilities. The assessment acknowledged that the preparation and investigation capabilities were very mature, and gaps existed in functions normally aligned with a security operations centre.

The project aims to improve the ability to detect incidents, both from internal and external threats, and to generate actionable and meaningful reports from the vast amount of security-relevant data the Department collects. In short, the Department's IT security capability is very good at investigative methods, and needs to increase proactive detection measures within the Department.

This activity directly supports the achievement of Milestone 8.1. A fundamental trust in the underlying information systems is a bedrock concept for any secure environment, and the ability to detect and remediate events is a foundational capability. The following are ways in which Member States can assist in increasing the Department's capabilities to detect IT security incidents:

- Provide support for the continued enhancement and upgrades of Arcsight, the IAEA's Security Event and Incident Management system's reporting capabilities (New Task Proposal #1);
- Provide an expert engagement to elevate the maturity level of the Security Operations Centre (SOC) incident detection capabilities (New Task Proposal #2);
- Provide training and share best practices for developing IT security operations capabilities (New Task Proposal #2);

- **Develop Systems that Detect Anomalous Activities and Behaviours in Safeguards IT Systems**

The Department's authorisation management system, policies, and numerous layers of IT defence serve to address both technical and human risks to the security of the Department's information. However, it is wellknown that security issues can occur both intentionally and unintentionally by those who have legitimate access to the information. The security event management systems in use by the Department's IT security operations are capable of storing vast amounts of security-relevant information. This information can be more thoroughly analysed for evidence of unusual or unauthorized activity on Safeguards systems, taking into account the user roles in the various systems, the types and

classification levels of the information, and other factors. Member States with very mature security event detection capabilities are requested to share knowledge with the Department on utilizing advanced logging, historical logs of access, event correlation, pattern matching, anomaly detection, and any other additional techniques for detecting suspicious user behaviour.

In *New Task Proposal #3,* Member States are requested to assist with the creation of systems and techniques which will automatically detect anomalous events and assist with the prevention of any unauthorized release of information.

- **Join The Forum of Incident Response and Security Teams (FIRST) In Order To Increase Incident Detection and Threat Intelligence**

In an effort to gain access to the latest threat intelligence and incident information, and to increase collaboration and information sharing with the global security community, the IAEA intends to join the Forum of Incident Response and Security Teams (FIRST). Joining FIRST will be a "whole house" effort and involve all of the IT security incident response resources in the IAEA.

In order to join FIRST, the information security capabilities of the IAEA will be thoroughly reviewed as candidate members and verified with an on-site visit by FIRST. Furthermore, education and conference participation will be required, as well as sponsorship by an existing member team.

To support this activity, requests will be made to Member States for the provision of security professionals who have guided organisations through the membership process and who will facilitate communication with existing MSSP-related incident response teams (*New Task Proposal # 4*) The project will also request that MSSPs assist with the IAEA's participation in FIRST's required training events and conferences. (New Task Proposal #5)

- **Deploy Comprehensive Endpoint Protection**

Numerous initiatives to develop and deploy increasingly sophisticated mobile platforms with Safeguards-specific tools, as well as Safeguards instrumentation with embedded operating systems, will benefit from a comprehensive endpoint protection capability.

Modern computing devices are heterogeneous and exhibit a different risk profile to traditional computers and laptops. To address these risks, the Department would like to investigate and then implement a comprehensive endpoint protection solution, which would include capabilities to patch systems automatically, update antivirus definitions, remediate risks, quarantine devices that fail system health checks, and verify devices comply with Departmental information security policies, before such devices are permitted access to secured resources. Additionally, the system will provide access to a wide variety of crucial security-pertinent data, which the IAEA can use in its event detection and correlation systems.

The goal of the project is to apply security policies uniformly to a wide variety of end devices. Capability 8 depends upon ensuring that the endpoints which connect to and process information through the computing environment of the Department. Countries in the MSSP system can support this project by providing the required resources for architecture, design, implementation assistance, hardware, and software. (New Task Proposal #6).

- **Evaluate and Implement Automated Security Testing Tools**

Proactive security testing for security issues in custom-developed software generally requires a large number of cases, which must be checked against each software interface. Therefore, undertaking effective security testing manually can become unwieldy.

As Capability 8 is developed, many custom applications, systems, and services will be deployed. Security testing tools can be used to test software and systems automatically, resulting in more efficient security testing and higher quality results and increased levels of protection. MSSPs will be requested to support the purchase of suitable automated security testing tools that can facilitate the efficient security testing of software (New Task Proposal #7).

- **Update Security Policies, Procedures, Standards, and Guidelines in an Internationally Recognised, Standardised Format**

The IAEA has established the ISO 27000 series as the standard for its information security management system and will request support from Member States' experts who have assisted other organizations through the adoption of the ISO 27001:2013 (Information Security) standard (New Task Proposal #8).

This work activity will be performed by Safeguards Department personnel (Activity #3) as part of an overall IAEA plan by the Central Security Coordinator.

***Milestone 9.3: Deploy secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices***

The activities associated with this milestone focus on enhancing the security and utility of the standard mobile devices in use throughout the IAEA, as well as extending the capabilities of those devices to specialised Safeguards systems.

- **Secure Communication and Access for Staff in the Field**

Supporting Safeguards staff in the field is a high priority for the Department. Staff in the field must have a secure, reliable, and convenient connection to IAEA headquarters in order to effectively perform their job functions.

The solutions delivered by this project serve to provide the Department with the means to collect, integrate, and analyse information at greater speed, facilitating the ability to fulfil its mandate. Some envisioned scenarios include that inspection plans could be updated "on-the-fly" from the IAEA's headquarters, while in-field staff could update information systems in real time.

Another pressing need is to utilize standard mobile platforms, such as standard mobile phones and tablets, for secure communications between in-field inspectors, management teams, and analysis groups. The Department has done some initial pilot deployments with in-field activitygroups and will begin a more formal assessment, requirements elicitation, and deployment of secure communication tools. MSSPs can support this activity by providing expertise, hardware, assessments of cloud-based services, and software support to implement such solutions, as well as training and guidance (New Task Proposal #9).

Furthermore, Member States are asked to assist with the requirements, design, and implementation of secured remote access capabilities for mobile devices. Member States are requested to provide threat assessment, architectural assistance, product and solution elaboration, development and implementation of a solution for in-field use that would allow the input and output of information into the Safeguards information systems and the synchronization of documentation and reports between mobile devices and IAEA information systems. This "synchronisation" capability would be foundational for inspectors and analysts.

Member States are also requested to share best practices and deployment guidelines for such solutions as part of helping the project deliver on this activity, in particular with regards to reference architectures, implementable design patterns, and expertise on the use of appropriate cloud technologies.

***Milestone 9.4 Ensure the Department's ability to recover from an IT failure.***

- **Develop and Demonstrate an Updated Disaster Recovery Programme in Alignment with the IAEA's Initiative for Business Continuity**

There is a need for the IAEA to be able to continue normal operations in the event of a major disaster in the Vienna International Centre's (VIC's) data centres, when access to data and infrastructure is not possible or not available. The data and backup infrastructure shall be available elsewhere for safeguards operations to resume in the shortest possible time, and is a critical component to ensure the availability of the Integrated Safeguards Environment. The Agency's Crisis Recovery Plan and the overall IAEA business continuity requirements also mandate the establishment of business continuity and disaster recovery facilities, built using appropriate infrastructure and technology, to save and secure the data and make it available for safeguards purposes.

The office of the IAEA's Central Security Coordinator will coordinate an effort to update and improve disaster recovery and business continuity capabilities through the IAEA, and the activities associated with this milestone will be largely dependent on the outcome of this initiative.

With New Task Proposal #10, the project requests support for business continuity, and disaster recovery expertise and guidance to aid in successfully delivering this project. This activity complements the existing regular budget activities related to implementing the Department of Safeguards new virtualization platform, which includes network, storage, and server resources in multiple locations throughout the IAEA headquarters and the Nuclear Material Laboratories in Seibersdorf. The initiative would also take into account the use of cloud and out-sourced services to achieve business continuity goals, where appropriate.

This security initiative will be performed in two phases. The first phase is the establishment of an alternate data centre within the Vienna International Center that will address failure scenarios with the primary data centre. The second phase will focus on the establishment of a remote alternate data centre that can provide business continuity in the event of a regional disaster. New Task Proposal #11 requests Member States' support to provide additional network equipment and cabling in the Vienna International Center to connect the primary and alternate data centres. A potential disaster recovery logical architecture is depicted in *Figure 1*.

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 8.1. | ESP | D 01921 | Enhance IT Forensics Capabilities | December 2014 |
| 8.1. | FRA | D 01901 | Sponsorship of a Safeguards Security Assessment (USA (D.194)) | March 2014 |
| | USA | D 01929 | | December 2014 |

During the 2012-2013 biennium, ESPD 01921 `Enhance Forensics Capabilities`, has achieved numerous deliverables over the course of the previous two years. Among these were tools, processes, procedures, training for IT forensics capabilities, and a gap analysis of the IT security operations capabilities of the Department. Further activities may be associated with this task going forward.

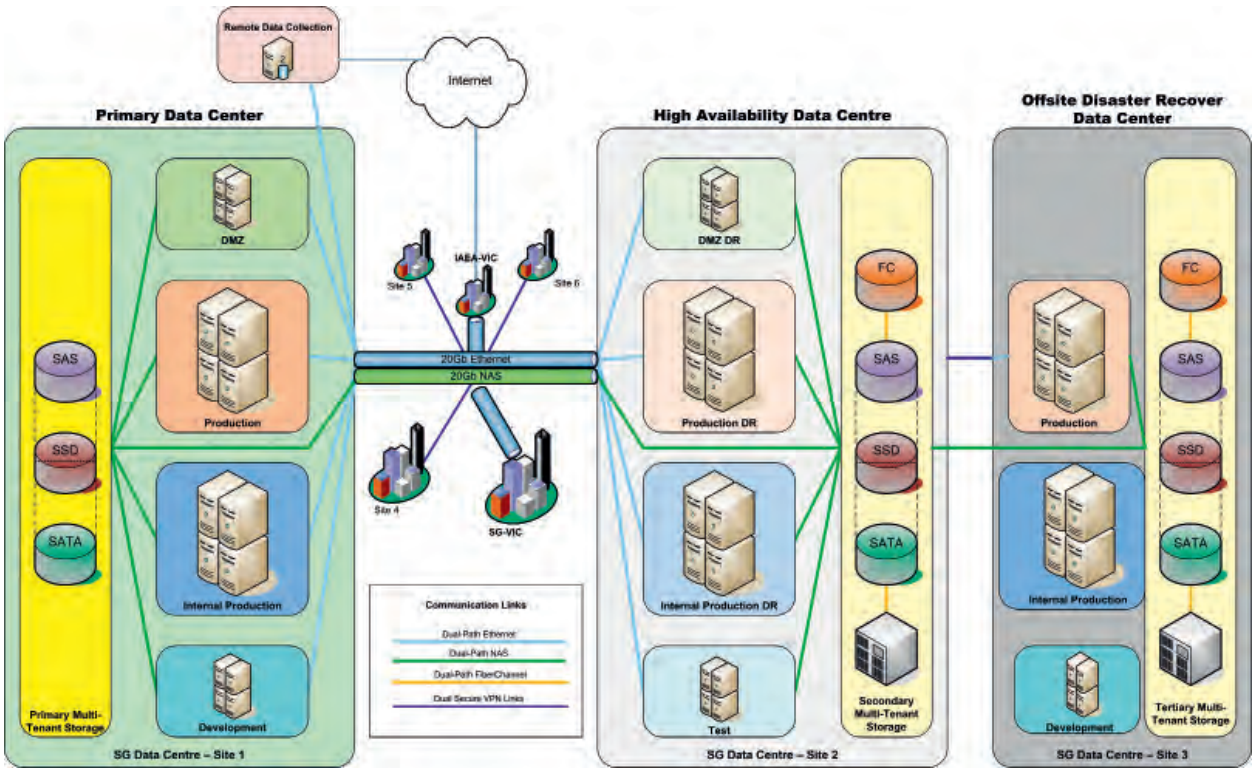
FRA D 01901 did not conduct any activities during the 2012-2013 biennium, but was extended into 2014 due to re-prioritization by the IAEA. The activities in FRA D 01901 will be conducted in early 2014 with an assessment and penetration test of the virtual desktop infrastructure (VDI) deployment.

In the 2012-2013 biennium USA D 01929 contributed a comprehensive assessment of the Department's IT infrastructure, looking for indicators of compromise (IOC) which is indicative of an advance, persistent, threat actor's presence. While no IOC were discovered, numerous improvements to the security posture of the Department's infrastructure were recommended and accepted. Further activities are currently in discussion with the USA MSSP related to additional assessments.

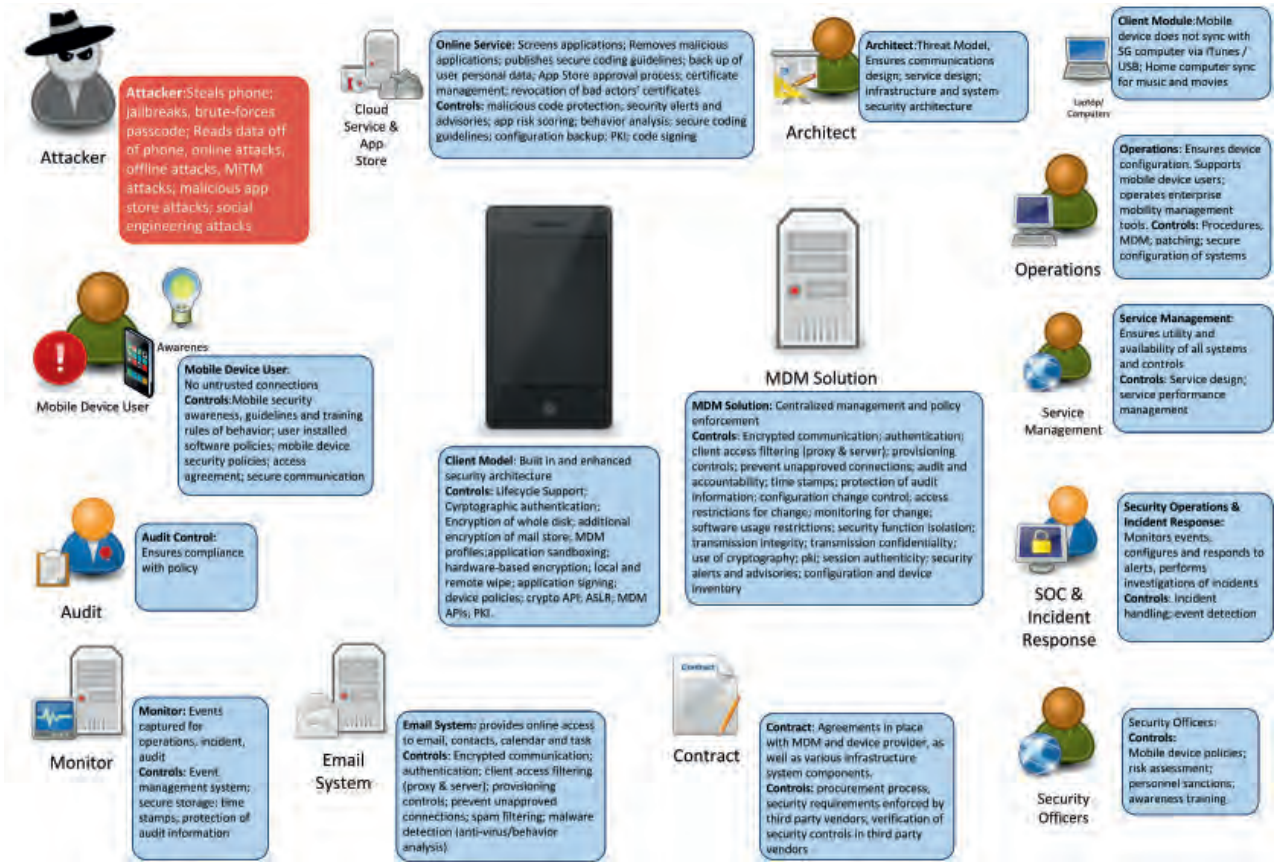
*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 8.1. | New Task Proposal #1 | Enhance the Safeguards Security Operations Center's (SOC) reporting and detection capabilities – Arcsight Product and Reporting Expertise | To be submitted to MSSP in 2014 |
| 8.1. | New Task Proposal #2 | Enhance Security Operations – Consultants For Security Operations Engineering Expertise and Enhanced Skills | To be submitted to MSSP in 2014 |
| 8.1. | New Task Proposal #3 | Design and Implement Systems that Automate the Detection of Anomalous and Unauthorized Behaviours on Safeguards IT Systems. | To be submitted to MSSP in 2014 |
| 8.1. | New Task Proposal #4 | Sponsorship of the IAEA's participation in the Forum of Incident Response Teams – expertise for guidance | To be submitted to MSSP in 2014 |
| 8.1. | New Task Proposal #5 | Assistance with the IAEA's participation in the Forum of Incident Response Team's required training and conferences. | To be submitted to MSSP in 2014 |
| 8.1. | New Task Proposal #6 | Deploy Comprehensive Endpoint Protection | To be submitted to MSSP in 2015 |
| 8.1. | New Task Proposal #7 | Evaluate and Implement Automated Security Testing Tools | To be submitted to MSSP in 2014 |
| 8.1. | New Task Proposal #8 | ISO 27001 Implementation for the IAEA – Consultants to provide expertise | to be submitted to MSSP in 2014 |
| 8.1., 9.3. | New Task Proposal #9 | Secure Communication and Access for Staff in the Field: Architecture, Risk Assessment, Expertise, and Equipment | To be submitted to MSSP in 2014 |
| 9.4. | New Task Proposal #10 | Develop Business Continuity – Expertise | To be submitted to MSSP in 2014 |
| 9.4. | New Task Proposal #11 | Develop Business Continuity – Equipment and Cabling | To be submitted to MSSP in 2014 |

## Attachments




s Figure 1: Overview of the proposed Safeguards logical data centre and disaster recovery facility architecture (logical storage view architecture and network links, security layers and system architecture not illustrated).




s Figure 2: An example threat model and controls coverage for mobile devices.

# SGIS-003

## Safeguards Information Systems and System Usability

**Project Manager: Gregg Whitaker** **Division: SGIS**

### 1 Introduction

The Department of Safeguards has improved the various processes underpinning safeguards implementation. However, forseen benefits cannot reach their full potential because the current safeguards information technology infrastructure is outdated, unreliable, fragmented and under-performing. For a number of reasons, the IT system is Insufficient in supporting all safeguards implementation processes that staff carry out on a day-to-day basis:

1. Development of the IT system started in the 1970s on a mainframe, which is outdated and incapable of efficiently handling the increasing volume and variety of data that the Department is having to process. In addition, the obsolete mainframe does not have the modern capabilities to protect confidential information.

2. Due to the outdated technology, the system is difficult to maintain or enhance, leaving protection and security of information increasingly at risk.

3. The necessary expertise to maintain and improve the existing outdated mainframe software and hardware is no longer commercially available and is not cost-effective. With the current information system and future business needs, the Department of Safeguards faces major operational risks.

The safeguards IT system includes more than 150 software applications to store and process safeguards data (e.g. States' declarations and inspection data), many of which are being used unevenly across the Department. Over the past few decades, information systems have been developed without an effective strategy and architecture to make them fit and function together to meet the current information challenges. Some systems reside on the outdated mainframe and some reside outside of it on the safeguards local area network (SG-LAN). Project SGIS-003 aims to develop a modern, reliable information system that will better support the evolving safeguards implementation. The system will make use of all available safeguards-relevant information from various sources, while ensuring that deployed software solutions meet the necessary integrity and confidentiality requirements. The key elements of the project include the need for software modernization with improved usability features, and an information repository in a secure environment with enhanced analytical capabilities to reduce silos and the duplication of data. A firm foundation upon which to build a more effective information system has already been developed in recent years by the ISIS Re-engineering Project (IRP).

### 2. Overview

The existing information technology challenges are further amplified by the growing volume of information. Information available to the Agency has increased considerably in recent years and is expected to continue to increase in the future, adding to the risk of information overload. Many organizations are resorting to technological solutions to filter (e.g. data mining), organize (e.g. information architecture) and analyse information. Over recent years, significant progress has been achieved in the deliverables produced by the IRP that are of direct use to Project SGIS-003, and are a firm foundation upon which the new information system can be built. As an example, the Integrated Safeguards Environment (ISE) built by the IRP will house safeguards-relevant data and software applications to be populated by the new project.

Project SGIS-003 will focus on:

1. **Software modernization**. Thirteen technologically outdated software applications and associated data essential to safeguards implementation will be re-engineered and transferred to a new platform, and the old mainframe computer will be decommissioned. The Safeguards Information System will allow the handling of a wider range and greater volume of information;

2. **Information repository.** All safeguards information will be relocated and integrated in a secure IT environment that makes information available in a managed and user-friendly manner. The benefits to the Department will be an increase in the availability of structured information for analysis with strengthened security capabilities;

3. **Analytical capabilities**. New cost-effective software solutions will be employed and further developed to improve the ability of analysts to access, collaborate, and maintain knowledge of the on-going evaluation process. For example, analysts will be able to consider multiple formats of safeguards-relevant information, including temporal and spatial information sources;

4. **Enhanced system usability**. User-friendliness of secure collaborative information systems is an important consideration in the development of the Safeguards Information Systems. As such, the user experience must address efficiency, effectiveness and satisfaction. Revised business processes to support new data workflows require custom graphical user interfaces that allow views from different perspectives; i.e., implementation activities, analysis and evaluation, geographical, nuclear fuel cycle, and chronological.

The SGIS-003 project will be conducted in collaboration with all stakeholders. Although the primary end-users of the project include the entire Department of Safeguards, other stakeholders include the Offices Reporting to the Director General, the Division of Information Technology (Department of Management), the Department of Nuclear Safety and Security as well as the Member States.

