STR-382

Development and Implementation Support Programme for Nuclear Verification 2016–2017

Vienna, February 2016

IAEA
International Atomic Energy Agency

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 the Development and Implementation Support (D&IS) Programme for Nuclear Verification, which has been in place since 2001. This programme, which is linked to the Long-Term R&D Plan 2012–2023, is a key tool for the Department of Safeguards, helping to sharpen and sustain capabilities that enable a unique mission.

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 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 Member State Support Programmes (MSSPs) towards our most urgent development 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 we undertake to achieve the 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.

This past year has been a historic one for the non-proliferation regime, with the successful agreement of the Joint Comprehensive Plan of Action (JCPOA) between Iran and the E3/EU+3. The IAEA is now undertaking the necessary verification and monitoring of Iran's nuclear-related commitments under the JCPOA. This will require a significant and sustained effort by the IAEA for many years to come. Being called upon to serve such a crucial role highlights once again the continuing importance of IAEA verification to international peace and security.

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 2016–2017

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 IAEA Department of Safeguard's projects and plans to support the implementation of safeguards in a manner which is effective, efficient and encourages innovation and excellence.

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

D&IS PROGRAMME OBJECTIVES

The Department has prepared its D&IS Programme for the biennial period 2016–2017 to prioritize activities, define key achievement targets, and inform MSSP and Departmental resource allocation decisions in the context of the Department's total work portfolio.

The D&IS Programme aims to meet both shorter-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 operating conditions.

Each of the D&IS Programme project plans that follow aims 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.

The D&IS Programme has been prepared in accordance with the Department's *Long-Term R&D Plan, 2012–2023*[1].

PLANNING FRAMEWORK

The Projects described in this document, are designed to contribute to the achievement of the strategic objectives for Major Programme 4 (Nuclear Verification), as outlined in the Agency's Programme and Budget 2016-2017:

1. *Deter the proliferation of nuclear weapons by detecting early the misuse of nuclear material or technology, and by providing credible assurances that States are honouring their safeguards obligations.*
2. *To remain ready to assist with verification tasks, in accordance with the Agency's Statute, in connection with nuclear disarmament or arms control agreements, as requested by States and approved by the Board of Governors.*

The *Long-Term R&D Plan 2012-2023* sets out the *capabilities* that the Department needs in the long-term to achieve its strategic objectives and the key *milestones* that are required to be met towards achieving those capabilities. These are technical capabilities for which Member State R&D support is or may be needed. Each

[1] A summary of the IAEA Department of Safeguards Long-Term R&D Plan, 2012-2023, is available at https://www.iaea.org/safeguards/symposium/2014/images/pdfs/STR_375_--_IAEA_Department_of_Safeguards_Long-Term_R%26D_Plan_2012-2023.pdf

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

The Department continues to integrate the D&IS Programme with the *Long-Term R&D Plan 2012-2023*. In 2016, the Department will begin the process of updating the latter. Following this update, the Department will look at restructuring the D&IS Programme to more closely align development activities with needed long-term capabilities. In the current edition of the D&IS Programme, each project identifies relevant long-term R&D capabilities or milestones being addressed, any additional, high-level objectives the projects aim to achieve, and key achievement targets for the coming biennium. These targets are specific and will be used to monitor and measure progress in subsequent project reporting.

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 improvement or extension of *existing* techniques and technologies. Funding is derived from MSSPs, the IAEA's regular budget and other extra-budgetary contributions.

This D&IS Programme endeavours to describe *all* development activities being undertaken within the Department in each Project area, regardless of the funding resource. 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 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 only MSSP-supported activities. The IAEA's biennial Programme and Budget documentation 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. These include, for example, training for inspectors, refinement or replacement of equipment and systems.

The D&IS Programme does not cover Cost-Free Expert (CFE) and Junior Professional Officer (JPO) 'tasks', but development areas supported by the work of CFEs and JPOs are referenced.

PROGRAMME AND PROJECT MANAGEMENT

Coordination of D&IS activities is carried out by the Department's Division of Concepts and Planning. For the 2016–2017 biennium, the Department has identified 24 projects (including three new projects) to meet current and emerging safeguards needs. The projects and their respective managers are listed on page 6.

The execution of the programme is performed through activities planned within each of the 24 D&IS project plans that are described in the main body of this document. For activities involving MSSPs, the work is performed through Support Programme tasks. Each task has an IAEA and MSSP representative assigned to oversee the work.

PROJECT PLAN STRUCTURE

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 groups existing tasks with the milestones defined in the *Long-Term R&D Plan 2012-2023* 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
	  o Long-term direction
	  o Relevant capabilities and milestones from the *Long-Term R&D Plan 2012-2023*
	• Top priorities for the 2016-2017 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
Objectives	• Applicable milestones from the *Long-Term R&D Plan 2012-2023* • Any additional, high-level objectives • Key achievement targets, which detail deliverables that are specific, measurable, achievable, relevant and time-bound
Activities	• Description of specific activities planned during the biennium for each objective • References to active MSSP tasks, task proposals, and newly planned task proposals and internal activities, as well as cross-references to related Departmental projects • Highlights of recent achievements as appropriate

Project plans also contain tables describing development activities supported with regular budget funds. Links to regularly updated online tables of MSSP tasks by project area are also provided.

SIGNIFICANT CHANGES FOR 2016-2017

The 'Overview' section of each project plan has been adjusted to provide a holistic summary for each project, complete with the essential information on each project's scope, objectives, ties to the *Long-Term R&D Plan 2012-2023*, and top priorities.

This is the first time top priorities have been specifically identified for each project for each project. A full list of these top priorities for all projects can be found on page 7. To provide a more complete and timely picture of current MSSP activities for each project area, full task tables have been placed online. These are intended to be available to all readers; access has been simplified to the extent possible.

To improve the navigability of the programme, readers will find links to other parts of the document as well as relevant external content throughout the digital (PDF) version of the D&IS Programme document.

There are three new projects for the 2016-2017 biennium:

SGIM-009 - *State Declared Information Management*

This project 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.

SGOA-003 - *Fukushima Dai-ichi Safeguards*

This project 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.

SGVI-001 - *JCPOA Implementation*

This project addresses the need for additional resources to ensure the effective and credible implementation of IAEA verification and monitoring of Iran's nuclear-related commitments under the Joint Comprehensive Plan of Action (JCPOA).

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.

ADMINISTRATION OF MEMBER STATE SUPPORT PROGRAMME TASKS

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

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.

In the second quarter of 2016, the IAEA will release SPRICS 2.1, an update to SPRICS 2.0 that is intended to streamline and simplify some of the internal and external work-flows used by the system for task initiation, transmission and status reporting. SPRICS 2.1 will also fix some outstanding issues and incorporate feedback received from users.

With respect to the management of the D&IS Programme, the Department intends to pursue its policy of continual improvement. Over the 2016–2017 biennium, the Department will continue to further align the planning and implementation process for D&IS activities with the *Long-Term R&D Plan*. The D&IS Programme will also continue to include a prioritization process.

MEMBER STATE SUPPORT PROGRAMMES

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

List of Member State Support Programmes

Argentina (ARG SP)

Australia (AUL SP)

Belgium (BEL SP)

Brazil (BRZ SP)

Canada (CAN SP)

China, People's Republic of (CPR SP)

Czech Republic (CZ SP)

European Commission (EC SP)

Finland (FIN SP)

France (FRESPAS)

Germany (GER SP)

Hungary (HUN SP)

Japan (JASPAS)

Netherlands (NET SP)

Republic of Korea (ROK SP)

Republic of South Africa (RSA SP)

Russian Federation (RUS SP)

Spain (ESP SP)

Sweden (SWE SP)

United Kingdom (UK SP)

United States of America (US SP)

List of D&IS Projects and Project Managers 2016-2017

Project ID	Project Title	Project Manager	Responsible Division
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	Masato Hori	SGCP/CCA
SGCP-101	Quality Management	Snezana Konecni	SGCP/CPD
SGCP-102	Training	Jean-Maurice Crété	SGCP/CTR
SGIM-002	Geospatial Information Analysis	Karen Steinmaus	SGIM/ISI
SGIM-003	Information Analysis	SH/ISF	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	Alain Rialhe	SGIM/ISD
SGIS-002	Information Security and Infrastructure	Scott Partee	SGIS/IS
SGIS-003	Safeguards 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	Davis Hurt	SGOA/TRO
SGOC-001	Chernobyl	Sigitas Kurselis	SGOC/OC2
SGVI-001	JCPOA Implementation	Andrew Catton	SGVI
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	Martin Moeslinger	SGTS/TUS
SGTS-008	Instrumentation Technology Foresight	Dimitri Finker	SGTS/TND
SGTS-011	Unattended Measurements Techniques	Thierry Pochet	SGTS/TUS
SGTS-014	Remote Monitoring and Data Processing Systems	Jim Regula	SGTS/TSI
SGTS-015	Technologies for Possible New IAEA Verification Tasks	Kenneth Baird	SGTS/TSI

List of D&IS Project Top Priorities 2016-2017

Project	Project Top Priorities
SGAS-001 Destructive Analysis of Nuclear Materials	• Develop a new UF_6 sample collection method using alumina, which will reduce sample size and circumvent potential future restrictions on air transports of traditional UF_6 samples. • Develop the COMPUCEA technique for UF_6 enrichment as a means of reducing analysis and reporting times for inspections at enrichment facilities, while maintaining near-laboratory DA levels of precision. • Support development and training tasks at the OSL in Rokkasho, Japan in order to improve analytical capabilities. Examples include the design and production of a hot-cell scrubber for capturing radioactive off-gassing in a hot cell, and the development of new methods for measuring the Pu content from undissolved fines in high-active liquid waste samples. • Develop new coating materials to facilitate longer storage times for in-house produced working standards, which will reduce labor effort and decrease the volume of expensive radioactive waste.
SGAS-002 Environmental Sample Analysis Techniques	• Develop, implement and improve particle identification and isolation methods of single, nuclear material containing particles from environmental swipe samples for instrumental analysis. • Validate and apply the Scanning Electron Microscope (SEM/FIB-ToF) instrumental analysis technique for the identification and characterization of individual micrometer-sized particles and other relevant artifacts collected on environmental swipe samples. • Develop new and additional techniques for particle production, which will complement the current activities in the production of quality control (QC) materials for instrument calibration, method development and external quality control administered to the Network of Analytical Laboratories (NWAL). • Produce and distribute new quality control swipes containing uranium (U), plutonium (Pu) and mixed U/Pu 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 areas being particle analysis of environmental samples and quality assurance support. • Produce new quality control reference materials, particularly for particle analysis.

SGCP-003 Safeguards Approaches	• Develop templates and simple software tools to improve efficiency and consistency in performing acquisition path analysis (APA) and developing State-level approach (SLA).
	• Update the Physical Model to improve its completeness.
	• Draft and publish Safeguards Technical Reports (STRs) on:
	  o Geological repositories and encapsulation facilities
	  o Pyro-processing facilities
	  o Lessons learned from the Fukushima Dai-ichi accident.
	• Publish the remaining two 'Safeguards Implementation Practices' (SIP) Guides and organize workshops to familiarize stakeholders with the SIP Guides.

SGCP-101 Quality Management	• Fully implement the process-based approach within the Department and through that approach, drive forward continual improvement. • Implement measurement systems to monitor process performance. • Adapt the QMS tools and techniques to improve process performance. • Assess the effectiveness of the QMS in the Department and determine what adjustments are required, whilst maintaining the QMS.

SGCP-102 Training	• Update, develop and implement training courses and curriculum following guidance documents and capturing best practices for implementation of the State-level concept. • Develop a competency-based approach for training implementation, making full use of the Learning Management System deployed within AIPS Plateau 3[2]. • 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 Geospatial Information 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 image processing and exploitation and allow opportunities for analysts to participate in technical visits to nuclear fuel cycle (NFC) facilities. • Continue the development of new methods and capabilities that improve workflows and optimize use of resources, allowing analysts to focus on analysis.
SGIM-003 Information Analysis	• Evaluate data analysis methods and computerized tools to aid the analysis and presentation of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions. • Refine and further integrate scientific and technical literature monitoring processes in support of State evaluation, acquisition path analysis, and in-field activities. • Further enhance the Rapid News Service tool that was implemented last year to monitor news and streamline information management processes.
SGIM-007 Evaluation of Data from Environmental Sampling and Material Characterisation	• 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. • 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.
SGIM-008 Statistical Analysis	• Review and harmonize current random inspection schemes through the development, refinement and documentation of methodologies and processes for implementation; evaluate their effectiveness. • Review, update and consolidate the algorithms for the determination of measurement error uncertainties from calibration, paired-data, and 3-laboratory data analysis and for evaluating MUF, D, IMUF, and SRD. • Enhance and further develop analytical methodologies in support of State-level evaluations in the areas of material balance evaluations, 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 declaration information. • Improve the tools and methodologies for information exchange between States and the IAEA by implementing a web-based portal for the online submission of State declared information by SRAs. • Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of State declared information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions. • Continue efforts with Member States to enable provision of digital state-declared spatial information using standard, compatible formats, which allow the IAEA to directly ingest this information into existing and evolving information systems.

[2] The Agency-wide Information system for Programme Support (AIPS) is an Enterprise Resource Planning system launched in the Agency in 2011. AIPS replaces many of the organization's information systems with a single, standard platform. The system is being accompanied by new business processes and by the IAEA's adoption of International Public Sector Accounting Standards. "Plateau 3" of Agency-wide AIPS implementation was launched in 2015, and addresses, in particular, many Human Resources functionalities.

SGIS-002 **Information Security and Infrastructure**	• Implement a set of solutions to automate and improve the detection of events, system anomalies, and activities in the Department's information systems – particularly in the case of the Integrated Safeguards Environment (ISE). • Attain independent assessments of specific solutions for risk and vulnerabilities; supplement internal capacity to perform comprehensive or targeted penetration tests in efforts to improve the Department's security configurations and system designs. • 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 virtualized computing technologies and sandboxing techniques. • Develop and demonstrate an updated disaster recovery programme.
SGIS-003 **Safeguards Information Systems and System Usability**	• Integrate all safeguards relevant data and improved applications to better support safeguards implementation processes. • 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. • Develop/manufacture equipment necessary to support the safeguards approach. • Define the requirements specification and architecture for integrated data collection and evaluation system. • Developing the plan and procedures for Design Information Verification (DIV) during the construction and commissioning phases of the facility.
SGOA-003 **Fukushima Dai-ichi Safeguards**	• Maintain a reliable safeguards monitoring 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. • Develop measures to re-verify as much of the previously inaccessible nuclear material as possible.
SGOC-001 **Chernobyl**	• Finalize the update of the State-level safeguards approach (SLA) for Ukraine, which will include facilities under this project. • Complete the installation and authorization of safeguards equipment for verification use. • Install hardware and software for data collection, on-site review, remote transmission to the IAEA and analysis.

SGVI-001
JCPOA Implementation
	• Identify assistance that may be required from MSSPs to assist with the implementation of the JCPOA, particularly in the areas of:
	  o Software and analytical tools (in cooperation with SGIS-003 *Safeguards Information Systems and System Usability* and SGIM-003 *Information Analysis*);
	  o Specialized training (in cooperation with SGCP-102 *Training*); and
	  o Unattended monitoring equipment (in cooperation with multiple SGTS Projects).

SGTS-001 **NDA Techniques**	• Develop, evaluate and authorize a system for partial defect verification of fresh-fuel that does not require a priori information about the concentration of burnable poison. • Develop, evaluate and authorize tomography systems capable of performing genuine partial defect tests on inhomogeneous and impure nuclear material and spent fuel. • Establish a pool of 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 (in cooperation with SGTS-008). • Conduct a feasibility study of nuclear material assessment with in-field alpha spectrometry. • Enhance the functional performance and extend the area of use of existing NDA instruments, such as COMPUCEA (See SGAS-001 *Destructive Analysis of Nuclear Material*), FDET and DCVD. • Re-engineer the software package for IMCA-based applications to improve usability and maintainability.

SGTS-002 Improved Techniques and Instruments for Sealing and Containment Verification	• Modernize, sustain and improve the tamper resistance of sealing systems throughout their lifetime. • Develop a new generation of active seal called the Active Optical Loop Seal (AOLS). • Develop and deploy a new glass seal (GLAS) to be used in applications for which metal seals are currently utilized. • Continue to improve the overall security of safeguards instrumentation to the dynamic threat landscape.
SGTS-003 Surveillance Techniques	• Develop and authorize new, 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. • Ensure sustainability of current NGSS technology by implementing updates required by new needs from safeguards inspectors and updated Departmental IT security.
SGTS-008 Instrumentation Technology Foresight	• Implement ANPS (autonomous navigation and positioning for safeguards), as a means to structure and streamline the workflow of field instrumentation data. • Develop in situ analysis capabilities. • Evaluate the use of robotics to assist or automate tasks in the field. • Upgrade the Complementary Access toolkit for inspectors.
SGTS-011 Unattended Measurement Techniques	• Deploy the On-Line Enrichment Monitor (OLEM) at Operations' request. • Complete the Unattended Cylinder Verification System (UCVS) viability study. • Complete Phase II of the Unattended Gamma Emission Tomography (UGET) study. • Develop specifications for the next generation of UMS Data Acquisition module. • Complete the upgrade of VIFM systems with new ADM2 data acquisition modules. • Complete the upgrade of all other ageing UMS systems with up-to-date and standardized COTS components. • Consider a new approach for power management to support the aim of optimizing the life cycle cost of UMS systems.
SGTS-014 Remote Monitoring and Data Processing Systems	• Joint development with EURATOM of the all in one review program iRAP (the top priority for this project in the 2016-2017 biennium). • Building new NRT (near real time) components for upcoming large facilities. • Maintenance and expansion of the global RM network, while ensuring data security.

