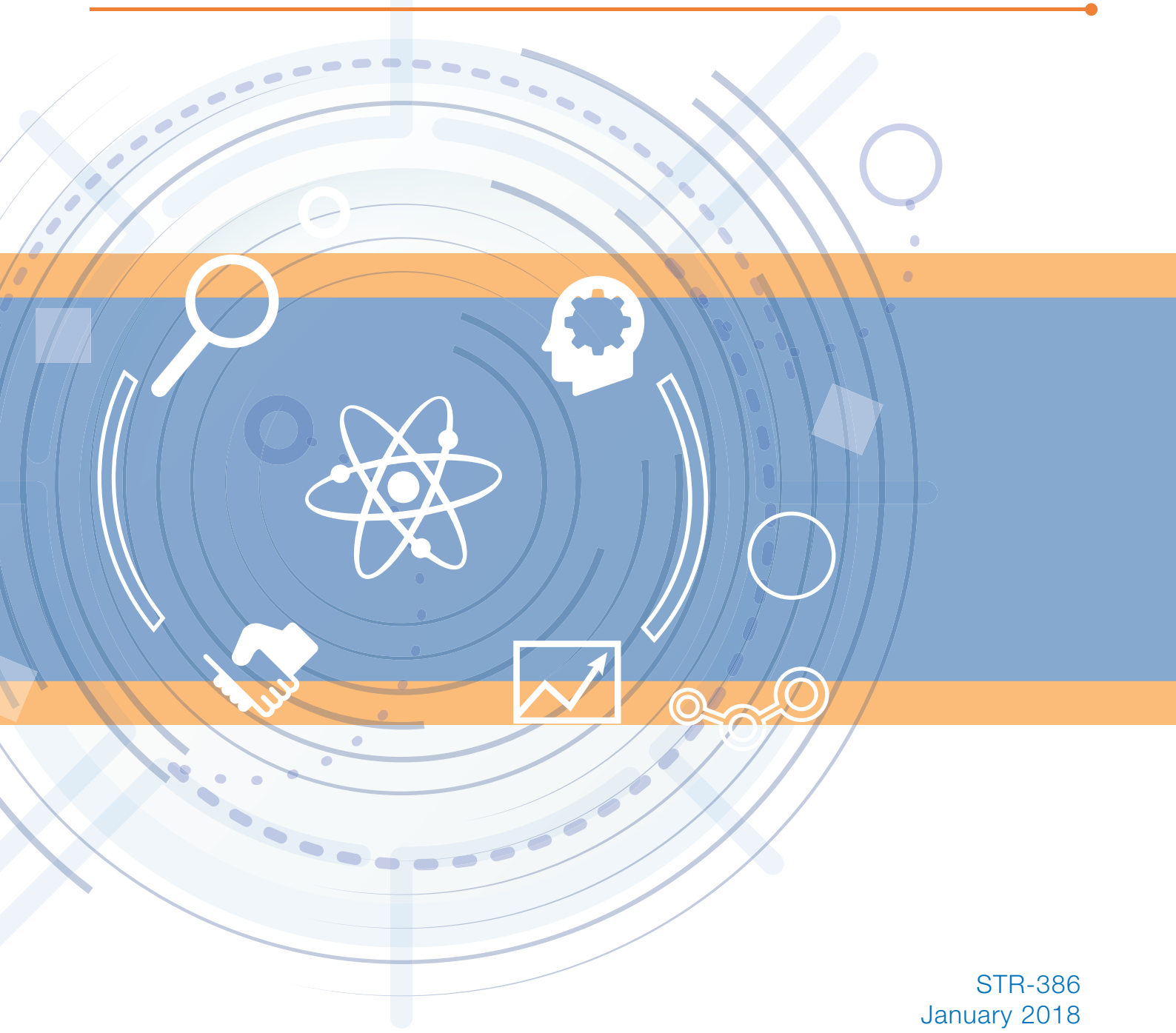
IAEA

Safeguards

Development and Implementation Support Programme for Nuclear Verification 2018—2019



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Foreword

IAEA safeguards make a vital contribution to international peace and security. The effectiveness of safeguards is achieved partly thanks to the continuous effort of the Department of Safeguards to ensure that it keeps pace with emerging challenges and opportunities in the field of nuclear verification.

Staying ahead of the game is not an easy task. The IAEA has no dedicated budget for research and development. Nor does it have all of the nuclear facilities and materials it would need to, inter alia, provide specialized training for inspectors, test equipment, and maintain the highest levels of quality and accuracy for analysis of samples taken in the field.

How then is the IAEA able to deploy the 'state of the art' tools, techniques, methodologies and expertise that are required for effective and efficient safeguards?

The answer lies with Member State Support Programmes (MSSPs), which provide additional financial and in-kind support through extrabudgetary contributions. The Department's needs for this additional support are described in the Development and Implementation Support (D&IS) Programme for Nuclear Verification, which has been in place since 2001. This programme, derived from the Agency's Programme and Budget 2018-19, and linked to the R&D Plan 2018–2029 and the Safeguards Strategic Plan, is a key tool for the Department of Safeguards, helping to sharpen and sustain capabilities that enable a unique mission in a context of increasing budgetary pressure.

These capabilities cover a diverse set of technical areas. Whether it is analysis of environmental samples, in-field measurements of nuclear material, evaluation of safeguards-relevant information, coping with specific verification challenges in different countries, or modernizing IT systems and ensuring the security and integrity of confidential information, the implementation of the D&IS Programme helps to keep the Department's activities and abilities commensurate with current threats and challenges.

I have spoken in other forums about the need to improve the productivity of the Department of Safeguards in light of our increasing responsibilities and static financial resources. We

are working hard to achieve this through better processes, use of technology and closer cooperation with Member States. The D&IS Programme is a component of this broader strategy, serving to marshal and focus resources from MSSPs towards our most urgent priorities.

The IAEA continues to depend on MSSPs to provide technology, expertise and resources that we could not otherwise obtain. Given the important role that MSSPs play in strengthening safeguards, it has become increasingly important to provide Member States and all of our stakeholders with a complete picture of the activities where additional support is needed in the coming biennium to achieve the strategic objectives we have identified. This document strives to do just that. We hope that you will use it (as we do) to better understand where we are, where we want to go, and to inform your decision-making about how best to help us get there.

Our Member States are counting on us to deliver credible safeguards conclusions each and every year. I look forward to strengthening our successful working partnerships with them in this biennium and beyond.

Tero Varjoranta

Deputy Director General
Head of the Department of Safeguards

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Introduction to the Development and Implementation Support Programme for Nuclear Verification 2018–2019

The purpose of this biennial document, *Development and Implementation Support (D&IS) Programme for Nuclear Verification*, is to inform the inspectorate, Member States, and other contributing organizations and stakeholders about the efforts of the IAEA Department of Safeguards in terms of development activities and needs for additional support for the implementation of safeguards in a manner which is effective, efficient and encourages innovation and excellence.

For some development activities, the resources to implement the *D&IS Programme* come from the Department itself. For many development activities and for some implementation activities where expertise and financial resources are not available, support from the Member State Support Programmes (MSSPs), including through extra-budgetary contributions from respective Member States, remains essential. The full implementation of the Nuclear Verification Programme would not be possible without the transfer of technology, expertise, and resources through the MSSP mechanism. The biennial *D&IS Programme* describes the scope of the Department's development and implementation activities that require support and provides a better understanding of where assistance is required to meet current and emerging safeguards needs.

D&IS PROGRAMME OBJECTIVES

The Department has prepared its *D&IS Programme* for the biennial period 2018–2019 to prioritize tasks, define key deliverables, and inform MSSPs and Departmental resource allocation decisions in the context of the Department's total work portfolio.

The *D&IS Programme* aims to meet both short-term needs and others that are part of longer-term R&D planning. It is driven by Departmentally-identified strategic needs, which are assessed against basic scientific information, advances in technology and research, IAEA experience associated with specific safeguards implementation, and changes in the operating environment.

Each of the *D&IS Programme* project plans that follow aim to:

- Describe specific short-term D&IS needs and priorities by project area;
- Connect short-term needs and activities to the Department's longer-term objectives;
- Help stakeholders to understand the necessity and significance of new task requests with relevant context and background information; and
- Inform Departmental and MSSP resource allocation decisions.

PLANNING FRAMEWORK

The Projects described in this document are designed to contribute to the achievement of the objectives for Major Programme 4 (Nuclear Verification). The Department's three over-arching strategic objectives are:

1. *To 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;*
1. *In accordance with the Agency's Statute, assist with other verification tasks, including in connection with nuclear disarmament or arms control agreements, as requested by States and approved by the Board of Governors; and*
1. *To continually improve the Department's performance and productivity to effectively carry out the Agency's verification mission.*

The Department of Safeguards conducts strategic planning, which enhances its capability to face future challenges and benefit from opportunities to ensure that safeguards implementation continues to be effective and efficient. The strategic planning framework supports good management of resources through continually monitoring the operating environment, establishing objectives that are prioritized to focus resources on top priorities; it avoids duplications and promotes programmatic and organizational coherence. Another key element supporting strategy execution is the development and enhancement of partnerships with respect to development and implementation support.

The Department's strategic planning framework is comprised of: the *IAEA Medium Term Strategy*, the *Agency's Programme and Budget*, the Department's *Strategic Plan*, the Safeguards *Research and Development (R&D) Plan*, and the *D&IS Programme*. Togeth-

er, these connect high-level strategic objectives, expected outcomes, and relevant R&D needs that require external support with implementation and development tasks that are either fully-funded in the regular budget or need additional financial or in-kind support. As a result, Department staff and external stakeholders should be able to understand how even the most specialized tasks are connected to the bigger picture of strengthening safeguards capabilities.

Medium Term Strategy

The *Medium Term Strategy 2018-2023* (GOV/2016/57), that was taken note of by the Board of Governors, was developed by a working group of the Board of Governors with the assistance of the Secretariat. The *Medium Term Strategy* guides the development of the *Agency's Programme and Budget* during the three biennia covered by it. It identifies priorities among and within its programmes for the achievement of the Agency's statutory objectives in an evolving international environment.

Agency's Programme and Budget

The *Agency's Programme and Budget 2018-2019* that was approved at the General Conference in 2017 as GC(61)/4 describes all approved activities that need to be carried out during the biennium. It also contains the approved budget that will be allocated to each of these activities. Several tasks of the programme remain unfunded due to budgetary constraints. For the Department of Safeguards, this unfunded part amounts to €23.8 million for 2018 and €21.9 million for 2019. In addition to these unfunded resources (human or material) that can be estimated in the context of a given budget, there is a substantial amount of other resources that cannot be easily tallied but are still essential for effective implementation of the verification mandate. These resources are, for example, new equipment and software resulting from R&D activities performed in Member States, the availability of nuclear facilities for testing or training purposes and the contributions of external experts.

Safeguards Strategic Planning

The Department of Safeguards initiated strategic planning in 2010. In 2017, the Department prepared an updated plan, in line with guidance provided by the Department's senior management and experience gained and lessons learned from the implementation of the previous strategic planning process.

Strategic planning takes a long-term view of the future. The external environment analysis and scenarios upon which it is based examine the Agency's operating environment until the year 2030. It identifies the strategic issues the Department of Safeguards needs to address. The Plan-on-a-page (page 6) outlines departmental objectives in four strategic focus areas: (1) delivering on the mission, (2) managing intellectual capital, (3) enhancing organizational performance, and (4) partnering for success.

The Department has defined priority objectives as well as actions to advance those departmental objectives.

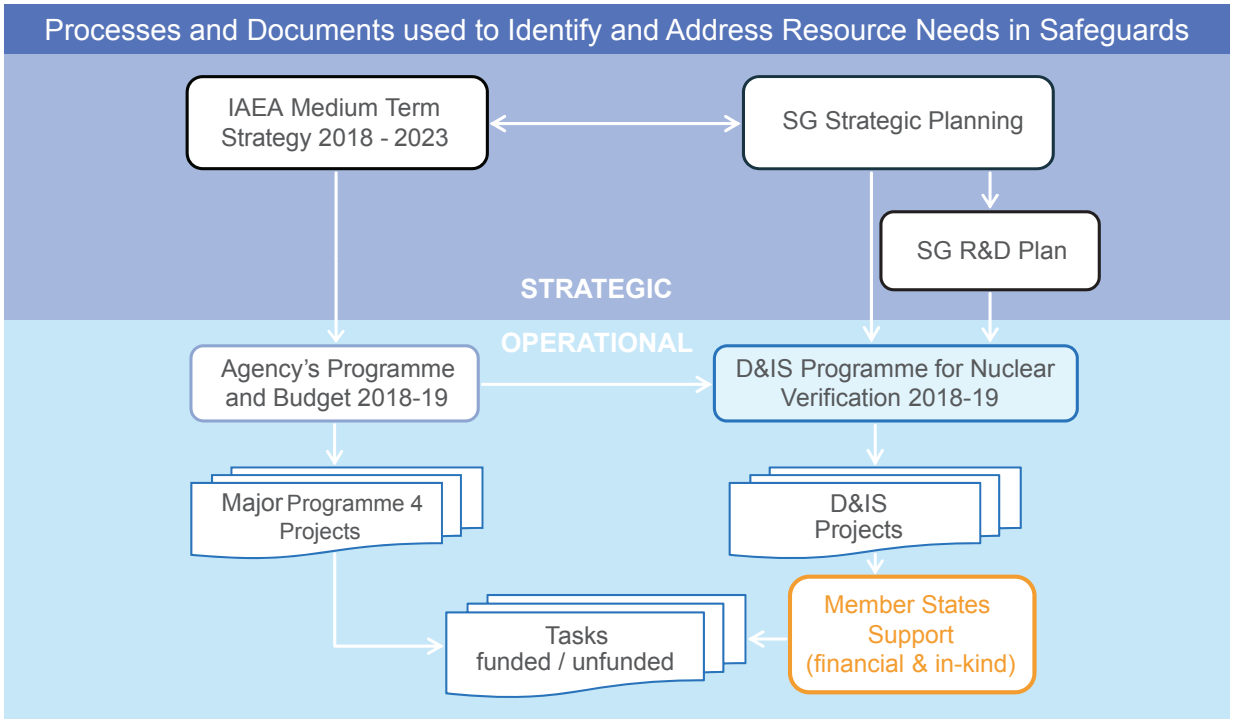


Figure 1. Processes and Documents used to Identify and Address Resource Needs in Safeguards

R&D Plan

The Department updated its *Long-Term R&D Plan, 2012-2023* to ensure consistency with recent strategic planning. The *R&D Plan* supports the implementation of the Department's priority strategic objectives by highlighting specific needs that are reliant on external support. The main table of the *R&D Plan* is included to the current *D&IS Programme for Nuclear Verification 2018-19* as an appendix beginning on page 209. The *R&D Plan* and the *D&IS Programme* both refer to the priority strategic objectives. In this way, all tasks have a clear connection to Departmental strategies for improving capabilities in pursuit of its mission.

The D&IS Programme

As in the past, the *D&IS Programme* serves as the bridge between strategy and execution with regard to the Department's efforts supported by external partners to improve capabilities within each technical project area. It gives a more detailed and technical description of those tasks of the *Agency's Programme and Budget* that are of an internal developmental nature and those that require external support. Each project identifies relevant priority strategic objectives or R&D needs being addressed for the coming two years.

D&IS PROGRAMME SCOPE

As its name suggests, the *D&IS Programme* contains two types of activities, those that address development of *new* techniques and technologies and those that support the deployment, maintenance, implementation or improvement of *existing* capabilities.

This *D&IS Programme* endeavours to describe *all* development activities being undertaken within the Department in each Project area, regardless of the funding source. This is an important part of ensuring that stakeholders have a complete picture of relevant work towards a given objective. This, in turn, will help stakeholders to understand where their contributions can make the greatest impact, by complementing existing efforts, helping to initiate activities in under-served areas of need, and/or avoiding duplicative work.

The *D&IS Programme's* development activities aim at, inter alia:

- *New capabilities* which have been identified through the Department's planning processes, and which address emerging and future needs.
- *Continual improvement* of the Department's processes, equipment/systems, tools, training, concepts and approaches, analysis services, and information acquisition, analysis and evaluation capabilities.
- *Technology enhancement* with efforts that focus on the Department's core capabilities and technologies, such as the development and customization of equipment.

In the area of safeguards implementation, the *D&IS Programme* covers MSSP-supported tasks that would otherwise remain unfunded. The *Agency's Programme and Budget* covers all other implementation-related work.

The *D&IS Programme*'s implementation support activities aim primarily at:

- *Sustainability* with efforts that focus on the Department's need to sustain core capabilities and technologies (including, e.g., training for inspectors, refinement or replacement of equipment and systems); and
- *Increased capacity* that is needed due to an increasing demand for verification activities or temporary efforts for gaining in productivity (including laboratory analytical services, IT services or training).

For the first time, the *D&IS Programme* also covers Cost-Free Expert (CFE) and Junior Professional Officer (JPO) 'tasks' in order to give a comprehensive view of the substantive support needed in terms of additional expertise and human resources.

PROGRAMME AND PROJECT MANAGEMENT

Coordination of D&IS activities is carried out by the Department's Division of Concepts and Planning. For the 2018–2019 biennium, the Department has identified 24 projects to meet current and emerging safeguards needs. One project was discontinued and one newly created (see details under "Significant changes" below). The projects and their respective managers are listed on page 8.

The execution of the programme is performed through tasks planned within each of the 24 D&IS project plans that are described in the main body of this document. For tasks 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

At the level of project plans, effort has been made to help the Department and MSSPs to understand the necessity and significance of new and continuing work. In addition, an appendix provided after the project plans links existing tasks with the strategic objectives and the R&D needs defined through strategic planning and reflected in the R&D Plan to help readers visualize a broad picture of current activities towards long-term goals.

Each project is described in terms of:

Overview

- Scope and purpose of the project
  - Objective
  - Linkage to Agency's Programme and Budget projects
  - Strategic objectives and R&D needs from the R&D Plan
- Top priorities for the 2018-2019 biennium

Background

- How the project fits into the Department's wider efforts
- The rationale underlying the project area
- Major challenges in the years to come
- Recent achievements and next steps

Expected Outcomes and Key Outputs

- Supported strategic objective and/or R&D needs
- Key outputs for the period 2018-19, which detail deliverables that are specific, measurable, achievable, relevant and time-bound

Tasks

- Description of specific tasks planned during the biennium for each expected outcome
- References to active MSSP tasks, task proposals, and newly planned task proposals and internal activities, as well as cross-references to related projects
- Highlights of recent achievements as appropriate
- Indications of future support needed

Project plans also contain tables describing development activities supported with regular budget funds.

SIGNIFICANT CHANGES FOR 2018-2019

In this biennium, the general outline of the projects remains the same compared to the previous one. However, changes have been made to key terminology and phrasing to align descriptions of activities with the Agency's Results-based Management terminology. For example, "Long term direction" has been replaced by "objective", and "key achievement target" has been replaced by "key outputs" contributing to the achievement of "expected outcomes".

The 'Overview' section of each D&IS project plan has been enhanced by specifying to which *Agency's Programme and Budget* Project the outcomes of the D&IS project will contribute. This shows the consistency between the *D&IS Programme* and the *Agency's Programme & Budget*.

There is one new project for the 2018-2019 biennium:

SGCP-004 *Strategic Planning and Partnerships*

This project addresses the need for managing strategic planning related processes – from foresight and related risks analysis, through strategy formulation and execution – in the Department of Safeguards for the period 2018-2019. It also describes efforts to enhance partnerships that are increasingly important for a successful implementation of the verification mandate of the Department.

One project has been discontinued:

SGTS-015 *Technologies for Possible new IAEA Verification Tasks*

The project contained no active task and no specific need was anticipated for the coming two years. Possible upcoming needs in this area can be covered by one of the other existing projects.

As noted above, information about Cost-Free Experts (CFEs) and Junior Professional Officers (JPOs) and all the vital work they perform to support the work and plans described in the *D&IS Programme* has also been included this biennium.

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.

When a task is completed, an application report is prepared by the task officer or project manager and submitted to 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 or lessons learned.

ADMINISTRATION OF MEMBER STATE SUPPORT PROGRAMME TASKS

Existing MSSP tasks and new task proposals are included within the activities of each relevant project. These tasks are administered by the Department's Support Programme Coordination Team (SPCT) in the Section for Strategic Planning and External Coordination (CPC), Division of Concepts and Planning (SGCP), together with MSSP Coordinators. The appointed MSSP Coordinator is the IAEA's main point-of-contact with each respective Member State concerning projects and associated tasks.

In 2015, the IAEA launched the SPRICS 2.0 system. SPRICS 2.0 is a web-based task management system intended to facilitate collaboration between the IAEA and MSSPs. SPRICS 2.0 serves as the administrative platform through which users on both sides can monitor progress, access records, and retrieve and share task-related information.

In 2017, work to improve the functionalities of SPRICS 2.0. was started (see SGCP-004 and SGIS-003) and will continue through 2018-2019.

THE FUTURE

The Department will continue to rely on MSSPs to provide the necessary technology, expertise, and resources 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 2018–2019 biennium, the Department will continue to further align the planning and implementation process for D&IS activities with Departmental strategic planning and the *R&D Plan*. The *D&IS Programme* will also continue to include a prioritization process. Efforts to maintain and extend existing partnerships and identify new ones will be continued for the benefit of the Agency's successful implementation of the verification mandate.

MEMBER STATE SUPPORT PROGRAMMES

A list of all existing Member State Support Programmes is shown on page 7.

Plan-on-a-page

Objectives in the strategic plan

MISSION

STRATEGIC OBJECTIVES

VISION

Delivering on the mission

Our core activities

- **V.1** Strengthen information collection and analysis
- **V.2** Reinforce State evaluation
- **V.3** Align procedures to support SG at the State level
- **V.4** Enhance SG effectiveness monitoring and evaluation
- **V.5** Employ fit-for-purpose and state-of-the-art methodologies

Our technical capabilities

- **T.1** Strengthen instrumentation capabilities for verification
- **T.2** Enhance sensitivity, reliability and timeliness in sample analysis
- **T.3** Support all SG processes through IT
- **T.4** Manage SG technology assets strategically
- **T.5** Identify and exploit innovations

Managing intellectual capital

Our people and knowledge

- **W.1** Reform human resource management
- **W.2** Promote a high performance work culture
- **W.3** Treat knowledge as an organizational asset
- **W.4** Advance workforce diversity, including gender

Partnering for success

Our stakeholders

- **S.1** Communicate proactively and transparently
- **S.2** Resolve priority areas of difficulty in SG implementation
- **S.3** Advance safeguards-by-design
- **S.4** Leverage and establish partnerships

Enhancing organizational performance

Our org. capacity

- **C.1** Develop organizational agility
- **C.2** Strengthen management processes
- **C.3** Strengthen departmental communication and coordination
- **C.4** Secure and optimally manage financial resources

Our preparedness

- **P.1** Ensure information security
- **P.2** Increase resilience and prepare for disaster recovery
- **P.3** Monitor and prepare for evolving proliferation challenges
- **P.4** Maintain readiness for other verification tasks
- **P.5** Prepare for new types of facilities and decommissioning

VALUES

Integrity | Professionalism | Respect for diversity

List of Member State Support Programmes

- **Argentina (ARG SP)**
- **Australia (AUL SP)**
- **Belgium (BEL SP)**
- **Brazil (BRZ SP)**
- **Canada (CSSP)**
- **China (CPR SP)**
- **Czech Republic (The) (CZ SP)**
- **European Commission (EC SP)**
- **Finland (FIN SP)**
- **France (FRESPAS)**
- **Germany (GER SP)**
- **Hungary (HUN SP)**
- **Japan (JASPAS)**
- **Netherlands (The) (NET SP)**
- **Republic of Korea (The) (ROK SP)**
- **Russian Federation (The) (RUS SP)**
- **South Africa (RSA SP)**
- **Spain (ESP SP)**
- **Sweden (SWE SP)**
- **United Kingdom of Great Britain and Northern Ireland (The) (UK SP)**
- **United States of America (The) (US SP)**

List of D&IS Projects and Project Managers 2018-2019

Project ID	Project Title	Project Manager	Responsible Division/Section
SGAS-001	Destructive Analysis of Nuclear Materials	Steven Balsley	SGAS/NML
SGAS-002	Environmental Sample Analysis Techniques	Stephan Vogt	SGAS/ESL
SGAS-003	Analysis Support and NWAL Coordination	Paul Martin	SGAS/CSS
SGCP-003	Safeguards Approaches	Jin Yong Doo	SGCP/CCA
SGCP-004	Strategic Planning and Partnerships	Eric Pujol	SGCP/CPC
SGCP-101	Quality Management	Roy Fitzgerald	SGCP/CPD
SGCP-102	Training	Jean-Maurice Crété	SGCP/CTR
SGIM-002	Satellite Imagery Analysis	Michael Flory	SGIM/ISI
SGIM-003	Information Analysis	Brian Aubert	SGIM/ISF
SGIM-007	Evaluation of Data from Environmental Sampling and Material Characterisation	Diane Fischer	SGIM/IFC
SGIM-008	Statistical Analysis	Robert Binner	SGIM/IFC
SGIM-009	State Declared Information Management	Snezana Konecni	SGIM/ISD
SGIS-002	Information Security and Infrastructure	Scott Partee	SGIS/IS
SGIS-003	Information Systems and System Usability	Gregg Whitaker	SGIS/PS
SGOA-002	Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX)	Christophe Creusot	SGOA/OA2
SGOA-003	Fukushima Dai-ichi Safeguards	Bruno Chesnay	SGOA/TRO
SGOC-001	Chernobyl	Sigitas Kurselis	SGOC/OC2
SGVI-001	JCPOA Implementation	Andrew Catton	SGVI/OVI2
SGTS-001	NDA Techniques	Mikhail Mayorov	SGTS/TND
SGTS-002	Improved Techniques and Instruments for Sealing and Containment Verification	Bernard Wishard	SGTS/TSI
SGTS-003	Surveillance Techniques	Antony Lavietes	SGTS/TUS
SGTS-008	Instrumentation Technology Foresight	Dimitri Finker	SGTS/TND
SGTS-011	Unattended Measurement Techniques	Thierry Pochet	SGTS/TUS
SGTS-014	Remote Monitoring and Data Processing Systems	Jim Regula	SGTS/TSI

List of D&IS Project Top Priorities 2018-2019

Project	Project Top Priorities
SGAS-001 **Destructive Analysis of Nuclear Materials**	• Complete facility-scale testing of the Cristallini UF_6 sampling technique, which would mitigate the impact of potential restrictions on air transport of UF_6 samples; • Implement a new hot-cell scrubber system at the OSL in Japan for trapping gaseous ruthenium during dissolution of high-activity liquid waste samples; • Test new foam-based additives to facilitate longer storage times for Pu and mixed U-Pu working standards produced in-house, which will reduce labour and decrease the volume of expensive radioactive waste.
SGAS-002 **Environmental Sample Analysis Techniques**	• Develop, implement and improve methods for identifying and isolating nuclear material-containing particles from environmental swipe samples; • Develop new methodologies for using the Scanning Electron Microscope (SEM/FIB-ToF) to characterize individual micrometer-sized particles collected on environmental swipe samples; • Develop and implement the Laser Ablation ICP-MS technique, and develop capabilities to use a large-geometry secondary ion mass spectrometer (LG-SIMS) for accurate and precise measurement of the isotopic composition of uranium/plutonium containing micrometer-sized particles.
SGAS-003 **Analysis Support and NWAL Coordination**	• Ensure efficient and effective operation of the NWAL, including participation in inter-laboratory comparison exercises; • Implement expansion of the NWAL, with the main focus on particle analysis of environmental samples and quality assurance support; • Coordinate and support the production of new quality control reference materials, particularly for particle analysis.
SGCP-003 **Safeguards Approaches**	• Develop methodologies and guidance for improving the assessment of acquisition path steps, including State's technical capability to develop and/or acquire nuclear fuel cycle technologies and facilities, nuclear material diversion and facility misuse scenarios; • Update the Physical Model to incorporate the latest technological developments; • Develop safeguards implementation guidelines for facilities under decommissioning and safeguards concepts for post-accident facilities under decommissioning.
SGCP-004 **Strategic Planning and Partnerships**	• Strengthen tools, methods and processes for executing the Department's strategic plan, including communication, implementation and monitoring; • Strengthen foresight mechanisms to identify, monitor, analyse and address changes in the operating environment and develop the tools, methods and processes to adapt to these changes, as necessary, in a more agile manner; • Organise a Safeguards Symposium to explore innovations, mobilise partnerships to address them, and identify ways to work together with the safeguards community to enhance the implementation of safeguards.

Project	Project Top Priorities
SGCP-101 **Quality Management**	• Continue to improve and mature the process-based approach implemented in the Department; • Upgrade QMS tools and techniques for improving and monitoring process performance; • Continually assess the effectiveness of the Department's QMS and implement improvements as needed.
SGCP-102 **Training**	• Contribute to meeting departmental strategic objectives by providing expertise, capturing best practices, developing new courses or adjusting existing courses; • Develop a competency-based approach for training implementation, making full use of the Learning Management System deployed within the Agency-wide Information System for Programme Support (AIPS); • Develop and implement a training programme to support States System of Accounting for and Control of nuclear material (SSACs) in developing their capabilities for collecting safeguards relevant information within the country and for conducting domestic inspections.
SGIM-002 **Satellite Imagery Analysis**	• Conduct further research into the processing, analysis and safeguards applications of synthetic aperture radar (SAR) and thermal infrared (IR) satellite imagery, and develop and implement analytical products to enable wider use of SAR and IR imagery within the Department; • Provide specialist training for analysts on satellite imagery exploitation and allow opportunities for analysts to participate in familiarization visits to nuclear fuel cycle facilities; • Continue to identify new methods and capabilities that effectively integrate all source information with commercial satellite imagery in a collaborative geographic information system (GIS) workspace.
SGIM-003 **Information Analysis**	• Complete planned enhancements on a system to collect, process, and manage text-based safeguards-relevant semi-structured and unstructured open source information, to include automatic collection of information from identified sources, and mechanisms for adding structure to unstructured data; • Optimize the use of multimedia information collection, analysis, and integration in State evaluation and preparation for in-field activities, through the development and deployment of specialized tools, methods, and procedures; • Continue to work to integrate open source data sets with other safeguards information and systems, including for declared information consistency analysis and in-field activity preparation, to enable its use in techniques such as link analysis and geospatial visualization, and to develop all necessary use cases and procedures.
SGIM-007 **Evaluation of Data from Environmental Sampling and Material Characterisation**	• Explore and develop statistical techniques and evaluation methodologies that improve data evaluation and the application of signatures detectable through environmental sampling and material characterisation, including the use of elemental and morphological data; • Expand the current understanding of the detectable signatures (isotopic, elemental and morphological characteristics of key materials) of nuclear fuel cycle activities, including the formation, fate and transport of particles in the environment.

Project	Project Top Priorities
SGIM-008 **Statistical Analysis**	• Review, update and consolidate the algorithms for the determination of measurement error uncertainties from calibration, paired-data, and 3-laboratory data analysis, for evaluating MUF, D, IMUF, and SRD, calculate sampling plans, detect significant operator-inspector differences and for implementing NRTA; • Review and harmonize current random inspection schemes through the development, refinement and documentation of methodologies and processes for their implementation and evaluation of their effectiveness; • Enhance and further develop analytical methodologies in support of State-level evaluations in the areas of material balance evaluation, determination of detection probabilities, and nuclear material flow analysis.
SGIM-009 **State Declared Information Management**	• Update and deploy tools and methodologies for States to collect, store and submit State declared information; • Deploy the State Declarations Portal, a web-based portal for the online submission of State declared information by SRAs, as a tool for information exchange between States and the IAEA. • Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility.
SGIS-002 **Information Security and Infrastructure**	• Improve the Department's information security and IT security skills with targeted training on specific topics related to threat detection, incident response, secure software development, security designs, continuous monitoring, event management, digital forensics, and security architecture; • Enhance the endpoint and server security configuration of the Department's IT infrastructure with additional security functions through the use of next generation endpoint security techniques; • Develop and demonstrate an updated disaster recovery programme.
SGIS-003 **Information Systems and System Usability**	• Successfully complete MOSAIC and ensure that the Department's modernized IT system efficiently and effectively supports safeguards implementation processes, building upon MOSAIC investment and good practices. • Develop new safeguards IT capabilities and enhance existing IT capabilities that will optimize Departmental operations in order to effectively and efficiently carry out the IAEA's verification mission. • Ensure the confidentiality, integrity and availability of safeguards information.
SGOA-002 **Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX)**	• Develop/consolidate a safeguards approach in line with the State-level Approach (SLA) for Japan; • Develop/manufacture equipment necessary to support the safeguards approach; and • Define the requirements specification and architecture for an integrated data collection and evaluation system.

Project	Project Top Priorities
SGOA-003 **Fukushima Dai-ichi Safeguards**	• Maintain a reliable safeguards system at the Fukushima Dai-ichi site capable of providing credible assurance that nuclear material cannot be removed from the damaged facilities without the IAEA's knowledge; • Make improvements and adjustments to the monitoring system to accommodate changes in the remediation status of the damaged facilities on the site; and, • Develop measures to re-verify as much of the previously inaccessible nuclear material as possible.
SGOC-001 **Chernobyl**	• Finalize procedures for safeguards application at facilities under this project; • Complete the installation, adjustment and authorization of safeguards equipment for verification use.
SGVI-001 **JCPOA Implementation**	• Contribute to the development of software and analytical tools (in cooperation with SGIS-003 Safeguards Information Systems and System Usability); • Organise specialized training (in cooperation with SGCP-102 Training).
SGTS-001 **NDA Techniques**	• Capitalize on results of Passive Gamma Emission Tomography System (PGET) development and authorization project by implementation of the system for Encapsulation Plant for Geological Repositories (EPGR) Project and other safeguards verification activities that require application of partial defect tests on spent nuclear fuel; • Deploy Fast Neutron Coincidence Collar at nearly all safeguarded fuel fabrication facilities, that manufacture nuclear fuel assemblies containing burnable poison rods; • Continue performance evaluation of the NDA instruments for detection of non-radiation Nuclear Fuel Cycle (NFC) signatures (such as those based on LIBS and Raman technologies) and supported by the creation of a repository for reference NFC signature materials; • Perform re-engineering of the Inspector-level software suite for various Multichannel Analyser based applications to improve usability and maintainability.
SGTS-002 **Improved Techniques and Instruments for Sealing and Containment Verification**	• Develop a new generation of active seal called the Active Optical Loop Seal (AOLS); • Develop and deploy a new glass seal (GLAS), or hybrid seals containing glass and other structural materials, to be used in applications for which metal seals are currently utilized; • Continue to improve the overall security of safeguards instrumentation so as to defend against a dynamic threat landscape.
SGTS-003 **Surveillance Techniques**	• Complete the development, assessment, and authorization of modular and highly efficient surveillance review software to replace the currently used and obsolete General Advanced Review Software (GARS); • Complete the development, assessment, and authorization of the analogue camera NGSS module; • Identify and evaluate safeguards-relevant applications of new and/or emerging technologies to broaden the capabilities of surveillance through incorporation of alternate technologies (e.g. RF, ultrasonics, acoustics, sonar, and hyperspectral imaging).

Project	Project Top Priorities
SGTS-008 **Instrumentation Technology Foresight**	• Structure and streamline the workflow of field instrumentation data by deploying, maintaining and continuously improving the Multicomponent Inspector Kit (previously known as Complementary Access Kit), including IRIS software (Instruments Records Integration for Safeguards); • Finalize the development and authorize the next generation of Cerenkov Viewing Devices; • Evaluate the use of robotics to assist or automate tasks in the field.
SGTS-011 **Unattended Measurement Techniques**	• Complete Version 2 of the On-Line Enrichment Monitor (OLEM) software with documentation; • Complete Phase II of the Unattended Cylinder Verification System project; • Develop the next generation UMS Data Acquisition platform.
SGTS-014 **Remote Monitoring and Data Processing Systems**	• Continue joint all-in-one review program iRAP (Inspector Review and Analysis Platform) with EURATOM (the top priority for this project in the 2018-2019 biennium); • Install and test new NRT (near real time) components for upcoming large facilities in Ukraine; • Select and authorise new Virtual Private Network (VPN) hardware for the RDT network and, in addition, identify and/or develop an alternative VPN hardware/software with additional security capabilities.

Overview of Objectives, Expected Outcomes and Key Outputs

Project	Objective		
	Expected Outcomes	**Key Outputs**	**Expected completion date**
SGAS-001 Destructive Analysis of Nuclear Materials	**Enhance Nuclear Material Laboratory (NML) and On-Site Laboratory (OSL) effectiveness by continuing to explore and develop techniques and capabilities that meet the Department's current and projected analytical needs for the analysis of nuclear material samples.**		
	Expected outcome 1.) Improved analytical capabilities of the NWAL through development of new certified reference materials (CRMs), better preservation of existing stocks of CRMs, as well as enhanced use of working standards and new technologies for extending the shelf life of such working standards. (In support of T.2.R4 and T.2.R5)	• One to two laboratory-based workshops and/or training courses hosted in Seibersdorf in support of subject-specific topics identified by the IAEA in partnership with MSSPs and other safeguards laboratory stakeholders	December 2019
		• One or two laboratory-based trials to test the application of novel materials for shelf life extension of large-sized dried spikes	December 2019
		• Modernization of software for the NML controlled potential coulometry system, which is used for the validation of plutonium working standards	December 2019
	Expected outcome 2.) Developed and implemented techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples. (In support of T.2.R1)	• Support for the field implementation of the COMPUCEA method in UF_6 enrichment plants	December 2019
		• Results of facility-scale testing of the ABACC-Cristallini UF_6 sampling method, which will reduce sample size and circumvent potential future restrictions on air transports of traditional UF_6 samples	December 2019
		• Development of quality control samples for new analytical techniques, e.g., for the light impurity elements in uranium ore concentrate samples	December 2019
	Expected outcome 3.) Enhanced analytical capabilities of the On-Site Laboratory (OSL) in Japan through capacity building and improved methodologies and techniques. (In support of T.2.R3)	• Support for training and testing in destructive and non-destructive analytical systems as they apply to the OSL (including, but not limited to, approaches for the determination of Pu on undissolved particles, software development for improved evaluation of HKED results, and newcomer training in spent fuel reprocessing technologies)	December 2019

SGAS-002 Environmental Sample Analysis Techniques	**Enhance the Environmental Sample Laboratory (ESL)'s effectiveness by continuing to explore, develop, and implement advanced analytical capabilities in support of the Department's needs for the analysis of environmental samples.**		
	Expected outcome 1.) Provision of external quality control and reference materials, as well as technical expertise, through optimized utilization of the expanded NWAL. (In support of T.2.R2 and T.2.R4)	• Working group report on way forward for an optimized and prioritized provision of particle materials • Additional reference and quality control materials (about one per year) to carry out a sound external quality control programme administered through the NWAL	One per year December 2019
	Expected outcome 2.) Developed techniques, methods and equipment to detect signatures of nuclear activities in environmental samples. (In support of T.2.R2 and T.2.R6)	• Implementation of the laser ablation (LA) sampling technique in combination with inductively coupled plasma mass spectrometry (ICP-MS) to analyse plutonium and mixed uranium/plutonium particles complementing the existing capability of isotopic characterization of uranium containing particles using LG-SIMS • Implementation of the Fission Track particle identification method • Report on a feasibility study on isotopic characterization of plutonium containing particles using LG-SIMS	December 2019 December 2018 December 2019
	Expected outcome 3.) Established plan for equipment replacement, including resource mobilization strategy, to ensure the sustainability of the ESL's operations in terms of capabilities and capacities. (In support of T.4.R2)	• Equipment replacement plan and strategy for fund mobilization	December 2018

SGAS-003 Analysis Support and NWAL Coordination	**Enhance the effectiveness and efficiency of the NWAL's provision of analytical support to the IAEA's verification mission, in particular with respect to sample analysis capacity, quality, and timeliness and departmental needs.**		
	Expected outcome 1.) Expanded IAEA Network of Analytical Laboratories (NWAL) and quality controlled analytical services. (In support of T.2.R2, T.2.R3, and T.2.R4)	• Qualification of one additional NWAL member for the analysis of safeguards samples	December 2019
		• Qualification of one additional NWAL member for provision of reference materials	December 2019
		• Organisation of one to two inter-laboratory comparison exercises per year	December 2019
	Expected outcome 2.) Maintained and upgraded Safeguards Laboratory Analysis Information Management System (SALIMS). (In support of T.2 Enhance sensitivity, reliability and timeliness in sample analysis.)	• Release of upgraded SALIMS v1.1.	December 2019
SGCP-003 Safeguards Approaches	**Develop and implement innovative and effective concepts and approaches to continue to meet safeguards challenges.**		
	Expected outcome 1.) Improved ability to fully implement the State-level concept through the development of internal guidance documents and additional tools for the development of State-level safeguards approaches. (In support of V.2.R1)	• Methodology and guidance for assessing acquisition path steps, including a State's technical capability to hypothetically develop nuclear fuel cycle technologies and facilities as well as nuclear material diversion and facility misuse scenarios	December 2019
	Expected outcome 2.) Increased ability to detect undeclared nuclear material and activities through update and improvement of the 'Physical Model'. (In support of P.3.R1)	• Updated Physical Model (all volumes)	June 2019
	Expected outcome 3.) Enhanced ability to safeguard new types of facilities through development of safeguards concepts for pyro-processing plants and small modular and/or Gen IV reactors. (In support of P.5.R2)	• Safeguards Technical Report on safeguards concepts and supporting measures for a pyro-processing facility	December 2019
		• Safeguards concepts and supporting measures for a High Temperature Gas Cooled Reactor Pebble Modules (HTR-PM) plant	December 2019
	Expected outcome 4.) Enhanced ability to safeguard new types of facilities through development of safeguards by design guidance documents. (In support of S.3.R1)	• Three Safeguards by design (SBD) guidance documents on "International Safeguards in the Design of Facilities for Long Term Spent Fuel Management", "International Safeguards in the Design of Reprocessing Plants" and "International Safeguards in the Design of Enrichment Plants"	December 2018
		• Use of the industry standardized UF_6 cylinder identifier	December 2018

	Expected outcome 5.) Improved ability to verify facilities under the decommissioning phase through the development of Safeguards implementation guidelines and concepts. (In support of P.5.R1)	• Safeguards implementation guidelines for facilities under decommissioning • Specific safeguards concepts for post-accident facilities under decommissioning based on lessons learned from Fukushima Dai-ichi and Chernobyl	June 2019 December 2019
SGCP-004 Strategic Planning and Partnerships	**Assure appropriate management and implementation of departmental strategic planning processes, methodologies and tools. Develop new and enhance external partnerships to effectively address current and future challenges and opportunities relevant to safeguards implementation.**		
	Expected outcome 1.) Strengthened tools, methods and processes for executing the Department's strategic plan. (In support of C.2.R1)	• Development of processes and tools to support strategy implementation, monitoring and reporting (including the alignment of KPIs, in collaboration with SGCP-101) • Update of the Strategy portal to support implementation, monitoring and reporting (including the alignment of KPIs, in collaboration with SGCP-101)	July 2019 December 2019
	Expected outcome 2.) Improved organisational ability to identify and adjust to changes in the operating environment in a flexible and timely manner. (In support of P.3.R1)	• Organization of and report on the Emerging Technologies Workshop 2019 • Organization of a Scenario Development Workshop • Organization of and report on exchanges with foresight practitioners (in collaboration with SGTS-008) • Report on the review of the Operating Environment • Organization of an Annual Strategy Workshop considering plan implementation monitoring, updating scenarios, operating environment, adjusting strategic priorities	July 2019 July 2019 July 2019 July 2019 December 2019

	Expected outcome 3.) Enhanced stakeholder awareness and understanding of safeguards and nuclear verification. (In support of S.1 Communicate proactively and transparently and S.4 Leverage and establish partnerships)	• Organization of a Symposium on International Safeguards, "Building Future Safeguards Capabilities" • Report/proceedings of, and action plan resulting from the Symposium	November 2018 May 2019
	Expected outcome 4.) Optimized use of MSSP support through alignment of tasks with strategic objectives and close coordination with MSSPs. (In support of S.4 Leverage and establish partnerships and C.4 Secure and optimally manage financial resources)	• External release of updated R&D Plan • Upgraded SPRICS (in collaboration with SGIS-003) • Summary reports of annual or bi-annual bilateral meetings with MSSPs • List comparing needs from R&D Plan with actual current and planned partner activities (compiled with assistance from MSSPs and other partner organizations)	February 2018 December 2019 ongoing December 2018
SGCP-101 Quality Management	**Continue to mature a Department-wide quality management system and monitor, analyse, and report on its effectiveness.**		
	Expected outcome 1.) Enhanced integration of quality management principles into the implementation of safeguards. (In support of C.2 Strengthen management processes)	• Upgraded Document Manager application to provide an enhanced and more efficient process to create, review, publish and search for documents supporting the QMS	December 2019
	Expected outcome 2.) Developed, fully implemented and continually improved process-based approach within the management system. (In support of C.2.R1)	• Implementation of prioritized actions identified in the 2017 self-assessment on the maturity of the Department's Quality Management System • Support for the implementation of monitoring performance in the Department, based on the identified set of key performance indicators • Enhanced e-learning courses of Agency staff on QMS	December 2018 December 2018 December 2019
	Expected outcome 3.) Improved management of knowledge and knowledge retention. (In support of W.3 Treat knowledge as an organizational asset)	• List of strategic actions and activities to enhance methods for capturing and transferring knowledge within the Department	December 2018
	Expected outcome 4.) Enhanced financial transparency and accountability for safeguards implementation through the continued development and refinement of the cost calculation methodology. (In support of C.4 Secure and optimally manage financial resources)	• Procedures and practices for further utilizing the Department's cost calculation methodology to assess the impact of implementation of process changes	December 2019

SGCP-102 Training	**Establish competency profiles for current and future missions and challenges in the area of safeguards as identified by Departmental long-range strategic planning; transfer these competencies to safeguards staff and staff of State Systems of Accounting for and Control of Nuclear Material (SSACs) through courses built upon a systematic approach to training, emphasizing not only technical competencies but also behavioural competencies, and including an assessment mechanism.**		
	Expected outcome 1.) Enhanced ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards through the establishment of a training programme that meets the Department's needs. (In support of V.1.R2, V.2.R1, V.5.R3, and W.1.R1)	• Annual training programme validated for relevance and accuracy by an internal focus group meeting	November 2018 & 2019
	Expected outcome 2.) Enhanced ability to detect undeclared nuclear material and activities through development and delivery of relevant training. (In support of V.1.R2, V.2.R1, V.5.R3, P.5.R2, and W.1.R1)	• Results of an internal focus group meeting to verify the application and relevance of training on analytical techniques • Training courses on information collection and analysis developed and delivered in accordance with the Annual Departmental Training Programme	December 2019 December 2019
	Expected outcome 3.) Enhanced ability to safeguard new types of facilities through identification of training needs and training delivery to reflect the approaches and equipment for safeguarding these new facility types, including consultation with States developing such facilities. (In support of P.5.R1 and P.5.R2)	• Results of an internal focus group meeting to identify training needs related to safeguarding of pebble-bed reactors, small modular reactors and molten salt reactors • Training courses covering new types of facilities developed and delivered in accordance with the Annual Departmental Training Programme	December 2018 December 2019
	Expected outcome 4.) Maintained and enhanced ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s) through development and delivery of relevant training courses. (In support of T.1.R3, T.1.R4 and W.1.R1)	• Development of a Bulk Handling Facilities Training Course with at least two additional MSSPs • Training courses at locations offered by Member States Support Programmes covering the full set of technical and integrated content in the IAEA Training Programmes for 2018 and 2019 • Development and delivery of a course on writing skills for safeguards • Full management of the safeguards training programme through the Learning Management System (LMS) deployed within AIPS Plateau 3	December 2019 December 2019 June 2018 June 2018
	Expected outcome 5.) Developed training tools, using also advanced methods such as virtual reality, immersive learning systems and web-based training. (In support of T.5.R5)	• Results of an internal focus group meeting to evaluate needs for developing new tools supporting mission preparation and retention of critical knowledge • Computerized model of a bulk handling facility	December 2018 December 2018

		• Training manual on Spent Fuel and Waste Management	December 2018
	Expected outcome 6.) Effective and efficient support to SRA's training through training delivery and development of training material and remote delivery methods. (In support of T.3.R1 and S.2.R1)	• Training programme to support SSACs in developing their capabilities for collecting safeguards relevant information within the country and for conducting domestic inspections • Training courses for SRAs developed and delivered as requested	December 2018 December 2019
SGIM-002 Satellite Imagery Analysis	**Continuously improve the IAEA's ability to acquire, analyse, and exploit satellite imagery and geospatial information to support verification activities.**		
	Expected outcome 1.) Enhanced analytical process through evaluation and testing of new sensors, imaging capabilities, tools and techniques and provision of more and different information to the analysts. (In support of T.3.R3, V.1.R1, and V.4.R1)	• Advanced radar techniques incorporated into routine imagery analytical reporting • Commercial satellite imagery acquired from diverse sources to ensure the integrity and authenticity of satellite imagery as an open source of information	December 2019 ongoing
	Expected outcome 2.) Enhanced staff skills in processing and analysing satellite imagery to detect signatures of undeclared activity, improve analysis of nuclear fuel cycles, and better support the State evaluation process. (In support of W.1.R1)	• Training on Esri GIS Applications in support of GES enhancements • Attendance at geospatial international conferences (GEOINT, Esri) • On-site training in imagery observables of the nuclear fuel cycle	December 2019 ongoing December 2019
	Expected outcome 3.) Enhanced collaborative analysis through enabling the consumption of information from other relevant applications (e.g. APS and SGMD) and exposing geospatial information to other applications in ISE (e.g., State File, Collaborative Analysis Platform and Geospatial Data Integration) (In support of V.1.R3)	• Release of upgrades to the GES: an enterprise task management system, additional data management capabilities, and the capability to interact directly between expert applications (RemoteView/Esri ArcGIS)	December 2019

SGIM-003 Information Analysis	**Enhance the IAEA's ability to collect and analyse information in support of the IAEA's verification mission, in particular with respect to the State evaluation process and in support of in-field verification activities.**		
	Expected outcome 1.) Enhanced assessment of nuclear programmes and detection of inconsistencies in States' declarations through the development of optimized tools and methods for the collection, processing, and management of currently utilized Safeguards-relevant open source information. (In support of V.1.R1).	• Integration of the European Media Monitor (EMM) as a data source into the OSIS 2.0 system	July 2019
		• Results of testing of other tools, such as the OSINT suite and the Big Table, developed by the Joint Research Centre (JRC)	December 2019
		• Review and optimization of current open source information search and collection methodologies and techniques	July 2019
	Expected outcome 2.) Enhanced assessment of nuclear programmes and detection of inconsistencies in States' declarations through the development of optimized tools and processes to update and diversify the pool of safeguards-relevant open source information (in cooperation with SGIS-003). (In support of V.1.R2)	• Development and deployment of tools, methods, and procedures for the optimized use of multimedia information analysis under the SG-Multimedia Project	December 2019
		• Identification, collection, processing, and integration of information from new safeguards-relevant information sources	On-going
		• Development and deployment of new tools and methods to optimize the continuous monitoring of new sources of information	On-going
	Expected outcome 3.) Improved State evaluation process through continuously improved open source information analysis methods and computerized tools to aid the analysis of large amounts of structured, semi-structured, and unstructured data. (In support of V.5.R3)	• Identification and collection of requirements for a system to enhance the management and analysis of information related to international nuclear cooperation	December 2018
		• Identification and collection of requirements for tools to enhance the analysis of safeguards-relevant information on trade and industrial capabilities of States, including through the use of data visualization.	On-going
		• Establishment of a documented strategy for utilizing data visualization and network analysis on structured and semi-structured open source information (including trade data)	On-going
		• Development, deployment, and enhancement of tools, following above strategy	On-going
		• Member State peer reviews of tools and methods and reports, consultancies, employment of highly qualified staff, and training to continuously improve the open source analysis methodologies and procedures	On-going

		• Training for trade and technology analysis unit	On-going
	Expected outcome 4.) Improved integration of open source information in 'all source' information analysis, contributing towards collaborative analysis and in line with MOSAIC. (In support of V.1.R3)	• Integration of open source information collections with ISE State Files, Palantir, and other MOSAIC applications (in collaboration with SGIS-003)	July 2019
SGIM-007 Evaluation of Data from Environmental Sampling and Material Characterisation	**Enhance the IAEA's ability to structure, organise, evaluate, interpret and present data from environmental sampling and material characterisation in support of the IAEA's verification mission, in particular with respect to the IAEA's ability to detect undeclared nuclear material and activities.**		
	Expected outcome 1.) Developed elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and their application to the analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools. (In support of V.5.R2)	• Collection of uranium impurity data and fuel burnup inventories obtained from studies completed by Member States for integration into existing SGIM-IFC evaluation libraries	December 2018
		• Release of upgraded MSTAR'12 cascade modelling software to include side streams	December 2018
		• Development of beta software for alCHEMy, evaluation software for cross referencing isotopic and elemental data with nuclear fuel cycle (physical model) signatures	December 2019
	Expected outcome 2.) Developed statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results. (In support of V.5.R1)	• Deployment of the DAVE software for evaluation of trace element and isotopic signatures in uranium samples	June 2018
		• Deployment of the INDEPTH software for identifying fuel burnup, starting enrichments, and cool down times	June 2018
		• Release of customized Visual Sampling Plan software for providing detection/non-detection confidence levels	December 2018
	Expected outcome 3.) Maintained and upgraded ES Evaluation software tools and applications to meet future safeguards information technology requirements and ensure no loss of service. (In support of T.3.R4)	• Release of software upgrades related to the new information landscape and validation testing of all ES evaluation software, in preparation of the transition to 64-bit personal computers using Windows 10	June 2019

SGIM-008 Statistical Analysis	**Review, enhance and develop statistical verification and evaluation methodologies and tools to optimize verification implementation plans and information analysis.**		
	Expected outcome 1.) Reviewed, updated and consolidated algorithms for the determination of measurement error uncertainties from operator-inspector paired-data, 3-laboratory data, and calibration data. (In support of V.5.R3)	• STR on the uncertainty quantification (UQ) methodologies used as a basis for UQ methods applied to safeguards verification data	December 2018
	Expected outcome 2.) Reviewed, updated and consolidated methodologies applied to the evaluation of MUF, D, IMUF, and SRD in the context of material balance evaluation. (In support of T.3.R2)	• Technical document (most likely an STR) on the methodologies and implementation of the methodologies in relevant analytical software	December 2019
	Expected outcome 3.) Further developed sampling methodologies described in STR-381 and practical implementation procedures for these methodologies. (In support of V.5.R1).	• Practical implementation procedures for inclusion in the inspector's handbook and associated software requirements for implementing the sample size methodologies described in STR-381 (Statistical Methods for Verification Sampling Plans) for the purpose of verification activities	December 2018
	Expected outcome 4.) Improved and harmonized random inspection schemes (including short notice random inspections (SNRIs)) and methodologies developed to evaluate their effectiveness. (In support of V.5.R1 and V.5.R3)	• A set of standard random inspection schemes developed and documented, including standard evaluation methodologies as a basis for a more harmonized approach of implementing and evaluating such schemes in verification activities in continuation of a collaboration with SGCP (See also SGCP-003)	December 2019
	Expected outcome 5.) Standardized methodologies for calculating detection probabilities achieved through verification activities on facility and State levels with the aim of evaluating the effectiveness of quantitative verification activities specified in State-level approaches. (In support of V.5.R1)	• Developed and documented methodologies for determining detection probabilities achieved in the implementation of verification activities specified in State-level approaches	December 2019
	Expected outcome 6.) Methodologies reviewed, requirements documented and developed for a harmonized NRTA system for future implementation in, inter alia, the Rokkasho Reprocessing Plant (RRP) and J-MOX facilities. (In support of V.5.R3)	• Requirements document specifying the methodologies and data requirements for a harmonized NRTA system	December 2019

	Expected outcome 7.) Enhanced data visualization software for nuclear material flow analysis, and additional capabilities of the software to represent acquisition path analysis results, verification requirements and achieved verification results, using structured nuclear material accountancy and verification data (in collaboration with SGIS-003). (In support of V.4.R1)	• Data visualization software available for use by responsible operations divisions in ISE and addition of further enhancements	Ongoing
	Expected outcome 8.) Developed Bayesian approaches making use of historical verification data in the evaluation of safeguards information. (In support of V.5.R1)	• Technical guidance document, based on the continuation of the methodological work begun on Approximate Bayesian Computation for UQ	December 2019
	Expected outcome 9.) Investigated feasibility of intelligent systems for analysing non-quantitative data, eliciting analyst conclusions, and aggregating analyst conclusion across multiple disparate data sources in order to assist analysts in drawing broad State-level conclusions with a measured degree of confidence. (In support of T.5.R1)		Ongoing
	Expected outcome 10.) Investigated accountancy and measurement requirements and gathered experience with factors affecting material balance evaluation at pyro-processing facilities (see also SGCP-003). (In support of V.5.R3)	• Model material balance approach for a pyro-processing facility using results from the USA/ROK Joint Fuel Cycle Study	December 2019

SGIM-009 State Declared Information Management	**Enhance the IAEA's ability to collect, manage, analyse and utilize State declared information in support of the IAEA's verification mission, in particular with respect to the State evaluation process and support of in-field verification activities.**		
	Expected outcome 1.) Workflow implemented between exemptions and terminations of nuclear material with the nuclear material accounting database to allow automatic checking of State reporting. (In support of V.1.R1)	• Deployed quality control tool linking the decision-making process to the processing and evaluation of related inventory change reports	December 2019
	Expected outcome 2.) Developed and updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations with digital site maps attached, supporting the further integration of State declared information with other relevant information. (In support of T.3.R5)	• Developed software, "Reports Creation Tool" (RCT), for use by SRAs in creating and submitting accountancy reports • Updated software "Quality Control Verification Software" (QCVS) for nuclear material accountancy reports • "Protocol Reporter 3" (PR3), software to be widely deployed to States	December 2019 December 2019 December 2019
	Expected outcome 3.) State Declarations Portal largely deployed as a secure and authenticated communications between the IAEA and SRAs. (In support of T.3.R1)	• State Declaration Portal deployed to a maximum number of SRAs	December 2019
	Expected outcome 4.) Developed training material and remote delivery methods to support SRA training with reduced costs and increased accessibility (in collaboration with SGCP-102). (In support of S.2.R1 and T.5.R5)	• E-learning modules (maximum of 20 envisaged) for training SRAs on State declaration provision	December 2019
SGIS-002 Information Security and Infrastructure	**Make use of processes, people, technology, and tools to ensure the confidentiality, integrity, and availability of the information entrusted to the Department.**		
	Expected outcome 1.) Improved and automated detection of events, system anomalies, and activities in the Department's information systems – particularly in the case of the Integrated Safeguards Environment (ISE). (In support of P.1.R1)	• Additional automated platform alerting modules and correlation rules for the Department's Security Incident and Event Management Platform • Documented definition and implementation of security analytics	December 2019 December 2019
	Expected outcome 2.) Improved Department's security configurations and system designs through periodic independent assessments of specific solutions for risk and vulnerabilities and comprehensive or targeted penetration tests. (In support of P.1.R2)	• Reports on vulnerability assessments and penetration tests in order to identify potential issues with system configurations, to design solutions, and to verify security controls • Assessment report on the maturity level of the Secure Software Development Lifecycle in place within the Department • Improvement guide based on risk identified in the assessment report	Ongoing January 2019 January 2019