In the 2014–2015 biennium, the project will:

- Complete the migration of safeguards data from the mainframe to ISE;
- Begin to migrate non-mainframe safeguards data to ISE;
- Re-engineer existing systems and develop new tools to access safeguards data in ISE;
- Develop a single information repository to facilitate the integration of safeguards data;
- Enhance the usability of ISE and the Safeguards Portal;
- Enrich safeguards analytical capabilities to process large volumes of data.

The project will face many challenges in 2014–2015. The limited availabilities of required staff skills and financial resources will continue to drive the frequency of iterative developments to deliver business value to our stakeholders in a timely manner.

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014–2015 biennium, the project will contribute indirectly to the long-term attainment of 1) Capability 8 (*ability to use safeguards information in a fully integrated, secure environment, maintained and available to all who need it according to their role*) and 2) Capability 9 (*ability to communicate secure, authentic information that is fully compatible with ISE between the IAEA, SRAs and inspectors/equipment in the field*) identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1. The project will specifically address meeting the near-term attainment of Milestone 8.1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key achievement targets for 2014–15:* | Urgency |
|---|---|---|---|
| 8 | Ability to use safeguards information in a fully integrated, secure environment, maintained and available to all who need it according to their role. | 8.1 Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State.<br>• *Complete the migration of mainframe data to ISE (2014) and continue the integration of non-mainframe data to ISE (2015), including documents stored in Live Link and State File directories;[2015]*<br>• *Align IT capabilities with new Safeguards business processes in support of the State Level Concept by enhancing the usability of information systems with modern software and analytical tools in an integrated and collaborative working environment;[2015]* | H |
| 9 | Ability to communicate secure, authentic information that is fully compatible with ISE between the IAEA, SRAs and inspectors/ equipment in the field. | 9.1 Enhance field activity data and report management capabilities.<br>• *Enhance existing capabilities to support field activity data and reporting management involving secure communications, mobile devices, and offline functionality.[2015]*<br>• *Develop new capabilities to support field activity data and reporting management, involving an electronic inspection data package (eIDP), design information, additional protocol data and the transmission of state supplied data. [2015]* | H |

## 4. Activities

Funding and resources for much of the project's D&IS activities continue to play a major role in achieving the project's milestones in a timely manner. Some activities are supplemented by regular budget sources.

***Milestone 8.1 Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State.***

***Member State Support Programme task USA D01461 and USA D01564 provide some support for the following activities:***

- **Migration of mainframe data and the integration of non-mainframe data to ISE, including documents stored in Live Link and State File directories .**
  - To facilitate the development of an information repository in a secure collaborative environment, safeguards mainframe and non-mainframe data will be integrated and migrated to ISE.
- **Alignment of IT capabilities with new Safeguards business processes in support of the State Level Concept.**
  - Secure controlled access to safeguards data will require new authorization processes that provide easy and fast access to information. Updates to information security policies and business processes will be required to use safeguards information in a fully integrated, secure environment, maintained and available to all who need it, according to their role.
- **Implement new business capabilities for core business processes in ISE (USA D01461 & (USA D01564).**
  - Develop the functionality and tools needed to effectively integrate the large volume of state supplied data, master data, analytical data, and other source data in a secure collaborative

environment to support the changing business requirements for safeguards implementation activities.

***Milestone 9.1: Enhance Field activity data and report management capabilities. Member State Support Programme task USA D01461 and ESP* D01717 *provide some support for the following activities:***

- **Enhance existing capabilities for field activity data and reporting management**
  - Improve the capabilities to manage data in the field in a secure environment using mobile devices requiring offline functionality.
- **Develop new capabilities for field activity data and reporting management**
  - Develop new functionality to establish an electronic Inspection Data Package (eIDP), improve the transmission of state supplied data, and manage the additional protocol data.

### 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 8.1. | ESP | D 01717 | Enhanced Material Balance Evaluation and Reporting System | May 2014 |
| 8.1. | USA | D 01461 | IAEA Safeguards Information System Re-engineering Project (IRP) (D.151) | End 2014 |
| 8.1. | USA | D 01564 | Design and Definition for an Enhanced Information Analysis Architecture (D.159) | End 2015 |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 8.1. | New Task Proposal | Development of New Capabilities | To be submitted to MSSPs in 2014 |
| 8.1 . | New Task Proposal | Enhancement of Existing Capabilities | To be submitted to MSSPs in 2014 |
| 8.1. | New Task Proposal | Consolidation of Other Agency Systems | To be submitted to MSSPs in 2014 |
| 8.1. | New Task Proposal | Support to manage essential ad hoc requirements during the development of new business capabilities | To be submitted to MSSPs in 2014 |
| 9.1. | New Task Proposal | Support for the management of data between the IAEA, SRAs and inspectors in the field. | To be submitted to MSSPs in 2014 |

# SGOA-002

## Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX)

**Project Manager: Christophe Creusot** **Division: SGOA**

### 1. Introduction

Project SGOA-002 aims to develop and implement an effective and efficient safeguards system for the Japan MOX fuel fabrication plant (J-MOX). The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

The JNFL-1 site, located in the north of Japan, currently includes the large-scale Rokkasho reprocessing plant (RRP). In the near future, the site will include a number of additional facilities, including a mixed oxide (MOX) fuel fabrication plant (J-MOX), additional $UO_3$ storage and various low-level-waste treatment and storage facilities.

The preliminary design information for J-MOX was submitted in June 2005. Plant construction commenced in October 2010, but was suspended following the major earthquake and tsunami that struck Japan on 11 March 2011. Construction resumed in April 2012, mainly dealing with the foundations of the two main buildings. However, the future of J-MOX, linked to the overall future of the Japan Nuclear Fuel Cycle, is uncertain. Japan has not provided a new starting date for J-MOX commercial operation. As a consequence, limited efforts were devoted to J-MOX development and implementation activities in the previous biennium.

J-MOX safeguards systems are developed jointly with the Japanese Authorities. The J-MOX safeguards approach will include: design information examination and verification (DIE/DIV), near real time accountancy (NRTA), containment and surveillance (C/S) measures, process radiation monitoring, sampling for destructive and non-destructive analyses, and in-situ unattended and attended non-destructive assay (NDA) activities.

Should Japan provide an updated J-MOX schedule before, or during, the 2014-2015 biennium, the project's activities will focus mainly on:

- Developing/consolidating a safeguards approach in line with the state level approach;
- Developing/manufacturing equipment necessary to support the safeguards approach;
- Defining the requirements specification and architecture for the integrated data collection and evaluation system; and
- Developing the plan and procedures for design information verification (DIV) during the construction and commissioning phases of the facility.

### 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute indirectly to the long-term attainment of Capability 5 *(ability to deploy equipment at facilities to meet safeguards requirements)* in general, and specifically to meeting

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

the near-term attainment of Milestone 5.3, identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| 5 | Ability to deploy equipment at facilities to meet safeguards requirements. | 5.3 Develop improved tools and techniques to enable real time flow measurements of nuclear material, including $UF_6$ at enrichment facilities and plutonium at reprocessing facilities.<br>• *The following achievement targets will depend on Japan's provision of an updated J-MOX construction and commissioning schedule. Development has been put on hold until its receipt. The development of the joint use SG equipment, data collection system and evaluation software will be monitored through the J-MOX Joint Technical Committee (JTC) with all stakeholders on a regular basis. DIV will proceed according to construction schedule.*<br>• *Develop a safeguards approach for J-MOX, based on the basic elements agreed with Japan, and start the preparation of procedures for implementation;*<br>• *Design, test and install safeguards equipment (NDA, C/S) that provide high quality, independent and reliable results;*<br>• *Design, test and implement an integrated data collection and evaluation software for J-MOX, using synergies with the RRP Information System;*<br>• *Establish and implement DIE/DIV procedures that assure that the facility is constructed and will operate as declared, while ensuring that the safeguards approach remains adequate and robust. Carry out DIE/DIV activities from construction to MOX commissioning phases.* | M |

## 4. Activities

***Milestone 5.3 Develop improved tools and techniques to enable real time flow measurements of nuclear material, including $UF_6$ at enrichment facilities and plutonium at reprocessing facilities.***

The following projected activities include those funded by the IAEA regular budget and those expected to be funded by Member State Support Programmes (MSSPs). A number of MSSP umbrella tasks are active (refer to table 2) and contribute, or will contribute in the future, to the design and testing of the safeguards systems for J-MOX. The particular domains where support is expected include:

- Expert review of design of hardware (HW) and software (SW);
- (e.g. non-destructive assay (NDA), containment and surveillance (C/S), and identification (ID) readers);
- Assistance with authentication/protection of data;
- Assistance with development of an integrated data acquisition and evaluation system;
- Assistance with development and testing of evaluation software modules.

In addition, a number of other R&D projects within the Safeguards Department will contribute potentially to the development of the J-MOX systems, including: *SGTS-001 NDA Techniques*; *SGTS-003 Surveillance Techniques*; *SGTS-011 Unattended Measurements Techniques*; *SGTS-013 Universal NDA Data Acquisition Platform (UNAP)*; and *SGTS-014 Remote Monitoring and Data Processing System*.

MSSP support may be requested for the development of destructive analysis (DA) sample treatment, analysis and transportation procedures, as well as for the development of near real time material accountancy (NRTA) simulation tools.

Task UK D 1878 aims at providing a software tool to simulate the nuclear material accountancy system at a typical MOX plant. This will facilitate the IAEA's review of the J-MOX operator's accountancy system design, which helps in the design phase to evaluate the effectiveness of the IAEA's verification system and NRTA tools.

The conceptual design of the Advanced Material Accountancy Glove Box (AMGB) system, one of the key NDA systems developed by the IAEA for J-MOX, has been peer-reviewed under the task USA A 1801. A prototype of the AMGB verification NDA system was produced in 2010 and was tested at the JRC-Ispra in 2011/2013 under the task EC A 1778.

Initial tests were performed in Japan under the task JPN A 1721 to evaluate the potential use of new generation detectors (i.e. EMC-HPGe, CZT, and liquid scintillator neutron detectors) for J-MOX, as well as the long-term testing of the EMC-HPGe in 2013. Some work was done in parallel under UK A 1887 to provide a signal processor for liquid scintillator detection pulses. A prototype, referred to as the Mixed Field Analyzer (MFA) has been tested extensively.

Tests with a number of equipment items, including a EMC-HPGe, a lanthanum bromide (LaBr) detector, liquid scintillator neutron detectors, as well as magnetometers were performed in March 2012 under FRA A 1944 to validate the conceptual design for the J-MOX fuel rod verification system. Further MSSP support will be needed in the future for peer review of systems and prototype testing.

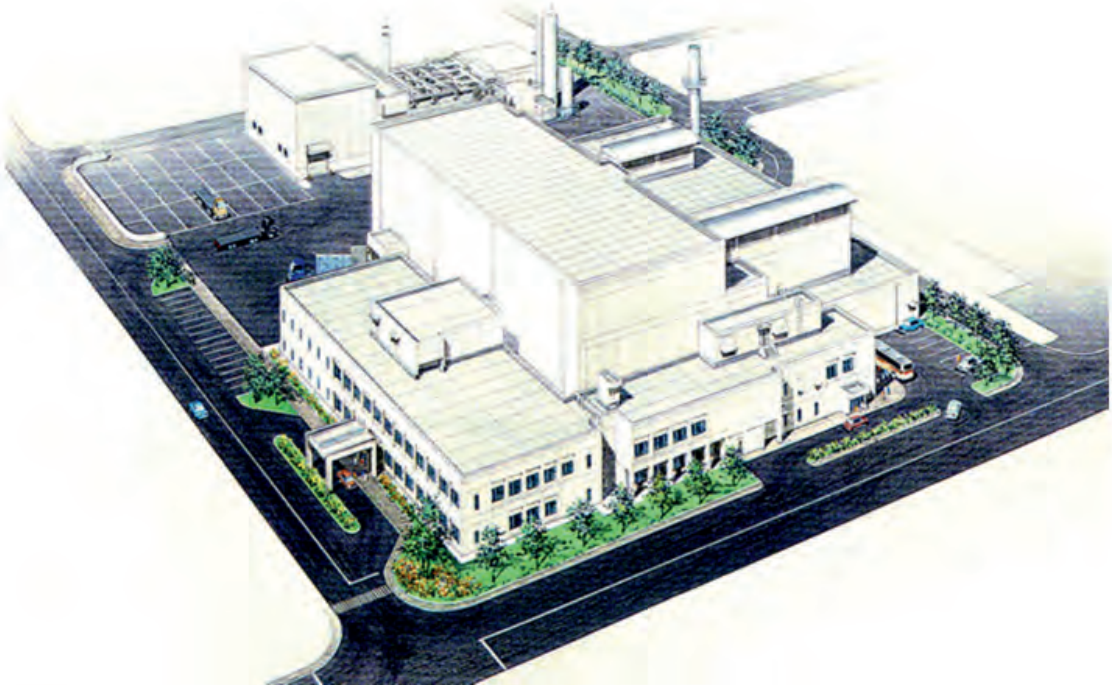
The development and implementation of an integrated data collection and evaluation system for J-MOX (named 'JADE') continues. High-level user requirements were gathered in 2010/2011. However, achievement of the subsequent steps will depend on the provision by Japan of the updated J-MOX schedule.

Umbrella tasks USA D 1802 and EC D 1779 were accepted at the end of 2008 in order to provide future assistance for the design, development, procurement, testing and installation of the JADE system. Sub-tasks will be defined as needs arise.

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

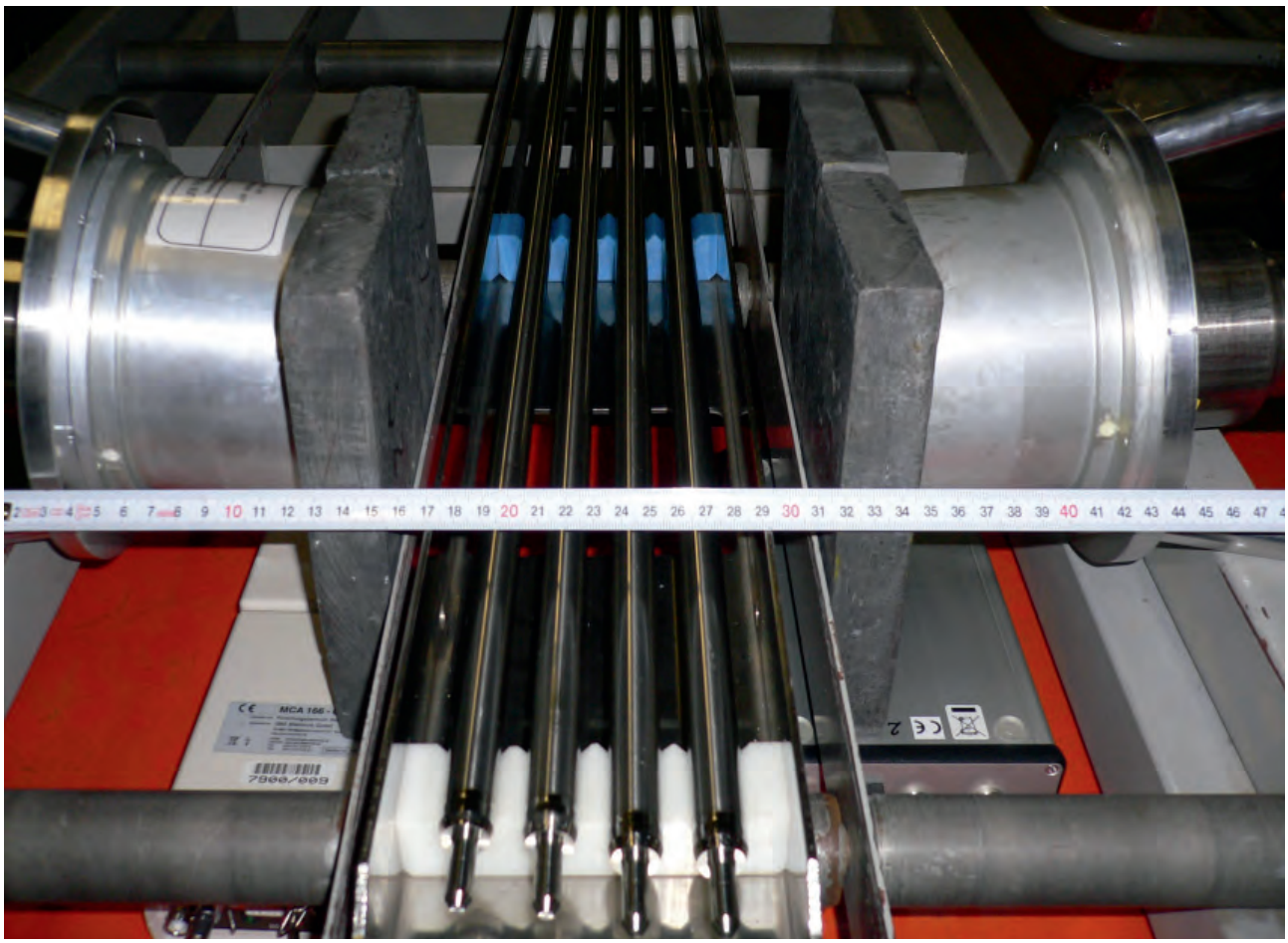
| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 5.. | EC | A 01778 | Support for the Safeguards Systems at the JNFL MOX Fuel Fabrication Plant (J-MOX) (UK (E12(e)), USA (A.280.01)) | * |
| | FRA | A 01944 | | * |
| | UK | A 01887 | | * |
| | USA | A 01801 | | * |
| 5.. | JPN | A 01721 | Support for Development of J-MOX SG Systems (JU-02) | * |
| 5.3.. | EC | D 01779 | Support for the Data Collection and Evaluation System (JADE) at the JNFL MOX Fuel Fabrication Plant (J-MOX) (USA (D.176)) | * |
| | USA | D 01802 | | * |
| 5.3.. | UK | D 01878 | Development of a Software Tool to Simulate the Nuclear Material Accountancy System for MOX Facilities (D2(h)) | * |

* Target completion dates depend on the start of J-MOX commercial operation. As of the date of this project plan, those dates remain unknown.



s Figure 1: A bird's eye view of the future J-MOX plant.

s Figure 2 : Testing of the AMGB prototype



s Figure 3: Testing of the liquid scintillators with MOX fuel rods

# SGOC-001

## Chernobyl

### Project Manager: Sigitas Kurselis — Division: SGOC

### 1. Introduction

Project SGOC-001 aims to develop measures needed to implement safeguards at the new facilities being established at the Chernobyl site in the Ukraine. This facilities comprise the spent fuel processing plant, the dry spent fuel (SF) storage facility to store the fuel processed at the processing plant, and the New Safe Confinement (NSC) to be constructed over Unit 4.

This project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

The goal of this project (hereinafter "Chernobyl Project") is to apply safeguards in an effective and efficient manner at new facilities being constructed at the Chernobyl site. The facilities comprise: the processing plant for processing spent fuel from Chernobyl nuclear power plant Units 1-3, the dry spent fuel storage (Interim Storage Facility, or ISF-2) to store the fuel processed at the processing plant, and the NSC to be constructed over Unit 4. The processing plant and the dry spent fuel storage are expected to be in operation in 2015, and the NSC to be in place in 2016. The Agency's obligation is to ensure that safeguards are applied in accordance with of the Safeguards Agreement on all source or special fissionable material[1] (INFCIRC/550).

Project SGOC-001 was initiated in 2001. Due to technical problems experienced during the construction of the new facilities at the Chernobyl site, construction was suspended in 2003 and the project was delayed subsequently. In January 2013, the Ukrainian State Regulatory Authority, the facility operator and the construction contractor HOLTEC requested the Agency to provide technical details of equipment to be installed at the processing facility of ISF-2 (see figure 1).

In the 2014-2015 biennium, the project will:

- Finalize the update of the State level safeguards approach (SLA) covering, *inter alia*;
  - Spent fuel (SF) transfer from ISF-1 to the processing facility;
  - flow of nuclear material inside the processing facility;
  - transfer of processed spent fuel assemblies from the processing facility to the dry storage;
  - dry SF storage;
  - activities at the NSC;
- Complete the installation and authorization of safeguards equipment for verification use;
- Implement hardware and software for data collection, on-site review, remote transmission to the IAEA and analysis.

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute directly to the long-term attainment of Milestone 12.1 in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability or milestone | Capability or milestone Description | Milestone<br>*Key achievement targets for 2014-15:* | Urgency |
|---|---|---|---|
| **12** | Ability to take on technical challenges and opportunities, and emerging tasks. | 12.1 Assist with Chernobyl, Fukushima and DPRK related activities as requested.<br>• *Develop approaches, instruments and associated methods and install relevant equipment to maintain continuity of knowledge of safeguarded nuclear material. The following activities will begin in 2015:*<br>• *During transfer from ISF-1 to ISF-2 and from ISF-2 to dry storage*<br>• *During processing in ISF-2*<br>• *In dry storage*<br>• *In NSC* | M |

## 4. Activities

Funding and resources for most of the project's development and implementation support activities are provided by Member State Support Programmes, which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources.

***Milestone 12.1: Assist with Chernobyl, Fukushima and DPRK related activities as requested***

- For the Chernobyl site interim spent fuel storage (ISF-2):
  - All undamaged spent fuel assemblies will be transported to the processing facility, processed and loaded into shielded, dry, double-wall canisters (DWC) and moved to the dry storage facility. A preliminary safeguards approach was prepared in 2005-2006. However, taking the broader safeguards conclusion for Ukraine into account (drawn since 2010) and the recent simplification of the nuclear material flow in the processing facility, a new simpler safeguards approach will be developed as a part of the SLA for Ukraine.
  - To provide continuity-of-knowledge about the transfer of nuclear material from the ISF-1 to the dry storage facility and the processing stage at ISF-2, site-specific methods and instruments will be developed and implemented.
  - On-site data integration will be required to optimize inspection activities and data review, and to synchronize records of events taking place in different locations. All surveillance and non-destructive assay (NDA) data will be collected in one place on the site for review and for transmission to IAEA Headquarters in Vienna.
- For the Chernobyl site new safe confinement (NSC) (see figure 2):
  - In 2006, safeguards equipment was installed at the main access points of the existing shelter for the detection of movements of nuclear material out of the area. The equipment, comprising containment and surveillance (C/S) and NDA devices was upgraded in 2013 and will continue to be used in the 2014-2015 biennium.