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

Project	Long-term Direction		
	Objectives	**Key Achievement Targets**	**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.**		
	Objective 1.) Utilize the expanded NWAL in order to • provide external quality control and reference material, and • provide technical expertise. (In support of Milestone 10.1)	• Host a Technical Meeting organized by Member State Support Programmes, aimed at issuing a practical set of guidelines for the production of working standards production for the NML and other laboratories with safeguards roles, such as facility operators, NWAL and state-level authority labs. • Develop new coating materials to facilitate longer storage times for in-house produced working standards, which will reduce production effort and decrease the volume of expensive radioactive waste.	June 2016 June 2017
	Objective 2.) Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples. (In support of Milestone 10.3)	• Finalize a new COMPUCEA method for UF_6 enrichment. Once implemented, this new method will reduce analysis and reporting times for inspections at enrichment facilities, while maintaining near-laboratory DA levels of precision. • Develop a new UF_6 sample collection method using alumina, which will reduce sample size and circumvent potential future restrictions on air transports of traditional UF_6 samples.	June 2016 December 2017
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 analytical needs for the analysis of environmental samples.**		
	Objective 1.) Utilize the expanded NWAL in order to • provide external quality control and reference material, and • provide technical expertise. (In support of Milestone 10.1)	• Host a working group aimed at discussing a focused effort on provision of particle materials and prioritizing production of such. • Produce additional reference and quality control materials to carry out a sound external quality control programme administered to the NWAL.	December 2016 December 2017
	Objective 2.) Develop techniques, methods and equipment to detect signatures of nuclear activities	• Validate the newly installed Scanning Electron Microscope/Focused Ion Beam – Time-of-Flight Mass Spectrometer (SEM/FIB-ToF) instrument for imaging (BSE, SE)	June 2016

	in environmental samples. (In support of Milestone 10.2)	and elemental mapping (EDX, ToF-SIMS) of micrometer-sized particles and other artifacts of safeguards relevance.	
		• Develop the laser ablation (LA) sampling technique in combination with inductively coupled plasma mass spectrometry (ICP-MS) to analyze plutonium and mixed uranium/plutonium particles complementing the existing capability of isotopic characterization of uranium containing particles using LG-SIMS. • Develop the μ-Raman technique to characterize micrometer-sized particles containing nuclear materials and other safeguards relevant micro-artifacts. • Develop new and improve existing identification methods to more reliably find small particles in an excess background of material.	December 2016 June 2017 December 2017
SGAS-003 Analysis Support and NWAL Coordination	**Enhance the NWAL's effectiveness and efficiency in provision of analytical support to the IAEA's verification mission, in particular with respect to the NWAL's sample analysis capacity, quality and timeliness, based on Departmental needs.**		
	Objective 1.) Utilise the expanded NWAL in order to • provide external quality control and reference material, and • provide technical expertise. (In support of Milestone 10.1)	• Qualify one additional NWAL member for particle analysis of environmental samples. • Qualify one additional NWAL member for analysis of nuclear material samples. • Qualify one additional NWAL member for provision of reference materials. • Complete one to two inter-laboratory comparison exercises per year. • Produce new quality control reference materials, particularly for uranium particle analysis.	December 2017 December 2017 December 2017 December 2017 December 2017
SGCP-003 Safeguards Approaches	**Develop and implement innovative and effective concepts and approaches to continue to meet safeguards challenges.**		
	Objective 1.) Prepare additional guidance for the on-going development of State-level safeguards approaches: • The use of State-specific factors • Acquisition path analysis • The specification of options for Headquarters and in-field activities required to meet the technical objectives • The link between the State evaluation process	• To improve efficiency and consistency in performing APA and developing SLA: Develop additional templates Develop simple software tools.	March 2016 June 2016
		• Produce further documentation with quantifiable technical parameters for evaluation in the guides for performing APA and developing SLA.	December 2017

	and development of SLAs and AIPs. (In support of Milestone 1.2)		
	Objective 2.) Develop additional tools to support the development of State-level safeguards approaches: • The analysis, representation, and prioritization of acquisition paths • The assessment of overall safeguards effectiveness • The determination of technical objectives. (In support of Milestone 1.3)	• Develop a software tool to support APA and SLA process steps, including the visualization of acquisition paths, assessment of steps, time assessment of paths, establishment and prioritization of technical objectives, and identification of safeguards measures/activities in order to inform determination of the frequency and intensity of safeguards activities.	December 2017
	Objective 3.) Develop approaches to more fully utilize SRA data and verification findings, where appropriate, to achieve efficiencies. (In support of Milestone 1.4)	• Identify performance measures and technical competences which will enable the Agency to assess and more fully utilize the technical capability and verification findings of the SRA.	June 2017
	Objective 4.) Develop safeguards guidance for States, including web-based versions, addressing topics such as: • Regulatory authority • Design information • Inspections and complementary access • Imports and exports. (In support of Milestone 1.5)	• Publish remaining two SIP guidance documents on provision of information to the IAEA and undertaking collaborative approaches to safeguards implementation. • Organize at least two workshops to familiarize States with the SIP Guides.	December 2016 December 2017
	Objective 5.) Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles. (In support of Milestone 2.3)	• Update the Physical Model to improve its completeness and usability. o Update volumes 2, 3, 4, 7, 8. o Update volumes 1, 5, 6, 9, 10, 11.	June 2016 December 2017
	Objective 6.) Develop generic safeguards approaches for pyro-processing plants and small modular and/or Gen IV reactors.	• Develop a safeguards approach and supporting measures for a specific pyro-processing facility; draft a Safeguards Technical Report for safeguarding generic pyro-processing plants.	December 2017

	(In support of Milestone 3.1)		
	Objective 7.) Develop safeguards techniques applicable to geological repositories. (In support of Milestone 3.2)	• Draft a Safeguards Technical Report on technical measures that could be potentially useful for safeguarding future geological repositories and encapsulation facilities.	December 2016
	Objective 8.) Develop a mechanism to enable safeguards to be considered early in the facility design process. (In support of Milestone 3.4)	• Issue all facility specific safeguards-by-design (SBD) documents. • Provide input to an industry driven project for development and implementation of a standardized UF_6 cylinder identifier.	December 2016 December 2017
	Objective 9.) Consult with Member States with established naval nuclear propulsion programmes for development of future verification arrangements in this area. (In support of Milestone 4.1)	• Consult with Member States with established naval nuclear propulsion programmes to identify challenges and develop possible solutions relevant to development of concepts and tools for future verification arrangements in this area.	December 2016
	Objective 10.) Assist with Chernobyl, Fukushima and DPRK related activities as requested. (In support of Milestone 12.1)	• Draft a Safeguards Technical Report for lessons learned from Fukushima Dai-ichi accident.	June 2017
SGCP-101 Quality Management	**Continue to implement a Department-wide quality management system; monitor, analyse, and report on its effectiveness.**		
	Objective 1.) Develop safeguards policy, guidelines and processes to more fully implement safeguards at the State level. (In support of Milestone 1.1)	• Implement the approved Internal Quality Audit Programme and perform process reviews as scheduled. • Implement the planned reviews in the process review schedule.	December 2017 December 2017
	Objective 2.) Develop, and implement fully, the process-based approach within the management system and continually improve its processes.	• Complete an assessment of the QMS's maturity, using ISO 9004:2009 as a reference. • Complete an impact analysis of the requirements of ISO 9001:2015 for the QMS. • Design and deliver training on the QMS and its tools as part of the Departmental training programme.	December 2017 December 2017 December 2017
	Objective 3.) Improve the management of knowledge and encourage knowledge retention.	• Provide and maintain active and approved document repositories for the Department on the SG LAN and, as determined, in ISE.	December 2017

		• Facilitate the process to identify the knowledge resources that are at risk and must be retained, recommend methods for transferring the knowledge and support the implementation as necessary to maintain these resources in the Department.	December 2017
	Objective 4.) Enhance financial transparency and accountability for safeguards implementation through the continued development of the cost calculation methodology.	--	--
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.**		
	Objective 1.) Contribute to the long-term attainment of ensuring the ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards. (In support of Capability 1)	• Organize a focus group meeting to verify the relevance and accuracy of each annual training programme.	November 2016 & November 2017
	Objective 2.) Contribute to the long-term attainment of ensuring the ability to detect undeclared nuclear material and activities. (In support of Capability 2)	• In conjunction with Project SGIM-003, develop and implement a new analytic training course for procurement. • Organize a focus group meeting to verify the application and relevance of analytical techniques.	March 2017 December 2017
	Objective 3.) Develop training to reflect the approaches and equipment for safeguarding new facility types, including consulting with States developing such facilities to help assess what training is required. (In support of Milestone 3.3)	• Complement the existing training programme with a course on pyro-processing in the Republic of Korea.	December 2016
	Objective 4.) Contribute to the long-term attainment of ensuring the ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s).	• Organize courses at locations offered by Member States Support Programmes covering the full set of technical and integrated content in the IAEA Training Programmes for 2016 and 2017. • Develop and conduct a course on writing skills for safeguards.	December 2017 June 2017

	(In support of Capability 13)	• Develop and conduct a comprehensive training programme for radiation protection and industrial safety. • Manage the safeguards training programme through the LMS deployed within AIPS Plateau 3.	June 2017 June 2017
	Objective 5.) Develop training tools using advanced methods such as virtual reality, immersive learning systems and web-based training: • Develop prototype virtual reality systems, test and evaluate performance • Include immersive learning for all types of fuel cycle facilities • Develop web-based tools for specific safeguards equipment • Develop signal (neutron/gamma) simulators to generate responses from equipment during training (In support of Milestone 13.1)	• Complete the publication of nuclear fuel cycle training manuals. • Evaluate the effectiveness of immersive training for pressurized heavy water reactors and determine how the approach could be extended to fuel fabrication plants.	June 2016 December 2016
	Objective 6.) Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility. (In support of Milestone 13.2)	• Develop and implement a training programme to support SSACs in developing their capabilities for collecting safeguards relevant information within the country and for conducting domestic inspections.	December 2017
SGIM-002 Geospatial Information Analysis	**Continuously improve the IAEA's ability to acquire, analyse, and exploit satellite imagery and geospatial information to support verification activities.**		
	Objective 1.) Evaluate and develop analytical methodologies, tools, and techniques for 'all source analysis' to detect signatures of undeclared activity, improve analysis of nuclear fuel cycles and support the State evaluation process. (In support of Milestones 2.3 and 2.4)	• Evaluate and test new sensors, imaging capabilities, tools and techniques to enhance the analytical process and provide analysts with more and different information to support operational requirements.	July 2016
	Objective 2.) Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a Safeguards agreement and declarations under an additional protocol, and an	• Successfully enable the consumption of information from other relevant applications (e.g., Additional Protocol Reporter and SGMD) exposing geospatial information to other applications in ISE to support collaborative analysis (e.g., State File, Collaborative Analysis Platform) in collaboration with SGIS-003.	March 2016

	electronic State file containing all safeguards-relevant information about each State. (In support of Milestone 8.1)	• Complete planned upgrades to the GES.	December 2016
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 support of in-field verification activities.**		
	Objective 1.) Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations. (In support of Milestone 2.1)	• Continuously improve integrated, all source reporting through Member State assistance / consulting, peer reviews, employment of highly qualified staff and training. • Improve the management system to anchor quality and generate better quantitative data on general open source contributions to the Department of Safeguards.	Ongoing December 2016
	Objective 2.) Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization. (In support of Milestone 2.3)	• Select and implement methodologies that help analysis of large, disparate data sets through link analysis and visualization (tailored to SGIM needs, contributing towards collaborative analysis in the Department and aligned with MOSAIC (See SGIS-003)) • In conjunction with SGCP-102, implement a new analytic training course for trade and procurement information.	July 2016 March 2017
	Objective 3.) Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions. (In support of Milestone 2.4)	• Complete planned enhancements to the Rapid News Service tool to monitor news and streamline information management processes.	July 2017
	Objective 4.) Identify and obtain specialized support and expertise on specific topics as Departmental needs arise.	--	--

SGIM-007 Evaluation of Data from Environmental Sampling and Material Characterisation	**Enhance the IAEA's ability to structure, organize, 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.**		
	Objective 1.) Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools. (In support of Milestone 2.2)	• Obtain the collection of uranium impurity data and fuel burnup inventories from studies completed by Member States for integration into existing SGIM-IFC evaluation libraries.	December 2016
	Objective 2.) Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results. (In support of Milestone 2.5)	• Complete and deploy the prototype DAVE[3] software for evaluation of trace element and isotopic signatures in uranium samples.	December 2016
SGIM-008 Statistical Analysis	**Review, enhance and develop statistical verification and evaluation methodologies and tools to optimize verification implementation plans and information analysis.**		
	Objective 1.) Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results. (In support of Milestone 2.5)	• Review and harmonize current random inspection schemes (including short notice random inspections (SNRIs)) and develop methodologies to evaluate their effectiveness. Publish the results, including procedures for their practical implementation, in a technical document. (See also SGCP-003)	December 2016
		• Review, update and consolidate the algorithms for the determination of measurement error uncertainties from operator-inspector paired-data, 3-laboratory data, and calibration data. Publish the methodology in a set of technical documents and upgrade the software application for its implementation.	December 2016
		• Review, update and consolidate the methodologies applied to the evaluation of MUF, D, IMUF, and SRD in the context of material balance evaluation. Publish the methodologies in a technical document and implement the relevant analytical software.	July 2017

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

		• Develop standardized methodologies for calculating detection probabilities achieved through verification activities on facility and State levels. Publish the methodologies in a technical document.	December 2017
		• Further develop and implement data visualization software for nuclear material flow analysis, and develop additional capabilities to the software to represent acquisition path analysis results, verification requirements and achieved verification results, using structured nuclear material accountancy and verification data. (See also SGIS-003)	July 2016 (initial production development) July 2017 (additional enhancement)
		• Develop a harmonized NRTA system in line with the requirements for the overall Rokkasho Reprocessing Plant (RRP) and J-MOX projects.	Target for RRP: December 2016
		• Develop Bayesian approaches making use of historical verification data in the evaluation of safeguards information, and publish guidance in a technical document.	December 2017
		• Demonstrate feasibility of intelligent systems for analyzing non-quantitative data, eliciting analyst conclusions, and aggregating analyst conclusions across multiple disparate data sources in order to assist analysts in articulating the level of confidence in their assessments. Publish study results and recommendations in a technical document. (See also SGIS-003)	December 2017
		• Investigate accountancy and measurement requirements and gather experience with factors affecting material balance evaluation at pyro-processing facilities. (See also SGCP-003)	December 2017
SGIM-009 State Declared Information Management	**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.**		
	Objective 1.) Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations. (In support of Milestone 2.1)	• Make available all State declared data, the associated authority data and related analytical assessments (including AP information and GIS data) on one common platform for analysts.	December 2017

	Objective 2.) Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions. (In support of Milestone 2.4)	• Develop a methodology and tool that utilizes deterministic and heuristic methods for identifying safeguards relevant issues within a large stream of diverse but related information.	December 2017
	Objective 3.) Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State. (In support of Milestone 8.1)	• Enable reliable, electronic availability of data items contained in verbose documents such as subsidiary arrangements and facility attachments.	December 2017
	Objective 4.) Create links between exemptions and terminations of nuclear material with the nuclear material accounting database to allow automatic checking of State reporting. (In support of Milestone 8.2)	--	--
	Objective 5.) Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file. (In support of Milestone 9.1)	• Deploy the updated software packages PR (Protocol Reporter) software for Additional Protocol declarations and QCVS (Quality Control Verification Software) for nuclear material accountancy reports to SRAs. • Develop and implement a framework to enable States to provide digital, GIS-ready site maps attached to additional protocol declarations under Article 2.a.(iii) declarations in close collaboration with SGIM-002.	December 2017 December 2017
	Objective 6.) Deploy secure and authenticated communications between the IAEA and SRAs. (In support of Milestone 9.2)	• Develop and implement a means of secure, electronic two-way communication (as a web-based portal) between the IAEA and the relevant State Authorities.	December 2017
	Objective 7.) Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility. (In support of Milestone 13.2)	• Increase the quality and availability of training material and tools for SRAs in the context of State declared information provision, including for remote training delivery.	December 2017

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.		
	Objective 1.) Implement a set of solutions to automate and improve the 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 Milestone 8.1)	• Develop baselines of information system activities in the Department's secure computing environments in order to then build detection capabilities for anomalous behaviours which could indicate compromise or misuse. • Create a "big data" platform for the long-term storage and subsequent reporting to improve security measurements, correlations, incident review, and threat intelligence capabilities in the Department's secure network.	March 2017 December 2017
	Objective 2.) Obtain independent assessments of specific solutions for risk and vulnerabilities as well as to supplement internal capacity to perform comprehensive or targeted penetration tests in efforts to improve the Department's security configurations and system designs.	• Perform vulnerability assessments and penetration tests in order to identify potential issues with system configurations, to design solutions, and to verify security controls. • Assess the maturity level of the Secure Software Development Lifecycle in place within the Department and provide an improvement guide based on risk.	Ongoing March 2016
	Objective 3.) 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.	• Provide internal misuse training for Departmental IT security staff. • Train 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. • Conduct a training course on utilizing encryption and other cryptographic techniques in services-oriented application development projects.	December 2016 2016-2017 May 2016
	Objective 4.) Add endpoint and server security protection capabilities of the Department's IT infrastructure with additional security functions through the use of virtualized computing technologies and sandboxing techniques. (In support of Milestone 8.1)	• Investigate the use of automated dynamic analysis of email and web content to detect suspicious network traffic, file modifications, or configuration changes within the Department's in-house email system. • Identify and implement a solution to mitigate threats from the use of web browsing on the Department's computers through the use of non-persistent, virtualized computing resources. • Create secured, thin-client access to the Department's networking resources based on virtualized desktop computing technology.	September 2016 April 2017 December 2017
	Objective 5.) Deploy secure and authenticated communications between inspectors in the field	--	--

	and IAEA headquarters/regional offices. (In support of Milestone 9.3)		
	Objective 6.) Ensure the Department's ability to recover from an IT failure. (In support of Milestone 9.4)	• Design, implement and test IT infrastructure to ensure the operational continuity of core IT services to the Department of Safeguards. Build in redundancy and high availability features which reduce or eliminate interruptions to Safeguards staff in the event of major interruptions to the primary Safeguards data centre.	May 2017
	Objective 7.) Support 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 Milestone 8.1)	--	--
SGIS-003 Safeguards 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.**		
	Objective 1.) Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations. (In support of Milestone 2.1)	• Provide a generic solution for the assembly and processing of electronic verification packages with electronic content of all associated evidence used for the evaluation of in-field verification activities. • Develop new capabilities in support of the State Evaluations process. • Integrate and enable visualization of safeguards information with geographical data in a user friendly manner.	December 2016 December 2017 December 2016
	Objective 2.) Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization. (In support of Milestone 2.3)	• In a common/collaborative platform, integrate all safeguards relevant data such as state declarations, collection of open source information, results of verification activities and other available sources of Safeguards (SG) relevant data. • Extend the collaborative analytical platform to support structured analysis of all safeguards relevant data against the Physical Model. • Support analysis of acquisition/diversion path analysis for the development of State Level Approaches. • Develop enhanced analytical capabilities for the integration of nuclear fuel cycle tools with the analysis of open source and acquisition path analysis.	July 2017 December 2017 December 2017 December 2017
	Objective 3.) Develop a fully integrated, secure	• Enhance the usability of the State File with an integrated view of all information	December 2017

	safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State. (In support of Milestone 8.1)	related to a State, including documents and information residing in other systems.	
		• Integrate the Complementary Access data (CA) with other inspection verification activities where the collected information can be processed, analysed, compared, and evaluated.	December 2017
		• Provide support for the management of technical objectives and applicable safeguards measures.	December 2017
	Objective 4.) Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file. (In support of Milestone 9.1)	• Increase the efficiency of the declared data processing and analysis process.	July 2016
		• Integrate all Safeguards State declarations in ISE to ensure completeness and correctness of the information.	December 2016
		• Improve communications and the electronic exchange of State-supplied data between HQ and Member States.	December 2017
		• Improve the capability to evaluate verification activities and prepare the Safeguards Implementation Report (SIR) and the Data Evaluation Report (DER).	June 2016
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).**		
	Objective 1.) Deploy equipment at facilities to meet safeguards requirements. (In support of Capability 5)	• Develop a safeguards approach for J-MOX, based on the basic elements agreed with Japan, and start the preparation of procedures for implementation.	Date Unconfirmed
		• Design, test and install safeguards equipment (NDA, C/S) that provide high quality, independent and reliable results.	Date Unconfirmed
		• Design, test and implement an integrated data collection and evaluation software for J-MOX, using synergies with the RRP Information System.	Date Unconfirmed
		• Establish and implement DIE/DIV procedures that assure that the facility is constructed and will operate as declared, while ensuring that the safeguards approach remains adequate and robust. Carry out DIE/DIV activities from construction to MOX commissioning phases.	Date Unconfirmed
SGOA-003 Fukushima Dai-ichi Safeguards	**Maintain adequate safeguards for the inaccessible nuclear materials and facilities at the Fukushima Dai-ichi nuclear site.**		
	Objective 1.) Identify and obtain specialized support and expertise on monitoring systems capable of providing credible assurance that nuclear material is not removed from the damaged facilities.	• Design, develop and deploy reliable and effective monitoring systems using surveillance devices, radiation detectors or other methods.	December 2017