	Expected outcome 3.) Improved Departmental information security and IT security skills through targeted training on specific topics related to threat detection, incident response, secure software development, security designs, continuous monitoring, event management, digital forensics, and security architecture. (In support of W.1.R1)	• Training of Department staff in targeted IT security areas identified as critical needs, such as new technologies, security metrics, security incident response, digital forensics, specific security products, and secure software and systems development processes	2018-2019
	Expected outcome 4.) Enhanced endpoint and server security protection capabilities of the Department's IT infrastructure through the use of next generation techniques. (In support of P.1.R2)	• Implementation of a next generation endpoint security solution for the clients and servers in the general purpose computing network • Implemented solution to mitigate threats from the use of web browsing on the Department's computers through the use of non-persistent, virtualized computing resources and spread this capability to additional computing environments • Secured, thin-client access to the Department's networking resources based on virtualized desktop computing technology	May 2019 January 2019 May 2018
	Expected outcome 5.) Deployed secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices. (In support of P.1 Ensure information security)	• Implementation of a secure messaging solution for a mobile workforce that supports chat and voice communications and applies confidentiality protections to a level that meets the Department's assurance criteria • Pilot, design, and deployment of an end-to-end security and management solution which provides the controls and capabilities necessary to enable secure email on standard mobile devices such as iPhones. The solution will work with the Agency's Public Key Infrastructure and support hardware protection of private keys used for S/MIME secure email	May 2018 December 2018
	Expected outcome 6.) Enhanced ability of the Department to recover from an IT failure. (In support of P.2.R1)	• Fully implemented Phase I of SGIS Disaster Recovery Project, including plan to respond to a disaster scenario and upgraded IT infrastructure • Advanced Phase II of SGIS Disaster recovery Project, including plan to respond to an alternative disaster scenario, upgraded dual purpose IT infrastructure in Seibersdorf and procedure documentation	December 2019 December 2019
	Expected outcome 7.) Support to the Department's access, authorisation, and information classification initiatives in order to ensure information is available to those who need it while protecting the confidentiality and integrity of that data. (In support of P.1.R2)	• Expert reports on authorization management, information classification, and information access management areas, as required	December 2019

SGIS-003 Information Systems and System Usability	**Enhance the IAEA's ability to collect and analyse information in support of the IAEA's verification mission, in particular with respect to the State evaluation process and support of in-field verification activities.**		
	Expected outcome 1.) Enhanced integration of diverse 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 support of T.3.R2, T.3.R3 and V.1.R3)	• Additional legacy systems integrated for the statistical evaluation of State declared and verification data and the probabilistic calculations which inform verification approaches (e.g. sampling plans and random inspection schemes) (in cooperation with SGIM-008) • Enhanced geo-reference capabilities in Safeguards applications to improve the integration of geo-tagged information for analysis activities. (in cooperation with SGIM-002)	December 2019 December 2019
	Expected outcome 2.) Enhanced tools and systems for 'all source analysis', to support the detection of signatures of undeclared activity and improve the analysis of nuclear fuel cycles. (In support of V.1.R1 and V.4.R1)	• Expanded Department's capability to translate languages in Safeguards IT applications. (in cooperation with SGIM-003) • New IT capabilities identified for the integration and visualization of safeguards data in support of the Physical Model and the acquisition/diversion path analysis for the development of State-level Approaches. (in cooperation with SGIM-008)	December 2019 December 2019
	Expected outcome 3.) Enhanced capabilities to evaluate data analysis methods and computerized tools to aid the analysis of large amounts of all-source information in order to support the State evaluation process. (In support of V.1.R1, V.1.R3 and V5.R3)	• Developed functionality to view all State-relevant data in the State File, including integration of documents and information residing in other systems, the organization of non-structured data, and the process to analyse and evaluate information. (in cooperation with SGIM-003) • Continued development of the Natural Language Processing task, moving from the development stage to the deployment stage (in collaboration with SGVI-001 and SGIM-003)	December 2019 December 2019
	Expected outcome 4.) Enhanced 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. (In support of T3.R1 and T3.R5)	• Enhanced IT capabilities identified to securely exchange electronic data for the Department and Member States	December 2019

SGOA-002 Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX)	**Develop and implement an effective and efficient safeguards system for the Japan MOX fuel fabrication plant (J-MOX).**		
	Expected outcome 1.) Developed effective and efficient safeguards approach and procedures for J-MOX. (In support of V.5 Employ fit-for-purpose and state-of-the-art methodologies)	• Safeguards approach for J-MOX, based on the basic elements agreed with Japan • 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	2022 2021
	Expected outcome 2.) Developed, tested and deployed verification systems at facilities to meet safeguards requirements. (In support of T.1.R3, T.1.R5, T.5.R8, and V.5.R3)	• Designed, tested and installed safeguards equipment (NDA, C/S) that provide high quality, independent and reliable results • Designed, tested and implemented integrated data collection and evaluation software for J-MOX, using synergies with the RRP Information System	2022 2022
SGOA-003 Fukushima Dai-ichi Safeguards	**Maintain adequate safeguards for the inaccessible nuclear materials and facilities at the Fukushima Dai-ichi nuclear site.**		
	Expected outcome 1.) Specialized support and expertise on monitoring systems capable of providing credible assurance that nuclear material is not removed from the damaged facilities (in close collaboration with SGTS-001 and SGTS-002). (In support of P.4.R2)	• Design, development and deployment of reliable and effective monitoring systems using surveillance devices, radiation detectors or other methods	December 2018
	Expected outcome 2.) Specialized support and expertise on technical options for in-situ verification of currently inaccessible material (in close collaboration with SGTS-001). (In support of P.4.R2)	• Design and development of new verification techniques (i.e. non-destructive analysis based, optical devices, etc.) for in-situ verification of nuclear material (particularly spent fuel) at the damaged facilities	December 2019
	Expected outcome 3.) Enhanced knowledge about the status of the nuclear material in the damaged cores through an independent analysis of all available information to date. (In support of P.4.R2)	• A report, based on the compilation of all relevant information published after the accident and the analysis of this data, to assess the status and the approximate location of the nuclear material in the reactor buildings	December 2019

SGOC-001 Chernobyl	**Develop and implement effective and efficient safeguards systems at the Chernobyl site.**		
	Expected outcome 1.) Finalized procedures for safeguards application at facilities under this project. (In support of P.4.R2)	Finalized procedures covering: • SF transfer from the wet storage at ChNPP to the ISF-2 conditioning facility • Flow of nuclear material inside the conditioning facility • Transfer of spent fuel from the conditioning facility to the dry storage • The dry spent fuel storage • Activities at the NSC	 June2018 June 2018 June 2018 June 2018 July 2018
	Expected outcome 2.) Completed installation, adjustment and authorization of safeguards equipment for verification use (in close collaboration with SGTS-014). (In support of P.4.R2)	• Authorization of safeguards equipment for verification use at ISF-2 • Installation and authorization of safeguards equipment for verification use at NSC	June 2018 End 2018
SGVI-001 JCPOA Implementation	**Develop and implement effective and efficient verification and monitoring of Iran's nuclear-related commitments under the JCPOA.**		
	Expected outcome 1.) Maintain capabilities for the verification and monitoring of Iran's nuclear-related commitments under the JCPOA. (In support of V.1.R3 and W.1.R1)	• Contributions to the development of the Natural Language Processing task, advising on the move from the development stage to the deployment stage (in collaboration with SGIS-003) • Continued deployment of specific training for members of the Office of Verification in Iran (in collaboration with SGCP-102)	December 2019 December 2019

SGTS-001 NDA Techniques	**Develop and improve performance and detection capabilities of equipment/ methods to verify, detect, check and monitor nuclear material (including irradiated material) and nuclear activities.**		
	Expected outcome 1.) Developed instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations. (In support of T.5 Identify and exploit innovations)	• Results of assessment of capabilities of portable Laser induced breakdown spectrometer (LIBS) for impurity Content Determination in Uranium Bearing Material	December 2018
	Expected outcome 2.) Developed elemental and isotopic signatures of nuclear fuel cycle activities and processes for the calibration of instruments. (In support of V.5.R2)	• Repositories of basic nuclear fuel cycle indicator and signature materials, relevant infrastructure for carrying out experimental tests with such materials, and comprehensively-characterized collected materials	December 2018
	Expected outcome 3.) Developed improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition. (In support of T.1 Strengthen instrumentation capabilities for verification, and T.5 – Identify and exploit innovations)	• Results of performance evaluation of the Compact Gamma Tomography System (delivered to the IAEA in 2017), with the goal of authorizing the system for inspection use	December 2018
	Expected outcome 4.) Deployed 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. (In support of T.1 Strengthen instrumentation capabilities for verification, and T.5 Identify and exploit innovations)	• Deployment of a Passive Gamma Emission Tomography (PGET) for non-routine (EPGR) and routine (such as verification of dismountable spent nuclear fuel) activities that require verification with partial defect test	December 2019
	Expected outcome 5.) Deployed alternative NDA instruments (for instance, based on liquid scintillators) to improve performance in neutron coincidence counting techniques applied to various types of fissile material. (In support of T.5.R8)	• Results of test and deployment of the re-designed FNCL at fuel fabrication plants where the nuclear fuel containing burnable poison rods is manufactured	December 2018

	Expected outcome 6.) Re-designed, improved or upgraded safeguards equipment and systems, implementing an improved cost/benefit assessment methodology for the design and operation of safeguards equipment. (In support of T.1 Strengthen instrumentation capabilities for verification , T.5 – Identify and exploit innovations, and T.2.R1)	• Re-designed Cask Radiation Profiling System (CRPS) to replace phased-out components of the old CRPS	December 2018
		• COMPUCEA application extended towards UF_6 enrichment	December 2018
		• New fast neutron probe for performance of the zero-power reactor noise analysis for verification of research reactors and critical assemblies	December 2019
		• Re-designed ICVD to allow image recording and special processing to essentially enhance image quality (in cooperation with SGTS-008)	December 2019
		• Development of an Inspector-level integrated data acquisition and analysis software application	December 2019
SGTS-002 Improved Techniques and Instruments for Sealing and Containment Verification	**Develop and provide implementation support for sealing systems and containment verification instruments, identify areas where improved techniques and capabilities are required, systematically plan for the next generation of seals, and investigate the applicability of new and evolving technologies.**		
	Expected outcome 1.) Modernized and sustained sealing systems with increased tamper resistance are available for use in safeguards. (In support of T.5.R10 and T.1.R6)	• Results of field testing of the Active Optical Loop Seal (AOLS)	December 2018
		• Result of field testing of the glass seal (GLAS)	December 2018
		• Deployment of GLAS reader and integration of the GLAS reader into an All-in-One reader with the Cobra and AOLS, as these developments proceed	December 2018
		• Field testing of the unattended proximity seal for casks (UPSC)	December 2019
	Expected outcome 2.) Developed and maintained sealing systems for facility-specific applications. (In support of T.5.R10)	• Results of field testing of a Laser Curtain for Containment (LCCT)	June 2019
		• Laboratory and field testing of Universal UF_6 Reader (UF_6R)	December 2019
		• Release of new version of the Ultrasonic Optical Sealing Bolt (UOSB) and its reader for more effectively implementing joint-use arrangements	June 2018
	Expected outcome 3.) Improved and expanded techniques, tools and procedures for containment verification. (In support of T.5.R10)	• Report on the effectiveness of visual inspections of casks in cases where continuity of knowledge (CoK) is lost	On-hold, pending available resources

	Expected outcome 4.) Based on research and development results, implemented new and novel technologies that can be applied for secure sealing and containment verification systems. (In support of T.5.R10)	Solutions developed for: • Tampering Indicating Covers (TIC1) • Tampering Indications of Cables (TIC2) • Tamper Indication of Cabinets (TIC3)	 June 2018 June 2018 December 2018
	Expected outcome 5.) Expanded and improved capabilities to identify and mitigate the vulnerabilities of safeguards equipment and data derived from equipment. (In support of T.1.R9)	• Annual vulnerability assessment and review reports	December 2018
	Expected outcome 6.) Increased data security of safeguards equipment. (In support of T.1.R9)	• Establishment of an assessment centre for safeguards instruments and their use based on attacking and defending security teams	December 2018 and 2019
SGTS-003 Surveillance Techniques	**Provide advanced surveillance equipment and technologies to improve and optimize Departmental operations and capabilities to effectively carry out the IAEA's safeguards mission.**		
	Expected outcome 1.) Enhanced ability to deploy equipment at facilities to meet safeguards requirements through development of highly effective and cost efficient optical surveillance measures with improved security features. (In support of T.1.R2)	• Working prototype for benchmark testing developed in collaboration with Project SGTS-014, (Phase 1 development of new surveillance review software) • External battery power unit for extended XCAM operation in stand-alone, unpowered applications • Results of assessment of shape recognition module • Assessment results of the VideoZoom module • Integration and prototype testing of the surveillance review software tool	December 2019 January 2018 March 2019 March 2018 October 2019
	Expected outcome 2.) Improved tools and techniques developed to facilitate the detection of undeclared activities at nuclear facilities. (In support of T.1.R3)	• Results of evaluation through laboratory and field testing of the 3DLR laser scanner-based Design Information Verification (DIV) tool for routine containment verification tasks	December 2018
	Expected outcome 3.) Improved tools and techniques developed to enable real time monitoring and flow measurements of nuclear material (e.g., UF_6 cylinders, spent fuel casks) at nuclear facilities. (In support of T.1.R5)	• Results of assessment of the applicability of the L2IS Laser Item Identification System, in new enrichment plants and spent fuel storage facilities (In collaboration with project SGTS-002)	July 2018

	Expected outcome 4.) Improved response to new threats resulting from technology advancements through advanced intrusiveness and vulnerability analysis on current and future use of unattended systems. (In support of T.1.R9)	• Results of the evaluation and vulnerability assessment of the DCM-A1, next generation analogue camera recording module	June 2018
SGTS-008 Instrumentation Technology Foresight	**Identify, test, adapt and deploy emerging technical advances in other scientific fields and optimize them for use in safeguards.**		
	Expected outcome 1.) Developed and implemented technology foresight horizon scanning process for external, potentially-relevant research and development (R&D) fields. (In support of T.5 Identify and exploit innovations, and S.4 Leverage and establish partnerships)	• Partnerships with new external stakeholders (those not yet involved with safeguards) to identify and evaluate R&D activities and technologies in the domains of non-destructive assay, containment, surveillance, and destructive analysis. (In collaboration with SGCP-004) • Quarterly Technology Preliminary Evaluation Report	December 2019 Ongoing
	Expected outcome 2.) Technologies identified and solutions implemented for gaps identified in technologies currently in use for safeguards and laboratory activities. (In support of T.1 Strengthen instrumentation capabilities for verification, T.5 Identify and exploit innovations, T5.R1 and T5.R2)	• Evaluated, customized and authorized commercial in-situ analysis capabilities • Deployment, after authorization, of two gamma imaging systems: one portable system, one mobile system • Full replacement of the former Complementary Access Kits by the new Multicomponent Inspector Kit, including IRIS software (Instruments Records Integration for Safeguards) as a means of structuring and streamlining the use of field instrumentation data • Development and authorization of the next generation of Cerenkov Viewing Device (XCVD) • Winners of robotics challenge selected for further development	December 2018 December 2018 December 2019 December 2019 December 2018

SGTS-011 Unattended Measurement Techniques	**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.**		
	Expected outcome 1.) Developed tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities. (In support of T.1.R4)	• Results of monitoring the stability and accuracy of installed OLEM systems • Version 2 of the OLEM software • Report on assessment of OLEM's reliability and associated recommendations	June 2019 December 2019 December 2019
	Expected outcome 2.) Improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities. (In support of T.1.R5)	• Prototype of an Unattended Cylinder Verification System (UCVS) installed in a Gas Centrifuge Enrichment Plant (GCEP) (Phase II) • Report on the application and verification of joint-use data collected at enrichment plants	December 2019 December 2019
	Expected outcome 3.) Developed appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle. (In support of T.1.R6)	• Upgrade campaign of VIFM systems with new ADM2 (NGAM) data acquisition modules and updated power subsystems • Completed upgrade of all other UMS systems • Installed developed irradiated fuel counting system at a Pebble Bed reactor in China (depending on safeguards approach completion) • Installed new systems developed for safeguarding fuel at CANDU reactors (depending on safeguards approach completion)	December 2018 December 2019 December 2019 December 2019
	Expected outcome 4.) Increased proportion of deployed unattended systems that are sustainable, standardized, and modular, with increased use of Commercial-Off-The-Shelf (COTS) products. (In support of T.1 Strengthen instrumentation capabilities for verification, and T.4 Manage SG technology assets strategically)	• Evaluation, development, testing, and deployment of components and equipment that fulfil the requirements of being sustainable, standardized, and modular, with increased use of COTS products	ongoing

SGTS-014 Remote Monitoring and Data Processing Systems	**Develop, implement and maintain remote monitoring and data processing software and hardware infrastructure to expand the contribution of remote monitoring to the effectiveness and efficiency of IAEA safeguards.**		
	Expected outcome 1.) In collaboration with EURATOM, continued development of the iRAP review programme. (In support of T.1.R1)	• Deployment of a version of iRAP that includes complete surveillance and electronic seal review, using improved operator declaration integration	December 2019
	Expected outcome 2.) Installed and tested new NRT (near real time) components in large facilities. (In support of T.1.R5)	• New NRT (near real time) components installed and tested in Ukraine in following facilities: ISF-2 (2018) and CSFSF (2019)	December 2019
	Expected outcome 3.) Improved VPN hardware for the RDT network. (In support of T.1.R9)	• Selection and authorization of new VPN hardware for the RM network • Identification of an additional alternate VPN hardware (e.g. open source solutions) including development of security enhancements to the hardware/software with support for smart card cryptography tokens	Mid-2018 December 2019
	Expected outcome 4) Improved efficiency of equipment maintenance by introducing iOS-based apps, initially to monitor RDT system status. (In support of T.1 Strengthen instrumentation capabilities for verification)	• Release of ROOGLE 2	December 2018

SGAS-001

Destructive Analysis of Nuclear Materials

Project Manager: Steven Balsley

Division: SGAS

1. Overview

This document describes plans for developing and implementing new or strengthened processes supporting laboratory[1] practices related to destructive analysis of nuclear material samples for the period 2018-2019.

During the 2018-2019 biennium, Project SGAS-001 will pursue the following objective:

Enhance Nuclear Material Laboratory (NML) and On-Site Laboratory (OSL) effectiveness by continuing to explore and develop techniques and capabilities that meet the Department's current and projected analytical needs for the analysis of nuclear material samples.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.7.001 Analytical services and sample analysis*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objective		R&D Needs	
T.2	*Enhance sensitivity, reliability and timeliness in sample analysis*	T.2.R1	Improve analytical timeliness of dealing with special and high priority demands for analysis by means of the reduction of sample size, the application of in-situ analysis and by strengthening the response regime (e.g. COMPUCEA, Cristallini method).
		T.2.R3	Support the improvement of Member States' analytical quality for nuclear material accountancy (i.e. for better Operators' analytical systems).
		T.2.R4	Develop/expand a set of reference materials with NWAL assistance, and produce/distribute working reference materials to support Member States' analytical quality.
		T.2.R5	Continue to reduce and manage nuclear material holdings stored at the Nuclear Material Laboratory (NML) in line with safeguards needs, and identify long-term sustainable solutions for disposal of nuclear materials, particularly plutonium and highly-enriched uranium.

SGAS-001 addresses the development of analytical capabilities in the area of nuclear material analysis. Technologies that improve analytical precision, decrease sample size (and therefore waste), shorten processing times, offer new modes of sample treatment, and/or improve the stability of working standards are within the scope of the project.

For the 2018-2019 biennium, the project's top priorities are to:

- Complete facility-scale testing of the Cristallini UF_6 sampling technique, which would mitigate the impact of potential restrictions on air transport of UF_6 samples;

[1] Nuclear Material Laboratory (NML), including the On-Site Laboratory Team (OSL Team) in Japan.

- Implement a new hot-cell scrubber system at the OSL in Japan for trapping gaseous ruthenium during dissolution of high-activity liquid waste samples;
- Test new foam-based additives to facilitate longer storage times for Pu and mixed U-Pu working standards produced in-house, which will reduce labour and decrease the volume of expensive radioactive waste.

SGAS-001 is coordinated with projects *SGAS-003 Analysis Support and NWAL Coordination* and *SGIM-007 Evaluation of Data from Environmental Sampling and Material Characterisation*.

2. Background

Destructive analysis (DA) of nuclear material samples in a dedicated laboratory, with fit-for-purpose instrumentation and quality-controlled methods, produces the most precise and accurate results for safeguards evaluators and inspectors. However, transporting nuclear material samples from the field to the lab takes time and operating a radiological laboratory is costly. This project addresses these issues by examining new technologies and methods that, among other things, could enhance timeliness and reduce radiological waste. For example, collecting very small UF_6 samples on alumina pellets may both reduce shipping times and cut down on expensive-to-dispose laboratory waste. Similarly, the miniaturization of instrumentation and the improvement of detector design may provide an on-site DA capability for a variety of different uranium materials. On-site DA technologies offer much improved timeliness of analysis results with near-DA quality, but come at the cost of greater reliance on the facility operator for laboratory infrastructure and safety, the need for subject-matter experts (analysts) to accompany inspectors to facilities and perform specific chemical steps in the field (e.g., preparation and dissolution of samples), and the need for a higher level of containment and surveillance.

Safeguarding the Rokkasho Reprocessing Plant (RRP) in Japan represents a significant challenge for the IAEA. The OSL at Rokkasho facilitates the fast treatment and direct reporting of sample analyses from the plant. New technologies and methodologies specific to the OSL are an important emphasis of the project. For example, the emission of radioactive gases during dissolution of hard-to-dissolve samples may trigger alarms in the exhaust stack of the OSL. Novel technologies are sought to enable either the capture of these gases before exhaust, or the measurement of plutonium in the particulate fraction without the need for dissolution.

Nuclear certified reference materials (CRMs) are a precious commodity, and the supply of key CRMs is difficult to sustain for reference material producers because of tighter national and international safety regimes, higher production costs, and the shrinking availability of suitable source material. The shelf life of plutonium working standards for concentration determination is hampered by the mechanical instability of the material, due to radiolysis. The project therefore addresses novel technologies for the stabilization of working standards, which would greatly increase shelf life and reduce production effort and waste.

3. Expected Outcomes and Key Outputs

In order to reach Project SGAS-001's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/ or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Improved analytical capabilities of the NWAL through development of new certified reference materials (CRMs), better preservation of existing stocks of CRMs, as well as enhanced use of working standards and new technologies for extending the shelf life of such working standards. **(In support of T.2.R4 and T.2.R.5)**	

Expected Outcomes and Key Outputs	Expected Completion Date
One to two laboratory-based workshops and/or training courses hosted in Seibersdorf in support of subject-specific topics identified by the IAEA in partnership with MSSPs and other safeguards laboratory stakeholders	December 2019
One or two laboratory-based trials to test the application of novel materials for shelf life extension of large-sized dried spikes	December 2019
Modernization of software for the NML controlled potential coulometry system, which is used for the validation of plutonium working standards	December 2019
Expected outcome 2.) Developed and implemented techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples. **(In support of T.2.R1)**	
Support for the field implementation of the COMPUCEA method in UF_6 enrichment plants	December 2019
Results of facility-scale testing of the ABACC-Cristallini UF_6 sampling method, which will reduce sample size and circumvent potential future restrictions on air transports of traditional UF_6 samples	December 2019
Development of quality control samples for new analytical techniques, e.g., for the light impurity elements in uranium ore concentrate samples	December 2019
Expected outcome 3.) Enhanced analytical capabilities of the On-Site Laboratory (OSL) in Japan through capacity building and improved methodologies and techniques. **(In support of T.2.R3)**	
Support for training and testing in destructive and non-destructive analytical systems as they apply to the OSL (including, but not limited to, approaches for the determination of Pu on undissolved particles, software development for improved evaluation of HKED results, and newcomer training in spent fuel reprocessing technologies)	December 2019

4. Tasks

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 objectives. Some activities are supplemented by regular budget sources.

Expected outcome 1.) ***Improved analytical capabilities of the NWAL through development of new certified reference materials (CRMs), better preservation of existing stocks of CRMs, as well as enhanced use of working standards and new approaches for extending the shelf life of such working standards.*** **(In support of T.2.R4)**

The NML utilizes nuclear certified reference materials (CRMs) for instrument calibration and quality control of measurements. Many commercial laboratories associated with bulk nuclear material handling facilities do the same. The reliable availability of particular CRMs is essential to the operation of the NML. As such, the importance of stakeholder efforts to ensure the continuing supply is difficult to overstate. (See Project SGAS-003 for additional details.). Unfortunately, the production and distribution of nuclear CRMs is becoming increasingly difficult and expensive. One means of reducing the consumption of nuclear CRMs is to develop working standards, which may be produced from legacy material a laboratory has in stock. One example of this is the supply of fully-characterized commercial uranium fuel pellets (JNT 01877 BRZ), which are used for instrument calibration and quality control (e.g., for COMPUCEA).

The extension of shelf life for plutonium-bearing reference materials is also of great interest. Longer shelf lives translate to less need for wasting unusable units, and more effective use of precious CRMs. EC A 1606 is investigating the use of new cellulose nitrate foams for mixing with U-Pu nitrate working standards. The

solidified foam mixture mitigates the flaking of mixture and longer mechanical stability in the vial. JPN A 1795 supports the production of reference material plutonium from in-house stock material, thus placing less emphasis on the use of CRM plutonium. External verification of reference materials made in the NML is an important part of assuring the quality of in-house standards. This work is facilitated by EC A 1806, and SGAS-001 is looking to expand the number of laboratories that can support this important work. An independent measurement technique for the validation of in-house plutonium standards is vital to the NML's internal quality control system. Controlled potential coulometry (CPC) is used in the NML to independently verify plutonium amount contents of in-house standards. Other laboratories involved in plutonium processing and/or measurement have expressed strong interest in acquiring CPC or further developing existing capabilities. A new joint task will be created that brings together the main stakeholders in order to capitalize on existing knowledge and develop new methodologies in the area of CPC. The NML expects to modernize the CPC software in the coming biennium (USA A 1049).

Implementation of the external quality control of NWAL laboratories contributing to the destructive analysis of nuclear materials is described in the SGAS-003 project plan.

Expected outcome 2.) ***Developed and implemented techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples.*** **(In support of T.2.R1)**

Uranium hexafluoride samples are regularly collected from enrichment facilities and shipped to the NML for isotopic composition determination by destructive analysis. These samples are shipped in specialized containers containing several grams of UF_6 in solid form. Although the air transport of gram-sized UF_6 is approved by the International Air Transport Association (IATA), a full ban on Type A transports of UF_6 is under discussion in various national regulatory air transport venues. The Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) "Cristallini" method was recently the subject of an intercomparison exercise, which showed that the new method is robust and fit for purpose (ARG A1769 and BRZ A 1764). Work is underway to publish the new technique as an American Standard for Testing and Materials (ASTM) standard and to initiate testing in commercial enrichment facilities. MSSP support for the facility-scale testing is being sought.

The adaptation of the chemical preparation steps for COMPUCEA determination of UF_6 enrichment was validated in 2017 with the support of the European Commission (EC A 2003). Successful implementation of this new preparation method holds promise for rapid turnaround results with laboratory-like DA uncertainties in the field. (See Project SGTS-001 for additional details.)

Three new light element (C, H, N, O, S, Cl, F) DA techniques were developed by NML in the last biennium in support of the need to define the starting point of safeguards for uranium ore concentrate samples. The quantitative determination of these elements is also requested on more pure uranium product samples for characterization purposes. A new task request will be developed in the 2018-2019 biennium to define new analytical methods, exchange calibration and quality control schemes, and develop quality control samples for external verification. In addition, SGAS-001 may also explore an expanded capability to sample and identify volatile organic compounds (VOC). Detailed information on VOC in uranium ore concentrate samples may aid in the verification of declared material sources and the understanding of processes in place at domestic uranium ore mills.

Expert assistance in the areas of mass spectrometry and radiochemistry facilitates the testing of new analytical approaches and the improvement of existing methods (JPN A 1963).

Finally, development of DA techniques for samples taken from pyroprocessing facilities will become increasingly important for the NML within the biennium, and specific related development activities will be identified in accord with SGCP-003.

Expected outcome 3.) ***Enhanced capabilities of the On-Site Laboratory (OSL) in Japan through capacity building and improved methodologies and techniques.*** **(In support of T.2.R3)**

The OSL directly supports the DA requirements for safeguarding the Rokkasho Reprocessing Plant (RRP). Training and method improvement at the OSL are important factors for maintaining the staff in full

readiness for a fully operational reprocessing facility and MOX fuel fabrication facility (JPN A 1345). The OSL utilizes two full-time hybrid k-edge densitometry (HKED) systems as the main "workhorse" measurement instruments. New calibration approaches, improved analysis algorithms, and extended measurement applications for the HKED will assure that the systems not only continue to underpin the analytical basis of the OSL, but will broaden the scope of analytical uses of the instrument beyond their current extent (USA A 2091, EC A 1391).

The OSL also has the particular challenge of processing high-activity liquid waste with measureable quantities of plutonium residing in the undissolved fines fraction. Dissolution tests in the OSL have shown that volatile fission products are released as a result of the more aggressive treatment. Specifically, ^{106}Ru tetraoxide is the main volatile component. Since the OSL does not have scrubbers for trapping volatile fission products, radiation monitors in the exhaust stack are triggered. The easiest and most robust solution for precluding radiation alarms is to trap the volatile fission products before the exhaust monitors are triggered. Development of a customized scrubber system (USA A 2158) for fitting into the OSL hot cell has resulted in a working prototype that is close to complete, and a novel approach to measuring Pu using the X-ray component of the HKED system together with a special stirrer system (JNT A 1946 EC and FRA) is in the hot test phase.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.7.001 Analytical services and sample analysis* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
2	1	UF_6 COMPUCEA (2018.01)	UF_6 enrichment by COMPUCEA	June 2018

4.3 Attachments

Figure 1: Prototype of the ruthenium scrubber for On-Site Laboratory (OSL) (Ruthenium Absorber Scrubber Project: RASP)

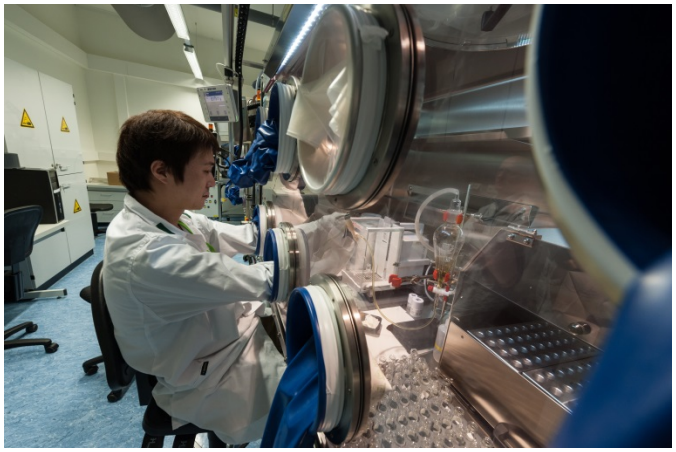


Figure 2: A chemist aliquots a small weighed quantity of mixed uranium – plutonium solution into a penicillin vial under glove box conditions. Each vial is an in-house reference material, and will be used later by the IAEA for verification of spent fuel samples

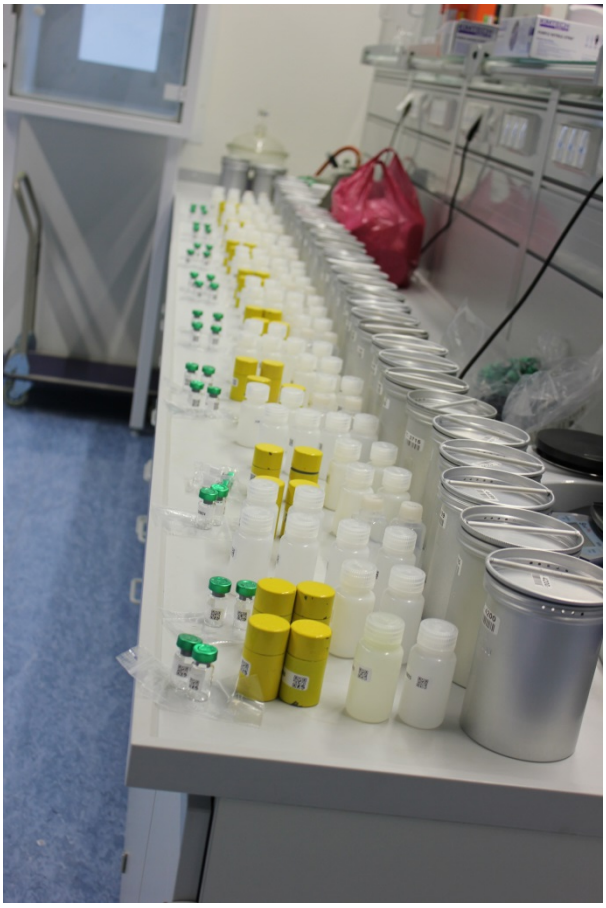


Figure 3: Made-in-Nuclear Material Laboratory (NML) uranium reference materials ready to be packaged and shipped to a facility for spiking inspection samples

SGAS-002

Environmental Sample Analysis Techniques

Project Manager: Stephan Vogt

Division: SGAS

1. Overview

This document describes plans for developing and implementing advanced analytical methods and quality control materials for the analysis of environmental samples within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGAS-002 will pursue the following objective:

Enhance the Environmental Sample Laboratory (ESL)'s effectiveness by continuing to explore, develop, and implement advanced analytical capabilities in support of the Department's needs for the analysis of environmental samples.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.7.001 Analytical services and sample analysis*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.2	*Enhance sensitivity, reliability and timeliness in sample analysis*	T.2.R2	Further improve the quality assurance and control (QA/QC) for the Agency's NWAL for safeguards, including SAL, in the area of particle analysis in particular.
		T.2.R4	Develop/expand a set of reference materials with NWAL assistance, and produce/distribute working reference materials to support Member States' analytical quality.
		T.2.R6	Develop and implement methods 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 • Isotopic characterization of Pu containing particles using FT-LAICPMS and LG-SIMS
T.4	*Manage SG technology assets strategically*	T.4.R2	Develop and execute a long-term replacement plan for analytical equipment at SG Analytical Laboratories, with appropriate mix of regular and extra-budgetary funds.

SGAS-002 aims at enhancing the IAEA's ability to timely detect undeclared use of nuclear material and/or technology by strengthening the IAEA's analytical capabilities at the Office of Safeguards Analytical Services (SGAS). 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 Material Characterisation*.

For the 2018-2019 biennium, the project's top priorities are to:

- Develop, implement and improve methods for identifying and isolating nuclear material-containing particles from environmental swipe samples;
- Develop new methodologies for using the Scanning Electron Microscope (SEM/FIB-ToF) to characterize individual micrometer-sized particles collected on environmental swipe samples;
- Develop and implement the Laser Ablation ICP-MS technique, and develop capabilities to use a large-geometry secondary ion mass spectrometer (LG-SIMS) for accurate and precise measurement of the isotopic composition of uranium/plutonium containing micrometer-sized particles.

2. Background

The main objective of the ESL is to provide information to the Department for drawing conclusions about the absence of undeclared nuclear material and activities. This requires continuous development of new and existing analytical methods and techniques for the analysis of environmental samples. Detection of uranium or plutonium, either in the whole sample ("bulk analysis"), or in the form of micrometer-sized particles, supports the early detection of undeclared nuclear activities. Superior identification methods for location of particles of interest and lower detection limits for elements of interest (such as uranium (U), plutonium (Pu) or fission and activation products) will allow for earlier and more reliable detection of undeclared nuclear material and activities, including possible sources and sample histories.

Challenges to be addressed include: finding and measuring, more reliably, U or Pu particles in the presence of an excess of background material by scanning electron microscopy (SEM) or secondary ion mass spectrometry (SIMS); lowering detection limits for bulk analysis of Pu in swipe samples to below femtogram; improving 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 developing and producing quality control materials to assess the performance of analytical laboratories that measure environmental samples, thus improving the reliability of their data to support the drawing of safeguards conclusions. In parallel, new analytical techniques are being developed continually and the IAEA 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 U or Pu-containing particles identified by other methods such as the Fission Track (FT) technique, Electron Microscopy, passive track detection, and LG-SIMS.

3. Expected Outcomes and Key Outputs

In order to reach Project SGAS-002's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and / or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Provision of external quality control and reference materials, as well as technical expertise, through optimized utilization of the expanded NWAL. **(In support of T.2.R2 and T.2.R4)** The IAEA will continue to make use of the competences and resources of the NWAL and associated laboratories to develop new reference material (RM) and quality control (QC) materials for safeguards particle analytical investigations, and certified reference materials (CRM) for instrumental calibrations and method validations.	
Working group report on way forward for an optimized and prioritized provision of particle materials	One per year
Additional reference and quality control materials (about one per year) to carry out a sound external quality control programme administered through the NWAL	December 2019

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 2.) Developed techniques, methods and equipment to detect signatures of nuclear activities in environmental samples. **(In support of T.2.R2 and T.2.R6)**	
Implementation of the laser ablation (LA) sampling technique in combination with inductively coupled plasma mass spectrometry (ICP-MS) to analyse plutonium and mixed uranium/plutonium particles complementing the existing capability of isotopic characterization of uranium containing particles using LG-SIMS	December 2019
Implementation of the Fission Track particle identification method	December 2018
Report on a feasibility study on isotopic characterization of plutonium containing particles using LG-SIMS	December 2019
Expected outcome 3.) Established plan for equipment replacement, including resource mobilization strategy, to ensure the sustainability of the ESL's operations in terms of capabilities and capacities. **(In support of T.4.R2)**	
Equipment replacement plan and strategy for fund mobilization	December 2018

4. Tasks

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 objectives. Some tasks, such as maintaining analysis capabilities at the state-of-the-art, are supplemented by the regular budget within project *4.1.7.001 Analytical services and sample analysis*.

This project focuses on the 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 aim of development efforts in this area is 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.

Expected outcome 1.) ***Provision of external quality control and reference material, as well as technical expertise, through an optimized utilization of the expanded NWAL.*** **(In support of T.2.R2 and T.2.R4)**

SGAS-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 (see SGAS-003). The IAEA will continue to specify such materials as the need arises and collaborate with Member State laboratories in their production.

Contacts have been established with partner laboratories in Member States with a view to provide additional particle QC materials using various production techniques. The feasibility of the application of these techniques to safeguards needs is under review. The IAEA intends to issue task proposals to support the sustainable production and characterization of diversified particle QC materials in Member States.

Task GER A 1961 "Production of Particle Reference Materials (C.45)" involves the production of mono-disperse particles using a Vibrating Orifice Aerosol Generator. The recent technical achievements reported by Forschungszentrum Juelich (FZJ) in Germany on the production of mono-disperse uranium particles are extremely promising and the suitability of produced particles for use in quality assurance purposes has been demonstrated. The mono-disperse particles will be used mainly for instrument calibration and method validation, but also for QC material production. First production batches (IRMM-183, IRMM-021, IRMM-023 and others) of micrometer-sized uranium particles have been received and are being characterized.

Additional work is needed to find alternative methods for collecting high-yield, manipulable, mono-dispersed QC particles.

Task EC A 1966 "Production of Particle Reference Materials" supports preparation of feed solutions from bulk certified reference materials (CRMs) for particle production at the FZ-Juelich (GER A 1961), and characterization and certification of select U, Pu, and U/Pu particles as reference materials by the JRC in Geel, Belgium. Feed solutions from additional CRMs and new CRM mixes are in preparation.

A working group on particle QC production convened for the first time in spring 2016 and will meet again immediately following the Technical Meeting on ES Particle Analysis in October 2017. The group of international subject matter experts reviews requirements, identifies specifications, sets priorities, and advices on appropriate solutions to produce the needed particle QC materials. While the IAEA leads the overall preparation of QC samples for ES particle analysis for provision to the NWAL, using as input particle materials produced by outside laboratories, the need to ensure sustainability and to identify and secure appropriate resources for the production of particle QC materials and QC samples calls for extended cooperation with the MSSPs in this area.

In 2016, the IAEA successfully completed the in-house production and characterization of a set of environmental QC swipes achieving mixing of particle QC materials and their deposition onto blank swipes, and using temporary laboratory space. These samples were used in the 2017 ES particle proficiency test. Efforts are ongoing to secure permanent laboratory space dedicated to the sustainable production of QC swipes, and supported by MSSP contributions (see SGAS-003).

Expected outcome 2.) ***Developed techniques, methods and equipment to detect signatures of nuclear activities in environmental samples.*** **(In support of T.2.R1)**

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

The ESL continues to implement new, highly-sophisticated methods for the analysis of environmental samples. A new state-of-the-art TESCAN Lyra 3 scanning electron microscope (SEM) with secondary electron (SE) and backscattered electron (BSE), energy-dispersive X-ray (EDX), Focused Ion Beam (FIB) column and a low-resolution Time of Flight-Secondary Ion Mass Spectrometer (ToF-SIMS) was installed and is being put into operation for automated searching and detection of particles containing U and/or Pu, and other safeguards relevant artifacts identified on swipe samples. Other NWALs have commissioned (or will soon commission) similarly sophisticated SEM instrumentation for the investigation of swipe samples. A focused approach to develop procedures for these state-of-the-art instruments has been discussed and n SP-1 task is under consideration.

The large-geometry secondary ion mass spectrometer (LG-SIMS) has been in continuous operation for the detection and isotopic analysis of U-containing particles from environmental samples. The instrument has been analyzing about 20% of the total sample volume for U-particle analysis, or about 100 samples per annum. New types of analytical requests required development of new, ad-hoc measurement protocols to analyse for safeguards relevant nuclides such as ^{233}U, ^{232}Th, and Li isotopic abundance of Particles of Interest (POI). A request for a Cost-Free-Expert is underway to support the LG-SIMS team's efforts to further develop and implement analytical advances and data evaluation strategies. Feasibility of location and characterization of Pu particles by LG-SIMS has been demonstrated in MS laboratories. However, the availability of resources (specifically, a dedicated radiological work space) needs to be studied. This activity includes identifying and preparing appropriate particle standards for instrument calibration; use of alpha track detection to verify the location of Pu particles on planchets over time; establishing the methodology for routine search of for Pu particles with widely varying U to Pu ratios; and, with varying Pu isotopic characteristics, demonstrating the advantages for routine safeguards implementation of an expanded multi-detector system for the U/Pu system.

Sensitive methods of radiometric screening of samples using gamma and X-ray fluorescence spectrometry have been implemented, thus providing rapid and sensitive information in a non-destructive way before samples are submitted for detailed analysis at SAL or the NWAL. The key objective of this project is to improve on all the above methods in order to reduce the detection limits for Pu by bulk analysis to the

sub-femtogram range per sample, to improve the sensitivity and accuracy of particle analysis data provided by SEM/FIB-ToF-SIMS, and LG-SIMS, to develop age-dating methods for Pu and U particles and to improve the sensitivity and timeliness of screening methods.

Ongoing activities under task EC B 1752, "Training on Mass Spectrometry and Other Analytical Techniques" will continue for the foreseeable future in collaboration with the JRC in Geel, Belgium, which has expertise in highly accurate and precise thermal ionization mass spectrometry (TIMS) and the Institute for Transuranium Elements (ITU) in Karlsruhe, Germany, which has expertise in TIMS, ICP-MS and SIMS, including LG-SIMS.

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

Task JPN A 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.

ESL staff are actively involved in developing and implementing techniques and methods to identify U- and Pu-containing particles, or so-called Particles of Interest (POI), in a matrix of non-nuclear material. The major POI targets are HEU, Pu and ^{233}U. To differentiate POIs from the non-nuclear matrix, methods such as position sensitive detectors and fission tracks will be used. The latter method requires that particles are spread over a plastic track etch film and fixed in their position in a layer of collodion, for example. Track etching of the film after either passive exposure to particles comprising Pu (alpha-tracks) or after active irradiation with thermal neutrons to induce fission of ^{235}U (fission tracks) will reveal Pu and U containing particles. These can then be selectively removed by cutting the area of interest around the particle using the LMD system and transferred for instrumental analysis using mass spectrometry. Tests will also be pursued to measure particles still embedded in the collodion or other adequate compound, not interfering with the direct instrumental measurement. Using a position sensitive detector will potentially allow for the immediate identification of POIs on the swipe matrix or the sample substrate used for instrumental measurement, such as SEM or LG-SIMS. The new SEM will also be employed for screening and POI identification from swipe samples followed by characterization using the SE, BSE, EDX and ToF-SIMS techniques built into the instrument.

Tasks FRA A 2002 and CZ A 2007 "Fission Track Technique for Spatially-Resolved Analysis of U and Pu Particles in Swipe Samples" will support the further development of the fission track technique to identify POIs. Task CZ A 2007 will develop conditions for optimum irradiation of the samples, while task FRA A 2002 will develop methods of identifying and manipulating POIs prior to instrumental measurement.

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 but it is challenging to apply such methods to individual particles (i.e., picogram to nanogram amounts). The age-dating of Pu particles using ^{241}Am in-growth has been demonstrated but the age-dating of U-particles using ^{230}Th or ^{231}Pa in-growth requires extreme sensitivity and is not yet possible. Current activities are focused on improvement of the accuracy and precision of Pu age dating and viable schemes for U particle measurements.

The second key objective of the activities under this outcome is to develop laboratory tools in support of environmental sampling implementation and enhancement of the ESL's capabilities.

The analysis of bulk samples at the sub-femtogram level will be facilitated by the recently validated 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. Testing of bulk analytical methods over the past biennium indicate that detection limits in the sub-femtogram level are achievable. A second MC-ICP-MS instrument has been installed and validation in the low-level wing of the new Nuclear Material Laboratory (NML) is about to be completed. This instrument will be used for intermediate level samples, i.e. those too "hot" for the ESL and too low in concentration of actinides for handling in the NML. Laser ablation ICP-MS was

tested in the low-level wing of the new NML for its sensitivity and ability to provide information about particles in a sample including both nuclear (U, Pu) and non-nuclear particles. Improved screening of environmental samples will be accomplished with a re-designed X-ray fluorescence instrument. The existing "TRIPOD" system was successfully upgraded (stronger excitation source and new generation of SDD detectors) and the new "PI" system is anticipated to be commissioned by the end of 2017.

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 UK LG-SIMS facility and UK SIMS experts will continue aiming at improvement of 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" are equivalent to 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 SIMS experts.

The femtosecond Laser Ablation (LA) system for the analysis of individual particles using the MC-ICP-MS instrument has been relocated to the Low-Level Wing in the NML and will be used in combination with ICP-MS instrumentation for the rapid analysis of nuclear and non-nuclear particles. This technique will complement the isotopic characterization of uranium containing particles using the LG-SIMS instrument. Cooperation with Member States laboratories in that field would be welcome.

Expected outcome 3.) ***Established plan for equipment replacement, including resource mobilization strategy, to ensure the sustainability of the ESL's operations in terms of capabilities and capacities.*** **(In support of T.4.R2)**

The sustainability of ESL operations in terms of capabilities and capacities has been and will continue to be discussed within the Department of Safeguards and together with external stakeholders. Several highly-sophisticated mass spectrometric instruments introduced as part of the ECAS project will require a timely replacement to prevent the Agency from losing the capability to analyse samples internally. Most prominently, the LG-SIMS instrument, with a replacement value of approximately 5 million euros and the Thermal Ionization (TIMS) and Inductively-Coupled-Plasma Mass Spectrometers (ICP-MS), at replacement costs of between 0.7 and 1.5 million euros respectively, need to be considered.

SGAS has drafted a strategy paper on the Agency's long-term LG-SIMS capability and engaged in discussions with Member States. A meeting with Member State representatives and technical experts from Canada, the European Commission, Germany, UK, US and Japan on long-term sustainability was held on 16 October 2017 in Seibersdorf.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.7.001 Analytical services and sample analysis* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
1	1	Production of QC materials (2018.02)	Produce new QC swipes for particle and bulk analytical techniques	Ongoing (Target 1 new set per annum)
2	2	Improve particle micro-manipulation techniques (2018.02)	Provide feedback to particle producers on the characteristics of their particles relevant to manipulation for use in making QC swipes	December 2019
	3	Improve sample preparation methods for bulk analysis (2018.02)	Implement sample decomposition methods using microwave assisted digestion and fusion for special sample types	December 2018
	4	LA-ICP-MS for particle analysis (2018.02)	Develop LA-MC-ICP-MS for particle analysis	December 2019
	5	Fission track (2018.02)	Implement identification of uranium and/or plutonium particles by fission track	December 2019
	6	MC-ICP-MS analysis of single particles (2018.02)	Develop method for analyzing pre-selected particles containing plutonium and mixed uranium/plutonium particles by MC-ICP-MS after dissolution at ultra-low concentration levels	December 2018
	7	The feasibility study on isotopic characterization of plutonium containing particles using LG-SIMS (2018.02)	Study the methodology to be applied for routine search of Pu particles with widely varying U to Pu ratios, and with varying Pu isotopic characteristics. Demonstrate the advantages for routine safeguards implementation of an expanded multi-detector system for the U/Pu system	December 2019

4.3 Attachments

Figure 1: Femtosecond Laser Ablation System coupled to MC-ICP-MS for the analysis of particles and other solid matrices

SGAS-003

Analysis Support and NWAL Coordination

Project Manager: Paul Martin

Division: SGAS

1. Overview

This document describes the plans for developing and implementing analysis support and coordination of the IAEA Network of Analytical Laboratories (NWAL) for the period 2018–2019.

During the 2018-2019 biennium, Project SGAS-003 will pursue the following objective:

Enhance the effectiveness and efficiency of the NWAL's provision of analytical support to the IAEA's verification mission, in particular with respect to sample analysis capacity, quality, and timeliness and departmental needs.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.7.001 Analytical services and sample analysis*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objective		R&D Needs	
T.2	*Enhance sensitivity, reliability and timeliness in sample analysis*	T.2.R2	Further improve the quality assurance and control (QA/QC) for the Agency's NWAL for safeguards, including SAL, in the area of particle analysis in particular.
		T.2.R3	Support the improvement of Member States' analytical quality for nuclear material accountancy (i.e. for better Operators' analytical systems).
		T.2.R4	Develop/expand a set of reference materials with NWAL assistance, and produce/distribute working reference materials to support Member States' analytical quality.

SGAS-003 addresses the development, implementation, and enhancement of processes for analysis support and coordination of the NWAL. Laboratory members of the NWAL assist the IAEA in its verification mission by carrying out safeguards sample analysis and/or quality assurance support activities. The goal is to ensure the smooth running of routine analytical operations, within agreed timeliness and quality targets.

For the 2018-2019 biennium, the project's top priorities are to:

- Ensure efficient and effective operation of the NWAL, including participation in inter-laboratory comparison exercises;
- Implement expansion of the NWAL, with the main focus on particle analysis of environmental samples and quality assurance support;
- Coordinate and support the production of new quality control reference materials, particularly for particle analysis.

2. Background

The IAEA collects nuclear material and environmental samples during safeguards inspections in order to verify the correctness and completeness of Member State declarations regarding their nuclear activities. Nuclear material sample analyses primarily support the material balance evaluations used to verify Member State declarations of nuclear material holdings. Environmental sample analyses are focused 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 (U) and plutonium (Pu) as well as the average isotopic composition in the sample. Particle analysis techniques are used to measure the uranium and plutonium isotopic composition of individual particles.

The NWAL provides a fundamental service to IAEA safeguards. In addition to providing supplemental analytical capability and capacity, the NWAL provides a measurement quality control (QC) function, offers a pool of expertise in the analysis of safeguards samples, undertakes research on characterization of U and Pu materials, and manufactures and provides reference materials for use during measurement of safeguards samples. Presently, the NWAL consists of the IAEA Safeguards Analytical Laboratories in Seibersdorf, Austria (the Nuclear Material Laboratory, NML, and the Environmental Sample Laboratory, ESL) and 22 other qualified laboratories of the Member States and the European Commission. In 2017, the China Institute of Atomic Energy (CIAE) qualified for particle analysis of environmental samples, and the Savannah River National Laboratory (SRNL) of the US Department of Energy (DOE) qualified for nuclear material analysis for accountancy purposes.

End-users of the NWAL analysis reports are Departmental evaluators and Divisions of Operations staff, who receive and evaluate these analytical data. During NWAL technical meetings (TMs), 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 and efficiency of safeguards sample analyses, and revises technical objectives for performance monitoring of analytical services.

Various challenges remain to be addressed. Efforts continue to monitor and control analytical performance in terms of timeliness and quality and to further strengthen the NWAL quality control (QC) programme. In particular, the need for appropriate reference materials for uranium and plutonium particle analysis needs to be addressed. The Agency continues to rely on Member State Support Programmes (MSSPs) for provision of highly specialized certified reference materials and contribution to external proficiency testing of NWAL performance.

The improvement of existing methods or development of new analytical methods for nuclear material analysis and environmental sample analysis are addressed by the projects SGAS-001 *Destructive Analysis of Nuclear Materials* and SGAS-002 *Environmental Sample Analysis Techniques*, respectively.

3. Expected Outcomes and Key Outputs

In order to reach Project SGAS-003's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and / or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Expanded IAEA Network of Analytical Laboratories (NWAL) and quality controlled analytical services. **(In support of T.2.R2, T.2.R3, and T.2.R4)**	
Qualification of one additional NWAL member for the analysis of safeguards samples	December 2019
Qualification of one additional NWAL member for provision of reference materials	December 2019
Organisation of one to two inter-laboratory comparison exercises per year	December 2019
Expected outcome 2.) Maintained and upgraded Safeguards Laboratory Analysis Information Management System (SALIMS). **(In support of T.2 Enhance sensitivity, reliability and timeliness in sample analysis)**	
Release of upgraded SALIMS v1.1	December 2019

4. Tasks

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 objectives. Some activities, e.g., NWAL analyses, are supplemented by regular budget sources. The IAEA pays a fixed amount for each type of sample and analysis. A number of MSSP tasks offer administrative vehicles to account for the supplementary funds.

Expected outcome 1.) ***Expanded IAEA Network of Analytical Laboratories (NWAL) and quality controlled analytical services.*** **(In support of T.2.R2, T.2.R3, and T.2.R4)**

Particle analysis of environmental samples is carried out by the IAEA ESL plus nine NWAL members: the University of Western Australia (UWA), the China Institute of Atomic Energy (CIAE), the EC's Joint Research Centre (JRC) in Karlsruhe, the Commissariat à l'Energie Atomique (CEA) in France, the Japan Atomic Energy Agency (JAEA), the Korea Atomic Energy Research Institute (KAERI), the Laboratory for Microparticle Analysis (LMA) in the Russian Federation, the Atomic Weapons Establishment (AWE) in the UK, and the Air Force Technical Applications Center (AFTAC) in the United States. Support in this area is provided under six MSSP tasks (AUL A 0859, EC X 1969, JPN X 2004, ROK X 2265, RUS X 1515 and UK X 1045) to account for the supplementary funds made available by the Australian, EC, Japanese, Russian, and UK Support Programmes to contribute to the costs of the analysis of safeguards samples made by their respective NWAL members. In addition, tasks FRA X 1941 and USA A 1081 provide general support to the Safeguards Analytical Laboratories. 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) would be welcomed. Separately, the IAEA is working to develop in-house fission-track analysis capability in conjunction with two MSSPs; details of this effort are provided in SGAS-002.

Bulk analysis of environmental samples is carried out by the IAEA ESL plus ten NWAL members: the Australian Nuclear Science and Technology Organization (ANSTO), the Instituto de Radioproteção e Dosimetria (IRD) in Brazil, CEA, JAEA, KAERI, the Khlopin Radium Institute (KRI) in the Russian Federation, and Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest National Laboratory (PNNL) of the United States DOE. Support in this area is provided under four MSSP tasks (AUL A 0859, JPN X 2004, ROK X 2265 and RUS X 1515). In addition, one laboratory is presently under qualification (HUN A 1834). There is limited need for additional capacity beyond the current qualified and candidate laboratories.

At present, all nuclear material sample analyses for accountancy purposes are performed by the IAEA NML. However, support from the NWAL in the area of nuclear material analysis is required for quality assurance purposes and to provide backup capacity in the event that the NML is unavailable. A core group of three laboratories is able to receive, prepare, and process the safeguards samples for analysis: JRC Karlsruhe, the CEA Laboratoire d'Analyses Nucléaires Isotopiques et Elémentaires (LANIE), and the DOE Savannah River National Laboratory (with support for JRC provided by task EC X 1969). This group of laboratories therefore provides QC for the entire measurement process, including sample preparation. A supplementary group, capable of receiving samples that have undergone chemical preparation in the NML, is being established. This second group of laboratories would provide QC for the final measurement systems only. Three laboratories are presently under qualification for this purpose (BEL A 1758, CAN A 1950, and NET A 1974).

One laboratory is presently qualified under the NWAL for analysis of heavy water samples: the Magyar Tudományos Akadémia (MTA) in Hungary. To add supplementary capacity in this area, one additional laboratory is under qualification in Argentina (ARG A 1906).

The availability of fit-for-purpose reference materials is the cornerstone of analytical QC, and therefore reference material provision is a specific category of membership under the NWAL. Such materials are necessary for proper instrument calibration, traceability to the International Organization for Standardization (ISO) standards, measurement control and uncertainty quantification. A number of tasks continue 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 NML). Four members of the NWAL provide such reference materials: JRC/Geel, the Commission d'Etablissement des Méthodes d'Analyse (CETAMA) in France, KRI, and the DOE New Brunswick Laboratory (NBL), with support provided under EC A 0318, FRA A 1101, RUS A 0491, and USA A 1496, respectively. In addition, UK C 1742 serves as a vehicle for the provision of reference materials from the UK National Physical Laboratory (NPL). It is of paramount importance to IAEA safeguards that these capabilities to provide and distribute specialized reference materials are maintained. The IAEA continues to encourage the preservation of existing stocks through more enhanced use of working standards and development of new approaches for extending the shelf life of such working standards (see SGAS-001).