- The safeguards approach for Unit 4 will be updated as a part of the SLA for Ukraine, taking the NSC into account.
- Facility-specific methods and instruments (NDA and C/S) will be developed and implemented in the NSC.
- The need for safeguards equipment inside the Unit 4 reactor hall will be investigated. Where necessary, appropriate equipment will be installed.

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 12.1. | USA | JNT E 01445 | Safeguards system for Chernobyl Unit 4 ("Shelter") (C.111) | 2016 |
| 12.1. | USA | E 01361 | Integrated Safeguards System for Chernobyl SF Conditioning Facility (Part 2/3 of Chernobyl Transfer and Conditioning Campaign) (E.130.1) | 2016 |

## 4.2. In-house Development Activities

*Table 3. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 12.1. | 1 | Interim spent fuel storage ISF-2 | To revise the safeguards approach and to install the necessary equipment to provide continuity of knowledge about the nuclear material to be processed at ISF-2. | First half of 2015 |
| 12.1. | 2 | Monitoring system for spent fuel container transport | To install a monitoring system to provide continuity of knowledge about the nuclear material to be transferred from ISF-1 to ISF-2. | 2014 |
| 12.1. | 3 | Site data integration | To collect data from the new rail wagon, ISF-2 and NSC and to transfer collected data to IAEA Headquarters. | First half of 2015 |
| 12.1. | 4 | SG equipment for RH 4 | To complete an analysis of the need for equipment inside reactor hall unit 4 and to install that equipment if required. | 2014 |
| 12.1. | 5 | New safe confinement | To revise the safeguards approach for unit 4 and to install equipment for the application of safeguards to material in unit 4 | 2016 |

## Attachments

s Figure 1. A view of the the ISF-2processing facility.

s Figure 2. A view of the Chernobyl site new safe confinement (NSC)

# SGTS-001

## NDA Techniques

**Project Manager: Mikhail Mayorov** **Division: SGTS**

### 1. Introduction

This document describes the plans for developing and implementing non-destructive assay (NDA) methods and systems for the assessment and verification of nuclear material, and instrumentation associated with other inspector field activities such as design information verification and complementary accesses, within the Department of Safeguards for the period 2014–2015. It has been produced in accordance with the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2] and the key milestones necessary to achieve those capabilities.

### 2. Overview

There are three main driving forces for research, development and implementation of new NDA products and technologies establishing the main directions and methodology needed to acquire instruments in the area of portable and resident NDA equipment.

The first driving force is the natural progress in information technology (IT) and communication technologies, nuclear and industrial electronics, and enhanced performance of radiation detection equipment for nuclear security applications. This progress allows IAEA Safeguards to benefit from modern, commercially available components and solutions, with little or no investment to improve performance incrementally in the existing systems.

The second driving force is a growing concern about the number and diversity of portable and resident NDA systems with similar functionality, but with a different design. Here, Project SGTS-001 aims to develop and deploy instruments where functionality can be integrated easily into a reduced number of multipurpose systems. Currently, there are over 50 authorized portable and resident non-destructive assay (PRNDA) systems, and this number has been growing with the authorization of three to five new systems a year. There should be a continuation of the effort expended to utilize a modular design concept for existing and new PRNDA systems, to monitor the life-cycle of the existing systems, and to replace obsolete systems, in a timely manner with newer instruments, possessing enhanced and improved functionality.

Finally, there are existing gaps in safeguards technical approaches and new challenges that the IAEA is facing, such as: the verification of the completeness of a State's declaration, including the absence of undeclared material and activities, application of safeguards at bulk facilities, and the pyro-processing of spent fuel. Further research in these areas will help the Department of Safeguards deliver appropriate instrumentation to support of safeguards implementation needs.

Project SGTS-001 supports the *Long-Term R&D Plan, 2012–2023*, particularly with efforts to achieve the long-term attainment of Capability 2 (*Increased ability to detect undeclared nuclear material and activities*); Capability 5 (*Ability to deploy equipment at facilities to meet safeguards requirements*); Capability 6 (*Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products*); and Capability 10 (*Ability to provide analytical services through the NWAL to support foreseen future verification requirements*).

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf)

Project SGTS-001 will continue contributing to tasks managed under other D&IS projects, including projects SGTS-011*Unattended Measurement Techniques* and SGTS0-15 *Technologies for new IAEA Verification Mandates*. Conversely, Project SGTS-008 *Instrumentation Technology Foresight* is expected to assist in exploring alternatives to investigated technologies and provide input as to applicable and possible technological breakthroughs relevant to the scope of SGTS-001.

## 3. Direction(s): Capabilities and Milestones

During the 2014-2015 biennium, Project SGTS-001 will contribute directly to the attainment of Milestones 2.2, 2.6, 5.4, 5.5, 5.6, 5.7, 5.8 and 6.2, identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>Key achievement targets for 2014-15: | Urgency |
|---|---|---|---|
| 2 | Increased ability to detect undeclared nuclear material and activities | 2.2. Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools.<br><br>*Establish a reference library with a collection of non-radiation signatures of metallic alloys, inorganic and organic compounds, specific to the nuclear fuel cycle (NFC) [December 2015]* | H |
| | | 2.6. Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations.<br><br>*Select, evaluate, customize and authorize commercial off-the shelf equipment for detection of non-radiation signatures of the NFC [December 2015]* | H |
| 5 | Ability to deploy equipment at facilities to meet safeguards requirements | 5.4. Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding storage/transport containers at all points in their life-cycle.<br><br>*Authorization of the Dual-Slab Verification Detector [July 2015]* | M |
| | | 5.5. Develop methods to verify fresh fuel in shipping containers without opening the containers.<br><br>• *Re-engineer the Inspector Multichannel Analyser (IMCA) software package based on the GENIE-2000 package currently embedded in the IMCA software to incorporate the functions of other stand-alone gamma spectra analysis software;*<br><br>• *Ensure the sustainability and maintenance of software for plutonium-isotopics and uranium enrichment to determine nuclear characteristics;*<br><br>• *Development algorithms for isotopic analysis of uranium and plutonium samples using medium resolution gamma-spectrometry (with LaBr3, CZT detectors) for the improved attribute test capability. [December 2015]* | M |
| | | 5.6 Develop improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.<br><br>• *Develop the methodology for the on-site bias defect analysis of uranium or thorium ore concentrates, $UF_6$ and impure and dirty scrap materials using the Combined Procedure for Uranium Concentration and Enrichment Assay (COMPUCEA);*<br><br>• *Develop and manufacture a compact tomographic gamma scanner. [December 2015]* | M |

| Capability | Capability Description | Milestone<br><br>Key achievement targets for 2014-15: | Urgency |
|---|---|---|---|
| | | 5.7 Develop more sensitive and less intrusive alternatives to existing instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage.<br>• *Develop an improved technique for irradiated fuel attribute test;*<br>• *Evaluate a prototype tomographic spent-fuel detector system.* [May 2014] | M |
| | | 5.8 Develop alternative instruments, for instance based on liquid scintillators, to improve performance in neutron coincidence counting techniques applied to various types of fissile material.<br>• *Develop a prototype liquid scintillator-based coincidence counter;*<br>• *Evaluate and select a fast neutron detector for neutron coincidence counting applications. [December 2015]* | M |
| 6 | Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products | 6.2 Develop neutron counting systems reducing the use of 3He or offering equivalent functional and technical alternatives.<br>• *Evaluate Boron-10 hybrid proportional counters for neutron coincidence counters;*<br>• *Develop the next generation Cherenkov viewing device (CVD);*<br>• *Authorize a hand-held pressure differential device for the purpose of measuring liquid levels in tanks at reprocessing facilities. [May 2014]* | M |

## 4. Activities

Research tasks under Project SGTS-001 in the 2014-2015 biennium, will comprise two nearly equal groups: of Member State Support Programmes (MSSP) tasks and in-house activities. MSSP tasks will continue to play an essential role in strengthening the IAEA safeguards system. However, in-house activities will play an increasingly important role as IAEA coordinated projects typically take shorter times for implementation and require fewer resources. Some of the projects, in particular those aiming at development of new or upgraded instrumentation, are intended to embed specific MSSP tasks, where applicable. The implementation support tasks will primarily address specific technical issues, targeting the incremental performance improvement of the existing applications and the authorization of commercial off-the-shelf instruments for inspection use.

***Capability 2: Increased ability to detect undeclared nuclear material and activities.***

With MSSP support, the IAEA has developed, authorized and implemented various devices, capable of detecting nuclear fuel cycle (NFC) radiation signatures. Examples include: the multi-purpose radionuclide identification device HM-5 customized under GER A 01271 "Software for Hand-Held Gamma Spectrometer" and a Hand-held Neutron Monitor (HHNM model KSAR1U.06). Two further instruments, the Portable Radionuclide Identification Scanner (PRIS model: AT6101C-SG) and the Portable Radionuclide Identification Pager (PRIP model nanoRAIDER) will be authorized for inspection use by the commencement of 2014, completing the IAEA tool box of the instruments for detection of NFC radiation signatures.

The instrument toolbox for on-site detection of non-radiation signatures is also under development, with the expected completion of development and authorization by the end of 2014. The instruments will utilize laser-induced breakdown spectrometry (LIBS), Raman spectrometry and X-ray fluorescence spectrometry techniques to analyse on-site materials for elemental and chemical composition. During the 2014-2015 biennium, Project SGTS-001 will contribute to the attainment of Milestone 2.2 *(Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes;* and Milestone 2.6 *(Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities).* Both tasks will be in-house activities primarily, but cooperation with the European Community MSSP support programme is foreseen at the later stage.

In the first stage of this activity, commercially available, of-the-shelf instruments for elemental and chemical composition analysis, such as Thermo Scientific™ FirstDefender RMX, Niton XL3t XRF analyzer, Tracer IV SERIES Handheld XRF from Bruker, Rigaku FirstGuard™ hand-held Raman analyzer, hand-held LIBS (being developed under CAN MSSP Task A 01855) and others, will be compared side-by-side. The most promising instrument will be selected for in-depth evaluation and customization. The second stage will be the acquisition of the relevant signatures that may serve as NFC indicators, such as special iron, aluminum, beryllium and zirconium alloys, pure carbide, uranium, fluorine and organic compounds, special acids, boron and lithium. The work will be done at JRC-ITU Institute for Trans-uranium Elements (Karlsruhe, Germany) and at the IAEA Analytical Laboratories. The signatures will be specific to the instruments and material concerned.

***Capability 5: Ability to deploy equipment at facilities to meet safeguards requirements.***

The vast majority of R&D tasks within Project SGTS-001 will target the long-term achievement of Capability 5. Efforts will include the coordination of relevant on-going MSSP tasks and coordinated development of new instruments, techniques, solutions and software for various NDA applications, as well as incremental performance improvements to existing applications, which will be authorized for inspection use.

At present, there are number of MSSP tasks that target Capability 5. In order to develop appropriate safeguards equipment that can establish and maintain knowledge of spent fuel in shielding storage/transport containers at all points in their life-cycle (Milestone 5.4), Project SGTS-001 will pursue the authorisation of the Dual-Slab Verification Detector, developed at the Los Alamos National Laboratory (LANL) for attribution measurements of Ukrainian BN-350 spent fuel in dual-use casks (DUC) at dry storage sites. This device is designed for passive neutron measurements at four specific locations around the exterior of DUC to establish signature "fingerprints" for each cask. Periodic consistency verification of such fingerprints will provide continuity of knowledge, even if traditional containment and surveillance measures fail.

High functionality and technical performance of medium resolution $LaBr_3$ and CdZnTe detectors for fresh and spent fuel attribute tests have made these detectors a standard tool for IAEA the verification of State declarations. In order to develop a method capable of verifying fresh fuel in shipping containers without opening (Milestone 5.5), as well as widening the area of application of $LaBr_3$ and CdZnTe detectors, a new task is proposed to develop an algorithm for isotopic analysis of uranium and plutonium samples using medium resolution gamma spectrometry. This joint effort with the European Safeguards Research and Development Association (ESARDA) NDA Working Group activity will comprise three steps: acquisition of nuclear material spectra with the authorized PRNDA equipment, such as CdZnTe MMCC and LaBr MMCL detectors, development and improvement of the algorithms for isotopic composition and enrichment analysis for medium-resolution gamma-ray spectrometers, and performance evaluation of the algorithms by the semi-empirical spectra injection technique [e.g. replicative assessment of spectrometric equipment (RASE) technique]. The outcome of this task will include recommendations on usability, accuracy and identified limitations of the medium-resolution gamma spectrometry and the relevant software for plutonium isotopics and uranium enrichment measurements.

JNT A 1684 "Sustainability and Maintenance of Software for Pu-isotopics and U-enrichment" will continue with the implementation of a spectra database for performance testing of codes and the development of performance criteria and suitable test procedures. The task is expected to be completed in 2014.

Another envisaged task will focus on the development of an integrated data acquisition and analysis software package to work with InSpector-2000 Multichannel Analyser (IMCA), which is associated with the Genie2000 software, and incorporates functionality of multiple existing data analysis codes in one package. The latter includes codes, such as those used for uranium and plutonium spent fuel attribute tests, MGA/MGAU, FRAM, NaIGEM, LabRod and LabPel. The new software package will integrate and provide a common unified graphical user interface for the spectrum acquisition, processing and analysis, which currently use applied NDA methodologies and based on modern and sustainable technologies, allowing maintenance and modification of the software, depending on emerging safeguards needs.

In order to address the development of improved instruments and techniques for verification of waste and scrap nuclear material with impure composition of heterogeneous isotopic composition (Milestone 5.6), Project SGTS-001 will continue the efforts of EC A 1507 "COMPUCEA upgrading" task. The COMPUCEA is a transportable analytical system for uranium elemental assay and $^{235}U$ enrichment measurement in pellets, powders, scrap and other uranium bearing materials. The accuracy of the method meets the ITV2010 requirements for destructive assay (DA) measurements and its analytical performance was confirmed by comparison of the field analysis with the IAEA laboratory results. The COMPUCEA was authorized as Category A (approved for inspection use) equipment in May 2011. Since then, it has been employed successfully in the on-site bias-defect verification measurements of 68 DA samples taken at fuel fabrication facilities during the physical inventory verification (PIV) activities in 2011, 2012 and 2013. The immediate availability of an accurate analytical results and a follow-up analysis capability proved to be the major benefit of the COMPUCEA on-site measurements, contributing to the improved effectiveness of the verification campaigns.

Project SGTS-001 also addresses the development of customized technical solutions for specific, non-routine safeguards implementation activities. One such task, also in support of Milestone 5.7, is an internal task (IAEA Task 1196 in table 4 below) – "Development of the Improved Technique for Irradiated Fuel Attribute Test". Under this task, SGTS-001 will include activities to develop a scientific and technical solution for the attribute test of irradiated fuel that is based on the direct observation of uranium signature(s) in the measured item. To confirm fuel item integrity (i.e. partial defect test), the IAEA has successfully drawn on the MSSP task JNT A 01508,"DCVD Additional Capabilities Performance Testing" to authorize the Digital Cerenkov Viewing Device (DCVD) for partial defect testing in 2011. Alternative approaches, such as the Self-Induced Neutron Resonance Densitometry (SINRD) explored under task USA A 1668, did not perform as well, although the SINRD technique could be applied successfully to trans-uranium compounds, such as those from pyro-processing. The feasibility of confirming the presence of individual irradiated fuel rods by passive emission tomography has been demonstrated under the joint MSSP task, JNT A 01510, "Prototype Tomographic Spent-Fuel Detector System". A measurement campaign was conducted successfully at Finnish the Olkiluoto boiling water reactor (BWR) in March 2013. The next step will be to conduct a measurement campaign on pressurized water reactor (PWR) fuel to prove the feasibility of passive emission tomography on large fuel assemblies. Acquired knowledge is instrumental to the unattended gamma emission tomography (UGET) system task (JNT A 1955) that has been established to explore the feasibility of passive emission tomography in an unattended mode.

Under Milestone 5.8 (Develop alternative instruments to improve performance in neutron coincidence counting *techniques applied to various types of fissile material*), the Project will continue to integrate a coincidence counting system, based on liquid scintillators provided under task NET A 1958 and associated fast pulse-shaping electronics developed by Hybrid Instruments under the MSSP task UK A 1951. The effort is driven predominately driven by the promising pathway to improve the performance of the passive and active neutron coincidence counting technique by the near elimination of accidentals by utilizing a very short (about 100 ns) coincidence time gate. Associated support for the modelling and simulation was provided by the EC MSSP under task EC A 1362. The project will result in an operational prototype of a fast neutron active collar which will be tested and characterized using real nuclear material in 2014.

Successful completion of the MSSP task USA A 01607 "Development of ISOCS Self Modelling Capabilities" (A.267), has significantly improved the IAEA's capability to involve quantitative gamma spectrometry on a large range of objects. However, both the neutron multiplicity and the in-situ object counting system (ISOCS) approach continue to reach their limits when the distribution of the nuclear material in the assessed object becomes inhomogeneous or when different grades of nuclear material (i.e. for instance mixed scraps of low and high enriched Uranium are mixed together in containers. In such cases, the tomographic technique offers the capability to assay objects in three dimensions, thus significantly reducing the uncertainties associated with knowledge of the matrix and the distribution of the nuclear material. Using extra-budgetary contributions, the Project will specify and procure a compact tomographic gamma scanner, specifically tailored to unique IAEA requirements.

***Capability 6: Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products.***

The IAEA's toolbox of instruments supporting safeguards implementation is very extensive and currently includes over 50 varieties of NDA devices and systems. Many were developed and authorized decades ago, such as the (circa 1985) Improved Cerenkov Viewing Device (ICVD), primarily used to identify irradiated fuel assemblies, and the (circa 1985) Electromanometer (ELTM), for measurement of level in the tanks with plutonium-containing liquids at reprocessing plants, and therefore are behind the performance of their modern "equivalents". The other group of instruments, involving $^{3}$He-filled proportional counters have been designed and manufactured at the times when $^{3}$He was a bi-product of tritium production for defence applications. Three tasks will be implemented in 2014-2015 to address these cases and contribute toward achieving the IAEA ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products.

***Milestone 6.1 – Implementation an improved cost/benefit assessment methodology for the design and operation of safeguards equipment.***

To contribute to the abovementioned key direction, SGTS-001 has established a new in-house activity "Development on next generation Cherenkov Viewing Devices (CVD)" (see 1198 in table 4 below). The goal of this task is to develop and validate a conceptual design of an upgraded handheld CVD. The upgraded instrument should increase the sensitivity of the current device and include recording functions. The work will investigate the possibility of reusing parts of the ICVD, such as ultra violet (UV) lenses and should assess if a lightweight sensor would still require the use of a light intensifier for acceptable performance. Commercially available components will be used for the instrument design. The cost of the upgrade of a single ICVD should not exceed 15 % of the total cost of a new instrument. Once the hardware design has been completed and successfully tested for qualitative measurement, the performances for quantitative measurements will be assessed.

***Milestone 6.2 – Development of neutron counting systems reducing the use of $^{3}$He or offering equivalent functional and technical alternatives.***

One of the most promising technical alternatives to $^{3}$He detectors in neutron coincidence counting applications is "improved" counters, known as "B-10+", or hybrid detectors, which consist of boron-lined proportional counters filled with about 25% to 50% atmosphere of $^{3}$He gas. This technical solution improves efficiency of pure $^{10}$B-lined proportional counters by 100%, but requires much less $^{3}$He (the standard pressure of $^{3}$He in neutron counters is at least 4 atm.).

Based on this technology Reuter-Stokes has designed a prototype of BWR fuel neutron coincidence collar and made it available for evaluation. Under the SGTS-001 internal activity 10, "Evaluation of B-10 hybrid detectors for neutron coincidence counting technique", the Project will evaluate the system's performance and develop recommendations on the potential use of hybrid detectors for attended and unattended NDA applications, requiring thermal neutron detection. The estimated completion date of the task is July-August 2014.