	(See also SGIM-002)		
	Objective 2.) Identify and obtain specialized support and expertise on technical options for in-situ verification of currently inaccessible material. (See also SGIM-002)	• Design and develop 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 2016
	Objective 3.) Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of data in order to assist in drawing soundly based safeguards conclusions. (See also SGIM-002) (in support of Milestone 2.4)	• Develop integrated review software tools to analyse data from the radiation monitoring system and the surveillance equipment at Fukushima Dai-ichi site.	July 2017
SGVI-001 JCPOA Implementation	**Develop and implement effective and efficient verification and monitoring of Iran's nuclear-related commitments under the JCPOA.**		
	Objective 1.) Develop options and approaches for possible future mandates as required or requested that respect sensitive and proprietary information. (In support of Milestone 11.1)	• Identify areas in which MSSPs could assist in the implementation of the JCPOA.	December 2016
SGOC-001 Chernobyl	**Develop and implement effective and efficient safeguards systems at the Chernobyl site.**		
	Objective 1.) Finalize the update of the State-level safeguards approach (SLA) for Ukraine.	• Update the state level approach for Ukraine covering: Spent fuel 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.	 June 2016 June 2016 June 2016 June 2016 June 2016
	Objective 2.) Complete the installation and authorization of safeguards equipment for verification use.	• Complete installation and authorization for safeguards equipment for verification use for IFS-2. • Complete installation and authorization for safeguards equipment for verification use for NSC.	August 2016 Early 2017

	Objective 3.) Install hardware and software for data collection, on-site review, remote transmission to the IAEA and analysis.	--	--
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.**		
	Objective 1.) Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations. (In support of Milestone 2.6)	• In accordance with the safeguards equipment authorization guidance document, select, evaluate, customize and authorize a hand-held Raman spectrometry-based chemical compounds identification device.	December 2016
	Objective 2.) Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools. (In support of Milestone 2.2)	• Develop a prioritized list of NFC indicator and signature materials to be contributed by Member States. • Create repositories of basic NFC indicator and signature materials and create or adapt the relevant infrastructure for carrying out experimental tests with such materials. Comprehensively characterize collected materials. • Begin experimental tests of instrumentation using the created repository of dual-use materials and testing infrastructure. • Perform feasibility studies and a pilot deployment of in-field alpha spectrometers for nuclear material identification and isotopic composition analysis; establish the necessary procedures for application of the methodology within the Department of Safeguards.	March 2016 June 2017 December 2017 December 2017
	Objective 3.) Develop improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition. (In support of Milestone 5.6)	• Develop a methodology for, and perform the evaluation of, the Compact Gamma Tomography System which was procured in 2015, with the goal of authorizing the system for inspection use.	December 2016
	Objective 4.) 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. (In support of Milestone 5.7)	• Improve PGET by shortening the acquisition time from hours to a few minutes and by adding the capability to detect neutrons; perform tests of PGET with a range of different fuel types; develop operating procedures for PGET; pursue authorization of PGET for application in attended mode.	December 2017

	Objective 5.) 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. (In support of Milestone 5.8)	• Re-design the data acquisition system of the FNCL to improve usability; successfully complete performance evaluation and pursue authorization of the instrument.	October 2016
	Objective 6.) Implement an improved cost/benefit assessment methodology for the design and operation of safeguards equipment. (In support of Milestone 6.1)	• 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. • Procure the services required for re-design of software applications in such a way as to enable in-house maintenance and support.	December 2017 December 2017
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.**		
	Objective 1.) Modernize and sustain sealing systems used in safeguards and increase their tamper resistance.	• Develop and deploy the Active Optical Loop Seal (AOLS). • Field test the glass seal (GLAS). • Develop and deploy the AOLS / EOSS Reader. • Develop and deploy the GLAS reader.	December 2017 June 2016 December 2016 December 2016
	Objective 2.) Develop and maintain sealing systems for facility specific applications.	• Create a version of Ultrasonic Optical Sealing Bolt (UOSB) for more effectively implementing joint-use arrangements. • Determine whether technical challenges can be overcome to improve the usability of the UOSB Handheld Reader.	December 2017 December 2017
	Objective 3.) Improve and expand techniques, tools and procedures for containment verification.	• Initiate an MSSP task to examine the effectiveness of visual inspections of casks in cases where CoK is lost.	December 2017
	Objective 4.) Research, develop, and implement new and novel technologies that can be applied for secure sealing and containment verification systems.	• Identify and develop solutions for: Tampering Indicating Covers (TIC1); Tampering Indications of Cables (TIC2); and Tamper Indication of Cabinets (TIC3).	 December 2016 December 2017 December 2017
	Objective 5.) Expand and improve capabilities to identify and mitigate the vulnerabilities of	• Establish an assessment centre for safeguards instruments and their use based on	December 2017

	safeguards equipment and data derived from equipment.	attacking and defending security teams.	
	Objective 6.) Act as focal point to increase data security of safeguards equipment.	--	--
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.**		
	Objective 1.) Ability to deploy equipment at facilities to meet safeguards requirements. (In support of Capability 5)	• In collaboration with Project SGTS-014, complete the Phase 1 development of new surveillance review software, providing a working prototype for benchmark testing.	December 2016
	Objective 2.) Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation). (In support of Milestone 5.1)	• Enhance the existing 3DLR laser scanner-based Design Information Verification (DIV) tool to be applicable for routine containment verification tasks.	August 2017
	Objective 3.) Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities. (In support of Milestone 5.3)	• Assess the applicability of the L2IS Laser Item Identification System in new enrichment plants.	July 2017
	Objective 4.) Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements. (In support of Milestone 7.2)	• Complete the evaluation and vulnerability assessment of the DCM-A1, Next Generation analogue camera recording module.	December 2016
SGTS-008 Instrumentation Technology Foresight	**Identify, adapt and deploy emerging technical advances in other scientific fields and optimize them for use in safeguards.**		
	Objective 1.) Develop and implement a technology foresight horizon scanning process for external, potentially relevant research and development (R&D) fields. (In support of Milestone 12.2)	• Establish partnerships with new external stakeholders, 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.	December 2017

	Objective 2.) Implement solutions for gaps identified in technologies currently in use for safeguards and laboratory activities.	• Evaluate and customize commercial in-situ analysis capabilities. Report on results to stakeholders. • Identify and deploy a gamma imaging solution addressing at least one specific safeguards scenario. • Implement an autonomous navigation and positioning system, included in the standard instrumentation kit used by inspectors for CA and DIV, along with the processing software used to structure and streamline the instrument data workflow. • Upgrade the Complementary Access kit with up-to-date technologies; make it modular and compact.	December 2016 June 2017 December 2017 December 2016
	Objective 3.) Evaluate identified technologies for possible safeguard applications.	• Conduct a technology demonstration workshop on robotics. • Issue and distribute a quarterly Technology Preliminary Evaluation Report.	December 2016 Ongoing
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.**		
	Objective 1.) Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation). (In support of Milestone 5.1)	• Improve, evaluate and test upgraded solution monitoring software.	December 2017
	Objective 2.) Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities. In support of Milestone 5.2)	• Complete the viability study of the UCVS at an enrichment facility.	June 2016
	Objective 3.) Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities. (In support of Milestone 5.3)	• Deploy the OLEM at an enrichment facility upon Operation request.	December 2016
	Objective 4.) Develop appropriate safeguards equipment to establish and maintain knowledge of	• Develop further the MUD2 capabilities to accommodate different types of sensors and detectors.	December 2016

	spent fuel in shielding/storage/transport containers at all points in their life cycle. (In support of Milestone 5.4)	• Complete the upgrade of VIFM systems with new ADM2 data acquisition modules. • Complete the upgrade of all other UMS systems.	December 2017 December 2017
	Objective 5.) 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. (In support of Milestone 5.7)	• Complete evaluation of gamma-ray emission tomography methodology for unattended use in verification of fuel assembly integrity. This might include Phase II of the Unattended Gamma-ray Emission Tomography (UGET) project, if approved.	December 2017
	Objective 6.) Increase the proportion of deployed unattended systems that are sustainable, standardized, and modular, with increased use of COTS products. (In support of Capability 6)	• Complete the upgrade of UMS systems with up-to-date and standardized COTS components including data acquisition modules, computers, and power management modules. • Complete the upgrade of VIFM systems with new ADM2 data acquisition modules.	December 2017 December 2017
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.**		
	Objective 1.) In collaboration with EURATOM, develop and implement an all-in-one review program.	• Complete and deploy a version of iRAP that includes surveillance, seals, operator declaration integration, and reporting tools.	December 2016
	Objective 2.) Assist with preparations to safeguard new large facilities by building new NRT components to support remote monitoring.	--	--
	Objective 3.) Expand and maintain the global RM network while ensuring data security.	--	--
	Objective 4.) Improve the efficiency of facility inspections by introducing iOS-based apps, initially to monitor RM system status.	• Launch a prototype iOS-based (or similar) inspector tool for field use to assist with common tasks.	July 2017

SGTS-015 Technologies for Possible New IAEA Verification Tasks	Make ready for implementation instruments and measurement techniques and tools needed to support new IAEA verification mandates.		
	Objective 1.) Develop options and approaches for possible future mandates as required or requested (e.g. fissile material cut off treaty, arms control) that respect sensitive and proprietary information.	--	--

Projects

SGAS-001

Destructive Analysis of Nuclear Materials

Project Manager: Steven Balsley

Division: SGAS

1. Overview

This document describes the plans for developing and implementing new or strengthened processes supporting laboratory[4] practices in the Analytical Services Division (SGAS) related to the destructive analysis of nuclear material samples within the Department of Safeguards for the period 2016-2017.

During the 2016-2017 biennium, Project SGAS-001 will pursue the following Long-Term Direction:

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 project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
10. Ability to provide analytical services through the NWAL to support verification requirements.	10.1 Utilize the expanded NWAL, in order to: • Provide external quality control and reference material • Provide technical expertise	H
	10.3 Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples.	H

SGAS-001 aims to develop new or improved analytical capabilities in the area of nuclear material analysis. Technologies that improve analytical precision, decrease sample size (and therefore waste), offer new modes of sample treatment, and improve the stability of working standards are within the scope of the project.

For the 2016-2017 biennium the project's top priorities are:

- Develop a new UF_6 sample collection method using alumina, which will reduce sample size and circumvent potential future restrictions on air transports of traditional UF_6 samples.
- Develop the COMPUCEA technique for UF_6 enrichment as a means of reducing analysis and reporting times for inspections at enrichment facilities, while maintaining near-laboratory DA levels of precision.
- Support development and training tasks at the OSL in Rokkasho, Japan in order to improve analytical capabilities. Examples include the design and production of a hot-cell scrubber for capturing radioactive off-gassing in a hot cell, and the development of new methods for measuring the Pu content from undissolved fines in high-active liquid waste samples.
- Develop new coating materials to facilitate longer storage times for in-house produced working standards, which will reduce labor effort and decrease the volume of expensive radioactive waste.

SGAS-001 is closely related to, and coordinated with, projects SGAS-003 *Analysis Support and NWAL Coordination* and SGIM-007 *Evaluation of Data from Environmental Sampling and Destructive Analysis*.

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

2. Background

Destructive analysis of nuclear material samples in a dedicated laboratory with fit-for-purpose instrumentation and quality-controlled methods, produces the most precise and accurate analytical results for safeguards evaluators and inspectors. The time required to transport nuclear material samples from the field to the lab, and the cost of running a radiological laboratory are the main disadvantages. This project addresses these issues by examining new technologies and methods that, among other things, hold the promise to improve timeliness and reduce radiological waste. For example, the possibility of 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 destructive analysis capability for a variety of different uranium materials. On-site DA technologies hold the promise of 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 (preparation and dissolution of sample), and the need for a higher level of containment and surveillance.

Safeguarding the Rokkasho Reprocessing Plant in Japan represents a significant challenge for the IAEA. The OSL at Rokkasho facilitates the fast treatment and direct reporting of analyses of samples from the plant. New technologies and methodologies specific to the OSL are an important emphasis of the project. Enhanced use of the hybrid k-edge densitometry systems at OSL, plutonium recovery from high-active liquid waste samples for making better inventory close-out estimates, and optimized MOX pellet dissolution and measurement are examples of research and development areas needed at the OSL to maintain and improve the high level of safeguards at Rokkasho.

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. Operator facilities and safeguards laboratories are encouraged to reduce the use of nuclear CRMs and rely more on working standards for routine quality control of their measurement systems. Working standards may be produced from well-characterized bulk material or well-characterized material held in a laboratory's archive. 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. Objectives and Key Achievement Targets

In order to support Project SGAS-001's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/ or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Utilize the expanded NWAL in order to (1) provide external quality control and reference material, and (2) provide technical expertise. **(In support of Milestone 10.1)** The IAEA will continue to leverage the competencies and resources of the NWAL to not only develop new certified reference materials (CRMs) for safeguards, but also to encourage the preservation of existing stocks of CRMs through more enhanced use of working standards, and new approaches for extending the shelf life of such working standards.	
Host a Technical Meeting organized by Member State Support Programmes, aimed at issuing a practical set of guidelines for the production of working standards production for the NML and other laboratories with safeguards roles, such as facility operators, NWAL and state-level authority labs.	June 2016
Develop new coating materials to facilitate longer storage times for in-house produced working standards, which will reduce production effort and decrease the volume of expensive radioactive waste.	June 2017

Objective 2.) Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples. **(In support of Milestone 10.3)**	
Finalize a new COMPUCEA method for UF_6 enrichment. Once implemented, this new method will reduce analysis and reporting times for inspections at enrichment facilities, while maintaining near-laboratory DA levels of precision.	June 2016
Develop a new UF_6 sample collection method using alumina, which will reduce sample size and circumvent potential future restrictions on air transports of traditional UF_6 samples.	December 2017

4. Activities

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

Objective 1.) ***Utilise the expanded NWAL in order to (1) provide external quality control and reference material, and (2) provide technical expertise.*** **(In support of Milestone 10.1)**

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 in-house or working standards. Often these are issued from or produced from legacy materials that a facility has used for years but lacks the know-how required (e.g., homogeneity and stability testing) to meet the requirements of a certified reference material and/or traceability to a primary standard. A technical meeting that provides specific instructions and hands-on exercises on preparing working standards is needed to introduce a practical set of guidelines for laboratories such as the NML to follow. The technical meeting will primarily address the needs of laboratories directly or indirectly involved in the measurement of samples related to safeguards (there will be a forthcoming Task Proposal for a joint task to be supported by the US SP and EC SP).

Nuclear CRMs or working standards require special shelf life considerations. Not only does the material change compositionally as the radioactive constituents decay, but the physical properties of the material may also be altered to a point where the material is no longer useful. Radioactive decay is well understood and therefore the compositional change of a nuclear CRM or properly prepared working standard can be calculated as long as the starting properties are well known. In contrast, the physical properties of a nuclear CRM or working standard material subject to radiolysis cannot be easily accommodated. For example, plutonium radiolysis of solid U-Pu nitrate working standards will eventually cause the material to crack and flake, making it almost unusable because of the loss of material during processing. Likewise, the build-up of hydrogen and oxygen in sealed glass ampoules of solution-based U-Pu standards presents specific long-term storage risks. The IAEA wishes to meet these challenges through innovative technological means, including the potential use of new cellulose nitrate foams as a cap for U-Pu nitrate working standards. Early testing shows good results for keeping samples intact for many months, thus holding promise for extending the shelf life of precious working standards and perhaps also CRMs (EC A 1606).

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.

Objective 2.) ***Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples.*** **(In support of Milestone 10.3)**

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 IAEA is exploring new UF_6 sampling techniques, based on the ABACC Cristallini method, that would not only mitigate potential restrictions for the transport of conventional UF_6 safeguards samples, but would also greatly reduce the amount uranium processed by the NML (JNT ARG A1769 and BRZ A 1764). SGAS intends to participate in the intercomparison exercise organised by ABACC to qualify the Cristallini method for ASTM in 2016 or 2017, according to the schedule of ABACC.

In addition to exploring new methods for the collection of UF_6, SGAS-001 is exploring the application of its second generation COMPUCEA (Combined Procedure for Uranium Concentration and Enrichment Assay) systems to in-field UF_6 enrichment determination. The technique was developed in the Institute for Transuranium Elements (EC JRC, Karlsruhe) and since 2007, it has been in routine use by EURATOM during physical inventory verification campaigns at European fuel fabrication plants for determination of U elemental content and ^{235}U enrichment in uranium oxide pellets and powders. The adaptation of the chemical preparation steps for COMPUCEA determination of UF_6 enrichment is currently being studied by SGAS and SGTS staff in the NML (Internal Activity), and with the European Commission (EC A 2003). Successful implementation of this new COMPUCEA method holds promise for near-real time enrichment results with laboratory-like DA uncertainties in the field. (See Project SGTS-001 for additional details.)

The OSL in Rokkasho, Japan directly supports the DA requirements for safeguarding the Rokkasho Reprocessing Plant (RRP). 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 total plutonium content of the HALW samples is less than 1 g/L, and the majority of samples contain less than 0.02g/L plutonium in the liquid phase. Nevertheless, there are measureable quantities of plutonium associated with the undissolved fraction. Considering the high plutonium throughput of RRP, the IAEA has determined that measurement of the plutonium content in the undissolved fraction of the HALW samples is important. The easiest and most robust solution for precluding radiation alarms is to trap the volatile fission products before the exhaust monitors are triggered. The IAEA is exploring the development of a customized scrubber system (SP-1 14/NML-003) for fitting into the OSL hot cell, as well as novel approaches to measuring the Pu using the X-ray component of the HKED system together with a special stirrer system (JNT EC A 1832 and FRA A 1858).