In the area of environmental sample analysis, the highest priority is assigned to the sustainable provision of appropriate reference materials for uranium and plutonium particle analysis. The Forschungszentrum Jülich (FZJ) in Germany has made many technical achievements in the production of mono-disperse uranium particles as part of its qualification effort for the NWAL (task GER A 1960; see also task GER A 1961 under SGAS-002). Beyond this effort, the spectrum of needs for particle QC reference materials is wide and calls for further support from MSSPs. Contacts have been established with partner laboratories in Member States with a view to provide additional particle QC materials using various production techniques. The feasibility of application of these techniques to safeguards needs is under review (see SGAS-002). The IAEA intends to issue task proposals to support the sustainable production and characterization of diversified particle QC materials in Member States.

In 2016 the IAEA successfully completed the in-house production and characterization of a set of environmental QC swipes, achieving mixing of particle QC materials and their deposition onto blank swipes, while using temporary laboratory space. These samples were used in the 2017 ES particle proficiency test. Efforts are ongoing to secure permanent laboratory space dedicated to the sustainable production of QC swipes, and supported by MSSP contributions.

In 2018 LLNL and NBL are expected to complete the production of a new, ultra-high-purity Pu-244 standard, which the DOE will provide to the IAEA and all members of the NWAL performing bulk analysis of environmental samples. The source material for this effort was produced through a trilateral cooperation between the United States, the Russian Federation, and the IAEA (under the now-completed task USA A 0909).

In addition to all the above contributions, there is a continuing need for uranium reference materials with high precision minor isotope composition, plutonium reference materials with high precision isotopic composition, and production of uranium-plutonium LSD spikes. There is also a growing need for new reference materials to meet evolving safeguards requirements: reference materials for trace element characterization of uranium, reference materials for material age-dating techniques, and heavy water reference materials.

Assessing the 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 important for assuring the 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.

Tasks EC A 0267 and FRA A 1100, "Analytical Quality Control Services" focus on proficiency testing mainly through the distribution of certified reference materials from the EC JRC in Geel (Belgium) and CETAMA, respectively. Whereas JRC/Geel administers the Nuclear Signatures Inter-laboratory Measurement Evaluation Programme (NUSIMEP) and the 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 Safeguards Analytical Laboratories participate in these exercises. Task USA A 1497 hosts participation of SAL in the Safeguards Measurement Evaluation (SME) programme organized by the US/DOE New Brunswick Laboratory (NBL) and task RUS A 1514 hosts participation of Russian laboratories in external QC exercises (interlaboratory comparison exercises or proficiency tests) for nuclear material analysis and analysis of environmental samples (ES). To complement these external schemes, SGAS has developed statistical software appropriate for analysing proficiency test data under a number of experimental designs and technical objectives, and has designed, conducted, and/or analysed inter-laboratory comparisons in the areas of destructive analysis of nuclear materials (2015 and 2017 Nuclear

Material Round Robins), particle analysis of environmental samples (2015 and 2017 ES particle proficiency tests), bulk analysis of environmental samples (2015 ES bulk inter-laboratory comparison by IAEA and 2015 ES bulk round robin sponsored by the US Department of Energy (DoE)), gamma spectrometry (2014 and 2017 high-resolution gamma spectrometry proficiency tests), and impurities analysis (2016 inter-laboratory comparison in impurity analysis). Results from these tests were discussed with participating laboratories during TMs, during which recommendations were made that the IAEA repeat such exercises regularly in the future. The IAEA will continue to pursue this objective and intends to fully establish proficiency test schemes which follow international standards and cover all analytical techniques of safeguards significance. In particular, organization of a first IAEA inter-laboratory comparison exercise on particle characterization by scanning electron microscope/energy dispersive x-ray spectroscopy (SEM/EDX) is foreseen during the 2018-2019 biennium.

Expected outcome 2.) ***Maintained and upgraded Safeguards Laboratory Analysis Information Management System (SALIMS) v1.1.*** **(In support of T.2 Enhance sensitivity, reliability and timeliness in sample analysis)**

Building upon its existing IT architecture and past successes with the development of the NML Laboratory Information Management System (LIMS) and its integration into the wider SALIMS Portal platform, the IAEA intends to leverage the advantages of the SALIMS Portal to continue to integrate its business systems and processes, consolidate its databases, and expand the LIMS to cover NWAL coordination, facilitate QC monitoring, and include data management at the ESL. Laboratory-specific development needs have been collected, scoped as individual tasks, and prioritized. Development tasks which require in-depth business knowledge or low/medium effort are ongoing using internal development resources. However, as these are limited, the IAEA has requested USSP support (task proposal 16/CSS-001) to address the remaining tasks and achieve the SALIMS v1.1 development project during the 2018-2019 biennium.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.7.001 Analytical services and sample analysis* in the *Agency's Programme and Budget 2018-2019*.

Member State Support Programme (MSSP) Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task#	Task Title (Agency's task cross reference)	Description	Expected Completion Date
1	1	Organise IAEA NM round robin exercise (2018.04)	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to NMA analysis.	September 2019
	2	Organise IAEA impurity inter-laboratory comparison exercise (2018.04)	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to impurity analysis of safeguards samples.	December 2019

Expected outcome	Task#	Task Title (Agency's task cross reference)	Description	Expected Completion Date
	3	Organise IAEA gamma spectrometry inter-laboratory comparison exercise (2018.04)	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to gamma spectrometry analysis of safeguards samples.	December 2018
	4	Organise IAEA ES bulk analysis inter-laboratory comparison exercise (2018.04)	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to ES bulk analysis of safeguards environmental samples.	December 2018
	5	Organise IAEA SEM/EDX inter-laboratory comparison exercise (2018.04)	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the laboratories with regard to particle characterization by scanning electron microscope/energy dispersive x-ray spectroscopy (SEM/EDX).	December 2019
	6	Organise IAEA ES particle analysis inter-laboratory comparison exercise (2018.04)	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to ES particle analysis of safeguards environmental samples.	December 2019
2	7	Deliver upgraded SALIMS v1.1 (2018.04)	Further integration of SGAS IT systems and streamlining of SGAS processes in a coherent and sustainable fashion, across all safeguards analytical laboratories, under the IT architecture which was successfully implemented for the NML LIMS. Development of LIMS functionalities supporting data management at the ESL, NWAL coordination and QC monitoring, and continued enhancements of the NML LIMS.	December 2019

4.3 Attachments

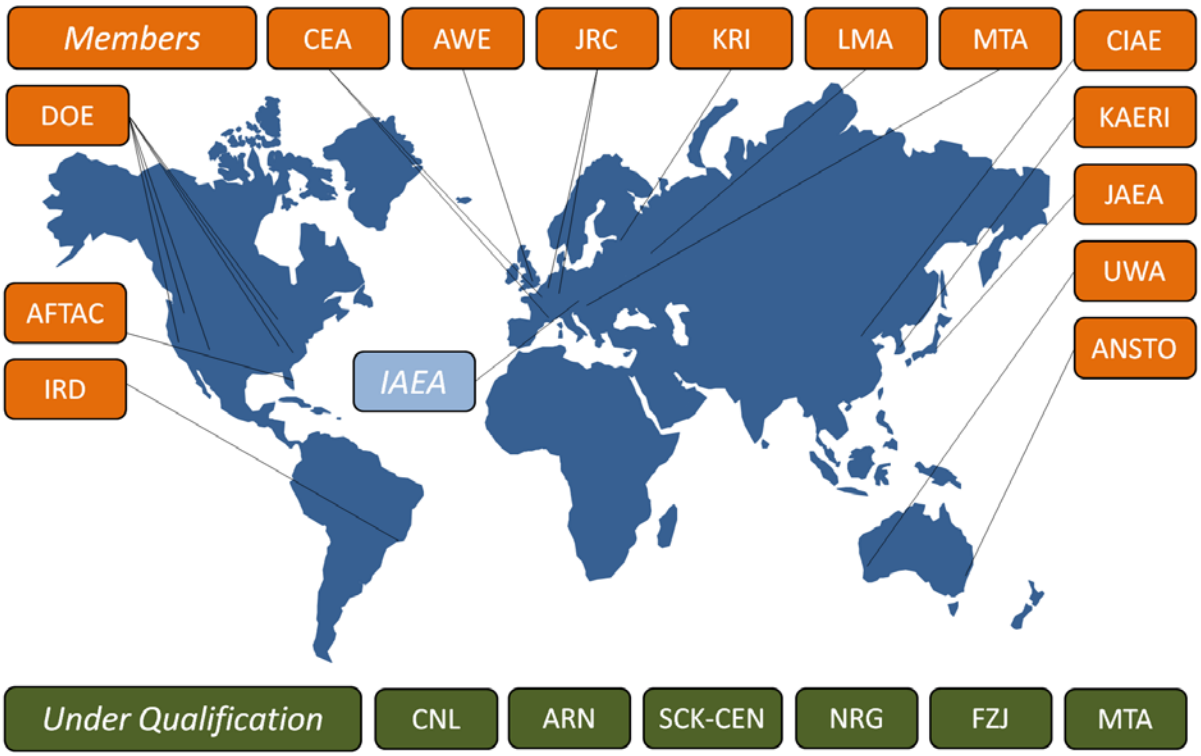


Figure 1: IAEA Network of Analytical Laboratories

Figure 2: IAEA Technical Meeting on 2017 Nuclear Material Round Robin

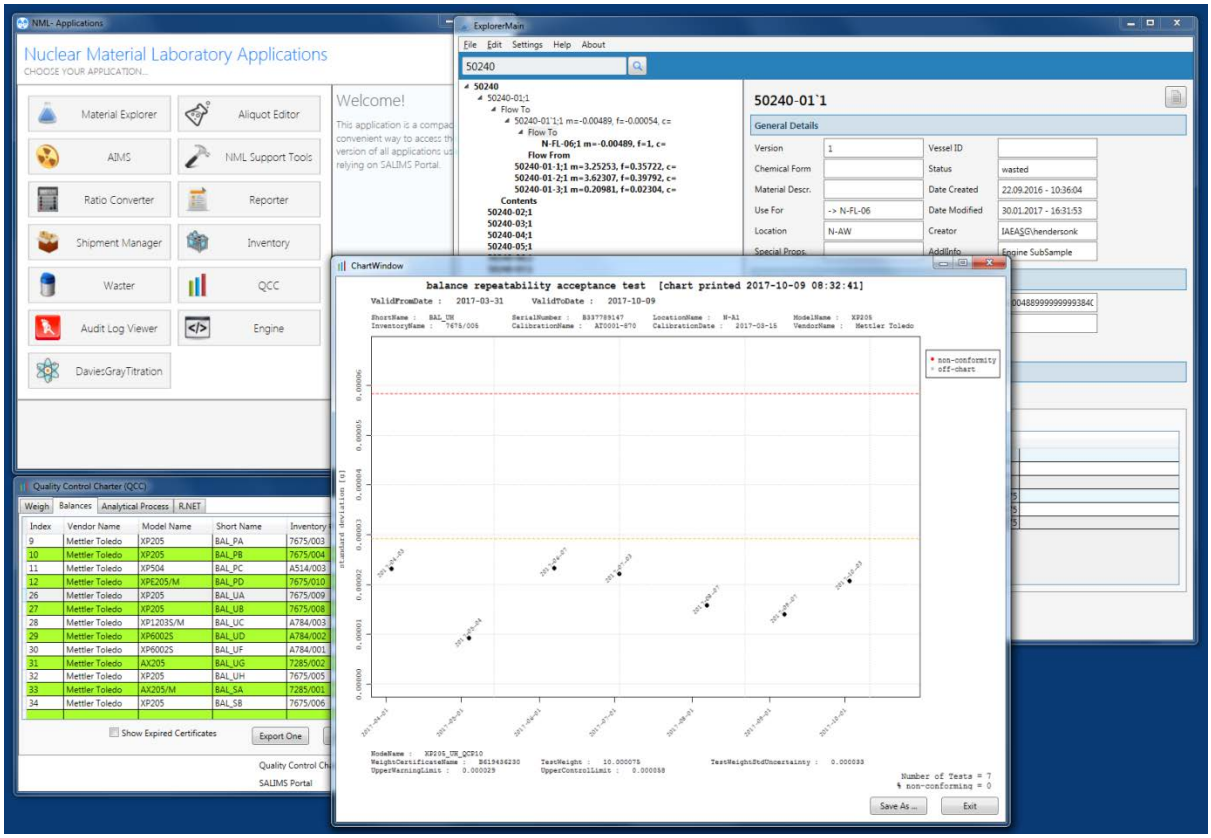


Figure 3: Screenshot of SALIMS

SGCP-003

Safeguards Approaches

Project Manager: Jin Yong DOO

Division: SGCP

1. Overview

This document describes the plans for developing and implementing safeguards concepts and approaches within the Department of Safeguards for the period 2018-2019.

During the 2018-2019 biennium, Project SGCP-003 will pursue the following objective:

Develop and implement innovative and effective concepts and approaches to continue to meet safeguards challenges.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.1.002 Safeguards approaches and concepts.*

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
P.3	*Monitor, assess and prepare for evolving nuclear proliferation challenges*	P.3.R1	Maintain awareness of changes in the nuclear landscape and associated proliferation risks, including the impact of non-State actors on the safeguards system.
P.5	*Prepare for new types of facilities and decommissioning*	P.5.R1	Address identified gaps in facility-specific guidance, training and tools for conducting verification activities during decommissioning.
		P.5.R2	Based on the prospects and timing for emerging nuclear fuel cycle facilities (e.g. pyroprocessing plants, geological repositories) develop and deploy as appropriate: • safeguards concepts • tools • techniques • training
S.3	*Advance safeguards-by-design*	S.3.R1	Identify and pursue opportunities for the Agency and Member States to promote the early consideration of safeguards among the nuclear industry.
V.2	*Reinforce State evaluation*	V.2.R1	Develop a set of reference materials to assist SEGs in the assessment of a State's capability to accomplish acquisition path steps which take into account the level of maturity of the State's nuclear fuel cycle and associated technical capabilities.

Project SGCP-003 addresses the development, demonstration, implementation, and enhancement of safeguards concepts and approaches. This includes the following activities:

- Review and update safeguards implementation documents to ensure that safeguards are implemented effectively;
- Assist the Operations Divisions in the design and implementation of State-level safeguards approaches through further development of methodologies and guidance; and
- Develop safeguards concepts early in the design process for new types of facilities.

For the 2018-2019 biennium, the project's top priorities are to:

- Develop methodologies and guidance for improving the assessment of acquisition path steps, including State's technical capability to develop and/or acquire nuclear fuel cycle technologies and facilities, nuclear material diversion and facility misuse scenarios;
- Update the Physical Model to incorporate the latest technological developments;
- Develop safeguards implementation guidelines for facilities under decommissioning and safeguards concepts for post-accident facilities under decommissioning.

2. Background

In order to continue to draw sound safeguards conclusions and to increase confidence that States are abiding by their safeguards obligations, the IAEA has been developing and applying a concept for safeguards implementation that is oriented towards a 'State as a whole' approach. Development and testing of internal procedures and guidance for implementing State-level safeguards have been carried out, including guidance on performing acquisition path analysis (APA) and developing State-level approaches (SLAs) for States with comprehensive safeguards agreements. Further improvement of procedures and guidance has been taking place based on the feedback from SLA development.

To improve preparedness for future safeguards needs, it is important to develop effective and efficient safeguards concepts early in the design process of new types of facilities, including pyro-processing plants and small modular and/or Gen IV reactors.

It is in the interest of both States and the IAEA to cooperate to facilitate the practical implementation of safeguards. Effective cooperation depends upon States and the IAEA sharing a common understanding of their respective rights and obligations. Toward this end, valuable contributions toward the development and testing of safeguards concepts, guidelines and approaches have already been provided by Member States through the Member State Support Programmes (MSSPs). These contributions continue to be of paramount importance to the Project's ability to meet Department expectations. End-users are primarily the Operations Divisions carrying out safeguards activities.

3. Expected Outcomes and Key Outputs

In order to reach Project SGCP-003's objective and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Improved ability to fully implement the State-level concept through the development of internal guidance documents and additional tools for the development of State-level safeguards approaches. **(In support of V.2.R1)** Based on lessons learned from the ongoing SLA development, and as part of the actions for State-level safeguards implementation, the project will continue to develop templates, tools and reference material to support the development of SLAs.	
Methodology and guidance for assessing acquisition path steps, including a State's technical capability to hypothetically develop nuclear fuel cycle technologies and facilities as well as nuclear material diversion and facility misuse scenarios	December 2019
Expected outcome 2.) Increased ability to detect undeclared nuclear material and activities through update and improvement of the 'Physical Model'. **(In support of P.3.R1)**	
Updated Physical Model (all volumes)	June 2019

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 3.) Enhanced ability to safeguard new types of facilities through development of safeguards concepts for pyro-processing plants and small modular and/or Gen IV reactors. **(In support of P.5.R2)**	
Safeguards Technical Report on safeguards concepts and supporting measures for a pyro-processing facility	December 2019
Safeguards concepts and supporting measures for a High Temperature Gas Cooled Reactor Pebble Modules (HTR-PM) plant	December 2019
Expected outcome 4.) Enhanced ability to safeguard new types of facilities through development of safeguards by design guidance documents. **(In support of S.3.R1)**	
Three Safeguards by design (SBD) guidance documents on "International Safeguards in the Design of Facilities for Long Term Spent Fuel Management", "International Safeguards in the Design of Reprocessing Plants" and "International Safeguards in the Design of Enrichment Plants"	December 2018
Use of the industry standardized UF_6 cylinder identifier	December 2018
Expected outcome 5.) Improved ability to verify facilities under the decommissioning phase through the development of Safeguards implementation guidelines and concepts. **(In support of P.5.R1)**	
Safeguards implementation guidelines for facilities under decommissioning	June 2019
Specific safeguards concepts for post-accident facilities under decommissioning based on lessons learned from Fukushima Dai-ichi and Chernobyl	December 2019

4. Tasks

Most of the following tasks will be performed by Safeguards Department personnel. Further assistance will be required from MSSPs for some activities.

Expected outcome 1.) ***Improved ability to fully implement the State-level concept through the development of internal guidance documents and additional tools for the development of State-level safeguards approaches.*** **(In support of V.2.R1)**

There has been an on-going effort to prepare guidance for updating SLAs to make greater use of 'State as a whole' considerations.

Based on experience gained in updating SLAs, and for further improvement of the effectiveness and efficiency of State-level safeguards implementation, new methodologies and guidance documents will be developed in 2018-19 for assessing acquisition path steps, including a State's technical capability to hypothetically develop nuclear fuel cycle technologies and facilities, as well as nuclear material diversion and facility misuse scenarios. MSSP support will be required and coordinated under an umbrella task 'Technical assistance on methodology and guidance for implementation of Safeguards at the State-level' (BEL C 2277, BRZ C 2311, CAN C 2238, CZ C 2224, EC C 2305, FRA C 2261, GER C 2245, HUN C 2236, JPN C 2230, SWE C 2218, UK C 2268, USA C 2241).

Expected outcome 2.) ***Increased ability to detect undeclared nuclear material and activities through update and improvement of the 'Physical Model'.*** **(In support of P.3.R1)**

The Physical Model (PM) 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 analysed to ensure that the list of signatures and indicators is complete and

the weighting of the indicators is accurate with respect to any evolution in fuel cycle technology. The Physical Model should be organized and accessible such that it facilitates analysis by SEGs. Expert group meetings (AUL C 2298, CZ C 2317, EC C 2304, FIN C 2290, GER C 2299, JPN C 2289, SWE C 2291, UK C 2297 and USA C 2303) will be continued until 2018 to improve the Physical Model completeness and usability.

Expected outcome 3.) ***Enhanced ability to safeguard new types of facilities through development of safeguards concepts for pyro-processing plants and small modular and/or Gen IV reactors.*** **(In support of P.5.R2)**

Task ROK C 2263 'Development of Safeguards Measures and Equipment for a Pyroprocessing Plant using Related Facilities (PRIDE, ACPF and DFDF) in ROK' started in 2017. Tasks JNT C 1953 ROK and USA were started in 2012 to keep the IAEA informed and involved in 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 Department-wide concepts for safeguarding future pyro-processing facilities and for assessing a State's overall pyro-processing capability. Separate MSSP tasks (EC C 1917, FRA C 1943, JPN C 1962 and ROK C 1885) have been established with the goal of producing a Safeguards Technical Report (STR) for safeguarding pyro-processing plants.

A new MSSP task proposal was issued in 2017 to develop safeguards concepts and supporting measures for a High Temperature Gas Cooled Reactor Pebble Modules (HTR-PM) plant in China. Once the task is accepted by China, the safeguards concepts and supporting measures will be developed in 2018-19.

Expected outcome 4.) ***Enhanced ability to safeguard new types of facilities through development of safeguards by design guidance documents.*** **(In support of S.3.R1)**

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

Three SBD guidance documents will be published in 2018: "International Safeguards in the Design of Facilities for Long Term Spent Fuel Management", "International Safeguards in the Design of Reprocessing Plants" and "International Safeguards in the Design of Enrichment Plants".

The development of a standardized UF_6 cylinder identifier (in collaboration with SGTS-002) is an industry driven project, for which the working group is led by the World Nuclear Transport Institute (WNTI). The IAEA has been involved from an early design phase (USA C 2137 'UF_6 Cylinder Universal Identifier'), allowing safeguards needs and requirements to be taken into consideration during development. The UF_6 cylinder identifier is expected to improve effectiveness and efficiency of verification activities and information analysis of the IAEA, and also benefit industry stakeholders and state regulatory authorities (SRAs).

Expected outcome 5.) ***Improved ability to verify facilities including post-accident facilities under decommissioning through the development of Safeguards implementation guidelines and concepts.*** **(In support of P.5.R1)**

The IAEA and Japan have established the Fukushima Task Force (TF) to coordinate safeguards implementation at the Fukushima Dai-ichi site. A substantial amount of nuclear material remains inaccessible for verification due to the March 2011 tsunami and ensuing reactor accidents.

The IAEA will develop safeguards implementation guideline for facilities under decommissioning and specific safeguards concepts for post-accident facilities under decommissioning based on lessons learned from the safeguards implementation at Fukushima Dai-ichi and Chernobyl sites.

A CFE position (JPN C 2274) was established with the goal of developing safeguards implementation guideline for facilities under decommissioning and specific safeguards concepts for post-accident facilities under decommissioning.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.1.002 Safeguards approaches and concepts* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 Attachments

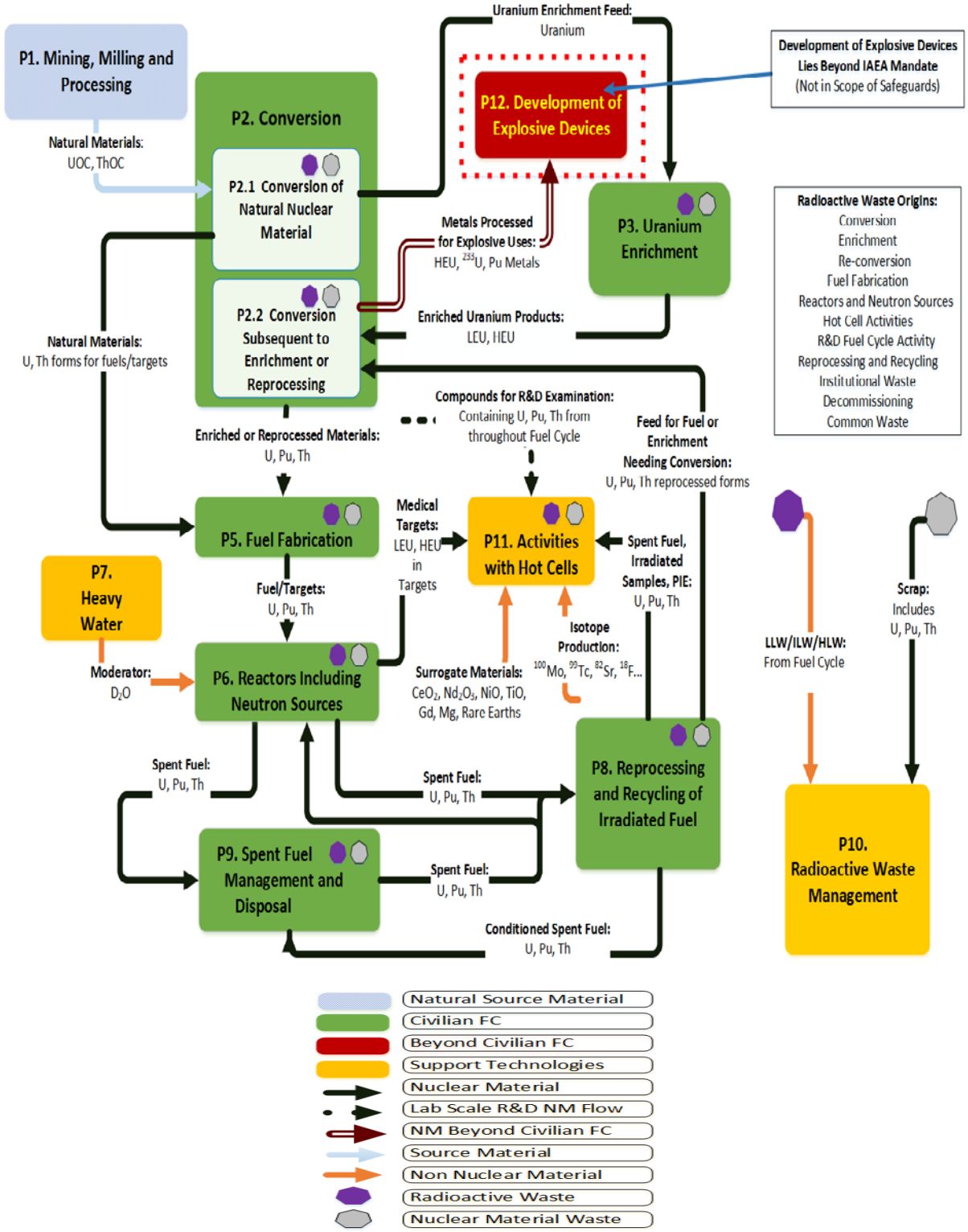


Figure 1: Schematic overall structure of the revised Physical Model

SGCP-004

Strategic Planning and Partnerships

Project Manager: Eric Pujol

Division: SGCP

1. Overview

This document describes the plans for managing strategic planning related processes – from foresight and related risk analysis through strategy formulation and execution – in the Department of Safeguards for the period 2018-2019. It also describes efforts to enhance partnerships that are increasingly important for successful implementation of the verification mandate of the Department.

During the 2018-2019 biennium, Project SGCP-004 will pursue the following objectives:

Assure appropriate management and implementation of departmental strategic planning processes, methodologies and tools. Develop new and enhance external partnerships to effectively address current and future challenges and opportunities relevant to safeguards implementation.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.1.001 Strategic planning and coordination.*

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
C.2	*Strengthen management processes*	C.2.R1	Develop effective and sustainable strategic management processes to enable effective horizontal and vertical strategy execution.
P.3	*Monitor, assess and prepare for evolving nuclear proliferation challenges*	P.3.R1	Maintain awareness of changes in the nuclear landscape and associated proliferation risks, including the impact of non-State actors on the safeguards system.

This project contributes to the Department of Safeguards' efforts to enhance the effectiveness of safeguards and organizational performance in line with results based management, as mentioned in the Agency's Medium Term Strategy (MTS) for 2018-2023.

For the 2018-2019 biennium, the project's top priorities are to:

- Strengthen tools, methods and processes for executing the Department's strategic plan, including communication, implementation and monitoring;
- Strengthen foresight mechanisms to identify, monitor, analyse and address changes in the operating environment and develop the tools, methods and processes to adapt to these changes, as necessary, in a more agile manner;
- Organize a Safeguards Symposium to explore innovations, mobilise partnerships to address them, and identify ways to work together with the safeguards community to enhance the implementation of safeguards.

2. Background

The Department of Safeguards conducts strategic planning to enhance its capability to face future challenges and benefit from opportunities to ensure that safeguards implementation continues to be effective and efficient. The strategic planning framework supports good management of resources through continually monitoring the operating environment, establishing objectives that are prioritized to focus resources on top priorities. It avoids duplications and promotes programmatic and organizational

coherence. A key element supporting strategy execution is the development of new and existing partnerships with respect to development and implementation support.

Project SGCP-004 contributes to the identification and processing of Departmental development and implementation support needs through programmatic planning, appropriate communication, and enhanced coordination. The latter is essential to ensure that the efforts undertaken by our partners to support the Department are effective, relevant, deployable and sustainable. It is likewise essential that partners perceive the global picture of how their efforts (e.g., tasks) contribute to helping the Department face identified challenges. SGCP-004 is the Departmental mechanism for ensuring clear, meaningful and continuous coordination from the strategic objective level through to the implementation of individual tasks that support those objectives. SGCP-004 also facilitates resource mobilization and contributes to Department's efforts towards improving productivity without compromising the credibility and quality of safeguards conclusions.

An important contribution to partnership enhancements comes from holding, every four years, the Symposium on International Safeguards. SGCP-004 brings a major contribution to the organization of these symposia, which engage the broader safeguards community to help the Department of Safeguards face existing and future implementation challenges.

It is anticipated that activities performed in the framework of SGCP-004 will require financial resources from the regular budget and from extra-budgetary sources. Support from the MSSPs in the form of expertise and other in-kind support is also expected.

3. Expected Outcomes and Key Outputs

In order to reach Project SGCP-004's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Strengthened tools, methods and processes for executing the Department's strategic plan. **(In support of C.2.R1)**	
Development of processes and tools to support strategy implementation, monitoring and reporting (including the alignment of KPIs, in collaboration with SGCP-101)	July 2019
Update of the Strategy portal to support implementation, monitoring and reporting (including the alignment of KPIs, in collaboration with SGCP-101)	December 2019
Expected outcome 2.) Improved organisational ability to identify and adjust to changes in the operating environment in a flexible and timely manner. **(In support of P.3.R1)**	
Organization of and report on the Emerging Technologies Workshop 2019	July 2019
Organization of a Scenario Development Workshop	July 2019
Organization of and report on exchanges with foresight practitioners (in collaboration with SGTS-008)	July 2019
Report on the review of the Operating Environment	July 2019
Organization of an Annual Strategy Workshop considering plan implementation monitoring, updating scenarios, operating environment, adjusting strategic priorities	December 2019

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 3.) Enhanced stakeholder awareness and understanding of safeguards and nuclear verification. **(In support of S.1 Communicate proactively and transparently and S.4 Leverage and establish partnerships)**	
Organization of a Symposium on International Safeguards, "Building Future Safeguards Capabilities"	November 2018
Report/proceedings of, and action plan resulting from the Symposium	May 2019
Expected outcome 4.) Optimized use of MSSP support through alignment of tasks with strategic objectives and close coordination with MSSPs. **(In support of S.4 Leverage and establish partnerships and C.4 Secure and optimally manage financial resources)**	
External release of updated R&D Plan	February 2018
Upgraded SPRICS (in collaboration with SGIS-003)	December 2019
Summary reports of annual or bi-annual bilateral meetings with MSSPs	ongoing
List comparing needs from R&D Plan *with actual current and planned partner activities (compiled with assistance from MSSPs and other partner organizations)*	December 2018

4. Tasks

This Section includes tasks funded by the IAEA regular budget and tasks expected to be funded by extra budgetary contributions from the Member States Support Programmes (MSSPs).

Expected outcome 1.) ***Strengthened tools, methods and processes for executing the Department's strategic plan.*** **(In support of C.2.R1)**

The Department has had an internal strategic plan since 2010. In 2016-2017, stakeholders from the whole Department contributed to a major update of that strategic plan, facilitated by external assistance (GER C 2286). Under the strategic planning framework, substantiated strategic documents are consistently aligned, from the strategic plan through the verification chapter of the *Agency's Medium Term Strategy*, the relevant *IAEA Programme and Budget*, the *Research and Development Plan* (*R&D Plan*), and the *D&IS Programme*.

To support continuous improvement, a major priority in the coming biennium is to further develop the tools, methods and processes supporting effective strategy execution, including communication and implementation monitoring aspects. These developments require additional, human, financial and in-kind resources to develop, evaluate and establish effective tools methods and processes.

In collaboration with the project SGCP-101, key performance indicators indicating progress towards stated outcomes relevant to the strategic plan will be also developed. Relevant reporting requirements will be detailed and implementation review meetings instituted. The Strategy Portal will be enhanced to support such monitoring and reporting requirements.

For these activities MSSPs will be solicited regarding (1) the provision of external expertise (e.g., JPO/CFE experts and consultants) to develop the processes, methods and tools for strategy execution and, (2) the sponsorship of external training and/or development opportunities to support departmental strategy execution.

Expected outcome 2.) ***Improved organisational ability to identify and adjust to changes in the operating environment in a flexible and timely manner.*** **(In support of P.3.R1)**

The Department continually monitors its operating environment in order to plan and prepare to face challenges and make use of opportunities. The Department is improving its foresight process to regularly and more frequently assess changes in its operating environment and make adjustments to its priorities accordingly. This process supports both the analysis and the execution phases of the Departmental strategic plan.

As part of the strategic analysis, a periodic Emerging Technologies Workshop will continue to be conducted to increase the Department's awareness about and preparedness for addressing emerging technologies (nuclear and non-nuclear) and to begin to identify methodologies and technologies that could aid the work of the Department.

A scenario development exercise will be conducted to envisage and start preparing for a wider set of futures. In that vein, regular exchanges with foresight and strategy practitioners will support peer learning and identification of evolutions in strategic foresight techniques.

An annual strategy workshop will be held with the objective to review the Department's strategic plan and adjust strategic priorities to changes in the operating environment as necessary.

For these activities MSSP support will be solicited for (1) the provision of external expertise (e.g. JPOs, experts and consultants) to conduct research and analysis, particularly for internal and external environment analysis; (2) facilitation and other expert assistance in conducting workshops, particularly for strategic prioritization by senior management; (3) support for external experts' participation in workshops, particularly the sponsorship of travel costs, and; (4) sponsorship of external training or development curricula for IAEA staff in the field of foresight and strategic planning.

Expected outcome 3.) ***Enhanced stakeholder awareness and understanding of safeguards and nuclear verification.*** **(In support of S.1 Communicate proactively and transparently and S.4 Leverage and establish partnerships)**

In 2018, the Symposium "Building Future Safeguards Capabilities" will look ahead to promising emerging technologies and innovative approaches as opportunities to strengthen and streamline how we implement safeguards, at headquarters and in the field, together with our partners in Member States.

The objectives of the symposium are to:

- Generate new ideas on methods and technologies to substantially improve the IAEA's technical capabilities and generate efficiencies in the way it works;
- Mobilize partnerships beyond traditional safeguards-oriented areas, to increase the Department's awareness about and preparedness for addressing the challenges and opportunities of emerging technologies – both nuclear and non-nuclear; and
- Engage the safeguards community in sharing experiences, building capabilities, and finding ways to streamline and improve the implementation of safeguards in the field and at headquarters.

The 2018 Safeguards Symposium was identified as a major output for the Department of Safeguards for the Programme and Budget cycle 2018-2019. However, no regular budget was allocated to the organization of the event.

At the time of drafting this programme, support was already secured from a number of MSSPs under tasks ARG C 2310, CZ C 2316, EC C 2300, FIN C 2307, FRA C 2334, GER C 2320, HUN C 2301, JPN C 2302, ROK C 2333, RSA C 2332, RUS C 2329, SWE C 2309 and UK C 2295.

Two Junior Professional Officers (JPOs) (JPN C 2331 and RUS C 2329) will support the organisation of the symposium.

Further support will be welcome in the form of funding for the event organization and funding for attendance of participants from developing countries. Support to participation of keynote speakers, panellists, consultants and temporary assistance is also welcome; further financial support is needed to cover organizational costs for supplies, support services, security services, equipment rentals, and

publishing and hospitality. In-kind support is also requested to support sessions design, slides/abstract review, programme development and promotion or outreach to target audiences.

The findings and outcomes of the Symposium will be summarised in a report including follow-up actions. This report will be issued by June 2019.

Expected outcome 4.) ***Optimized use of MSSP support through alignment of tasks with strategic objectives and close coordination with MSSPs.*** **(In support of S.4 Leverage and establish partnerships and C.4 Secure and optimally manage financial resources)**

With a steadily increasing workload not covered by proportionate increases of budget, in years to come the Department of Safeguards must continue efforts to become more capable, productive and agile. It must also ensure that departmental priorities, as represented in the recently updated Strategic Plan, are being properly supported, and that external stakeholders have the information they need to provide timely, meaningful assistance. This cannot be achieved without an enhanced coordination of the invaluable support provided by Member States through their MSSPs to IAEA safeguards.

A diverse range of support is provided by MSSPs, including equipment development, facility access for training, laboratory-based analytical support and expertise. The partnership between the IAEA and participating Member States is crucial in enabling the IAEA to develop the capabilities that ensure continued effective implementation of safeguards throughout the world, and to meet contemporary and future challenges. Close follow-up and regular interactions with MSSPs is essential to ensure an optimized use of the support provided. The Agency coordinates annual and bi-annual MSSP meetings where advancement and follow-up actions for each task and prospects for new task proposals are discussed in detail. Valuable support is provided by a CFE (JPN F 2271) contributing to the efficient and effective implementation of projects and tasks under the *D&IS Programme*.

For the 2018-2019 biennium, consideration of the alignment of MSSP tasks and new task proposals with needs derived from the updated Strategic Plan will be a high priority. To this end, the Department is publishing an updated *Research and Development (R&D) Plan* alongside this *D&IS Programme for Nuclear Verification 2018-2019*. The Department's *R&D Plan* supports the implementation of the Department's strategic plan by highlighting priority needs that could not be addressed without external support. It also reflects changes to the Department's operating environment and priorities since 2012 when the previous *Long-Term R&D Plan* was published. Current and forthcoming tasks that make use of external support will be evaluated and contextualized through references to R&D needs specified in the updated plan.

Following publication of the *R&D Plan*, beginning 2018, the Department of safeguards will compile information from external partners and stakeholders (including MSSPs) regarding their existing and planned activities that may have direct relevance to safeguards R&D needs as presented in the plan; this information will be provided to points of contact and Departmental action owners to ensure best alignment of support to prioritized needs for improved capabilities for the Department.

The second version of the Support Programme Information and Communication System (SPRICS 2.0) was released in 2014, and has garnered significant feedback from MSSPs following full implementation in support to official task-related correspondence. While the implementation has been successful in a number of respects, it has fallen short of internal expectations due to some lingering issues. The long-standing vision for SPRICS 2.0 has been for it to serve as a simple, user-friendly and comprehensive source for task related information and actions, both for the Department of Safeguards and for MSSPs. However, a number of characteristics of the system impeded the realisation of that vision, particularly for users within the Department of Safeguards. In 2015, a development plan for upgrading the system to version SPRICS 2.1 was launched. The SPRICS 2.1 is expected to remove key barriers to widespread use and benefit from the system within the Department. While partially complete, additional significant improvements to SPRICS 2.1 are expected in 2018. Following the successful re-release and testing of SPRICS 2.1, an outreach effort will be launched to re-introduce the system and its new, simplified features to its users. An Associate Programme Information and Communication Officer (JPO - USA F 2269) is liaising between the Support Programme Coordination Team, departmental project managers, MSSP representatives and the system developers (see SGIS-003) to identify and implement needed improvements. The JPO will coordinate SPRICS 2.1 outreach and content-improvement activities in 2018 and 2019.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.1.001 Strategic planning and coordination* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 Attachments

Figure 1: Members of the Safeguards Senior Management discussing the departmental strategy

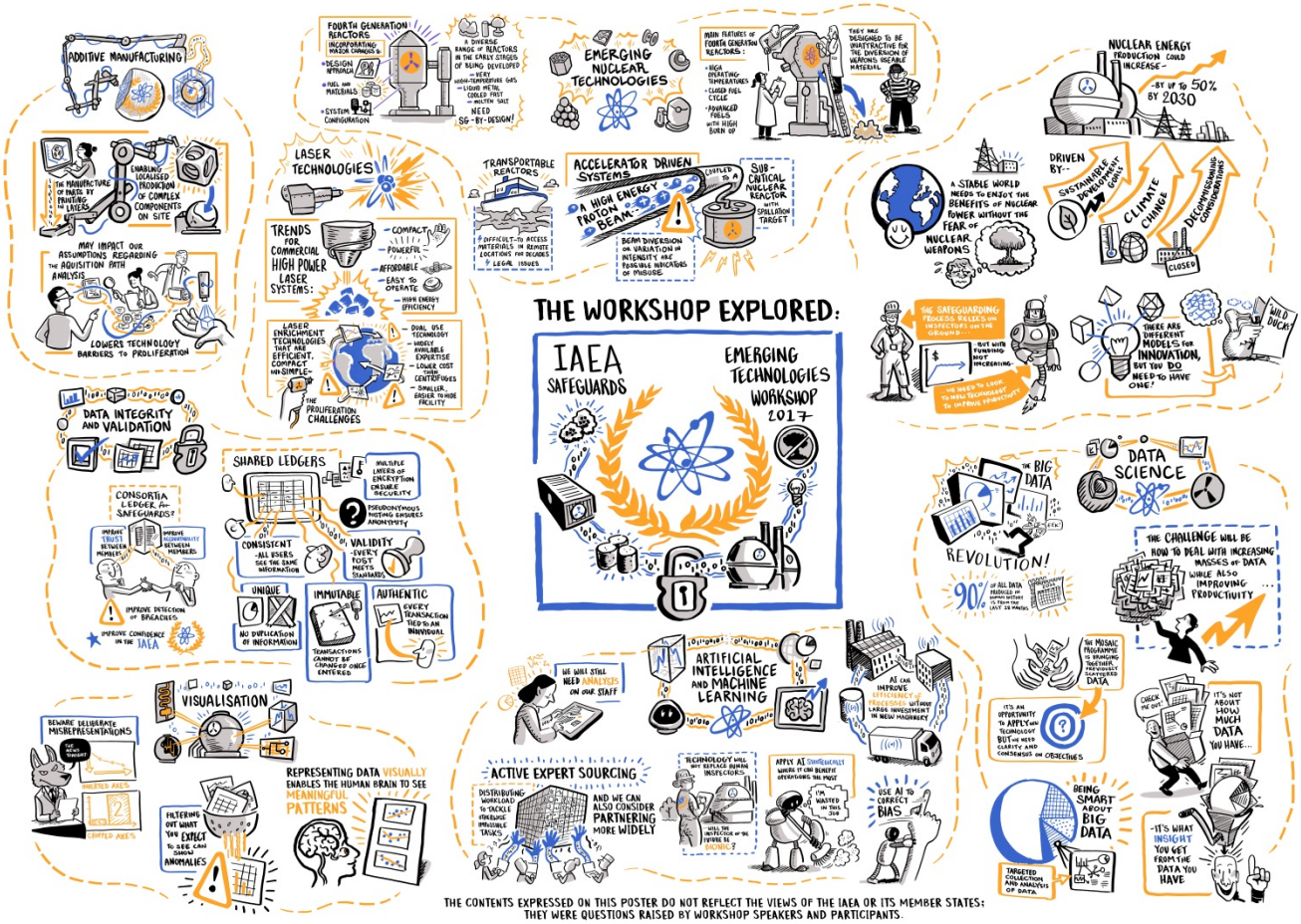


Figure 2: Summary of the Emerging Technologies Workshop, 2017

Figure 3: 2018 Symposium on International Safeguards Poster

Figure 4: MSSP Coordinators Meeting, 2016, IAEA headquarters

SGCP-101

Quality Management

Project Manager: Roy L. Fitzgerald
Division: SGCP

1. Overview

This document describes the plans for developing, implementing and enhancing processes and management tools supporting the Department of Safeguards' Quality Management System (QMS) for the period 2018 - 2019.

During the 2018-2019 biennium, Project SGCP-101 will pursue the following objective:

Continue to mature a Department-wide quality management system and monitor, analyse, and report on its effectiveness.

The plan detailed here is fully aligned with the objectives of Agency's projects *4.0.0.002 Quality management* and *4.1.1.003 Process design*.

The project supports the following R&D Need from the *R&D Plan*:

Priority Objective		R&D Need	
C.2	*Strengthen management processes*	C.2.R1	Develop effective and sustainable strategic management processes to enable effective horizontal and vertical strategy execution.

Project SGCP-101 focuses on providing support to the Department of Safeguards in the implementation and maturation of a quality management system in alignment with the requirements of the ISO 9001 quality management system standard.

For the 2018-2019 biennium, the project's top priorities will be to:

- Continue to improve and mature the process-based approach implemented in the Department;
- Upgrade QMS tools and techniques for improving and monitoring process performance;
- Continually assess the effectiveness of the Department's QMS and implement improvements as needed.

2. Background

The Department's Quality Management System provides the framework for accomplishing the objective of drawing soundly based safeguards conclusions for all States and the Department uses a process-based approach aligned with the ISO 9001 requirements.

Several initiatives supporting the maturation of the QMS have been on-going for some time. These initiatives support the management of the QMS infrastructure, promoting the use of quality tools and techniques and developing and using tools or techniques to support continual improvement. Major elements of the Department's QMS include the condition report system, the Internal Quality Audit (IQA) Programme, the SG process management framework and its performance monitoring, documentation control, engagement of people and knowledge management, and further development of cost methodology tools and applications. Stakeholders for the Department's QMS include staff in the Department of Safeguards, the Board of Governors, and Member States who have an interest in the outcome of the Secretariat's verification and evaluation activities.

Most of the funding for quality management related activities comes from the regular budget. MSSP support will be required to enable the Department to develop further the QMS, to advance the measurement of performance and knowledge management, and to train staff.

3. Expected Outcomes and Key Outputs

In order to reach Project SGCP-101's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/ or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Enhanced integration of quality management principles into the implementation of safeguards. **(In support of C.2 Strengthen management processes)**	
Upgraded Document Manager application to provide an enhanced and more efficient process to create, review, publish and search for documents supporting the QMS	December 2019
Expected outcome 2.) Developed, fully implemented and continually improved process-based approach within the management system. (In support of C.2.R1)	
Implementation of prioritized actions identified in the 2017 self-assessment on the maturity of the Department's Quality Management System	December 2018
Support for the implementation of monitoring performance in the Department, based on the identified set of key performance indicators	December 2018
Enhanced e-learning courses of Agency staff on QMS	December 2019
Expected outcome 3.) Improved management of knowledge and knowledge retention. (In support of W.3 – Treat knowledge as an organizational asset)	
List of strategic actions and activities to enhance methods for capturing and transferring knowledge within the Department	December 2018
Expected outcome 4.) Enhanced financial transparency and accountability for safeguards implementation through the continued development and refinement of the cost calculation methodology. **(In support of C.4 Secure and optimally manage financial resources)**	
Procedures and practices for further utilizing the Department's cost calculation methodology to assess the impact of implementation of process changes	December 2019

4. Tasks

Most of the tasks supporting this project will be performed by staff in the Department of Safeguards under projects *4.0.0.002 Quality management* and *4.1.1.003 Process design* with further assistance requested from Member State Support Programmes on an as-needed basis.

Expected outcome 1.) ***Enhanced integration of quality management principles into the implementation of safeguards.*** **(In support of C.2 Strengthen management processes)**

The framework for QMS needs some enhancements to more fully support consistent implementation of State level safeguards processes and for supporting further alignment of processes and procedures. This

includes upgrading the Departments' existing Document Manager application. A new document management and workflow support project will allow a more efficient and effective method for creating, delivering, reviewing, approving and storing and accessing processes and procedures.

Efforts will also be undertaken to strengthen and enhance the Departments' Internal Quality Audit (IQA) Programme. The assessment methodology and capability will be reviewed during the 2018–2019 biennium to better address process effectiveness, and to evolve to meet the needs of the Department. The following sub-activities are planned:

- Introduce a risk-based approach for developing and implementing annual IQA programmes;
- Introduce greater rigor for the presentation and tracking results, findings and corrective actions.

MSSP support may be requested to implement these tasks.

Expected outcome 2.) ***Developed, fully implemented and continually improved process-based approach within the management system.*** **(In support of C.2.R1)**

In 2017, the Department completed a self-assessment on the maturity and implementation of the Departments' QMS. This maturity assessment was conducted using ISO 9004:2009 against the ISO 9001:2015 standard. The results and findings from this assessment are being compiled and prioritized. This prioritized list will be utilized to develop a roadmap to close gaps and improve the overall maturity of the QMS.

Task UK C 2005 supported the development of key performance indicators for the Department of Safeguards. Additional efforts will be undertaken in 2018-19 to implement the use of key performance indicators. This task will involve defining a sub-set of measures and data that will be visually displayed on a dashboard. It will provide a clear presentation of trends and information to help management evaluate whether processes are operating effectively and efficiently.

In conjunction with the QMS assessment noted above, QMS training materials will be reviewed and modified as necessary in the 2018-2019 biennium. In particular, it is envisioned that the JNT B 1277 USA task to support quality assurance techniques might be expanded to add development of the on-line basic QMS training to replace outdated training material. Additional training on topics such as root cause analysis, information management and management review offerings are also considered necessary to support the implementation of the QMS.

Expected outcome 3.) ***Improved management of knowledge and knowledge retention.*** **(In support of W.3 Treat knowledge as an organizational asset)**

In the 2018-2019 biennium, the knowledge management strategy will be further developed to ensure that effective knowledge management practices are implemented. The USA C 1892 task on implementing Departmental "Day to Day" Knowledge Management will be instrumental in providing support for evaluating the current framework, strategy and tools.

Activities will focus on:

- The retention of job-critical knowledge from staff leaving the Department.
- Developing new means and methods for capturing and disseminating critical knowledge.

Expected outcome 4.) ***Enhanced financial transparency and accountability for safeguards implementation through the continued development of the cost calculation methodology.*** **(In support of C.4 Secure and optimally manage financial resources)**

The cost calculation model and methodology for calculating safeguards implementation costs, as well as the comparison of costs of safeguards measures, continues to evolve. Updating the model and using the model to estimate safeguards implementation costs by State for the Safeguards Implementation Report will periodically require the support of an external consultant to conduct reviews and refine the cost model as needed. In addition, a number of processes and activities will be used to test how the cost model may be utilized to assess overall improvements or efficiencies of process improvements.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the projects *4.0.0.002 Quality management* and *4.1.1.003 Process design* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (Agency's task cross-reference)	Description	Expected Completion Date
1	1	Documentation and Records Management (4.0.0.002-2018.01)	Implement a new application and processes to support a more efficient and effective means for creating, delivering, and accessing processes and procedures within the Department of Safeguards.	December 2019
2	2	Performance Measuring and Monitoring (4.1.1.003-2018.01)	Further develop the means and methods to evaluate and monitor process performance through the use of dashboards to facilitate the evaluation of process efficiency and effectiveness.	December 2018
	3	QMS training (4.0.0.0.002-2018.04)	Identify, develop and deliver customized training on quality management tools and techniques.	Ongoing
3	4	Improved knowledge management and encouragement of knowledge-sharing (4.0.0.002-2018.03)	Further develop the Department's knowledge management strategy, and support the Agency's knowledge management activities.	Ongoing

4.3 Attachments

Figure 1: Quality Policy

SGCP-102

Training

Project Manager: Jean-Maurice Crété

Division: SGCP

1. Overview

This document describes the plans for developing and implementing training within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGCP 102 will pursue the following objective:

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

The plan detailed here is fully aligned with the objectives of Agency's projects *4.1.1.004 Staff training and traineeship* and *4.1.1.005 Training and assistance to SSAC*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
P.5	*Prepare for new types of facilities and decommissioning*	P.5.R1	Address identified gaps in facility specific guidance, training and tools for conducting verification activities during decommissioning.
		P.5.R2	Based on the prospects and timing for emerging nuclear fuel cycle facilities (e.g. pyroprocessing plants, geological repositories) develop and deploy as appropriate: • safeguards concepts • tools • techniques • training
S.2	*Resolve priority areas of difficulty in SG implementation*	S.2.R1	Develop training material and remote delivery methods (e.g., E-Learning) to support SRA training with reduced costs and increased accessibility.
T.1	*Strengthen instrumentation capabilities for verification*	T.1.R3	Assess existing techniques to detect misuse of reprocessing plants (real time detection of Pu separation).
		T.1.R4	Improve tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment plants.
T.3	*Support all SG processes through IT*	T.3.R1	Further develop the State Declarations Portal as a tool that optimizes the quality and usability of State-declared information and enhances the State-Secretariat communication on State declarations.
T.5	*Identify and exploit innovations*	T5.R.5	Develop training tools using technologies such as virtual reality, immersive learning systems and web-based training.
V.1	*Strengthen Information Collection and Analysis*	V.1.R2	Make use of new sources of openly available information, including from multimedia, and address the associated information management needs.

Priority Objectives		R&D Needs	
V.2	*Reinforce State Evaluation*	V.2.R1	Develop a set of reference material to assist SEGs in the assessment of a State's capability to accomplish acquisition path steps which take into account the level of maturity of the State's nuclear fuel cycle and associated technical capabilities.
V.5	*Employ fit-for-purpose and state-of-the art methodologies*	V.5.R3	Explore data analysis methods and tools to strengthen State evaluation and synthetize information to improve confidence in the Secretariat's conclusions, exploiting opportunities emerging from "big data" innovations (e.g. optimal random verification schemes, nuclear material flow analysis, material balance evaluation, near real time accountancy and process monitoring tools).
W.1	*Reform human resource management*	W.1.R1	Develop and maintain, through training, new expertise required by the Department, where needed, with the help of Member States.

The project supports the above R&D Needs from the *R&D Plan* by:

- Contributing to the development of new equipment taking into account existing competencies in the Department;
- Contributing to the testing of new equipment or techniques during relevant training courses; and
- Ensuring that training courses are updated or developed in a timely manner to enable safeguards staff or staff from SSACs to take full advantage from the outcomes of R&D actions.

SGCP-102 addresses the training needs for safeguards implementation, for the IAEA Department of Safeguards and for States that have a safeguards agreement with the IAEA.

For the 2018-2019 biennium, the project's top priorities are to:

- Contribute to meeting departmental strategic objectives by providing expertise, capturing best practices, developing new courses or adjusting existing courses;
- Develop a competency-based approach for training implementation, making full use of the Learning Management System deployed within the Agency-wide Information System for Programme Support (AIPS);
- Develop and implement a training programme to support State Systems of Accounting for and Control of nuclear material (SSACs) in developing their capabilities for collecting safeguards relevant information within the country and for conducting domestic inspections.

2. Background

With developments in safeguards and nuclear fuel cycle related technologies, 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), and the introduction of new safeguards equipment and technologies, training needs have significantly evolved and increased.

In addition, training courses for Member States' officials 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 safeguards 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. Four 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 most advanced training technologies and techniques, as well as best practices accumulated in the Department;
- Coping with an increasing turn-over in the inspectorate by retaining critical knowledge in senior positions despite a strict rotation policy, and providing new inspectors with the necessary training opportunities when the recruitment flow increases significantly;
- Offering a balanced training programme to meet the needs of safeguards staff, particularly inspectors and analysts, in the areas of both technical and behavioural competencies; and
- Meeting a very broad range and variety 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.

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."

The regular budget funds salaries of training staff and basic operating costs, some travel for Safeguards staff, and the Traineeship Programme in part.

Extrabudgetary funds are used for most training courses and travel for courses, as well as for Cost-Free Experts. The value of in-kind contributions are difficult for the IAEA to accurately estimate, as such figures are negotiated directly between individual MSSPs and operators or vendors (e.g. for organization of a course at a National Laboratory in the United States).

As in the past, the 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, requires strong support from Member States on logistical and technical matters.

The Training Section (CTR) applies the Systematic Approach to Training (SAT). The SAT is a methodology for managing training programmes. It is an orderly, logical approach to determining what people must know and do at a particular job or in a specific profession. The systematic approach to training ensures that people are prepared for their work by having the necessary knowledge, skills, and attitudes to do their job. The SAT is the training methodology promoted by the IAEA.

There are five main phases in the systematic approach to training: training needs analysis, design of training courses, development of training materials, implementation of training courses, and evaluation of training effectiveness.

Each step of the SAT implemented by CTR has "achievements" and "issues". Key recent achievements for the Project include:

- All verification activities are covered by training courses (Complementary Access (CA), Design Information Verification (DIV), inspection, activities at HQ).
- All training courses have clear learning objectives specified in the yearly Departmental Training Programme.
- The Training Section receives excellent support from other divisions through provision of instructors, facilitators or expert reviewers.
- Training tools using 3D modelling have been developed: a comprehensive computerized model of a pressurized heavy-water reactor (PHWR) that includes safeguards features and allows

simulating a DIV in an interactive manner; a model of a fuel fabrication plant including safeguards features and procedures; and a basic tool for setting up a surveillance system for a storage facility.

- All courses required by the Department, specifically the Operations Divisions, have been conducted. In 2016, 86 different courses were held, some offered several times during the year, which amounted to a total of 157 training courses, of which 32 were held outside IAEA Headquarters. Specific training needs for the implementation of the JCPOA have been met.
- A mechanism to evaluate training courses effectiveness has been put in place covering customer satisfaction for all courses, and the impact of training for courses including an important field part during which the learning gained by the participant can be evaluated during interactive exercises, e.g. CA training.

For the future, in addition to solving the aforementioned issues, three main activities should be considered:

- Identifying the key Departmental processes in order to focus training courses on developing skills and abilities required for the strategic points of these key processes;
- Implementing competency-based training management; and
- Complementing training provided by MTHR for career development to meet specific Departmental needs.