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current active and standby MSSP development and implementation tasks*

| MSSP | Task No. | Task Title | Applicable Capability / Milestone | Target Completion Date |
|---|---|---|---|---|
| BEL | A 01086 | Calibration of Underwater Coincidence Counter | 5. | June 2014 |

| MSSP | Task No. | Task Title | Applicable Capability / Milestone | Target Completion Date |
|---|---|---|---|---|
| CAN | A 01855 | Technical Support for the Prototype Portable Hand-Held LIBS System (PHHL) | 2.6. | December 2014 |
| CZ | A 01566 | Test Bed Facility for Spent Fuel Verification Systems | 5. | December 2014 |
| EC | A 00860 | Qualification Testing of New Safeguards Equipment | 5. | December 2014 |
| GER | A 01271 | Software for HHGS | 5.7. | December 2014 |
| GER | A 01791 | Digital Upgrade of Mini Multi-Channel Analyser (MMCA) (C.40) | 5.7. | June 2014 |
| HUN | A 01667 | Development and Evaluation of a Multiplicity Spectrometer Prototype | 5.8. | Extended until December 2014 |
| UK | A 01729 | Technical Manuals and Procedures for Safeguards Instrumentation (E11) | 5. | December 2014 |
| USA | A 00931 | NDA Implementation Support - Instruments and Techniques (A.252) | 5. | December 2014 |
| USA | A 01668 | Spent Fuel Fissile Measurements Using Self-Induced Neutron Resonance Densitometry (SINRD) (A.273) | 5.7. | Proposed to be terminated |
| USA | A 01842 | Technical Manuals and Procedures for Safeguards Instrumentation (A.285) | 5. | December 2014 |
| EC, FIN, SWE | JNT A 01510 | Prototype Tomographic Spent-Fuel Detector System | 5.7. | June 2014 |
| EC, FRA, USA | JNT A 01684 | Sustainability and Maintenance of Software for Pu-isotopics and U-enrichment | 5. | December 2014 |
| EC | A 01362 | Modelling, Testing and Training for NDA and URM equipment | 5. | December 2014 |
| UK | A 01951 | Fast Neutron Detector Pulse shape Discriminator System | 5. | December 2014 |

## 4.2. In-house Activities

*Table 4. Current and standby in-house activities*

| Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|
| 1 | In-house activity 1198. Development of next generation of CVD | The goal of this task is to develop and validate a concept design of an upgraded handheld CVD. The upgraded instrument should increase the sensitivity of the current device and include recording functions. The task will investigate the possibility of reusing parts of the ICVD, such as UV lenses and should assess if a lightweight sensor would still require the use of a light intensifier for acceptable performance. Commercially available components will be used for the instrument design. | November 2014 |
| 2 | In-house activity 1196. Development of Improved Technique for Irradiated Fuel Attribute Test | TND is performing the development of a scientific and technical solution for the attribute test of irradiated fuel that is based on the direct observation of uranium signature(s) in the measured item. | April 2014 |
| 3 | In-house activity 1186. Authorization of the next generation of Neutron Coincidence Counting electronics and data reduction software | The objective of this project is to authorize the next generation neutron multiplicity counting electronics, JSR-15 and PTR-32 by organizing their procurement, the compatibility upgrade of relevant data acquisition software (i.e. INCC) through the USSP, their functionality evaluation test, and proper documentations for their authorization. | June 2014 |

| Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|
| 4 | In-house activity 1188. Portable Radionuclide Identification Devices for Complementary Access Applications | The objective of this` project is to select, evaluate and authorize a family of Portable Radionuclide Identification Devices (PRID) compliant with SG-EQ-PRID-UR-0001 User Requirements | June 2014 |
| 5 | In-house activity 1193. Re-design of CBVB Hoist With Stepping Motor and Control Unit | SGTS/TND develops and implements a new electro-mechanical part of the Hoist by replacing the existing Servo motor, its Controller and a Remote control with a new design. Functional part of the CANDU Bundle Verifier for Baskets (CBVB) device, i.e. the collimated CdZnTe detector with preamplifier and MCA-527, Suspension mechanism with the twin winding drums and baseplate and Data acquisition laptop, will remain unchanged | May 2014 |
| 6 | In-house activity 1197. Evaluation and Testing of the mMCA-527 in Preparation for Authorized SG Use | The project objective is to outline a systematic approach to evaluating and testing the new MMCA-527 with the aim of identifying potential problems and coordinating their resolution in a timely manner with the manufacturer.<br>The end deliverable will be successful integration of the new mMCA-527 into the SG regime. | June 2014 |

*Table 5. Proposed and planned in-house activities*

| Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|
| 1 | Establishment of reference library and collection of non-radiation signatures of metallic alloys, inorganic and organic compounds, specific for Nuclear Fuel Cycle | See description under Milestone 2.2 above. | December 2015 |
| 2 | Selection, evaluation, customization and authorization of commercial off-the shelf equipment for detection of non-radiation signatures of Nuclear Fuel Cycle | See description under Milestone 2.6 above. | December 2015 |
| 3 | Authorization of DSVD neutron counting system | See description under Milestone 5.4 above. | July 2014 |
| 4 | Development of a gamma/x-ray acquisition and analysis software, based on modern and sustainable technologies, that will perform IMCA functions and incorporate functions of other standalone gamma spectra analysis software | See description under Milestone 5.5 above. | December 2015 |
| 5 | Development of algorithms for isotopic analysis of Uranium/Plutonium samples using medium resolution gamma-spectrometry (LaBr3, CZT) for the improved attribute test capability. | See description under Milestone 5.5 above. | December 2015 |
| 6 | Development of the methodology for the on-site bias defect analysis of uranium ore concentrates, $UF_6$ and impure and dirty scrap materials using COMPUCEA | See description under Milestone 5.6 above. | December 2015 |
| 7 | Evaluation and selection of a fast neutron detector for neutron coincidence counting applications | See description under Milestone 5.7 above. | December 2014 |
| 8 | Authorization of hand-held pressure differential device for the purpose of` measuring liquid levels in tanks at reprocessing facilities | Authorize a hand-held pressure differential device for the purpose of` measuring liquid levels in tanks at reprocessing facilities. | May 2014 |

| Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|
| 9 | Development and manufacturing of a Compact Tomographic Gamma Scanner | Specify and procure a compact tomographic gamma scanner, specifically tailored to unique IAEA requirements. | December 2015 |
| 10 | Evaluation of $^{10}B$ hybrid detectors for neutron coincidence counting technique | See description under Milestone 6.2 above. | May 2014 |

# SGTS-002

## Techniques and Instruments for Sealing and Containment Verification

**Project Manager: Bernard Wishard** **Division: SGTS**

### 1. Introduction

Project SGTS-002 develops and deploys containment verification and sealing devices, which are required by the Department of Safeguards to meet its needs to maintain continuity of knowledge of nuclear material in containers, to protect IAEA instrumentation physically, and to ensure integrity of Member State equipment where joint-use arrangements apply. An overarching element of the project is to assess and enhance the physical security of instruments and to ensure integrity, authenticity, and confidentiality of their data, from which independent safeguards related information conclusions are drawn.

The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

Project SGTS-002 supports the Department in the development and implementation of seals and containment verification technologies, which are needed for new safeguards applications, as well as the modernization of legacy equipment. The project also includes elements that raise the security level of all equipment and certain procedures against threats ensuring integrity, confidentiality and authenticity of safeguards equipment and associated data. Security requires dynamic tools and techniques to identify the threat vectors, assess vulnerabilities, and provide solutions that lower the risk of attack.

Activities under the project are consistent with the Department's need to acquire and deploy safeguards equipment that is sustainable, standardized, modular, and based on the greatest possible use of commercial off-the-shelf (COTS) products. A fundamental element of Project SGTS-002 is the development of technologies that enhance cooperation with facility operators, reduce costs of implementing containment, and decrease the efforts needed to verify containment and data. This requires a balance that optimizes security, usability, and cost-effectiveness.

Project SGTS-002 supports the *Long-Term R&D Plan, 2012–2023*, particularly with regard to achieving Capabilities 5 and, 6 (see Table 1). There are a number of containment projects that focused on decreasing the effort of sealing dry storage canisters (Milestone 5.4), as well as implementing special sealing solutions in Japan, and decreasing the equipment needed by the Inspectorate.

To ensure the robustness of sealing systems in the field and the authenticity of remotely obtained seal and containment verification data, independent vulnerability assessments have been completed on the Laser Surface Authentication System (LSAS), the Laser Mapping for Cylinder Verifier (LMCV) for canisters and casks, and the Remote Monitoring Sealing Array (RMSA). Vulnerability reviews have been completed on the Ultrasonic Optical Sealing Bolt (UOSB) and the *iReader*. Vulnerability reviews will commence in 2014 on the glass seal, which is a potential replacement for the metal E-CAP seal[3].

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1 http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

2 As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

3 Safeguards Techniques and Equipment, 2003 Edition (http://www-pub.iaea.org/MTCD/publications/PDF/NVS1-2003_web.pdf)

Recent accomplishments include the construction and deployment of the next generation reader for the COBRA (type V) seal that allows the comparison of high-resolution images using a user-friendly interface, a new adhesive seal, which is ready for routine use; and the completion of a successful test for a technique detecting intrusion of cables.

A major technical challenge faced by the Project is the deployment of containment systems that can be implemented and used with greater efficiency through enhanced cooperation and joint-use of sealing and containment devices, while minimizing the number and cost of equipment items and decreasing inspector effort. However, such improvements must be accomplished in a manner that maintains physical and information security, meeting IAEA requirements for deterrence and tamper detection.

The project also coordinates its development and implementation activities with projects SGTS-003 *Surveillance Techniques*, SGTS-008 *Novel Technologies in Support of Safeguards Implementation*, SGTS-011 *Unattended Measurement Techniques*, SGTS-014 *Remote Monitoring and Data Processing Systems* and SGTS-015 *Technologies for New IAEA Verification Mandates*. In particular, the development of techniques and instruments for sealing and containment, which contribute to Project SGTS-015, will be managed under Project SGTS-002, to provide system analysis, define specific requirements and integrate results. These activities are further described within the SGTS-015 project plan.

End-users are primarily operation divisions carrying out safeguards verification activities.

In the 2014-2015 biennium, the project will:

- Review tasks and activities with respect to the *Long-Term R&D Plan, 2012–2023*, identifying priorities and appropriate work plans (January 2014);
- Finalize field trials for the RMSA and complete its authorization for inspection use;
- Deploy the LMCV system;
- Finalize field trials for UOSB;
- Evaluate a low-cost active seal prototype developed jointly with the JRC;
- Perform vulnerability review, detailed testing, and prototype evaluation of a glass seal prototype;
- Conduct a feasibility study and, if required, develop a prototype hydro-acoustic containment system;
- Automate the CAPS verification using robotics to improve the efficiency of seals verification, freeing personnel for customer services tasks and decreasing the likelihood of contamination at IAEA Headquarters;
- Support the deployment of the Universal Instrument Token (UIT);
- Perform security assessments of safeguards instruments and containment systems;
- Integrate high-security radio-frequency identification (RFID) tags into one or several classes of passive seals.

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, SGTS-002 will contribute to the long-term attainment of Capability 5 (*ability to deploy equipment at facilities to meet safeguards requirements*) and Capability 6 (*ability to acquire and deploy safeguards equipment that is sustainable with increased use of COTS*) in general, and specifically to meeting the near-term attainment of Milestone 5.4 identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key achievement targets for 2014-15:* | Urgency |
|---|---|---|---|
| **5** | Ability to deploy equipment at facilities to meet safeguards requirements. | 5.4 Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.<br>• *Field test the low-cost seal [December 2014]*<br>• *Deploy the LMCV to replace one component of dual containment and surveillance (C/S) [December 2015]* | H |
| **6** | Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products.<br>• *Assess and evaluate glass seal prototypes as potential replacements for the metal E-Cap seal, which is a 50 year old design [January 2015]*<br>• *Deploy the iReader for multiple seal types to decrease equipment carried by Inspectors in the field [December 2015]*<br>• *Deploy UIT based on smart card technology to store certificates and private keys securely [December 2015]*<br>• *Integrate high-security RFID tags into one or several types of passive seals; develop management systems and readers for these tags; conduct a field test; and evaluate results [December 2015]* | | |

## 4. Activities

Funding and resources for many of the project's development and implementation support activities are provided by MSSPs, which continue to play an important role in contributing to Capability 6 and in achieving the project's Milestone 5.4. Several activities are supplemented by regular budget sources.

***Milestone 5.4: Develop safeguards equipment to establish and maintain continuity of knowledge of spent fuel.***

- Finalize the field testing of the RMSA;
- Field test the low-cost seal;
- Deploy the LMCV to replace one component of dual C/S;
- Finalizing field trials for UOSB;
- Perform vulnerability review, detailed testing, and prototype evaluation of a glass seal prototype.

***Capability 6: Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products.***

- Develop the *i*Reader for multiple seal types to decrease equipment carried by inspectors in the field;
- Support the deployment of UIT based on smart card technology to securely store certificates and private keys. (Not related to any MSSP activity);
- Integrate high-security RFID tags into passive seals, such as the COBRA seal, the glass seal and/or the paper seals. This will increase the overall security and usability of these seals. (Not related to any MSSP activity);
- Perform security assessment of safeguards instruments and containment systems. (Not related to any MSSP activity)

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 5.4 | EC | E 01549 | Laser Surface Mapping of Canister Closure Welds | December 2015 |
| 5.4 | EC | E 01559 | Update of the Ultrasonic Sealing Bolt | December 2015 |
| 5.4 | USA | E 01771 | Development of a Remotely Monitored Sealing Array (RMSA) | December 2015 |
| 5.4 | EC | E 01849 | Development of a Low-cost Active Electronic Seal | December 2014 |
| 6 | GER | E 01890 | EOSS Sealing Systems Implementation Support (D.36) | December 2014 |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 5.4 | EC E 1849 | Development of Low-Cost Electronic Seal | December 2015 |

## 4.2. In-house Development Activities

*Table 4. Current In-house Development Activities*

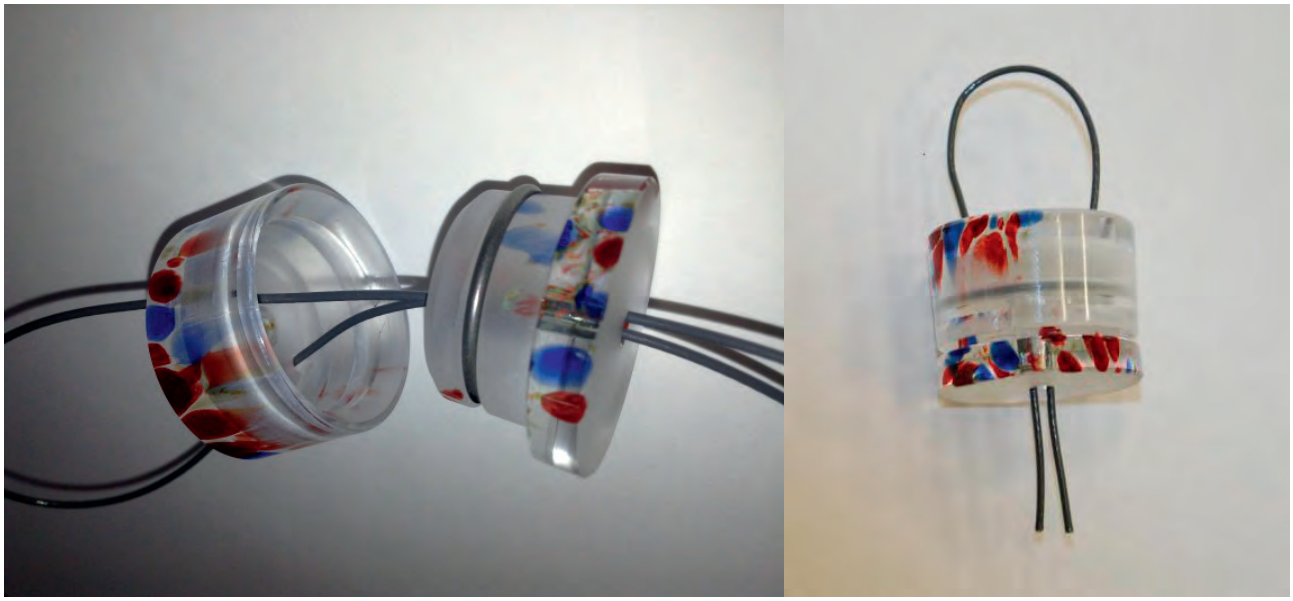
| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 6 | 1 | *iReader* for multiple seal types. | Develop an all-in-one reader that will decrease equipment carried by inspectors in the field, noting that the next generation of seals readers will be required to read RFIDs, active seals and glass seals. | December 2015. |
| 6 | 2 | Universal instrument token (UIT) | Support the deployment of UITs in the field. | December 2015 |
| 6 | 3 | Glass Seal | Assess and evaluate glass seal prototypes as potential replacement for the metal E-Cap seal. | January 2015 |
| 6 | 4 | RFID and Sealing Technology | RFID-Technology is gaining more and more importance in the fields of logistics, public transport, electronic id and access solutions. The progress of shrinking the process to 60 nm has led to very powerful but small chips fulfilling highest security standards.<br><br>A feasibility study on the analysis of the advantages of combining existing sealing technologies, like the COBRA seal and the glass seal with RFID technology, was completed in 2013. The study showed that improvements in terms of security and usability can be achieved. Based on these results, activities will move forward on the integration of high-security RFID seals in passive seals, such as the COBRA seal, the glass seal, and, potentially, also the paper seal. | December 2015 |
| 6 | 5 | Security assessment of safeguards instruments and containment systems | Because the threat vectors for safeguards instrumentation are dynamic there is a continual need for the Department to perform on-going security assessments of safeguards instruments, containment systems, and data collection archival and review processes. The assessment of security must be based on current knowledge of threats and potential vulnerabilities. Systems must be initially assessed and then periodically checked as part of their life cycle of maintenance. | On-going |

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 5.4 | 6 | Hydro-acoustic containment system | Spent fuel ponds pose a number of problems for containment systems since sealing must be performed in water up to 10 meters in depth. Additionally, surveillance cannot be maintained without lighting. A potential solution is to use active hydro-acoustic signals to generate an image of spent fuel items underwater. | December 2015 |

*Table 5. Proposed and planned in-house activities*

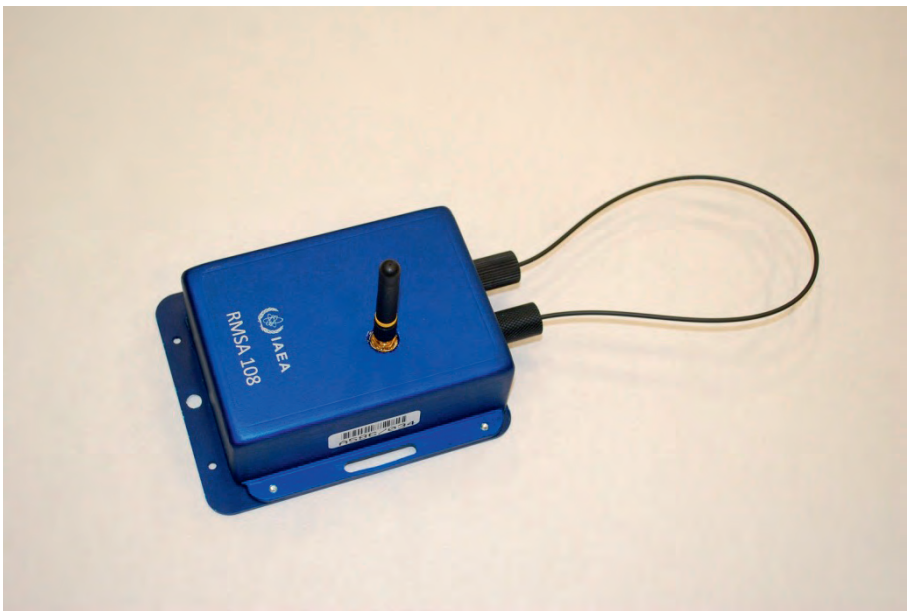
| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 5.4 | 1 | Feasibility assessment of a fibre optic seal that detects motion and gamma radiation | Active seals that use fiber optic loops capable of detecting gamma radiation pulses and vibration may be valuable to safeguards implementation where it is necessary to determine material immobilization. This in-house activity will conduct a feasibility assessment of a fibre optic seal that detects motion and gamma radiation. | December 2015 |

## Attachments:

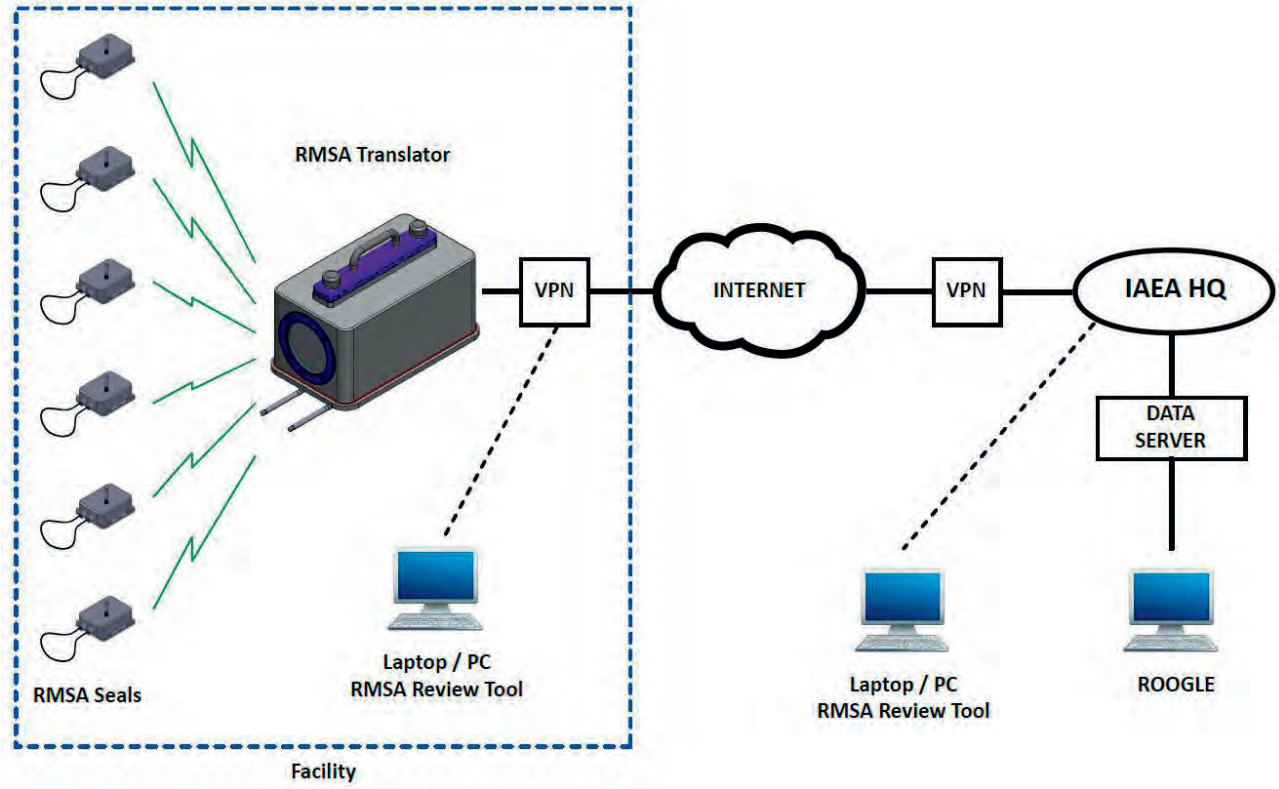


[s] Figure 1. Glass seal, potential replacement of CAPS metal seal

s Figure 2. Ultrasonic Optical Sealing Bolt (UOSB), passive and active sealing technologies in one.