Finally, development of DA techniques for samples taken from pyroprocessing facilities will become a focus for the NML within the biennium, and specific related development activities will be identified in accord with SGCP-003, Objective 6.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[5] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

[5] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
2	1	UF_6 COMPUCEA	UF_6 enrichment by COMPUCEA	June 2016

4.3 Attachments

Figure 1. Example of the variety of safeguards samples submitted to the Nuclear Material Laboratory

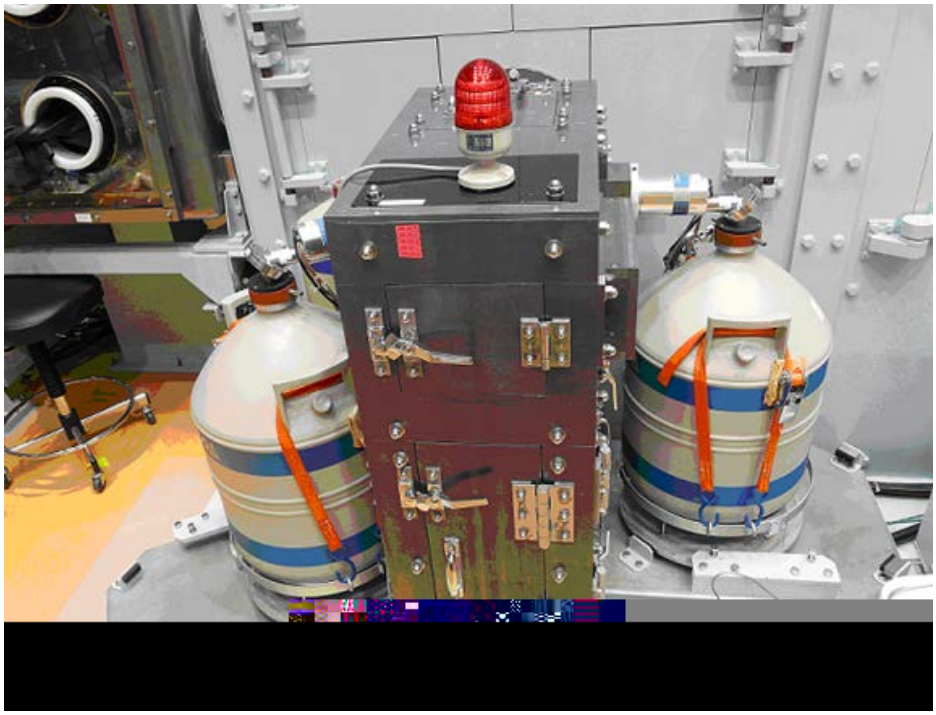

Figure 2. Hybrid k-edge densitometer at the On-Site Laboratory, Rokkasho, Japan

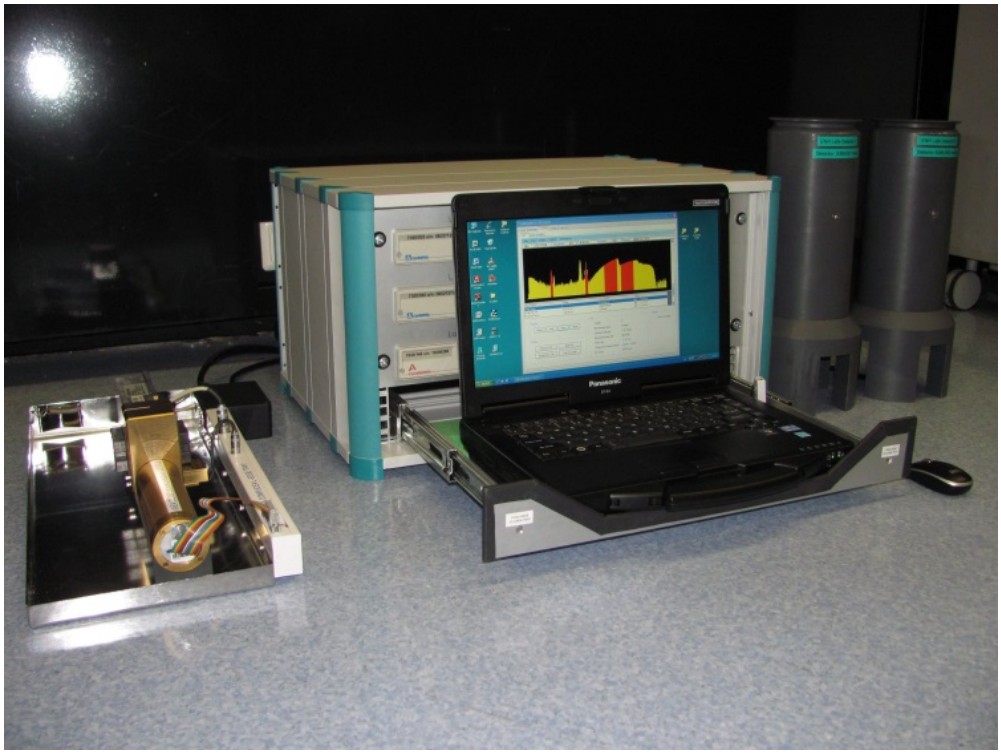

Figure 3. IAEA Generation 2 COMPUCEA system

SGAS-002

Environmental Sample Analysis Techniques

Project Manager: Stephan Vogt

Division: SGAS

1. Overview

This document describes the 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 2016–2017.

During the 2016-1017 biennium, Project SGAS-002 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
10. Ability to provide analytical services through the NWAL to support verification requirements.	10.1 Utilize the expanded NWAL, in order to: • Provide external quality control and reference material • Provide technical expertise	H
	10.2 Develop techniques, methods and equipment to detect signatures of nuclear activities in environmental samples.	H

SGAS-002 aims at strengthening the IAEA's competence with early detection of the possible misuse of nuclear material and/or technology, and by supporting the goal of strengthening the IAEA's analytical capabilities at the Safeguards Analytical Laboratories (SAL). The SGAS-002 project is closely related to and coordinated with projects SGAS-003 *Analysis Support and NWAL Coordination* and SGIM-007 *Evaluation of Data from Environmental Sampling and Destructive Analysis*.

For the 2016-2017 biennium, the project's top priorities are:

- Develop, implement and improve particle identification and isolation methods of single, nuclear material containing particles from environmental swipe samples for instrumental analysis.
- Validate and apply the Scanning Electron Microscope (SEM/FIB-ToF) instrumental analysis technique for the identification and characterization of individual micrometer-sized particles and other relevant artifacts collected on environmental swipe samples.
- Develop new and additional techniques for particle production, which will complement the current activities in the production of quality control (QC) materials for instrument calibration, method development and external quality control administered to the Network of Analytical Laboratories (NWAL).
- Produce and distribute new quality control swipes containing uranium (U), plutonium (Pu) and mixed U/Pu particles.

2. Background

The development of new and enhanced analytical methods for environmental samples is essential for the timely/early detection of undeclared nuclear material and activities. All aspects of environmental sample processing are affected by the development of improved sampling equipment and procedures, more sensitive screening methods, more accurate bulk and particle analysis methods, improved data evaluation methods (including uncertainty estimation), and quality control materials to check the performance of analytical laboratories. The main objective is to provide information to the Department for drawing conclusions about the absence of undeclared nuclear material and activities.

The improvement of analytical methods and techniques for the analysis of environmental samples will bring high quality information to benefit the drawing of safeguards conclusions, in particular about the absence and presence of undeclared nuclear materials and activities. Detection of uranium or plutonium, either in the whole sample ("bulk analysis"), or in the form of micrometer-sized particles, allows for early detection of materials, such as highly-enriched uranium (HEU), or activities such as separation of plutonium, which might be indicators of an undeclared nuclear activity. Enhanced identification methods for location of particles of interest and, in general, lower detection limits for elements of interest such as uranium, plutonium or fission and activation products, will render earlier and more reliable detection of undeclared material and activities including possible sources and sample histories.

Challenges to be addressed include: to find and measure, 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), lower detection limits for Pu in swipe samples to below femtogram, to improve 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 to develop and produce 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 addition, new analytical techniques are being developed all the time 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 and Electron Microscopy.

The structuring of this project is based on identifying needs by discussion with the safeguards data evaluators, inspectors and outside experts. From such discussions, priorities for new developments in forensic analysis methods or improvements in existing techniques are derived, along with the associated measures of performance that must be met. This information is then turned into task proposals by Member State Support Programmes or assigned to IAEA staff as part of their duties funded under the regular budget. New instrumentation is procured from regular or extra-budgetary sources and laboratory facilities to house them are provided. Training of IAEA staff is also carried out in order to continuously improve the quality of measurements at SAL. All developments carried out at SAL through the MSSP or regular budget are communicated and transferred to the NWAL for the benefit of the entire environmental sampling implementation.

3. Objectives and Key Achievement Targets

In order to support Project SGAS-002's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Utilize the expanded NWAL in order to (1) provide external quality control and reference material, and (2) provide technical expertise. **(In support of Milestone 10.1)** The IAEA will continue to make use of the competences and resources of the NWAL and associated laboratories to develop new reference (RM) and quality control (QC) materials for safeguards particle analytical investigations, and certified reference materials (CRM) for instrumental calibrations and method validations.	

Host a working group aimed at discussing a focused effort on provision of particle materials and prioritizing production of such.	December 2016
Produce additional reference and quality control materials to carry out a sound external quality control programme administered to the NWAL.	December 2017
Objective 2.) Develop techniques, methods and equipment to detect signatures of nuclear activities in environmental samples. **(In support of Milestone 10.2)**	
Validate the newly installed Scanning Electron Microscope/Focused Ion Beam – Time-of-Flight Mass Spectrometer (SEM/FIB-ToF) instrument for imaging (BSE, SE) and elemental mapping (EDX, ToF-SIMS) of micrometer-sized particles and other artifacts of safeguards relevance.	June 2016
Develop the laser ablation (LA) sampling technique in combination with inductively coupled plasma mass spectrometry (ICP-MS) to analyze plutonium and mixed uranium/plutonium particles complementing the existing capability of isotopic characterization of uranium containing particles using LG-SIMS.	December 2016
Develop the μ-Raman technique to characterize micrometer-sized particles containing nuclear materials and other safeguards relevant micro-artifacts.	June 2017
Develop new and improve existing identification methods to more reliably find small particles in an excess background of material.	December 2017

4. Activities

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

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.

Objective 1.) ***Utilize the expanded NWAL in order to (1) provide external quality control and reference material, and (2) provide technical expertise.*** **(In support of Milestone 10.1)**

Development and production of quality control materials to improve the reliability of analytical data reported by SGAS-ESL and the NWAL is the key objective of the activities under this objective.

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

Task GER A 1961 "Production of Particle Reference Materials (C.45)" involves the testing of a Vibrating Orifice Aerosol Generator for more precise control of the particle size and composition. Significant progress has been made over the past two years. The recent technical achievements reported by Forschungszentrum Juelich (FZJ) in Germany on the production of mono-disperse uranium particles are extremely promising. The suitability of produced particles for use in quality assurance purposes was demonstrated. The mono-disperse particles will be used mainly for instrument calibration and method validation, but also for QC material production. First production batches of micrometer-sized uranium particles are anticipated for 2016.

Task EC A 1966 "Production of Particle Reference Materials" supports preparation of feed solutions from bulk 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 Institute for Reference Materials and Measurement (IRMM) in Geel, Belgium. Feed solutions from CRMs IRMM-021 and IRMM-023 are in preparation and will be delivered to the FZ-Juelich in early 2016.

It was recommended at the recent Technical Meeting on ES Particle Analysis from 10-13 November 2015 in Vienna, that the IAEA establish a working group on particle QC production to review requirements, identify specifications, set priorities, and advice on appropriate solutions to produce the particle QC materials. The working group will consist of national subject matter experts from various Member States and a first meeting is envisioned for 2016. While the IAEA intends to lead the preparation of QC samples for ES particle analysis for provision to the NWAL, using as input particle materials produced by outside laboratoriesm, 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.

Objective 2.) ***Develop techniques, methods and equipment to detect signatures of nuclear activities in environmental samples.*** **(In support of Milestone 10.2)**

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

The ESL has or is about to implement a number of 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) has been 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. At the recent Technical Meeting on ES particle analysis in Vienna, the Russian LMA NWAL introduced its new Electron Microscope (TESCAN Lyra 3). This system has a similar configuration as the IAEA's SGAS-ESL's instrument; a collaborative effort in developing its safeguards applications has been discussed. A focused approach to develop procedures for this state-of-the-art instrumentation has also been discussed and an SP-1 is under consideration.

The large-geometry secondary ion mass spectrometer (LG-SIMS) has been in continuous operation for the past years 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 analyze for safeguards relevant nuclides such as ^{233}U, ^{232}Th, and Li isotopic abundance of Particles of Interest (POI).

Sensitive methods of radiometric screening of samples using gamma and X-ray fluorescence spectrometry have been implemented, thus giving rapid and sensitive information in a non-destructive way before samples are submitted for detailed analysis at SAL or the NWAL. The key 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 Institute for Reference Materials and Measurement (IRMM) 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 Comissariat à l'Energie Atomique et aux Energies Alternatives (CEA) in the highly sensitive measurement of U and Pu by ICP-MS.

Task USA A 1081 "Support to SAL" will continue to be used in 2016-2017 to train new IAEA staff from the ESL in techniques appropriate to clean-room laboratories and for the selective and efficient separation of U, Pu, and Am from environmental samples.

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

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

studied for its efficiency and effectiveness at the ESL. A more homogeneous distribution of particles on the substrates surface was evident, but the instruments additional cabling requirements make it difficult to use under cleanroom conditions working in glove bags. It has been concluded that the system may be valuable for multiple substrate preparations such as for QC material production, but it is not applicable for routine field sample preparation. The high cost for the instrument's sampling head, which needs to be discarded after each preparation, renders this approach prohibitive.

Several highly sophisticated mass spectrometric instruments acquired and placed into operation over the past several years will require a timely replacement to prevent the IAEA from losing the capability of analyzing samples internally. Most prominently, the LG-SIMS instrument purchased in 2009 and with a replacement value of approximately 5 million euros, will require near-term attention. The LG-SIMS instrument currently analyzes about 20% of the annual sample volume, or about 100 samples each year. At this level, the instrument is operating at its maximum capacity, running 24/7 for about 11 months per year, with one month set aside for preventive and corrective maintenance. A typical life expectancy is around 10-12 years, after which the instrument may require major refurbishment or replacement. Refurbishment will take the instrument offline for analytical services for 6-12 months (not including procurement and scheduling), before resuming operations at a cost of a 1-2 million euros. Replacement of the existing instrument will require several years lead time, to acquire the necessary funds, complete the procurement process, build the instrument at the manufacturer (about 1-2 years, depending on demand), and complete delivery, installation and bringing the new instrument online. The total estimated time is about 3-6 years, depending on the availability of funding. This requires special attention from the Department of Safeguards so as not to lose core analytical capabilities. Similarly, the Thermal Ionization (TIMS) and Inductively-Coupled-Plasma Mass Spectrometers (ICP-MS), at replacement costs of between 0.7 and 1.5 million euros, need to be considered. Two of the TIMS instruments used for the high accuracy and precision measurements of nuclear material samples (mass spectrometry resides administratively in the ESL) have been in operation for 3-8 years, with a life expectancy of 10-12 years.

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. To differentiate POI's 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, for example, collodion. 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. Development of μ-Raman investigations of POIs will also be tested in the ESL during the 2016-2017 biennium.
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 be used to develop conditions for optimum irradiation of the samples and task FRA A 2002 to develop methods of identifying and manipulating POIs prior to instrumental measurement. Assistance will also be provided in developing the μ-Raman technique at the ESL.

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 (milligrams) but it is challenging to apply such methods to individual particles (picogram to nanogram amounts). The age-dating of Pu particles using Am-241 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. Presently, activities are focused on the improvement of the accuracy and precision of Pu age dating and viable schemes for U particle measurements.

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

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 is under validation in the low-level wing of the new Nuclear Material Laboratory. 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 Nuclear Material Laboratory. Laser ablation ICP-MS will be tested in the low-level wing of the new Nuclear Material Laboratory for its sensitivity and ability to provide unique information about particles in a sample including both nuclear (U, Pu) and non-nuclear particles. Improved screening of environmental samples will be accomplished with re-designed X-ray fluorescence instruments. The existing "TRIPOD" system is currently undergoing an upgrade (stronger excitation source and new generation of SDD detectors) and a new "PI" system to build redundancy is anticipated to be completed in 2016.

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 their SIMS experts.

A femtosecond Laser Ablation (LA) system for the analysis of individual particles using the MC-ICP-MS instrument has been installed and tested in the ESL. It will be used in combination with ICP-MS instrumentation in the low-level laboratories of the new NML for the analysis of mixed U/Pu and Pu containing particles. This technique will complement the isotopic characterization of uranium containing particles using the LG-SIMS instrument.

A Laser Micro-Dissection (LMD) and a Fission-Track Microscope system have been procured for the identification and localization of micrometer-sized particles prior to their analysis using mass spectrometric techniques and/or SEM investigations.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[6] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	Production of QC materials	Produce new QC swipes for particle analytical techniques	Ongoing (Target 1 new set per annum)
2	2	Development of the μ-Raman technique	Bring the new μ-Raman instrument into operation and test for characterization of uranium containing particles	December 2017

[6] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

4.3 **Attachments**

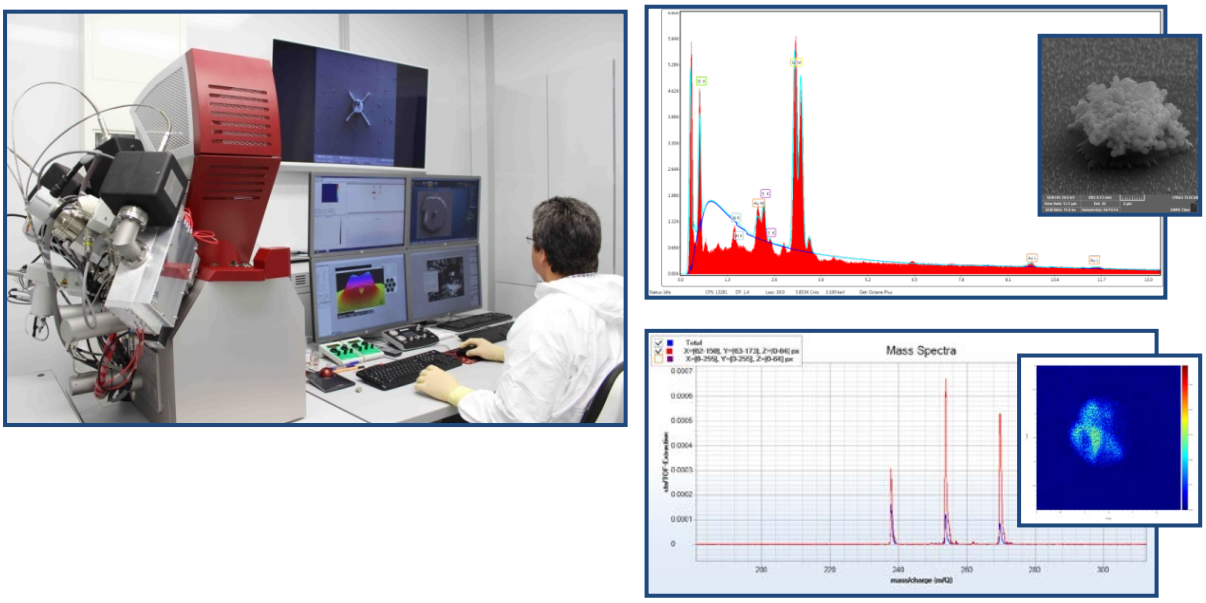

Figure 1. TESCAN Lyra 3 Scanning Electron Microscope/Focused Ion Beam – Time-of-Flight Secondary Ion Mass Spectrometer (SE image and EDX Spectrum of an uranium oxide particle; laterally resolved ion image and mass spectrum of uranium oxide particle)

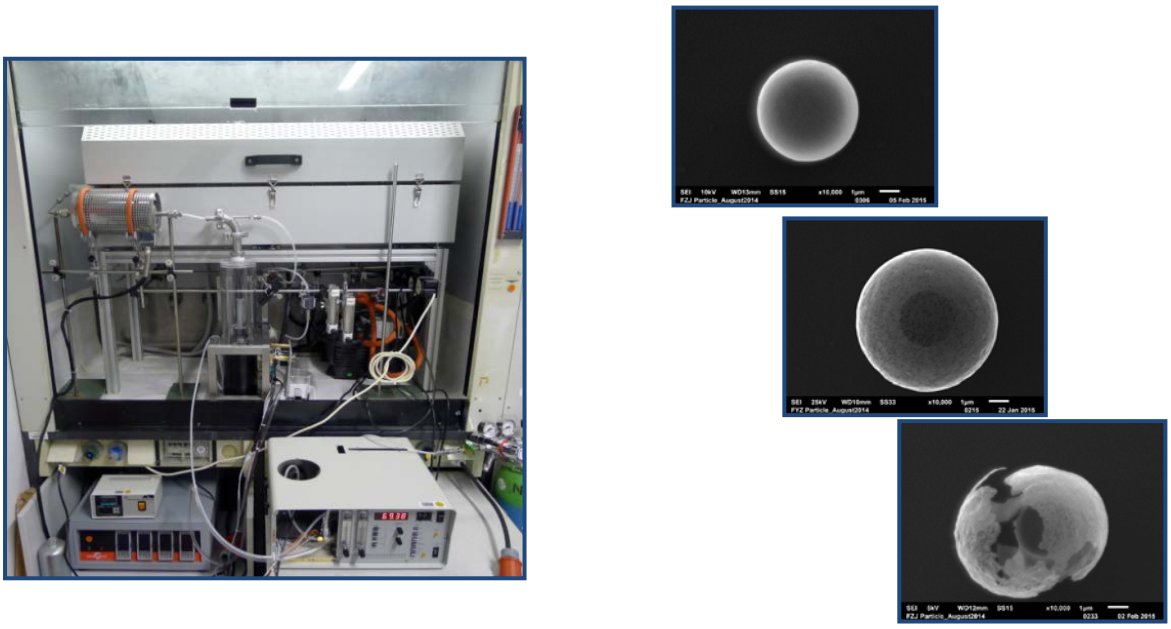

Figure 2. Vibrating Orifice Aerosol Generator (property of the IAEA, installed and operated at the FZ-Juelich) and images of mono-disperse uranium oxide particles.