3. Expected Outcomes and Key Outputs

In order to reach Project SGCP-102's objective and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and / or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Enhanced ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards through the establishment of a training programme that meets the Department's needs. **(In support of V.1.R2, V.2.R1, V.5.R3, and W.1.R1)**	
Annual training programme validated for relevance and accuracy by an internal focus group meeting	November 2018 & 2019
Expected outcome 2.) Enhanced ability to detect undeclared nuclear material and activities through development and delivery of relevant training. **(In support of V.1.R2, V.2.R1, V.5.R3, P.5.R2, and W.1.R1)**	
Results of an internal focus group meeting to verify the application and relevance of training on analytical techniques	December 2019
Training courses on information collection and analysis developed and delivered in accordance with the Annual Departmental Training Programme	December 2019
Expected outcome 3.) Enhanced ability to safeguard new types of facilities through identification of training needs and training delivery to reflect the approaches and equipment for safeguarding these new facility types, including consultation with States developing such facilities. **(In support of P.5.R1 and P.5.R2)**	
Results of an internal focus group meeting to identify training needs related to safeguarding of pebble-bed reactors, small modular reactors and molten salt reactors	December 2018
Training courses covering new types of facilities developed and delivered in accordance with the Annual Departmental Training Programme	December 2019

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 4.) Maintained and enhanced ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s) through development and delivery of relevant training courses. **(In support of T.1.R3, T.1.R4, and W.1.R1)**	
Development of a Bulk Handling Facilities Training Course with at least two additional MSSPs	December 2019
Training courses at locations offered by Member States Support Programmes covering the full set of technical and integrated content in the IAEA Training Programmes for 2018 and 2019	December 2019
Development and delivery of a course on writing skills for safeguards	June 2018
Full management of the safeguards training programme through the Learning Management System (LMS) deployed within AIPS Plateau 3	June 2018
Expected outcome 5.) Developed training tools, using also advanced methods such as virtual reality, immersive learning systems and web-based training. **(In support of T.5.R5)**	
Results of an internal focus group meeting to evaluate needs for developing new tools supporting mission preparation and retention of critical knowledge.	December 2018
Computerized model of a bulk handling facility	December 2018
Training manual on Spent Fuel and Waste Management	December 2018
Expected outcome 6.) Effective and efficient support to SRA's training through training delivery and development of training material and remote delivery methods. **(In support of T.3.R1 and S.2.R1)**	
Training programme to support SSACs in developing their capabilities for collecting safeguards relevant information within the country and for conducting domestic inspections	December 2018
Training courses for SRAs developed and delivered as requested	December 2019

4. Tasks

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 objectives. Some activities are supplemented by regular budget sources.

Expected outcome 1.) ***Enhanced ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards through the establishment of a training programme that meets the Department's needs.*** **(In support of V.1.R2, V.2.R1, V.5.R3 and W.1.R1)**

To ensure that the existing training programme meets Departmental training needs regarding the implementation of the State-level Concept, reviewing and updating courses' learning objectives and contents, as well as identifying possible new courses is necessary, taking into account changes in the reference documentation or identification of best practices. Training courses and curriculum following guidance documents for the implementation of the State-level concept will be developed or updated as needed. An internal focus group meeting will validate the relevance and accuracy of the annual Safeguards training programme.

Expected outcome 2.) ***Enhanced ability to detect undeclared nuclear material and activities through development and delivery of relevant training.*** **(In support of V.1.R2, V.2.R1, V.5.R3, P.5.R2, and W.1.R1)**

To ensure the collection and processing of data and to convert data into usable information, a comprehensive set of courses has been established, including training on analytical techniques. The scope of application of analytical methods is significantly growing worldwide. It is necessary to verify the relevance and comprehensiveness of this set of courses, and ensure that State Evaluation Groups (SEGs) take full advantage of it.

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 already 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. The course is expected to complement a specific training aiming to develop skills for procurement analysis applied to nuclear or nuclear related trade. 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 has been 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 1823.
- A State Evaluation Strategy seminar was developed on internal resources in 2010. This seminar is highly recommended for staff members of SEGs.
- 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, SWE B 1373, and Specialist Training for IAEA's Imagery Analysts, 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. It is provided by the USA under voluntary contributions.
- Developing Analytical Skills for Safeguards, UK B 1940, aims to provide staff, especially members of SEGs, 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 was considered that, in order to fully own the analytical processes it uses, the Department should be able to deliver this training with its own resources in the mid-term. The course takes place on an annual basis and goes very well. In order to increase the pool of instructors, staff who already took the course as trainees participate in a course in the UK that takes place once a year. The objective is to expose future trainers/facilitators to a course conducted by UK trainers to train IAEA trainers on how to teach this specific course.
- 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 in the field knowledge gained and competencies acquired during the Nuclear Fuel Cycle and Indicators training course, UK B 1991.
- A training course has been developed with internal resources to provide analysts and inspectors with the necessary knowledge and skills to effectively use the Collaborative Analysis Platform (CAP). 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, HUN B 1525, USA B 1415, and EC B 1563).

Expected outcome 3.*) Enhanced ability to safeguard new types of facilities through identification of training needs and delivery of training to reflect the approaches and equipment for safeguarding these new facility types, including consultation with States developing such facilities to help assess what training is required.* (In support of P.5.R1 and P.5.R2)

The existing training programme covers most of the needs expressed by Operations Divisions. However, it needs to be complemented in the area of pebble-bed reactors, small modular reactors and molten salt reactors. Additional support will be required.

The pyro-processing 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. A pilot course for a pyro-processing course at an engineering scale demonstration facility took place in 2016. The course is now offered on a yearly basis with the support of ROK B 2217.

A training course on Laser Isotopes Separation Technology, FRA B 1506, is part of the long-term planning, in line with the latest developments in this technology. An additional seminar has been developed internally with the support of the Photonics Institute of the Technische Universität Wien, to ensure staff have a basic understanding of the technology and associated safeguards challenges.

Expected outcome 4.) *Maintained and enhanced ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s) through development and delivery of relevant training courses.* (In support of T.1.R3, T.1.R4, and W.1.R1)

The Learning Management System (LMS) deployed within AIPS Plateau 3 offers the possibility for a competency-based management of training activities. Important work has already been carried out to identify competencies required for verification activities. However, before making full use of the LMS, it is necessary to come up with an integrated competency framework developed in coordination with MTHR, and to adapt the LMS to the specifics of training for safeguards, particularly regarding selection of trainees (the enrolment process) and a training tracking system. A JPO (USA B 2208) brings the necessary expertise in information network for ensuring a smooth transition into the LMS, from establishing courses catalogue to developing the IT tools for moving towards a competency-based training.

An important part of the training programme aims to develop procedure-based technical skills for verification activities, and to develop the ability to perform verification activities (inspections, design information verification, complementary access) through integrated training courses organized in real nuclear facilities, research centres or laboratories. 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 now taking place at ITU. The first course at ITU took place in 2015 as a comprehensive refresher course on NDA techniques, to be taken five years after the basic course at Los Alamos.
- 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 on each site. It is complemented by a DCVD Partial Defect Test course (SWE B 1933 and CAN B 1930).

- The Advanced Plutonium Verification Course is conducted in the US with support provided under USA B 0086 and in Russia under RUS B 1719. It is complemented by Plutonium Diversion Detection, USA B 2256, 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, statistical approaches and practical tools and techniques. A pilot course has been offered in 2017 and went extremely well.
- 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.
- 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.
- A new course 'Training on Application of iRAP software for Unattended and Remote Monitoring' EC B 2019, is being developed as the software is deployed. The support will be required on a long-term basis.
- A CFE Expert – Nuclear Instrumentation Training Expert (USA B 2109) – provides the necessary high level of expertise, specialization and assistance for designing, implementing and assessing training courses for NDA techniques applied during safeguards inspections. In addition, this allows a closer and more effective cooperation between users and developers in the area of NDA techniques and equipment.

Nuclear activities verification

- The Comprehensive Inspection Exercise for light water reactors is supported by CZ B 1431, HUN B 1065 and Slovakia. 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 ROK B 1895 and SWE B 1328. At least two courses are necessary per year on a long-term basis. Safeguarding bulk handling facilities requires specific yearly training because of their complexity and their safeguards significance. Those facilities may not be always available for training because of operating constraints. A third and a fourth location are therefore necessary, in case one or two facilities are not available. Contact has been initiated with new MSSPs in this regard.
- Design Information Verification Exercise at Bulk Handling Facilities, UK B 1990, remains part of the training programme and will be required on a long-term basis.
- Design Information Verification at Research Reactors, JNT B 1757 BEL, CZ, USA is 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.
- Practical safeguards at Gas Centrifuge Enrichment Plants, UK B 1797, GER B 1896 and NET B 1852, is required on a long-term basis. The course reinforces 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 on 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. A specific training has been developed for the Office for Verification in Iran. This course will be required on a long-term basis.

- 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 2155, 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, 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. Specific scenarios have been developed to support the Office for Verification in Iran. These are key courses of the training programme and will be required on a long-term basis.
- Technical Visits to Uranium Mines, CZ B 1526, has been a flagship course for some time. Due to the end of operations at the mine, CZ SP is currently looking at alternatives to try to provide similar support This would not involve a mine visit, but appropriate training from the state mining company's school of U production (part of the World Nuclear University). The IAEA will propose the CZ SP a new SP-1.
- Training Course on Nuclear Material Accounting in Action, CZ B 1558, should continue.
- The Introduction to Safeguards Course is supported by the Czech Republic and Slovakia with visits to nuclear power plants in both countries. This course is a key component for 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. Both courses will be required on a long-term basis.
- A course on Verification at Hot Cells and Glove Boxes has been developed under USA B 2202. It includes training on how to plan and conduct environmental sampling, followed by interpreting the results of the analysis of the samples in order to identify whether or not undeclared activities took place. The course will be required on a long-term 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 inspectors training both for new inspectors 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 FIN B 1699.
- 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.
- USA B 2154 provides a key support for developing and conducting executive coaching for Directors and Section Heads, in line with the DDG's plan for strengthening managerial and leadership skills in the Department.

- A writing skills course (four sessions per year) will be developed internally. Its objective is to enable safeguards staff to report on their activities in a clear, concise and factual manner.
- The IAEA Statute, Article III.A.6, requires the IAEA to establish standards of safety (i.e., the Basic Safety Standards and supporting documents) and to provide for the application of these standards to its own operations. The IAEA Radiation Safety Regulations (Administrative Manual Part X) states that each Director in Charge shall "ensure that occupationally exposed persons are suitably trained and qualified". While the existing training has improved and continues to be improved, it has been clearly identified that resources are not available to perform a comprehensive training needs analysis which would take into account the specific missions that IAEA staff, particularly Safeguards staff, have to carry out in nuclear facilities which are not operated by the IAEA. Such analysis and definition of associated training courses are conducted under 'Radiation Safety Training' USA B 2093 and CAN B 2103. In addition:
- A 'Uranium Hexafluoride Sampling Risks and Safety Course' has been developed with internal resources to take into account lessons learned from the field, and is offered on a regular basis with the support of Seibersdorf Analytical Laboratory.
- A 'Sampling Logistic Refresher Training' has been developed on internal resources with the support of the Office of Safeguards Analytical Services (SGAS) and is offered on a regular basis. The course objective is to remind inspectors of the proper handling procedures for safeguards samples to ensure safety and to avoid delays in analytical process.
- A 'Train the Trainer' programme will be organized to develop trainer capabilities and ensure trainers are up to date with latest techniques.

Expected outcome 5.) ***Developed training tools, using also advanced methods such as virtual reality, immersive learning systems and web-based training.*** **(In support of T.5.R5)**

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 has been developed with the US under USA B 1912 and includes an interactive module simulating a DIV. A software, developed under EC B 1876, serves to train facility officers and safeguards technicians in optimizing surveillance systems. ROK B 1907 offers the development of a computerized model of a bulk handling facility for training inspectors on safeguards at this type of facility. These training tools are integrated into relevant training courses, such as those offered and supported by ROK B 1872, CAN B 1624, UK B 1903 and ICAS. These tools are also 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, allowed to make available a set of eight manuals providing a comprehensive technical background on the various steps of the nuclear fuel cycle to inspectors and analysts. 7 documents have been published: 'Mining and Milling' 'Conversion' 'Fuel Fabrication', 'Research Reactors, Critical Assemblies and Accelerator Driven Neutron Sources', 'Nuclear Power Plants', and 'Reprocessing'. 'Spent Fuel and Waste Management' is being finalized.

Expected outcome 6.) ***Effective and efficient support to SRA's training through training delivery and development of training material and remote delivery methods.*** **(In support of T.3.R1 and S.2.R1)**

SSAC courses have been reviewed in order to make better use of interactivity and visualization (in collaboration with SGIM-009). The feedback and lessons learned are extremely positive. However, training needs to be improved for two key roles of SSACs: collecting complete and correct information, and verifying correctness and completeness of information by domestic inspections before communicating this information to national authorities and the IAEA. Support for Member States, namely SSAC training and ISSAS missions, are mostly funded through extrabudgetary resources (US NNSA, Japan, Republic of Korea). Access to the Nuclear Security Fund is no longer permitted by the Division of Nuclear Security. 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:

- Support to assist 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). An e-Learning programme on Safeguards developed in the framework of the interactive e-learning series explaining the *IAEA's Milestones Approach* to introducing a nuclear power programme is available on the IAEA website. A representative of the Training Section participates in Integrated Nuclear Infrastructure Review Missions for areas of safeguards concerns;
- '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 2018 Traineeship Programme;
- International SSAC training courses, including for SQP States, organized in the US, funded by US voluntary contributions;
- Regional Training Course on SSAC, BRZ B 1811;
- SSAC Training course for States developing a nuclear power programme is offered with the support of the ROK SP;
- Consultations and Support to Member States, FRA B 1447;
- Training Courses for SSAC Personnel, RUS B 1107;
- Promotion of synergies with training centres or institutions such as ISPRA and some US national laboratories capable of complementing the training provided by the IAEA (e.g. in non-destructive assay measurements requiring nuclear material); and
- Close cooperation with the other Departments of the IAEA. The Department of Safeguards is fully involved in the implementation of integrated work plans developed as a follow-up of Integrated Nuclear Infrastructure Review Missions, preparation of reference documents by Nuclear Energy, or regular Infrastructure Coordination Meetings organized by Nuclear Energy, for areas of safeguards concerns.

In addition, the support provided by one CFE from Japan (JPN B 2273) and one CFE from the US (USA B 2017) has proven extremely effective and efficient to carry out all required activities for SSAC training and for establishing and maintaining the required level of cooperation between IAEA departments for IAEA-wide activities supporting the development of peaceful nuclear power programmes, for supporting the development of SSACs in some specific regions like Central Asia and Africa and for contributing to the development of reference documentation.

It must be noted that there is a need for ensuring a harmonization mechanism among all stakeholders providing Member States with training to build their capacities for developing nuclear energy or to implement 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).

Harmonization and cooperation for education and training in the area of non-proliferation are carried out with other educational institutions and entities, such as the International Nuclear Safeguards and Engagement Programme (INSEP - United States of America), the Integrated Support Centre for Nuclear Non-Proliferation and Nuclear Security (ISCN – Japan), the International Nuclear Non-proliferation and Security Academy (INSA – Republic of Korea), the Vienna Centre for Disarmament and Non-Proliferation (VCDNP – Austria) and the Middlebury Institute of International Studies at Monterey **(**MIIS – United State of America**).**

Activities with INSEP, ISCN and INSA aim to support developing and maintaining SSACs through international, regional or national courses to ensure that training delivered is consistent with reference documents published by the IAEA and to enable States to meet IAEA safeguards needs regarding

collecting, processing and communicating to the IAEA safeguards relevant and accurate information required by their safeguards agreements and protocols.

Activities with VCDNP and MIIS aim to support educational programmes for students or diplomats to ensure that concepts and basic knowledge presented are consistent with IAEA safeguards implementation.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the projects *4.1.1.004 Staff training and traineeship* and *4.1.1.005 Training and assistance to SSAC* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (agency's task cross reference)	Description	Expected Completion Date
1	1	Supporting the implementation of the State-level concept (4.1.1.004-2018.01)	Develop training courses and curriculum following guidance documents for the implementation of the State-level concept.	Ongoing
2	2	State evaluation strategy seminar (4.1.1.004-2018.01)	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.	Ongoing
4	3	Writing skills course (4.1.1.004-2018.01)	Develop training to enable safeguards staff to report in a clear, concise and factual manner.	June 2018

4.3 Attachments

Figure 1: State Systems of Accounting for and Control of Nuclear Material (SSAC) Training, 2017, Republic of Korea

Figure 2: Advanced Training on Nuclear Fuel Cycle Facilities to Assist State Evaluation, 2017, United Kingdom

Figure 3: Introductory Course on Agency Safeguards (ICAS) Training, 2017, Vienna

SGIM-002

Satellite Imagery Analysis

Project Manager: Michael Flory

Division: SGIM

Note: Project SGIM-002 has been renamed *Satellite Imagery Analysis* from the previous *Geospatial Information Analysis* to better reflect the core business of the project's goals and activities.

1. Overview

This document describes the plans for developing and implementing Project SGIM-002 *Satellite Imagery Analysis*, within the Department of Safeguards for the period 2018-2019.

During the 2018-2019 biennium, Project SGIM-002 will pursue the following objective:

Continuously improve the IAEA's ability to acquire, analyse, and exploit satellite imagery and geospatial information to support verification activities.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.5.003 State infrastructure analysis*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.3	*Support all SG processes through IT*	T.3.R3	Build on the development of geographic information system (GIS) technology to enhance geo-based information sharing and related analysis.
V.1	*Strengthen information collection and analysis*	V.1.R1	Enhance the set of expert tools necessary to process the variety of SG-relevant information and implement them, with emphasis on timely responses and cost-effectiveness.
		V.1.R3	Further integrate safeguards information to strengthen all-source information analysis and make it more user-friendly (e.g. via the Collaborative Analysis Platform).
V.4	*Enhance SG effectiveness monitoring and evaluation*	V.4.R1	Identify and deploy analytical tools, including data visualization, to better measure and analyse performance and take advantage of capabilities provided by MOSAIC.
W.1	*Reform human resource management*	W.1.R1	Develop and maintain, through training, new expertise required by the Department, where needed, with the help of Member States.

Detailed analysis of satellite imagery and all-source geospatial information is an accepted and essential element of the IAEA's verification of compliance with safeguards agreements. It has demonstrated its value, and is routinely used as a reference source to:

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

Project SGIM-002 is focused on improving processes, workflows and methodologies that will further enhance the Department's ability to manage, analyse, and disseminate actionable imagery and geospatial analysis and information in a timely manner.

For the 2018-2019 biennium, the project's top priorities are to:

- Conduct further research into the processing, analysis and safeguards applications of synthetic aperture radar (SAR) and thermal infrared (IR) satellite imagery, and develop and implement analytical products to enable wider use of SAR and IR imagery within the Department;
- Provide specialist training for analysts on satellite imagery exploitation and allow opportunities for analysts to participate in familiarization visits to nuclear fuel cycle facilities;
- Continue to identify new methods and capabilities that effectively integrate all source information with commercial satellite imagery in a collaborative geographic information system (GIS) workspace.

2. Background

Geospatial information plays a significant role in monitoring nuclear fuel cycle sites and activities, verifying States' declarations, planning and supporting verification activities, and detecting and investigating undeclared activities. Geospatial information has become one of the most important information sources available to the Department of Safeguards for remotely monitoring nuclear sites and activities, especially in areas where inspectors do not have direct access. Imagery continues to play an essential role in assessing situations and informing the Secretariat as well as Member States. The use of GIS technologies is critical to this endeavor, making possible the combination and comparison of the geographic information contained within imagery with other data sources covering the same geographic extent. The use of GIS permits analysts to process, store, manage, retrieve and create geospatial data as well as to analyse this information spatially.

In recent years, both opportunities and challenges for satellite imagery analysis have expanded dramatically. New, high spatial and spectral resolution sensors with significantly improved re-visit times (temporal resolution) provide unprecedented opportunities to monitor sites and activities. This enables IAEA imagery analysts to provide better analysis with higher levels of confidence, which ultimately supports the strengthening of IAEA safeguards. In addition to optical imagery, commercial imaging radars, infrared sensors and satellite-based video have the potential to enhance the analytical process and provide analysts with more and different information to support operational requirements. In addition, new tools and methods (mostly commercial) have been developed to support and enhance the geospatial workflow, such as pre-processing scripts and tools to semi-automatically generate a series of standard image products that are ready for analysis.

In 2017, the Division of Information Management (SGIM) deployed the upgraded Geospatial Exploitation System (GES 2) into the Department's Integrated Safeguards Environment (ISE). GES 2 leverages the latest GIS and Web technologies to provide: increased and sustained system performance; additional system capabilities (3D, metadata access, and full motion video capability); and improved integration to/from other systems/datasets within ISE. GES 2 was developed with the business users in mind and addresses the primary mission of the Section, namely satellite imagery analysis. In the future, with the migration of more safeguards-relevant data and applications into ISE under Project SGIS-003, the challenge is to foster more integration between tools and data to better support collaborative analysis.

To improve processes, workflows and methodologies that will further enhance the Department's ability to manage, analyse, and disseminate satellite imagery and geospatial analysis, the Department must continue to recruit experienced staff with a strong technical background in imagery analysis and a workable knowledge of GIS software, and provide them with training opportunities to further improve their understanding of the nuclear fuel cycle and its imagery signatures. Increasing demands within the Department for geospatial information, the requirements for monitoring in areas of safeguards concern or conflict where the IAEA has no direct access, and the need to integrate and exploit safeguards-relevant information across the Department pose significant challenges that require on-going development and long-term investments.

Most of the funding for the acquisition of commercial satellite imagery comes from the regular budget. MSSP support will be required to enable the Department to focus on evaluating new sensors, techniques and tools to support analysis and integration activities.

3. Expected Outcomes and Key Outputs

In order to reach Project SGIM-002's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Enhanced analytical process through evaluation and testing of new sensors, imaging capabilities, tools and techniques and provision of more and different information to the analysts. **(In support of T.3.R3, V.1.R1, and V.4.R1)**	
Advanced radar techniques incorporated into routine imagery analytical reporting	December 2019
Commercial satellite imagery acquired from diverse sources to ensure the integrity and authenticity of satellite imagery as an open source of information.	ongoing
Expected outcome 2.) Enhanced staff skills in processing and analysing satellite imagery to detect signatures of undeclared activity, improve analysis of nuclear fuel cycles, and better support the State evaluation process. **(In support of W.1.R1)**	
Training on Esri GIS Applications in support of GES enhancements	December 2019
Attendance at geospatial international conferences (GEOINT, Esri)	ongoing
On-site training in imagery observables of the nuclear fuel cycle	December 2019
Expected outcome 3.) Enhanced collaborative analysis through enabling the consumption of information from other relevant applications (e.g. APS and SGMD) and exposing geospatial information to other applications in ISE (e.g., State File, Collaborative Analysis Platform and Geospatial Data Integration) **(In support of V.1.R3)**	
Release of upgrades to the GES: an enterprise task management system, additional data management capabilities, and the capability to interact directly between expert applications (RemoteView/Esri ArcGIS).	December 2019

4. Tasks

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 within Agency's project *4.1.5.003 State infrastructure analysis*.

Expected outcome 1.) ***Enhanced analytical process through evaluation and testing of new sensors, imaging capabilities, tools and techniques and provision of more and different information to the analysts.*** **(In support of T.3.R3, V.1.R1, and V.4.R1)**

A continuing issue for 2018-2019 is to expand and diversify sources of imagery upon which to base analytical activities. UK D 1329 provides the ability to acquire non-standard imagery for priority tasks. Over the last several years, this has been a shared resource with SGIM-003, serving to ensure the integrity and authenticity of satellite imagery as an open source of information. Satellite-based radar and video, as well as new infrared sensors, have the potential to enhance the analytical process and provide analysts with more and different information to support operational requirements. UK D 1819 provides experience from subject matter experts on priority tasks on an ad-hoc basis. In 2015, a CFE radar specialist (CAN D 2018)

joined the section. In 2018-2019, the expert's focus will be to incorporate proven, production-level, Safeguards-related satellite radar processes and products into SGIM's State Infrastructure Analysis (ISI) capability (CAN D 1976, FIN D 1996, GER D 1983 and JPN D 1995), and to continue to evaluate, improve, develop and apply new Safeguards-applicable radar techniques, software, and data. Task JNT D 1657 with the French, Japanese and German Support Programmes supports this effort.

In 2012 the European Commission pledged an in-kind voluntary contribution to the IAEA in the form of commercial satellite imagery over nuclear sites of common interest to EURATOM and the IAEA. In 2013, the IAEA agreed to all European Space Agency's (ESA) terms and conditions, signed the Global Monitoring for Environment and Security (GMES) sub-license, and began to receive commercial satellite imagery under this arrangement. This licence is valid until 2020.

Visualization and 3D analysis is a growing area for the Department. The ability to represent sites and facilities in 3D with modelled buildings and infrastructure and textured digital elevation has proven invaluable in the context of managed access visits, when inspectors generally have a single chance to visit a site and conduct verification activities. Further work is being done in collaboration with SGCP-102 under the new task 17/OA3-001, Development of 3D Models for Critical Nuclear Facilities.

The US Support Programme is assisting SGIM-ISI through the recruitment of a CFE Image Scientist and Remote Sensing Technical Expert from early 2018. The expert will be primarily responsible for working with imagery analysts and support staff to identify and implement value-added post-processing techniques that could further enhance the exploitation of commercial satellite imagery, both electro-optical and radar.

Expected outcome 2.) Enhanced staff skills in processing and analysing geospatial imagery to detect signatures of undeclared activity, improve analysis of nuclear fuel cycles, and better support the State evaluation process. **(In support of W.1.R1)**

Training in support of image processing, image analysis and geospatial technologies remains a critical need. NET B 1851, GER D 1457, USA B 1442 and UK B 1655 are used for technical training support. In recent years, training has focused on use of commercial software, radar exploitation, and advanced image analysis techniques. This has been supported using a combination of regular and extrabudgetary sources.

Future training requirements are needed to ensure that SGIM analysts remain up-to-date with the latest commercial imagery and GIS software developments available. In particular, training associated with Textron Systems' RemoteView software suite and ESRI's GIS applications (ArcGIS Pro, Story Maps, Op Dashboard) has been identified as likely to provide greater opportunities to effectively integrate all source geospatial information with imagery analysis in a collaborative workspace.

Staff in the section will also continue to significantly benefit from familiarization visits to nuclear fuel cycle sites/facilities with the active support and participation of Member States (CAN B 1484, GER B 1456, SWE B 1504). Similarly, attendance at satellite imagery and GIS industry events allows staff to stay current with new and emerging industry developments and standards. Priority events include GEOINT, DGI Europe and ESRI annual conferences. These are typically supported using a combination of regular budget and MSSP contributions.

Expected outcome 3.) Enhanced collaborative analysis through enabling the consumption of information from other relevant applications (e.g. APS and SGMD) and exposing geospatial information to other applications in ISE (e.g., State File, Collaborative Analysis Platform and GDI). **(In support of V.1.R3)**

In 2017, the GES 2 is being updated to include adaptation of its data model architecture, performance and enhanced functionalities. The functionalities will include mechanisms to ingest, view and analyze State provided data, such as site maps reported to the Agency under Article 2.a.(iii) of Additional Protocols. These activities are linked with activities of Digital Declaration Site Maps (DDSM) from Project SGIM-009 and will be implemented in collaboration with SGIS-003.

In 2018-2019, the integration of satellite imagery reports with the State File will be improved to allow users to conduct full-text searches on all satellite imagery analysis reports within ISE.

4.1 MSSP Development and Implementation Support Tasks

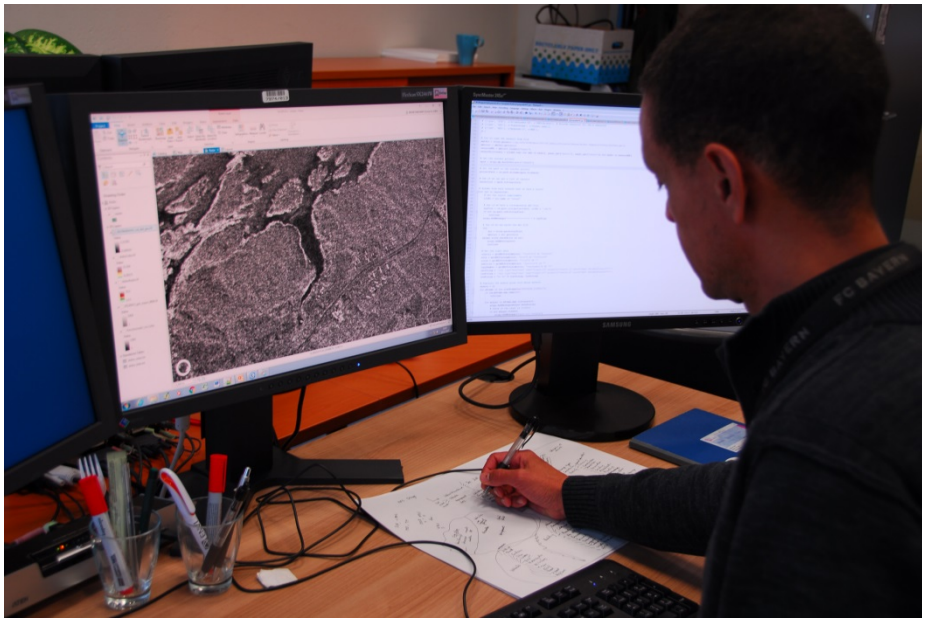
MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.5.003 State infrastructure analysis* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Tasks #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
1	1	Evaluation of new sensor capabilities (2018.03)	SGIM-ISI is working with SGTS-008 on evaluating new and evolving satellite capabilities (e.g., PlanetLabs)	2019
	2	Evaluation of new sensor capabilities (2018.03)	SGIM-ISI is working with commercial vendors on evaluating new and evolving sensor capabilities (Google's Skybox, Urthcast)	Ongoing

4.3 Attachments



Figures 1 & 2: Analysts in the State Infrastructure Analysis Section working with electro-optical and radar imagery sources

SGIM-003

Information Analysis

Project Manager: Brian Aubert

Division: SGIM

1. Overview

This document describes plans for further developing methodologies and processes for all parts of the open source information analytical cycle, namely identification, collection, processing, analysis, dissemination, and information management. It also guides the development of improved technologies that aid in all steps of the open source information analysis cycle, including the analysis of trade and procurement data, scientific and technical publications, and multimedia information within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGIM-003 will pursue the following objective:

Enhance the IAEA's ability to collect and analyse information in support of the IAEA's verification mission, in particular with respect to the State evaluation process and in support of in-field verification activities.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.5.004 Information collection and analysis*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
V.1	*Strengthen information collection and analysis*	V.1.R1	Enhance the set of expert tools necessary to process the variety of SG-relevant information and implement them, with emphasis on timely responses and cost-effectiveness.
		V.1.R2	Make use of new sources of openly available information, including from multimedia, and address the associated information management needs.
		V.1.R3	Further integrate safeguards information to strengthen all-source information analysis and make it more user-friendly (e.g. via the Collaborative Analysis Platform).
V.5	*Employ fit-for-purpose and state-of-the-art methodologies*	V.5.R3	Explore data analysis methods and tools to strengthen State evaluations and synthesize information to improve confidence in the Secretariat's conclusions (e.g., optimal random verification schemes, nuclear material flow analysis, material balance evaluation, near real-time accountancy and process monitoring tools).

SGIM-003 focuses on collecting, analysing and integrating disparate information sources to detect possible inconsistencies in nuclear programmes and States' declarations in support of the State evaluation process. The rapidly expanding volume of safeguards-relevant information necessitates a continuous process of further development and long-term investment in technology and tools to collect, analyse, organize and present valuable information in a clear and accessible manner.

For the 2018-2019 biennium, the project's top priorities are to:

- Complete planned enhancements on a system to collect, process, and manage text-based safeguards-relevant semi-structured and unstructured open source information, to include automatic collection of information from identified sources, and mechanisms for adding structure to unstructured data;
- Optimize the use of multimedia information collection, analysis, and integration in State evaluation and preparation for in-field activities, through the development and deployment of specialized tools, methods, and procedures;
- Continue to work to integrate open source data sets with other safeguards information and systems, including for declared information consistency analysis and in-field activity preparation, to enable its use in techniques such as link analysis and geospatial visualization, and to develop all necessary use cases and procedures.

2. Background

Open source information, including trade and procurement data, scientific and technical (S&T) literature, and multimedia information, is an important element of an effective safeguards system. Open source information is now routinely used to verify correctness, completeness, and the consistency of State declarations. Integration of safeguards-relevant open source information strengthens the analysis of States' declarations and information resulting from in-field activities. In particular, open source information can be integrated with other available information to assist in the planning of State evaluation activities both at headquarters and in-field, and can be used to identify indications of potentially undeclared activities or materials.

Information is collected from a wide range of open sources, including international and national news media, commercial databases and websites, government reports and databases, new media sources and S&T literature databases. The Safeguards-wide dissemination of open source information in the OS Library in the Integrated Safeguards Environment (ISE) and in the Open Source Highlights daily newsletter maintains on-going awareness of safeguards and non-proliferation developments and issues. The accumulation of safeguards-relevant information also provides a historical archive that can be utilized to better assess the development of activities relevant to safeguards in regard to states' legal obligations with the Agency.

Effectively meeting the challenges and opportunities in support of drawing soundly-based safeguards conclusions requires on-going development and long-term investment in technology, tools, and methods that effectively collect relevant open source information, filter out 'noise', and organize safeguards-relevant information in a clear and accessible manner. Another challenge lies in ensuring that the information that already exists in internal databases and archives is used optimally, and continues to be fully integrated with other available information—this also requires further development in information management tools and methods.

The identification and collection of requirements for the tools and methods associated with effectively utilizing open source information originates in SGIM with collaboration with the Operations divisions and other users. Following those requirements, SGIS develops and deploys the majority of required software applications. Specific expert software tools are also developed in SGIM. For the development of information systems running on the Safeguards platform, the collaboration between SGIM and SGIS is essential to ensure user satisfaction, compatibility and maintainability of systems that will facilitate the integration of safeguards data.

Most of the funding for information collection and analysis comes from the Department's regular budget. MSSP support will be requested to focus on specific areas, including the development of analytical methodologies and capabilities, assistance in diversifying sources, improving the technology and expert tools required, and the provision of subject matter experts in relevant nuclear fuel cycle fields.

3. Expected Outcomes and Key Outputs

In order to reach Project SGIM-003's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Enhanced assessment of nuclear programmes and detection of inconsistencies in States' declarations through the development of optimized tools and methods for the collection, processing, and management of currently utilized Safeguards-relevant open source information. **(In support of V.1.R1)**	
Integration of the European Media Monitor (EMM) as a data source into the OSIS 2.0 system	July 2019
Results of testing of other tools, such as the OSINT suite and the Big Table, developed by the Joint Research Centre (JRC)	December 2019
Review and optimization of current open source information search and collection methodologies and techniques	July 2019
Expected outcome 2.) Enhanced assessment of nuclear programmes and detection of inconsistencies in States' declarations through the development of optimized tools and processes to update and diversify the pool of safeguards-relevant open source information (in cooperation with SGIS-003). **(In support of V.1.R2)**	
Development and deployment of tools, methods, and procedures for the optimized use of multimedia information analysis under the SG-Multimedia Project	December 2019
Identification, collection, processing, and integration of information from new safeguards-relevant information sources	On-going
Development and deployment of new tools and methods to optimize the continuous monitoring of new sources of information	On-going
Expected outcome 3.) Improved State evaluation process through continuously improved open source information analysis methods and computerized tools to aid the analysis of large amounts of structured, semi-structured, and unstructured data. **(In support of V.5.R3)**	
Identification and collection of requirements for a system to enhance the management and analysis of information related to international nuclear cooperation	December 2018
Identification and collection of requirements for tools to enhance the analysis of safeguards-relevant information on trade and industrial capabilities of States, including through the use of data visualization	On-going
Establishment of a documented strategy for utilizing data visualization and network analysis on structured and semi-structured open source information (including trade data)	On-going
Development, deployment, and enhancement of tools, following above strategy	On-going
Member State peer reviews of tools and methods and reports, consultancies, employment of highly qualified staff, and training to continuously improve the open source analysis methodologies and procedures	On-going

Expected Outcomes and Key Outputs	Expected Completion Date
Training for trade and technology analysis unit	On-going
Expected outcome 4.) Improved integration of open source information in 'all source' information analysis, contributing towards collaborative analysis and in line with MOSAIC. **(In support of V.1.R3)**	
Integration of open source information collections with ISE State Files, Palantir, and other MOSAIC applications (in collaboration with SGIS-003)	July 2019

4. Tasks

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 objectives. Some activities are supplemented by regular budget sources.

Expected outcome 1.) ***Enhanced assessment of nuclear programmes and detection of inconsistencies in States' declarations through the development of optimized tools and methods for the collection, processing, and management of currently utilized Safeguards-relevant open source information.*** **(In support of V.1.R1)**

For 2018-19, the objective is to complete the planned enhancements on tools and methods to collect, process, and manage text-based safeguards-relevant semi-structured and unstructured open source information, to include automatic collection of information from identified sources, and mechanisms for adding structure to unstructured data.

The SGIM Global Monitoring Team has for several years utilized the European Media Monitor (EMM) together with the NewsDesk product that was customized for SGIM use (EC D 1880) by the European Commission Joint Research Centre (JRC) at Ispra to monitor news and create newsletters. Several enhancements have recently taken place, including improvements in the search engine. Relatedly, SGIM-ISF has recently deployed the Open Source Information System 2.0, a tool that further automates many of the information monitoring, collection and analytic structuring tasks for the Global Monitoring Team and for open source analysts working in State Evaluation Groups. This system ties in with the NewsDesk tool, taking advantage and enhancing many of the capabilities that JRC built into the system. SGIM-ISF will continue to work with the JRC including further integrating EMM as a data source into the OSIS 2.0 system. SGIM-ISF is also seeking to test other tools developed by the JRC to support open source search and collection requirements.

One JPO under RUS D 2232 has been extended into 2018 and one new CFE under ROK D 2252 will be available through 2018. Several new or replacement JPOs and CFEs will be available in the 2018-2019 biennium under USA D 2014, USA D 2123, USA D 2260, UK D 2013 and JPN D 1733.

Analysis of scientific and technical literature can provide indications of undeclared nuclear activity, as well as additional assurance on the correctness and completeness of States' declarations under Comprehensive Safeguards Agreements and Additional Protocols. To that end, scientific and technical literature monitoring processes are being further developed, including through incorporation of relevant techniques from professional bibliometric and semantic searching (with continued support by JNT D 1902 FRA and USA, although new activities are not excluded). This monitoring system builds further on existing search strategies and methodologies optimized to identify and organize safeguards-relevant articles and to disseminate them to Safeguards staff responsible for their evaluation.

Expected outcome 2.) ***Enhanced assessment of nuclear programmes and detection of inconsistencies in States' declarations through the development of optimized tools and processes to update and diversify the pool of safeguards-relevant open source information.*** **(In support of V.1.R2)**

The goal is to develop optimized tools and processes to identify new sources and types of data, to include new text-based information sources, multimedia information, and trade data, and enable the efficient collection, processing, analysis, integration, and management of this data. In the biennium 2018-2019, the use of multimedia information analysis and its integration in State evaluations and preparation for in-field activities will be further optimized. It will require MSSP support in the form of expert support (USA D 1126) in tool assessment, development of use cases, methodologies, procedures, and training materials, as well as expert support in multimedia analysis and forensics.

The IAEA seeks to constantly expand the sources of safeguards relevant information upon which to base its analysis to support the drawing of safeguards conclusions. Such work has been on-going since 2008–2009 with regular budget funding and will be continued in 2018–2019. A continuing issue 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, ROK D 1213) and retrieval of information from new media (BEL D 1478, RSA D 1489).

One such additional source of information that requires further development is patent classification codes with respect to the Physical Model; support from in-house experts has already been provided but the remaining areas of the Physical Model that have not yet been sufficiently covered will be required (in collaboration with SGCP-003). Additionally, a number of sources for trade and procurement data have been identified and evaluated for use. Support is needed to continue this process (EC D 1662, UK D 1916 and HUN D 1919); assistance from Member States will be sought to develop the use of a number of sources in the context of the MOSAIC project (in collaboration with SGIS-003).

Expected outcome 3.) ***Improved State evaluation process through continuously improved open source information analysis methods and computerized tools to aid the analysis of large amounts of structured, semi-structured, and unstructured data.*** **(In support of V.5.R3)**

Open source analysis methods and tools need to be continuously improved for drawing soundly-based safeguards conclusion. This includes enhancing the analysis of technical information and large quantities of structured, semi-structured, and unstructured data, in order to detect signatures of possible undeclared activity; improving analysis of nuclear fuel cycles and activities possibly related to weaponization; and supporting the State evaluation process including the development of acquisition path analysis (APA) and State-level approaches (SLAs).

To better facilitate the analysis of trans-national issues, the development of a system to manage open source information related to international nuclear cooperation has been initiated. Such a system would both allow deeper analysis of open source information already existing in the SGIM-ISF OS Library, and would also enable easier processing and analysis of such issues in future collection.

New tools and methods for enhanced analysis of safeguards-relevant information on trade and industrial capabilities are being developed for use in the State Evaluation process, to support the development of APAs and SLAs, for consistency analysis of State declaration, and the detection of potential indicators of undeclared activities.

New methodologies that help the analysis of large, disparate data sets through link analysis and visualization will be developed for Safeguards, spanning the entire range of analytical activity from the classification of information sources to efficient and effective information retrieval; this may include further work on the development of a customized ontology, taking into account development towards shared analytical platforms in the Department.

Inputs from specialized technical consultants play a significant role in enhancing the Department's capability to evaluate new technologies and complex issues. Provision of consultants with extensive experience in particular aspects of open source analysis by Member States (USA D 1126, UK D 1819, and AUL D 1915) and 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. A number of technical conferences and trade fairs will be visited for this purpose. Member State support in this regard remains indispensable.

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) has proven effective in raising the competence levels of analysts, and will be continued.

Expected outcome 4.) ***Improved integration of open source information in 'all source' information analysis.*** **(In support of V.1.R3)**

It is increasingly necessary to optimize the integration of open source information into tools and methods for 'all source analysis' in order to detect possible signatures of undeclared activity, to improve analysis of nuclear fuel cycles and activities possibly related to weaponization, and to support the State evaluation process and drawing of soundly-based safeguards conclusions. Work will continue to integrate open source data sets with other safeguards information and systems, including for declared information consistency analysis and in-field activity preparation, and to develop use cases and procedures tailored to SG needs, enabling their use in tools and techniques (including link analysis and geospatial and other visualizations) deployed through MOSAIC in support of collaborative analysis in the Department.

SGIM-ISF will continue to collaborate closely with SGIS-003 to further structure and integrate its open source information collections into other SG systems, including (but not limited to) ISE State Files, Palantir, and other MOSAIC applications.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.5.004 Information collection and analysis* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks (in cooperation with SGIS)

Expected outcomes	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
1	1	Text-based OS automation (2018.04)	Complete planned enhancements on tools and methods to collect, process, and manage text-based safeguards-relevant semi-structured and unstructured open source information, to include automatic collection of information from identified sources, and mechanisms for adding structure to unstructured data.	July 2019
	2	Search and collection (2018.04)	Review and optimize current open source information search and collection methodologies and techniques, including developing and deploying any necessary tools.	July 2019

Expected outcomes	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
2	3	Multimedia analysis (2018.04)	Optimize the use of multimedia information analysis and integration in State evaluation and preparation for in-field activities, through the development and deployment of tools, methods, and procedures.	December 2019
	4	New OS sources (2018.04)	Continue to identify and collect information from new safeguards-relevant information sources, and develop and deploy new tools and methods to optimize the continuous monitoring such sources of information	On-going
3	5	International nuclear cooperation (2018.04)	Develop and deploy a system to enhance the management and analysis of information related to international nuclear cooperation	January 2019
	6	Trade and industrial infrastructure tools (2018.04)	Develop and deploy tools and methods to enhance the analysis of safeguards-relevant information on trade and industrial capabilities of States, including through the use of data visualization tools.	On-going
	7	Visualization and network analysis (2018.04)	Develop strategy for utilizing data visualization and network analysis on structured and semi-structured open source information (including trade data); develop and enhance tools as necessary	On-going
4	8	Information integration (2018.04)	Continue to work to integrate open source data sets with other safeguards information and systems, including for declared information consistency analysis and in-field activity preparation, to enable its use in techniques including link analysis, and geospatial and other visualizations, and to develop all necessary use cases and procedures, tailored to SG needs, contributing towards collaborative analysis in the Department, and in line with MOSAIC	On-going

4.3. Attachments

Figure 1: State Factor Analysis Section's Nuclear Trade Team

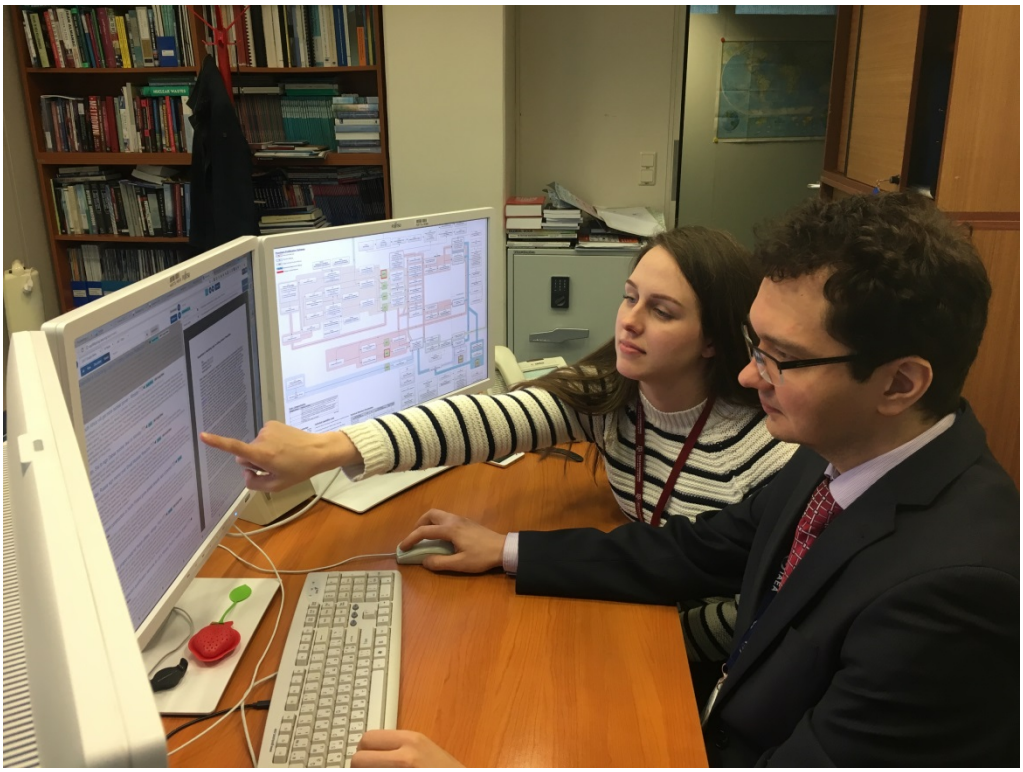


Figure 2: Junior Professional Officers (JPOs) reviewing the daily open source collection as part of the Global Monitoring Team

Figure 3: State Factor Analysis Section's Science and Technology Team

SGIM-007

Evaluation of Data from Environmental Sampling and Material Characterisation

Project Manager: Diane Fischer

Division: SGIM

1. Overview

This document describes plans for developing and implementing new capabilities for assessing results from environmental sampling and the characterisation of uranium materials within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGIM-007 will pursue the following objective:

Enhance the IAEA's ability to structure, organise, evaluate, interpret and present data from environmental sampling and material characterisation in support of the IAEA's verification mission, in particular with respect to the IAEA's ability to detect undeclared nuclear material and activities.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.5.02 Nuclear fuel cycle information analysis*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.3	*Support all SG processes through IT*	T.3.R4	Maintain and continue to upgrade the environmental sampling database and the process modelling tools as well as the database and tools that support trace elements analysis (material characterization).
V.5	*Employ fit-for-purpose and state-of-the-art methodologies*	V.5.R1	Upgrade existing and develop new statistical methodologies applied to the: • Evaluation of quantitative and qualitative verification data including at the State level (e.g., for nuclear material balance evaluation, random inspections) • Measurement of verification performance (in terms of detection probability) and the associated level of confidence at the facility and state level • Design of random verification schemes (minimizing resources for the same level of effectiveness).
		V.5.R2	Strengthen knowledge of the elemental and isotopic signatures of the nuclear fuel cycle and processes that are specifically detectable through material characterization and environmental sample analyses, and develop expert systems and methodologies that advance data evaluation and enhance continuity of knowledge.

SGIM-007 addresses the development of mathematical, statistical and graphical tools for relating elemental, morphological, and isotopic data from environmental sampling and material characterisation to nuclear fuel cycle activities and processes. The project focuses on optimising current procedures and tools, exploring new evaluation and sampling approaches, and expanding the understanding of the detectable signatures, including the formation, fate and transport of particles of various elemental compositions.

For the 2018-2019 biennium, the project's top priorities are to:

- Explore and develop statistical techniques and evaluation methodologies that improve data evaluation and the application of signatures detectable through environmental sampling and material characterisation, including the use of elemental and morphological data;
- Expand the current understanding of the detectable signatures (isotopic, elemental and morphological characteristics of key materials) of nuclear fuel cycle activities, including the formation, fate and transport of particles in the environment.

2. Background

Environmental sampling is an essential verification measure that provides technical information to detect indications of undeclared nuclear material and activities and to support the drawing of safeguards conclusions regarding the absence of undeclared nuclear material and activities. Material characterisation aids in identifying the composition and purity of uranium material that meets the conditions of paragraph 34(c) of INFCIRC/153 (Corr.) and is required to be placed under safeguards. Both environmental sampling and material characterisation contribute to the State evaluation process by providing information that is generated by the Department and not available through other sources.

The Division of Information Management (SGIM) is responsible for evaluation of environmental sampling and material characterisation data. The Operations Divisions within the Department are end users of such information when incorporating such information for support of in-field activities, while the ultimate end-use for the Department as a whole is the contribution toward the State evaluation process and the drawing of safeguards conclusions. As possible deception scenarios, the IAEA will continue to experience challenges in maintaining an effective and efficient safeguards verification system. Therefore, all aspects of the environmental sampling and material characterisation planning, implementation and evaluation require continual advancement to improve verification capability and reliability. This includes investigating sampling strategies, processing and evaluating sample-related information and laboratory analysis results, modelling nuclear-fuel-cycle processes, and quality control of the entire process.

Most of the funding for this data evaluation contributing directly to safeguards implementation comes from the Department's regular budget. MSSP support will be requested to address the development or optimization of statistical techniques and evaluation methodologies that improve data evaluation and further the use of elemental and morphological data. The main areas of tasks supported by 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 isotopic and elemental 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 IAEA.

SGIM-007 is closely related to and coordinated with the two projects aimed at improving quality and reliability of the laboratory analyses of safeguards samples: SGAS-002 *Environmental Sample Analysis Techniques* and SGAS-003 *Analysis Support and NWAL Coordination*.

3. Expected Outcomes and Key Outputs

In order to reach Project SGIM-007's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Developed elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and their application to the analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools. **(In support of V.5.R2)** The IAEA seeks to expand its understanding of the detectable signatures (isotopic, elemental, and morphological characteristics of key materials) of nuclear fuel cycle activities, including the formation, fate, and transport of particles in the environment.	
Collection of uranium impurity data and fuel burnup inventories obtained from studies completed by Member States for integration into existing SGIM-IFC evaluation libraries	December 2018
Release of upgraded MSTAR'12 cascade modelling software to include side streams	December 2018
Development of beta software for alCHEMy, evaluation software for cross referencing isotopic and elemental data with nuclear fuel cycle (physical model) signatures	December 2019
Expected outcome 2.) Developed statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results. **(In support of V.5.R1)** The IAEA seeks to explore and develop statistical techniques and evaluation methodologies that improve data evaluation and the understanding of signatures observable through environmental sampling and material characterisation, including the use of elemental and morphological data.	
Deployment of the DAVE software for evaluation of trace element and isotopic signatures in uranium samples	June 2018
Deployment of the INDEPTH software for identifying fuel burnup, starting enrichments, and cool down times	June 2018
Release of customized Visual Sampling Plan software for providing detection/non-detection confidence levels	December 2018
Expected outcome 3.) Maintained and upgraded ES Evaluation software tools and applications to meet future safeguards information technology requirements and ensure no loss of service. **(In support of T.3.R4)** The IAEA seeks to ensure the ES evaluation tools are compatible with the department's migration to new operating systems and computer architecture, therefore software and applications must be validated and incompatibilities remedied.	
Release of software upgrades related to the new information landscape and validation testing of all ES evaluation software, in preparation of the transition to 64-bit personal computers using Windows 10	June 2019

4. Tasks

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 objectives. Some tasks are supplemented by regular budget sources within Agency's project *4.1.5.02 Nuclear fuel cycle information analysis*.

Expected outcome 1.) ***Developed elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and their application to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools.*** **(In support of V.5.R2)**

In the 2018-2019 biennium, the IAEA will undertake activities that enlarge the reference data related to nuclear fuel cycle elemental and isotopic signatures. Such reference data bolsters the environmental sampling data analysts' ability to evaluate environmental sampling data by providing comparative data, thereby improving confidence in evaluation conclusions. Tasks that will extend reference data for various nuclear signatures include the expansion of the library of radionuclide inventory based on WIMSD[1] calculations that model reactor irradiation scenarios for multiple reactor designs and fuel configurations (UK A 1853); and the continuing investigation of uranium elemental signatures (EC A 1753, BRZ A 1766, and CZ A 2223). Uranium ore concentrate samples from a plant in the Czech Republic have been collected and are undergoing analysis. The reporting and evaluation of the results are expected to be completed during this period. Expansion of the MSTAR[2] enrichment application is under consideration to include multiple streams (side-feed and/or side-product) and coupled cascades (USA A 1498). Further support from the MSSP will be sought to investigate and expand our understanding of nuclear fuel cycle elemental and isotopic signatures.

In addition, the IAEA is conducting several studies in 2018-2019. The first is a continuation of the examination of the detectable signatures related to a post-detonation nuclear event using the typical environmental sampling analytical methods. Analysis of specimens from ground zero of the Trinity site using gamma and particle techniques has been completed. The next steps being considered are the use of bulk and elemental analysis. A second major study, alCHEMy, involves evaluating elemental signatures related to the nuclear fuel cycle (NFC). The ongoing work will include establishing a reference database of elements and chemical compounds associated with NFC activities. An application is being developed to cross reference the reference database with large data sets of ES elemental and isotopic particle data to aid in identifying material combinations associated with nuclear activities. Once established, alCHEMy will provide a systematic and sustainable approach to evaluating elemental data.

Lastly, the development of new and existing sampling and analysis approaches will be explored through technical meetings and inter-laboratory comparisons with the network laboratories for environmental sampling in conjunction with SGAS-003. Because the IAEA also seeks to expand the understanding of the detectable signatures, including the various elemental compositions, one of the proposed inter-laboratory comparisons will focus on elemental characterisation of particles collected on a swipe. The IAEA may also have an opportunity to study the ES signatures related to pyro-processing as part of the Integrated Recycling Test being organized under SGCP-003.

Expected outcome 2.) ***Developed statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results.*** **(In support of V.5.R1)**

The IAEA is interested in exploring and developing statistical techniques and evaluation methodologies that optimize data evaluation and exploit the signatures detectable through environmental sampling and material characterisation, including the use of elemental and morphological data.

The DAVE software is a customized multicomponent analysis software that will enhance existing capabilities to evaluate and identify uranium elemental signatures (USA A 1975). Testing and deployment of this software package is underway. Another application being developed by the US Department of

[1] WIMSD: The Winfrith improved multi-group scheme is a deterministic code system for reactor lattice cell calculation on a wide range of reactor geometries.

[2] 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.

Energy for the IAEA is INDEPTH, which will identify fuel burnup, starting enrichments, and cool down times based on irradiated nuclear materials (uranium and plutonium isotopic values). The application is essentially a reverse burn-up code that could identify production sources of irradiated nuclear material found on ES swipes. The IAEA also seeks to investigate Bayesian statistical techniques to assess detection and/or confidence levels for environmental sampling through the use of software called Visual Sampling plan (VSP) (USA A 2306). If proven to be suitable for IAEA use with respect to ES sampling, the VSP software could be used to quantify a confidence level for ES evaluation conclusions.