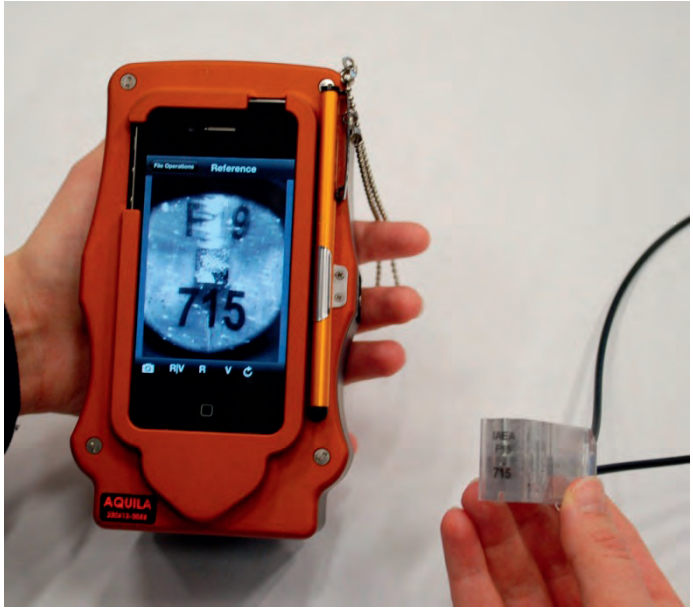



s Figure 3. Remotely Monitored Sealing Array (RMSA) Electronic Seal

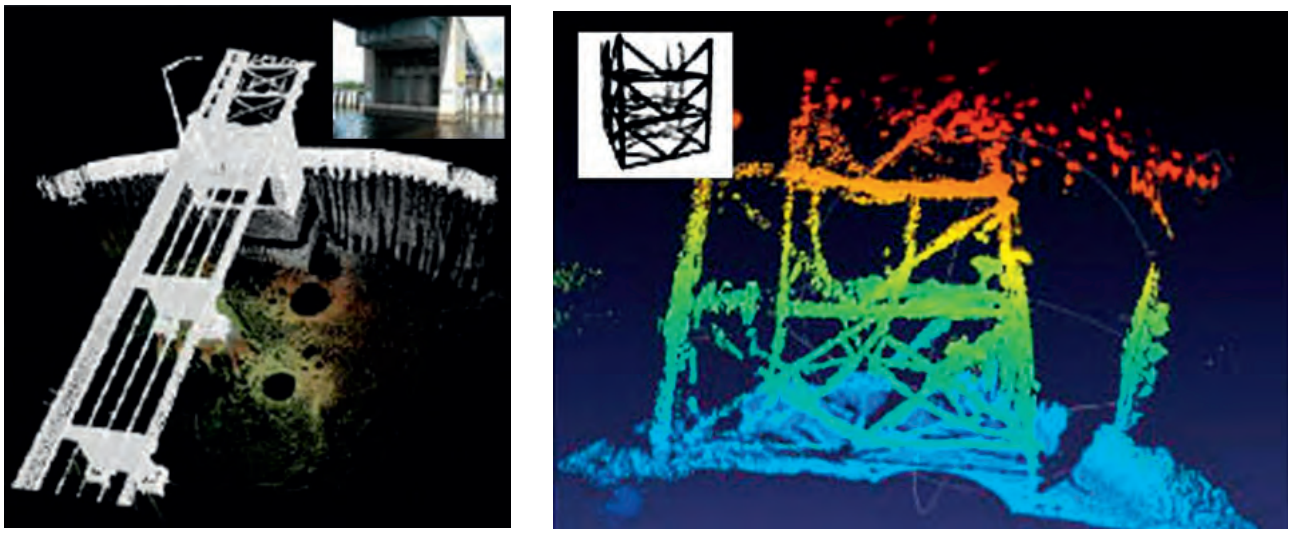



s Figure 4. RMSA system topology

s Figure 5. LMCV Weld scanner on DSC flange




s Figure 6. iCOBRA, COBRA seal verification system



s Figure 7. Hydro-Acoustic Monitoring

# SGTS-003

## Surveillance Techniques

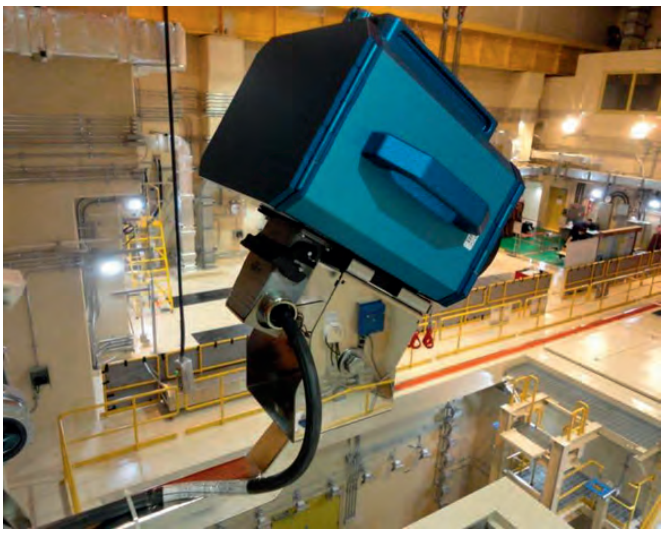
### Project Manager: Martin Moeslinger — Division: SGTS

### 1. Introduction

This document describes the plans for developing and implementing optical surveillance equipment within the Department of Safeguards for the period 2014–2015. Project SGTS-003 supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

Project SGTS-003 covers the development and implementation of optical surveillance equipment needed for new safeguards applications and the replacement of legacy equipment and surveillance instruments for routine safeguards inspection activities. Optical surveillance equipment, lighting solutions and laser-based verification instruments are provided to all IAEA inspection divisions in support of safeguards implementation.



s Figure 1 – The Next Generation Surveillance Camera (NGSS) new generation camera installed at a nuclear reactor facility

The project currently supports the *Department's Long Term R&D Plan 2012-2023*, particularly with regard to achieving Capability 5 (*ability to deploy equipment at facilities to meet safeguards requirements*). In the 2014–2015 biennium, the project will also undertake activities that support the IAEA's efforts in achieving Capability 7 (*ability to make maximum efficiency savings by the use of remote monitoring of operators' and unattended IAEA equipment*).

The methods and technologies identified under Project SGTS-003 for research, development and implementation are carefully selected to meet the challenges of emerging and future safeguards implementation regimes. A particular focus of the Project's R&D activities is the development, standardization and modularization of surveillance data analysis techniques to reduce the burden currently presented to Safeguards inspectors and

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

analysts. The project also coordinates its efforts with projects *SGTS--002 Techniques and Instruments for Sealing and Containment Verification*, *SGTS-008 Novel Technologies in Support of Safeguards Implementation*, *SGTS-011 Unattended Measurement Techniques*, *SGTS-014 Remote Monitoring and Data Processing Systems* and *SGTS-015 Technologies for New IAEA Verification Mandates.*

The most recent achievements include: substantial progress in the field implementation of the Next Generation Surveillance System (NGSS) cameras and systems to replace ageing DCM14[3] based surveillance systems[4]; authorization of the Laser Item Identification System (L2IS) for routine Safeguards use; and the miniaturization and authorization of the 3-Dimensional Laser Range-Finder (3DLR), used *inter alia* for design information verification (DIV).

[s] Figure 2 – The new, miniature 3DLR laser scanner

The major challenges ahead for a successful execution of Project SGTS-003 remain the availability of sufficient human and financial resources, which are essential for the Department to benefit fully from its investment in advanced technologies development, like the NGSS.

In the 2014-2015 biennium, the project will:

- Provide, specifications and requirements for a surveillance review software module for the new SG equipment data review platform based on CRISP (Feb 2014);
- Develop a new, standardized low voltage power subsystem for all surveillance equipment, taking full advantage of available commercial-of-the-shelf battery and power supply technology (Mar 2015);
- Finish the development of a protective cover to be used for NGSS cameras installed in harsh environment outdoor applications (Jan 2014);

[3] DCM14 is the acronym for "digital camera module – one for all applications"

[4] By August 2013, more than 100 NGSS cameras had been deployed in the field.

- Monitor the progress made in surveillance technology research and evaluate commercially available alternatives to traditional optical surveillance systems with a focus on laser-, radar- and ultrasonic based surveillance technology (on-going activity);
- Demonstrate the applicability of commercial of-the-shelf (COTS) technology to address the need for a miniature, unattended camera for short-term temporary surveillance (Sep 2015);
- Develop a wireless communication module for the NGSS camera (Dec 2014).

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute indirectly to the long-term attainment of *Capability 5* in general, and specifically to meeting Milestones 5.1 and 5.3 identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1. The project will also undertake activities that support the IAEA's efforts generally in achieving Capability 7.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| 5 | Ability to deploy equipment at facilities to meet safeguards requirements. | 5.1. Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of plutonium (Pu) separation)<br>*Conduct a series of field tests to benchmark the applicability of the 3DLR technology as an alternative to traditional containment verification or sealing measures. A related report will be presented by June 2015.* | M |
| | | 5.3. Develop improved tools and techniques to enable real-time flow measurements of nuclear material, including uranium hexafluoride ($UF_6$) at enrichment facilities and Pu at reprocessing facilities.<br>*L2IS is currently authorized for use at the Rokkasho enrichment plant. The technology's applicability will be assessed for other enrichment plants and for facilities handling bulk nuclear material. A related assessment report will be presented by December 2014.* | M |
| 7 | Ability to make maximum efficiency savings by the use of remote monitoring of operators' and unattended IAEA equipment. | 7.2: Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.<br>*Complete an addition to the NGSS camera, to support operator-owned analogue cameras including a related security vulnerability assessment. [September 2015]* | H |

## 4. Activities

Funding and resources for most of the project's D&IS activities are provided by MSSPs, which continue to play a major role in achieving the project's milestones. Some activities are supplemented by regular budget sources as detailed in section 4.2.

***Capability 5: Ability to deploy equipment at facilities to meet safeguards requirements.***

- Under task FRA E 01818 an "artificial retina" technology (CALADIOM®) is investigated for applicability within current and future safeguards surveillance solutions. CALADIOM® is based on intelligent dynamic pattern recognition and behavioural analysis of objects of interest. The data analysis is performed at the optical sensor level and has the potential to reduce the amount of data generated by cameras dramatically and the resource requirements associated in further data processing. This is one of the major upcoming challenges for the next decade. Related field-testing of

the technology conducted under task CZ A 1883. Assessment of the work performed under this task suggests that it will be beneficial to implement such technology at the surveillance review end (post-processing). This task directly supports "In-house Activity #1" and Project SGTS-014 by providing specifications and requirements for a new, modular surveillance review software tool, which is compatible with a comprehensive, Departmental sensor data review platform[5].

- Task GER E 01341 provides the support framework for enabling and improving remote monitoring performance with currently installed digital image surveillance systems, based on the DCM14 module. As DCM14-based systems are being replaced by the NGSS, a new task shall provide similar resources for the NGSS technology in maintaining efficient remote connectivity and joint-use over the whole NGSS life-cycle. The new task has been proposed under 13/TUS-001 (Table-3) and is expected to be accepted by December 2013.

***Milestone 5.1: Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation).***

- The 3DLR laser scanner-based DIV tool was developed under task EC E 01425. Its authorized application base has been extended to a wider range of DIV activities by miniaturization, making the instrument more self-contained with greater portability. The 3DLR is a convenient tool to verify the design characteristics of complex facilities like reprocessing plants. By using further improved laser scanner technology it is planned to enhance the 3DLR's applicability to even a broader range of containment verification needs by December 2014.

***Milestone 5.3: Develop improved tools and techniques to enable real time flow measurements of nuclear material, including $UF_6$ at enrichment facilities and Pu at reprocessing facilities.***

- The L2IS Laser Item Identification System was developed under task EC E 01696. L2IS is capable of monitoring 100% of the real-time flow of $UF_6$ cylinders at nuclear material bulk handling facilities, for example, enrichment plants. L2IS is currently authorized for safeguards use at the Rokkasho Enrichment Plant, Japan, where it performs an automatic identification of $UF_6$ cylinders as they pass to/from the process area. The assessment of the applicability of L2IS at other enrichment or reprocessing facilities is planned to be completed by December 2014.

***Milestone 7.2: Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.***

- Task proposal 13/TUS-002 (Table-3) for "Analogue Camera Support for the NGSS DCM-C5 Surveillance Core Component" is expected to be accepted by December 2013. Under this task, an analogue input to the NGSS camera, supporting *inter alia* operator owned cameras, will be provided. The task will further provide active, electronic protection of the video cable used to connect such analogue cameras. A related vulnerability assessment of the technology is planned to be completed by March 2015.

[5] Please also see Project SGTS-014.

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 5. | CZ | A 01883 | Smart Sensor for Enhanced Surveillance (2SES) Field Test | December 2015 |
| 5. | FRA | E 01818 | Evaluating the Enhancement of Surveillance Using Intelligent Camera Technology (CALADIOM based) | December 2015 |
| 5.1. | EC | E 01425 | 3D Laser Range Finder for Design Verification | December 2015 |
| 5.1. | EC | E 01636 | Software Engineering Support for 3D Camera Development | December 2014 |
| 5.3. | EC | E 01696 | L2IS: Laser Item Identification System | December 2014 |
| 5. | GER | E 01341 | Remote Monitoring and Unattended Digital Surveillance Systems (D.34) | December 2014 |
| 5. | GER | E 01982 | NGSS Product Lifecycle Support | on-going |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 5. | 13/TUS-002 | Analog Camera Support for the NGSS DCM-C5 Surveillance Core Component | Outstanding with GER. |
| 5. | 13/TUS-004 | Research, Development and Evaluation of a Surveillance Review Software based on Automatic Image Summaries (VideoZoom) | Outstanding with EC. |
| 5. | 13/TUS-005 | Scientific and Technical Support for 3D Laser Range Finder (3DLR) | Outstanding with EC. |

## 4.2. In-house Development Activities

*Table 4. Current and Standby In-house Development Activities*

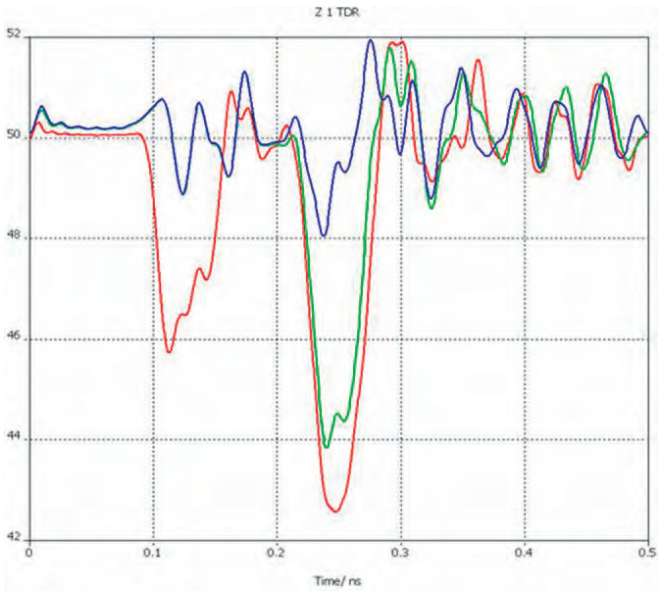
| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| **7** | 1 | Provide specifications and requirements for new surveillance review software module | In collaboration with Project SGTS-014 provide, specifications and requirements for a surveillance review software module for the new SG equipment data review platform based on CRISP. | February 2014 |
| **5** | 2 | NGSS Underwater Camera Housing Development | Conduct field testing and finish the certification of new, underwater camera housing for the NGSS camera (regular budget). | March 2014 |
| **5** | 3 | Develop new, standardized power modules for surveillance system implementation. | Finish the selection and development of a new, standardized low voltage power subsystem for all surveillance equipment, taking full advantage of available commercial-off-the-shelf battery and power supply technology (regular budget). | March 2015 |

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 5 | 4 | Development of Outdoor cover for the NGSS camera | Finish the development and certification of a protective cover to be used for NGSS cameras installed in harsh environment outdoor applications (regular budget). | January 2014 |
| 5 | 5 | Develop and implement infrastructure for the Department's surveillance laboratories | Develop and implement infrastructure like hard- and software tools for the Department's surveillance laboratories to increase efficiencies in sustaining surveillance equipment testing and implementation (regular budget). | On-going activity |
| 5 | 6 | Monitor and evaluate progress made in surveillance technology research | Monitor the progress made in surveillance technology research and evaluate commercially available alternatives to traditional optical surveillance systems with a focus on laser-, radar- and ultrasonic based surveillance technology. | On-going activity |

*Table 5. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 5 | 1 | Evaluate commercial "smartphone" technology for SG applicability | Demonstrate the applicability of commercial off-the-shelf (COTS) technology to address the need for a miniature, unattended camera for short-term temporary surveillance (regular budget).<br>Upon the successful evaluation it is foreseen to propose a new task for an SG specific application development for the selected platform with a goal of completion by June 2015. | September 2015 |
| 7 | 2 | Develop wireless communication interface for the NGSS camera | Develop a fully integrated WLAN based communication module for the NGSS camera to eliminate the need for data cables in certain SG applications (regular budget). | December 2014 |

## Attachments




s Figure 3 - Active tamper indication on analogue surveillance camera connections by Time Domain Reflectometry (TDR). Shown are the reflectograms of an undisturbed video cable (blue colour) and the cable after tempering tampered (tapped) at various distances (red and green colour)

s Figure 4 - New NGSS Underwater Camera Housing with remotely controlled optics

# SGTS-008

## Instrumentation Technology Foresight

### Project Manager: Dimitri Finker — Division: SGTS

### 1. Introduction

This document describes the plan for Project SGTS-008 for the period 2014–2015 for identifying, developing and evaluating emerging technologies and instruments that are intended to support safeguards implementation needs within the Department of Safeguards. Project SGTS-008 supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

Project SGTS-008 addresses development, evaluation, implementation, and enhancement of technological capabilities in the area of equipment and methods supporting IAEA safeguards laboratory and field activities. The potential use of new techniques is also studied and developed further where needed.

The project supports the *Long-Term R&D Plan, 2012–2023*, particularly with regard to Milestone 12.2 *(developing and implementing a technology foresight horizon scanning process for external, potentially relevant R&D fields)*. In the period of the 2014-2015 biennium, Project SGTS-008 will pursue additional capabilities related to the implementation of assay, measurement, detection, surveillance and sealing and covered by Capabilities 2, 3, 5, 6, and 10 (see Table 4 for full capability descriptions). More specifically, the project will establish and operate a technology foresight structured methodology, focusing on the instrumentation aspects of the implementation of safeguards. It also addresses the IAEA's role in verifying the absence of undeclared production and processing of fissile material.

The previous Project SGTS-008 "Novel Technologies" introduced emerging technologies for Safeguards, such as laser-induced breakdown spectroscopy (LIBS) or the hand-held Raman instrument. In the 2014-2015 biennium, Project SGTS-008 will continue to monitor a broad range of innovations but with an emphasis on evaluating how commercially available innovations can be applied to field missions carried out by IAEA inspectors. The focus will be to:

- Establish a new process for systematic outreach methods and technologies to detect technological novelties;
- Identify and analyse gaps in technologies currently in use for safeguards field and laboratory activities;
- Establish partnerships with external stakeholders to channel information from developers, commercial suppliers to internal stakeholders in charge of the implementation of various technologies in the domains of non-destructive assay, containment/surveillance and destructive analysis;
- Conduct evaluation of identified technologies with regards to possible safeguards application.

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will establish a sustainable and documented process for technology foresight. Deliverables from the project will contribute mainly to development and implementation support efforts of Projects SGTS-001 *(NDA Techniques)*, SGTS-002 *(Techniques and Instruments for Sealing and Containment Verification)*, SGTS-003 *(Surveillance Techniques)*, SGTS-011*(Unattended Measurement Techniques)*, and SGTS-014 *(Remote Monitoring and Data Processing Systems)*, pursuing the attainment of milestones identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 4. The project may also contribute to projects SGCP-003 *(Safeguards Approaches)* and SGAS-002 *(Environmental Sample Analysis Techniques)* in regard to novel technologies capable of supporting the detection of undeclared activities, facilities and materials early.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

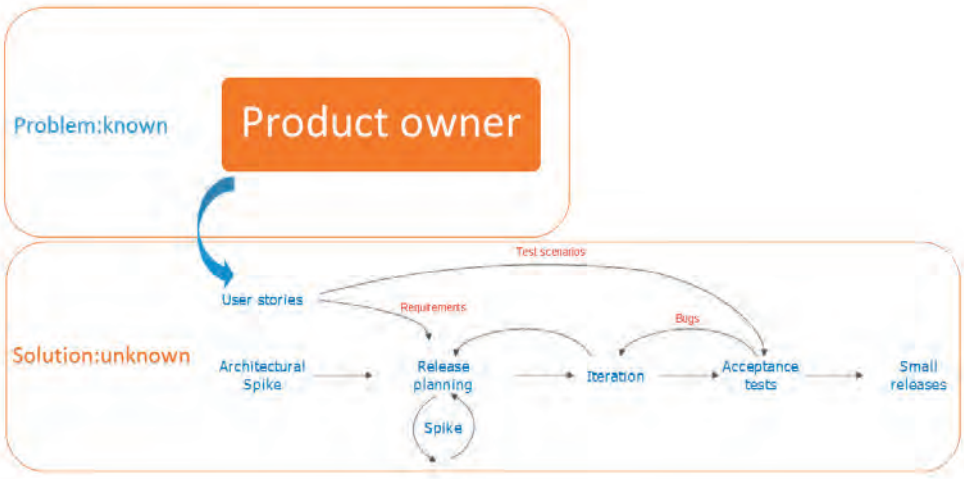
| Cap-ability | Capability Description | Milestone<br><br>Key achievement targets for 2014-15: | Urgency |
|---|---|---|---|
| 12 | Ability to take on technical challenges and opportunities, and emerging tasks. | 12.2. Develop and implement a technology foresight horizon scanning process for external, potentially relevant research and development (R&D) fields.<br>• *Establish and document a sustainable process for the implementation of technology foresight covering technologies that focus on the instrumentation applicable to safeguards field and laboratory activities* [Dec. 2014];<br>• *Issue and distribute a quarterly Technology Preliminary Evaluation Report on potential emerging technologies to the Department of Safeguards* [Quarterly release, on-going];<br>• *Conduct and present a comparative exploration of new technologies for SG inspectors, including indoor positioning, portable mass spectrometry, material identification instrumentation, and micro seismic monitoring* [Dec. 2015]. | H |

## 4. Activities

Technology foresight is about identifying or developing new products and services within a context of high uncertainty. Useful innovations for the IAEA may occur through multiple mechanisms:

- Repositioning reapplication of existing technologies, for use in Safeguards in another field;
- Deploying products or processes already used by IAEA to a new location or for new applications;
- Devising new processes that may identify a value that was previously hidden;
- Introducing novel scientific discoveries.