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) within the Department of Safeguards for the period 2016–2017.

During the 2016-1017 biennium, Project SGAS-003 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
10. Ability to provide analytical services through the NWAL to support verification requirements.	10.1 Utilise the expanded NWAL in order to (1) provide external quality control and reference material, and (2) provide technical expertise.	H
	10.2 Develop techniques, methods and equipment to detect signatures of nuclear activities in environmental samples including • Age determination of U and Pu relevant to the origin of nuclear materials • Analysis of impurities relevant to the origin of source materials • Particles morphology for identifying operational processes • Reliably finding smaller particles of interest in an excess of background material	H
	10.3 Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples.	H

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 smooth running of routine analytical operations, within agreed timeliness and quality targets.

For the 2016-2017 biennium, the project's top priorities are:

- Ensure efficient and effective operation of the NWAL, including participation in inter-laboratory comparison exercises.
- Implement expansion of the NWAL, with the main focus areas being particle analysis of environmental samples and quality assurance support.
- Produce 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 declarations made by Member States on their nuclear activities. Nuclear material sample analyses are primarily used to 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 and plutonium 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 Network of Analytical Laboratories 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 (Nuclear Material Laboratory, NML, and Environmental Sample Laboratory, ESL) and 20 other qualified laboratories of the Member States and the European Commission. In 2014, the French Laboratoire d'Analyses Nucléaires Isotopiques et Elémentaires (LANIE) of the Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA) qualified for nuclear material analysis for accountancy purposes. The Korea Atomic Energy Research Institute (KAERI) in the Republic of Korea was qualified for bulk and particle analysis of environmental samples in 2014 and 2015, respectively.

End-users are Departmental evaluators and Divisions of Operations staff who receive and evaluate analytical data produced by the NWAL members. 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 of safeguards sample analyses, and revises technical objectives for performance monitoring of analytical services.

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

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 for Nuclear Materials* and SGAS-002 *Environmental Sample Analysis Techniques*, respectively.

3. Objectives and Key Achievement Targets

In order to support Project SGAS-003's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and / or finalized during the 2016-2017 biennium and can be structured under the following objective:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Utilise the expanded NWAL in order to (1) provide external quality control and reference material, and (2) provide technical expertise. **(In support of Milestone 10.1)**	
Qualify one additional NWAL member for particle analysis of environmental samples.	December 2017
Qualify one additional NWAL member for analysis of nuclear material samples.	December 2017
Qualify one additional NWAL member for provision of reference materials.	December 2017
Complete one to two inter-laboratory comparison exercises per year.	December 2017

Produce new quality control reference materials, particularly for uranium particle analysis.	December 2017

4. Activities

Funding and resources for most of the project's development and implementation support activities are provided by Member State Support Programmes, which continue to play a major role in achieving the project's objectives. Some activities are supplemented by regular budget sources; in particular, to cover the costs of NWAL analyses. The IAEA pays a fixed amount for each type of sample and analysis. A number of MSSP tasks (AUL A 0859, EC X 1969, JPN X 2004, RUS X 1515, and UK X 1045) offer administrative vehicles 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, a French Support Programme task (FRA X 1941) provides more general support for environmental sample and nuclear material sample analysis.

Objective 1.) ***Utilise the expanded NWAL in order to (1) provide external quality control and reference material, and (2) provide technical expertise.*** **(In support of Milestone 10.1)**

Particle analysis of environmental samples is carried out by NWAL members under five MSSP tasks (AUL A 0859, EC X 1969, JPN X 2004, RUS X 1515 and UK X 1045). In addition, one laboratory is presently under qualification (CPR A 1725). Provision of additional capacity for particle analysis by fission-track thermal ionization mass spectrometry (FT-TIMS) and large geometry-secondary ion mass spectrometry (LG-SIMS) is welcome.

Bulk analysis of environmental samples is carried out by NWAL members under three MSSP tasks (AUL A 0859, JPN X 2004 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 samples are analysed at the NML (IAEA) in Seibersdorf. However, a group of NWAL members is required for nuclear material analysis for quality assurance purposes and also to provide backup capacity in the case that the NML should be offline. A core group of laboratories is able to receive, prepare, and process the safeguards samples for analysis (EC X 1969 and FRA A 1479). 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 will provide quality control for the final measurement systems only. Four laboratories are presently under qualification for this purpose (BEL A 1758, CAN A 1950, NET A 1974, and USA A 1956).

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

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 an important tool 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 Institute for Reference Materials and Measurements (IRMM, part of the European Commission Joint Research Centre in Geel, Belgium) and the Commission d'Établissement des Méthodes d'Analyse (CETAMA) in France, respectively. Whereas IRMM administers the Nuclear Signatures Inter-laboratory Measurement Evaluation Programme (NUSIMEP) and Regular European Inter-laboratory Measurement Evaluation Programme (REIMEP), CETAMA has various materials (plutonium, uranium, impurities) under the Étude de la Qualité des Résultats d'Analyse dans l'Industrie Nucléaire (EQRAIN) programme. The Safeguards Analytical Laboratories participate in these exercises. Task FRA A 1101 hosted NML participation to the UOC Feldspath nb1 inter-laboratory comparison exercise organized by CETAMA in order to determine uranium, major impurity elements (Mo, V, Zr, Fe, Ca, Mg) as well as rare earth elements (La, Ce, Sm, Eu, Gd, Dy, Yb, and Lu) and to recertify the uranium ore concentrate Feldspath. The NML will use the recertified UOC Feldspath material to improve quality control and calibration of its ICP-MS.

To complement these external schemes, SGAS has developed statistical software appropriate for analyzing 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 Nuclear Material Round Robin), particle analysis of environmental samples (2015 ES particle proficiency test), 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 high-resolution gamma spectrometry proficiency test), impurities analysis (2016 inter-laboratory comparison in impurity analysis). Results from these tests are discussed with participating laboratories during Technical Meetings. 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 2016-2017 biennium.

The availability of fit-for-purpose reference materials is the cornerstone of analytical QC. They are necessary for proper instrument calibration, traceability to the International Organization for Standardization (ISO) standards, measurement control and uncertainty quantification. A number of tasks serve to provide special reference materials for quality assurance of analytical performance as well as special source materials for production of secondary reference materials, mostly large-size dried (LSD) spikes, for the IAEA NML. Specifically, tasks EC A 0318, FRA A 1101, RUS A 0491, UK C 1742, and USA A 1496 provide such materials from IRMM, CETAMA, Khlopin Radium Institute (KRI), UK National Physical Laboratory (NPL) and US DoE New Brunswick Laboratory (NBL), respectively. It is of paramount importance to IAEA safeguards that these capabilities to provide and distribute specialized reference materials are preserved.

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. In addition, there is a growing need for new reference materials to meet evolving safeguards requirements: reference materials for trace element characterization of uranium, environmental reference materials, especially for particle analysis, reference materials for material age-dating techniques, and heavy water reference materials.

Among all growing needs, the highest priority is assigned to the sustainable provision of appropriate reference materials for uranium and plutonium particle analysis. The recent technical achievements reported by Forschungszentrum Jülich (FZJ) in Germany on the production of mono-disperse uranium particles (see task GER A 1961 under SGAS-002 project) are extremely promising. The suitability of produced particles for use in quality assurance purposes was demonstrated. Further developments of this production capability are being considered by FZJ. While these efforts might develop into NWAL qualification of FZJ for provision of reference materials under task GER A 1960, the spectrum of needs for particle QC reference materials is wide and calls for further support from MSSPs.

Beyond the development of new certified reference materials for safeguards, the IAEA will also continue to leverage the competencies and resources of the NWAL to encourage the preservation of existing stocks through more enhanced use of working standards and the development of new approaches for extending the shelf life of such working standards.

The upgrade of the Laboratory Information Management System (LIMS), used by the NML for its daily operations, was completed on 2 December 2014 on time and on budget (USA D 1934). The AIMS 2.0 system was ported to .NET to guarantee long-term maintainability for the LIMS and includes new functionalities, as well as enhancements to existing capabilities. AIMS 2.0 contributes directly to the NML mission, delivering quality and timely analytical results to safeguards data evaluators. It is integrated into the wider SALIMS Portal platform developed by the IAEA based on three-tier architecture (an AIMS 2.0 user interface, middle logic tier processing data, performing calculations and making logical decisions, and the underlying database layer). The AIMS 2.0 project close-out meeting concluded with the full success of this development project, from the user as well as from the management perspective.

Building upon the existing architecture, the IAEA intends to leverage the advantages of the SALIMS Portal platform to continue to integrate its business systems and processes, consolidate its databases, and expand the LIMS to cover NWAL coordination, facilitate internal QC monitoring, and include data management at the ESL. Future laboratory-specific development needs have been collected and prioritized. Some internal tasks have already started. However, as internal development resources are limited, the IAEA intends to request MSSP support of its LIMS development efforts during the 2016-2017 biennium.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[7] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	NWAL dashboard	Development and implementation of a monitoring system for Key Performance Indicators (KPIs) covering sample distribution to and analysis by the NWAL.	December 2016
	2	IAEA NM round robin exercise	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to NMA analysis.	September 2017
	3	IAEA impurity inter-laboratory comparison exercise	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to impurity analysis of safeguards samples.	February 2016
	4	IAEA gamma spectrometry inter-laboratory comparison exercise	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to gamma spectrometry analysis of safeguards samples.	November 2016
	5	IAEA ES bulk analysis inter-laboratory comparison exercise	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to ES bulk analysis of safeguards environmental samples.	November 2016
	6	IAEA SEM/EDX inter-laboratory comparison exercise	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).	November 2017
	7	IAEA ES particle analysis inter-laboratory comparison exercise	Inter-laboratory exercise to evaluate the analytical capabilities and performance of the NWAL laboratories with regard to ES particle analysis of safeguards	November 2017

[7] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

			environmental samples.	
	8	Upgrade of the Laboratory Information Management System (LIMS)	Progressive enhancements of the NML LIMS; 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.	December 2017

4.3 Attachments

Figure 1. Certified plutonium reference materials used by SGAS

Figure 2. New shipping containers used for UF_6 shipments

SGCP-003

Safeguards Approaches

Project Manager: Masato Hori

Division: SGCP

Note: Mr Masato Hori will depart from the IAEA in February 2016. A new Project Manager will be identified shortly.

1. Overview

This document describes the plans for developing and implementing safeguards concepts and approaches within the Department of Safeguards for the period 2016–2017.

During the 2016-2017 biennium, Project SGCP-003 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
1. Ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards.	1.2 Prepare additional guidance for the on-going development of State-level safeguards approaches: • The use of State-specific factors • Acquisition path analysis • The specification of options for Headquarters and in-field activities required to meet the technical objectives • The link between the State evaluation process and development of SLAs and AIPs.	H
	1.3 Develop additional tools to support the development of State-level safeguards approaches: • The analysis, representation, and prioritization of acquisition paths • The assessment of overall safeguards effectiveness • The determination of technical objectives.	M
	1.4 Develop approaches to more fully utilize SRA data and verification findings, where appropriate, to achieve efficiencies.	H
	1.5 Develop safeguards guidance for States, including web-based versions, addressing topics such as: • Regulatory authority • Design information • Inspections and complementary access • Imports and exports.	M
2. Increased ability to detect undeclared nuclear material and activities.	2.3 Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles.	M

3. Ability to safeguard new types of facility.	3.1 Develop generic safeguards approaches for pyro-processing plants.	M
	3.2 Develop tools and techniques to characterize seismic signals in geological repositories.	M
	3.4 Develop a mechanism to enable safeguards to be considered early in the facility design process.	M
4. Ability to provide credible assurances that nuclear material used in non-proscribed military activities, specifically naval propulsion, is not used for the production of nuclear weapons of other nuclear explosive devices.	4.1 Consult with Member States with established naval nuclear propulsion programmes for development of future verification arrangements in this area.	H
12. Ability to take on technical challenges and opportunities, and emerging tasks.	12.1 Assist with Chernobyl, Fukushima and DPRK related activities as requested.	M

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 plans will efficiently provide for effective safeguards;
- Assist Operations Divisions in the design and implementation of State-level safeguards approaches; Further develop concepts for implementing safeguards at the State-level, to improve effectiveness and efficiency and to apply a non-discriminatory approach for all States;
- Develop generic safeguards approaches for new facility types to provide a basis for the development of safeguards approaches for new facilities; and
- Provide guidance and assistance to States to improve their performance in the implementation of safeguards and to strengthen cooperation between the IAEA and the State (or regional) authority responsible for safeguards implementation (SRA).

For the 2016-2017 biennium, the project's top priorities are:

- Develop templates and simple software tools to improve efficiency and consistency in performing acquisition path analysis (APA) and developing State-level approach (SLA).
- Update the Physical Model to improve its completeness.
- Draft and publish Safeguards Technical Reports (STRs) on:
    - Geological repositories and encapsulation facilities
    - Pyro-processing facilities
    - Lessons learned from the Fukushima Dai-ichi accident.
- Publish the remaining two 'Safeguards Implementation Practices' (SIP) Guides and organize workshops to familiarize stakeholders with the SIP Guides.

2. Background

As part of this project, in order to continue to draw soundly based 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 more towards a 'State as a whole' approach. Development and testing of internal procedures and guidance to implement State-level safeguards have been carried out, including guidance on performing APA and developing 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 and implement more effective and efficient safeguards concepts and technologies for new types of facilities. Those include geological repositories, spent fuel encapsulation plants and pyro-processing facilities.

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. Safeguards Implementation Practices (SIP) guides have been developed to increase States' understanding of the safeguards obligations of both States and the IAEA, and to improve the cooperation between States and the IAEA in safeguards implementation.

Toward this end, valuable contributions related to the development and testing of safeguards concepts, guidelines and approaches have already been provided by Member States through the Member State Support Programmes. These contributions continue to be of paramount importance to the Project's ability to meet Department expectations. End-users are primarily Operations Divisions carrying out safeguards activities.

3. Objectives and Key Achievement Targets

In order to support Project SGCP-003's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Prepare additional guidance for the on-going development of State-level safeguards approaches: • The use of State-specific factors • Acquisition path analysis • The specification of options for Headquarters and in-field activities required to meet the technical objectives • The link between the State evaluation process and development of SLAs and AIPs. **(In support of Milestone 1.2)**	
To improve efficiency and consistency in performing APA and developing SLA:	
Develop additional templates	March 2016
Develop simple software tools.	June 2016
Produce further documentation with quantifiable technical parameters for evaluation in the guides for performing APA and developing SLA.	December 2017
Objective 2.) Develop additional tools to support the development of State-level safeguards approaches: • The analysis, representation, and prioritization of acquisition paths • The assessment of overall safeguards effectiveness • The determination of technical objectives **(In support of Milestone 1.3)**	

Based on feedback from the ongoing SLA development, and as part of the actions for State-level safeguards implementation, the project will need to develop templates, software tools and reference material to support development of SLAs.	
Develop a software tool to support APA and SLA process steps, including the visualization of acquisition paths, assessment of steps, time assessment of paths, establishment and prioritization of technical objectives, and identification of safeguards measures/activities in order to inform determination of the frequency and intensity of safeguards activities.	December 2017
Objective 3.) Develop approaches to more fully utilize SRA data and verification findings, where appropriate, to achieve efficiencies. **(In support of Milestone 1.4)**	
Identify performance measures and technical competences which will enable the Agency to assess and more fully utilize the technical capability and verification findings of the SRA.	June 2017
Objective 4.) Develop safeguards guidance for States, including web-based versions, addressing topics such as: • Regulatory authority • Design information • Inspections and complementary access • Imports and exports. **(In support of Milestone 1.5)**	
Publish remaining two SIP guidance documents on provision of information to the IAEA and undertaking collaborative approaches to safeguards implementation.	December 2016
Organize at least two workshops to familiarize States with the SIP Guides.	December 2017
Objective 5.) Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles. **(In support of Milestone 2.3)**	
Update the Physical Model to improve its completeness and usability.	
Update volumes 2, 3, 4, 7, 8	June 2016
Update volumes 1, 5, 6, 9, 10, 11	December 2017
Objective 6.) Develop generic safeguards approaches for pyro-processing plants and small modular and/or Gen IV reactors. **(In support of Milestone 3.1)**	
Develop a safeguards approach and supporting measures for a specific pyro-processing facility; draft a Safeguards Technical Report for safeguarding generic pyro-processing plants.	December 2017
Objective 7.) Develop safeguards techniques applicable to geological repositories. **(In support of Milestone 3.2)**	
Draft a Safeguards Technical Report on technical measures that could be potentially useful for safeguarding future geological repositories and encapsulation facilities.	December 2016
Objective 8.) Develop a mechanism to enable safeguards to be considered early in the facility design process. **(In support of Milestone 3.4)**	
Issue all facility specific safeguards-by-design (SBD) documents.	December 2016
Provide input to an industry driven project for development and implementation of a standardized UF_6 cylinder identifier.	December 2017
Objective 9.) Consult with Member States with established naval nuclear propulsion programmes for development of future verification arrangements in this area. **(In support of Milestone 4.1)**	

Consult with Member States with established naval nuclear propulsion programmes to identify challenges and develop possible solutions relevant to development of concepts and tools for future verification arrangements in this area.	December 2016
Objective 10.) Assist with Chernobyl, Fukushima and DPRK related activities as requested. **(In support of Milestone 12.1)**	
Draft a Safeguards Technical Report for lessons learned from Fukushima Dai-ichi accident.	June 2017

4. Activities

Most of the following activities will be performed by Safeguards Department personnel. Further assistance will be required from Member State Support Programmes for some activities.