Expected outcome 3.) ***Maintained and upgraded ES Evaluation software tools and applications to meet future safeguards information technology requirements and ensure no loss of service.*** **(In support of T.3.R4)**

The IAEA continues to improve its information technology to stay abreast with the latest computer technology and infrastructure. As new operating systems or computer architectures are adopted by the Office of Information and Communication Systems, the software tools used by ES evaluators must be tested against the new standards to ensure operability. Over the 2018-2019 biennium, all the tools and applications currently in use will have to be validated in preparation of the transition to 64-bit computers using Windows 10. Some incompatibilities have already been identified and will have to be remedied.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.5.002* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development tasks

Expected outcome	Task	Task Title (Agency's task cross-reference)	Description	Expected Completion Date
1	1	2018 Technical Meeting on Bulk Analysis for Environmental Sampling (2018.02)	Biennial meeting with Bulk Analytical Laboratories of the NWAL, in coordination with SGAS.	November 2018
	2	Third Inter-laboratory exercise on HRGS analysis of ES swipe samples (2018.02)	Inter-laboratory exercise to compare laboratory performance of HRGS analysis of common samples (QC swipe samples). Organized in cooperation with SGAS.	November 2018
	3	Post-detonation signatures (2018.02)	Phase 3 of a study to gain experience on the detectable signatures related to a post-detonation nuclear event using the typical ES analytical methods. Swipes from various pieces of trinitite will undergo bulk and/or SEM analysis. The results will be evaluated and documented in a technical paper.	December 2018
	4	2019 Technical Meeting on Particle Analysis for Environmental	Biennial meeting with network laboratories involved with ES particle analysis, to discuss current and future	November 2019

Expected outcome	Task	Task Title (Agency's task cross-reference)	Description	Expected Completion Date
		Sampling (2018.02)	developments, and to draft recommendations for future actions. Organized in coordination with SGAS.	
	5	SEM inter-laboratory comparison (2018.02)	In coordination with SGAS, SGIM-IFC will develop the objectives and sample parameters for the first SEM inter-laboratory comparison for particle analysis.	November 2019
	6	Study of elemental signatures and optimization of alCHEMy (2018.02)	Using the alCHEMy reference database and data visualization functions, elemental data from known facilities will be evaluated in order to optimize methodologies, determine analytical needs, and complete sensitivity studies.	December 2019
2	7	Testing of the DAVE search engine for assessing origin of uranium ore concentrates (UOC) (2018.02)	Staff assessment of DAVE capabilities for identifying the origin of UOC through the use of known UOC samples. Initial tests have been completed and functional improvements to the software have been requested. When modifications to the software are made, testing will resume.	March 2018
	8	Expansion of functionality of ENVISDA (2018.02)	ENVISDA is an ES Evaluator tool to aid in evaluation of data and generation of reports. Development will continue to expand functionality, including interactive features.	December 2019
3	9	Compatibility tests of ES evaluation software (2018.02)	Upgrade and validation testing of all ES evaluation software in preparation of the transition to 64-bit personal computers using Windows 10.	December 2019

4.3 Attachments

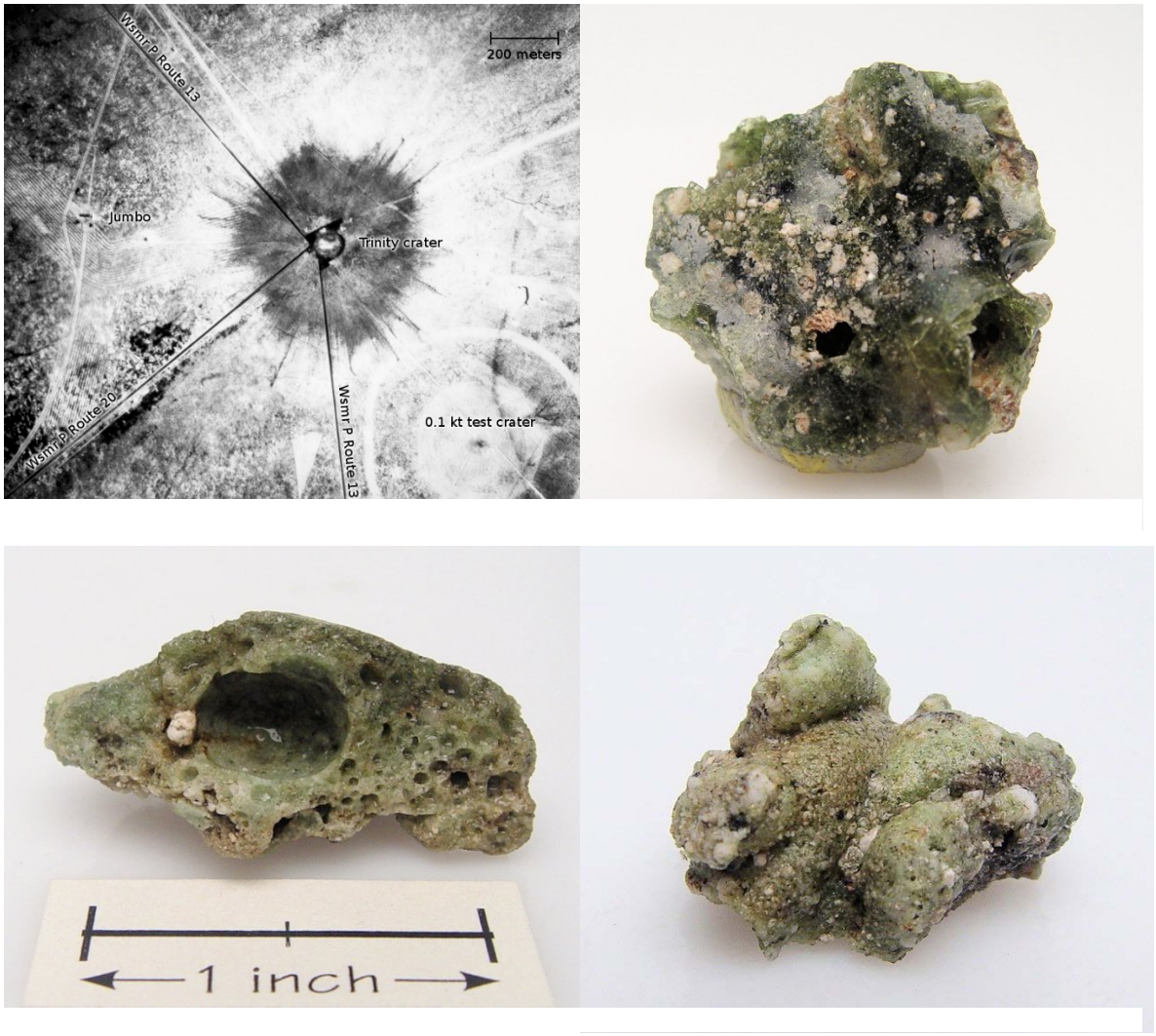


Figure 1: Overhead view of Trinity blast crater and Trinitite specimens used for study on nuclear post-detonation signatures

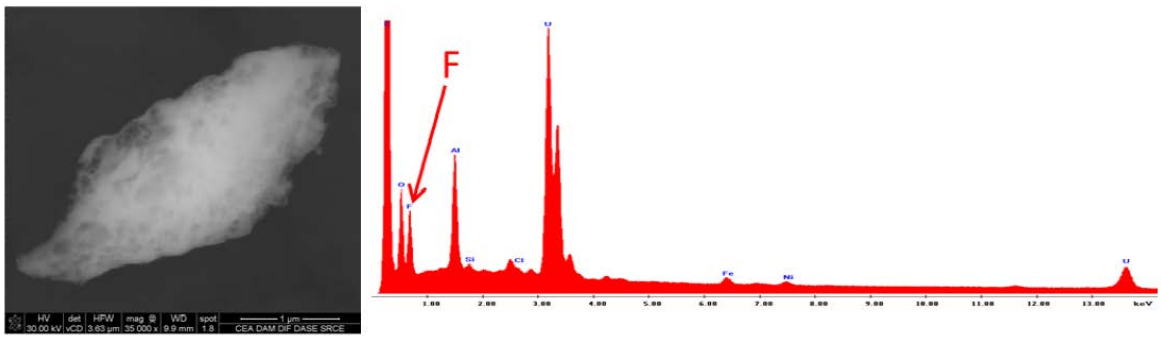


Figure 2: Scanning Electron Microscope (SEM) image and associated nergy Dispersive X-Ray Spectroscopy (EDX) spectrum of an uranium-bearing particle in which fluorine was also detected

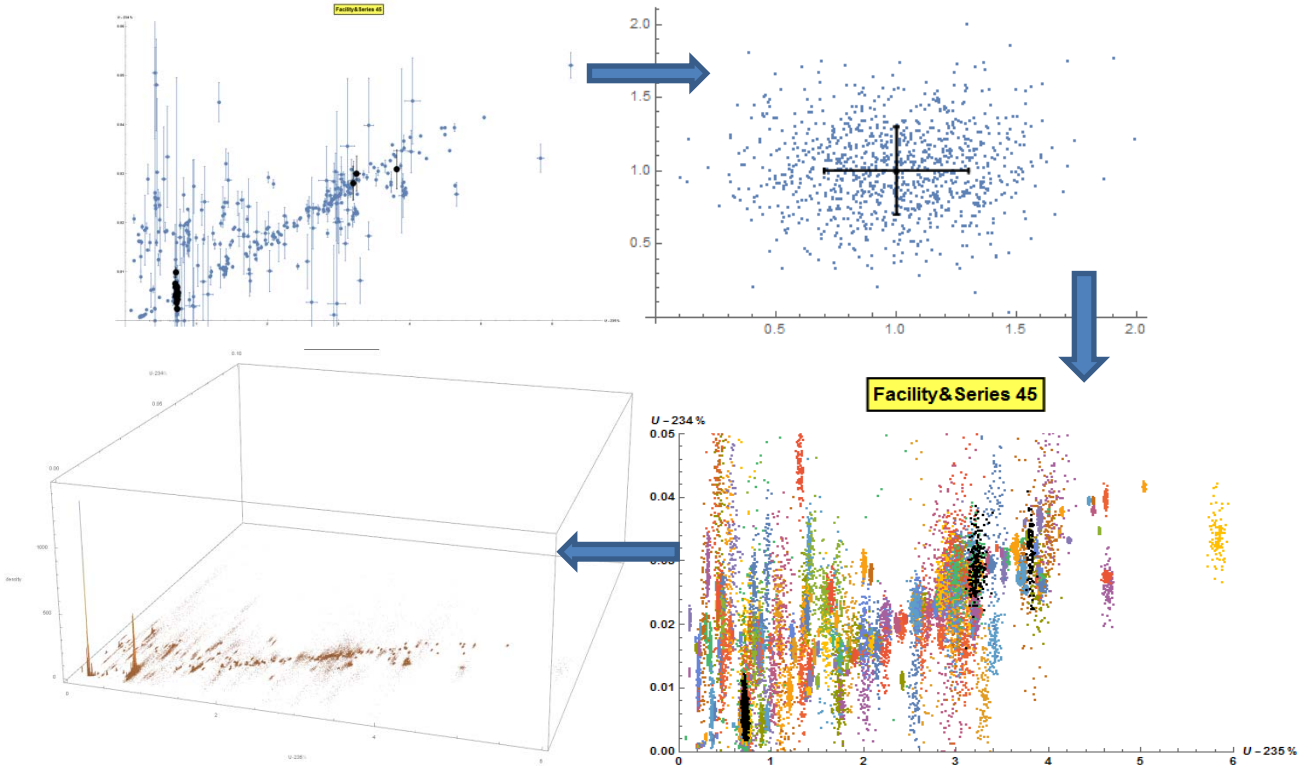


Figure 3: aICHEMy isotopic data transformation

SGIM-008

Statistical Analysis

Project Manager: Robert Binner

Division: SGIM

1. Overview

This document describes plans for developing and implementing statistical methodologies for supporting the design and evaluation of safeguards approaches, inspection activities and related data, and the optimization of resources within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGIM-008 will pursue the following objective:

Review, enhance and develop statistical verification and evaluation methodologies and tools to optimize verification implementation plans and information analysis.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.5.002 Nuclear fuel cycle information analysis.*

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.3	*Support all SG processes through IT*	T.3.R2	As part of STEPS (Statistical Testing, Evaluation and Planning for SG) project, re-engineer and integrate all the legacy systems used for the statistical evaluation of State declared and verification data and the probabilistic calculations that inform verification approaches (e.g. sampling plans and random inspection schemes).
T.5	*Identify and exploit innovations*	T.5.R1	Identify, evaluate and test promising applications of robotics and machine learning/artificial intelligence to improve the effectiveness and efficiency of safeguards.
V.4	*Enhance SG effectiveness monitoring and evaluation*	V.4.R1	Identify and deploy analytical tools, including data visualization, to better measure and analyse performance and take advantage of capabilities provided by MOSAIC.
V.5	*Employ fit-for-purpose and state-of-the-art methodologies*	V.5.R1	Upgrade existing and develop new statistical methodologies applied to the: • Evaluation of quantitative and qualitative verification data including at the State level (e.g., for nuclear material balance evaluation, random inspections) • Measurement of verification performance (in terms of detection probability) and the associated level of confidence at the facility and state level • Design of random verification schemes (minimizing resources for the same level of effectiveness).
		V.5.R3	Explore data analysis methods and tools to strengthen the synthesis and evaluation of information (e.g., optimal random verification schemes, nuclear material flow analysis, material balance evaluation, near real-time accountancy and process monitoring tools).

SGIM-008 addresses the development and enhancement of statistical methodologies in support of material balance evaluation, inspection/verification activities, and State declared information analysis. In particular, these methodologies cover the areas of: uncertainty quantification (UQ) for operator-inspector paired data, 3-laboratory data (Operator, SSAC/RSAC, IAEA), and calibration data; sampling plan methodologies; evaluation of material unaccounted for (MUF), the D Statistic (D), inspector's estimate of MUF (IMUF), and Shipper-Receiver Difference (SRD) in the context of evolving safeguards approaches; evaluation, review and harmonization of random inspection schemes; development of optimized Near-Real Time Accountancy (NRTA) systems for plutonium bulk handling facilities (BHF); and further enhancement of data visualization tools for nuclear material flow and acquisition path analysis.

For the 2018-2019 biennium, the project's top priorities are to:

- Review, update and consolidate the algorithms for the determination of measurement error uncertainties from calibration, paired-data, and 3-laboratory data analysis, for evaluating MUF, D, IMUF, and SRD, calculate sampling plans, detect significant operator-inspector differences and for implementing NRTA;
- Review and harmonize current random inspection schemes through the development, refinement and documentation of methodologies and processes for their implementation and evaluation of their effectiveness;
- Enhance and further develop analytical methodologies in support of State-level evaluations in the areas of material balance evaluation, determination of detection probabilities, and nuclear material flow analysis.

2. Background

The main purpose of statistical analysis activities within the Department of Safeguards is twofold: 1) to provide credible assurance, as mandated by safeguards agreements, that no nuclear material is diverted through material imbalance (Material Unaccounted for, MUF) or falsification of operators' declarations (D) in bulk handling facilities (BHF); and, 2) to contribute to the optimization of safeguards approaches by designing effective and efficient random verification methodologies (e.g. sample size calculations, development of random inspection schemes), associated methodologies to evaluate their effectiveness, and statistical data visualization tools.

The evolution of safeguards concepts in the last decades and the considerable increase in the amount and type of information to be processed and analysed in a context of static or even diminishing resources provides the main impetus driving the project. The need for optimized analysis methods and tools touches all areas of statistical data evaluation. In particular uncertainty quantification, material balance evaluation, design and evaluations of random inspection schemes, timely detection of process imbalances in sensitive BHFs, and State-level nuclear material flow analysis are affected.

In this framework, the scope of the project is to review and, when appropriate, to enhance existing statistical methodologies; to design new methodologies for the evaluation of State-declared data and of verification data from safeguards implementation schemes and/or from innovative nuclear fuel cycle facilities; to improve existing and develop new computerized implementation, evaluation and visualization tools for enhancing and streamlining the verification and evaluation process; and to support the development of optimum random verification schemes.

As such, the end-users of methodologies and tools developed under this project are staff members of the Safeguards Department who are: 1) involved in the statistical analysis of safeguards data, the planning and implementation of inspections and the distribution of inspection resources; 2) analytical laboratory and instrumentation specialists; 3) State Evaluation Groups (SEGs) who are tasked to perform relevant State-level evaluations using statistical analysis results as a major source of information in the evaluation process.

Regular budget resources are used for the regular implementation of statistical data analysis business processes. However, development work is almost exclusively reliant on MSSP funding. In particular, Cost Free Experts (CFEs), Junior Professional Officers (JPOs), and MSSP support tasks are increasingly the sole source available for providing methodological development and support tasks in specific areas such as:

sampling methodologies; uncertainty quantification (UQ); optimization approaches to inspection/verification design; process simulation software; NRTA development and documentation; and intelligent decision analysis support. CFEs may also be engaged for future tasks, for example, to further explore the use of Bayesian methodologies.

3. Expected Outcomes and Key Outputs

In order to reach Project SGIM-008's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and / or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Reviewed, updated and consolidated algorithms for the determination of measurement error uncertainties from operator-inspector paired-data, 3-laboratory data, and calibration data. **(In support of V.5.R3)** Particularly in light of the implementation of the State-level concept, new and enhanced statistical methodologies for evaluating accountancy and verification data and supporting design and evaluation of safeguards approaches are required.	
STR on the uncertainty quantification (UQ) methodologies used as a basis for UQ methods applied to safeguards verification data	December 2018
Expected outcome 2.) Reviewed, updated and consolidated methodologies applied to the evaluation of MUF, D, IMUF, and SRD in the context of material balance evaluation. **(In support of T.3.R2)**	
Technical document (most likely an STR) on the methodologies and implementation of the methodologies in relevant analytical software	December 2019
Expected outcome 3.) Further developed sampling methodologies described in STR-381 and practical implementation procedures for these methodologies. (**In support of V.5.R1**)	
Practical implementation procedures for inclusion in the inspector's handbook and associated software requirements for implementing the sample size methodologies described in STR-381 (Statistical Methods for Verification Sampling Plans) for the purpose of verification activities	December 2018
Expected outcome 4.) Improved and harmonized random inspection schemes (including short notice random inspections (SNRIs)) and methodologies developed to evaluate their effectiveness. **(In support of V.5.R1 and V.5.R3)**	
A set of standard random inspection schemes developed and documented, including standard evaluation methodologies as a basis for a more harmonized approach of implementing and evaluating such schemes in verification activities in continuation of a collaboration with SGCP (See also SGCP-003)	December 2019
Expected outcome 5.) Standardized methodologies for calculating detection probabilities achieved through verification activities on facility and State levels with the aim of evaluating the effectiveness of quantitative verification activities specified in State-level approaches. **(In support of V.5.R1)**	
Developed and documented methodologies for determining detection probabilities achieved in the implementation of verification activities specified in State-level approaches	December 2019

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 6.) Methodologies reviewed, requirements documented and developed for a harmonized NRTA system for future implementation in, inter alia, the Rokkasho Reprocessing Plant (RRP) and J-MOX facilities. **(In support of V.5.R3)**	
Requirements document specifying the methodologies and data requirements for a harmonized NRTA system	December 2019
Expected outcome 7.) Enhanced data visualization software for nuclear material flow analysis, and additional capabilities of the software to represent acquisition path analysis results, verification requirements and achieved verification results, using structured nuclear material accountancy and verification data (in collaboration with SGIS-003). **(In support of V.4.R1)**	
Data visualization software available for use by responsible operations divisions in ISE and addition of further enhancements	Ongoing
Expected outcome 8.) Developed Bayesian approaches making use of historical verification data in the evaluation of safeguards information. **(In support of V.5.R1)**	
Technical guidance document, based on the continuation of the methodological work begun on Approximate Bayesian Computation for UQ	December 2019
Expected outcome 9.) Investigated feasibility of intelligent systems for analysing non-quantitative data, eliciting analyst conclusions, and aggregating analyst conclusion across multiple disparate data sources in order to assist analysts in drawing broad State-level conclusions with a measured degree of confidence. **(In support of T.5.R1)**	Ongoing
Expected outcome 10.) Investigated accountancy and measurement requirements and gathered experience with factors affecting material balance evaluation at pyro-processing facilities (see also SGCP-003). **(In support of V.5.R3)**	
Model material balance approach for a pyro-processing facility using results from the USA/ROK Joint Fuel Cycle Study	December 2019

4. Tasks

Funding and resources for most of the project's development and implementation support tasks are provided by Member State Support Programmes (MSSPs), which continue to play a vital role in achieving the project's objectives. Some tasks are supplemented by regular budget sources.

Expected outcome 1.) ***Reviewed, updated and consolidated algorithms for the determination of measurement error uncertainties from operator-inspector paired-data, 3-laboratory data, and calibration data.*** **(In support of V.5.R3)**

This expected outcome will mainly be achieved through support from a MSSP CFE task (USA A 1989 – Expert – Statistical and Probabilistic Methodologies for Inspection Approaches and Verification Result Analysis), who will produce an STR on uncertainty quantification, and through additional in-house development work, JPO support (USA D 2275 – JPO-Statistical Data Evaluator), and consultancy.

Expected outcome 2.) ***Reviewed, updated and consolidated methodologies applied to the evaluation of MUF, D, IMUF, and SRD in the context of material balance evaluation.*** **(In support of T.3.R2)**

This expected outcome will be achieved through in-house development work and through support from a MSSP CFE task (USA A 1989 – Expert – Statistical and Probabilistic Methodologies for Inspection Approaches and Verification Result Analysis) and JPO task (USA D 2275 – JPO-Statistical Data Evaluator).

In light of the re-engineering project for statistical analysis software (STEPS) which is ongoing, the methodologies and statistical tests associated with evaluating the material balance and determining achieved detection probabilities are being reviewed and updated and will be documented.

Expected outcome 3.) ***Further developed sampling methodologies described in STR-381 and practical implementation procedures for the methodologies.*** **(In support of V.5.R1)**

This expected outcome will be achieved through major support from a MSSP task (GER D 1925 - Optimization Approaches to Inspection/Verification Design) and through in-house development work in the SGIM and Operations divisions. The sampling methodologies published in STR-381 (produced by a CFE funded through support task GER A 1937) need to be further enhanced and will be translated into user-friendly procedures and software to be used in-field during verification activities.

Expected outcome 4.) ***Improved and harmonized random inspection schemes (including short notice random inspections (SNRIs)) and methodologies developed to evaluate their effectiveness.*** **(In support of V.5.R1 and V.5.R3)**

This expected result will be achieved through support from a MSSP task (GER D 1925 - Optimization Approaches to Inspection/Verification Design) and through in-house development work, in consultation with SGCP. Various random inspection schemes are implemented in State-level safeguards approaches without having a consistent framework for requirements and evaluation methodologies for these schemes, and a uniform standard for such inspections will be developed in consultation with SGCP.

Expected outcome 5.) ***Standardized methodologies for calculating detection probabilities achieved through verification activities on facility and State levels with the aim of evaluating the effectiveness of quantitative verification activities specified in State-level approaches.*** **(In support of V.5.R1)**

This expected outcome will be achieved through major support from a MSSP task (GER D 1925 - Optimization Approaches to Inspection/Verification Design) and through in-house development work. In light of the development of new State-level approaches (SLA) for most States, methodologies for determining achieved detection probabilities through the verification activities specified in the SLAs will be developed.

Expected outcome 6.) ***Methodologies reviewed, requirements documented and developed for a harmonized NRTA system for future implementation in, inter alia, the Rokkasho Reprocessing Plant (RRP) and J-MOX facilities.*** **(In support of V.5.R3)**

This expected outcome will be achieved through MSSP tasks (UK D 2308 and FRA D 2288 - NRTA system documentation and requirements gathering), which will produce comprehensive documentation on the requirements, including methodologies and needed data sources, for a standard NRTA software to be developed based on the output from this task. In light of the approaching start-up of major plutonium bulk-handling facilities (RRP and JMOX), an up-to-date NRTA system for these facilities needs to be developed with increasing urgency, and a new task proposal for implementing the documented NRTA requirements may be issued after completion of this task.

Expected outcome 7.) ***Enhanced data visualization software for nuclear material flow analysis, and additional capabilities of the software to represent acquisition path analysis results, verification requirements and achieved verification results, using structured nuclear material accountancy and verification data.*** **(In support of V.4.R1)**

This expected outcome will be achieved through in-house development work (in collaboration with SGIS-003), and, depending on the regular budget resources available for continuing development work on the visualization tool to add further functionality such as to incorporate verification requirements, achieved verification results, and acquisition path analysis results in the visualizations, a task proposal may be issued to support further development.

Expected outcome 8.) ***Developed Bayesian approaches making use of historical verification data in the evaluation of safeguards information.*** **(In support of V.5.R1)**

This expected outcome will be achieved through major support from a MSSP CFE task (USA A 1989 - Expert - Statistical and Probabilistic Methodologies for Inspection Approaches and Verification Result Analysis). The CFE is working on incorporating Bayesian methods in uncertainty quantification and has published papers on this work which will form the basis for an IAEA technical document detailing the methodology. Further CFE support for this task is foreseen after the tenure of the current CFE ends at the end of 2018.

Expected outcome 9.) ***Investigated feasibility of intelligent systems for analyzing non-quantitative data, eliciting analyst conclusions, and aggregating analyst conclusion across multiple disparate data sources in order to assist analysts in drawing broad State-level conclusions with a measured degree of confidence.*** **(In support of T.5.R1)**

This expected outcome will be achieved through a MSSP task (BEL D 1917 - Demonstration of Intelligent Decision Analysis Support in Safeguards Evaluation). Based on the results of a feasibility study, further development work will be defined which may require additional MSSP task support.

Expected outcome 10.) ***Investigated accountancy and measurement requirements and gathered experience with factors affecting material balance evaluation at pyro-processing facilities*** **(see also SGCP-003). (In support of V.5.R3)**

This expected outcome will be achieved through in-house work in SGIM in conjunction with SGCP. The IAEA as a member of the trilateral safeguards and security working group (SSWG) under the USA/ROK Joint Fuel Cycle Study (JFCS) will use results from this study as a basis for developing a model material balance approach for pyro-processing facilities.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.5.002 Nuclear fuel cycle information analysis* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 Attachments

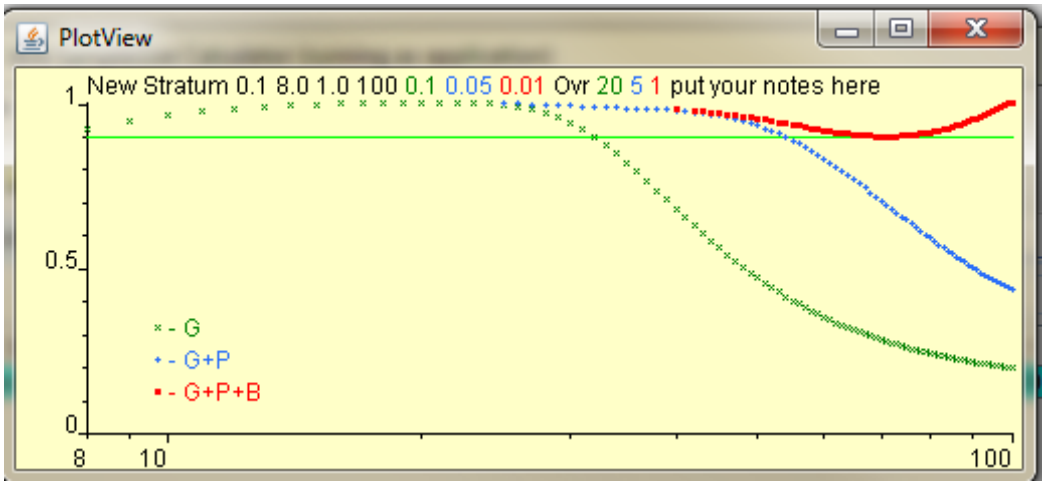


Figure 1. Detection Probability Plot

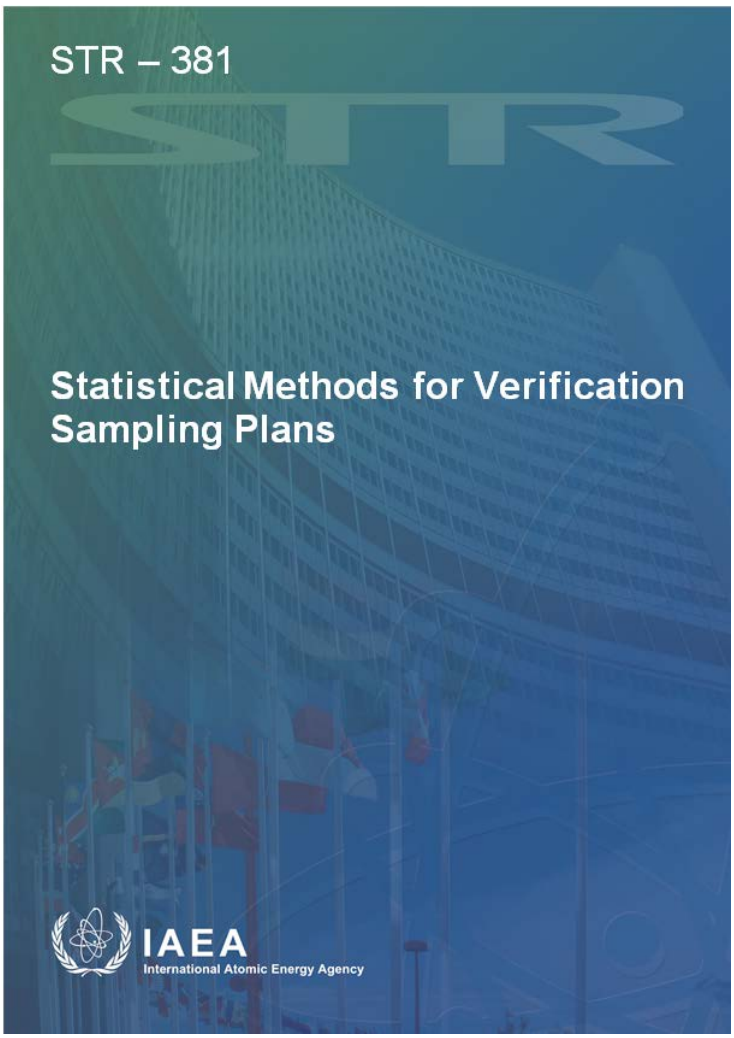


Figure 2. A Safeguards Technical Report (STR) on Sampling Plans

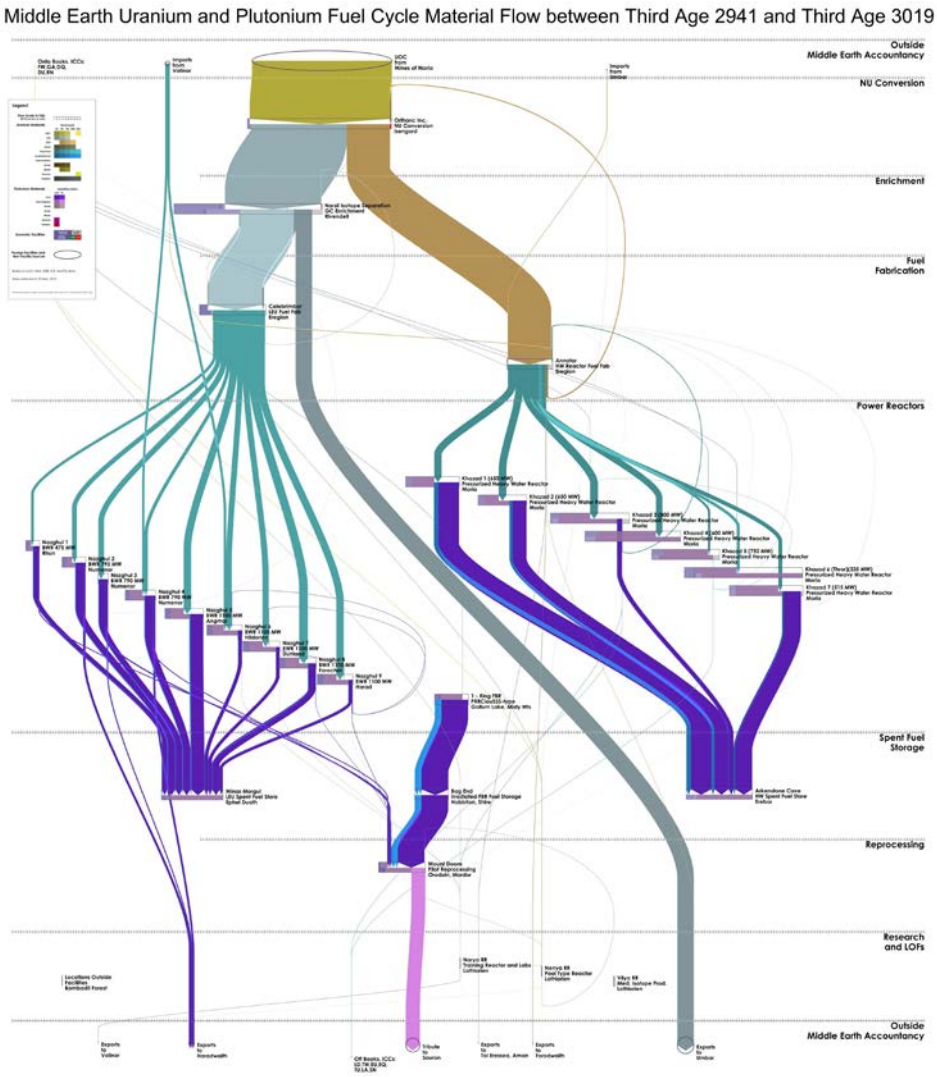


Figure 3. State nuclear material flow

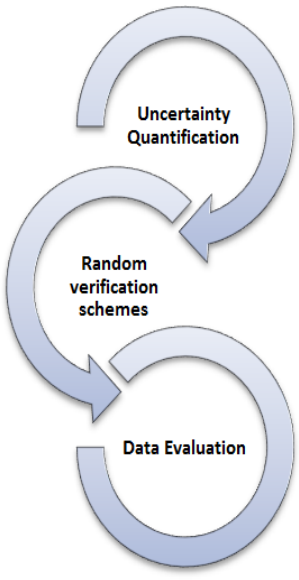


Figure 4. The three high-level interdependent statistical methodology development areas

SGIM-009

State Declared Information Management

Project Manager: Snezana Konecni

Division: SGIM

1. Overview

This document describes the plans for developing and implementing the process and methodologies to collect, analyse and manage State declared information within the Department of Safeguards for the period 2018–2019.

During the 2018-1019 biennium, Project SGIM-009 will pursue the following objective:

Enhance the IAEA's ability to collect, manage, analyse and utilize State declared information in support of the IAEA's verification mission, in particular with respect to the State evaluation process and support of in-field verification activities.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.5.001 Declared information analysis*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
S.2	*Resolve priority areas of difficulty in SG implementation*	S.2.R1	Develop training material and remote delivery methods (e.g., E-Learning) to support SRA training with reduced costs and increased accessibility.
T.3	*Support all SG processes through IT*	T.3.R1	Further develop the State Declarations Portal as a tool that optimizes the quality and usability of State-declared information and enhances the State-Secretariat communication on State declarations.
		T.3.R5	Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations.
T.5	*Identify and exploit innovations*	T.5.R5	Develop training tools using technologies such as virtual reality, immersive learning systems and web-based training.
V.1	*Strengthen information collection and analysis*	V.1.R1	Enhance the set of expert tools necessary to process the variety of SG-relevant information and implement them, with emphasis on timely responses and cost-effectiveness.

SGIM-009 addresses the development of processes and methods that will further enhance the collection, management and analysis of State declared information, including nuclear material accounting data, declarations under the Additional Protocol and the Voluntary Reporting Scheme, and transfers of materials that have not yet reached a composition and purity suitable for fuel fabrication or for being isotopically enriched. More specifically, the project focuses on improvements in the transmission of information between States or regional authorities (SRA) and the IAEA and on integrating different information sources to detect inconsistencies between nuclear programmes and States' declarations in support of the State evaluation process. The constantly expanding volume of safeguards-relevant information poses significant challenges that require on-going development and long-term investment in technology and tools to organize valuable information in a clear and accessible manner.

For the 2018-2019 biennium, the project's top priorities are to:

- Update and deploy tools and methodologies for States to collect, store and submit State declared information;
- Deploy the State Declarations Portal, a web-based portal for the online submission of State declared information by SRAs, as a tool for information exchange between States and the IAEA.
- Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility.

2. Background

The collection, management and analysis of State declared information is a core obligation of the IAEA, and it is an essential element in the State evaluation process. State declared information can provide early indications of potentially undeclared nuclear activities. With the help of Member States, progress has been made to improve proper analytical methods in support of safeguards activities.

Key attributes of the IAEA's operating environment include communication with State or regional authorities (SRA). This has necessitated different means of communication for a secure, reliable and efficient transfer of information.

Over the past years, information technology has changed drastically. This opens up new avenues for more efficient exchange and management of information and causes increased concerns regarding information security. This has impacted the design of the IAEA's secure IT platform, the 'Integrated Safeguards Environment' (ISE) and has had a profound impact on many workflows and procedures within the IAEA. These activities are linked with activities from Projects SGIS-003 *Information Systems and System Usability* and SGIS-002 *Information Security and Infrastructure*.

During the last 2-3 years, some major achievements in that context include the successful migration of data and analysis codes from a mainframe based IT system to a distributed server architecture. As one might expect, this modernization encourages better integration of diverse information repositories and identification of relevant synergies.

The work of the Section for Declared Information Analysis (ISD) is closely connected with the other sections in the Division of Information Management (SGIM) and with the Department's verification activities.

Most of the funding for declared information management comes from the Department's regular budget within Agency's project *4.1.5.001 Declared information analysis*. MSSP support will be requested to focus on specific areas, including the development of analytical methods and capabilities, assistance in advancing communication tools and other development in coordination with Project SGIS-003 *Information Systems and System Usability*.

3. Expected Outcomes and Key Outputs

In order to reach Project SGIM-009's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Workflow implemented between exemptions and terminations of nuclear material with the nuclear material accounting database to allow automatic checking of State reporting. **(In support of V.1.R1)**	
Deployed quality control tool linking the decision-making process to the processing and evaluation of related inventory change reports	December 2019

Expected outcomes and Key Outputs	Expected Completion Date
Expected outcome 2.) Developed and updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations with digital site maps attached, supporting the further integration of State declared information with other relevant information. **(In support of T.3.R5)**	
Developed software, "Reports Creation Tool" (RCT), for use by SRAs in creating and submitting accountancy reports	December 2019
Updated software "Quality Control Verification Software" (QCVS) for nuclear material accountancy reports	December 2019
"Protocol Reporter 3" (PR3), software to be widely deployed to States	December 2019
Expected outcome 3.) State Declarations Portal largely deployed as a secure and authenticated communications between the IAEA and SRAs. **(In support of T.3.R1)**	
State Declaration Portal deployed to a maximum number of SRAs	December 2019
Expected outcome 4.) Developed training material and remote delivery methods to support SRA training with reduced costs and increased accessibility (in collaboration with SGCP-102). **(In support of S.2.R1 and T.5.R5)**	
E-learning modules (maximum of 20 envisaged) for training SRAs on State declaration provision	December 2019

4. Tasks

Most of the following tasks will be performed by Safeguards Department personnel with regular budget support within Agency's project *4.1.5.001 Declared information analysis*. Further assistance will be required from Member State Support Programs for some tasks.

Expected outcome 1.) ***Workflow implemented between exemptions and terminations of nuclear material with the nuclear material accounting database to allow automatic checking of State reporting.*** **(In support of V.1.R1)**

SGIM-009 will finalize the development and deployment of a quality control tool that links the items of the decision-making process (State request, request evaluation, approval/denial of request) to the processing and evaluation of related inventory change reports. This work is expected to be pursued with regular budget resources in collaboration with SGIS within the MOSAIC project.

Expected outcome 2.) ***Developed and updated software tools for use by SRAs in creating and submitting accountancy reports*** and additional protocol declarations with digital site maps attached, ***supporting the further integration of State declared information with other relevant information.*** **(In support of T.3.R5)**

Ongoing activity under this objective focuses on the upgrade of software tools for preparing AP declarations and nuclear material accounting reports.

The re-development or substantial update of the Quality Control Verification Software 'QCVS' software, which is distributed to State or regional authorities (SRAs) to support the syntactically correct creation of computer readable nuclear material accountancy (NMA) reports, is another urgent task that will depend heavily on the availability of MSSP support.

The 'Protocol Reporter 3' (PR3) software, which is intended to assist States in the creation, management and submission of declarations pursuant to their obligations under the Additional Protocol, has been developed with MSSP support but additional support for the deployment phase will be required. In PR3, digital declaration site maps (DDSM) can be added as attachments to the 2.a.(iii) declarations. A continuing

need under the Project SGIM-009 for 2018-2019 is to further evaluate and optimize States' processes of submitting digital declaration site maps. In 2018-19, the Project SGIM-009 will also work to support SRAs to establish capabilities to review and analyse declarations using a GIS software and analysis (in collaboration with SGIM-002).

In order to modernize the process of report creation in those States who do not have the IT capacity to provide nuclear material accountancy reports in a computer readable format, the creation of a "Reports Creation Tool (RCT)" is needed. Collaboration with the US support programme has been initiated in 2017 to implement this task.

Expected outcome 3.) ***State Declarations Portal largely deployed as a secure and authenticated communications between the IAEA and SRAs.*** **(In support of T.3.R1)**

A 'State Declarations Portal', a web-based portal, for the online submission of State declared information by SRAs to the SGIM Declared Information Analysis Section (SGIM/ISD) is available since the middle of 2017 and a deployment phase is ongoing. Benefits in terms of increased efficiency are expected from the use of the State Declaration Portal. Member States' willingness and cooperation to implement it will be required.

Expected outcome 4.) ***Developed training material and remote delivery methods to support SRA training with reduced costs and increased accessibility.*** **(In support of S.2.R1 and T.5.R5)**

In order to support SRA training on State declarations processes with reduced costs and increased accessibility, the possibilities for effectively delivering training by remote means needs to be investigated. MSSP support will be important for both the development of e-learning modules in the State declarations processes as well as for remote delivery methods. In response to our request for support titled "Creation of e-learning modules, supporting the preparation of State declared information", there are currently four active tasks, CAN D 2240, ROK D 2242, RSA D 2251 and ARG D 2283. Discussions are ongoing to define under which form they can contribute to the project.

In addition, the IAEA is proposing updated software products to be distributed to Member States and has developed new means of communication with State or regional authorities (SRA) via the State Declarations Portal. As a result, an activity to develop new and appropriate training materials is urgently required.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.5.001 Declared information analysis* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 Attachments

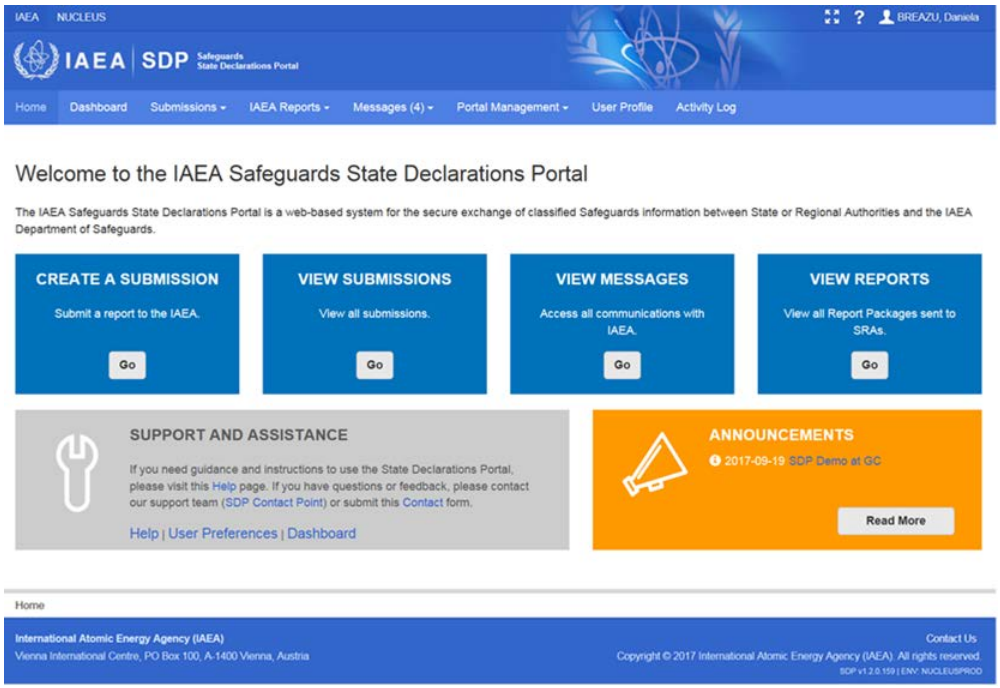


Figure 1: Screenshot of IAEA Safeguards State Declarations Portal

Figure 2: Screenshot of the pilot e-learning module (under development) on Safeguards reporting obligations for transfers of nuclear material

SGIS-002

Information Security and Infrastructure

Project Manager: M. Scott Partee

Division: SGIS

1. Overview

This document describes plans for developing and implementing Information Security and Infrastructure within the Department of Safeguards for the period 2018-2019. During the creation of this plan, the information security results from within MOSAIC (completion in May, 2018) and the IAEA's Five Year Security Roadmap were also considered to ensure that SGIS-002 represents the Department's specific information security (IT) and infrastructure needs for the biennium and is complementary to those efforts.

During the 2018-2019 biennium, Project SGIS-002 will pursue the following objective:

Make use of processes, people, technology, and tools to ensure the confidentiality, integrity, and availability of the information entrusted to the Department.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.9.002 ICT infrastructure and support.*

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
P.1	*Ensure information security*	P.1.R1	Improve the capability to quickly identify and react to security events within the Department's information systems.
		P.1.R2	Improve Information Security capabilities in areas of risk: management, auditing and reporting; vulnerability management; threat intelligence; and improve processes, procedures and standards.
P.2	*Increase resilience and prepare for disaster recovery*	P.2.R1	Address requirements (processes and technology) for carrying out mission-critical functions (needed for continued delivery of SG conclusions) in case of disasters (e.g. disruptive, massive cyber-attack or physical loss of critical infrastructure).
W.1	*Reform human resource management*	W.1.R1	Develop and maintain, through training, new expertise required by the Department, where needed, with the help of Member States.

SGIS-002 addresses the development of information security and infrastructure capabilities within the Department of Safeguards. The project's overall scope includes improvement and developments to a large and diverse set of capabilities including business continuity, secure communications, information systems' security, IT security incident detection, and mobile technology security.

For the 2018-2019 biennium, the project's top priorities are to:

- Improve the Department's information security and IT security skills with targeted training on specific topics related to threat detection, incident response, secure software development, security designs, continuous monitoring, event management, digital forensics, and security architecture;
- Enhance the endpoint and server security configuration of the Department's IT infrastructure with additional security functions through the use of next generation endpoint security techniques;
- Develop and demonstrate an updated disaster recovery programme.

2. Background

Information security is crucial to the work of the Department of Safeguards and is one of the Department's key infrastructure capabilities. The Department has a long-standing commitment to investing in security in order to reduce risk to information and systems that are mission critical to the Department's objectives.

Activities within the scope of Project SGIS-002 for the 2018-2019 biennium are focused on developing practical solutions and enhancing specific skills and capabilities required by the Department to best protect safeguards information. These were developed with the understanding that the IAEA has a commitment to information security and protections, controls, capabilities, and activities must be targeted at areas in which they have the greatest benefit.

The Department's effectiveness in information security depends primarily upon success in focusing the best resources available towards the areas that either require the most improvement or reside in critical areas of risk. The ability to baseline and improve the security of systems and to automatically detect important events is essential for the Department. The Department's business requires sustained and frequent interaction with internet-based resources by certain groups of staff. Protecting these groups and their work from cyber-attack is one of the Department's highest priorities.

The Department of Safeguards is responsible for the vast majority of the IAEA's classified information. While investing in IT security in all areas of the IAEA is important, activities in SGIS-002 are focused on improving information security and infrastructure in specific ways that help achieve the Department's strategic objectives and provide improvements in the areas closest to the most sensitive information.

Most of the funds for information security and infrastructure come from the Department's regular budget. Member State Support Programmes, however, have a long history of contributing improvements in information security for the Department, including valuable assistance in creating the Department's IT Forensics Lab through equipment and training, providing targeted and general security assessments, and sponsoring experts, developing incident detection capabilities through the sponsorship of dedicated Cost-Free Experts (CFEs), and information exchange opportunities.

This project coordinates with SGIS-003 *Information Systems and System Usability* and SGTS-014 *Remote Monitoring and Data Processing Systems*.

3. Expected Outcomes and Key Outputs

In order to reach Project SGIS-002's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Improved and automated detection of events, system anomalies, and activities in the Department's information systems – particularly in the case of the Integrated Safeguards Environment (ISE). **(In support of P.1.R1)**	
Additional automated platform alerting modules and correlation rules for the Department's Security Incident and Event Management Platform	December 2019
Documented definition and implementation of security analytics	December 2019
2.) Improved Department's security configurations and system designs through periodic independent assessments of specific solutions for risk and vulnerabilities and comprehensive or targeted penetration tests. **(In support of P.1.R2)**	
Reports on vulnerability assessments and penetration tests in order to identify potential issues with system configurations, to design solutions, and to verify security controls	Ongoing
Assessment report on the maturity level of the Secure Software Development Lifecycle in place within the Department	January 2019

Expected Outcomes and Key Outputs	Expected Completion Date
Improvement guide based on risk identified in the assessment report	January 2019
Expected outcome 3.) Improved Departmental information security and IT security skills through targeted training on specific topics related to threat detection, incident response, secure software development, security designs, continuous monitoring, event management, digital forensics, and security architecture. **(In support of W.1.R1)**	
Training of Department staff in targeted IT security areas identified as critical needs, such as new technologies, security metrics, security incident response, digital forensics, specific security products, and secure software and systems development processes	2018-2019
Expected outcome 4.) Enhanced endpoint and server security protection capabilities of the Department's IT infrastructure through the use of next generation techniques. **(In support of P.1.R2)**	
Implementation of a next generation endpoint security solution for the clients and servers in the general purpose computing network.	May 2019
Implemented solution to mitigate threats from the use of web browsing on the Department's computers through the use of non-persistent, virtualized computing resources and spread this capability to additional computing environments.	January 2019
Secured, thin-client access to the Department's networking resources based on virtualized desktop computing technology.	May 2018
Expected outcome 5.) Deployed secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices. **(In support of P.1 Ensure information security)**	
Implementation of a secure messaging solution for a mobile workforce that supports chat and voice communications and applies confidentiality protections to a level that meets the Department's assurance criteria	May 2018
Pilot, design, and deployment of an end-to-end security and management solution which provides the controls and capabilities necessary to enable secure email on standard mobile devices such as iPhones. The solution will work with the Agency's Public Key Infrastructure and support hardware protection of private keys used for S/MIME secure email	December 2018
Expected outcome 6.) Enhanced ability of the Department to recover from an IT failure. **(In support of P.2.R1)**	
Fully implemented Phase I of SGIS Disaster Recovery Project, including plan to respond to a disaster scenario and upgraded IT infrastructure	December 2019
Advanced Phase II of SGIS Disaster recovery Project, including plan to respond to an alternative disaster scenario, upgraded dual purpose IT infrastructure in Seibersdorf and procedure documentation	December 2019
Expected outcome 7.) Support to the Department's access, authorisation, and information classification initiatives in order to ensure information is available to those who need it while protecting the confidentiality and integrity of that data. **(In support of P.1.R2)**	
Expert reports on authorization management, information classification, and information access management areas, as required	December 2019

4. Tasks

Most of the following tasks will be performed by Safeguards Department personnel. Further assistance will be required for MSSPs for some tasks.

Expected outcome 1.) ***Improved and automated detection of events, system anomalies, and activities in the Department's information systems – particularly in the case of the Integrated Safeguards Environment (ISE).*** **(In support of P.1.R1)**

The Department will continue leveraging its existing security event analysis platforms based on big data concepts in order to detect anomalies, provide long-term security and event information for reporting, and enhance the search of event information for operational and incident response purposes.

In the last three biennia, MSSPs have supported the development of the Department's incident detection and digital forensics capabilities through a combination of training, a task to enhance IT forensics capabilities (ESP D 1921) and through Cost-Free Experts (US D 2157). Through this task, the Department gained advanced expertise in working effectively with an information security environment. In 2018-2019, the Department seeks to improve and expand this capability through the introduction of several new tasks, which will be mapped to specific key outputs. These efforts will work in concert with the IAEA's overall efforts to increase event detection capabilities throughout the IAEA.

Additional MSSP support will be requested to provide expertise and customized tools to create automated platform alerting modules and to develop event correlation rules for the Department's Security Incident and Event Management (SIEM) platform.

Expected outcome 2.) ***Improved Department's security configurations and system designs through periodic independent assessments of specific solutions for risk and vulnerabilities and comprehensive or targeted penetration tests.*** **(In support of P.1.R2)**

Existing tasks for the sponsorship of a safeguards security assessment (FRA D 1901 and USA D 1929) have provided invaluable results, which have had a measureable positive impact on the Department's information systems' security. In 2015, the IAEA established a standardized IT security risk assessment process and entered a commercial relationship to provide such services. These risk assessment services would complement the additional and more specific requests under this objective. In 2018-2019, the project will request the continuation of these tasks as well as additional requests to more MSSPs for specific penetration tests, security reviews, and vulnerability assessments. Member States are welcomed to support the existing task or to sponsor the additional task proposal.

Support from the MSSP will be request for an independent assessment of the Department's Secure Software Development Lifecycle (SSDLC), in order to measure its maturity, and provide a roadmap, and support improving the software development process in use throughout the Department.

Expected outcome 3.) ***Improved Departmental information security and IT security skills through targeted training.*** **(In support of W.1.R1)**

Keeping abreast of the latest techniques, tools, threats, and technologies is a major component of ensuring that the Department's IT staff have the ability to defend the Department's systems from attack, compromise, or misuse. The Department invests significantly in such training, and MSSPs have generously provided support in the past.

Additional MSSP support will be needed to keep the Department abreast of the latest developments in information security, which is critical for the effectiveness and efficiency of the Department's IT and information security personnel. The IAEA funds training within the limits of the regular budget, negotiating the most cost-effective training arrangements, usually for larger target groups.. This serves the overall IT training needs of the IAEA. However, such arrangements do not cover rapid developments and specialized areas of expertise that are often necessary for the Department's staff members responsible for securing safeguards information. This task covers highly-specific and advanced training opportunities for topics such as incident response, insider threat detections, developing indicators of compromise, highly-secured architectures and systems.

Expected outcome 4.) ***Enhanced endpoint and server security protection capabilities of the Department's IT infrastructure through the use of next generation techniques and continuous improvement to the security and usability of the end user computing equipment (including mobile computers).*** **(In support of P.1.R2)**

The Department retains a computing environment which requires internet access for accessing web-based resources and internet email as well as for accessing the general-purpose information technology and communications services of the Agency as a whole. Despite the stringent controls implemented for safeguards information, the systems on this general purpose network are exposed to internet-based threats and, given the risk this poses to safeguards information, additional mitigating measures must be put in place.

For the achievement of the outcomes related to this milestone, a Cost-Free Expert job description has been created and will be requested from the MSSPs to ensure the effective and impactful implementation of the following solutions. In addition to the solutions below, the continuous improvement of the security and usability of the end user computing equipment is fundamental.

The Department will request MSSP support to support the implementation of a next generation endpoint security solution for the general purpose computing network. This assistance would be in the form of assessments of products against the Department's needs as well as financial support for the procurement of the solution.

MSSP Support will also be requested for the identification and implementation of a solution to mitigate threats from the use of web browsing on the Department's computers. The solution will use non-persistent, virtualized computing resources to provide web browsing capabilities to machines on the Department's internet-oriented network. Such an implementation seeks to ensure that malware, malicious scripts, and attempts to compromise machines take place on the virtualized resource, where they can be detected and immediately removed without impacting staff members' computers. This mitigation strategy is deemed highly effective by security experts, but the implementation of such technology presents many complicated issues to resolve.

With support from the MSSP, the project will seek to leverage the same technology, but through the use of thin clients to present whole desktop experiences to the end user. This type of configuration also serves to reduce the cost for deploying occasional-use computers for specific purposes.

Expected outcome 5.) ***Deployed secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices.*** **(In support of P.1 Ensure information security)**

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.

MSSP support will be required to utilize standard mobile platforms, such as the standard mobile phones and tablets, for secure communications between in-field inspectors, management teams, and analysis groups. SGIS has done some initial pilot deployments with in-field activities groups 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 third party services, and software support to implement such solutions, as well as training and guidance.

Expected outcome 6.) ***Enhanced ability of the Department to recover from an IT failure.*** **(In support of P.2.R1)**

There is a need for the Department to be able to continue normal operations in the event of a major disaster in the Department's primary data centre, when access to the 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 IAEA'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 project to achieve this outcome is divided into two phases. Phase I of the SGIS Disaster Recovery Project aims to provide an IT infrastructure which is capable of delivering IT services to the Department of Safeguards in the event that either the main Safeguards data centre or the secondary Safeguards data centre become inoperable. Phase I should be completed within this biennium:

1. Provide a plan to respond to a scenario in which the Safeguards computer systems operated by SGIS, located in the two Safeguards date centres in the VIC become unavailable. The intent is to restore operations as quickly as possible with the latest and most up-to-date available data. This plan is designed to reduce the number of decisions which must be made if such an event occurs.
2. Design, implement, test and commission IT infrastructure in the alternate centre which is capable of providing the defined IT services for the Department of Safeguards and NSNS. This will be achieved through various high availability implementation techniques.

Phase II of the SGIS Disaster Recovery Project aims to provide an IT infrastructure which is capable to deliver IT services to the Department of Safeguards for an alternate scenario. Moreover, this IT infrastructure will have a dual purpose capability. The timeline for complete implementation exceeds the biennium, but work will start throughout 2018-2019. The major objectives of this phase are to:

1. Provide a plan to respond to a scenario in which the entire VIC, becomes unavailable. The intent is to restore IT operations as quickly as possible from a tertiary site with the latest and most up-to-date available data.
2. Design, implement, test and commission IT infrastructure in the data centre located in the Nuclear Materials Laboratory (NML) at Seibersdorf which is capable of providing two functions. Primarily, it will serve as the test environment for the Integrated Safeguards Environment (ISE). Secondly, and in order to maximize efficiencies, this IT infrastructure can be repurposed to provide core ISE IT services in the event of a disaster at the VIC. Therefore serving as a high availability environment for Safeguards.
3. Provide a procedure describing how to quickly and securely repurpose the ISE test environment into an environment capable of providing core IT services which are normally available in ISE. Additionally, it will provide a procedure which describes how to quickly and securely repurpose the existing LAN and deploy virtual desktop PCs in NML giving a limited number of Safeguards Staff members access to ISE IT resources. Thus enabling select Safeguards staff members to securely access ISE from NML in the event of a disaster at the VIC.

Member State support in the form of hardware, software, expertise on business continuity and disaster recovery, assessments and reviews will be sought to support the delivery of both phase I and phase II. 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 (NML) in Seibersdorf. The requested expertise will take the form of a Cost-Free Expert, consultancies, expert engagements, and assessments of products related to disaster recovery and business continuity.

Member State support may also provide additional network and security equipment as well as cabling to connect primary and alternate data centres in order to build in business continuity, redundancy, and high availability features which reduce or eliminate interruptions to Safeguards staff in the event of major interruptions to the primary Safeguards data center.

Expected outcome 7.) ***Support to the Department's access, authorization, and information classification initiatives in order to ensure information is available to those who need it while protecting the confidentiality and integrity of that data.*** **(In support of P.1.R2)**

The achievement of this outcome will entail provision of support for consultations, assessments, and expert engagements to provide assurance for project deliverables in the authorization management, information classification, and information access management areas.

Member States are welcome to support these activities by providing expertise and financial support to provide targeted assessments, reviews, and consultation engagements of procedures, processes, tools, and systems related to authorization, authentication, and classification of information assets.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.9.002 ICT infrastructure and support* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

SGIS-003

Information Systems and System Usability

Project Manager: Gregg Whitaker

Division: SGIS

1. Overview

This document describes plans to continue developing, implementing and maintaining an integrated information technology (IT) system to support the safeguards implementation processes within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGIS-003 will pursue the following objective:

Enhance the IAEA's ability to collect and analyse information in support of the IAEA's verification mission, in particular with respect to the State evaluation process and support of in-field verification activities.

The plan detailed here is fully aligned with the objectives of Agency's projects *4.1.9.001 ICT development* and *4.3.1.001 Modernisation of Safeguards Information technology (MOSAIC)*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.3	*Support all SG processes through IT*	T.3.R1	Further develop the State Declarations Portal as a tool that optimizes the quality and usability of State-declared information and enhances the State-Secretariat communication on State declarations.
		T.3.R2	As part of the STEPS (Statistical Testing, Evaluation and Planning for SG) project, re-engineer and integrate all the legacy systems used for the statistical evaluation of State declared and verification data and the probabilistic calculations that inform verification approaches (e.g. sampling plans and random inspection schemes).
		T.3.R3	Build on the development of geographic information systems (GIS) technology to enhance geo-based information sharing and related analysis.
		T.3.R5	Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations.
T.4	*Manage SG assets strategically*	T.4.R1	Execute a long-term maintenance and replacement plan for the safeguards information technology system as a follow-up to MOSAIC.
V.1	*Strengthen information collection and analysis*	V.1.R1	Enhance the set of expert tools necessary to process the variety of SG-relevant information and implement them, with emphasis on timely responses and cost-effectiveness.
		V.1.R3	Further integrate safeguards information to strengthen all-source information analysis and make it more user-friendly (e.g. via the Collaborative Analysis Platform).
V.4	*Enhance SG effectiveness monitoring and evaluation*	V.4.R1	Identify and deploy analytical tools, including data visualization, to better measure and analyse performance and take advantage of capabilities provided by MOSAIC.