Agile project management processes will yield timely viability assessment of innovative solutions.




[s] Figure 1: Agile project development process

This methodology will allow the Department to not only accelerate the implementation of promising new technologies, but as importantly, make it possible to discard at an early stage solutions that are not fit for Safeguards use.

### 4.1. MSSP Development and Implementation Support Tasks

MSSP tasks will essentially be used in three areas:

- To facilitate and extend the outreach capabilities of SGTS, e.g. in fields that have been identified, requiring specific expertise to be further investigated;
- To tackle specific issues arising during the early stages of project development, and requiring extensive R&D effort;
- To qualify and deploy in a larger scale the solution initiated under technology foresight in-house efforts.

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 12.2. | ROK | ROK A 01894 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | AUL | AUL A 01856 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | NET | NET A 01850 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | ESP | ESP A 01826 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | JPN | JPN A 01798 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | SWE | SWE A 01671 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | FRA | FRA A 01641 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 12.2. | ARG | ARG A 01637 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | EC | EC A 01634 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | GER | GER A 01633 | MSSP Umbrella Task: Support for Novel Technologies (A.38) | End 2015 |
| 12.2. | FIN | FIN A 01628 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | CAN | CAN A 01622 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | RUS | RUS A 01621 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | BEL | BEL A 01615 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | BRZ | BRZ A 01601 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |
| 12.2. | UK | UK A 01599 | MSSP Umbrella Task: Support for Novel Technologies (A7(h)) | End 2015 |
| 12.2. | HUN | HUN A 01597 | MSSP Umbrella Task: Support for Novel Technologies | End 2015 |

No specific MSSP tasks are planned to be initiated within the project in the 2014-2015 biennium.

## 4.2. In-house Development Activities

*Table 3. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 12.2. | 1 | Indoor positioning | Comparative exploration of indoor positioning technologies for SG inspectors. | June 2015 |
| 12.2. | 2 | In situ mass spectrometry | Comparative exploration of options for portable and transportable mass spectrometry for inspectors, in cooperation with SGAS-001 *(Destructive Analysis of Nuclear Materials)* and SGAS-002 *(Environmental Sample Analysis Techniques)*. | End 2015 |
| 12.2. | 3 | Continuous Technology Evaluation | Continuous research and subsequent preliminary evaluation of technologies potentially useful to IAEA safeguards.<br>Production of "*Quarterly Technology Preliminary Evaluation Report*". | On-going |
| 12.2. | 4 | Scanning the Horizon workshop | Contribute as SGTS representative to the SGCP workshop "Scanning the Horizon".<br>Coordinate related follow up activities. | February 2014 |

*Table 4. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 12.2 | 1 | Technology outreach | Conduct outreach activities with external technology stakeholders, analysing and disseminating information relative to relevant technological and scientific developments. | On-going |
| 12.2 | 2 | Technology Foresight process | Establish a sustainable and systemic process for implementation of the technology foresight function within the Department. | End 2014 |
| 12.2 | 3 | Gap analysis | Collect user need from divisions of operation on complementary access instrumentation. | June 2014 |
| 12.2 | 4 | Inspector Data Tablet | Evaluate options and requirements for the Inspector Data Tablet for remote monitoring applications. | End 2014 |
| 12.2 | 5 | Material identification workshop | Design and coordinate an evaluation workshop on material identification (Raman, X-ray fluorescence (XRF), LIBS, Fourier transform infrared spectroscopy (FTIR), mid-infrared (MIR) spectroscopy) in cooperation with Departmental NDA specialists. | End 2014 |
| 12.2 | 6 | Micro seismic monitoring | Evaluate options for micro-seismic monitoring of underground geological repositories. | End 2015 |

# SGTS-011

## Unattended Measurement Techniques

**Project Manager: Thierry Pochet** **Division: SGTS**

### 1. Introduction

This document describes the plans for developing and implementing unattended measurement techniques within the Department of Safeguards for the period 2014 - 2015. This project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

The main long-term target of the SGTS-011 project is to provide optimized unattended measurement techniques that enhance present safeguards equipment methods and capabilities for the detection and monitoring of declared and undeclared nuclear material and activities.

The project objectives for SGTS-011 in the 2014-2015 biennium are similar to those introduced in the previous 2012-2013 biennium plan. The scope of the project encompasses the following four key objectives:

1. The study of potential uses for new non-destructive assay (NDA) methodologies, measurement techniques and sensors for unattended applications, pertinent to safeguards implementation requirements and the required capabilities, as identified in the *Long-Term R&D Plan, 2012–2023*;

2. The development and standardization of new generic software for multiple data type collection, review and analysis, which will be compatible with all unattended monitoring system (UMS) data generators. Review and analysis software will provide powerful and sophisticated methods of for data reduction and interpretation, which will efficiently and effectively assist inspector effort;

3. The development of standard NDA techniques specifically tailored for unattended use;

4. The development of modern electronic modules for NDA measurement systems, including front-end electronics and computer-less data acquisition (DAQ) systems, which would include all necessary security, power management, and redundancy features for unattended use, in particular to allow secure remote data collection through networks. The development effort must be driven by a standardization approach and a strict cost-effectiveness policy in view of optimizing system maintainability and associated life cycle costs.

The above key objectives mainly address the needs for the long-term Capabilities 5 (*ability to deploy equipment at facilities to meet safeguards requirements*) and 6 (*ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products*), as identified and described in the *Long-Term R&D Plan, 2012–2023*. The project also contributes to the attainment of Milestone 3.1 for the development of generic safeguards approaches for pyro-processing plants and to Milestone 12.1 (*assist with Chernobyl, Fukushima and DPRK related activities as requested*).

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

Several Departmentally-needed monitoring systems will be developed and implemented over the 2014-2015 biennium. These activities will occur in parallel with the on-going maintenance and refurbishment of the older systems, which currently represent more than 50% of project activities.

A number of the SGTS-011 key objectives are shared with other Departmental projects. The most prominent project connections are with *SGTS-001 NDA Techniques, SGTS-013 Universal NDA Data Acquisition Platform (UNAP), SGTS-014 Remote Monitoring and Data Processing Systems*, and *SGTS-015 Technologies for New IAEA Verification Mandates*.

Several key objectives were achieved successfully in the 2012-2013 biennium:

- First prototypes of a new data acquisition system (ADM2, or "NGAM[3]" – Next Generation of ADAM) (see Figure 1) were received and thoroughly tested for field deployment in 2014 (key objective #4);
- Phase 1 of the OLEM (On-Line Enrichment Monitor) project was completed in October 2012, and Phase 2 (development and testing of field prototypes) was accepted by the USA Member State Support Program (USSP) in January 2013;
- A new Mobile Detection Unit (MUD2[4]), with extended features, was developed successfully, tested and is now authorized for Safeguards use (key objective #4);
- A new Silo Entry Gate Monitor (F-SEGM[5]), based on scintillating fibres, has been developed and is currently under evaluation (key objective #1);
- The facility-wide upgrade and standardization project, for all Chernobyl nuclear power plant (NPP) unattended systems, was completed in May 2013. The refurbishment of all UMS systems at Rokkasho Reprocessing Plant (RRP) will be completed by early 2014 (key objective #4);
- The development and implementation of a new and sophisticated Unattended Monitoring System (UMS) system to characterize undocumented fuel prior to long-term storage at a storage facility in Canada. (key objective #1).

s Figure 1: The ADM2 data acquisition module is a direct drop-in replacement for ADAM modules in all VIFM & SEGM systems. It includes eight SCA and eight digital inputs, a native Ethernet-TCP/IP based module with Web interface, USB sticks for data storage, and data authentication capability. (Capability 6)

The end-users that will benefit from Project SGTS-011's activities are inspectors performing safeguards verification activities. The primary outcomes of SGTS-011 will be the enhancement and expansion of the Agency's unattended technical capabilities, and the streamlining of the process for designing, building,

3 NGAM is the acronym for the Next Generation of ADAM, where ADAM is the acronym for Autonomous Data Acquisition Module

4 MUD2 is the acronym for Mobile Unit Detection – Version 2

5 F-SEGM is the acronym for Scintillating Fibre based Silo Entry Gate Monitor

installing and maintaining UMS. The former will help meet current and emerging verification challenges in a resource-constrained environment, while the latter will reduce costs, particularly labour and life-cycle costs, for the deployment and maintenance of UMS. Improvements in data reduction and analysis software will reduce the time and effort that safeguards inspectors must devote to understanding and utilizing UMS data streams, and thereby reduce costs associated with training and troubleshooting. The series of tasks and sub-tasks that have been defined to meet these objectives will be accomplished through a combination of internal resources and Member State Support Programme (MSSP) contributions.

- During the 2014-2015 biennium, the Project SGTS-011 will address several outstanding issues and challenges related to UMS development and implementation, and undertake the following activities:
- Implement an integrated logistic support approach to improve the reliability, usability and maintainability of UMS systems;
- Develop, test and deploy new detectors (e.g. gamma proportional counters, Geiger–Müller tubes, solid-state detectors, liquid scintillators), modern front-end electronics, new NGAM, UNAP[6] data acquisition modules, and systems: MUD2, F-SEGM and UFDM-2[7] (a transportable version of the unattended fork detector monitor);
- Complete user requirements for an efficient and user-friendly analysis software for unattended measurements that can be integrated seamlessly with the overarching collect and review software;
- Adapt and evaluate the following NDA and analytical methods to unattended operation:
  - Undertake field implementation testing of the On-Line Enrichment Monitor (OLEM);
  - Complete the technical viability assessment of the Unattended Cylinder Verification Station (UCVS);
  - Complete Phase I (initial design study) of the Unattended Gamma Emission Tomography (UGET);
  - Evaluate new techniques such as active interrogation (for both neutron and high-energy photons), and fast coincidence methods for unattended monitoring applications.
- Collaborate with other projects and with the inspection divisions to define concepts for unattended measurement systems that address emerging and potential future needs, including disarmament, the Plutonium Management Disposition Agreement (PMDA), the Japanese mixed-oxide (MOX) fuel facility (J-MOX), new facility types such as pyro-processing, fuel repositories, encapsulation plant and geological repositories;
- Fully refurbish previously deployed monitoring systems in Japan and elsewhere to meet current standards and implement new UMS in India, Pakistan, Japan, RoK, and Ukraine.

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, Project SGTS-011 will contribute mainly to the long-term Capabilities 5 and 6 and specifically to achieving Milestones 5.1, 5.2, 5.3, 5.4, and 5.7 identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1 below.

[6] UNAP is the acronym for the unattended NDA platform

[7] UFDM-2 is the acronym for Unattended Fork Detector Monitor – Version 2

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

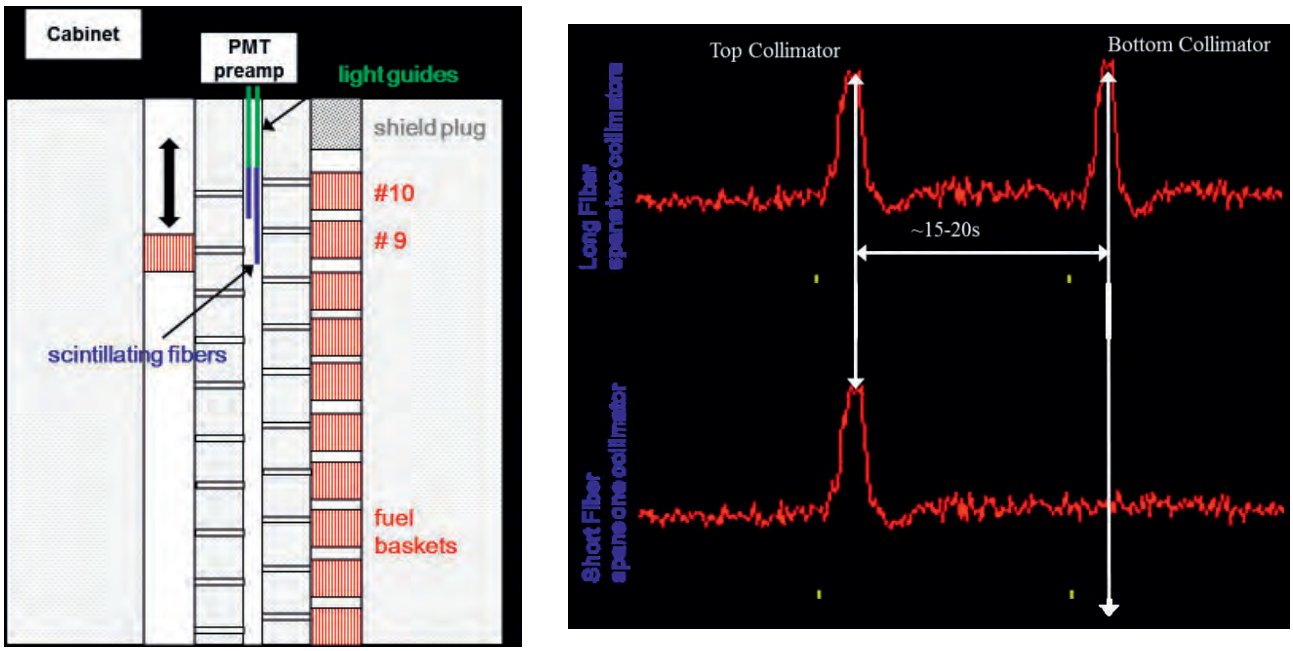
| Cap-ability | Capability Description | Milestone<br><br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| **5** | Ability to deploy equipment at facilities to meet safeguards requirements.<br>*Deploy and implement required safeguards instruments and systems in the field.* | | |
| | | 5.1. Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation)<br>*Improve, evaluate and test upgraded solution monitoring software* [end 2014]. | L |
| | | 5.2. Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities.<br>*Complete the viability study of the UCVS at an enrichment facility* [end 2015]. | H |
| | | 5.3. Develop improved tools and techniques to enable real time flow measurements of nuclear material, including $UF_6$ at enrichment facilities and Pu at reprocessing facilities.<br>*Field test OLEM prototypes* [end 2014] at an enrichment facility. | M |
| | | 5.4. Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.<br>*Complete the authorization of the MUD2.* [Oct. 2014] (Regular budget – Activity #5). | M |
| | | 5.7. Develop more sensitive and less intrusive alternatives to existing instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage<br>*Conduct a quantitative assessment of the viability of passive gamma-ray emission tomography for high-fidelity verification of fuel assembly integrity [January 2015]* | H |
| **6** | Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products.<br>*Develop, provide evaluate, upgrade, deploy Departmentally-needed instruments and systems.* | | |

## 4. Activities

Funding and resources for several of the project's development and implementation support activities are provided by MSSPs, which continue to play a major role in achieving the project's milestones. Other activities are supplemented by regular budget sources.

***Capability 5: Ability to deploy equipment at facilities to meet safeguards requirements.***

- Project SGTS-011 will continue to cooperate with and support the upgrading, testing and the implementation of software and hardware for critical UMS. This will include several proposed NDA techniques needed for the PMDA task, currently managed under Project SGTS-015, and the UMS which form part of the J-MOX Project. For the latter, Project SGTS-011 has analysed the proposals for future UMS systems and proposed one alternative based on unattended gamma-ray spectroscopy for the verification of MOX fuel rod characteristics, such as active length and plutonium content.
- Field-testing of a new fibre-optic based SEGM (see Figure 2) at a Member State facility will be completed by July 2014, with authorization and deployment by October 2014.
- Upon authorization of the NGAM and UNAP data acquisition systems for inspector use, upgrade all VIFM and MGBS/SRBS systems worldwide This campaign will start in early 2014 and will last several years, and will be supported by three on-going MSSP tasks: USA A01351 (Support for Development of the Safeguards System at Rokkasho Reprocessing Plant (RRP)); USA E01274 (URM Systems Standardization and Support); and CAN E01530 (VIFM Implementation Support).




[s] Figure 2: The fibre-optic based SEGM used to monitor the loading of spent fuel baskets into silos. By utilizing thin and flexible scintillating fibres, they can easily be inserted into silo verification tubes, reducing collimator alignment problems. (Capability 5)

***Milestone 5.1: Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation).***

- The task EC A01661 currently supports the Milestone 5.1 through the development of the solution monitoring software for a large reprocessing facility. The task includes the development of reference signatures for about 50 vessels, as well as upgrades to the user interface. So far, reference signatures for 20 of the most important vessels were tested and refined, based on the available data. First versions of several reference signatures developed by the IAEA, with support from JRC-Ispra, were integrated into the configuration module by the contractor *Euriware* in 2012. The first version of the upgraded user interface was delivered by *Euriware*[8], and following its testing by the IAEA and JRC Ispra several corrections/improvements were identified and reported for implementation.

  Future work will involve a comprehensive analysis of the user interface event-handling function, as well as an analysis of the impact produced by the software upgrades on the evaluation module. This activity is pending the release of the final updated software by *Euriware*

  Further work on reference signatures relies on the availability of additional representative data and is therefore pending the re-start of facility operations. According to the current schedule, commercial operation is not expected before mid-2014.

***Milestone 5.2: Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities, and***
***Milestone 5.3: Develop improved tools and techniques to enable real time flow measurements of nuclear material, including $UF_6$ at enrichment facilities and Pu at reprocessing facilities.***

- The IAEA is developing a flexible toolbox of technologies that is consistent with its State-level approach to safeguards implementation. The toolbox includes three different unattended measurement systems,:

  - The OLEM, which could provide continuous enrichment measurement for all of the declared gas flowing through unit header pipes;

[8] http://euriware.areva.com/EN/euriware-84/euriware-who-are-we.html

- The UCVS, which could provide unattended verification of the declared uranium mass and enrichment of all of the declared cylinders moving through the plant; and

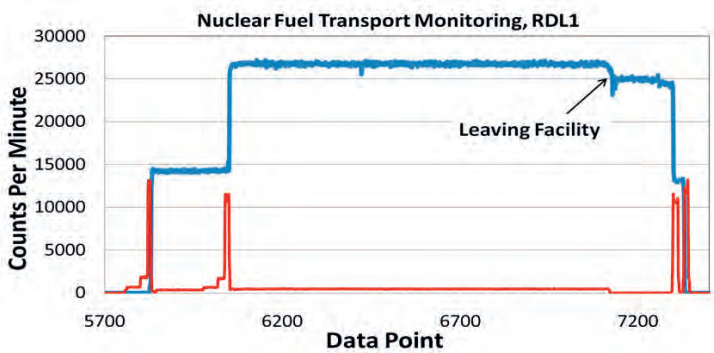
- The application and verification of an 'NDA Fingerprint' to preserve verification knowledge on the contents of each cylinder throughout its life in the facility.

Phase II of the OLEM project (under tasks UK A01868 and USA A01913) started in early 2013. It is expected that the US Department of Energy (DOE) will complete the proof-of-principle field-testing at Capenhurst facility in the UK by the end of 2013. By March 2014, two prototypes will be ready for long-term field-testing that will probably be performed at Louisiana Energy Services (LES) gas centrifuge plant in the USA for a period of approximately six months. Data will be analysed thoroughly during the following months to determine the achievable accuracy of the system for the on-line monitoring of product, tails and feed material flowing through the high-pressure side of unit header pipes. By December 2014, the IAEA will decide whether or not to procure an industrial grade OLEM for potential deployment in 2015.

If accepted, MSSP task proposal 13/TUS-003 (*Viability of an Unattended Cylinder Verification Station (UCVS) for Enrichment Plant Safeguards*) will proceed in phases and should be completed in about four years. The first phase, which should be completed by December 2015, covers refinement of user requirements, development and documentation of preliminary hardware and software design specifications for a flexible field-prototype UCVS, modelling-based assessment of predicted performance over a plausible range of cylinder parameters and diversion scenarios, field-testing of initial prototype in a low-risk operational environment, comparative evaluation of candidate NDA methods, and development of life-cycle cost estimates.

***Milestone 5.4: Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.***

- The unattended portable MUD2 device (see Figure 3) that is currently under development (regular budget) contributes to the attainment of Milestone 5.4. MUD2 is a battery-powered device that records nuclear radiation data over several weeks, while attached to a spent fuel container. By default, the device includes a neutron detector. However, an additional input for gamma-rays signatures can be added. The MUD2 preliminary design was completed in 2012. The device was tested successfully in 2013. Mechanical re-engineering will take place by March 2014 providing the device with a more robust enclosure, which is optimized for outdoor applications under a range of environmental conditions, and capable of hosting several measurement channels. The upgraded version should be available for field deployment by October 2014.



[s] Figure 3: The MUD2 is a portable device equipped with neutron (and optional gamma-ray) detection capabilities to maintain CoK during spent fuel container transportation. (Milestone 5.4)

***Milestone 5.7: Develop more sensitive and less intrusive alternatives to existing NDA instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage.***

No IAEA authorized instrument is currently available to support unattended partial defect verification of spent fuel. Some best available attended use instruments have limitations. Following the May 2013 kick-off

coordination meeting, it was decided that the Unattended Gamma Emission Tomography System (UGET) being developed jointly under task JNT A01955 (EC/FIN/SWE/USA) may be capable of addressing the IAEA's need for unattended partial defect verification of spent fuel. The project is planned to last about four years, and consists of two phases. Key outcomes for Phase 1 (initial design study), which should be completed by January 2015, are as follows:

- Quantitative assessment of the viability of passive gamma-ray emission tomography for high-fidelity verification of fuel assembly integrity;
- Objective assessment of implementation considerations and life-cycle costs;
- Preliminary viability assessment of gamma-ray tomography for other applications.

Phase 2, which should be completed by the end of 2017, will focus on the design, fabrication and testing of the field-prototype instrument, in unattended and/or attended operational modes. Key outcomes from the second phase will be empirical data and field experience to support an IAEA decision regarding the technical, operational and life-cycle viability of UGET under various implementation assumptions and requirements.