Objective 1.) ***Prepare additional guidance for the on-going development of State-level safeguards approaches.*** **(In support of Milestone 1.2)**

and

Objective 2.) ***Develop additional tools to support the development of State-level safeguards approaches.*** **(In support of Milestone 1.3)**

Note: Description encompasses activities for Objectives 1 and 2.

There has been an on-going effort to prepare additional guidance for updating State-level approaches in order to evolve safeguards implementation by making greater use of 'State as a whole' considerations (see Figure 1: Process supporting safeguards implementation). Guides to perform APA and develop SLAs had been developed, tested and approved during the previous biennium (2014-15). The outcomes of the Member State Support Programme Joint Task (JNT C 1871 EC, FRA, GER, HUN, UK, USA) 'APA Methodologies and Software Packages' has been incorporated into Departmental guides and development of tools.

Additional templates and tools have been developed based on feedback from State Evaluation Groups (SEGs) to improve efficiency and consistency in performing APA and developing SLA.

Based on experience in updating SLA, a work plan to improve guides for performing APA and developing SLA will be developed for further improvement of effectiveness and efficiency of State-level safeguards implementation.

Changes to the guidance documents supporting the development and implementation of safeguards approaches are required to implement State-level safeguards and improve effectiveness and efficiency of safeguards implementation. Currently, there are technical documents and guides covering a variety of implementation issues. During 2016 and 2017, a review of technical documents and guides will be performed to assess consistency with State-level safeguards. Tentative areas for the review and development of new technical documents or guides include: (1) update technical guidance related to termination of safeguards on measured discards and safeguards for spent fuel transfers to dry storage; (2) determine further applications of random, unannounced and remote data-triggered inspections to increase effectiveness and efficiency; (3) develop approaches for monitoring and evaluating the effectiveness of safeguards implementation; and (4) develop more effective and efficient safeguards measures and activities to detect misuse of facilities and to detect undeclared nuclear material and activities.

Objective 3.) ***Develop approaches to more fully utilize SRA data and verification findings, where appropriate, to achieve efficiencies.*** **(In support of Milestone 1.4)**

Safeguards implementation under the IAEA-EURATOM 'new partnership approach' has provided a foundation for developing concepts to evaluate and make full use of the findings of SRA in order to achieve efficiencies and increase effectiveness. The IAEA will identify approaches which will enable the Agency to assess and more fully utilize the technical capability and verification findings of SRAs.

Objective 4.) ***Develop safeguards guidance for States, including web-based versions.*** **(In support of Milestone 1.5)**

To facilitate cooperation between the IAEA and States in safeguards implementation, and to improve States' understanding and performance, the IAEA has been preparing a new series of Safeguards Implementation Guides.

(JNT C 1959 'Member State Contributions to IAEA Topical Guidance on Safeguards Implementation' with AUL, BRZ, CAN, CZ, EC, FIN, FRA, GER, HUN, JPN, NET, ROK, RSA, SWE, UK, USA).

Since 2013, two SIP Guides, including 'Safeguards Implementation Practices Guide on Facilitating IAEA Verification Activities' and 'SIP Guide on Establishing and Maintaining State Safeguards Infrastructure', were developed and published as IAEA Services Series 30 and 31. Two other SIP Guides, addressing the Provision of Information to the IAEA, and Collaborative Approaches to Safeguards Implementation, are now in the final stages of editing, after which they will undergo internal review, approval, and then publication. All SIP Guides are made available on the Assistance for States webpage.

In 2016, two workshops will be held in Vienna to introduce the SIP Guides with lectures and exercises to work through the material contained in the SIP Guides. Experts who participated in developing each SIP Guide will be invited to assist as facilitators/lecturers/experts under a follow on SP-1 (15/CPC-004). Travel support has been provided by JASPAS and the US SP for developing country participants to the Infrastructure Workshop.

Objective 5.) ***Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles.*** **(In support of Milestone 2.3)**

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 analyzed 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 State Evaluation Groups of State fuel cycle capabilities.

Objective 6.) ***Develop generic safeguards approaches for: pyro-processing plants and small modular and/or Gen IV reactors.*** **(In support of Milestone 3.1)**

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

Task JNT C 1953 was 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 a Department-wide approach 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 generic pyro-processing plants.

Objective 7.) ***Develop safeguards techniques applicable to geological repositories.*** **(In support of Milestone 3.2)**

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

The model safeguards approaches for spent fuel conditioning plants and geological repositories has been discussed at ASTOR meetings. On-going development of the safeguards equipment and technologies applicable to the facilities such as seismic monitoring, virtual containment and quantitative measurements will be reviewed and discussed.

During the 2015 ASTOR meeting in the Republic of Korea, preparation of a report on technical measures that could be potentially useful for safeguarding future geological repositories under the framework of ASTOR was discussed. Based on the discussion, the outline of a Safeguards Technical Report on geological repositories and encapsulation facilities has been developed and will be reviewed at the 2016 ASTOR meeting in the United States.

Objective 8.) ***Develop a mechanism to enable safeguards to be considered early in the facility design process.*** **(In**

support of Milestone 3.4)

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

In 2008, the IAEA enlisted the cooperation of Member States in promoting SBD through MSSP tasks (ARG C 1770, BEL C 1746, BRZ C 1767, CAN C 1739. CPR C 1748, EC C 1726, FIN C 1829, FRA C 1792, GER C 1780, JPN C 1738, ROK C 1724, UK C 1755, and USA C 1734).

With the help of these MSSPs, a publication to explain the general principles and benefits of SBD was published in April 2013 in the IAEA Nuclear Energy series as No. NP-T- 2.8. Work is progressing well in six facility specific SBD guidance publications. The guidance for Nuclear Reactors has been published in the IAEA Nuclear Energy series as No. NP-T-2.9. The guidance for Long-Term Spent Fuel Management, Fuel Fabrication and Uranium Conversion facilities has been completed and is in the final IAEA formatting and printing process, with publication expected shortly. With support from the US SP, the last two guides, Reprocessing and Enrichment, have been finalized and is expected to be published by the end of December 2016.

The development of a standardized UF_6 cylinder identifier 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. If realizable, 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 SRAs.

Objective 9.) ***Consult with Member States with established naval nuclear propulsion programmes for development of future verification arrangements in this area.*** **(In support of Milestone 4.1)**

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

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

Objective 10.) ***Assist with Chernobyl, Fukushima and DPRK related activities as requested.*** **(In support of Milestone 12.1)**

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. This project is dependent on the schedules of the decommissioning activities in and around the Fukushima Dai-ichi site.

As part of this objective, SGCP will assist SGOA in compiling a Safeguards Technical Report (STR) documenting lessons learned from Fukushima Dai-ichi accident sharing implementation practices for safeguarding a facility in the event of a catastrophic accident.

For additional information on safeguards-relevant development and implementation support activities for the Fukushima Dai-ichi site, please see project SGOA-003 *Fukuskima Dai-ichi Safeguards*.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[8] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	Develop additional tools and simple software tools	Develop additional templates and simple software tools to improve efficiency and consistency in performing APA and developing SLA.	Additional templates: March 2016 Simple software tools: June 2016
	2	Further documentation of guides	Further documentation with quantifiable technical parameters for evaluation in the guides for performing APA and developing SLA.	December 2017
2	3	Develop software tools	Develop a software tool to support APA and SLA process steps, including the visualization of acquisition paths, assessment of steps, time assessment of paths, establishment and prioritization of technical objectives, and identification of safeguards measures/activities in order to inform determination of the frequency and intensity of safeguards activities.	December 2017
3	4	Identify performance measures and technical competences to fully utilize SRA findings	Identify performance measures and technical competences which will enable the Agency to assess and more fully utilize the technical capability and verification findings of the SRA.	June 2017
5	5	Update Physical Model	Update the Physical Model to improve its completeness and usability.	Volumes 2, 3, 4, 7, 8: June 2016 Volumes 1, 5, 6, 9, 10, 11: December 2017
8	6	Issue SBD documents	Issue all facility specific safeguards-by-design (SBD) documents.	December 2016
9	7	Identify challenges and develop possible solutions for safeguarding	Consult with Member States with established naval nuclear propulsion programmes to identify challenges and develop possible solutions relevant to development of concepts	December 2016

[8] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

		naval nuclear propulsion programmes	and tools for development of future verification arrangements in this area.	
10	8	Fukushima STR	Draft a Safeguards Technical Report for lessons learned from Fukushima Dai-ichi accident.	June 2017

4.3 Attachments

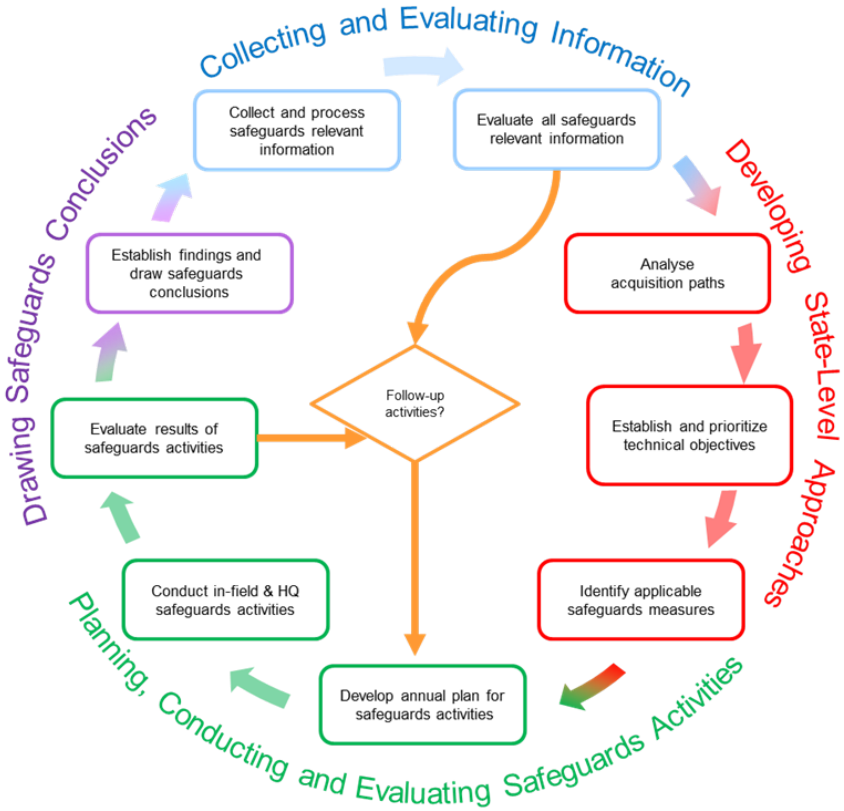

Figure 1. Process supporting safeguards implementation

SGCP-101

Quality Management

Project Manager: Snezana Konecni

Division: SGCP

1. Overview

This document describes the plans for developing, implementing and enhancing processes and management tools within the scope of the Quality Management System (QMS) of the Department of Safeguards for the period 2016-2017.

During the 2016-2017 biennium, Project SGCP-101 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
1. Ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards.	1.1 Develop safeguards policy, guidelines and processes to more fully implement safeguards at the State level.	H

Project SGCP-101 focuses on providing support to the Department of Safeguards to implement the QMS in accordance with the requirements of the management standard ISO 9001. As the management standard identifies processes as the core of the system, the project focuses on designing, improving and managing safeguards processes.

For the 2016-2017 biennium, the top priorities for SGCP-101 are to:

- Fully implement the process-based approach within the Department and through that approach, drive forward continual improvement.
- Implement measurement systems to monitor process performance.
- Adapt the QMS tools and techniques to improve process performance.
- Assess the effectiveness of the QMS in the Department and determine what adjustments are required, whilst maintaining the QMS.

2. Background

The QMS provides the framework for accomplishing the objective of drawing soundly-based safeguards conclusions for all States.

The current scope of the project includes the development and implementation of a process-based QMS that is in accordance with ISO 9001:2008. During the 2016-2017 biennium the QMS will be brought into line with ISO 9001:2015.

Within the QMS, there are a number of initiatives of a long-term nature that have been pursued over time. These relate to the management of the infrastructure for the QMS, promoting the use of tools and techniques, assessing their effectiveness, and adapting them to meet Departmental requirements. These include:

- The **Condition Report (CR) system**, which is designed to prevent undesirable events or conditions that have occurred from re-occurring, has been implemented as part of the QMS. The CR system, which replaced the former Corrective Action Report (CAR) system, was introduced in 2014. The use of the system

is growing, requiring enhancements to the system that are being made in partnership with the Safeguards Office of Information and Communication Systems (SGIS).

- The **Internal Quality Audit (IQA) Programme**, is now an established element of the QMS. In 2015, a new organizational entity, the Section for Safeguards Performance and Quality (SPQ), was established. The Section Head is assigned as the Departmental Quality Manager and is responsible for the Departmental internal quality audit programme. The Departmental Quality Manager is assigned as the focal point for liaising with the Office of Internal Oversight (OIOS) on audits and evaluations in the Department of Safeguards. The Department will continue to rely on a pool of qualified internal quality auditors to implement the internal quality audit programme.
- Specific activities relating to **process management** including the continued support to the safeguards information management system in the context of the Modernization of Safeguards Information Technology (MOSAIC, see SGIS 003) with regard to coordinating and providing input to user specifications, identifying process implications, and working with process owners and stakeholders to determine appropriate changes.
- Using the results of Departmental **performance management** as indicators of process performance. Updating the Departmental process framework with assigned process owners, clarifying their responsibilities, and providing active support for process owners to discharge their responsibilities within the Department. This will be implemented through systematic process reviews to ensure that processes continue to be fit for purpose, are adequately defined, and have the appropriate documentation.
- The QMS **Document Manager**, which is the official Departmental document repository, continues to be improved and will also be assessed in the context of MOSAIC, particularly with regard to providing HQ (online) and field (offline) support to the core verification processes. It provides staff with new resources and tools for access to active and approved Safeguards documents.
- The **cost calculation methodology** is used as a tool to support decision-making in the Department. Results of the cost calculation methodology are used in process improvement to quantify potential efficiency gains and to provide effort estimates for the impact of new approaches and concepts. The effort estimates used in the cost calculation methodology are revised according to new responsibilities, functions and processes as a result of changes in the Department.
- A system to support **knowledge retention** activities for departing and retiring staff in the Department of Safeguards is fully established and is used extensively by managers in the Department.
- **QMS training** in different aspects of quality management is delivered as part of the dedicated Departmental training programme.

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

3. Objectives and Key Achievement Targets

In order to support Project SGCP-101's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and / or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Develop safeguards policy, guidelines and processes to more fully implement safeguards at the State level. **(In support of Milestone 1.1)**	
Implement the approved Internal Quality Audit Programme and perform process reviews as scheduled.	December 2017
Implement the planned reviews in the process review schedule.	December 2017
Objective 2.) Develop, and implement fully, the process-based approach within the management system and continually improve its processes.	
Complete an assessment of the QMS's maturity, using ISO 9004:2009 as a reference.	December 2017

Complete an impact analysis of the requirements of ISO 9001:2015 for the QMS.	December 2017
Design and deliver training on the QMS and its tools as part of the Departmental training programme.	December 2017
Objective 3.) Improve the management of knowledge and encourage knowledge retention.	
Provide and maintain active and approved document repositories for the Department on the SG LAN and, as determined, in ISE.	December 2017
Facilitate the process to identify the knowledge resources that are at risk and must be retained, recommend methods for transferring the knowledge and support the implementation as necessary to maintain these resources in the Department.	December 2017
Objective 4.) Enhance financial transparency and accountability for safeguards implementation through the continued development of the cost calculation methodology.	

4. Activities

Most of the activities will be performed by Safeguards Department staff. Further assistance will be required from Member State Support Programmes for some activities.

Objective 1.) ***Develop safeguards policy, guidelines and processes to more fully implement safeguards at the State level.*** **(In support of Milestone 1.1)**

Process management: The task of systematically reviewing shared safeguards processes and providing active support for process owners including performing analyses and reviews, producing process descriptions, procedures and maps continues as a priority activity. The project will continue to provide support to MOSAIC as described earlier.

Measurement and analysis systems will be developed and implemented to provide process owners with clear identification of trends in the Department's processes, and whether the processes are operating effectively and efficiently (CAN C 1978, UK C 2005).

Gaps and weaknesses identified through process performance monitoring, and as a result of internal quality audits and condition reports will be addressed through process improvement activities. Training of staff in the use of a range of facilitation strategies and techniques to assist in this process by leading structured discussions when facilitating group discussion has been provided and will continue to be provided.

Objective 2.) ***Develop, and implement fully, the process-based approach within the management system and continually improve its processes.***

Monitoring of the implementation and maturity of the QMS: In order to monitor the overall progress in implementing the QMS, and to help indicate where more effort is required, an assessment is planned for the 2016–2017 biennium. This assessment of the QMS's maturity will be conducted using ISO 9004:2009 as a reference. Regular budget funds and resources are used for these activities, and MSSP support is not envisaged at this time.

Impact of ISO 9001:2015: There will be an assessment of the impact on the QMS of the revision of ISO 9001:2008. This will be reported as part of the regular management review of the QMS, which can aid communication of the importance of the QMS to staff. Regular budget funds and resources are used for these activities, and MSSP support is not envisaged at this time.

Condition Report (corrective and preventive actions) system: The use of the Condition Report system continues to be promoted in the Department to identify the underlying causes of incidents and track the implementation of corrective and preventive actions, to identify trends and to facilitate the exchange of lessons learned. MSSP support may be used to enhance the Department's capability through the training of relevant staff in Root Cause Analysis methodology.

The Internal Quality Audit (IQA) Programme: The audit methodology and capability will be reviewed during the 2016–2017 biennium to better address process effectiveness, and to evolve to meet the needs of the Department. The following sub-activities are planned:

- Audits will be conducted according to the approved IQA Programme;
- Process/activities assessments: A successful pilot process review was conducted in 2015, and this methodology will be used to review processes or parts of processes as identified by process owners.