Priority Objectives		R&D Needs	
V.5	*Employ fit-for-purpose and state-of-the-art methodologies*	V.5.R3	Explore data analysis methods and tools to strengthen the synthesis and evaluation of information (e.g. optimal random verification schemes, nuclear material flow analysis, material balance evaluation, near real-time accountancy, and process monitoring tools).

The Agency requires adequate Information and Communication Technology (ICT) to support the Department of Safeguards' mandate in all areas requiring timely and secure circulation of information. The availability of information to conduct effective and efficient verification activities, including analysis, requires highly secure and reliable networks, telecommunications, databases, document management, collaboration tools and highly specialized business solutions, all of which must remain continuously operational. Appropriate information must also be securely available to all stakeholders at headquarters, regional offices, facilities, and travelling staff.

SGIS-003 aims to continue the modernization of safeguards IT systems while strengthening the protection of safeguards information. The modernization efforts help to achieve efficiencies and improve effectiveness of safeguards implementation, establish a basis for improved communication with State/regional authorities, improve institutional memory and rely more on electronic documentation and signatures.

For the 2018-2019 biennium, the project's top priorities are to:

- Successfully complete MOSAIC and ensure that the Department's modernized IT system efficiently and effectively supports safeguards implementation processes, building upon MOSAIC investment and good practices.
- Develop new safeguards IT capabilities and enhance existing IT capabilities that will optimize Departmental operations in order to effectively and efficiently carry out the IAEA's verification mission.
- Ensure the confidentiality, integrity and availability of safeguards information.

2. Background

Information technology (IT) is central to the data and information processing necessary for implementing IAEA safeguards. Through the Modernization of the Safeguards Information Technology (MOSAIC) project, the current safeguards IT system has been replaced with modern systems in a secure environment. The project enhances existing safeguards capabilities and helps to identify and develop new capabilities, while ensuring the protection of safeguards information.

Following initial preparations, modernization activities started with the establishment of a secure IT environment (2005–2009), followed by the partial modernization of software applications (2007–2011), and continued with the successful transfer of data and software applications to a new platform, the mainframe migration (2012–2015). Under the MOSAIC project and until its official completion in May 2018, the project will continue to deliver widespread and tangible benefits throughout the Department of Safeguards, and will continue to help processing data and managing information in ways that have not been possible on the old systems. The modern and secure IT platform improves the alignment of IT tools with safeguards implementation processes, leading to improved efficiency and effectiveness of safeguards implementation activities. Significant progress has been achieved with the deliverables produced by the MOSAIC project which serve as a firm foundation upon which new capabilities and the enhancement of existing capabilities can be built.

Activities under SGIS-003 include support for all in-field activities with improved offline processing capabilities; enhanced data integration and analytical capabilities; enhanced data visualization and geo-referenced capabilities; improvements to the 'virtual workspace' for staff to share information and work collaboratively; the prevention of unauthorized access to information; and new systems to facilitate cooperation with Member States.

For all development of information systems running on the Safeguards platform, the collaboration between SGIS and other Safeguards Divisions is essential to ensure user satisfaction, compatibility, and maintainability of systems that will facilitate the integration of safeguards data.

Additional resources for this continued effort are still needed to support the current MOSAIC, as well as new IT projects that will carry on through 2019. SGIS-003 will conduct these projects in close cooperation with all stakeholders, particularly with interrelated projects and activities across the Department and the IAEA. 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 Department of Nuclear Safety and Security, and Member States.

3. Expected Outcomes and Key Outputs

In order to reach Project SGIS-003's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Enhanced integration of diverse 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 support of T.3.R2, T.3.R3 and V.1.R3)**	
Additional legacy systems integrated for the statistical evaluation of State declared and verification data and the probabilistic calculations which inform verification approaches (e.g. sampling plans and random inspection schemes) (in cooperation with SGIM-008)	December 2019
Enhanced geo-reference capabilities in Safeguards applications to improve the integration of geo-tagged information for analysis activities (in cooperation with SGIM-002)	December 2019
Expected outcome 2.) Enhanced tools and systems for 'all source analysis', to support the detection of signatures of undeclared activity and improve the analysis of nuclear fuel cycles. **(In support of V.1.R1 and V.4.R1)**	
Expanded Department's capability to translate languages in Safeguards IT applications (in cooperation with SGIM-003)	December 2019
New IT capabilities identified for the integration and visualization of safeguards data in support of the Physical Model and the acquisition/diversion path analysis for the development of State-level Approaches (in cooperation with SGIM-008)	December 2019
Expected outcome 3.) Enhanced capabilities to evaluate data analysis methods and computerized tools to aid the analysis of large amounts of all-source information in order to support the State evaluation process. **(In support of V.1.R1, V.1.R3 and V.5.R3)**	
Developed functionality to view all State-relevant data in the State File, including integration of documents and information residing in other systems, the organization of non-structured data, and the process to analyse and evaluate information (in cooperation with SGIM-003)	December 2019
Continued development of the Natural Language Processing task, moving from the development stage to the deployment stage (in collaboration with SGVI-001 and SGIM-003)	December 2019

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 4.) Enhanced 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. **(In support of T.3.R1 and T.3.R5)**	
Enhanced IT capabilities identified to securely exchange electronic data for the Department and Member States	December 2019

4. Tasks

Most of the following tasks will continue to be implemented with Member State Support Programme (MSSP) support dedicated to MOSAIC (JNT D 2284 FIN, JNT D 2178 CZ, JNT D 2171 UK, JNT D 2107 ROK, JNT D 2106 USA, JNT D 2100 CAN). Beyond MOSAIC, further assistance will be required from MSSPs for some tasks that will be implemented within Agency's project *4.1.9.001 ICT development.*

Expected outcome 1.) ***Enhanced integration of diverse 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 support of T.3.R2, T.3.R3, andV.1.R3)**

The evolution of safeguards implementation requires new business capabilities to be developed and existing capabilities to be enhanced by modern information technologies. Continuing the efforts implemented in the MOSAIC project, further integration of safeguards data will continue to reduce manual entries, ensure accuracy and enhance findability. Linking unstructured documents to structured records will improve the IAEA's ability to detect inconsistencies that result in an increase in more efficient use of safeguards resources. For 2018-2019, SGIS-003 is aligned with the safeguards priority for integrated information systems and includes the following activities:

- Development of new capabilities to enhance the integration of the Protocol Reporter 3 software with related Safeguards IT applications;
- Updating the legacy software designed to assess Technical Cooperation (TC) and other Agency's technical assistance proposals, projects and procurement for Safeguards relevant activities and equipment;
- Building upon the achievements from the MOSAIC State-Level Data Configurator project to develop new IT capabilities that enhance the integration and management of safeguards technical objectives and applicable safeguards measures;
- Development of new IT capabilities to review and access Safeguards data to a larger group of users in support of the Additional Protocol process, the Facility Evaluation process and the preparation of the SIR to ensure completeness and correctness of the information by increasing the granularity and quality of the data that will save information analysts' time in preparing analytical reports;
- Development of new functionality to integrate geo-related information that is accessible in a user-friendly manner through a geographical map or image.

These activities represent a collaborative effort with the activities of project SGIM-*002 Satellite Imagery Analysis*, SGIM-003 *Information Analysis* and SGIM-009 *State Declared Information Management*.

Expected outcome 2.*) Enhanced tools, and systems for 'all source analysis', to support the detection of signatures of undeclared activity, and to improve the analysis of nuclear fuel cycles.* (In support of V.1.R1 and V.4.R1)

The timely collection and analysis of all safeguards-relevant information is the key to drawing and maintaining soundly-based safeguards conclusions. To accomplish this task, safeguards inspectors and analysts must be empowered with tools that allow for collaborative analysis of disparate information sets that cumulatively represent all available safeguards-relevant data. Software tools for all-source analysis are designed to streamline the work of analysts and inspectors, while also providing a holistic view of the total information available. The tools will facilitate analysts' ability to establish relationships between information from multiple sources, enabling new insights and the ability to place current understandings into perspective. ISE is hosting the safeguards portal (SG Portal project), promoting collaboration and the implementation of new analytical processes.

Member State research and development activities in all functional activities of the project will continue to be essential and will help in reaching a larger Departmental goal of fostering a more comprehensive analytical culture within the Department of Safeguards. Cash contributions greatly contributed to the successful implementation of the MOSAIC projects. In 2018-2019, cash contributions will still be the most effective form of support.

Specifically, MSSPs can assist the project with resources that:

- Procure, implement and validate additional machine-translation languages for the automatic translation of safeguards data in relevant safeguards IT applications; and
- Develop new capabilities for Safeguards IT applications that enhance the visualization of safeguards data for nuclear fuel cycle and acquisition path analyses.

These activities represent a collaborative effort with activities of project SGIM-003 *Information Analysis*, SGIM-008 *Statistical Analysis*, and SGIM-009 *State Declared Information Management*.

Expected outcome 3.) *Enhanced capabilities to evaluate data analysis methods and computerized tools to aid the analysis of large amounts of all-source information in order to support the State evaluation process.* (In support of V.1.R1, V.1.R3 and V.5.R3)

There is a growing need to access large volumes of data in support of Safeguards implementation processes. The Collaborative Analysis Platform (CAP) and the electronic State File (eSF) developed under the MOSAIC project created new opportunities to simplify access to large data sets and diverse data types.

In an effort to increase its effectiveness and efficiency, the Department of Safeguards has been developing and pilot-testing a big data collection and analysis system called the Collaborative Analysis Platform (CAP) to assist staff in the collection and analysis of safeguards relevant information. CAP is comprised primarily of two core systems: the IAEA Content Reification Engine (ICORE) and a commercially-available network analysis software package. ICORE is a system to automate the collection and categorization of information. For each document collected, ICORE determines the language used, the State(s) mentioned, and the step of the nuclear fuel cycle discussed. The information collected and categorized by ICORE is pushed to a commercially available analysis software package where it is fused with the rest of the information stored by the Department of Safeguards, analysed, and then archived in the Department of Safeguards' information repository - otherwise known as the electronic State File. The goal for ICORE is to create a copy of the nuclear relevant world wide web that can be analysed by the Department of Safeguards. The purpose of the task "Natural language processing investigative tooling and databases" is to establish a mechanism whereby MSSPs can provide support to the Department to improve the performance and usability of ICORE. The task has already been accepted by a number of MSSPs (CAN D 2234, CZ D 2207, FRA D 2267, JPN D 2211, ROK D 2244, UK D 2214 and USA D 2222) and further support will be welcome. SGVI has been the primary user of CAP to date, but many more State Evaluation Groups will be supported by CAP in the coming biennium. This project will be carried out in close collaboration with Project SGVI-001 *JCPOA Implementation*, as well as SGIM-003 *Information Analysis*.

Furthermore, the implementation of tasks aiming at enhancing the capability to view all State-relevant data in the State File, including integration of documents and information residing in other systems, the organization of non-structured data, and the process to analyse and evaluate information will continue. The Information Architects under CFE USA D 1952 and CFE USA D 2253 have greatly contributed in the activities related to this technical task.

Specifically, MSSPs can assist the project with resources that:

- Explore opportunities for enhanced capabilities of the Collaborative Analysis Platform (CAP) and electronic State File (eSF) project**.**

These activities represent a collaborative effort with activities of project SGVI-001 *JCPOA Implementation,* SGIM-003 *Information Analysis*, and SGIM-009 *State Declared Information Management*.

Expected outcome 4.) ***Enhanced 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.*** **(In support of T.3.R1 and T.3.R5)**

New business capabilities are needed to enhance the processing of State-supplied data and improve the quality of the data. Enhancing the IT systems facilitates the integration of data and reduces the security risk related to the exchange of data with Member States.

The State Supplied Data Handling (SSDH) system developed under the MOSAIC project supports the processing, dissemination and analysis of safeguards declarations provided by States to the IAEA, particularly Nuclear Material Accounting (NMA) declarations. With the development of the State Declaration Portal to securely exchange data with Member States, new opportunities exist to enhance the communication with Member States. The IT Systems Engineer under JPO USA A 2262 has greatly contributed to the activities related to this task. The IT Systems Engineer under JPO USA D 2312, planned to start in the first quarter of 2018, will also contribute in the activities related to this technical task.

The activity to develop new and enhance existing capabilities in support of State declaration data include:

- Completion of a study for further developing the State Declaration Portal as a tool that optimizes the quality and usability of State-declared information and enhances other State-Secretariat communication.

These activities represent a collaborative effort with activities of project SGIM-003 *Information Analysis*, SGIM-008 *Statistical Analysis*, and SGIM-009 *State Declared Information Management*.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.9.001 ICT development* and *4.3.1.001 Modernisation of Safeguards Information technology (MOSAIC) in the Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
4	1	State Declaration Portal (4.1.9.001-2018.01)	Extend existing capabilities to allow a broader range of information to be submitted, such as the secure transmission of inspection related communications and operational communications originating from facilities.	September 2019
1	2	Support Program Information and Communication System (SPRICS) (4.1.9.001-2018.01)	Evaluate SPRICS with the goal of simplifying the system to align it better with Member State and Department of Safeguards requirements. Update the system to improve the user experience, technology and security to meet current standards (in collaboration with SGCP-004).	September 2019
	3	Business Intelligence Reporting (4.1.9.001-2018.01)	Enhance and expand the capabilities of the SIR Analytical Tool to provide decision makers in the Department of Safeguards the information they need for actionable insight and better strategic decisions.	September 2019

4.3. Attachments

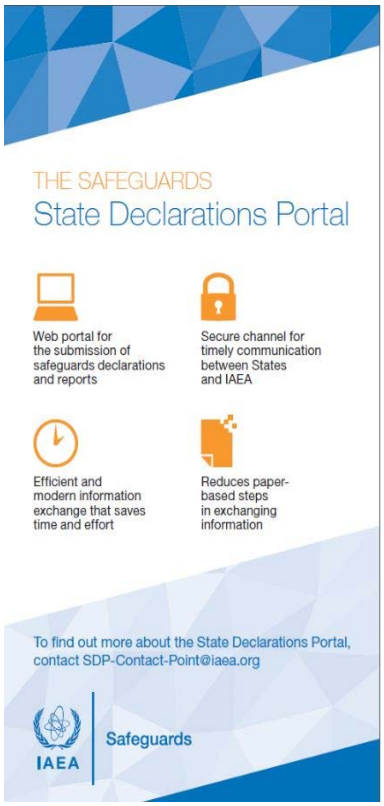


Figure 1: The State Declarations Portal

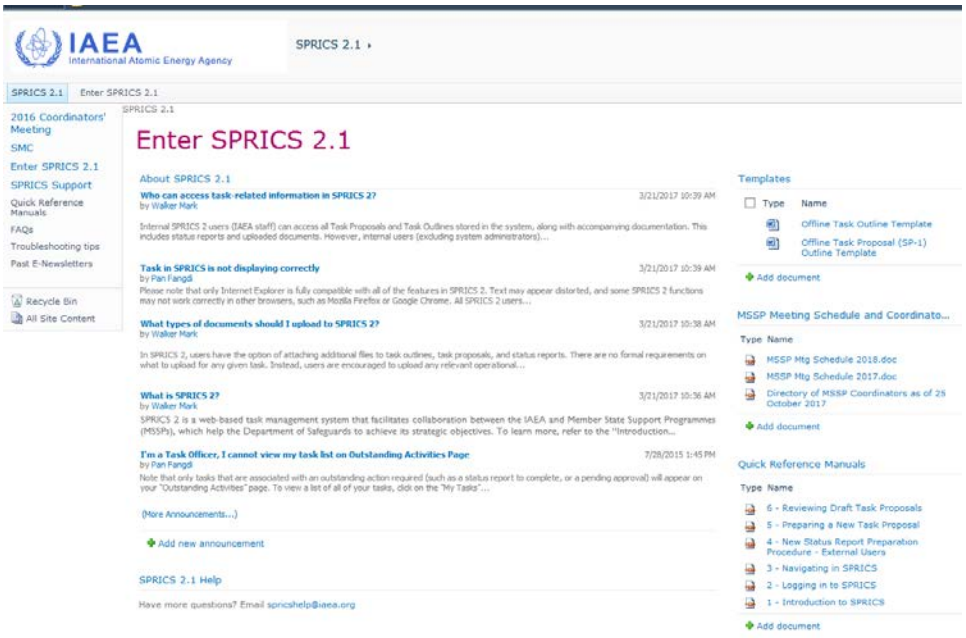


Figure 2: Support Programme Information & Communication System (SPRICS)

SGOA-002

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

Project Manager: Christophe Creusot

Division: SGOA

1. Overview

This document describes plans for developing and implementing an effective and efficient safeguards system for the Japan MOX fuel fabrication plant (J-MOX) within the Department of Safeguards for the period 2018-2019.

During the 2018-2019 biennium, Project SGOA-002 will pursue the following objective:

Develop and implement an effective and efficient safeguards system for the Japan MOX fuel fabrication plant (J-MOX).

The plan detailed here is fully aligned with the objectives of Agency's project *4.3.3.001 Develop and implement a safeguards approach for J-MOX*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.1	*Enable improved in-field verification capabilities*	T.1.R3	Assess existing techniques to detect misuse of reprocessing plants (real time detection of Pu separation).
		T.1.R5	Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment plants and conversion plants, and Pu at reprocessing plants.
T.5	*Identify and exploit innovations*	T.5.R8	Develop alternative fast neutron detectors that improve effectiveness and fieldability.
V.5	*Employ fit-for-purpose and state-of-the-art methodologies*	V.5.R3	Explore data analysis methods and tools to strengthen the synthesis and evaluation of information (e.g. optimal random verification schemes, nuclear material flow analysis, material balance evaluation, near real-time accountancy and process monitoring tools).

SGOA-002 addresses the development and implementation of the J-MOX safeguards systems. It includes the development of joint use equipment, data collection systems, and evaluation software which is monitored through the J-MOX Joint Technical Committee (JTC) with all stakeholders, including Japanese State Authorities and the operator. The development has been almost entirely on stand-by since 2013 as a result of delays in the construction of the facility. The facility will start in 2022 at the earliest according to information from the operator of the plant published at the end of 2017. However, construction will resume only after the completion of the safety review, which is on-going.

Should Japan provide an updated construction schedule for J-MOX during the 2018-2019 biennium, the project's top priorities would be to:

- Develop/consolidate a safeguards approach in line with the State-level Approach (SLA) for Japan;
- Develop/manufacture equipment necessary to support the safeguards approach; and
- Define the requirements specification and architecture for an integrated data collection and evaluation system.

2. Background

The Japan Nuclear Fuel Ltd. (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 main process building and the completion of the utilities building. Construction is currently awaiting further authorization by safety authorities. The safety review is performed based on updated safety regulations promulgated in response to the accident at Fukushima Daiichi, which might impact the current design of J-MOX. As a consequence of those multiple delays, limited efforts were devoted to J-MOX development and implementation activities in the previous biennium, and the plan for the forthcoming biennium will remain largely unchanged from the previous biennial plan unless construction resumes before the end of this biennium.

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. J-MOX safeguards verification systems are jointly developed with Japanese Authorities.

It is expected that most of the funding for development and implementation of the safeguards verification systems for J-MOX will come from the Department's regular budget. Member State Support Programme (MSSP) support will be requested to focus on specific areas, including the support to the development and testing of equipment and software dedicated to the J-MOX facility.

3. Expected Outcomes and Key Outputs

In order to reach Project SGOA-002's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Developed effective and efficient safeguards approach and procedures for J-MOX. **(In support of V.5 Employ fit-for-purpose and state-of-the-art methodologies)**	
Safeguards approach for J-MOX, based on the basic elements agreed with Japan	2022
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	2021
Expected outcome 2.) Developed, tested and deployed verification systems at facilities to meet safeguards requirements. **(In support of T.1.R3, T.1.R5, T.5.R8, and V.5.R3)**	
Designed, tested and installed safeguards equipment (NDA, C/S) that provide high quality, independent and reliable results	2022
Designed, tested and implemented integrated data collection and evaluation software for J-MOX, using synergies with the RRP Information System	2022

The attainment of the expected outcomes and delivery of the key outputs will depend on Japan's provision of an updated J-MOX construction and commissioning schedule. The development of the joint use safeguards equipment, data collection system, and evaluation software will be monitored through the J-

MOX JTC with all stakeholders on a regular basis. The DIV will proceed in accordance with the construction schedule.

4. Tasks

The following projected tasks include those funded by the IAEA regular budget and those expected to be funded by MSSPs.

Expected outcome 1.) ***Developed effective and efficient safeguards approach and procedures for J-MOX.*** **(In support of V.5 Employ fit-for-purpose and state-of-the-art methodologies)**

A safeguards approach needs to be developed for J-MOX, based on the basic elements agreed with Japan. The preparation of implementation procedures tailored for J-MOX will be started.

As soon as the construction of the plant restarts, DIE/DIV procedures can be established and implemented in order to assure that the facility is constructed and will operate as declared, while ensuring that the safeguards approach remains adequate and robust. The DIE/DIV activities will be conducted from construction to MOX commissioning phases.

Expected outcome 2.) ***Developed, tested and deployed verification systems at facilities to meet safeguards requirements.*** **(In support of T.1.R3, T.1.R5, T.5.R8, and V.5.R3)**

A number of MSSP umbrella tasks are opened 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);
- Assistance with development and testing of new systems (NDA, C/S, 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 Department will potentially contribute to the development of the J-MOX systems, including: SGTS-001 *NDA Techniques;* SGTS-003 *Surveillance Techniques*, SGTS-011 *Unattended Measurement Techniques*, and SGTS-014 *Remote Monitoring and Data Processing Systems*.

MSSP support might be requested for the development of DA sample treatment, analysis and transportation procedures, as well as for the development of NRTA simulation tools.

Task UK D 1878 provided 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. A peer review of a conceptual design for rods verification system was carried out in 2015 under the same task and another one based on a revised concept is foreseen for the 2018-2019 biennium.

Initial tests were performed in Japan under the task JPN A 1721 to evaluate the potential use of new generation detectors (i.e. electromechanically-cooled high-purity germanium (EMC-HPGe), Cadmium zinc telluride (CZT), and liquid scintillator neutron detectors) for J-MOX, as well as the long-term testing of the EMC-HPGe in 2013. Additional tests are foreseen in existing MOX facilities in Japan during the 2018-2019 biennium.

Tests with a number of equipment items, including an 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. Additional tests are foreseen at MELOX in France during next biennium.

Further MSSP support may be needed in the future for peer review of systems and prototype testing.

The development of J-MOX safeguards systems is carried out with the support of a CFE provided by the USA.

The development and implementation of an integrated data collection and evaluation system for J-MOX (named 'JADE') is currently on hold. High-level user requirements were gathered in 2010/2011. 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 to provide future assistance for the design, development, procurement, testing, and installation of the JADE system. Sub-tasks will be defined as needs arise.

Most of the above tasks were in stand-by in 2016-2017 and will be re-activated when an updated J-MOX construction and commissioning schedule is received.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.3.3.001 Develop and implement a safeguards approach for J-MOX* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 Attachments

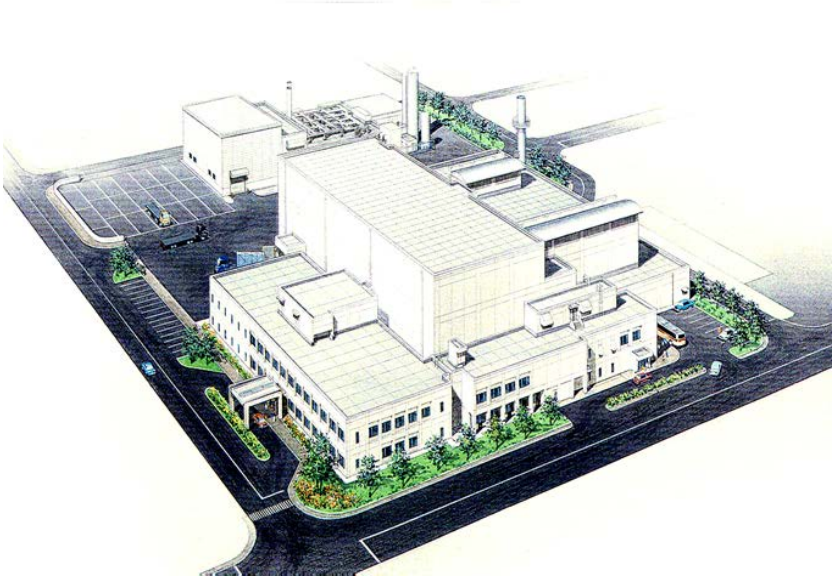


Figure 1: A bird's eye view of the future J-MOX plant

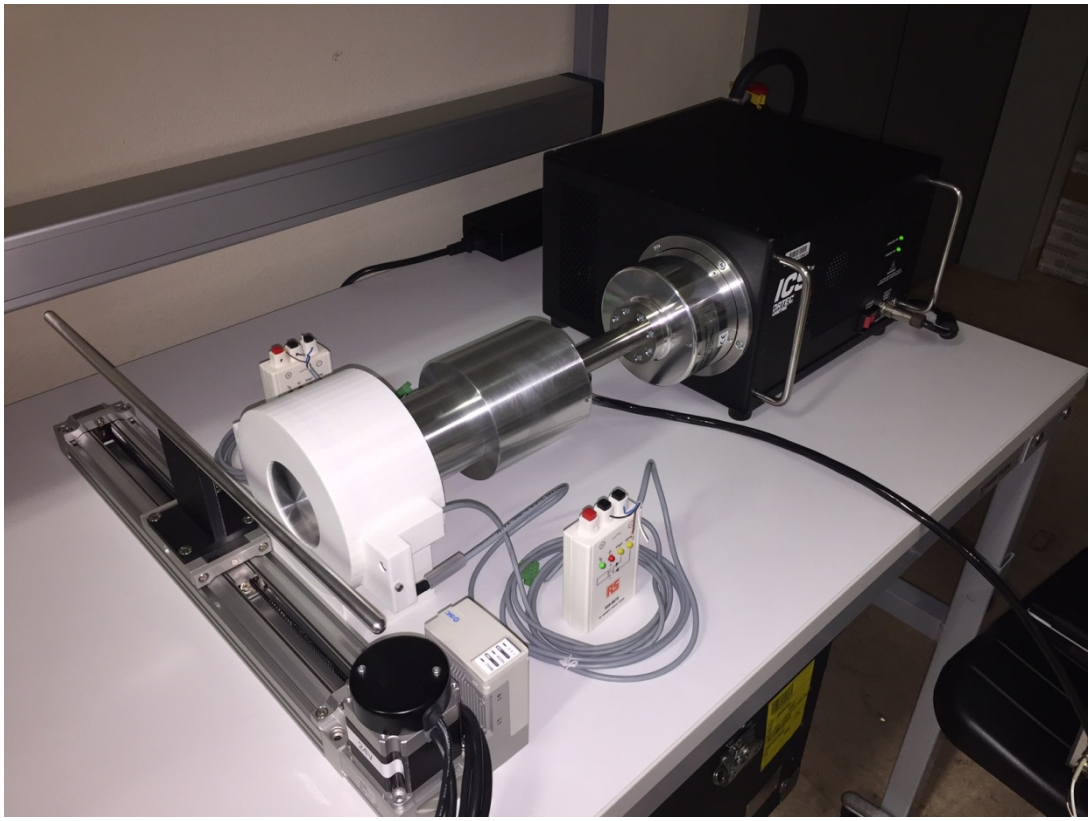


Figure 2: Testing of the fuel rod scanning system prototype

SGOA-003

Fukushima Dai-ichi Safeguards

Project Manager: Bruno Chesnay

Division: SGOA

1. Overview

This document describes the plans for developing and implementing Project SGOA-003, *Fukushima Dai-ichi Safeguards* within the Department of Safeguards for the period 2018–2019.

During the period 2018-1019, Project SGOA-003 will pursue the following objective:

Maintain adequate safeguards for the inaccessible nuclear materials and facilities at the Fukushima Dai-ichi nuclear site.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.2.001 Verification for States with CSA and AP in force.*

The project supports the following R&D Need from the *R&D Plan*:

Priority Objective		R&D Need	
P.4	*Maintain readiness for other verification tasks*	P.4.R2	Assist with Chernobyl and Fukushima related activities as requested.

SGOA-003 addresses the development of safeguards equipment and approaches for maintaining adequate safeguards for the inaccessible nuclear material and facilities at the Fukushima Dai-ichi nuclear site. Due to high levels of radiation and damaged infrastructure, it has not been possible since the accident in 2011 to verify some of the nuclear material at Fukushima, and it is expected that significant amounts of nuclear material will remain inaccessible for verification for several more years.

For 2018-2019, the project's top priorities are to:

- Maintain a reliable safeguards system at the Fukushima Dai-ichi site capable of providing credible assurance that nuclear material cannot be removed from the damaged facilities without the IAEA's knowledge;
- Make improvements and adjustments to the monitoring system to accommodate changes in the remediation status of the damaged facilities on the site; and,
- Develop measures to re-verify as much of the previously inaccessible nuclear material as possible.

2. Background

At the time of the large earthquake and tsunami that struck Japan in March 2011, there were six large nuclear power reactors on the Fukushima Dai-ichi site, as well as two spent fuel storage facilities, one pool-type and one dry-cask-type. All of the facilities were under IAEA safeguards and in full compliance with all relevant safeguards requirements.

The tsunami caused a 'station black-out' at Fukushima Dai-ichi, leading to considerable damage of the cores in Reactor Units 1, 2, and 3. Reactor Units 1, 3, and 4 subsequently exploded due to hydrogen gas buildup. IAEA inspectors entered the damaged site in October 2011 to re-establish safeguards to the extent possible. Due to the loss of electrical power to safeguards cameras, there was no surveillance data for that 7-month period at the reactors or spent fuel facilities. The IAEA's cameras and seals in Reactor Units 1-4 were either destroyed or rendered inaccessible.

Safeguards surveillance has been re-established on the site in accessible locations. Nuclear material has been re-verified in stages as infrastructure has been restored and as nuclear material has been gradually

removed from high-radiation areas. As of the end of 2017, the nuclear material inventories of Reactor Units 4, 5, and 6, as well as the inventories of both spent fuel storage facilities have been fully re-verified. The inventories of Reactor Units 1, 2, and 3 remain inaccessible.

The IAEA's safeguards approach is to monitor the perimeter of the damaged reactor area to ensure that no nuclear material can be removed from the damaged facilities without the IAEA's knowledge, and to supplement this monitoring with short-notice accesses to relevant locations on the site to ensure that no undeclared activities are taking place.

Japanese safeguards authorities (the Japan Safeguards Office (JSGO)), provide supplementary access rights and submit supplementary safeguards-relevant information to help the IAEA maintain adequate confidence that the declared nuclear material remains on the site. The IAEA and the Japanese authorities meet formally twice each year in the Fukushima Safeguards Task Force to review the status of safeguards at the site.

As remediation work continues at Fukushima Dai-ichi, infrastructure is being restored and radiation levels reduced. The IAEA will need to adjust and improve its monitoring systems to take account of these changes. Also, the IAEA wants to investigate options for in-situ verification of currently inaccessible nuclear materials, mainly spent fuel in the pools of Reactor Units 1, 2, and 3.

3. Expected Outcomes and Key Outputs

In order to reach Project SGOA-003's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Specialized support and expertise on monitoring systems capable of providing credible assurance that nuclear material is not removed from the damaged facilities (in close collaboration with SGTS-001 and SGTS-002). **(In support of P.4.R2)**	
Design, development and deployment of reliable and effective monitoring systems using surveillance devices, radiation detectors or other methods	December 2018
Expected outcome 2.) Specialized support and expertise on technical options for in-situ verification of currently inaccessible material (in close collaboration with SGTS-001). **(In support of P.4.R2)**	
Design and development of new verification techniques (i.e. non-destructive analysis based, optical devices, etc.) for in-situ verification of nuclear material (particularly spent fuel) at the damaged facilities	December 2019
Expected outcome 3.) Enhanced knowledge about the status of the nuclear material in the damaged cores through an independent analysis of all available information to date. **(In support of P.4.R2)**	
A report, based on the compilation of all relevant information published after the accident and the analysis of this data, to assess the status and the approximate location of the nuclear material in the reactor buildings	December 2019

4. Tasks

Most of the following tasks will be performed by Safeguards Department personnel within regular budget resources in Project *4.1.2.001 Verification for States with CSA and AP in force*. Further assistance may be required from Member State Support Programmes (MSSPs) for some tasks.

Expected outcome 1.) ***Specialized support and expertise on monitoring systems capable of providing credible assurance that nuclear material is not removed from the damaged facilities.*** **(In support of P.4.R2)**

In 2015, in collaboration with SGTS, several outdoor cameras and a new radiation monitor (Open Air Spent Fuel Monitor, (OASM)) have been installed to monitor spent fuel movements from the damaged facilities and to significantly contribute to the objective of confirming no diversion of declared material that is inaccessible on the site. The system has been updated with remote monitoring capabilities in 2016. Nevertheless, due to the increasing remediation works in and around the damaged facilities, improving and adjusting the monitoring capabilities will continue to be a priority in the future.

Expected outcome 2.) ***Specialized support and expertise on technical options for in-situ verification of currently inaccessible material.*** **(In support of P.4.R2)**

Currently, the verification of the spent fuels from Unit 4 has been performed at a nearby common spent fuel storage facility (CSFS) where the spent fuels are temporarily stored. The spent fuel of unit 3 is expected to be transferred to CSFS in 2018. For the remaining damaged facilities, Units 1-3, remediation and decontamination work is being carried out to prepare to remove the currently inaccessible material (nuclear material in the spent fuel ponds and cores). Investigating or developing new technical methods or systems to verify *in situ* the spent fuel would increase confidence that no declared nuclear material has been removed from the damaged facilities. This will be carried in collaboration with SGTS.

Expected outcome 3.) ***Enhanced knowledge about the status of the nuclear material in the damaged cores through an independent analysis of all available information to date*** **(In support of P.4.R2)**

Since the occurrence of the accident, a large amount of data (e.g. pressure, temperature, radiation, etc.) and other information (e.g. photographs, computer codes evaluations) have been produced.

A compilation and analysis of all relevant information published in the course of the accident would provide an improved knowledge of the characteristics and the location of the fuel inside the reactor pressure vessel (RPV) and the primary containment vessel (PCV). This would in turn improve the capabilities to design appropriate safeguards measures to be applied on this nuclear material. MSSP support will be required to implement this task.

4.1 MSSP Development and Implementation Support Tasks

At the time of drafting this plan, there is no active MSSP support task. MSSP support tasks would be followed-up and/or coordinated by Agency's staff under Agency's project(s) *4.1.2.001 Verification for States with CSA and AP in force*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 Attachments

Figure 1: View of Fukushima Dai-ichi site (Units 1-4) / IAEA monitoring equipment, Fukushima Dai-ichi Live Camera (images of Unit 1 side), Fukushima Dai-ichi Live Camera (images of Unit 4 side)

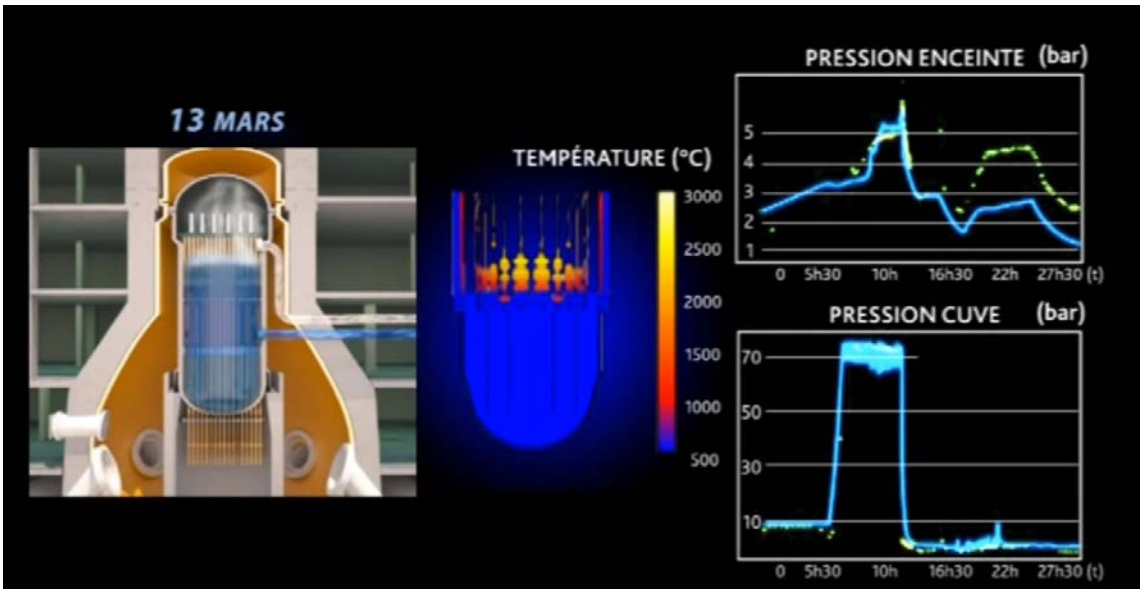


Figure 2: Simulation for Unit 1
© Radioprotection and Nuclear Safety Institute (IRSN) (https://www.youtube.com/watch?v=tjEHCGUx9JQ)

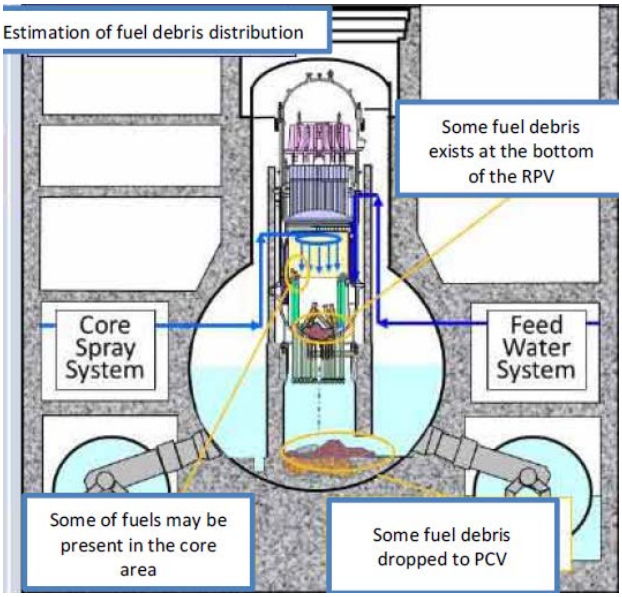


Figure 3: Estimation of fuel debris distribution in Unit 3
© International Research Institute for Nuclear Decommissioning

Figure 4: Inside primary containment vessel (PCV) Unit 3
© International Research Institute for Nuclear Decommissioning
(http://irid.or.jp/_pdf/Sympo2017_Kiyoura.pdf)

SGOC-001

Chernobyl

Project Manager: Sigitas Kurselis

Division: SGOC

1. Overview

This document describes plans for developing and implementing Project SGOC-001 within the Department of Safeguards for the period 2018–2019.

During the 2018-1019 biennium, Project SGOC-001 will pursue the following objective:

Develop and implement effective and efficient safeguards systems at the Chernobyl site.

The plan detailed here is fully aligned with the objectives of Agency's project *4.3.3.003 Develop and implement safeguards approaches for the Chernobyl NPP*.

The project supports the following R&D Need from the *R&D Plan*:

Priority Objective		R&D Need	
P.4	*Maintain readiness for other verification tasks*	P.4.R2	Assist with Chernobyl and Fukushima related activities as requested.

The purpose of the project is to apply safeguards in an effective and efficient manner at the new facilities being constructed at the site of the Chernobyl NPP (ChNPP). The new facilities comprise the Interim (dry) Spent Fuel Storage Facility 2 and the associated conditioning facility (collectively referred to as 'ISF-2'), and the New Safe Confinement (NSC) to be placed over the existing Shelter covering ChNPP Unit 4. The IAEA's obligation is to ensure that safeguards are applied, in accordance with the terms of the safeguards agreement (INFCIRC/550) on all nuclear material at these facilities, while avoiding undue interference in the operations of the facilities.

All three facilities are planned to start operation in 2018. Installation and tuning of the IAEA equipment at ISF-2 and installation in NSC will continue in 2018.

For the 2018-2019 biennium, the project's top priorities are to:

- Finalize procedures for safeguards application at facilities under this project;
- Complete the installation, adjustment and authorization of safeguards equipment for verification use.

2. Background

Project SGOC-001 was initiated in 2001. Due to technical problems experienced during the construction of the new facilities, construction was halted in 2003. In January 2013, Ukraine requested the Agency to provide the technical details of the equipment to be installed at the ISF-2 conditioning facility and dry storage. In August 2015, the IAEA submitted the technical details. During 2016-2017, a State-Level Safeguards Approach for Ukraine, which includes a general approach for the ISF-2, was developed. A system of safeguards technical measures was defined and implementation has started.

3. Expected Outcomes and Key Outputs

In order to reach Project SGOC-001's objective and achieve the associated R&D needs from the *R&D Plan*, tasks have to be continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Finalized procedures for safeguards application at facilities under this project. **(In support of P.4.R2)**	
Finalized procedures covering:	
- *SF transfer from the wet storage at ChNPP to the ISF-2 conditioning facility*	June 2018
- *Flow of nuclear material inside the conditioning facility*	June 2018
- *Transfer of spent fuel from the conditioning facility to the dry storage*	June 2018
- *The dry spent fuel storage*	June 2018
- *Activities at the NSC*	July 2018
Expected outcome 2.) Completed installation, adjustment and authorization of safeguards equipment for verification use (in close collaboration with SGTS-014). **(In support of P.4.R2)**	
Authorization of safeguards equipment for verification use at ISF-2	June 2018
Installation and authorization of safeguards equipment for verification use at NSC	End 2018

4. Tasks

Most of the following tasks will be performed by Safeguards Department personnel under Agency's Project *4.3.3.003 Develop and implement safeguards approaches for the Chernobyl NPP* with regular budget support. Further assistance will be required from Member State Support Programmes (MSSPs) for purchase of equipment and financing of duty trips related to installation and adjusting of the equipment. Assistance from the US Support Program (USA E 1361 and USA E 1445) may be used for this purpose.

Expected outcome 1.) ***Finalized procedures for safeguards application at facilities under this project.*** **(In support of P.4.R2)**

A preliminary safeguards approach was prepared in 2005-2006. Taking into account the broader conclusion for Ukraine (drawn since 2010) and the recent simplification of the nuclear material flow in the processing facility, a new safeguards approach needed to be developed. In August 2015, the principles of the safeguards approach to be applied during transfer to the ISF-2 were approved by the Technical Review Committee (TRC); they are incorporated in the updated SLA for Ukraine, which came into force on 1 May 2017. Detailed procedures for application of safeguards during spent fuel transfer, processing and storage are to be developed during the first half of 2018.

Expected outcome 2.) ***Completed installation and authorization of safeguards equipment for verification use.*** **(In support of P.4.R2)**

For ISF-2: the safeguards measures to be applied are based on an integrated monitoring system consisting of surveillance and neutron and gamma radiation detectors, which may be operated in unattended mode and in remote data transmission. Surveillance and radiation detectors will be installed in 2017/first quarter 2018 in the spent fuel conditioning facility as well as on the transfer equipment such as the railcar and the canister trolley. The integrated monitoring system provides continuity of knowledge on nuclear material to

be transferred from the wet spent fuel storage to the new dry storage facility, through the conditioning facility. These tasks will be coordinated with tasks in Project SGTS-014 *Remote Monitoring and Data Processing Systems*.

For the NSC: 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 surveillance (C/S) and NDA devices, was upgraded in 2013. Depending on the Safeguards Approach selected for the NSC, it may continue to be in use together with the new monitoring equipment that is to be installed. The new equipment shall cover removal points of the NSC in a similar way as for the existing shelter. Installation will be completed by the end of 2018.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.3.3.003 Develop and implement safeguards approaches for the Chernobyl NPP* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
1	1	Analysis of results of cold and hot tests (2018.01)	Analysis of the "as built" design and results of various tests shall be performed.	April 2018
	2	Development of detailed procedures (2018.01)	Detailed procedures to be developed and approved by TRC.	June 2018
2	3	Safeguards approach for NSC (2018.01)	Safeguards approach for the NSC should be finalized during the first quarter 2018.	March 2018
	4	Equipment infrastructure requirements for NSC (2018.01)	For equipment procurement and installation, infrastructure requirements are to be developed.	June 2018

4.3 Attachments

Figure 1: Chernobyl New Safe Confinement

Figure 2: The Interim (dry) Spent Fuel Storage Facility 2 and the associated conditioning facility (collectively referred to as 'ISF-2') Conditioning Facility

Figure 3: Interim (dry) Spent Fuel Storage Facility 2 (ISF-2)

SGVI-001

JCPOA Implementation

Project Manager: Andrew Catton

Division: SGVI

1. Overview

This document describes plans for coordinating the implementation of the Joint Comprehensive Plan of Action (JCPOA) within the Department of Safeguards for the period 2018-2019.

During the 2018-2019 biennium, Project SGVI-001 will pursue the following objective:

Develop and implement effective and efficient verification and monitoring of Iran's nuclear-related commitments under the JCPOA.

The plan detailed below is fully aligned with the objectives of Agency's project *4.2.1.002 Verification monitoring of Iran's JCPOA nuclear related commitments*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
V.1	*Strengthen information collection and analysis*	V.1.R3	Further integrate safeguards information to strengthen all-source information analysis and make it more user-friendly (e.g. via the Collaborative Analysis Platform).
W.1	*Reform human resource management*	W.1.R1	Develop and maintain, through training, new expertise required by the Department, where needed, with the help of Member States.

SGVI-001 addresses the potential need for additional resources to ensure the effective and credible implementation of the JCPOA. The project is intended to help coordinate resource requests and activities that are primarily for JCPOA implementation.

For the 2018-2019 biennium, the project's top priorities are to:

- Contribute to the development of software and analytical tools (in cooperation with SGIS-003 *Information Systems and System Usability*);
- Organise specialized training (in cooperation with SGCP-102 *Training*).

2. Background

On 14 July 2015, the E3/EU+3 and the Islamic Republic of Iran signed the JCPOA, which calls upon the IAEA to monitor and verify the nuclear-related measures set out in the agreement.

As a result of the JCPOA, Iran will provisionally implement the Additional Protocol (AP) to its safeguards agreement with the IAEA, and implement nuclear-related commitments, which are known as transparency measures. Under the AP, States grant the IAEA expanded rights of access to information and sites. As part of the transparency measures under the JCPOA, IAEA inspectors will have enhanced access to uranium mines and mills, and continuous surveillance of centrifuge manufacturing and storage locations. These measures go beyond the scope of Iran's Comprehensive Safeguards Agreement (CSA) and AP and will help the IAEA to have a better understanding of Iran's nuclear programme.

3. Expected Outcomes and Key Outputs

In order to reach Project SGVI-001's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Maintain capabilities for the verification and monitoring of Iran's nuclear-related commitments under the JCPOA. **(In support of V.1.R3 and W.1.R1)**	
Contributions to the development of the Natural Language Processing task, advising on the move from the development stage to the deployment stage (through SGIS-003)	December 2019
Continued deployment of specific training for members of the Office of Verification in Iran (in collaboration with SGCP-102)	December 2019

4. Tasks

Outside of the Member State Support Programme (MSSP) framework, Member States have provided significant extrabudgetary contributions in support of the verification and monitoring of Iran's nuclear-related commitments under the JCPOA. These financial contributions have substantively helped the IAEA to fund additional human resources, travel and analytical services that are required for this effort.

Expected outcome 1.) ***Maintained capabilities for the verification and monitoring of Iran's nuclear-related commitments under the JCPOA.*** **(In support of V.1.R3 and W.1.R1)**

The Office for Verification in Iran (SGVI) will greatly benefit from the development and pilot-testing of a big data collection and analysis system called the Collaborative Analysis Platform (CAP) to assist staff in the collection and analysis of safeguards relevant information. SGVI has been the primary user of CAP to date and will continue to actively support its development. This project will be carried out through Project *SGIS-003 Information Systems and System Usability*, in close collaboration with *SGIM-003 Information Analysis*.

Planned training courses relevant to the Office for Verification in Iran are mentioned in detail under *SGCP-102 Training*. Further specific training courses will be requested on an as-needed basis.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.2.1.002 Verification monitoring of Iran's JCPOA nuclear related commitments* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives, as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 Attachments

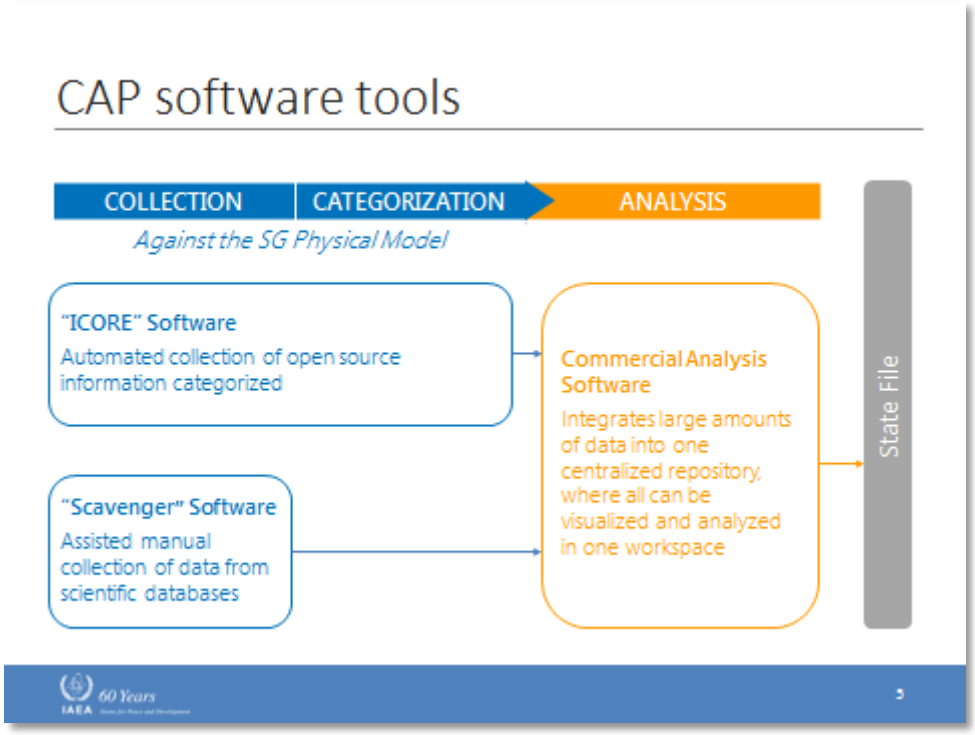


Figure 1: The Collaborative Analysis Platform (CAP) software tools
that collect, categorize, and analyse open source data against the Safeguards Physical Model

SGTS-001

NDA Techniques

Project Manager: Mikhail Mayorov

Division: SGTS

1. Overview

This document describes 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 access, within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGTS-001 will pursue the following objective:

Develop and improve performance and detection capabilities of equipment/ methods to verify, detect, check and monitor nuclear material (including irradiated material) and nuclear activities.

The plan detailed here is fully aligned with the objectives of Agency's projects *4.1.6.001 Portable and resident non-destructive assay equipment* and *4.3.2.001 Development of equipment components and stand-alone instruments*.

In 2018-2019, SGTS-001 will capitalize on progress made towards milestones from the previous *Long-Term R&D Plan*[1], specifically:

Capability	Milestone
2. Increased capability to detect undeclared nuclear material and activities.	2.6 Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations.
5. Ability to deploy equipment at facilities to meet safeguards requirements.	5.6 Develop improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.
	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.
	5.8 Develop alternative NDA instruments, for instance based on liquid scintillators, to improve performance in neutron coincidence counting techniques applied to various types of fissile material.

These milestones have not been carried forward as 'R&D needs' in the updated *R&D Plan* as mature solutions are now available and at the implementation stage. While further R&D is not being requested in these areas at this time, support from Member States on issues arising during implementation remains important, as outlined in Section 4.

[1] *IAEA Department of Safeguards Long-Term R&D Plan, 2012-2023*

In addition, the project supports the following R&D Needs from the updated *R&D Plan*:

Priority Objectives		R&D Needs	
T.2	*Enhance sensitivity, reliability and timeliness in sample analysis*	T.2.R1	Improve analytical timeliness of dealing with special and high priority demands for analysis by means of the reduction of sample size, the application of in-situ analysis and by strengthening the response regime (e.g. COMPUCEA, Cristallini method).
T.5	*Identify and exploit innovations*	T.5.R8	Develop alternative fast neutron detectors that improve effectiveness and fieldability.
V.5	*Employ fit-for-purpose and state-of-the-art methodologies*	V.5.R2	Strengthen knowledge of the elemental and isotopic signatures of the nuclear fuel cycle and processes that are specifically detectable through material characterization and environmental sample analyses, and develop expert systems and methodologies that advance data evaluation and enhance continuity of knowledge.

Beyond the current biennium, the project will support the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.1	*Strengthen instrumentation capabilities for verification*	T.1.R7	Evaluate implementation potential for calorimetry of plutonium samples when the commonly available passive neutron multiplicity measurements are not feasible.
		T.1.R8	Develop in-field alpha spectrometers (including sample preparation) for nuclear material identification and isotopic composition analysis.
T.5	*Identify and exploit innovations*	T.5.R6	Investigate and test fieldable neutron counting systems reducing the use of ^{3}He or offering equivalent functional and technical alternatives.
		T.5.R7	Develop and evaluate alternatives to photo-multiplier tubes for large neutron or gamma scintillation detectors.
		T.5.R9	Develop large room-temperature semiconductor medium-resolution gamma spectrometers to replace scintillation detector systems.

In 2018-2019, Project SGTS-001 will continue to take advantage of progress in nuclear electronics, information technologies, and the performance of radiation detection equipment. The project outcomes will empower the Department of Safeguards with new instruments and methodologies to improve the ability to verify the completeness of States' declarations, including with respect to the absence of undeclared material and activities.

For 2018-2019 biennium, the project's top priorities are to:

- Capitalize on results of Passive Gamma Emission Tomography System (PGET) development and authorization project by implementation of the system for Encapsulation Plant for Geological Repositories (EPGR) Project and other safeguards verification activities that require application of partial defect tests on spent nuclear fuel;

- Deploy Fast Neutron Coincidence Collar at nearly all safeguarded fuel fabrication facilities, that manufacture nuclear fuel assemblies containing burnable poison rods;
- Continue performance evaluation of the NDA instruments for detection of non-radiation Nuclear Fuel Cycle (NFC) signatures (such as those based on LIBS and Raman technologies) and supported by the creation of a repository for reference NFC signature materials;
- Perform re-engineering of the Inspector-level software suite for various Multichannel Analyser based applications to improve usability and maintainability.

2. Background

For the biennium 2018-2019, project SGTS-001 will be mainly focusing on the completion of tasks initiated earlier and on the implementation of the newly developed NDA systems. The goal is to increase the implementation rate of newly developed NDA instruments and methods, rather than increase the number of R&D tasks and associated activities.

Looking beyond the horizon of this biennium, and in order to give a preview of medium term needs, SGTS-001 would greatly benefit from MSSP contributions in the following areas:

- Calorimetry of plutonium samples when the commonly available passive neutron multiplicity measurements are not feasible;
- In-field alpha spectrometers for nuclear material identification and isotopic composition analysis, where accuracy of gamma spectrometry is insufficient and mass spectrometry is not a practical option due to required timeliness of the analysis results (the targeted facilities under safeguards would be conversion and enrichment plants);
- Alternative fast neutron detectors, such as stilbene-based crystals with sufficient gamma-neutron discrimination for in-field use;
- Alternative medium resolution solid-state gamma spectrometers with sensitivity, sufficient to replace low and medium resolution photomultiplier – based spectrometers.

3. Expected Outcomes and Key Outputs

In order to reach Project SGTS-001's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Developed instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations. **(In support of T.5 Identify and exploit innovations)**	
Results of assessment of capabilities of portable Laser induced breakdown spectrometer (LIBS) for impurity Content Determination in Uranium Bearing Material	December 2018
Expected outcome 2.) Developed elemental and isotopic signatures of nuclear fuel cycle activities and processes for the calibration of instruments. **(In support of V.5.R2)**	
Repositories of basic nuclear fuel cycle indicator and signature materials, relevant infrastructure for carrying out experimental tests with such materials, and comprehensively-characterized collected materials	December 2018

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 3.) Developed improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition. **(In support of T.5 Identify and exploit innovations, and T.1 Strengthen instrumentation capabilities for verification)**	
Results of performance evaluation of the Compact Gamma Tomography System (delivered to the IAEA in 2017), with the goal of authorizing the system for inspection use	December 2018
Expected outcome 4.) Deployed 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. **(In support of T.1 Strengthen instrumentation capabilities for verification, and T.5 Identify and exploit innovations)**	
Deployment of a Passive Gamma Emission Tomography (PGET) for non-routine (EPGR) and routine (such as verification of dismountable spent nuclear fuel) activities that require verification with partial defect test	December 2019
Expected outcome 5.) Deployed alternative NDA instruments (for instance, based on liquid scintillators) to improve performance in neutron coincidence counting techniques applied to various types of fissile material. **(In support of T.5.R8)**	
Results of test and deployment of the re-designed FNCL at fuel fabrication plants where the nuclear fuel containing burnable poison rods is manufactured	December 2018
Expected outcome 6.) Re-designed, improved or upgraded safeguards equipment and systems, implementing an improved cost/benefit assessment methodology for the design and operation of safeguards equipment. **(In support of T.1 Strengthen instrumentation capabilities for verification, T.5 Identify and exploit innovations, and T.2.R1)**	
Re-designed Cask Radiation Profiling System (CRPS) to replace phased-out components of the old CRPS	December 2018
COMPUCEA application extended towards UF_6 enrichment	December 2018
New fast neutron probe for performance of the zero-power reactor noise analysis for verification of research reactors and critical assemblies	December 2019
Re-designed ICVD to allow image recording and special processing to essentially enhance image quality (in cooperation with SGTS-008)	December 2019
Development of an Inspector-level integrated data acquisition and analysis software application	December 2019

4. Tasks

Most of the following tasks will be performed by Safeguards Department personnel. Further assistance will be required from Member State Support Programmes (MSSPs) for some activities. Contributions from the JPO task, NDA Simulation Engineer (USA A 2233), in the area of numerical model calculation, are particularly appreciated and relevant across several tasks described below.