The results of Phase II could then assist in the preparation of detailed technical specifications for the procurement of tomography instruments (unattended or attended), should the IAEA decide to pursue that path.

***Capability 6: Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products.***

- Project SGTS-011 includes implementation activities that address Capability 6. During the 2012-2013 biennium, UMS development embraced a standard and modular approach for the components to be used in systems. As a result, efforts were made by the Department to develop modern and modular components and to buy commercial off-the-shelf (COTS) equipment to the greatest possible extent, in order to simplify the maintainability of UMS systems and minimize component life-cycle costs. CAN E 1499 (Development of the Next Generation ADAM Module) task (see Figure 1), and USA E1715 (UNAP) task under the supervision of SGTS-013 are both dedicated to supporting the implementation of new standard data acquisition systems.

  In addition to the above current tasks, four new tasks are proposed for Project SGTS-011 that would be addressed internally under regular budget:

  - A survey of COTS technologies related to power management has been proposed to support the aim of increasing the maintenance cycles for UMS systems. The technologies will include an uninterruptible power supply in UMS instruments and other measures to extend the cycle of battery replacement. A new concept should be ready for implementation in July 2014 (New Task Proposal #1).

  - The evaluation of a new class of gamma-ray detectors, such as proportional counters and Geiger–Müller tubes, has been proposed to guide the eventual replacement of ion chamber detectors. If the tests are successful, these types of detectors will be added to the IAEA's pool of authorized UMS detectors, becoming available for field implementation.by July 2014 (New Task Proposal #2).

  - The use of a suitable COTS current to frequency converter (CFC) has been proposed to improve instrumentation performance. When utilized with an ion chamber, the CFC will produce a data acquisition digital pulse input rather than an analogue voltage current proportional to the input. Technical specifications could be submitted to potential vendors by January 2014, with candidate devises tested for field deployment in 2015 (New Task Proposal #3).

  - A COTS charge pulse injector has been proposed to facilitate the calibration of nuclear measurement chains in the field during regular maintenance or repair. A final technical specification will be proposed to potential vendors in June 2014 and sample devices could be tested by September 2014 and available for inspection use by January 2015 (New Task Proposal #4).

## 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 5., 5.4. | CAN | E 01499 | Development of the Next Generation ADAM Module | September 2014 |
| 5. | GER | A 01269 | Digital Unattended MCA (DIUM) (C.36) | On Stand-by |
| 5. | USA | A 01351 | Support for Development of the Safeguards System at Rokkasho Reprocessing Plant (RRP) (A.247) | On-going |
| 5.1. | EC | A 01661 | Consultation for Improvement, Evaluation and Testing of Solution Monitoring Software (SMS) | End 2015 |
| 5.1. | EC | E 01814 | Solution Monitoring System (SMMS) Hardware Upgrade | End 2013 |
| 5.2., 5.3. | UK<br>USA | A 01868<br>A 01913 | On-Line Enrichment Monitor (OLEM) (UK (E12 (d), USA (A.290)) | End 2015 |
| 5.7. | EC<br>FIN<br>SWE<br>USA | JNT A 01955 | Unattended Gamma Emission Tomography (UGET) for Partial Defect Detection - Phase I (EC, FIN, SWE, USA (A.294)) | End 2017 |
| 6. | CAN | E 01530 | VIFM Implementation Support | On-going |
| 6. | USA | E 01274 | URM Systems Standardization and Support (E.122) | On-going |

*Table 3. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 2.6. | - | A viability study of automated unattended environmental sampling and analysis for the detection of undeclared activities in declared facilities<br><br>Topics of interest will include techniques for collection (e.g. particulate or noble gases) and on-line analysis (e.g. using laser spectroscopy methods). Of primary concern is how unattended methods compare with current environmental sampling in terms of effectiveness and sensitivity. Unattended environmental sampling at centrifuge enrichment plants is the high priority, as successful development of an appropriate technology will support more timely detection of high enriched uranium (HEU) production, while significantly reducing the inspection effort currently devoted to swipe sample collection and analysis at a growing number of enrichment plants. A MSSP task will be proposed in 2014 to conduct a survey of current techniques appropriate for unattended sampling analysis at enrichment plants. Pending positive results of this survey, a path toward the testing and evaluation of available technologies will be defined in 2015. | Proposal to be submitted |
| 5.2., 5.3. | 13/TUS-003 | Assess the UCVS for enrichment plant safeguards.<br><br>Phase 1: refine user requirements; develop and document a preliminary hardware and software design for a flexible field-prototype. [End 2015] | Outstanding with EC and USA (2013) |

## 4.2. In-house Development Activities

Project SGTS-011 develops and tests new systems, technologies and component configurations for applications in future installations and contributes to other Safeguards related and Departmental Projects. Table 4 summarizes the Project's current and standby in-house development activities.

*Table 4. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 3.1. | 1 | UMS Design and Development for a pyro-processing facility | Install two UMS systems in a pyro-processing facility by July 2014: to detect the introduction of actual spent fuel into the facility, which may indicate facility misuse; and to monitor the electrical current supplied to the electro-refiner and electro-reducer. (Regular budget) | On-going activity over the biennium |
| 5. | 2 | Fibre-optic based SEGM | Complete the planned field-test by July 2014 and commence field deployment until December2014 (Regular budget). | End 2014 |
| 5. | 3 | UMS systems for J-MOX | Assist Project SGOA-002 (Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX)) with required UMS systems, including the implementation of a gamma-ray based system within the facility for MOX fuel rod characteristic verification.(Regular budget) | On stand-by until further notice |
| 5. | 4 | UMS systems for PMDA | Assist Project SGTS-015 (Technologies for Possible New IAEA Verification Tasks) with preliminary design and technical specifications for proposed UMS systems to address the PMDA task requirements (Regular budget) | On-going task over the biennium |
| 5.4. | 5 | MUD2: Mobile Unit Detection Device (version 2) | Re-engineer the device to include an improved industrial grade enclosure optimized for outdoor applications and to support several measurement channels (including neutron, gamma-ray and other sensors). (Regular budget) | September 2014 |
| 6. | 6 | UNAP testing in Unattended Mode | UMS assists the SGTS-13 project (Universal Data Acquisition Platform) for the testing of the UNAP device in Unattended mode (Regular budget). | July 2014 |
| 6. | 7 | UNAP de-engineering | Propose simplifications to the current UNAP design to reduce its cost. (Regular budget). | March 2014 |
| 6. | 8 | FEUM: Front-End Electronics for Unattended Monitoring | Develop and test a new preamplifier for unattended monitoring applications. (Regular budget) | End 2014 |
| 6. | 9 | UMS contribution to new Collect and Review Software Development | Assist Project SGTS-014 (Remote Monitoring and Data Processing Systems), by providing functional requirements and technical specifications for the development of a new integrated collect and review software infrastructure, which will be compatible with the entire UMS system family. (Regular budget) | On-going task over the biennium |
| 6.2. | 10 | Development of a Data Acquisition Module for liquid scintillator | Development of a data acquisition system for use with liquid scintillator detectors, capable of capturing and storing list mode data on multiple channels, as an alternative to $^{3}$He-filled tubes. The device is based on a National Instruments PXIc industrial 19-inch device, utilizing a field-programmable array (FPGA) allowing for reconfigurable functionality, and capable of capturing and storing list mode data on multiple channels. It is expected that the first prototype will be completed and delivered by July 2014. The overall functionality of the final system will be very flexible and configurable according to future application requirements. (Regular budget) | July 2014 |

*Table 5. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 3. | 1 | Generic safeguards approaches for pyro-processing plants | In support of the SGCP-03 project, two UMS will be developed for a pyro-processing facility by July 2014:<br>• Detection of actual spent fuel introduction into the facility,<br>• Monitoring of the electrical current supplied to the electro-refiner and electro-reducer<br>Project SGTS-011 has been undertaking the development of methods and instruments to support the safeguards approach for a pyro-processing demonstration facility, currently processing natural uranium as a surrogate for spent nuclear fuel. Neutron detectors will be used for monitoring the introduction of spent fuel into the facility for any indications of facility misuse. This instrument will be connected to a remotely-monitored, computer-less, radiation data logging (RDL1). A Bus Bar Monitoring System (BBMS) will be used to monitor the electrical current supplied to the electro-refiner and electro-reducer and will also incorporate an RDL1. Both systems will be installed by July 2014. It is possible that further support may be requested by the end-user during the biennium.<br>(Regular budget). | July 2014 |
| 6. | 2 | Viability study on Power management technology | Perform a viability study on power management strategies for UMS systems based on uninterruptible power supply devices and batteries to minimize maintenance costs (Regular budget). | End 2014 |
| 6. | 3 | Evaluation of new gamma-ray detectors for UMS applications | Evaluate new types of gamma-ray detectors for unattended use, such as Geiger–Müller tubes and gamma proportional counters (Regular budget). | March 2015 |
| 6. | 4 | Current to Frequency Converter (CFC). | Evaluate COTS devices capable of converting ion chamber generated current to pulses to avoid the use of special circuitry to measure low current waveforms (Regular budget). | End 2014 |
| 6. | 5 | UMS Calibration tool | Evaluate suitable COTS charge pulse injectors for field calibration of front-end electronics (Regular budget). | March 2015 |

# SGTS-013

## Universal NDA Data Acquisition Platform (UNAP)

**Project Manager: Kenneth Baird** **Division: SGTS**

### 1. Introduction

Project SGTS-013 aims to provide the IAEA with the ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products. Such equipment must be deployable at facilities to support safeguards mandates. The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 1. Overview

The project addresses the development, evaluation, enhancement and production of facility-resident, non-destructive assay (NDA) instruments for use in a wide range of safeguards applications. The project supports the *Long-Term R&D Plan, 2012–2023,* particularly with regard to achieving Capabilities 5 and 6 (see Table 1 for full capability descriptions).

The project's primary objectives are the following:

- To optimize and standardize NDA equipment for attended and unattended nuclear material verification and monitoring;
- To reduce the number of non-standardized safeguards systems and applications, thereby reducing maintenance and training efforts;
- To design and build an instrument that will acquire and process all types of NDA data (e.g., gamma, neutron-counting, power-monitoring, etc.) in attended and unattended modes, using a common platform, providing standardization, robustness and reliability; and
- To ensure continuity of measurement capability in light of anticipated planned obsolescence of several commonly used unattended monitoring systems (UMSs).

The Universal NDA Data Acquisition Platform (UNAP) instrument is intended to be used by Safeguards inspectors, primarily for measurements at facilities in unattended mode, using remote acquisition of data. However, the UNAP is also intended to be compatible with software used for attended measurements. In addition, the UNAP is intended to meet the needs of other nuclear monitoring and regulatory entities, such as the European Atomic Energy Community (EURATOM), and must therefore be suitable for joint-use applications.

In recent years, significant progress has been achieved in the design and development of prototype instruments and the following project milestones have been achieved:

- A full set of specifications for the UNAP was developed in consultation with NDA instrumentation experts, representing the end-users and other stakeholders;
- Vendors were selected to design and produce the hardware and software components for the instrument;

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] s described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

- Prototype units of the UNAP system, with basic operating software, were produced; and
- Factory acceptance testing was performed for the hardware and software, with issues identified and remedied.

In the 2014-2015 biennium, the project will:

- Review tasks and activities with respect to the *Long-Term R&D Plan, 2012–2023*, identifying priorities and appropriate work plans (January 2014);
- Conduct performance characterization of the UNAP; e.g., data, reliability, and performance analysis (May 2014);
- Conduct a comprehensive review, validation, and where necessary, revision of the requirements and specifications for procurement of production units (July 2014);
- Perform field evaluation of the UNAP prototypes at facilities, in cooperation with Member States (July 2014);
- Demonstrate the UNAP's range of field configurations and its use in performing unattended safeguards measurements (October 2014);
- Initiate procurement of the production model UNAP, thereby completing its commercialization (December 2014);
- Complete authorization of UNAP for inspector use (October 2015); and
- Analyse the feasibility of adding high-resolution, digital signal processor-based, multi-channel analyser compatibility to the current design (December 2015).

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute directly to the long-term attainment of Capabilities 5 (*ability to deploy equipment at facilities to meet safeguards requirements*) and 6 (*ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products*) identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| *Capability* | *Capability Description* | *Key Achievement Targets for 2014–15:* |
|---|---|---|
| 5 | Ability to deploy equipment at facilities to meet safeguards requirements. | • *Conduct performance characterization of the UNAP; e.g., data, reliability, and performance analysis (May 2014);*<br>• *Perform a field evaluation of UNAP prototypes, at one or more facilities, in cooperation with Member States (December 2015).* |
| 6 | Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products. | • *Conduct a comprehensive review, validation, and where necessary, revision of the requirements and specifications for procurement of production units (July 2014).* |

## 4. Activities

Funding and resources for the project's development and implementation support activities are provided by Member State Support Programmes (MSSPs), which continue to play a major role in achieving the project's milestones. Further activities are supplemented by regular budget sources.

***Capability 5: Ability to deploy equipment at facilities to meet safeguards requirements.***

Key activities in this area for the UNAP project include performance characterization testing and field-testing.

1. Performance characterization tests will be performed by Departmental experts who cover unattended monitoring, remote monitoring, and portable and resident NDA. Tests will also be conducted by EURATOM, in parallel with those performed at the IAEA, and will aim at stress testing the UNAP to find functional limits, characterizing the boundaries of its overall performance.

   Testing will focus on using the UNAP as it would be in the field, to identify ideal configurations, as well as features that affect maintenance, set-up, system security, and data analysis. Tests will use configurations analogous to those used with instruments the UNAP is intended to replace, including the JSR-12, AMSR, and MiniGRAND[3]. The IAEA will also perform additional environmental testing, to characterize limits of the UNAP's radiation tolerance. This test is also intended to be a gateway to field-testing, providing assurance to the end-users that the UNAP is ready to be further field-tested in facilities under safeguards.

   In addition to the performance of in-house testing, the IAEA will provide prototype instruments to MSSP counterparts for additional testing. The IAEA intends to distribute at least one prototype each to Los Alamos National Laboratory, Oak Ridge National Laboratory, EURATOM Headquarters, and the Joint Research Centre at Ispra, and will coordinate the development of test plans and data-sharing to ensure transparency and the comparability of results.

   This activity will be initiated in March 2014, and is expected to be completed by July 2014.

2. Field-testing will be used to compare the UNAP's performance to existing deployed equipment, to ensure measurement accuracy and comparability, and to identify any performance nuances or issues. Testing will also determine the feasibility of the UNAP as a joint-use instrument with EURATOM and JASPAS (EC E 01732; JPN 01720)

   Once the expert end-users are satisfied that the UNAP's performance is wellunderstood and that the system is ready to be operated in safeguarded facilities, field-testing will be initiated. Tests will be conducted while operating the UNAP in the field and in parallel with existing instruments, including the JSR-12, the AMSR, and the MiniGrand. Field-testing will identify the UNAP's range of configurations for field use and also provide the necessary measurement and reliability data that is required for authorization of the instrument for inspector use.

   The IAEA will work with the European Commission, Japanese, and the United States Support Programmes to identify locations for field-testing, coordinate testing plans, perform the tests and analyse the resulting data.

   This activity will be initiated in August 2014, and is expected to be completed by December 2015.

[3] *Safeguards Techniques and Equipment*, 2003 Edition (http://www-pub.iaea.org/MTCD/publications/PDF/NVS1-2003_web.pdf)

***Capability 6: Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products.***

Key activities in Project SGTS-013 include updates to the UNAP technical specification an independent UNAP cost-analysis, based on baseline requirements, as well as potential modifications; and the procurement of production model UNAPs.

1. Based on the performance characterization test results, changes will be made to the requirements for the UNAP production models. These changes are anticipated as enhancements of existing features to improve the UNAP's usability, reliability, and ease of maintenance, and to optimize the UNAP for production and commercialization. The revision will incorporate end-users' feedback, and will be peer-reviewed for technical accuracy, feasibility, and to ensure changes do not have unintended impacts to existing features. This activity is expected to start in January 2014, and be completed by July 2014.

2. An independent expert will perform a cost-estimate of the UNAP, based on the existing requirements and design. This is intended to provide the IAEA and other future commercial customers with estimates by which they can assess the instrument's fair market cost, and to guide budget planning. This will be considered the baseline cost estimate for the UNAP. An independent expert will also provide estimates of the cost of proposed changes to guide changes and assess trade-offs with the UNAP's technical specification for commercialization. This activity is expected to start in July 2014, and be completed by September 2014 (USA E 01715).

3. The US Support Program will procure production model UNAPs, with input and assistance from the IAEA on technical specifications and performance criteria. The procurement will complete the UNAP commercialization phase, making it a standardized, commercially-available instrument, optimized for safeguards use from the input provided by its end-users throughout the development life-cycle. This activity is expected to start in December 2014, and be completed by April 2015 (USA E 01715).

### 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 5, 6. | EC<br>JPN<br>USA | E 01732<br>E 01720<br>E 01715 | Development of a Universal Non-destructive Assay Data Acquisition Platform (UNAP) [JPN (JD-23), USA (E.157)] | December 2015 |

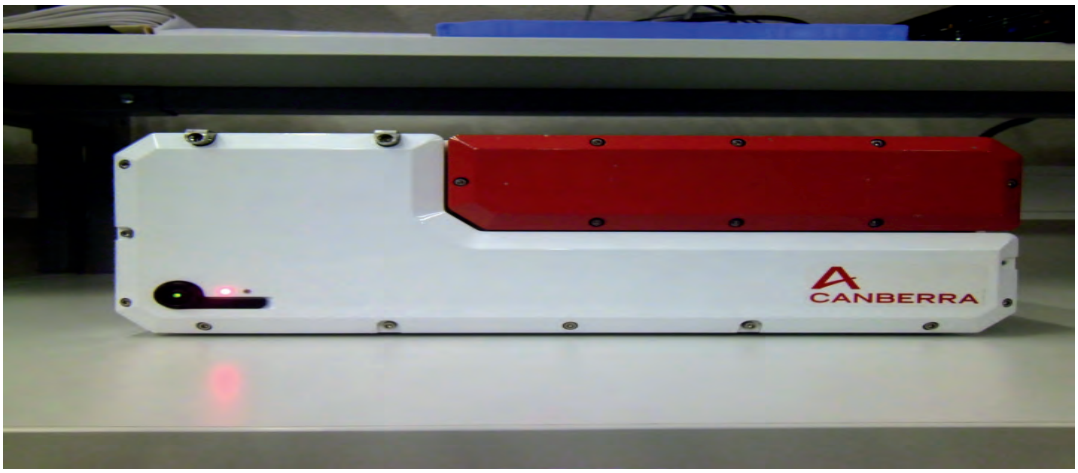
### 4.2. 4.2 In-house Development Activities

*Table 3. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| **5.** | 1 | Performance characterization testing | The IAEA will use in-house end-users to conduct performance characterization of the UNAP. | May 2014 |
| **6.** | 2 | Revise technical specifications | Conduct a comprehensive review, validation, and where necessary, revision of the requirements and specifications for procurement of production units. | July 2014 |

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| **6.** | 3 | Perform an independent cost analysis of the UNAP | The IAEA will arrange for an independent expert to perform a cost estimate of the UNAP, based on the existing requirements and design. This is intended to provide both the IAEA and other future commercial customers to assess the fair market cost of the instrument, to guide budget planning. This will be considered the baseline cost estimate for the UNAP. The independent expert will also provide estimates for the cost of proposed changes, in order to guide changes and assess trade-offs to the technical specification for commercialization of the UNAP. | September 2014 |
| **6.** | 4 | Production model procurement | Initiate procurement for production model UNAP instruments, thereby completing commercialization of the UNAP. | April 2015 |
| **5.** | 5 | Field Testing | The IAEA, in cooperation with Euratom, JRC-Ispra, and JASPAS, will conduct field testing of the UNAP for performance monitoring, as well as long-term stability and reliability data gathering. | December 2015 |

## Attachments




s Figure 1: Completed UNAP prototype - front panel vie

s Figure 2: Completed UNAP prototype - rear panel view

# SGTS-014

## Remote Monitoring and Data Processing Systems

### Project Manager: Jim Regula — Division: SGTS

### 1. Introduction

Project SGTS-014 develops, implements and maintains remote monitoring (RM) and data processing systems for the collection, transmission and review of safeguards and equipment data installed in facilities around the world. The project supports the Department's *Long-Term R&D Plan, 2012–2023*[3], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[4], and the key milestones necessary to achieve required capabilities.

### 2. Overview

Project SGTS-014 addresses the Department's development and implementation needs in the area of remote monitoring (RM) and data handling and processing, either for new safeguards applications or for the sustainability and maintenance of existing equipment. The focus of this project is therefore on development and implementation of equipment, software, and technological approaches for RM applications, RM infrastructure and general data processing. The project supports the *Long-Term R&D Plan, 2012–2023,* particularly with regard to achieving Capability 7 (see Table 1 for full capability descriptions). More specifically, the project focuses on data analysis (Milestone 2.4), improved methodology of equipment development (Milestone 6.1), cost-effective implementation of RM systems (Milestone 7.1) and enhanced RM network security (Milestone 7.2).

RM has expanded greatly in the last ten years. As of August 2013, there were 288 systems connected remotely: 169 surveillance and 119 unattended monitoring systems. This includes 636 cameras, and over 162 electronic seals, transferring over 4.5 Gigabytes of data per day to offices in Vienna, Tokyo, and Toronto. During the 2014-2015 biennium, the Remote Monitoring Team (RM Team) will continue to develop infrastructure, tools and methods for data transmission, data security, data integrity check and state-of-health (SoH) monitoring. The number of systems connected remotely is expected to increase 5-10% per year in the short term, new system types will be connected, and a standardized method of transfer will be implemented.

In the last two years, the RM Team has been tasked with software development projects, including Developing both code for equipment systems in the field and inspector review application methods. The three main areas of specific application development currently include: RAINSTORM (Real-time And Integrated Stream-Orientated Remote Monitoring) open-source code for the standardization of data transfer and authentication, which will enable equipment manufacturers to develop new systems faster), the integration of new equipment types into the RM infrastructure (e.g. the Next Generation Surveillance System (NGSS)), and negotiation of a joint development partnership with Euratom on the CRISP (Comprehensive Review Inspector Software Package) review software which will lead to shared IP (Intellectual Property) rights for the Agency, thereby allowing for software changes to be made in-house.