Documentation and Records Management: The Department's processes need to have an appropriate set of up-to-date and consistent documentation (e.g. policies, procedures and forms). With specific regard to process documentation, the document management system will also continue to be improved and implemented through the following sub-activities:

- The existing electronic document storage and retrieval system will be further improved based on experience gained. There will be a need to find an IT solution for the QMS Document Management System bearing in mind that Livelink may become obsolete and MTIT will switch to SharePoint.
- Staff assigned with document coordination and control responsibilities across the Department have identified and implemented a number of measures to ensure that document quality is sustained. These include ensuring documents have the appropriate information and level of detail, minimizing duplicate or unnecessary documents and ensuring documents are regularly reviewed, kept current and their metadata are recorded.
- The Department of Safeguards has moved to a working environment that includes a low side network (SG LAN) and a high side secure network (ISE). Documents may reside in one or both of these environments. In order to effectively utilise the information, certain governance and capabilities should be in place, including, inter alia, version control, metadata, and support for business process workflows. In order to address this, a new project, document management and workflow support project, was initiated as part of MOSAIC. The project objectives define the governance and capabilities for safeguards users to effectively access, utilise, process and store the documents they need in their working environment (for example, by the provision of an inspector handbook containing all the essential reference information required for inspection purposes, available in an up to date form both at HQ and in the field) (see Project SGIS-003).
- Forms and working papers have been reviewed and updated/redesigned, and electronic forms have been introduced with support from the UK Support Programme (UK A 1729 – Technical Manuals and Procedures for SG Instrumentation). Further work is being done to maintain forms and their use while meeting Departmental information security and classification requirements.

QMS training: Training on the different aspects of the QMS is being reviewed and modified. In order to design and deliver the QMS training in an effective manner, project staff need "train the trainer" training via MSSP support *(specific trainer through UK support programme).* In order to establish a common understanding of quality management in the Department, it is essential to replace the out-of-date computer based training module that was created 7-8 years ago with the support of the Canadian support programme (CAN B 1630) with an e-learning module.

Objective 3.) ***Improve the management of knowledge and encourage knowledge retention.***

Knowledge Management: To ensure that effective knowledge management practices are implemented in the Department, including exchange-of-information enhancement and the establishment of structures facilitating knowledge sharing, Project SGCP-101 activities continue to focus on:

- Retention of job-critical knowledge from staff leaving the Department. Project SGCP-101 will continue to implement the knowledge retention program for departing and retiring staff throughout the 2016–2017 biennium. This programme was initiated in the 2010–2011 biennium.
- Continue to provide support to the IAEA corporate knowledge management project.
- A new Departmental knowledge retention procedure (2015) is in place. This framework will continue to be improved and adapted as needed.
- Training on knowledge management will be conducted to help the Department understand what knowledge needs to be transfer and how staff would prefer to give and receive it.

Objective 4.) ***Enhance financial transparency and accountability for safeguards implementation through the continued development of the cost calculation methodology.***

Cost calculation model: The cost calculation model and methodology for calculating safeguards implementation costs, as well as the comparison of costs of safeguards measures, continues to evolve. There was a major effort in

2015 to extensively peer-review and enhance the model with MSSP support (USA F 1808) providing the services of two senior consultants. The initiative resulted in a robust and enhanced version of the model. Updating the model annually and using the model to estimate safeguards implementation costs by State in the Safeguards Implementation Report will continue in 2016-2017, utilizing a consultant to conduct expert periodic reviews of the cost model and support further application of the model.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017. [9] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	Implementation support for the management system (QMS)	Implement effectiveness measurements for Safeguards processes, including management review and reporting, key performance indicators, corrective and preventing measures (CRs), and internal quality audits (IQAs). Assess the implications of the introduction of ISO 9001:2015 for the Management System.	Ongoing
	2	Maintain and enhance safeguards documentation and records management	Further improve documentation and records management following quality management principles, and upgrade the Safeguards QMS document management system with new features.	Ongoing
	3	Management system training	Deliver training and advice on quality management tools and techniques.	Ongoing
	4	Developing a cost methodology for safeguards implementation	Implement and further enhance the Safeguards cost methodology and its application.	Ongoing
	5	Support to the Department's design and development of new guidelines and processes	Review existing Safeguards processes and where necessary, design new processes or improve processes with the support of QMS tools. This activity aims to ensure that Departmental processes consistently deliver efficient safeguards implementation and adapt to changing environments.	Ongoing
	6	Improved knowledge management and encouragement of knowledge-sharing	Further develop the Department's knowledge management strategy, and support the Agency's knowledge management activities.	Ongoing

[9] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

SGCP-102

Training

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1. Overview

This document describes the plans for developing and implementing training within the Department of Safeguards for the period 2016–2017.

During the 2016-2017 biennium, Project SGCP 102 will pursue the following Long-Term Direction:

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 project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
1. Contribute to the long-term attainment of ensuring the ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards.	1.1 Develop safeguards policy, guidelines and processes to more fully implement the State-level concept.	H
	1.2 Prepare additional guidance for the ongoing development of State-level safeguards approaches: • The use of State-specific factors • Acquisition path analysis • The specification of options for Headquarters and infield activities required to meet the technical objectives • The link between the State evaluation process and development of SLAs and AIPs.	H
	1.3 Develop additional tools to support the development of State-level safeguards approaches: • The analysis, representation, and prioritization of acquisition paths • The planning of safeguards activities • The assessment of overall safeguards effectiveness • The determination of technical objectives.	M
	1.4 Develop approaches to more fully utilize SRA8 data and verification findings, where appropriate, to achieve efficiencies.	H
	1.5 Develop safeguards guidance for States, including web-based versions, addressing topics such as: • Regulatory authority • Design information • Inspections and complementary access • Imports and exports.	M
2. Contribute to the long-	2.1 Integrate information sources, including satellite imagery, electronic	M

term attainment of ensuring the ability to detect undeclared nuclear material and activities.	data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.	
	2.2 Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical statistical and graphical tools.	H
	2.3 Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.	M
	2.4 Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.	M
	2.5 Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results.	M
	2.6 Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations.	H
3. Ability to safeguards new types of facility.	3.3 Develop training to reflect the approaches and equipment for safeguarding new facility types, including consulting with States developing such facilities to help assess what training is required.	L
13. Contribute to the long-term attainment of ensuring the ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s).	13.1 Develop training tools using advanced methods such as virtual reality, immersive learning systems and web-based training: • Develop prototype virtual reality systems, test and evaluate performance • Include immersive learning for all types of fuel cycle facilities • Develop web-based tools for specific safeguards equipment • Develop signal (neutron/gamma) simulators to generate responses from equipment during training.	M
	13.2 Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility.	M

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 2016-2017 biennium, the project's top priorities are:

- Update, develop and implement training courses and curriculum following guidance documents and capturing best practices for implementation of the State-level concept.
- Develop a competency-based approach for training implementation, making full use of the Learning Management System deployed within AIPS Plateau 3[10].

[10] The Agency-wide Information system for Programme Support (AIPS) is an Enterprise Resource Planning system launched in the Agency in 2011. AIPS replaces many of the organization's information systems with a single, standard platform. The system is being accompanied by new business processes and by the IAEA's adoption of International Public Sector Accounting Standards. "Plateau 3" of Agency-wide AIPS implementation was launched in 2015, and addresses, in particular, many Human Resources functionalities.

- 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.

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

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

- Providing safeguards staff with new skills and abilities while maintaining and enhancing existing competencies, particularly in nuclear material accountancy, by taking full advantage of most advanced training technologies and techniques, as well as best practices accumulated in the Department;
- Offering a balanced training programme to meet the needs of safeguards staff, particularly inspectors and analysts, in the areas of both technical and 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, as well as the Traineeship Programme.

Extrabudgetary funds are used for most training courses and travel for courses, as well as for Cost-Free Experts. The precise value of in-kind contributions are difficult for the IAEA to accurately assess as such figures are negotiated 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, implementation of an increasing number of international, regional and national SSAC training courses and workshops, and organization of ISSAS (IAEA SSAC Advisory Service) missions during the following two years also requires strong support from Member States on logistical and technical matters.

The Training Section applies the Systematic Approach to Training (SAT). The SAT is a methodology for managing training programs. 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.
- A comprehensive computerized model of a pressurized heavy-water reactor (PHWR) has been developed. The model includes safeguards features and allows simulating a DIV in an interactive manner. If feedback is positive, this approach will be expanded to other types of facilities.
- All courses required by the Department, specifically the Operations Divisions, have been conducted. In 2014, 88 different courses were held, some offered several times during the year, which amounted to a total of 153 training courses, of which 31 were held outside IAEA Headquarters.
- 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.

The key challenge at present is the lack of specific and dedicated human resources, specifically for the following two steps of the SAT, which require full time staff to carry out. The steps are:

- Training needs analysis, to establish clear competency profiles and business processes; and
- Evaluation, to create, process, monitor and manage questionnaires, surveys and recommendations for capturing lessons learned and identifying improvements for all training courses.

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

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

3. Objectives and Key Achievement Targets

In order to support Project SGCP-102's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and / or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Contribute to the long-term attainment of ensuring the ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards. **(In support of Capability 1)** In order 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.	
Organize a focus group meeting to verify the relevance and accuracy of each annual training programme.	November 2016 & November 2017

Objective 2.) Contribute to the long-term attainment of ensuring the ability to detect undeclared nuclear material and activities. **(In support of Capability 2)** In order to ensure the collection and processing of data and to convert data into usable information, a comprehensive set of courses has been established, including regarding training on analytical techniques. The scope of application of analytical methods is significantly growing worldwide. Some new areas, like training for analysis of nuclear-related procurement activities and networks, need to be developed. The areas in which procurement analysis can support safeguards implementation will be further explored in the coming biennium. This will include the development of a specialized training course. Verifying the relevance and comprehensiveness of this set of courses, and ensuring that State Evaluation Groups (SEGs) take full advantage of it is necessary.	
In conjunction with Project SGIM-003, develop and implement a new analytic training course for procurement.	March 2017
Organize a focus group meeting to verify the application and relevance of analytical techniques.	December 2017
Objective 3.) Develop training to reflect the approaches and equipment for safeguarding new facility types, including consulting with States developing such facilities to help assess what training is required. **(In support of Milestone 3.3)** The existing training programme covers most of the needs expressed by Operations Divisions. However, it needs to be complemented in the area of pyro-processing technologies, taking into account the development of such capabilities in non-nuclear weapons States.	
Complement the existing training programme with a course on pyro-processing in the Republic of Korea.	December 2016
Objective 4.) Contribute to the long-term attainment of ensuring the ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s). **(In support of Capability 13)** 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. To complement this part of the training programme, training courses to develop soft skills are also necessary. One important gap is the absence of a course to develop writing skills for reporting on safeguards verification activities and preparation of State evaluation reports. 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 enrollment process) and a training tracking system.	
Organize courses at locations offered by Member States Support Programmes covering the full set of technical and integrated content in the IAEA Training Programmes for 2016 and 2017.	December 2017
Develop and conduct a course on writing skills for safeguards.	June 2017
Develop and conduct a comprehensive training programme for radiation protection and industrial safety.	June 2017
Manage the safeguards training programme through the LMS deployed within AIPS Plateau 3.	June 2017

Objective 5.) Develop training tools using advanced methods such as virtual reality, immersive learning systems and web-based training: • Develop prototype virtual reality systems, test and evaluate performance • Include immersive learning for all types of fuel cycle facilities • Develop web-based tools for specific safeguards equipment • Develop signal (neutron/gamma) simulators to generate responses from equipment during training **(In support of Milestone 13.1)**	
Complete the publication of nuclear fuel cycle training manuals.	June 2016
Evaluate the effectiveness of immersive training for pressurized heavy water reactors and determine how the approach could be extended to fuel fabrication plants.	December 2016
Objective 6.) Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility. **(In support of Milestone 13.2).** SSAC courses have been reviewed in order to make better use of interactivity and visualization. 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.	
Develop and implement a training programme to support SSACs in developing their capabilities for collecting safeguards relevant information within the country and for conducting domestic inspections.	December 2017

4. Activities

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

Objective 1.) ***Contribute to the long-term attainment of ensuring the ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards.*** **(In support of Capability 1)**

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

Objective 2.) ***Contribute to the long-term attainment of ensuring the ability to detect undeclared nuclear material and activities.*** **(In support of Capability 2)**

Training needs are normally addressed by the annual Safeguards Departmental Training Programme. However, some new urgent training needs may emerge, which are not covered by planned training courses. A new course must then be designed at short notice, possibly requiring the support from experts or access to nuclear facilities, laboratories or sites from Member States offering different parts of the nuclear fuel cycle. Tasks FIN B 1949 and UK B 1936 provide this necessary flexibility.

A comprehensive set of training courses on information collection and analysis has been developed and will be complemented or updated as necessary:

- Training on Export Control Concepts and Standards from International Perspective, USA B 1800, is a key course, particularly for country officers and analysts. 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 1828.

- A State Evaluation Strategy seminar was developed on internal resources in 2010. This seminar is now a mandatory seminar for staff members of State Evaluation Groups (*Activity #1*).
- Training for Open Source Information Collection, SWE B 1838, has been updated to be more interactive and to integrate latest developments in web searching tools and techniques. Long-term support is requested.
- Satellite Imagery Training Courses, SWE B 1373, and Specialist Training for IAEA's Imagery Analysts, USA B 1442 and GER B 1456, managed under SGIM-002 project, should continue. The satellite imagery awareness training course focuses on how to take full advantage of satellite imagery for State evaluation and on-site activities, as an integrated training for inspectors and analysts.
- Analytical skills training is an important component of the training curriculum to support capability 2. It is provided by the USA under voluntary contributions.
- Developing Analytical Skills for Safeguards, UK B 1940, aims to provide staff, especially members of State Evaluation Groups, with required individual and collaborative analytical skills for taking advantage of all available information to perform consistency analysis of declared nuclear capabilities of States, to conduct nuclear material acquisition path analysis, and to prepare relevant information collection and processing plans. It 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. A course took place 6-10 July 2015 with IAEA trainers, and it went very well. Further to this course, two analysts who already took the course as trainees participated in a course in the UK. The objective was to expose future trainers/facilitators to a course conducted by UK trainers to train IAEA trainers on how to teach.
- 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 CA training courses, emphasis is put on definition of CA technical objectives and identification of location for conducting CAs (see below Workshop on Additional Protocol Activities, FIN B 1422, HUN B 1525, USA B 1415, and EC B 1563).

Objective 3.*) Develop training to reflect the approaches and equipment for safeguarding new types of facility, including consulting with States developing such facilities to help assess what training is required.* (In support of Milestone 3.3).

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 pyro-processing course at an engineering scale demonstration facility is being prepared for a pilot course to take place in 2016.

A training course on Laser Isotopes Separation Technology, FRA B 1506, is planned for 2016 and will be 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.

Objective 4.) *Contribute to the long-term attainment of ensuring the ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s).* (In support of Capability 13)

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, EC B 1750, which aims to provide experienced inspectors in charge of coordinating activities at facilities processing or storing plutonium or highly enriched uranium with an integrated set of analytical concepts and practical tools and techniques. The last offering of the course was in 2008. Discussions are taking place with the EC and the US to revive the course.
- A set of half-day seminars provides inspectors and analysts with the necessary background for understanding the mathematical rationale underlying safeguards verification strategies and the analytical treatment of quantitative data. It has been developed using internal resources with the support of SGIM (*Activity #3*).
- Nuclear Material Solution Accountancy and Verification Training, EC B 0620, and Training on Laser Range Finder, EC B 1844, remain part of the training programme and will be required on a long-term basis.
- With approximately 290 unattended and remote monitoring systems currently installed in the field, Training on Remote and Unattended Monitoring, USA B 1337, includes a generic part and a specific part. The course material is being updated to better reflect the new technologies and to incorporate real data sets in the practical exercises. A new course 'Training on Application of iRAP software for Unattended and Remote Monitoring' EC B 2019, is being developed. Both tasks will be required on a long-term basis.

Nuclear activities verification

- The Comprehensive Inspection Exercise for light water reactors is supported by CZ B 1431, HUN B 1065 and Slovakia, with BEL B 1433 as backup. These courses have been improved by strengthening the complementary access component. The successful completion of the course is mandatory for newly recruited inspectors after having completed the Introductory Course on Agency Safeguards (ICAS). Two courses per year will be required on a long-term basis.
- An Advanced Comprehensive Inspection Exercise at LWRs and CANDU reactors was successfully organized for the first time in 2010 in The Republic of Korea. It is supported by ROK B 1872 and will be required on a long term basis.
- The Comprehensive Inspection Exercise at Bulk Handling Facilities is supported by ROK B 1895 and SWE B 1328. At least two courses are necessary per year on a long term basis. A third location is therefore necessary, in case one facility is not available. Contact has been initiated with a new MSSP 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 USA, BEL, CZ, 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. It is expected to have this course in the future, including lessons learned from the 2012 pilot course.
- The IAEA's requirements for Inspector Training for CANDU Facilities, CAN B 1624, have been revised in order to focus on safeguards considerations for CANDU plants and the fuel monitor system.
- Training for inspection activities at JNC-1 site facilities organized jointly with the operator and State inspectors, JPN B 1812, focuses on fuel cycle related activities at JNC-1 and relevant safeguards approaches. It will be required on a long-term basis.
- Workshop on Additional Protocol Activities, FIN B 1422, HUN B 1525, USA B 1415, and EC B 1563, designed as full scope training for the implementation of complementary access (CA), is based on realistic scenarios jointly developed by the Department and the MSSPs. It has been expanded to train the inspectors on a wide range of facility types and operational situations. Emphasis is also put on the identification, definition and fulfilment of CA technical objectives. EC B 1563 has been revised with the support of ITU Karlsruhe and focuses on CAs at R&D centres. These are key courses of the training programme and will be required on a long-term basis.
- Technical Visits to Uranium Mines, CZ B 1526, and Training Course on Nuclear Material Accounting in Action, CZ B 1558, should continue.
- The 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. The first course is offered on an annual 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 FRA B 1708 and FIN B 1699. The first phase completed in 2009 under FRA B 1708 consisted in the identification of necessary and existing soft skills for safeguards activities through interviews and survey. The second phase consisted in designing training courses filling the gaps identified between necessary and existing soft skills. As an example, a course on Stress Management for Field Activities has been developed on internal resources (*Activity #2*). In addition, this task provided a sound basis to include specific needs for safeguards in the IAEA competency framework.
- A negotiation skills training course is supported by UK B 1874. Its objective is to train all safeguards staff responsible for negotiating safeguards implementation documents, like subsidiary agreements or facility attachments, or for dealing with State authorities on a routine basis.
- A writing skills course (four sessions per year) will be developed internally (*Activity #2*). 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 (*Activity #4)*.
- 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 (*Activity#5)*. 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.

Objective 5.) ***Develop training tools using advanced methods such as virtual reality, immersive learning systems and web-based training:***

- ***Develop prototype virtual reality systems, test and evaluate performance***
- ***Include immersive learning for all types of fuel cycle facilities***
- ***Develop web-based tools for specific safeguards equipment***
- ***Develop signal (neutron/gamma) simulators to generate responses from equipment during training.*** **(In support of Milestone 13.1)**

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. EC B 1876 aims at training facility officers and safeguards technicians in optimizing surveillance systems. ROK B 1907 offers a computerized model of a bulk handling facility for training inspectors on safeguards at this type of facility. These training tools are integrated into relevant training courses, such as those offered and supported by ROK B 1872, CAN B1624, UK 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, will 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. Five documents have been published: 'Fuel Fabrication', 'Research Reactors, Critical Assemblies and Accelerator Driven Neutron Sources', 'Nuclear Power Plants', 'Conversion' and 'Reprocessing'. 'Spent Fuel and Waste Management', 'Enrichment' and 'Mining and Milling' are being finalized.