Expected outcome 1.) ***Developed instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations.*** **(In support of T.5 Identify and exploit innovations)**

In 2016 the IAEA authorized for in-field verification activities a Raman spectrometry-based material identifier capable of in-field real-time identification of chemical compounds that might be indicators of undeclared nuclear material of nuclear fuel cycle-related activities. In addition to it, the instrument toolbox for on-site detection of non-radiation signatures currently contains the x-ray spectrometer and laser-induced breakdown spectrometer (LIBS) developed in 2017 under CAN A 1855. Another portable LIBS-based system is under procurement.

Under HUN A 2282 "Assessment of capabilities of portable LIBS for impurity Content Determination in Uranium Bearing Material" performance of the selected instruments will be further investigated.

Expected outcome 2.) ***Developed elemental and isotopic signatures of nuclear fuel cycle activities and processes for the calibration of instruments.*** **(In support of V.5.R2)**

The IAEA will continue with the acquisition of reference nuclear fuel cycle materials to adapt commercial off-the-shelf instruments to safeguards needs. Several MSSP tasks – USA A 2246, EC A 2200 and UK A 2215 – are already contributing to this task.

The substances of interest include, but are not restricted to, maraging steels, Al alloy 7075, Be-Cu/Li/Al alloys, Zyrcaloy, Na, Mg, and K metals and alloys, graphite of different purities in regard to neutron absorbents, special acids (formic, oxalic, hydrofluoric), special organic compounds (fomblin, methyl isobutyl ketone, dibutoxi diethyl ether, tri-n-butyl phosphate, thenoyltrifluoracetone, tri-lauryl amine, kerosene, dodecane) and other chemical substances that are used at various stages of the nuclear fuel cycle.

The repository of reference nuclear fuel cycle material will be established in the IAEA Nuclear Material Laboratory operated by SGAS; support from MSSPs with advanced nuclear fuel cycle capabilities has been requested.

Expected outcome 3.) ***Developed improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.*** **(In support of T.1 Strengthen instrumentation capabilities for verification, and T.5 Identify and exploit innovations)**

SGTS-001 will perform the evaluation and authorization of a compact gamma-tomography system (CGTS) for assessment of nuclear waste. The instrument (Figure 1) was manufactured and delivered to the IAEA in 2016-2017 to address a particular verification challenge: the quantitative verification of heterogeneous waste and scrap containing nuclear material. Neutron measurements may not be accurate enough to meet the accuracy of partial defect tests, since the matrix of the material (particularly with regard to hydrogen and neutron adsorbent compounds) is unknown and difficult to assay. An alternative solution is transmission-emission high-resolution spectrometry performed at the level of individual voxels in the inspected object. Expertise for software development will be used to provide a smoother authorisation process.

Expected outcome 4.) ***Deployed 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.*** **(In support of T.1 Strengthen instrumentation capabilities for verification, and T.5 Identify and exploit innovations)**

During the previous biennium 2016-2017, the IAEA, in cooperation with MSSP tasks JNT A 1510 EC and FIN, FIN A 1997, USA A 2015, JNT A 2272 SWE, JNT A 2258 FIN, JNT A 2315 USA and JNT A 2287 EC, re-designed the Passive Gamma Emission Tomography (PGET) system for partial and bias defect testing on spent fuel. The functional, technical and operational performance of the PGET System was thoroughly evaluated in laboratory and field tests on spent fuel assemblies with a wide range of designs, burnups and cooling times (Figure 2).

The PGET has demonstrated its ability to acquire, reconstruct and analyse the images of PWR, BWR and VVER-440 spent fuel assemblies with burnup from 5.7 GWd/tU to 58.0 GWd/tU and cooling time from less than 2 years to up to 26.6 years. Within five minutes, PGET was capable of detecting a single missing pin,

irrespective of its location in the SFA lattice, for all tested configurations. Additional features of the device, including ultra-fast four-channel analysers, medium resolution gamma spectrometry, and neutron detection, were found to be very useful for discrimination of the irradiated pins containing no fissile material (dummies, model fuel), as well as for the irradiation history consistency check. The PGET was also successfully deployed to perform the verification of pins in a closed container and to provide a semi-quantitative consistency check of the pin-by-pin irradiation history. Finally, the necessary infrastructure for PGET to perform routine functionality checks, preparation for the field use and performance tests was established at Atominstitut – Technical University in Vienna, Austria under the IAEA Technical Research Contract 22316. The PGET performance test on WWER-1000 SFAs is facilitated and organized under CZ A 1566.

In 2018-2019, SGTS-001 will complete the work on the development and validation of the numerical model of PGET under the task JNT A 2315 USA, and test algebraic image reconstruction algorithm under the task JNT A 2272 SWE. The Department also intends to prepare deployment of PGET for the encapsulation plant and geological repository (EPGR) project by addressing various scientific and technical aspects, e.g. testing of the PGET performance on the long cooling time / low burnup nuclear fuel designated for the Geological Repository in Finland; PGET performance evaluation in air; and improvement of the image reconstruction and analysis algorithm to mitigate the issue of false positive detections due uneven burnup distribution and presence of burnable poison rods. The project will also deal with aspects of unattended monitoring and joint use of PGET with Member States, or regional authorities (e.g. EURATOM).

Expected outcome 5.) ***Deployed alternative NDA instruments (for instance, based on liquid scintillators) to improve performance in neutron coincidence counting techniques applied to various types of fissile material.*** **(In support of T.5.R8)**

In 2017, the IAEA, in cooperation with its MSSP tasks NET A 1958, UK A 1951 and EC A 1362, completed the development of a liquid scintillator-based fast neutron coincidence counting system for uranium measurements in fresh fuel assemblies. A Fast Neutron Uranium Collar (FNCL) prototype and its MCNP model have been developed (see Figure 3). The FNCL is an active NDA system for ^{235}U assay in fresh fuel assemblies. The system uses up to twelve liquid scintillation detectors to directly detect fast neutrons.

Modern fuels containing burnable poisons such as gadolinium (Gd) have extremely high absorption cross-sections for thermal neutrons, and require corrections based on a declaration which cannot be independently verified. The fuel therefore must be interrogated using epithermal neutron fields to reduce the dependence on the poisons. This severely reduces the induced fission rate and extends measurement time. Current alternatives such as the fast-mode UNCL and the IAEA's fast-mode high efficiency UNCL depend on ^{3}He detectors (which are in short supply) and moderation. A move to direct detection of fast neutrons allows a significant reduction in measurement time for the same level of precision and reduces the dependence on Gd poisons thereby further reducing the risk of possible diversion scenarios.

During this biennium 2018-2019, the IAEA intends to start deployment of FNCL at fuel fabrication plants where the fuel containing burnable poison rods is being produced. Further improvement of usability will be performed under internal development task.

Expected outcome 6.) ***Re-designed, improved or upgraded safeguards equipment and systems, implementing an improved cost/benefit assessment methodology for the design and operation of safeguards equipment.*** **(In support of T.1 Strengthen instrumentation capabilities for verification, T.5 Identify and exploit innovations, and T.2.R1)**

The IAEA will enhance the performance and sustainability of existing NDA instruments by implementing incremental improvements for the hardware and software NDA toolkit. The general policy that is followed is to:

- Perform minor re-engineering of the instrument components and execute a number of tests and studies to demonstrate the improved performance of the new applications; and
- Procure the services required for re-design of software applications in such a way as to enable in-house maintenance and support.

Collectively, this group of tasks will include the following activities:

- Re-design of the Cask Radiation Profiling System (CRPS) to replace phased-out components of the old CRPS;
- Extending of COMPUCEA application towards UF_6 enrichment;
- Development of new fast neutron probe for use at low-power reactor noise analysis for verification of research reactors and critical assemblies (similar to that of FNCL, digital pulse-processing electronics will be used for gamma and neutron discrimination);
- In cooperation with SGTS-008, re-design of ICVD to allow image recording and special processing to essentially enhance image quality;
- Under MSSP tasks USA A 2094 and GER A 2278, development of an Inspector-level integrated data acquisition and analysis software application to work with the InSpector-2000, MMCA-527 and possibly other multichannel analysers that are available on the market. The application will incorporate the functionalities of multiple existing data analysis codes in one package, includingthose 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 spectrum acquisition, processing, and analysis – which use currently applied NDA methodologies and are based on modern and sustainable technologies – allowing maintenance and modification of the software according to emerging safeguards needs. The baseline for the user interface will be similar to the IAEA's MCA-Touch software.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under projects *4.1.6.001 Portable and resident non-destructive assay equipment* and *4.3.2.001 Development of equipment components and stand-alone instruments* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 Attachments

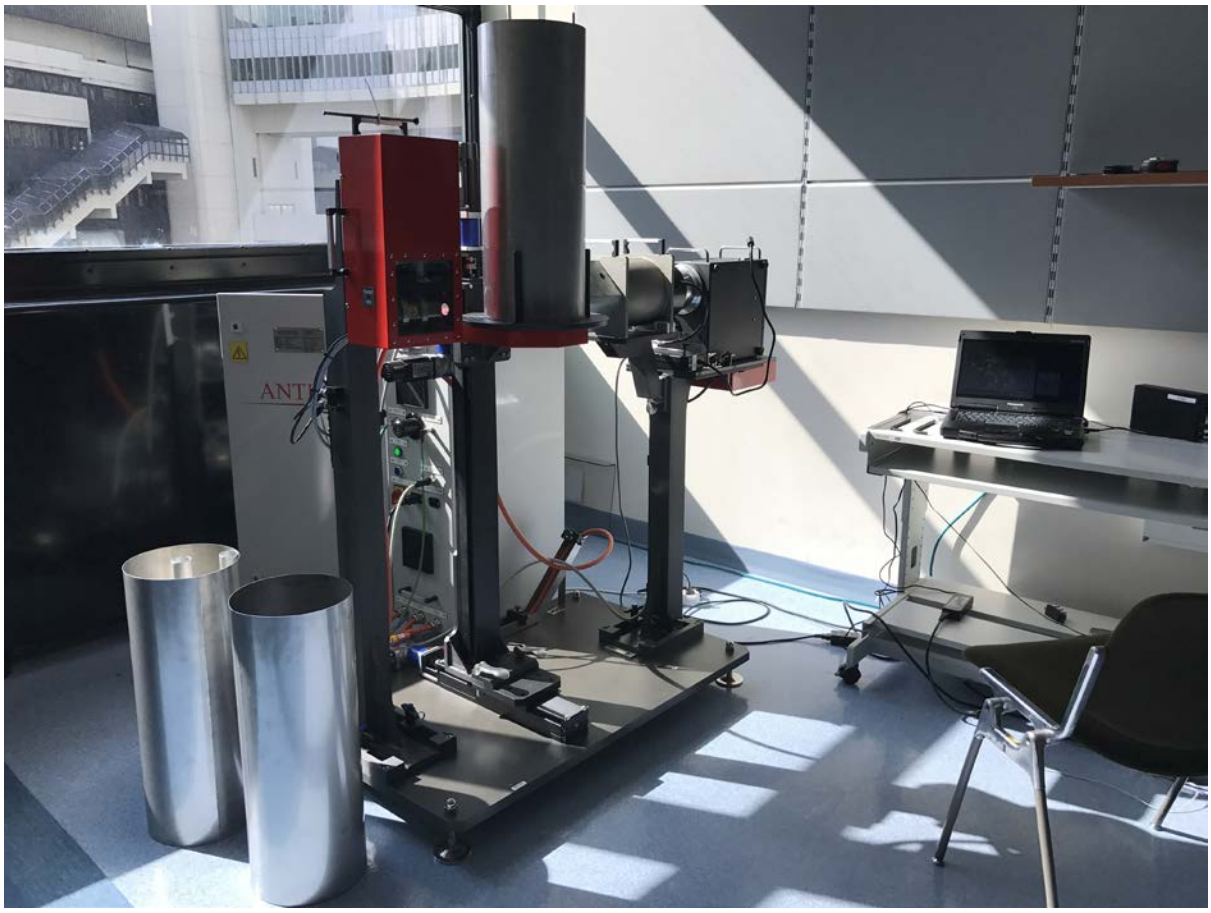
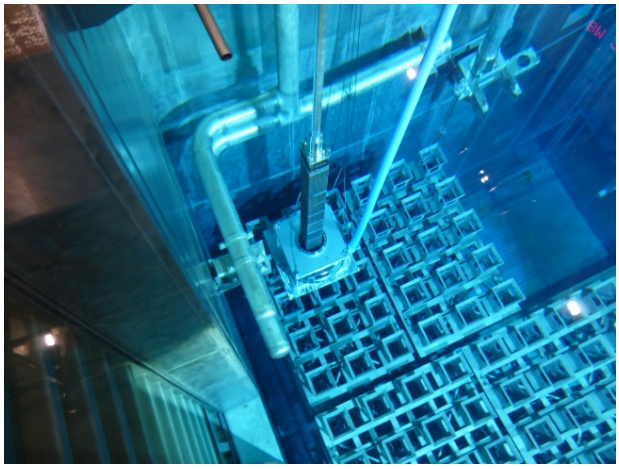


Figure 1. Compact Gamma Tomography System undergoing performance evaluation at the IAEA HQs



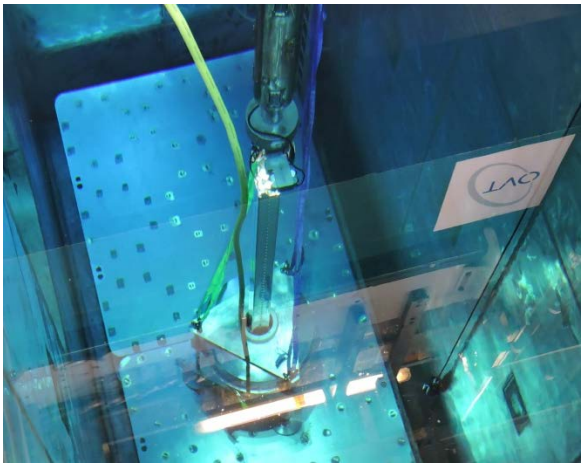


Figure 2&3. PGET is performing spent fuel verification of the PWR fuel (Ringhals) and WWER-440 (Loviisa)

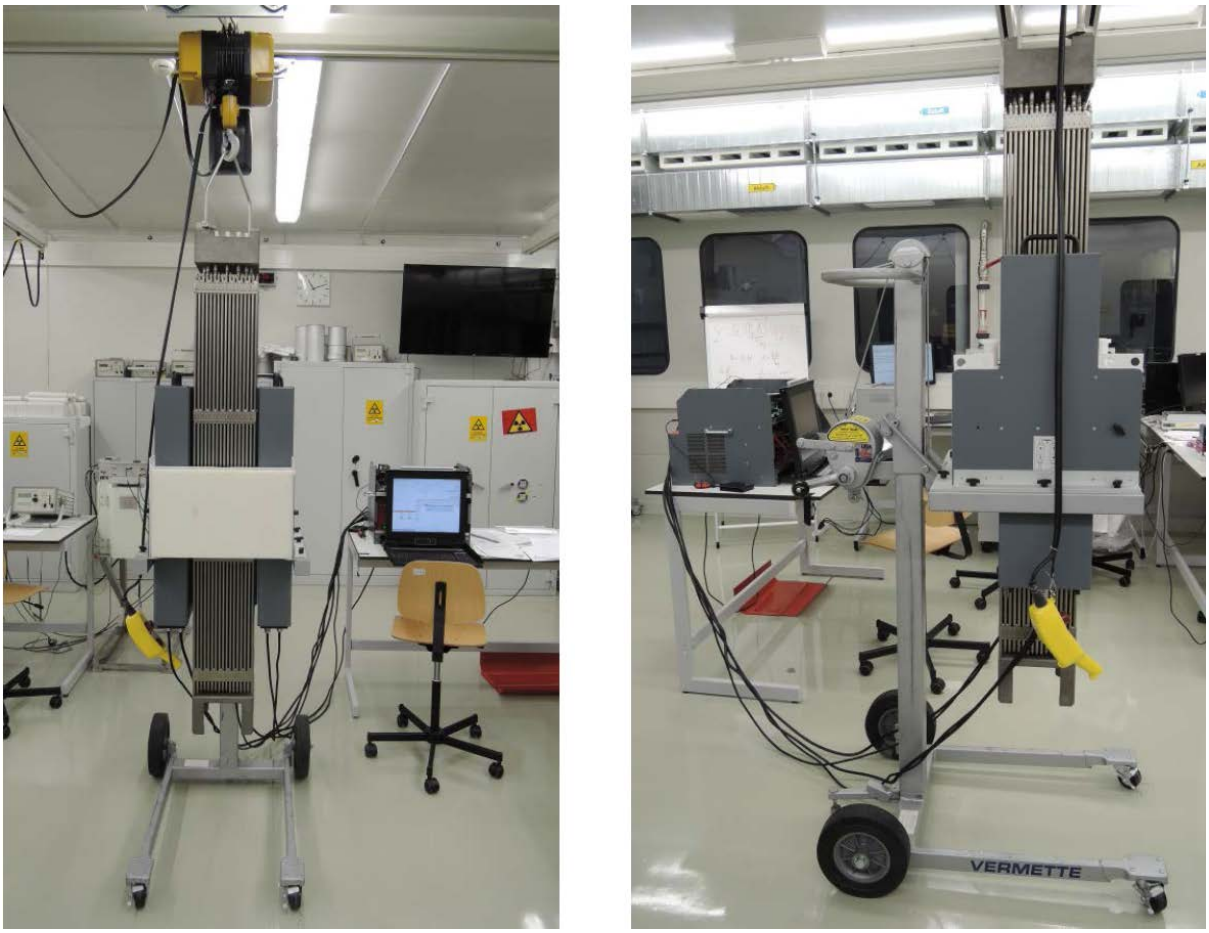


Figure 4&5. Fact Neutron Coincidence collar is undergoing performance evaluation on the fuel containing burnable poison rods

SGTS-002

Improved Techniques and Instruments for Sealing and Containment Verification

Project Manager: Bernard Wishard

Division: SGTS

1. Overview

This document describes the plans for developing and implementing sealing and containment verification systems as well as identifying vulnerabilities in safeguards equipment and protecting the data security of all safeguards equipment within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGTS-002 will pursue the following objective:

Develop and provide implementation support for sealing systems and containment verification instruments, identify areas where improved techniques and capabilities are required, systematically plan for the next generation of seals, and investigate the applicability of new and evolving technologies.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.6.004 Systems integration and coordination* and *4.3.2.001 Development of equipment components and stand-alone instruments.*

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.1	*Enable improved in-field verification capabilities*	T.1.R6	Develop safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.
		T.1.R9	Strengthen intrusiveness and vulnerability analyses on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.
T.5	*Identify and exploit innovations*	T.5.R10	Develop new Sealing System Technologies with improved security and economy.

In 2018-2019, the Project SGTS-002 will continue to focus on providing the inspectorate with the most effective and efficient sealing and containment verification technologies that meet the stringent safeguard requirements. The project also works to ensure the integrity and authenticity of instrument data. Finally, the project verifies that safeguards equipment is sufficiently robust against all attacks (either physical or cyber) through internal design reviews and independent third party vulnerability assessments.

For the 2018-2019 biennium, the project's top priorities are to:

- Develop a new generation of active seal called the Active Optical Loop Seal (AOLS);
- Develop and deploy a new glass seal (GLAS), or hybrid seals containing glass and other structural materials, to be used in applications for which metal seals are currently utilized;
- Continue to improve the overall security of safeguards instrumentation so as to defend against a dynamic threat landscape.

2. Background

Secure containment is essential to all safeguards approaches. Containment systems are required for every type of nuclear facility in the fuel cycle as well as special bilateral agreements. However, traditional sealing arrangements are frequently resource intensive and can expose inspectors to environmental risks. The projected growth of spent fuel in hard-to-access dry storage could triple in the next decade or two. New containment innovations are needed to more effectively address this, and other, verification burdens. In addition, there is the need for increased security, as any gaps in the IAEA's ability to detect tampering can greatly impact its credibility and/or its ability to respond timely. Therefore, enhanced security will continue to drive the need for better physical and cyber-security in containment as well as all safeguards systems. As budget limitations are expected to be a challenge, greater implementation of joint-use technologies must be a priority, wherever possible. These elements are leading the IAEA in the development of active systems using laser, ultrasonic, and radiofrequency techniques as containment mechanisms. Improving active systems reliability, decreasing their maintenance, and extending battery lives as long as possible will continue to be necessary for system success. Finally, as part of the authorisation process, all safeguards systems must be assessed for vulnerabilities and those vulnerabilities must be mitigated to an acceptable level based on defined threat models. Therefore, security assessments are addressed in the developmental plan.

A key objective remains the modernizing and sustaining of containment systems throughout their lifetime, and continually improving tamper resistance. As such, it remains essential to continuously identify and mitigate the vulnerabilities of safeguards equipment and data derived from equipment.

A priority is the implementation of a new generation of active seal called the Active Optical Loop Seal (AOLS). The AOLS implements asymmetric cryptography removing the weaknesses of symmetric keys, easing key management and the need for inspectors to carry USB tokens. It will be the first active seal with open hardware architecture and with software modifiable under a Joint Research Centre (JRC) license. As the EOSS will reach obsolesce by the end of 2020, the implementation of the AOLS is critical. Some positive steps in the development are completion of prototypes on schedule and security assessments by an external cyber-expert. However, the AOLS still requires numerous tests, vulnerability review, commercialization, and field-trials.

Another high-priority is the development of the metal seal replacement. The IAEA is receiving re-designed glass seal prototypes for laboratory testing in Q1 2018, and ideally field testing will be completed by Q4 2018. The new design should alleviate issues that were encountered with previous prototypes. Unlike the metal seal, the glass seal should have less undefined states to obfuscate verification. For example, glass cannot be deformed so as to hide tampering attempts. Also, the glass seal removes the need to tie knots in the attaching cable and provides the opportunity for in-the-field verification. As such, the glass seal should ensure higher security and require significantly less inspector resources.

To ensure integration of equipment with Departmental security policies, Project SGTS-002 coordinates regularly with SGIS-002 *Information Security and Infrastructure* on data security issues.

3. Expected Outcomes and Key Outputs

In order to reach Project SGTS-002's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium, and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Modernized and sustained sealing systems with increased tamper resistance are available for use in safeguards. **(In support of T.1.R6 and T.5.R10)**	
Results of field testing of the Active Optical Loop Seal (AOLS)	December 2018
Result of field testing of the glass seal (GLAS)	December 2018

Expected Outcomes and Key Outputs	Expected Completion Date
Deployment of GLAS reader and integration of the GLAS reader into an All-in-One reader with the Cobra and AOLS, as these developments proceed	December 2018
Field testing of the unattended proximity seal for casks (UPSC)	December 2019
Expected outcome 2.) Developed and maintained sealing systems for facility-specific applications. **(In support of T.5.R10)**	
Results of field testing of a Laser Curtain for Containment (LCCT)	June 2019
Laboratory and field testing of Universal UF_6 Reader (UF_6R)	December 2019
Release of new version of the Ultrasonic Optical Sealing Bolt (UOSB) and its reader for more effectively implementing joint-use arrangements	June 2018
Expected outcome 3.) Improved and expanded techniques, tools and procedures for containment verification. **(In support of T.5.R10)**	
Report on the effectiveness of visual inspections of casks in cases where continuity of knowledge (CoK) is lost	On-hold, pending available resources
Expected outcome 4.) Based on research and development results, implemented new and novel technologies that can be applied for secure sealing and containment verification systems. **(In support of T.5.R10)**	
Solutions developed for:	
• *Tampering Indicating Covers (TIC1)*	June 2018
• *Tampering Indications of Cables (TIC2)*	June 2018
• *Tamper Indication of Cabinets (TIC3)*	December 2018
Expected outcome 5.) Expanded and improved capabilities to identify and mitigate the vulnerabilities of safeguards equipment and data derived from equipment. **(In support of T.1.R9)**	
Annual vulnerability assessment and review reports	December 2018
Expected outcome 6.) Increased data security of safeguards equipment. **(In support of T.1.R9)**	
Establishment of an assessment centre for safeguards instruments and their use based on attacking and defending security team	December 2018 and 2019

4. Tasks

Funding and resources for some of 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 objectives. Many activities are supported by regular budget sources. The CFE position (previously USA A 2231) is currently vacant; a replacement is required to provide detailed electro-mechanical designs for complex containment systems that minimize inspector effort and improve security.

Expected outcome 1.) ***Modernized and sustained sealing systems with increased tamper resistance are available for use in safeguards. (In support of*** **T.1.R6 and T.5.R10)**

Active Optical Loop Seal (AOLS)

The Active Optical Loop Seal, developed under EC E 1849, is the first active seal with an open hardware and software architecture and is anticipated to replace the EOSS. Open architecture allows the IAEA to more thoroughly assess its security as well as change functions to meet containment requirements. The AOLS will also fully integrate asymmetric cryptography. This will significantly improve the key management, ease the burden on inspectors to carry USB tokens, and increase security. Once reengineering activities are finalised, deployment should be possible in 2019.

Glass Seal (GLAS)

Prototypes glass seal were found to break on closing, prompting a redesign. This has delayed field testing until additional laboratory testing can be conducted in Q1 2018. The need for a metal seal replacement remains, as many safeguards applications will benefit from the implementation of the glass seal. Should the new design be confirmed by usability tests in a laboratory setting, the IAEA will begin field trial in Q2 2018. In parallel to proceeding with a redesigned GLAS seal, the IAEA will also explore alternative solutions that may involve crowd sourcing.

New Seal Reader Developments

To minimize the equipment carried in the field, a passive seal reader capable of reading both the glass and Cobra seals has been developed by the JRC (EC E 2008). The new reader is more universal due to the fact that it connects via a USB port to mobile computer. Although successful for verifying Cobra seals, the iReader's optics were found to be inadequate for the more complex patterns planned for the glass seal. In a second phase of this development, an embedded version will be constructed that can also verify the AOLS/EOSS active seals. If successful, these developments will give inspectors an all-in-one reader, minimizing the equipment carried in the field, improving usability, and enhancing security.

Unattended Proximity Seal for Casks (UPSC)

Although limited progress has been made to date, the IAEA still seeks an active sealing system that provides a measure of confidence that continuity of knowledge (CoK) has been maintained on nuclear material casks during shipment, without the need for an inspector to verify either attachment or detachment. There are a number of bilateral or multilateral agreements (e.g. those with Nuclear Weapon States) which restrict the presence of inspectors at the loading and unloading of casks despite the IAEA requiring CoK during transport. The UPSC is intended to provide that confidence despite the inspector restriction. Should significant technical and security challenges be overcome such a system would also facilitate joint-use in traditional safeguards approaches. UPSC is being developed with the support of JRC under task EC E 1559.

Expected outcome 2.) ***Developed and maintained sealing systems for facility-specific applications.*** **(In support of T.5.R10)**

Laser Curtain for Containment (LCCT)

Spent fuel in large silo arrays presents a significant challenge to conventional containment, as the application of individual seals are too resource intensive and potentially prohibited from a radiological dose standpoint. The LCCT was developed by the JRC (EC E 2008). The LCCT creates a containment curtail which detects intrusion into predefined regions-of-interests (ROIs). Although its data is completely independent of optical surveillance – a requirement for dual C/S – the LCCT's two-dimensional spatial data complements video data camera well, providing inspectors with high confidence that CoK has been maintained. Preliminary field tests are positive but a fully engineered system needs to be developed and tested in Argentina (ARG A 2318). Field testing for a complete system is estimated to take place by Q1 2019.

Universal UF_6 Reader (UF_6R)

The IAEA remains supportive of the initiative of creating and implementing universal identification for UF_6 cylinders in cooperation with the US Department of Energy's Next Generation Safeguards Initiative (NGSI) and project SGCP-003. More than one hundred thousand UF_6 cylinders are currently in worldwide use with annual movements numbering in the thousands. A serious challenge for safeguards is that the cylinders do not have standardized and/or machine readable permanent labels. However, progress is being made as the IAEA's proposal for a stainless steel label (as shown below) has been integrated into the World Nuclear Transport Institute's (WNTI) guidelines for uniquely identifying UF_6 cylinders. The label is machine readable at a distance, and most importantly to the IAEA, it is fully authenticatable to a high certainty. The IAEA will work with the JRC (EC E 2008) to develop an authentication technique similar to the Laser Mapping of Cask Verification (LMCV) (EC E 1549). The ability to identify and authenticate UF_6 cylinders will reduce inspector effort and improve security. The IAEA will continue to provide technical assistance to this effort as the project proceeds.

Ultrasonic Optical Sealing Bolt for Joint Use (UBSJ)

The Ultrasonic Optical Sealing Bolt (UOSB) (EC E 1559) contains two independent sealing components (ultrasonic plus Cobra or EOSS). The UOSB has been installed on hundreds of spent fuel casks and is already saving significant inspector effort. However, current applications require the presence of an inspector to ensure the device has been attached correctly. There is a need for a version that provides unchangeable evidence of proper installation. In joint-use arrangements, such a version would save inspectors significant resources.

Expected outcome 3.) ***Improved and expanded techniques, tools and procedures for containment verification.*** **(In support of T.5.R10)**

Effectiveness of Visual Cask Inspections

A damaged or inadvertently removed seal on a hard to access container like a dry storage or transport cask risks the possibility of a loss of CoK. In such a scenario, inspectors may be forced to re-verify the nuclear material contents under extremely difficult and intrusive conditions. Therefore, the IAEA seeks to quantify, as for as possible, the effectiveness of visual inspections of these casks so as to potentially recover CoK. Pending interest from the MSSPs in supporting such a task, IAEA is currently designing a small-scale model for testing the effectiveness of visual and tactile inspections. The IAEA hopes to begin testing of a mock-up in 2018.

Expected outcome 4.) ***Based on research and development results, implemented new and novel technologies that can be applied for secure sealing and containment verification systems.*** **(In support of T.5.R10)**

Tamper Indicating Covers (TIC1)

Numerous applications call for various shaped and flexible enclosures that can be sealed and securely indicate tampering. The IAEA has constructed such covers for enrichment equipment on a short-term basis. However, long term CoK requires a much higher degree of tamper indication for enclosures, which must be assessed by a robust design review. The IAEA has tested covers integrating fibre optic strands with some success. This activity will be pursued further in 2018 with the objective of authorizing it for SG-use.

Tamper Indication of Cables (TIC2)

The replacement of tamper indicating conduit would greatly decrease the cost and complexity of UMS systems. The IAEA seeks a solution for the direct tamper indication of electronic cables. Preliminary research and studies have shown that converting and multiplexing electronic signals on single mode fibre optic cables has great promise when protected by an optical guard signal. The IAEA hopes to proceed with testing in 2018.

Tamper Indication of Cabinets (TIC3)

The IAEA seeks a device that actively indicates whether the inside of an equipment cabinets have been breached by an attacker. Video surveillance in this case is ineffective as cabinets must be kept cool and dark. Therefore, a simple to install, low-power, and low-maintenance device will be explored.

Expected outcome 5.) ***Expanded and improved capabilities to identify and mitigate the vulnerabilities of safeguards equipment and data derived from equipment.*** **(In support of T.1.R9)**

Vulnerability Assessments and Reviews

Unattended equipment must be assessed and vulnerabilities identified against clearly identified threat models. This is necessary so that mitigation of vulnerabilities can be implemented at a level deemed impractical to defeat. The IAEA has staff experts in both cyber and physical security which can oversee and when necessary perform vulnerability reviews.

Among others, the following systems require review or assessment:

- Active Optical Loop Seal and Reader
- Tamper Indicating Covers
- Laser Curtain for Containment

The IAEA will request MSSP assistance for certain aspects of testing vulnerabilities through task EC E 2008 and potentially other support programmes.

Expected outcome 6.) ***Increased data security of safeguards equipment.*** **(In support of T.1.R9)**

Security Assessment Centre (SAC) and Attack-Tree-Based Risk Management

The IAEA's nuclear safeguards instruments must be assessed frequently with a view to identifying potential attack vectors within dynamically evolving threat environments by agents with substantial resources and capabilities. The IAEA remains focused on developing an environment where the security of equipment can be assessed in a realistic environment when operated by inspectors in "Red Team/Blue Team" scenarios. These assessments will be used to evaluate risk and document vulnerabilities. An attack-tree method will be used to ameliorate the risk of the nuclear safeguards instruments being assessed. Support from MSSPs would be welcomed.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the *4.1.6.004 Systems integration and coordination* and *4.3.2.001 Development of equipment components and stand-alone instruments* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
1	1	Glass Seal (GLAS) (4.3.2.001-2018.05)	Glass seal prototypes required a redesign as they were too fragile. The new design will be tested in the laboratory for properties and usability Q1 2018. If successful, subsequent field trails could commence in Q2, 2018.	December 2019
3	2	Visual Cask Inspections (4.3.2.001-2018.05)	Construct a 1/8 scale mock-up of a generic dry storage canister. Use mock-up to determine the effectiveness of visual and tactile inspections as required by IAEA Policy paper #11.	December 2019
4	3	Tamper Indicating Covers (TIC1) (4.3.2.001-2018.05)	Many sealing applications, mostly focused on equipment, call for flexible enclosures that indicate tampering. The IAEA has constructed such covers for enrichment equipment on a short-term basis. However, long term CoK needs require strengthened enclosures, followed by design assessments. This activity will be pursued during the 2016-17 biennium and will also include enclosures for the transport of samples.	June 2018
	4	Tamper Indication of Cables (TIC2) (4.3.2.001-2018.05)	The replacement of tamper indicating conduit would greatly decrease the cost and complexity of UMS systems. The IAEA seeks a solution for 30 or more channels. In addition, analysis software must be developed that can identify a number of attacks with a minimum of false negatives and positives.	June 2018
	5	Tamper Indication of Cabinets (TIC3) (4.3.2.001-2018.05)	The IAEA seeks a device that actively indicates whether the inside of a cabinet has been breached by an attacker. Video surveillance in this case can be ineffective as cabinets must be kept cool and dark. Therefore, low-power, maintenance, and minimum review solutions are needed.	December 2018

4.3 Attachments

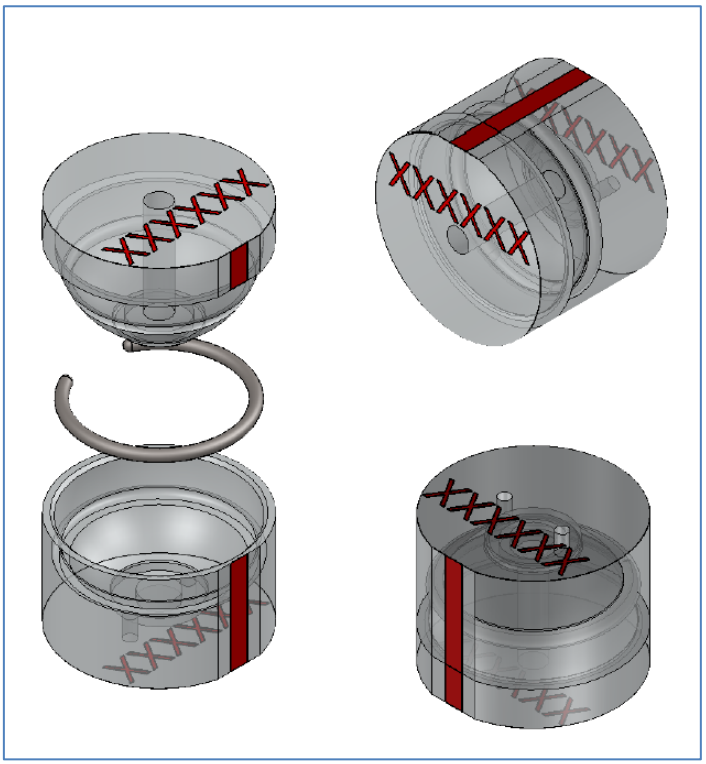


Figure 1. Latest design of the Glass Seal (GLAS) with a new self-aligning round bottom avoiding breaking on closure

Figure 2. The Ultrasonic Optical Sealing Bolt (UOSB) installed at a spent fuel storage facility saving significant inspector and facility resources

Figure 3. Latest tests of TIC demonstrate effectiveness in detecting tampering

Figure 4. IAEA's stainless-steel label for UF_6 cylinders integrated into the World Nuclear Transport Institute's (WNTI) guidelines

SGTS-003

Surveillance Techniques

Project Manager: Anthony Lavietes

Division: SGTS

1. Overview

This document describes plans for developing and implementing comprehensive surveillance technologies, software tools, and equipment within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGTS-003 will pursue the following objective:

Provide advanced surveillance equipment and technologies to improve and optimize Departmental operations and capabilities to effectively carry out the IAEA's safeguards mission.

The plan detailed here is fully aligned with the objectives of Agency's project *4.1.6.002 Unattended safeguards instrumentation* and *4.3.2.001 Development of equipment components and stand-alone instruments*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.1	*Strengthen instrumentation capabilities for verification*	T.1.R2	Develop the Next Generation Surveillance Review software (NGSR).
		T.1.R3	Assess existing techniques to detect misuse of reprocessing plants (real time detection of Pu separation).
		T.1.R5	Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment plants and conversion plants, and Pu at reprocessing plants.
		T.1.R9	Strengthen intrusiveness and vulnerability analyses on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.

Beyond the current biennium, the project will support the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.5	*Identify and exploit innovations*	T.5.R1	Identify, evaluate and test promising applications of robotics and machine learning/artificial intelligence to improve the effectiveness and efficiency of safeguards.
		T.5.R4	Define requirements for SG surveillance technology required beyond the next generation surveillance system (NGSS).

Project SGTS-003 covers the development and implementation of comprehensive 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 available for all IAEA inspection divisions in support of safeguards implementation.

For the 2018-2019 biennium, the project's top priorities are to:

- Complete the development, assessment, and authorization of modular and highly efficient surveillance review software to replace the currently used and obsolete General Advanced Review Software (GARS);
- Complete the development, assessment, and authorization of the analogue camera NGSS module;
- Identify and evaluate safeguards-relevant applications of new and/or emerging technologies to broaden the capabilities of surveillance through incorporation of alternate technologies (e.g. RF, ultrasonics, acoustics, sonar, and hyperspectral imaging).

2. Background

Optical surveillance is one of the core technologies used by the Department of Safeguards when implementing safeguards at nuclear facilities worldwide. Project SGTS-003 aims to continuously upgrade and improve the tools used by safeguards inspectors. The need for the development of new instrumentation is driven by the unavoidable obsolescence of currently used components and technologies. Moreover, instrumentation must be assessed periodically to ensure that capabilities remain adequate for designated applications, and to ensure that the fast advance of technological capabilities in the external environment has not resulted in unacceptable vulnerabilities. The development of new equipment adequate for efficient application in nuclear safeguards can be costly and is made possible, in large part, through cooperation with Member State Support Programmes (MSSPs), who provide essential contributions in terms of required financial resources and access to cutting-edge technology.

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. 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 analysts.

Recent achievements include:

- Significant progress in the field implementation of the Next Generation Surveillance System (NGSS) cameras and systems to replace aging DCM14 based surveillance systems;
- Meeting the goals of the surveillance equipment replacement plan;
- The authorization of an NGSS camera module with analogue input to support applications where special radiation hardened or operator owned cameras have to be used;
- Implementation of an integrated time domain reflectometry (TDR) technology for analogue camera data cables to eliminate the need for safeguards conduit;
- Initial assessment of ultra-high frequency (UHF)/ultra-wide band (UWB) passive RF tag technology for continuous item identification at a distance.

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.

The project coordinates its efforts with projects SGTS-002 *Improved Techniques and Instruments for Sealing and Containment Verification*, SGTS-008 *Instrumentation Technology Foresight*, SGTS-011 *Unattended Measurement Techniques*, and SGTS-014 *Remote Monitoring and Data Processing Systems*.

3. Expected Outcomes and Key Outputs

In order to reach Project SGTS-003's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and / or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Enhanced ability to deploy equipment at facilities to meet safeguards requirements through development of highly effective and cost efficient optical surveillance measures with improved security features. **(In support of T.1.R2)**	
Working prototype for benchmark testing developed in collaboration with Project SGTS-014, (Phase 1 development of new surveillance review software)	December 2019
External battery power unit for extended XCAM operation in stand-alone, unpowered applications	January 2018
Results of assessment of shape recognition module	March 2019
Assessment results of the VideoZoom module	March 2018
Integration and prototype testing of the surveillance review software tool	October 2019
Expected outcome 2.) Improved tools and techniques developed to facilitate the detection of undeclared activities at nuclear facilities. **(In support of T.1.R3)**	
Results of evaluation through laboratory and field testing of the 3DLR laser scanner-based Design Information Verification (DIV) tool for routine containment verification tasks	December 2018
Expected outcome 3.) Improved tools and techniques developed to enable real time monitoring and flow measurements of nuclear material (e.g., UF_6 cylinders, spent fuel casks) at nuclear facilities. **(In support of T.1.R5)**	
Results of assessment of the applicability of the L2IS Laser Item Identification System, in new enrichment plants and spent fuel storage facilities (In collaboration with project SGTS-002)	July 2018
Expected outcome 4.) Improved response to new threats resulting from technology advancements through advanced intrusiveness and vulnerability analysis on current and future use of unattended systems. **(In support of T.1.R9)**	
Results of the evaluation and vulnerability assessment of the DCM-A1, next generation analogue camera recording module	June 2018

4. Tasks

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

Expected outcome 1.) ***Enhanced ability to deploy equipment at facilities to meet safeguards requirements through development of highly effective and cost efficient optical surveillance measures with improved security features.*** **(In support of T.1.R2)**

Task EC E 1992 provides access to an innovative surveillance review method based on 'Automatic Image Summaries', developed by the Joint Research Center Ispra (JRC). In 2015, an updated version of their 'VideoZoom' tool was made available to the IAEA, allowing assessment of the software by using existing NGSS surveillance data. Further enhanced versions were provided in 2016 and 2017, extending the capabilities, increasing performance, and optimizing the design. Completion of the assessment and a

decision as to whether VideoZoom technology shall be implemented under 'In-house Task #1' and Project SGTS-014 is planned for July 2018.

Research on, and evaluations of, emerging 3D camera technologies are carried out under Task EC E 1636. Recent developments of 3D cameras for the automotive market (autonomous car navigation) are putting advanced technology into the reach of potential implementation within safeguards equipment. Currently, evaluated technologies include Velodyne sensors and Microelectromechanical Systems (MEMS) Lidar devices. The task is performed by the JRC and benchmark performance reports about the mentioned technologies are expected by December 2018. When compared to the currently used two-dimensional (2D) optical surveillance, active 3D cameras would strengthen the surveillance data authenticity and eliminate the need for ambient lighting. The work accomplished under this task provides essential input for the user requirements of safeguards surveillance equipment beyond the NGSS.

Task GER E 1982 provides life cycle support for the Next Generation Surveillance System (NGSS) to ensure sustainability of this technology. Activities performed under this task include changes and updates to address new needs from safeguards inspectors, enhancements to support changes in the IAEA's data security environment and Public Key Infrastructure (PKI), and firmware updates to address issues identified during acceptance testing and field implementation.

Task GER E 2255 provides for a Junior Professional Officer (JPO) to pursue the testing and analysis of radiation effects on solid state storage media (e.g. SD cards), considered critical components of the Next Generation Surveillance System (NGSS) instruments. In addition, system-level radiation effects on NGSS instrumentation will be included where possible. Activities are to include modelling and analysis of radiation effects on NGSS system components, testing of relevant components in representative radiation environments, and assisting in the development of mitigating actions to address any identified vulnerabilities. It is expected that extensive literature searches and technical exchanges with recognized experts in the field will be pursued.

Expected outcome 2.) ***Improved tools and techniques developed to facilitate the detection of undeclared activities at nuclear facilities.*** **(In support of T.1.R3)**

Under Task EC E 1993, the JRC provides scientific and technical support for the 3DLR laser scanner-based Design Information Verification (DIV) tool. 3DLR is successfully used in supporting safeguards at large and complex facilities like reprocessing plants and underground geological repositories for spent nuclear fuels. Work accomplished under this task is also aimed at enhancing the 3DLR's applicability to a broader range of containment verification needs by December 2018.

Expected outcome 3.) ***Improved tools and techniques developed to enable real time monitoring and flow measurements of nuclear material (e.g. in UF_6 cylinders, spent fuel casks) at nuclear facilities.*** **(In support of T.1.R5)**

The L2IS Laser Item Identification System was originally developed under task EC E 1696. L2IS is capable of monitoring the real-time flow of UF_6 cylinders at nuclear material bulk handling facilities, such as enrichment plants, and also has the ability to provide containment at spent fuel storage facilities. L2IS is currently authorized for safeguards use at the enrichment plant at Rokkasho, Japan to perform automatic identification of UF_6 cylinders as they pass to/from the process area. The ongoing assessment of the applicability of L2IS at other enrichment plants, nuclear material bulk handling facilities, and storage facilities is planned to be completed by July 2018.

Expected outcome 4.) ***Improved response to new threats resulting from technology advancements through advanced intrusiveness and vulnerability analysis on current and future use of unattended systems.*** **(In support of T.1.R9)**

Under task GER E 1994, an analogue input for the NGSS camera, supporting, inter alia, operator-owned cameras, was developed. The development included the implementation of sophisticated active, electronic protection of the video cable used to connect analogue cameras (by Spread Spectrum Time Domain Reflectometry, SSTDR). Prototypes, which were received in Q2/2015, have been implemented in the latest NGSS camera design (DCM-A1 module) and vulnerability assessment planned to be completed by June

2018 under SP-1 16/TUS-002 "Vulnerability Assessment of DCM-A1 SSTDR (Livewire)" with the US Support Program. This task also provides input to developments carried out under projects SGTS-002 and SGTS-011 potentially benefitting from the implementation of SSTDR technology.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the projects *4.1.6.002 Unattended safeguards instrumentation* and *4.3.2.002 Development of instrumentation systems and methodology* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
1	1	Develop a new external battery power unit for extended XCAM operation in stand-alone, unpowered applications (4.3.3.001 – 2018.04)	Utilizing standard components from existing surveillance systems (Li-Ion batteries, DCH-14 enclosures) and custom PCB-based interconnect modules, a fully compatible extended battery unit is being developed for unique applications.	January 2018
	2	Develop and implement infrastructure for the Department's surveillance laboratories (4.3.3.001 – 2018.04)	Develop and implement infrastructure like hardware and software tools for the Department's surveillance laboratories to increase efficiencies in sustaining surveillance equipment testing and implementation.	Ongoing
	3	Monitor and evaluate progress made in surveillance technology research (4.3.3.001 – 2018.04)	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.	Ongoing
	4	XMOS (NGSS) large scale multi-camera server development (4.3.3.001 – 2018.04)	XMOS is a surveillance server designed to replace the old DMOS multi-camera system server when upgrading to NGSS technology. XMOS is based on standard NGSS components augmented with an industrial touch screen panel PC and server software developed by SGTS in-house resources.	June 2018

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
	5	Vulnerability review of SSTDR technology implemented in analogue camera NGSS module phase 1 (4.3.3.001 – 2018.04)	The Spread Spectrum Time Domain Reflectometer (SSTDR) implemented in the analogue camera NGSS module (DCM-A1) needs to be assessed for potential vulnerabilities. Phase 1 of the assessment is a vulnerability review, which is carried out with in-house resources. Phase 2 will be a more comprehensive vulnerability assessment for which a USSP SP-1 is in progress.	Phase 2 to be completed in June 2018
	6	Develop wireless communication interface for the NGSS camera (4.3.3.001 – 2018.04)	Develop a fully integrated, secure wireless communication module for the NGSS camera to eliminate the need for data cables in certain SG applications.	December 2019
	7	Final testing of the Next Generation Surveillance Review Software development (4.3.3.001 – 2018.04)	Funded by regular budget and in cooperation with EURATOM, a Next Generation Surveillance Review software is being developed. Final lab testing followed by field testing is to be completed in the next phase.	June 2018

4.3 Attachments

Figure 1: Typical XCAM camera installation

Figure 2: Radiation-tolerant SD cards deployed with next generation surveillance systems (NGSS) in elevated radiation environments

SGTS-008

Instrumentation Technology Foresight

Project Manager: Dimitri Finker

Division: SGTS

1. Overview

This document describes plans for developing and implementing Project SGTS-008, *Instrumentation Technology Foresight*, within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGTS-008 will pursue the following objective:

Identify, test, adapt and deploy emerging technical advances in other scientific fields and optimize them for use in safeguards.

The plan detailed here is fully aligned with the objectives of Agency's project *4.3.2.002 Development of instrumentation systems and methodology*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objective		R&D Needs	
T.5	*Identify and exploit innovations*	T.5.R1	Identify, evaluate and test promising applications of robotics and machine learning/artificial intelligence to improve the effectiveness and efficiency of safeguards.
		T.5.R2	Identify areas in which technology challenges (e.g. expert crowdsourcing) could be an asset for developing the Department's technologies and methodologies.

SGTS-008 focuses on the identification, evaluation, testing, development and implementation of new or emerging technologies that could improve the effectiveness and efficiency of the implementation of safeguards. The IAEA has recognized and articulated the need to take full advantage of technical advances made outside the safeguards community to strengthen IAEA verification activities in a manner that is less costly, less 'custom' wherever possible, and more sustainable. For this reason, the IAEA has placed renewed emphasis on developing a robust in-house technology foresight capability.

For the 2018-2019 biennium, the project's top priorities are to:

- Structure and streamline the workflow of field instrumentation data by deploying, maintaining and continuously improving the Multicomponent Inspector Kit (previously known as Complementary Access Kit), including IRIS software (Instruments Records Integration for Safeguards);
- Finalize the development and authorize the next generation of Cerenkov Viewing Devices;
- Evaluate the use of robotics to assist or automate tasks in the field.

2. Background

The project will continue to monitor a broad scope of innovations and R&D developments and focus on the evaluation and implementation of available technologies. The Technology Foresight pipeline underlying the development cycle consists of the following stages:

For its first two biennia, the Technology Foresight Programme (started in 2014) was mostly focused on the identification and evaluation stages; new technologies were introduced to inspectors and evaluated. The focus of the programme for the upcoming biennium is to ensure that inspectors can make full use of the most promising technologies. This entails developing and fine-tuning products to specific safeguards use cases. Therefore, key outcomes now aim at testing in the fields, developing and authorizing innovative technologies.

Some of the challenges faced by the Department of Safeguards are not unique and exist in other fields. In the past few years, many of these fields have found solutions or are making significant technical advancements. These opportunities can be used to address internal challenges. This project is focused on identifying these challenges and the commercially available solutions available from non-traditional safeguards fields, and evaluating how they could be applied to safeguards.

Identifying advancements and their safeguards applications across a wide-variety of fields is one of the greatest challenges of this approach. Nonetheless, the IAEA has already evaluated several technical areas where innovations have recently occurred for their safeguards application and is beginning to make use of these solutions. Some of the most salient examples of new applications include:

- handheld 3D laser scanners, expanding the usage of 3D measurements for safeguards by allowing quantitative verifications of nuclear materials;
- the Multi-Component Inspector Kit (MCIK), which supersedes the former CA-kit (largely unchanged since its introduction in 2005) by providing not only a whole new range of capabilities in the field (such as chemical substance identification and indoor positioning) but also transforming how field data are collected and reported inside IRIS (Instrument Record Integration for Safeguards, illustrated in Figure 1);
- the next generation Cerenkov Viewing Device (XCVD), an example of how non-traditional approaches can provide a disruptive innovation for a workhorse instrument of safeguards verification, the ICVD.

The IAEA will continue to systematically evaluate other areas and make progress towards implementing identified solutions to address safeguards challenges.

Member State Support Programmes (MSSP) can support this project by:

- Facilitating and supporting the outreach efforts of the IAEA on specific topics, as identified;
- Supporting the early stages of adapting identified solutions;
- Providing resources for related R&D efforts to support the implementation of identified solutions; and
- Supporting the field testing and deployment of innovative technologies.

3. Expected Outcomes and Key Outputs

In order to reach Project SGTS-008's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Developed and implemented technology foresight horizon scanning process for external, potentially-relevant research and development (R&D) fields. **(In support of T.5 Identify and exploit innovations and S.4 Leverage and establish partnerships)**	
Partnerships with new external stakeholders (those not yet involved with safeguards) to identify and evaluate R&D activities and technologies in the domains of non-destructive assay, containment, surveillance, and destructive analysis. (In collaboration with SGCP-004)	December 2019
Quarterly Technology Preliminary Evaluation Report	Ongoing
Expected outcome 2.) Technologies identified and solutions implemented for gaps identified in technologies currently in use for safeguards and laboratory activities. **(In support of T.1 Strengthen instrumentation capabilities for verification, T.5 Identify and exploit innovations, T5.R1 and T5.R2)**	
Evaluated, customized and authorized commercial in-situ analysis capabilities	December 2018
Deployment, after authorization, of two gamma imaging systems: one portable system, one mobile system	December 2018
Full replacement of the former Complementary Access Kits by the new Multicomponent Inspector Kit, including IRIS software (Instruments Records Integration for Safeguards) as a means of structuring and streamlining the use of field instrumentation data	December 2019
Development and authorization of the next generation of Cerenkov Viewing Device (XCVD)	December 2019
Winners of robotics challenge selected for further development	December 2018

4. Tasks

Most activities are supported by regular budget sources within project *4.3.2.002 Development of instrumentation systems and methodology*. Funding and resources for some of the project's development and implementation support tasks are provided by MSSPs, which continue to play a major role in achieving the project's objectives. The set of umbrella tasks provided a convenient channel for the MSSP to provide support in an agile fashion.

Expected outcome 1: ***Developed and implemented technology foresight horizon scanning process for external, potentially relevant research and development (R&D) fields.*** **(In support of T.5 Identify and exploit innovations and S.4 Leverage and establish partnerships)**

As this project primarily focuses on identification and implementation of technologies that are commercially available in non-traditional safeguards fields, it is vital to establish and maintain partnerships with external stakeholders to be aware of their technical developments.

Organizing technology challenges has proven to be an effective and innovative mechanism to achieve these results. The latest challenge on robotics received more than 30 applications, originating from 17 countries.

We will seek to sustain and expand this outreach effort in the coming years: new challenge topics may be related tomography reconstruction algorithms to cross-disciplinary containment techniques.

MSSP efforts (FIN A 1628, GER A 1633, ROK A 1894, UK A 1599, USA A 1616, FRA A 1641, EC A 1634) to identify technology suppliers, advertise the challenge or directly support its organization (by funding candidates, hosting the challenge or providing technical observers) have been an essential factor to the success of these initiatives.

Expected outcome 2: ***Technologies identified and solutions implemented for gaps identified in technologies currently in use for safeguards and laboratory activities.*** **(In support of T.1 Strengthen instrumentation capabilities for verification, T.5 Identify and exploit innovations, T5.R1 and T5.R2)**

Once a technology has been evaluated and shows potential to positively impact the implementation of safeguards, solutions will be adapted and implemented in cooperation with stakeholders in the Department of Safeguards. The focus for this biennium will be on the evaluation of the next generation of Cerenkov Viewing Device (XCVD) and robotics platforms, as well as on gathering additional field experience of the systems identified for chemical identification and gamma imaging.

Additionally, the Department has spent significant effort since 2014 to evaluate and integrate a safeguards-specific solution for autonomous navigation and indoor positioning. This effort will continue during this period to support the deployments by operations and fully integrate the system with MOSAIC modules.

Support from MSSPs for specific technical developments and reports will continue (ARG A 1637, AUL A 1856, BEL A 1615, EC A 1634, FIN A 1628, CAN A 1622, FRA A 1641, GER A 1633, HUN A 1597, JPN A 1798, NET A 1850, ROK A 1894, RSA A 2010, UK A 1599, USA A 1616). Extra-budgetary funding for equipment and quick prototyping (USA A 1616) is valuable. MSSPs can also support these initiatives by allowing the IAEA to conduct field tests in representative facilities (EC A 1634, BRZ A 1601, FRA A 1641).

A JPO, recruited under task USA A 2124, will support the evaluation and authorization of the new systems developed under the Technology Foresight Programme by: 1) testing and evaluating instrumentation for selected safeguards usage, and; (2) developing and updating user requirements for safeguards instrumentation, equipment specifications, equipment test reports, equipment operational procedures and authorization reports.

The IAEA will continue to monitor and evaluate new areas for innovative solutions to address safeguards challenges. As such, the focus for 2018 will be on robotics and the possible solutions this field can provide to assist or partially automate safeguards tasks. Measurements conducted by inspectors are sometimes repetitive, and take place in high-dose environments; robotics is a possible solution to focus inspectors' time on high-value tasks in the field, while at the same time improving health and safety conditions. The IAEA has held a technology challenge on this topic at the end of 2017 and will test-field the most promising systems in 2018.