End-users are primarily operation divisions, carrying out safeguards verification activities, and Department engineers and technicians responsible for equipment in the field.

[3] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[4] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

In the 2014-2015 biennium, the project will:

- Propose workplans, tasks and activities in response to the Department's needed future capabilities identified in the *Long-Term R&D Plan, 2012–2023* (January 2014);
- Ensure the highest level of RM infrastructure security through on-going or periodic vulnerability testing.
- Contingent upon negotiations with States, continue to expand and upgrade RM infrastructure to transfer data in the most efficient, cost effective manner.
- Develop sustainable software applications to assist inspectors with safeguards data reviews and standardize RM interfaces for departmental equipment.

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute indirectly to the long-term attainment of Capability 7 (*ability to make maximum efficiency savings by the use of remote monitoring of operators' and unattended IAEA equipment*), and specifically to meeting the near-term attainment of Milestones 7.1 and 7.2, identified in the *Long-Term R&D Plan 2012-2023*. These are summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br>*Key Achievement Targets for 2014–15:* | Urgency |
|---|---|---|---|
| **2** | Increased ability to detect undeclared nuclear material and activities. | 2.4. Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information, in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.<br>*In partnership with Euratom contractors, modify the existing CRISP application to make it IAEA specific[3]. [December 2015]*<br>*Add new surveillance and electronic seal modules to CRISP [December 2015]* | M |
| **6** | Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products. | 6.1. Implement an improved cost/benefit assessment methodology for the design and operation of safeguards equipment.<br>*Install RAINSTORM, with standardize basic transfer and authentication methods, on all new equipment[4]. [December 2015]* | M |
| **7** | Ability to make maximum efficiency savings by the use of remote monitoring of operators' and unattended IAEA equipment. | *7.1.* Develop minimally intrusive techniques that are both secure and authenticated to enable the use of operator's systems, instruments and process monitoring for cost-effective safeguards implementation.<br>*Install advanced wireless options, Ethernet extenders, etc. at several facilities where the existing communication infrastructure is inadequate for Safeguards needs and retire all analogue modem systems [December 2014]* | H |
| | | 7.2: Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.<br>*Continue to assess, implement and upgrade communications, where required, to ensure the most secure and cost- effective communication links between locations in the field facility and IAEA offices. [December 2015]* | H |

[3] All CRISP IP rights will be shared with the IAEA & Euratom

[4] Equipment development time and cost will decline due to the use of RAINSTORM

## 4. Activities

Funding and resources for a small percentage of the project's D&IS activities are provided by MSSPs, which will continue to play a minor role in achieving the project's milestones. Most activities are supplemented by regular budget sources.

***Milestone 2.4: Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.***

- The RMT has negotiated with Euratom on a joint development project with the CRISP review software, in hopes of producing an "all-in-one" review application for inspectors that can review UMS and surveillance data (see activity #3),

***Milestone 6.1: Implement an improved cost/benefit assessment methodology for the design and operation of safeguards equipment.***

- RAINSTORM is in-house developed ANSI-standard C code to be freely distributed to equipment developers for the standardization of RM transfers and data authentication. Since data transfer methods and authentication are now Agency standards within RAINSTORM, this will eliminate two significant components for equipment developers and make design and manufacturing more timely and cost-effective.

***Milestone 7.1: Develop minimally intrusive techniques that are both secure and authenticated to enable the use of operator's systems, instruments and process monitoring for cost effective safeguards implementation.***

- The RMT constantly evaluates new and existing systems for cost-effectiveness. Many areas of networking are being considered, from the cabling and Internet providers at the facility, to infrastructure, data processing techniques, and review in IAEA offices. In the 2014-2015 biennium, SGTS-014 will: install advanced wireless solutions instead of costly cable; and provide Ethernet extending devices to use existing twisted pair cabling, and retire all analogue transfer systems.
- The GER E1859 task has allowed remote monitoring to be field tested in a German facility. The successful test is almost finished and a report will be issued by early 2014.

***Milestone 7.2: Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.***

- Achieving the highest level of network security is a main concern for RMT engineers who use state-of-the-art commercial solutions for critical components, in a standardized configuration, to ensure secure transfers and data-handling. Periodic outside examination of this infrastructure is of great assistance in maintaining this high level of security. In the 2014-2015 biennium, SGTS-014 will host several vulnerability assessments by outside experts on RM infrastructure to determine areas of improvement. From these assessments, security upgrades and patches will be implemented.

### 4.1. MSSP Development and Implementation Support Tasks

*Table 2. Current Active and Standby MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | MSSP | Task No. | Task Title | Target Completion Date |
|---|---|---|---|---|
| 7 | GER | E 01859 | Testing & Acceptance of Remote Monitoring Network Security for Facility Implementation (GER (D.37)) | Early 2014 |

## 4.2. In-house Development Activities

*Table 3. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 6.1. | 1 | RAINSTORM | ANSI standard C code for the free distribution to outside equipment developers that standardizes RM transfers and data authentication (regular budget). | December 2014 |
| 7. | 2 | RM Data Processing Enhancements | Integrating new SGTS equipment into the RM infrastructure. This list includes such diverse devices as NGSS (Next Generation Surveillance System), UNAP & RMSA (Remote Monitoring Sealing Array) (regular budget). | On-going |
| 2.4. | 3 | CRISP | The CRISP joint development partnership with Euratom will be used by the IAEA to develop source code that will achieve the goal of an all-in-one inspector review software program | December 2015 |
| 7. | 4 | Roogle | Web-based application for inspectors and technicians to monitor real-time status and state-of-health data for RM connected equipment in the field. Funding for this activity comes from regular budget sources. | On-going |

*Table 4. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 2.4. | 1 | Inspector Tablet | Initial requirements have been gathered for an inspector tablet to reduce the amount of paperwork and ease cumbersome activities during inspections. Actual development is planned to start in 2014. | December 2015 |

s Figure 1: RM satellite antennas mounted on the A-tower of IAEA HQ.

# SGTS-015

## Technologies for Possible New IAEA Verification Tasks

**Project Manager: Kenneth Baird** **Division: SGTS**

### 1. Introduction

Project SGTS-015 aims to develop technical tools for IAEA, and to ensure its readiness to contribute to verification activities associated with the reduction of special fissile material stockpiles and with disarmament initiatives. The project supports the Department's *Long-Term R&D Plan, 2012–2023*[1], which sets out the capabilities that the Department of Safeguards needs to achieve its strategic objectives[2], and the key milestones necessary to achieve those capabilities.

### 2. Overview

This project addresses the development of instruments and measurement techniques needed to support the implementation of future IAEA verification mandates. Specifically, this project contributes to developing Capability 11 of the Departmental *Long-Term R&D Plan, 2012–2023*, ensuring IAEA readiness to support possible new verification mandates.

Project SGTS-015 focuses on technical implementation and is closely tied to the approaches being considered in Project SGCP-003 *Safeguards Approaches.* The verification activities related to Project SGTS-015, by their very nature, will have different objectives compared to existing safeguards agreements. The Project has focused on R&D needs for a (draft) verification plan relevant to the Plutonium Management and Disposition Agreement (PMDA)[3]. However, the scope of this project may expand over time to include technical aspects of other agreements, either anticipated or in force. The outcome of the project is the production of measurement and analysis tools, systems and techniques that are ready for deployment.

Most of the tools and techniques being developed are for unattended use, with periodic on-site review and analysis of the data by Safeguards inspectors. It is possible that systems may not have remote monitoring of instrument 'state-of-health' (SoH). Therefore, a mechanism will be required to inform the facility operators of malfunctions and to trigger a corrective response.

To date, all progress on this project has been internal to the IAEA, with development of non-destructive assay (NDA) measurement strategies and concepts in line with the draft operational plans of the two signatory countries of the PMDA agreement. These included:

- Conceptual system designs for unattended measurement of plutonium isotopes in mixed oxide (MOX) powder and fuel rods;
- Conceptual system designs for unattended measurement of mixed oxide (MOX) assembly mass;
- Conceptual methods to maintain 'continuity of knowledge' (CoK) of PMDA fuel as it is transported from fuel fabrication facilities to designated reactors;
- Conceptual methods to regain CoK for lost-in-transit fuel assemblies;

[1] http://www.iaea.org/safeguards/documents/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R&D_Plan_2012-2023.pdf

[2] As described in the IAEA Department of Safeguards Long-Term Strategic Plan (2012-2023) (A summary of which is available at *http://www.iaea.org/OurWork/SV/Safeguards/documents/LongTerm_Strategic_Plan_(20122023)-Summary.pdf*)

[3] The PDMA is an agreement between the Government of the United States of America, and the Government of the Russian Federation, concerning the management and disposition of plutonium designated as no longer required for defence purposes and related cooperation (*c.f.* http://www.state.gov/documents/organization/18557.pdf)

- Conceptual methods to regain CoK for lost-in-transit fuel assemblies;
- Concepts for alerting operator of an instrumentation error in facilities where SoH information is not transmitted directly to the IAEA; and
- Automated data analysis concepts to reduce on-site inspector effort with the review of acquired information.

The above activities will continue in the 2014-2015 biennium and will move to the prototype stage once the operational concepts and user requirements are finalized.

Three new activities will also commence in the 2014-2015 biennium. The first is the development of NDA methods for confirming the level of irradiation of PMDA fuel assemblies for light water reactor (LWR) and fast-neutron reactor (FNR) reactor fuels. Accordingly, two proposals for Member State Support Programme (MSSP) tasks have been submitted to address this important issue and are expected to commence in early 2014.

The second activity will find technical solutions to address instances where the remote monitoring of NDA systems is not possible. In the case of instrument malfunction, a mechanism is needed to inform designated parties, whose responsibility it would be to notify the IAEA of equipment concerns and schedule a maintenance activity. Internal development of such mechanisms will be initiated in 2014.

The third activity planned for the 2014-2015 biennium will be the gathering of requirements for PMDA review software modules, which will be designed to meet the interface specifications for the review software being developed under SGTS-014 (*Remote Monitoring and Data Processing Systems*).

The first implementation for the tools developed in this project will be during the initial implementation phase of the PMDA agreement, which is tentatively planned for 2016. Thus, required systems designated for use in the 'front end' of the PMDA process (i.e., fuel fabrication) must move rapidly through the development phase in the 2014-2015 biennium in order to be available for the 2016-2017 implementation phase. The 'back-end' systems, such as those needed to confirm 'burn-up' of the designated fuel, require additional R&D and are anticipated to be needed in the following biennium.

Most of the key objectives listed below cannot be finalized in the 2014-2015 biennium. However, all anticipated investigation and development activities must be initiated in that time period in order to meet the final implementation deadline.

## 3. Capabilities, Milestones and Key Achievement Targets

During the 2014-2015 biennium, the project will contribute directly to the long-term attainment of Capability 11 (*ability to deal with new mandates*) in general, and specifically to meeting the near-term attainment of Milestone 11.1 identified in the *Long-Term R&D Plan 2012-2023* and summarized in Table 1.

*Table 1. Capabilities, Milestones and Key Achievement Targets for 2014–15*

| Capability | Capability Description | Milestone<br><br>*Key achievement targets for 2014-15:* | Urgency |
|---|---|---|---|
| 11 | Ability to deal with new mandates. | 11.1. Develop options and approaches for possible future mandates as required or requested (e.g., fissile material cut off treaty, arms control) that respect sensitive and proprietary information.<br>• *Develop and build prototype instrumentation to maintain CoK of PMDA fuel as it is shipped from fuel fabrication facilities to a PMDA designated reactor.*<br>• *Develop conceptual designs of NDA systems, including associated data acquisition, to confirm irradiation levels of spend designated fuel in PMDA LWR and FNR reactors.* | H |

## 4. Activities

Funding and resources for most of the project's D&IS activities are provided by extrabudgetary funds. Some activities, having applications for both existing and future IAEA mandates, are supplemented by regular budget sources.

***Milestone 11.1: Develop options and approaches for possible future mandates as required or requested (e.g. fissile material cut off treaty, arms control) that respect sensitive and proprietary information.***

- In 2013, two task proposals were submitted to MSSPs regarding the development of NDA systems to confirm irradiation levels of spent designated fuel in PMDA reactors. For LWRs, the Digital Cherenkov Viewing Device (DCVD) has been authorized for inspector use to detect partial defects in spent LWR Fuel. A proposal was submitted to request an in-depth investigation of the DCVD's ability to verify spent fuel irradiation history for LWR MOX fuel. A second task proposal was submitted to MSSPs regarding the development of NDA systems to confirm irradiation levels of spent designated fuel in PMDA FNRs. As the IAEA has less experience in the measurement of this type of spent fuel, the proposal does not suggest any specific technology for evaluation. As both proposals call for an experimental campaign to test the developed measurement system, it is expected that both tasks will extend beyond the 2014-15 biennium.

The following activities will commence upon finalization of the technical approach which will be undertaken by the United States (US) and the Russian Federation (RF) in order to satisfy the terms of the PMDA:

- The conceptual and prototype designs of all NDA systems, including the associated data acquisition system(s), will be finalized for use in the designated fuel fabrication facilities. This work will be performed by Departmental experts. The designs are expected to be minor modifications of systems currently deployed by the IAEA in support of safeguards. Non-standard elements of the designs will be prototyped and tested using extra-budgetary funds;

- Development will commence of efficient and cost-effective methods to maintain CoK of the fresh MOX fuel assemblies as they are transported from the fuel production facilities to the PMDA-designated reactors. Initial concepts will modify existing mobile radiation detector instrumentation for use with the MOX assemblies. The necessary operational procedures will be developed in cooperation with the PMDA parties. These procedures will be designed to ensure that the required transportation data is recorded for periodic IAEA analysis. Designs will be prototyped and tested using extra-budgetary funds;

- Methods to regain CoK of transported fresh fuel using novel asymmetric channel collimators have been explored in 2013 (see figure 1 and 2). Further detailed exploration will include additional simulation studies, and the development of prototype collimator systems for each type of reactor (LWR and FNR). Long-term tests on reference assemblies for each reactor type will be performed to validate these systems. Designs will be prototyped and tested using extra-budgetary funds;

- Should one, or both, parties of the PMDA agreement decide that transmission of system SoH data to the IAEA will be prohibited, then some 'mechanism' will be needed to inform designated parties, whose responsibility it would be to notify the Agency of equipment concerns, to schedule a maintenance activity. The 'mechanism' would include both the monitoring of NDA hardware components (to read various status signals, such as system temperature, high voltage status, etc.) and some automated 'real-time' examination of data to look for anomalies that may indicate detector failure. This work would be performed using extra-budgetary funds.

- It is assumed that data may only be analysed by inspectors during periodic visits to the designated PMDA facilities. To accommodate this constraint, the time required to review the data must be minimized further than that currently possible. Custom review software modules are required and should be designed to call an inspector's attention quickly and efficiently to any outlier measurements that are not in agreement with facility operator declarations. User requirements for these modules will be developed in the

2014-2015 biennium. By the end of the biennium, the IAEA will procure the development of the PMDA review modules using extra-budgetary funds. Requirements will be included for these modules to ensure that they interface seamlessly with the review software being developed in SGTS-014.

- Initial concepts for the measurement of plutonium isotopics in plutonium oxide (PuO2) powder and MOX fuel rods require the use of an electromechanically-cooled, high-resolution gamma spectrometer (HRGS) using high-purity germanium (HPGe) detector. R&D efforts, involving the use of medium energy resolution gamma spectrometers (such as LaBr) to measure plutonium isotopics, are of considerable interest because of reliability concerns. The applicability of such detector systems to measure plutonium isotopics is under evaluation in SGTS-001. The in-house evaluation effort is being funded through regular budget sources. MSSPs will be requested to support data collection and analysis algorithms.

### 4.1. MSSP Development and Implementation Support Tasks

Development activities under Project SGTS-015 to date have been performed in-house. For the 2014-2015 biennium, two MSSP development and implementation support tasks are planned. These are for activities related to the verification by NDA methods of the irradiation history of designated spent MOX fuel.

*Table 2. Proposed and Planned MSSP Development and Implementation Support Tasks*

| Applicable Capability or Milestone | Task Proposal ID. | Proposed Task Title | Comments |
|---|---|---|---|
| 11.1. | New Task Proposal #1 | Non-destructive Assay of Fast Neutron Reactor Spent Fuel for Burn-up Confirmation | Submitted to US and RF MSSPs in 2013 |
| 11.1. | New Task Proposal #2 | Verification of LWR spent fuel irradiation history by DCVD | Submitted to US and RF MSSPs in 2013 |

### 4.2. In-house Development Activities

Tables 3 and 4 list both the current and proposed future in-house development activities. Funding for these development activities will be carried out using extra-budgetary resources.

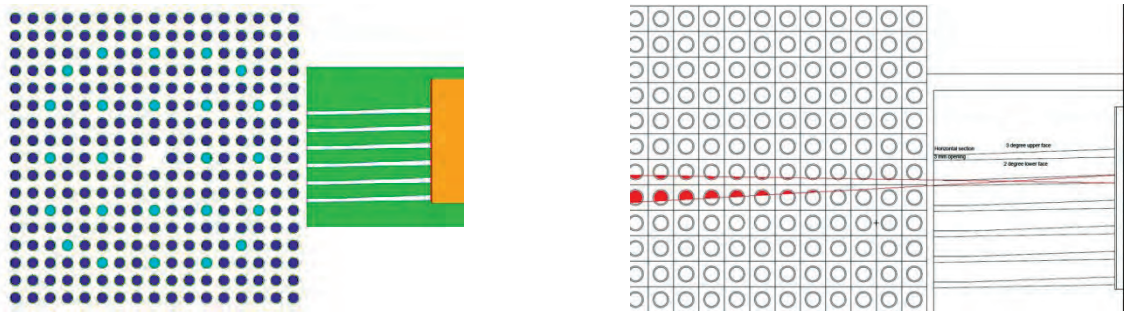
*Table 3. Current and Standby In-house Development Activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 11.1. | 1 | Design of NDA systems for MOX fuel fabrication facilities | Finalize both conceptual designs for the NDA systems, including associated data acquisition system(s), for use in the PMDA designated fuel fabrication facilities. | End 2014 |
| 11.1. | 2 | Development of efficient and cost effective means to maintain CoK of transported fresh PMDA fuel | Develop and build prototype instrumentation to maintain CoK of PMDA fuel as it is shipped from fuel fabrication facilities to PMDA designated reactors. | End 2015 |

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 11.1. | 3 | Advanced collimators exploration to re-verify plutonium isotopic composition in the fresh fuel assemblies | • Extend exploration work performed on novel collimator designs that utilize multiple, asymmetrical, slots to enhance the gamma signal from internal fuel pins in fresh fuel assemblies.<br>• This would allow re-verification of the plutonium isotopic composition in the fresh fuel assemblies, and thus be a method to regain CoK for assemblies transported from fabrication facilities to designated reactors. | End 2015 |

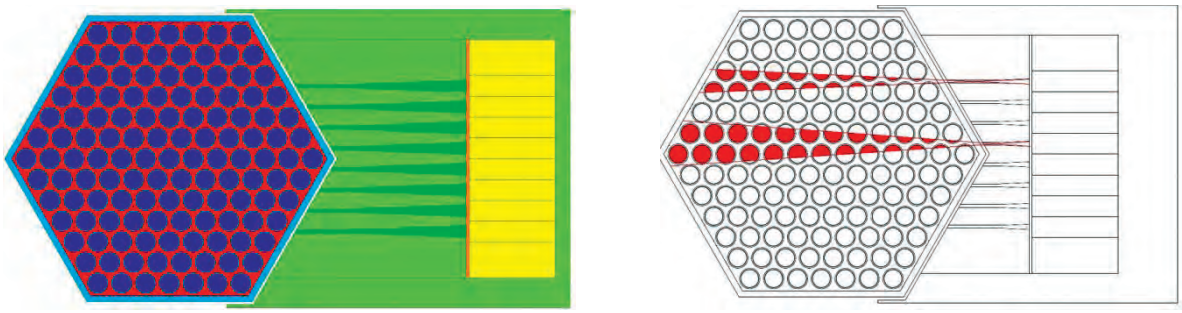
*Table 4. Proposed and planned in-house activities*

| Applicable Capability or Milestone | Activity # | Activity Title | Description | Target Completion Date |
|---|---|---|---|---|
| 11.1. | 1 | Development of mechanism to alert operators of NDA system malfunctions | Develop prototype hardware and data quality analysis algorithms, which may be used to notify operators of performance concerns necessitating intervention by IAEA system experts. | Dec. 2015 |
| 11.1. | 2 | Development of software review modules for PMDA | Develop software requirements, and prototype software modules, compatible with review tools being developed under SGTS-014. These modules would be designed to aid Safeguard Inspectors in the periodic review of acquired data while at PMDA facilities. | Dec. 2015 |



## Attachments

[s] Figure 1: An example of an advanced collimator concept to re-verify plutonium isotopic composition in LWR fresh fuel assemblies. The multiple asymmetric slots in the collimator (green) are designed to maximize the contribution of the most distant fuel pins to the overall measurement. A HRGS detector crystal would be placed in the region shaded orange. The figure on the right illustrates the relative contribution of each pin to the overall signal. The red shading illustrates the fraction of each pin that can be observed with a single collimator channel. Without such collimation, a measurement at this location would be dominated by the signal of the nearest pins, masking the contribution from pins farther away.



[s] Figure 2: An example of an advanced collimator concept to re-verify plutonium isotopic composition in FNR fresh fuel assemblies. As above, the multiple asymmetric slots in the collimator (green) are designed to maximize the contribution of the most distant fuel pins to the overall measurement. A HRGS detector crystal would be placed in the region shaded yellow. The figure on the right illustrates the relative contribution of each pin to the overall signal. The red shading illustrates the fraction of each pin that can be observed with a single collimator channel. Without such collimation, a measurement at this location would be dominated by the signal of the nearest pins, masking the contribution from pins farther away.

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