MSSPs can support these initiatives by coordinating technology outreach missions where technology foresight specialists can see a broad range of technologies and technology suppliers, including those not yet involved in Safeguards activities.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.3.2.002 Development of instrumentation systems and methodology* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcomes	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
1	1	Continuous technology evaluation (2018.03)	1) Continue research and subsequent evaluation of technologies for potential safeguards application. 2) Issue regular "Technology Preliminary Evaluation Report".	Ongoing
2	2	Multicomponent Inspector Kit (2018.03)	Deploy, maintain and continuously improve the Multicomponent Inspector Kit	On-going
	3	In situ analysis (2018.03)	Evaluate, customize and authorize commercial in-situ analysis capabilities, incl. chemical analysis	December 2018
	4	XCVD (2018.03)	Finalize the development and authorize the next generation Cerenkov Viewing Device	December 2019
	5	Gamma imaging (2018.03)	Authorize and deploy gamma imaging systems.	December 2018
3	6	Robotics Challenge (2018.03)	Field-test and finalize the evaluation of robotics systems.	December 2018

4.3 Attachments

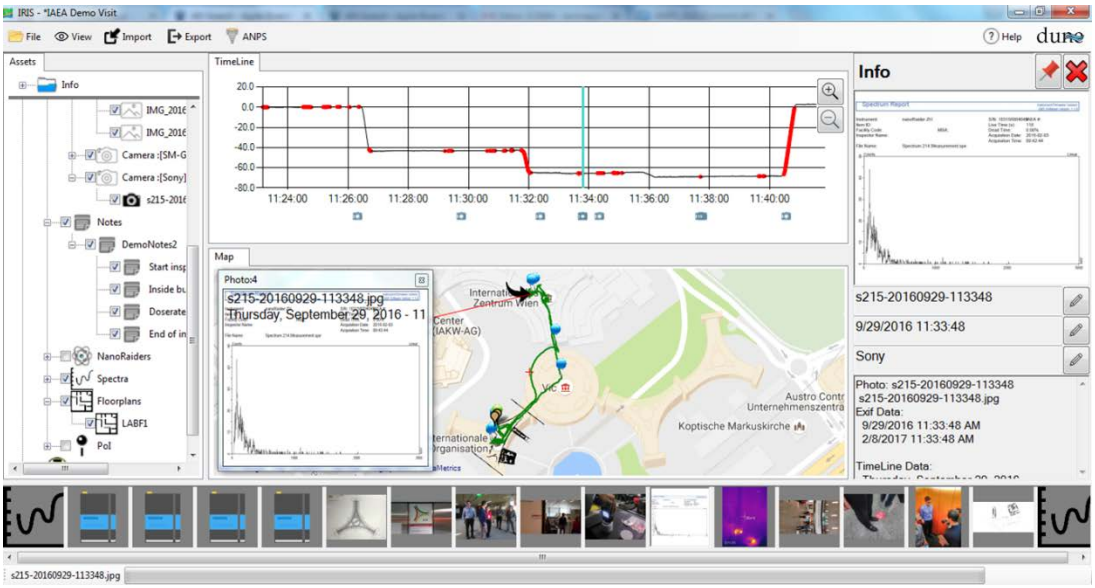


Figure 1. Integration of field data in Instruments Records Integration for Safeguards (IRIS)

Figure 2. Multicomponent Inspector Kit (MCIK) components and packaging

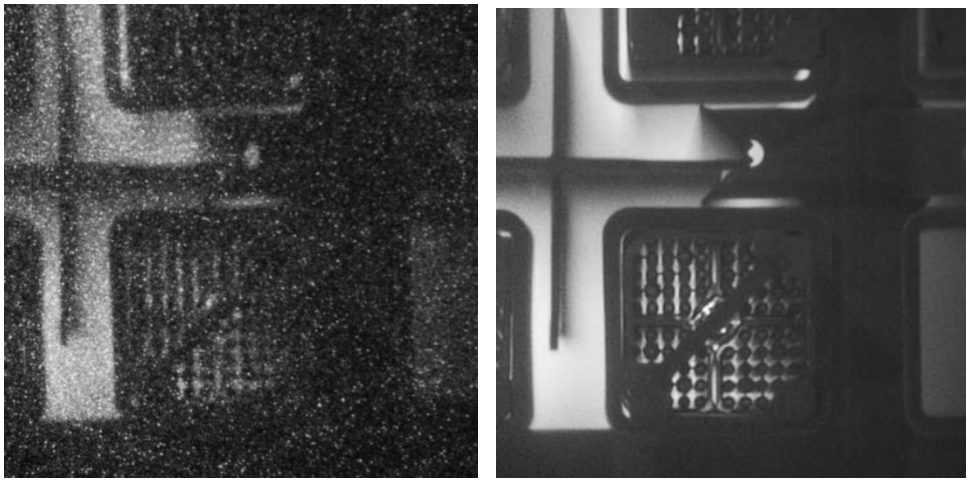


Figure 3. Image seen through a Cerenkov viewing device, before and after image processing

Figure 4. Cerenkov Viewing Device (XCVD) field test at Ringhals

Figure 5. IAEA Robotics Challenge, Brisbane, Australia, November 2017

SGTS-011

Unattended Measurement Techniques

Project Manager: Thierry Pochet

Division: SGTS

1. Overview

This document describes plans for developing and implementing unattended measurement techniques within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGTS-011 will pursue the following objective:

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 plan detailed here is fully aligned with the objectives of Agency's project *4.1.6.002 Unattended safeguards instrumentation* and *4.3.2.002 Development of instrumentation systems and methodology*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objective		R&D Needs	
T.1	*Strengthen instrumentation capabilities for verification*	T.1.R4	Improve tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities.
		T.1.R5	Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and conversion plants, and Pu at reprocessing facilities.
		T.1.R6	Develop safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.

Project SGTS-011 addresses the enhancement and expansion of the IAEA's unattended technical capabilities, and the streamlining of the process for designing, building, installing and maintaining unattended monitoring systems (UMS) for non-destructive assay (NDA) applications. 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 scope of Project SGTS-011 includes the following key efforts:

- The study of potential uses for new NDA methodologies, measurement techniques and sensors for unattended applications, pertinent to safeguards implementation requirements and the required capabilities;
- The selection or development of modern electronic modules and associated sensors and detectors for NDA measurement systems, including front-end electronics and computer-less data acquisition (DAQ) systems, which would include all necessary data security, power management, and redundancy features for unattended use, in particular to allow secure remote data collection through networks (the development effort shall be driven by a standardization and strict cost-effectiveness approach in view of optimizing systems' maintainability and associated life cycle costs);
- The development and standardization of new generic software for multiple data type collection, review and analysis, which will be compatible with all UMS data generators (review and analysis

software will provide powerful and sophisticated features for data reduction and interpretation, which will efficiently and effectively assist inspector effort).

For the 2018-2019 biennium, the project's top priorities are to:

- Complete Version 2 of the On-Line Enrichment Monitor (OLEM) software with documentation;
- Complete Phase II of the Unattended Cylinder Verification System project;
- Develop the next generation UMS Data Acquisition platform.

2. Background

Unattended systems are an essential part of the safeguards implementation approach. Unattended systems provide continuous monitoring and reduce inspector presence for routine monitoring tasks. The unattended systems also allow for measurements in access limited areas or areas with radiation, thereby reducing inspector exposure and health hazards. Data from unattended systems, when coupled with remote monitoring communications, can be reviewed remotely, which reduces the need for travel and increases efficiency.

The amount of nuclear material under safeguards is constantly growing. As a result, safeguards activities need to become more efficient. Development and implementation of additional unattended systems can help support additional safeguards activities by performing routine measurements and allowing inspectors to focus on data analysis and interpretation. Project SGTS-011 is essential for the development of new unattended systems and applications, and for supporting safeguards inspectors, the main end users. The project is also focused on reducing life-cycle costs associated with installation and maintenance by investing in modern electronics and components for unattended systems.

In the 2018-2019 biennium, these efforts will be continuing with the development and improvement of existing UMS and the development and implementation of UMS into new application areas. The project has supported, and will continue to support, unattended system use with the following:

— Development and support of new detector systems
  - testing of new types of fast-current preamplifiers for He-3 tubes and fission chambers
  - development and deployment of MUD2 (Mobile Detection Unit)
  - and F-SEGM (Fiber-optic based Silo Entry Gate Monitor))
— Development and testing of new customized electronic modules
  - signal booster module
  - full direct current (DC) power supply
  - current-to-pulse converter (CPC)
  - low current measurement module (UDCM: Unattended Dual-Current Monitor)
— New data acquisition
  - completion of the UMS requirements for a new generic Data Acquisition System (UDAM: Unattended Data Acquisition Module))
  - ADM2 (NGAM, Second Generation Adam Module) development and implementation
  - completion of the UMS requirements for the next generation of industrial computers
  - Activities related to the development of a multi-channel multiplicity shift-register for potential implementation in industrial environments
— Unattended systems for use in enrichment facilities
  - On-Line Enrichment Monitor (OLEM)
  - a prototype Unattended Cylinder Verification System (UCVS)

A number of the project's objectives are shared with other Departmental projects. The most prominent project connections are with SGTS-001 *NDA Techniques*, SGTS-014 *Remote Monitoring and Data Processing Systems*, SGOA-002 *Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX)*, SGOA-003 *Fukushima Dai-ichi Safeguards* and SGOC-001 *Chernobyl*.

3. Expected Outcomes and Key Outputs

In order to reach Project SGTS-011's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) Developed tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities. **(In support of T.1.R4)**	
Results of monitoring the stability and accuracy of installed OLEM systems	June 2019
Version 2 of the OLEM software	December 2019
Report on assessment of OLEM's reliability and associated recommendations	December 2019
Expected outcome 2.) Improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment plants and Pu at reprocessing plants. **(In support of T.1.R5)**	
Prototype of an Unattended Cylinder Verification System (UCVS) installed in a Gas Centrifuge Enrichment Plant (GCEP) (Phase II)	December 2019
Report on the application and verification of joint-use data collected at enrichment plants	December 2019
Expected outcome 3.) Developed appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle. **(In support of T.1.R6)**	
Upgrade campaign of VIFM systems with new ADM2 (NGAM) data acquisition modules and updated power subsystems	December 2018
Completed upgrade of all other UMS systems	December 2019
Installed developed irradiated fuel counting system at a Pebble Bed reactor in China (depending on safeguards approach completion).	December 2019
Installed new systems developed for safeguarding fuel at CANDU reactors (depending on safeguards approach completion)	December 2019
Expected outcome 4.) Increased proportion of deployed unattended systems that are sustainable, standardized, and modular, with increased use of Commercial-Off-The-Shelf (COTS) products. **(In support of T.1 Strengthen instrumentation capabilities for verification, and T.4 Manage SG technology assets strategically)**	
Evaluation, development, testing, and deployment of components and equipment that fulfil the requirements of being sustainable, standardized, and modular, with increased use of COTS products	ongoing

4. Tasks

Funding and resources for several of 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. Other activities are supplemented by regular budget sources. In particular the contribution of Junior Professional Officers (JPOs) and Cost-Free Experts (CFEs) are extremely important and highly appreciated by the IAEA for their numerous contributions. Specifically:

- The JPO under task USA A 2110 has been in the Project Engineering team since 2013 and has contributed to several projects including JMOX (SGOA-002) and the LEU Fuel Bank. He has

provided support to Pebble Bed reactor safeguards via Monte Carlo simulation, and also provides technical editing of documentation.

- The JPO under task USA E 2016 has been in the Unattended Monitoring Systems team since 2015. He is currently involved in several projects including Chernobyl (ISF2) (SGOC-001), the upgrade of UMS systems in Japan (Monju, Joyo), and the implementation of several new systems worldwide.
- The CFE under task USA E 2281 joined the Unattended Monitoring Systems Team in October 2017 and is supporting OLEM, UCVS, Pebble Bed reactor safeguards, reliability of SD cards in radiation environments, and upcoming Canadian spent fuel monitoring.

The activities described below are focused on near term goals for this biennium, but support the listed long range objectives, which will in many cases encompass multiple biennia.

Expected outcome 1.) ***Developed tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities.*** **(In support of T.1.R4)**

The IAEA is developing a flexible toolbox of technologies that is consistent with its State-level approach for safeguards implementation. The On-Line Enrichment Monitor (OLEM), which provides continuous enrichment measurement for all of the declared gas flowing through unit header pipes, is one of the three different unattended measurement systems included in this toolbox.

The "Phase II Additional Scope" of the OLEM project (under task USA A 1913) started in mid-2017. The scope of work for this task includes: (1) a sensitivity study evaluating how the original equipment performs under different ^{235}U signal to noise ratios and different detector types and sizes (single detector vs array of detectors), and how changing the collimation or filtration could influence the performance; (2) development of a version 2 of the OLEM software that will facilitate the current inspection work flow; and (3) a system reliability assessment and resulting recommendations.

Expected outcome 2.) ***Improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment plants and Pu at reprocessing plants.*** **(In support of T.1.R5)**

The Unattended Cylinder Verification System (UCVS), the second element of the toolbox for unattended measurement systems, could provide unattended verification of the declared uranium mass and enrichment of all of the declared cylinders moving through an enrichment plant.

Phase I of the UCVS project provided strong indications that an instrument of this type is viable and could be developed into an unattended system that would provide real- or near real-time material flow measurements at a large Gas Centrifuge Enrichment Plant (GCEP) (JNT A 1979 EC and USA). Phase II of the UCVS project will continue under JNT A 1979 and shall focus on establishing a reasonable state of readiness by the installation of an enhanced prototype at an actual GCEP.

The third component of the toolbox is the application and verification of joint-use data collected at enrichment plants. A study of joint-use data from enrichment plants is being conducted under tasks JNT A 1879 EC and FRA (in collaboration with project SGTS-001). The purpose of this task is primarily to study the possibilities of using operator sensor data (for example load cell data) for safeguard purposes in an authentic fashion. The investigation is considering potential issues associated with the joint use of facility generated data, data independence, and the possibilities of combining encrypted and unencrypted data sources to allow for robust data authentication.

Expected outcome 3.) ***Developed appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.*** **(In support of T.1.R6)**

The on-going campaign to upgrade all VIFM systems will continue worldwide with updated power subsystems and the new ADM2 (NGAM) data acquisition module. This campaign will last several years, and is supported by the on-going task CAN E 1530 'VIFM Implementation Support'.

The upgrade of other installed UMS systems continues with reliable, up-to-date and standardized COTS components. These technology upgrades will last several years, and are supported by the on-going tasks USA A 1351 'Support for Development of the Safeguards System at RRP' and USA E 1274 'URM Systems Standardization and Support'.

Upon the establishment of a Safeguards approach for the Chinese Pebble Bed reactor (HTR-PM), the UMS team will develop unattended systems to provide data for drawing safeguards conclusions. The system will likely consist of gamma ray spectroscopy systems to verify fresh pebbles prior to insertion in the core, and irradiated pebble burnup. Additionally, systems will be developed to monitor spent pebble storage.

Safeguards inspectors personnel in Canada have expressed a need to characterize spent fuel bundles and monitor their transfer from spent fuel ponds to dry storage sites at several facilities. In preparation of this request, the UMS Team will develop systems to monitor the flow of fuel bundles to these dry storages. Monitoring will consist of the number of items transferred and confirmation that they are nuclear material (I+H), as well as final confirmation that the items arrive unchanged at the dry storage site.

Expected outcome 4.) ***Increased proportion of deployed unattended systems that are sustainable, standardized, and modular, with increased use of COTS products.*** **(In support of T.1 Strengthen instrumentation capabilities for verification and T.4 Manage SG technology assets strategically)**

In order to minimise maintenance efforts and costs throughout the life cycle of equipment, the UMS team will continue to develop and procure instruments, components, and systems that are sustainable, standardized, and modular to the extent possible.

CAN E 1499 'Development of the Next Generation ADAM Module' and USA E 1274 'URM Systems Standardization and Support' are tasks that provide development support for upgrading and standardization of UMS components.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.1.6.002 Unattended safeguards instrumentation* and *4.3.2.002 Development of instrumentation systems and methodology* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
4	1	UMS Data acquisition (4.3.2.002-2018.01)	The UMS team has developed specifications for the next generation of UMS Data Acquisition module to address pulse and neutron coincidence counting as well as low current measurement, based on a modular approach, and on generic existing platforms devices. Consultation with potential vendors will take place in 2018 and testing of devices, if appropriate, will follow. Member States Support will only be solicited in case no suitable COTS solution could be identified.	December 2019
	2	Computers for UMS (4.3.2.002-2018.01)	The UMS team will select and evaluate new generation reliable and sustainable industrial computers for use in unattended systems (including new operating system versions) by mid-2018, prior to their field deployment by the end of 2018 and 2019.	July 2018

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
	3	Fast Current Preamplifier (4.3.2.002-2018.01)	A fast current preamplifier for counting measurement, allowing up to 100 meters of cable length between detector and preamplifier has been successfully tested in house. The device shall be further optimized and tested under real conditions by the end of 2018, for potential deployment in difficult to access, contaminated or high radiation areas, from 2019 onwards.	December 2018
	4	Power management methods (4.3.2.002-2018.01)	A survey of COTS technologies related to power management has been proposed to support the aim of increasing the maintenance cycles (time between regular, preventive maintenance) for UMS systems. Technologies included are an uninterruptible power supply for UMS instruments, new generation batteries (especially for portable systems like MUND2) and other measures to extend the cycle of battery replacement. A new concept should be ready for implementation by the end of 2018.	December 2018
	5	DC Power Supply for full DC UMS (4.3.2.002-2018.01)	The UMS team is developing a full direct current (DC) Power Supply that will be tested during the first half of 2018 and deployed during the next years.	July 2018
	6	Cable monitoring for tamper indication (4.3.2.002-2018.01)	The Time-Domain Reflectometry technology for tamper indication of signal cables and developed by PNNL will be tested under real conditions from a UMS perspective during 2018 and 2019.	December 2019
	7	New generation of gamma-ray detectors (4.3.2.002-2018.01)	The evaluation of new 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 the end of 2018.	December 2018
	8	Evaluation of new neutron detectors (4.3.2.002-2018.01)	In anticipation of future shortages of He-3 gas, the field evaluation of new types of neutron detectors is proposed to establish a reasonable state-of-readiness in replacing He-3 tubes in UMS systems should the need arise.	December 2019

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
	9	UDCM (4.3.2.002-2018.01)	Field testing of the UDCM (Unattended Dual-Current Module) will take place during 2018, and will be deployed in 2019, pending its commercial availability.	December 2018
	10	Multichannel Multiplicity Shift-register (4.3.2.002-2018.01)	Activities related to creation of a multi-channel multiplicity shift-register for industrial environments	December 2019

4.3 Attachments

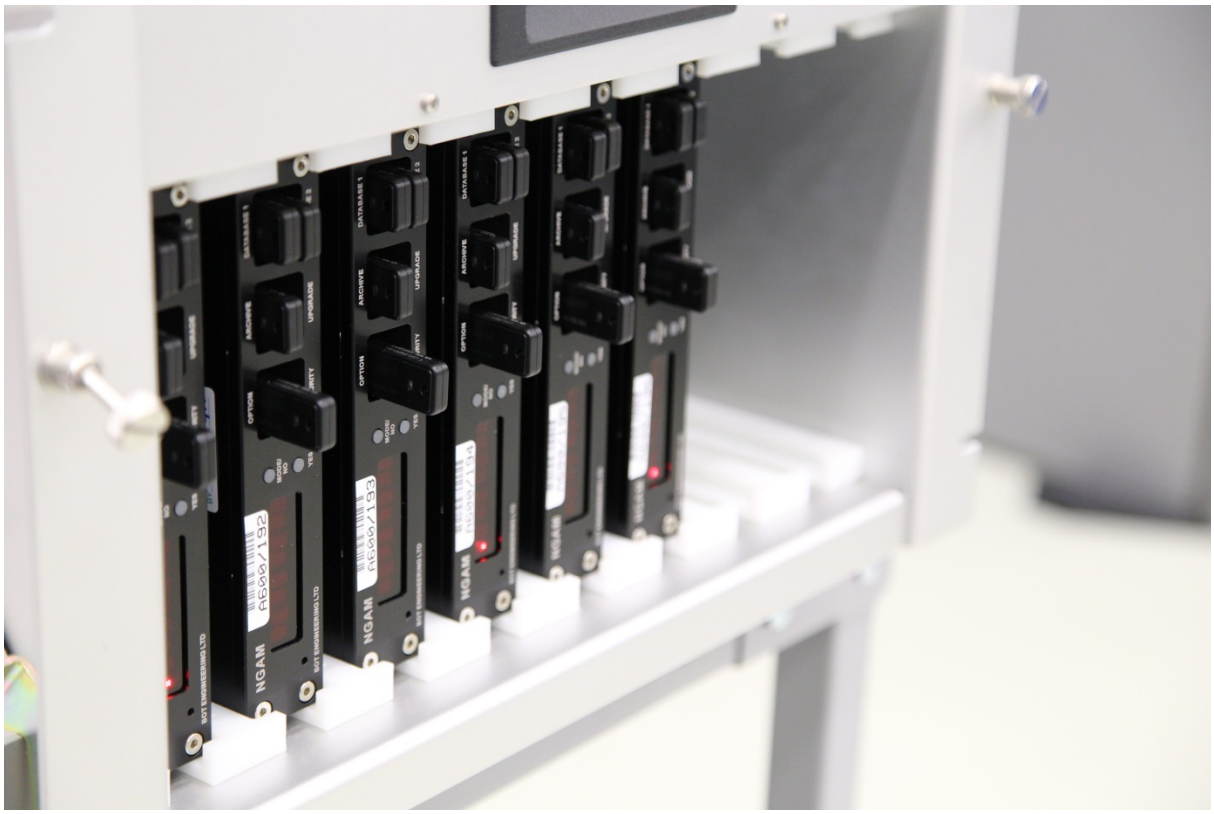


Figure 1. New ADM2 (NGAM) technology for VIFM systems used at CANDU reactors

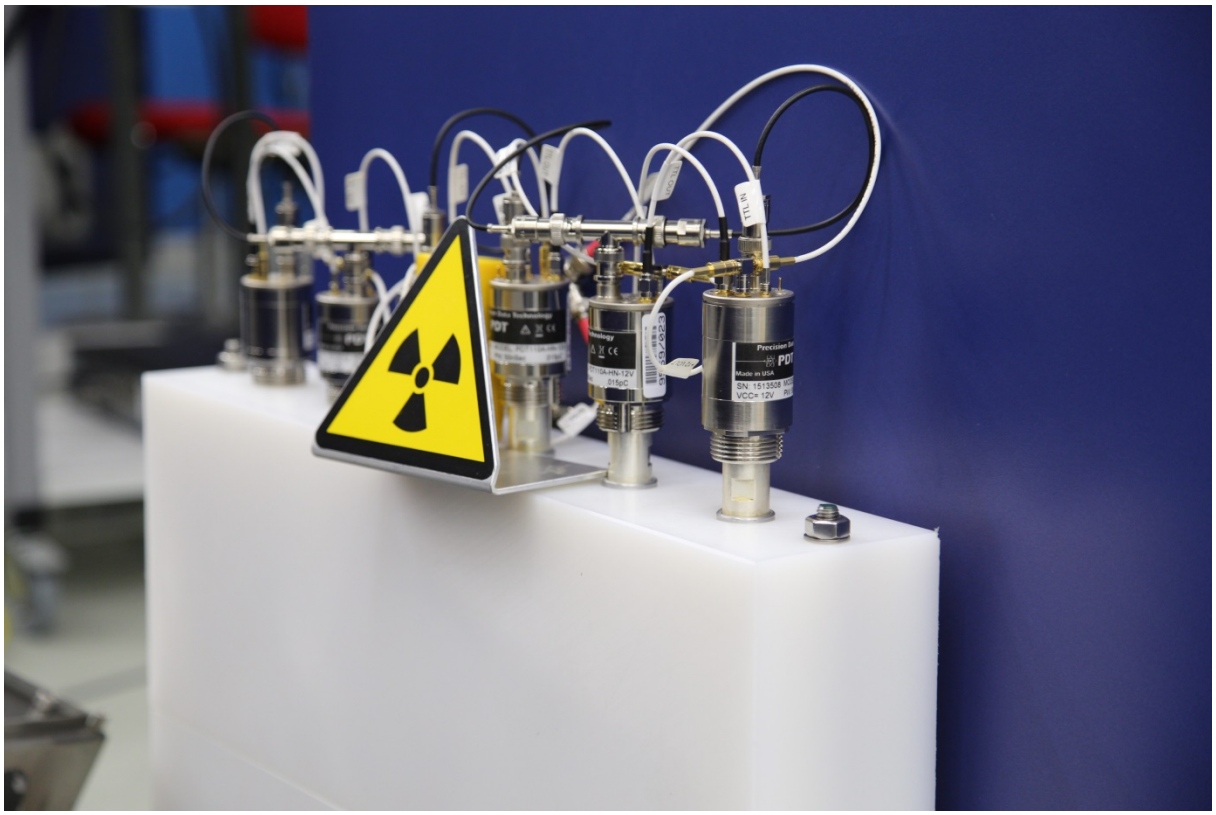


Figure 2. Neutron slab detector for testing alternatives to He-3 filled proportional counters

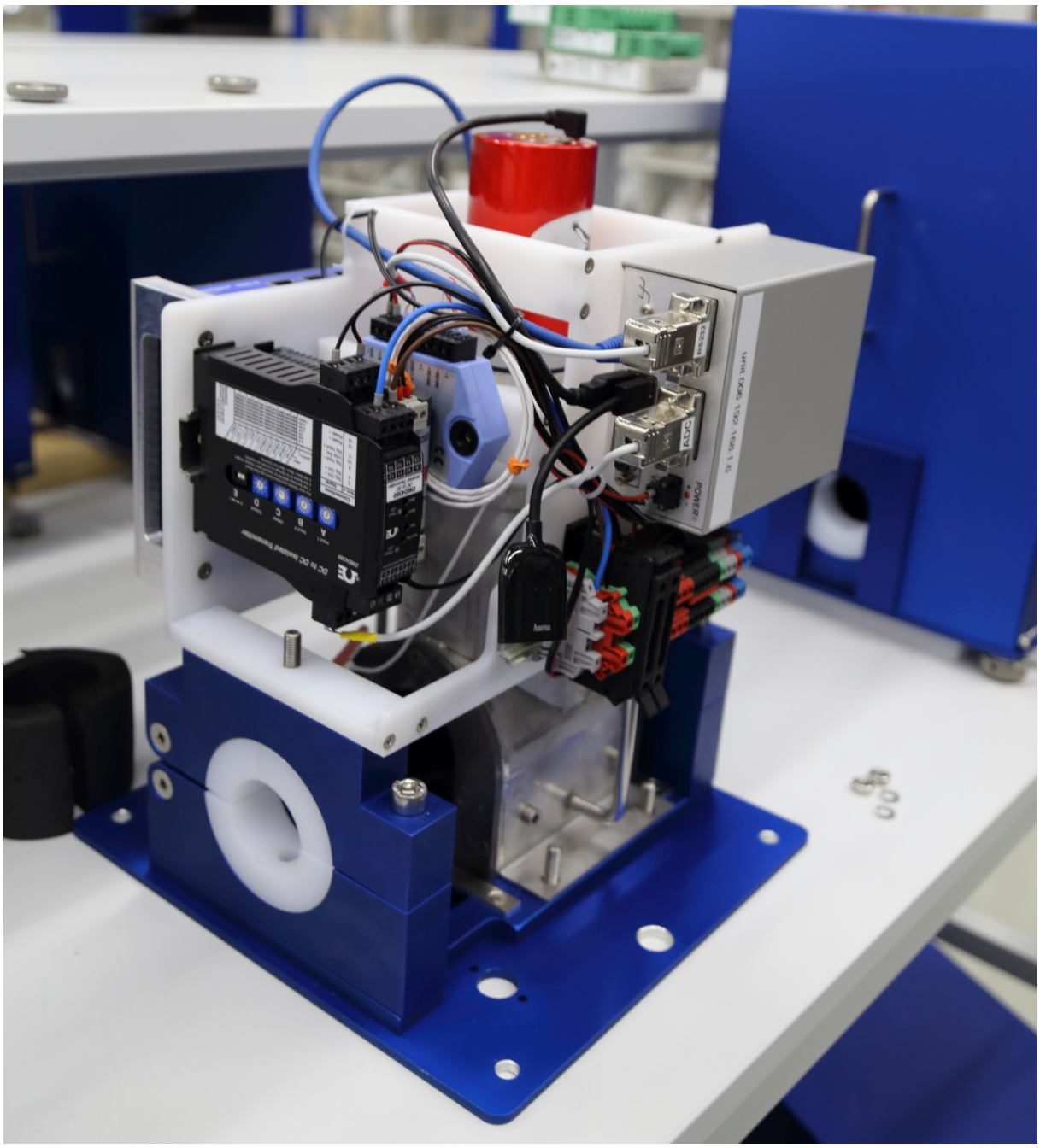


Figure 3. Under the hood of the On-Line-Enrichment-Monitor (OLEM)

SGTS-014

Remote Monitoring and Data Processing Systems

Project Manager: Jim Regula

Division: SGTS

1. Overview

This document describes plans for developing, implementing and maintaining remote monitoring (RM) and data processing systems for the collection, transmission and review of safeguards and equipment data installed in facilities around the world within the Department of Safeguards for the period 2018–2019.

During the 2018-2019 biennium, Project SGTS-014 will pursue the following objective:

Develop, implement and maintain remote monitoring and data processing software and hardware infrastructure to expand the contribution of remote monitoring to the effectiveness and efficiency of IAEA safeguards.

The plan detailed here is fully aligned with the objectives of Agency's project *4.3.2.002 Development of instrumentation systems and methodology*.

The project supports the following R&D Needs from the *R&D Plan*:

Priority Objectives		R&D Needs	
T.1	*Strengthen instrumentation capabilities for verification*	T.1.R1	Develop and introduce an integrated system of instrumentation data processing and review, with high level of automation and with unified user interface.
		T.1.R5	Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment plants and conversion plants, and Pu at reprocessing plants.
		T.1.R9	Strengthen intrusiveness and vulnerability analyses on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.

The purpose of this project is to support the use of remote data transmission (RDT) through the enhancement of hardware and software tools.

For the 2018-2019 biennium, the project's top priorities are to:

- Continue joint all-in-one review program iRAP (Inspector Review and Analysis Platform) with EURATOM (the top priority for this project in the 2018-2019 biennium);
- Install and test new NRT (near real time) components for upcoming large facilities in Ukraine;
- Select and authorise new Virtual Private Network (VPN) hardware for the RDT network and, in addition, identify and/or develop an alternative VPN hardware/software with additional security capabilities.

2. Background

Remote data transmission for IAEA safeguards began in 1997. Its main purpose was to connect systems in the field for the transfer of data, making inspections less frequent and remote systems easier to maintain. Along with ubiquitous low-cost terrestrial broadband, RDT grew 10-15% per year in the number of systems connected and data collected. Several years ago, the Department of Safeguards decided that the Remote Monitoring Team (RMT) would be the focal point for equipment software development in the

Safeguards Department's Division of Scientific and Technical Services (SGTS). The IAEA hired additional programmers and the application development has expanded. The RMT developed RAINSTORM in-house to standardize the RDT interface of newly developed equipment and provide a common data security approach. It is composed of C++ code freely distributed among outside equipment developers, free of charge. Through most of the last biennium, RDT in-house tools such as ROOGLE, which displays real-time RDT system status, was rewritten into ROOGLE2, incorporating a more modern database structure and upgrading the user information screen.

Over recent years, the Department of Safeguards has had difficulty maintaining existing review programs for equipment data because they are numerous and because the IAEA did not have access to the source code and lacked intellectual property (IP) rights. The IAEA attempted to obtain source code for an in-house effort to build an all-in-one review program. This effort led to a joint partnership with EURATOM on iRAP. The IAEA completely redesigned the Graphical User Interface (GUI) of iRAP with the assistance of an outside expert, along with numerous consultations with inspectors and technicians. In the second half of 2017, iRAP will roll out to specific inspectors and used to review and analyse data from any of the Department's unattended monitoring systems (UMS). Future iRAP capabilities will also include review of surveillance and electronic seals, IAEA Neutron Coincidence Counting (INCC) integration, and the importing of operator declarations.

Future large facilities such as geologic repositories will require NRT data processing and red/green status lights for the operator. New tools that accept operator declarations, automatically run an unattended analysis program (Auto-iRAP), and compile results for both the operator and the operations divisions, have been developed. The RMT has also built a NRT test bed during the last biennium.

The RMT has estimated that the RDT global network is complete by approximately 90%, with facilities in India, Argentina, and Brazil connected during the last biennium. Along with expansion, the security of the network is of the highest concern. The IAEA will continue to test new hardware VPN technologies, which will also include outside security audits.

Finally, the RMT has released the first iOS app in the Department of Safeguards, which shows the status of all RDT systems in a read-only display. The IAEA expects this to evolve over the long-term into an iOS-based inspector tool, helping to make inspections more efficient and paperless.

Most of the funding for information collection and analysis comes from the Department's regular budget. The Department of Safeguards may, however, request Member State Support Programme (MSSP) support to focus on specific areas, including the development of NRT tools and capabilities, assistance with security audits, and help with specific data review methods.

A number of the SGTS-014 key objectives are shared with other Departmental projects. The most prominent project connections are with SGTS-011 *Unattended Measurement Techniques* and SGIS-002 *Information Security and Infrastructure*.

3. Expected Outcomes and Key Outputs

In order to reach Project SGTS-014's objectives and achieve the associated R&D needs from the *R&D Plan*, tasks have to be initiated, continued and/ or finalized during the 2018-2019 biennium and can be structured under the following expected outcomes:

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 1.) In collaboration with EURATOM, continued development of the iRAP review programme. **(In support of T.1.R1)**	
Deployment of a version of iRAP that includes complete surveillance and electronic seal review, using improved operator declaration integration	December 2019

Expected Outcomes and Key Outputs	Expected Completion Date
Expected outcome 2.) Installed and tested new NRT (near real time) components in large facilities. **(In support of T.1.R5)**	
New NRT (near real time) components installed and tested in Ukraine in following facilities: ISF-2 (2018) and CSFSF (2019)	December 2019
Expected outcome 3.) Improved VPN hardware for the RDT network. **(In support of T.1.R9)**	
Selection and authorization of new VPN hardware for the RM network	Mid-2018
Identification of an additional alternate VPN hardware (e.g. open source solutions) including development of security enhancements to the hardware/software with support for smart card cryptography tokens	December 2019
Expected outcome 4) Improved efficiency of equipment maintenance by introducing iOS-based apps, initially to monitor RDT system status. **(In support of T.1 Strengthen instrumentation capabilities for verification)**	
Release of ROOGLE 2	December 2018

4. Tasks

Safeguards Department personnel will perform most of the following activities with regular budget funding under Agency's project *4.3.2.002 Development of instrumentation systems and methodology*. Further assistance will be required from MSSPs for some activities.

Expected outcome 1.) ***In collaboration with EURATOM, continued development of the iRAP review program.*** **(In support of T.1.R1)**

With the delivery of iRAP version 2.0, safeguards inspectors and technicians can review all unattended monitoring systems (UMS). The Department updated the graphics package and addressed performance issues with the addition of RMT algorithms. There are, however, still areas of development before the application is fully authorized for use by inspectors. Facility configurations are being prepared, INCC is being integrated into the code, and reporting/declaration tools must include safeguards requirements. An outside contractor is performing the majority of software development, paid through the regular budget. The IAEA and EURATOM share costs evenly for the majority of these development work packages.

The IAEA has also begun work on integrating a complete surveillance review module to iRAP. The surveillance unit has been relying on older (GARS) technology for the past several years while looking for alternatives. Developers will also add electronic seal review to iRAP in 2018. The IAEA currently intends for iRAP to be the future singular review application of SGTS equipment data. The CFE task (USA E 1988) has been active in the iRAP project.

Expected outcome 2.) ***Installed and tested new NRT (near real time) components in large facilities.*** **(In support of T.1.R5)**

When SG Operations need special verification within a facility process flow and the process needs to run continuously without the presence of inspectors, an NRT solution is typically considered. In most cases, the NRT solution will include one or more "green light" signals to the operator, indicating that the process may continue, and does not require IAEA inspector attention and/or verification. Therefore, NRT solutions must be robust because they will act as a legal basis for the operator to continue beyond the point where re-verification is feasible or even possible.

Some of the benefits of NRT are that it minimizes the need for in-situ inspector involvement and their associated delay and overhead on the operator. It provides NRT feedback to the facility operator whether

to proceed to the next step in the process. It reduces costs and risks associated with sending staff into the field. The main drawbacks of NRT are the complexity in implementation and increased maintenance and equipment costs.

The RMT has already built tools for this new concept in remote data processing. Examples include components to send and receive authenticated email messaging; code to provide immediate State of Health analysis for a certain device over a given time period, and development and testing of 'Auto-iRAP' a command line version that runs analysis in an automated manner.

Tasks conducted in Ukraine at facility ISF-2 will be coordinated with tasks in Project SGOC-001 *Chernobyl*.

The RMT has completed initial work in-house with regular budget support and the assistance of a JPO (USA D 2135). However, several new task proposals seeking specialized programming or hardware expertise could be anticipated during the 2018-2019 biennium. MSSP support in this regard may be important.

Expected outcome 3.) ***Improved VPN hardware for the RDT network*****. (In support of T.1.R9)**

Expansion of the RDT network infrastructure has continued with the 29th Member State added in August 2017. The security of the infrastructure remains of highest priority. The current VPN device used by the RMT is no longer available on the market and the IAEA has deemed the manufacturer's recommended replacement unacceptable. New units have not been available for purchase since 2015 and support for existing products is slowly being phased out until 2020. Although the IAEA had a small stockpile of the current VPN device, relying on a single vendor for VPN products posed a serious challenge as the inability to purchase new units could have stalled and/or prevented the installation/upgrade of critical remote monitoring systems. As a result, the IAEA released requirements for a new device in an official Agency bid in August 2017.

Authorization of the newly selected device will include the continuation of security audits or penetration tests by outside consultants. These audits are a very useful tool for gauging the current effectiveness of the hardware security.

It is also in the agency's best interest to identify one or more alternate VPN solutions. An open-source VPN solution is particularly desirable as it reduces the risks of relying on a single vendor and allows the IAEA to be directly, or indirectly, involved in bug fixes or adding new features. As a result of a review of open-source VPN devices, pfSense was recommended. A particular area of concern in VPN devices is key protection. As the RDT network lacks physical protection (beyond sealed cabinets/devices), key protection is an important facet of the RDT network security. In this respect, an open-source solution such as pfSense has an advantage as it could potentially be modified to support additional strong key protection (e.g. by using a smartcard cryptography token).

MSSP support has been important for RDT network infrastructure in the past (USA E 1735, CAN E 1931, GER E 1859); the RMT anticipates requesting future support.

Expected outcome 4.) ***Improved efficiency of equipment maintenance by introducing iOS-based apps, initially to monitor RDT system status.*** **(In support of T.1 – Strengthen instrumentation capabilities for verification)**

ROOGLE for iOS is a read-only application, developed in-house, that displays the latest status of all systems under RDT on an Agency standard Apple iPhone. It has been operational for over two years. This type of app may expand in the next biennium because similar devices will be carried by all inspectors and many routine inspection tasks could be automated using them. Examples include a metal seal log for tracking attaching/detaching seals, a bar code scanner for inventory control, seal reader, or an interface to portable NDA instruments. New task proposals could emerge from this wide-ranging development.

4.1 MSSP Development and Implementation Support Tasks

MSSP support tasks are followed-up and/or coordinated by Agency staff under the project *4.3.2.002 Development of instrumentation systems and methodology* in the *Agency's Programme and Budget 2018-2019*.

MSSP Coordinators, points of contact, and representatives as well as IAEA Safeguards staff members can find lists and summaries of MSSP task proposals and tasks on the Support Programme Information and Communication System (SPRICS). To gain access to SPRICS, please contact SPRICSHelp@iaea.org.

4.2 In-house Development Tasks

Expected outcome	Task #	Task Title (Agency's task cross reference)	Description	Expected Completion Date
1	1	iRAP Development (2018.05)	Limited in-house development will occur, as iRAP matures into an all-in-one equipment review tool.	December 2018
2	2	NRT at large future facilities (2018.05)	In-house development of near real-time software systems for the unique requirements posed by these facilities.	December 2018
4	3	iOS software development (2018.05)	In-house iOS software has currently replicated ROOGLE for the iPhone. Further development could take place in linking other portable equipment.	December 2018

4.3 Attachments

Figure 1: Newly installed shared remote monitoring server at the Argentine-Brazilian Agency for Accounting and Control of Nuclear Materials Headquarters, Brazil

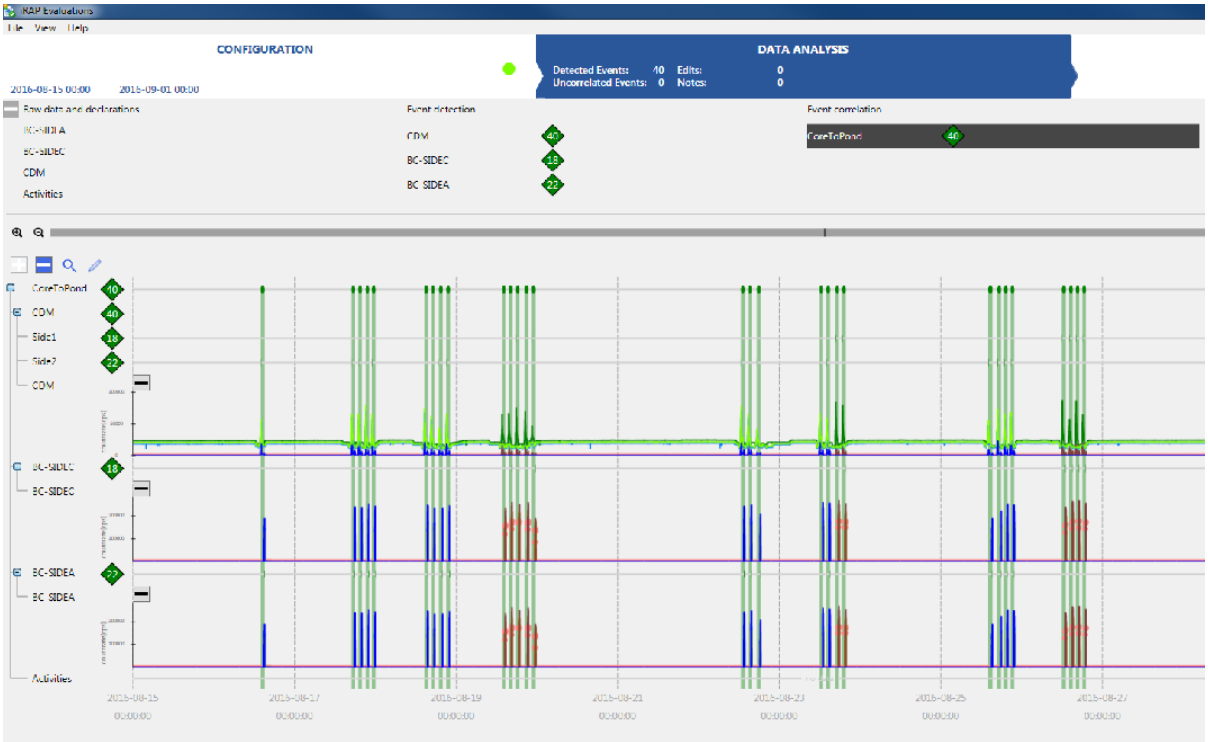


Figure 2: Screenshot of Inspector Review and Analysis Platform (iRAP) data analysis

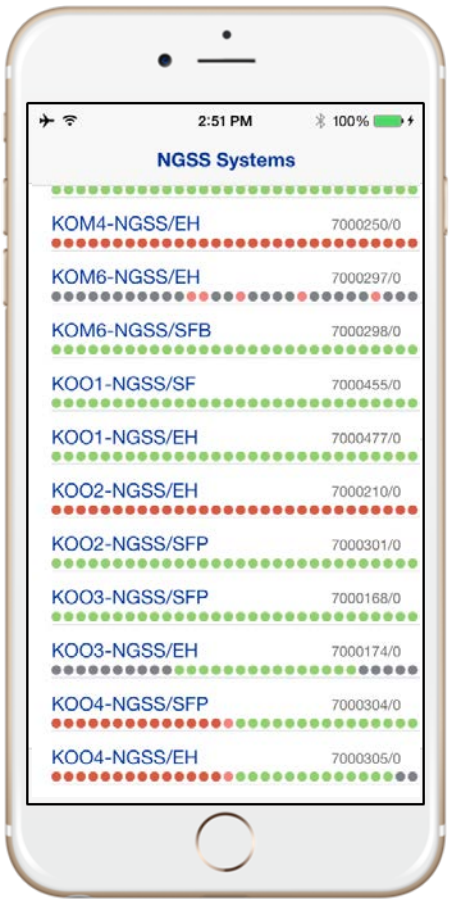


Figure 3: Screenshot of Roogle for iOS iPhone

Appendix 1

Table of Priority Objectives and R&D Needs with corresponding D&IS Projects

The complete *R&D Plan* can be found in STR-385.

R&D Needs		Type of Support Requested					Contributing D&IS Projects
		Financial Support	Expertise	R&D	Collaboration	Equipment, Materials & Access	
Strengthen information collection and analysis							
V.1.R1	Enhance the set of expert tools necessary to process the variety of SG-relevant information and implement them, with emphasis on timely responses and cost-effectiveness.	•	•	•	•		**SGIM-002 SGIM-003 SGIM-009 SGIS-003**
V.1.R2	Make use of new sources of openly available information, including from multimedia, and address the associated information management needs.	•	•		•	•	**SGCP-102 SGIM-003**
V.1.R3	Further integrate safeguards information to strengthen all- source information analysis and make it more user-friendly (e.g. via the Collaborative Analysis Platform).	•	•	•	•	•	**SGIM-002 SGIM-003 SGIS-003 SGVI-001**
Reinforce State evaluation							
V.2.R1	Develop a set of reference materials to assist SEGs in the assessment of a State's capability to accomplish acquisition path steps which take into account the level of maturity of the State's nuclear fuel cycle and associated technical capabilities.			•	•		**SGCP-003 SGCP-102**
Enhance SG effectiveness monitoring and evaluation							
V.4.R1	Identify and deploy analytical tools, including data visualization, to better measure and analyse performance and take advantage of capabilities provided by MOSAIC.	•	•	•	•	•	**SGIM-002 SGIM-008 SGIS-003**
V.4.R2	Evaluate process for introduction of Hypothesis testing approaches for nuclear material measurements, as an alternate to quantification methodology.			•	•		

R&D Needs		Type of Support Requested					Contributing D&IS Projects
		Financial Support	Expertise	R&D	Collaboration	Equipment, Materials & Access	
Employ fit-for-purpose and state-of-the-art methodologies							
V.5.R1	Upgrade existing and develop new statistical methodologies applied to the: • Evaluation of quantitative and qualitative verification data including at the State level (e.g., for nuclear material balance evaluation, random inspections) • Measurement of verification performance (in terms of detection probability) and the associated level of confidence at the facility and state level • Design of random verification schemes (minimizing resources for the same level of effectiveness).	•	•	•	•		**SGIM-007** **SGIM-008**
V.5.R2	Strengthen knowledge of the elemental and isotopic signatures of the nuclear fuel cycle and processes that are specifically detectable through material characterization and environmental sample analyses, and develop expert systems and methodologies that advance data evaluation and enhance continuity of knowledge.		•	•	•		**SGIM-007** **SGTS-001**
V.5.R3	Explore data analysis methods and tools to strengthen the synthesis and evaluation of information (e.g., optimal random verification schemes, nuclear material flow analysis, material balance evaluation, near real-time accountancy and process monitoring tools).		•	•	•		**SGCP-102** **SGIM-003** **SGIM-008** **SGIS-003** **SGOA-002**
Strengthen instrumentation capabilities for verification							
T.1.R1	Develop and introduce an integrated system of instrumentation data processing and review, with high level of automation and with unified user interface.	•	•		•		**SGTS-014**
T.1.R2	Develop the Next Generation Surveillance Review software (NGSR).	•	•		•		**SGTS-003**

R&D Needs		Type of Support Requested					Contributing D&IS Projects
		Financial Support	Expertise	R&D	Collaboration	Equipment, Materials & Access	
T.1.R3	Assess existing techniques to detect misuse of reprocessing plants (real time detection of Pu separation).		•	•	•		**SGCP-102 SGOA-002 SGTS-003**
T.1.R4	Improve tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment plants.		•	•			**SGCP-102 SGTS-011**
T.1.R5	Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment plants and conversion plants, and Pu at reprocessing plants.		•	•	•		**SGOA-002 SGTS-003 SGTS-011 SGTS-014**
T.1.R6	Develop safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/ transport containers at all points in their life cycle.		•	•	•		**SGTS-002 SGTS-011**
T.1.R7	Evaluate implementation potential for calorimetry of plutonium samples when the commonly available passive neutron multiplicity measurements are not feasible.		•				*SGTS-001*
T.1.R8	Develop in-field alpha spectrometers (including sample preparation) for nuclear material identification and isotopic composition analysis.			•			*SGTS-001*
T.1.R9	Strengthen intrusiveness and vulnerability analyses on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.		•		•		**SGTS-002 SGTS-003 SGTS-014**
Enhance sensitivity, reliability and timeliness in sample analysis							
T.2.R1	Improve analytical timeliness of dealing with special and high priority demands for analysis by means of the reduction of sample size, the application of in-situ analysis and by strengthening the response regime (e.g. COMPUCEA, Cristallini method).	•			•		**SGAS-001 SGTS-001**

R&D Needs		Type of Support Requested					Contributing D&IS Projects
		Financial Support	Expertise	R&D	Collaboration	Equipment, Materials & Access	
T.2.R2	Further improve the quality assurance and control (QA/ QC) for the Agency's NWAL for safeguards, including SAL, in the area of particle analysis in particular.	•			•	•	**SGAS-002 SGAS-003**
T.2.R3	Support the improvement of Member States' analytical quality for nuclear material accountancy (i.e. for better Operators' analytical systems).				•		**SGAS-001 SGAS-003**
T.2.R4	Develop/expand a set of reference materials with NWAL assistance, and produce/distribute working reference materials to support Member States' analytical quality.			•		•	**SGAS-001 SGAS-002 SGAS-003**
T.2.R5	Continue to reduce and manage nuclear material holdings stored at the Nuclear Material Laboratory (NML) in line with safeguards needs, and identify long-term sustainable solutions for disposal of nuclear materials, particularly plutonium and highly-enriched uranium.				•		**SGAS-001**
T.2.R6	Develop and implement methods 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 • Isotopic characterization of Pu containing particles using FT-LAICPMS and LG-SIMS		•	•	•	•	**SGAS-002**
Support all SG processes through IT							
T.3.R1	Further develop the State Declarations Portal as a tool that optimizes the quality and usability of State-declared information and enhances the State-Secretariat communication on State declarations.	•	•		•		**SGCP-102 SGIM-009 SGIS-003**

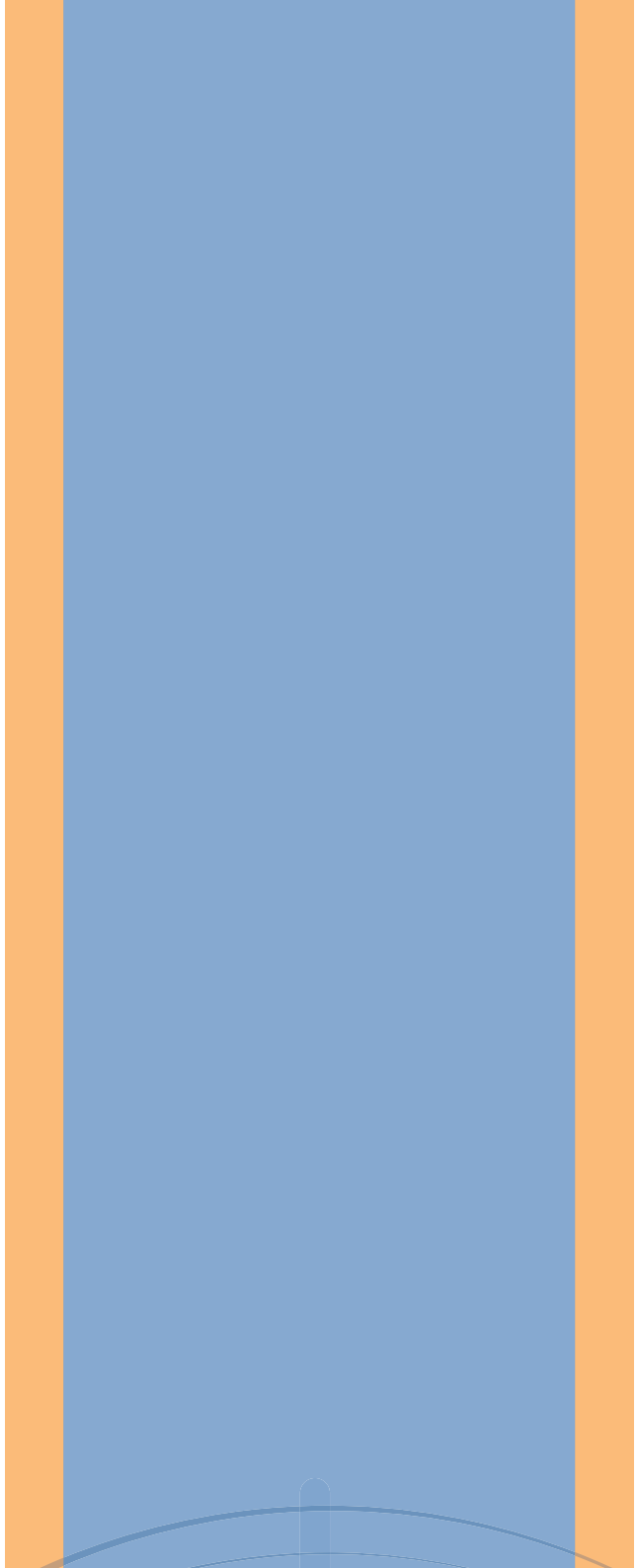
R&D Needs		Type of Support Requested					Contributing D&IS Projects
		Financial Support	Expertise	R&D	Collaboration	Equipment, Materials & Access	
T.3.R2	As part of STEPS (Statistical Testing, Evaluation and Planning for SG) project, re-engineer and integrate all the legacy systems used for the statistical evaluation of State declared and verification data and the probabilistic calculations that inform verification approaches (e.g. sampling plans and random inspection schemes).	•	•				**SGIM-008** **SGIS-003**
T.3.R3	Build on the development of geographic information system (GIS) technology to enhance geo-based information sharing and related analysis.	•	•	•	•	•	**SGIM-002** **SGIS-003**
T.3.R4	Maintain and continue to upgrade the environmental sampling database and the process modelling tools as well as the database and tools that support trace elements analysis (material characterization).	•					**SGIM-007**
T.3.R5	Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations.	•	•		•		**SGIM-009** **SGIS-003**
Manage SG technology assets strategically							
T.4.R1	Execute a long-term maintenance and replacement plan for the safeguards information technology system as a follow-up to MOSAIC.	•	•	•	•	•	**SGIS-003**
T.4.R2	Develop and execute a long-term replacement plan for analytical equipment at SG Analytical Laboratories, with appropriate mix of regular and extra-budgetary funds.	•			•	•	**SGAS-002**
Identify and exploit innovations							
T.5.R1	Identify, evaluate and test promising applications of robotics and machine learning/artificial intelligence to improve the effectiveness and efficiency of safeguards.	•	•	•	•	•	**SGIM-008** *SGTS-003* **SGTS-008**

R&D Needs		Type of Support Requested					Contributing D&IS Projects
		Financial Support	Expertise	R&D	Collaboration	Equipment, Materials & Access	
T.5.R2	Identify areas in which technology challenges (e.g. expert crowdsourcing) could be an asset for developing the Department's technologies and methodologies.		•		•		**SGTS-008**
T.5.R3	Monitor the potential utility of block chain technology for safeguards applications (e.g. nuclear material accounting).		•	•	•		
T.5.R4	Define requirements for SG surveillance technology required beyond the next generation surveillance system (NGSS).		•	•	•		*SGTS-003*
T.5.R5	Develop training tools using technologies such as virtual reality, immersive learning systems and web-based training.	•	•	•	•	•	**SGCP-102** **SGIM-009**
T.5.R6	Investigate and test fieldable neutron counting systems reducing the use of ^{3}He or offering equivalent functional and technical alternatives.	•		•	•	•	*SGTS-001*
T.5.R7	Develop and evaluate alternatives to photo-multiplier tubes for large neutron or gamma scintillation detectors.			•			*SGTS-001*
T.5.R8	Develop alternative fast neutron detectors that improve effectiveness and fieldability.			•	•	•	**SGOA-002** **SGTS-001**
T.5.R9	Develop large room-temperature semiconductor medium- resolution gamma spectrometers to replace scintillation detector systems.			•			*SGTS-001*
T.5.R10	Develop new Sealing System Technologies with improved security and economy.	•	•	•	•	•	**SGTS-002**
Reform human resource management							
W.1.R1	Develop and maintain, through training, new expertise required by the Department, where needed, with the help of Member States.	•	•	•	•	•	**SGCP-102** **SGIM-002** **SGIS-002** **SGVI-001**
Resolve priority areas of difficulty in SG implementation							
S.2.R1	Develop training material and remote delivery methods (e.g., E-Learning) to support SRA training with reduced costs and increased accessibility.	•	•		•		**SGCP-102** **SGIM-009**

R&D Needs		Type of Support Requested					Contributing D&IS Projects
		Financial Support	Expertise	R&D	Collaboration	Equipment, Materials & Access	
Advance safeguards-by-design							
S.3.R1	Identify and pursue opportunities for the Agency and Member States to promote the early consideration of safeguards among the nuclear industry.	•	•		•		**SGCP-003**
Strengthen management processes							
C.2.R1	Develop effective and sustainable strategic management processes to enable effective horizontal and vertical strategy execution.	•	•		•		**SGCP-004 SGCP-101**
Ensure information security							
P.1.R1	Improve the capability to quickly identify and react to security events within the Department's information systems.	•	•		•		**SGIS-002**
P.1.R2	Improve Information Security capabilities in areas of risk: management, auditing and reporting; vulnerability management; threat intelligence; and improve processes, procedures and standards.	•	•		•		**SGIS-002**
Increase resilience and prepare for disaster recovery							
P.2.R1	Address requirements (processes and technology) for carrying out mission-critical functions (needed for continued delivery of SG conclusions) in case of disasters (e.g. disruptive, massive cyber-attack or physical loss of critical infrastructure).	•	•				**SGIS-002**
Monitor, assess and prepare for evolving nuclear proliferation challenges							
P.3.R1	Maintain awareness of changes in the nuclear landscape and associated proliferation risks, including the impact of non-State actors on the safeguards system.	•	•		•		**SGCP-003 SGCP-004**
Maintain readiness for other verification tasks							
P.4.R1	Enhance readiness to resume safeguards/verification/ monitoring activities in the DPRK, when so requested.	•	•	•	•	•	

R&D Needs		Type of Support Requested					Contributing D&IS Projects
		Financial Support	Expertise	R&D	Collaboration	Equipment, Materials & Access	
P.4.R2	Assist with Chernobyl and Fukushima related activities as requested.	•	•	•	•	•	**SGOA-003 SGOC-001**
Prepare for new types of facilities and decommissioning							
P.5.R1	Address identified gaps in facility-specific guidance, training and tools for conducting verification activities during decommissioning.	•	•	•	•		**SGCP-003 SGCP-102**
P.5.R2	Based on the prospects and timing for emerging nuclear fuel cycle facilities (e.g. pyroprocessing plants, geological repositories) develop and deploy as appropriate: • safeguards concepts • tools • techniques • training	•	•	•	•	•	**SGCP-003 SGCP-102**

Type of Support	Definition
Financial Support	Contribution through direct fund provision
Expertise	Provision of a cost-free expert, junior professional officer, or temporary consultant
R&D	Research and development activities, undertaken within Member States or partner organizations, that are designed to improve safeguards capabilities
Collaboration	Consultations or correspondence with experts through, for example, meetings workshops, training, etc.
Equipment/ Materials / Access	Provision or transfer of equipment, reference materials, working standards, provision of access to facilities for testing, training, etc.



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