Objective 6.) Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility. (In support of Milestone 13.2)

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

- 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;
- '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 2016 Traineeship Programme;

- International SSAC training courses, including for SQP States, organized in the US, funded by US voluntary contributions;
- Regional Training Course on SSAC, AUL B 1693, AUL B 1823 and BRZ B 1811;
- Consultations and Support to Member States, FRA B 1447;
- Training Courses for SSAC Personnel, RUS B 1107;
- 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 capacity building plans developed by Technical Cooperation, preparation of reference documents by Nuclear Security or Nuclear Energy, or monthly Infrastructure Coordination Meetings organized by Nuclear Energy, for areas of safeguards concerns.

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 Nonproliferation 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

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[11] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

[11] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	Supporting the implementation of the State-level concept	Develop training courses and curriculum following guidance documents for the implementation of the State-level concept.	December 2016
2	2	State evaluation strategy seminar	The seminar consists of stimulating overview lectures and practical exercises, involving introduction and use of the physical model, available and contemporary analytical tools and interactive role-play of two teams simulating developing a State-level Approach, followed by a review and discussion session.	Ongoing
3	3	Uranium hexafluoride sampling risks and safety course	To provide participants with an overview of the risks associated with UF_6 sampling, describe good handling practices and discuss practical planning aspects for in-field activities.	Ongoing
	4	Sampling logistic refresher training	To remind inspectors of the proper handling procedures for safeguards samples to ensure safety and to avoid delays in analytical process.	Ongoing
4	5	Stress management for field activities	The course provides the participants with a better understanding of their individual stressors and provides options for improving responsiveness and for managing stress more effectively in the field, especially in the context of CA visits.	Ongoing
	6	Writing skills course	Develop training to enable safeguards staff to report in a clear, concise and factual manner.	June 2016
	7	Set of half-day sessions on statistics, export information, accountancy related data processing and other specifics topics	To provide the participants with skills to improve the quality of communication and collaboration between inspectors and analysts by refining the understanding of the objectives and methods of probabilistic verification approaches and statistical data evaluation methodologies applied in safeguards.	Ongoing
1, 2, 3, 4, 5, 6	8	Providing of lecturers and technical training officers or coordinators	Support provided by all divisions, particularly Operations Divisions, for the implementation of the training programme.	Ongoing

4.3 Attachments

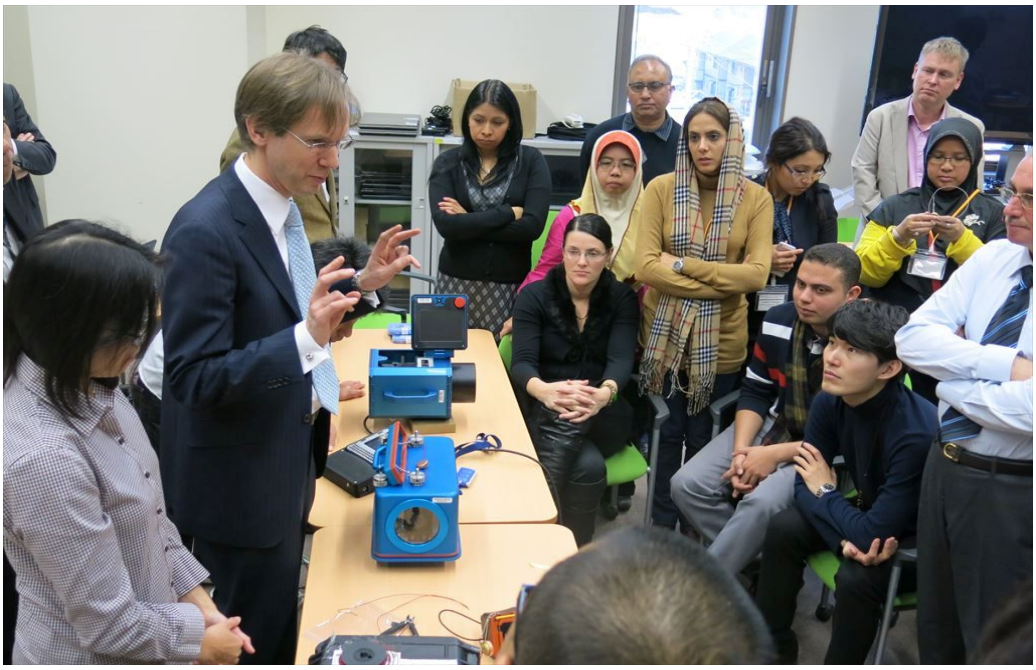

Figure 1. SSAC training in Tokai, Japan

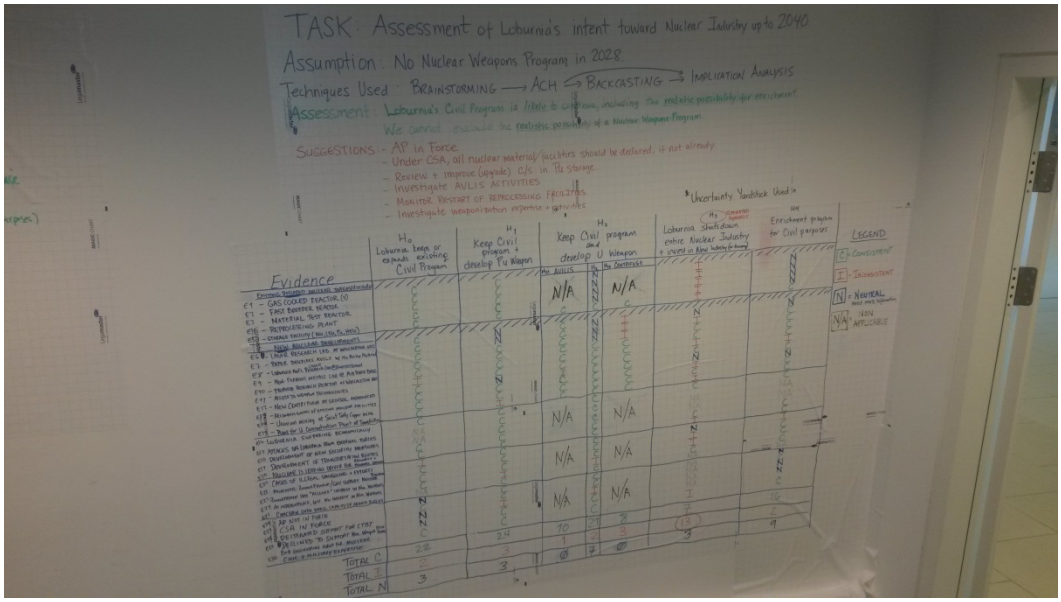

Figure 2. Risk assessment exercise

Figure 3. Analytical skills training

SGIM-002

Geospatial Information Analysis

Project Manager: Karen Steinmaus

Division: SGIM

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

1. Overview

This document describes the plans for developing and implementing Project SGIM-002 *Geospatial Information Analysis*, within the Department of Safeguards for the period 2016-2017.

During the 2016-2017 biennium, Project SGIM-002 will pursue the following Long-Term direction:

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

The project supports the Long-Term R&D plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
2. Increased ability to detect undeclared nuclear material and activities.	2.3 Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.	M
	2.4 Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.	M
8. Ability to use safeguards information in a fully integrated, secure environment, maintained and available to all who need it according to their role.	8.1 Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a Safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State.	H

Review and analysis of geospatial information is an accepted and essential element of the IAEA's verification of safeguards agreements. Geospatial information 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 NFC-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 geospatial information (imagery and imagery-derived products) in a timely manner.

For the 2016-2017 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 image processing and exploitation and allow opportunities for analysts to participate in technical visits to nuclear fuel cycle (NFC) facilities.
- Continue the development of new methods and capabilities that improve workflows and optimize use of resources, allowing analysts to focus on analysis.

2. Background

Geospatial information plays a significant role in monitoring nuclear fuel cycle (NFC) 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 IAEA's 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 Fukushima incident serves as an example (See *ICA Newsletter*). The use of Geographic Information System (GIS) technologies are 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 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, new 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 2012, the Division of Information Management (SGIM) fully deployed the Geospatial Exploitation System (GES) into the Department's Integrated Safeguards Environment (ISE). A Departmental goal for deploying and integrating software applications and systems into a secure IT environment (ISE) with a focus to provide access to geospatial information for those who need it was achieved. Integrating the GES into the ISE environment came as a significant achievement due to the complexity of the security requirements and methods used for protecting confidentiality. The GES provides capabilities for users across the Department to efficiently gain access to commercial satellite imagery, site plans and imagery analysis reports on a need to know basis. In the future, with the migration of more safeguards-relevant data and applications in 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 actionable geospatial information (imagery and imagery-derived products), the Department must recruit strong technical staff and provide them with training opportunities. 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. Objectives and Key Achievement Targets

In order to support Project SGIM-002's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium. Project SGIM-002's objectives and key achievement targets can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Evaluate and develop analytical methodologies, tools, and techniques for 'all source analysis' to detect signatures of undeclared activity, improve analysis of nuclear fuel cycles and support the State evaluation process. **(In support of Milestones 2.3 and 2.4)** In addition to existing sources of imagery, the IAEA seeks to constantly expand and diversify sources of imagery upon which to base its analysis. This serves to ensure the integrity and authenticity of satellite imagery as an open source of information.	
Evaluate and test new sensors, imaging capabilities, tools and techniques to enhance the analytical process and provide analysts with more and different information to support operational requirements.	July 2016
Objective 2.) Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a Safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State. **(In support of Milestone 8.1)**	
Successfully enable the consumption of information from other relevant applications (e.g., Additional Protocol Reporter and SGMD) exposing geospatial information to other applications in ISE to support collaborative analysis (e.g., State File, Collaborative Analysis Platform) in collaboration with SGIS-003.	March 2016
Complete planned upgrades to the GES.	December 2016

4. Activities

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

Objective 1.) ***Evaluate and develop analytical methodologies, tools, and techniques for 'all source analysis' to detect signatures of undeclared activity, improve analysis of nuclear fuel cycles and support the State evaluation process.*** **(In support of Milestones 2.3 and 2.4)**

A continuing issue for 2016-2017 is to expand and diversify sources of imagery upon which to base analysis 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. (See *2014 Safeguards Symposium paper EPR #736*). UK D 1819 provides experience from subject matter experts on priority tasks and on an ad-hoc basis. In 2015, a CFE radar specialist joined the section. A task proposal requesting assistance for establishing a workflow for the processing and analysis of high-resolution thermal IR remains outstanding (12/ISI-002). In 2016-2017, the expert's focus will be to assess the capabilities of space-based radar as a complement to already established optical satellite imagery for addressing safeguards requirements and establishing processing and analysis workflows to better integrate radar into SGIM's State Infrastructure Analysis (ISI) production. Task JNT D 1657 with the French, Japanese, US and German Support Programmes supports this effort.

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. The ability to accurately measure and represent height and elevation is sometimes critical from the standpoint of understanding function. Two tasks have supported this technical area- SWE D 1706 and GER D 1657. SWE D 1706 uniquely uses high-resolution optical image pairs to accurately measure building heights for constructing 3D models and assessing function. GER D 1657 is developing high-resolution digital surface models (DSM) of nuclear sites. Because of the confidentiality of safeguards information, the ability to generate this information in-house is required. Continued development is necessary on both tasks. ISI staff are also supporting SGTS-008 in the areas of inertial navigation and 3D laser scanning/measurements to support in-field capabilities.

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 support automating processing and analysis (Python and IDL workflows and geoprocessing tools) and 3D visualization/ modelling using commercial products such as ArcGIS Pro, ArcGIS Earth and Sketchup.

Staff in the section will also continue to benefit from technical visits to NFC sites/facilities with the active support and participation of Member States (CAN B 1484, GER B 1456, SWE B 1504). Similarly, attendance at remote-sensing and GIS industry events allows staff to stay current with 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.

Objective 2.) ***Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under Safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State.*** **(In support of Milestone 8.1)**

The IAEA has successfully deployed the Geospatial Exploitation System (GES) into the Department's Integrated Safeguards Environment (ISE), the first analytical capability to be deployed in ISE. The GES development was funded using a combination of regular budget and MSSP support (USA D 1477 and UK D 1329). The GES provides capabilities for users across the Department to efficiently gain access to commercial satellite imagery, site plans and imagery analysis reports on a need to know basis. In 2015, under the MOSAIC project (see Project SGIS-003), satellite imagery analysis reports were exposed to users through the State File. This provided another means of access for all satellite imagery analysis reports on all States to users across the Department on a need to know basis.

In 2016-2017, there is a need to fully integrate the satellite imagery reports with the State File to allow users to conduct full-text searches on all satellite imagery analysis reports within ISE. Within the Department, there is also a need to continue to improve access control management for applications within ISE. This is ongoing under SGIS' Authorization Management Project, which ultimately will provide application-independent access to information within ISE. SGIM continues to work with SGIS on requirements related to GES access control, policies that drive authorization decision-making, testing in SGIS' Test Environment, and deployment in the Production Environment. This will ensure that access control management is aligned across all data and applications in ISE. These activities are being conducted under SGIS-003, and in concert with SGIM-003. (See *2013 INMM paper EPR #429* and *2015 INMM paper EPR #592* for more information).

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[12] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	Evaluation of new sensor capabilities	ISI is working with SGTS-008 on evaluating new and evolving satellite capabilities (e.g., PlanetLabs)	2017
	2	Evaluation of new sensor capabilities	ISI is working with commercial vendors on evaluating new and evolving sensor capabilities (Google's Skybox, Urthcast)	Ongoing
2	3	Imagery from the EC/ESA	Under a (formal) voluntary contribution from the EC, ISI is receiving commercial satellite imagery from ESA's Copernicus Data Warehouse.	2020

[12] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

4.3 Attachments

Figure 1. SGIM analysts conducting collaborative analysis

Figure 2. SGIM analysts conducting collaborative analysis

Figure 3. An example of a site plan generated by SGIM-ISI

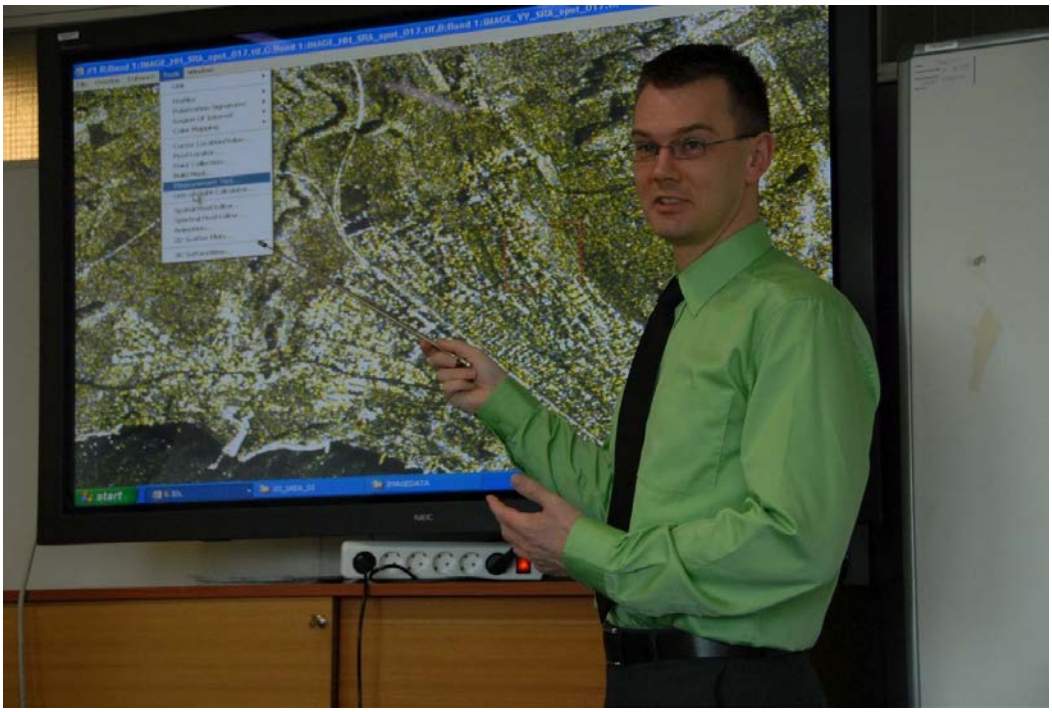

Figure 4. German Support Programme training in radar interpretation

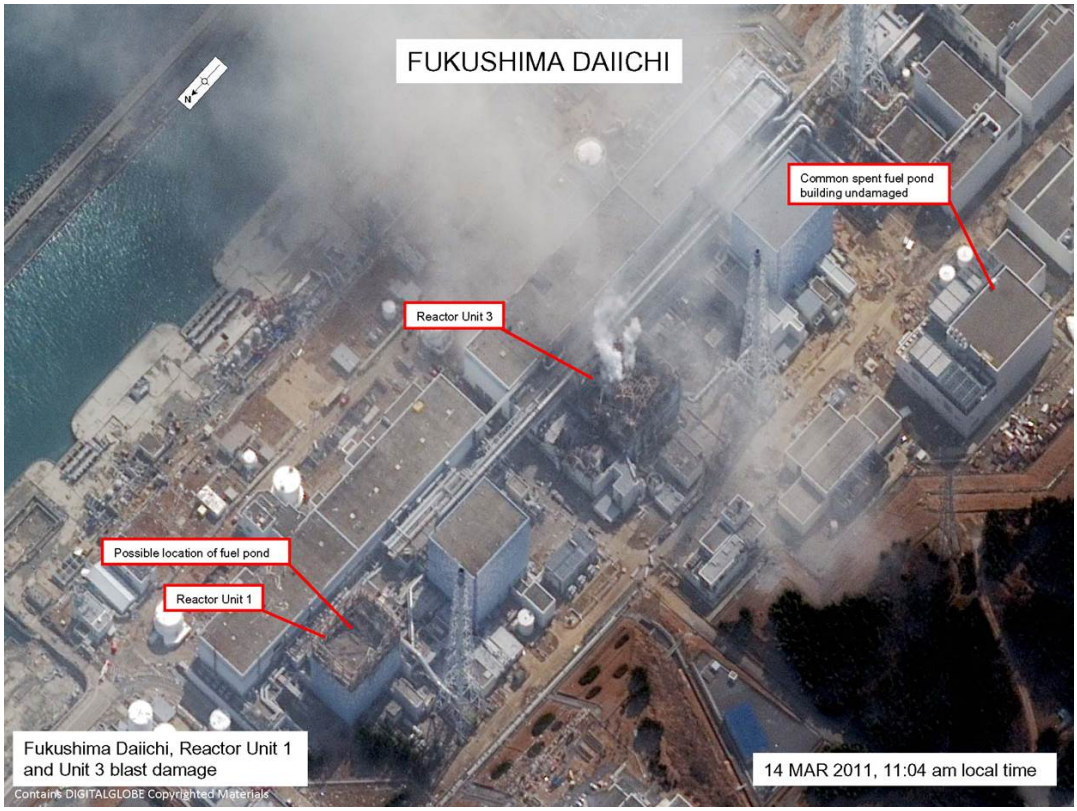

Figure 5. An example of the products provided to the IAEA's Incident and Emergency Centre (IEC)

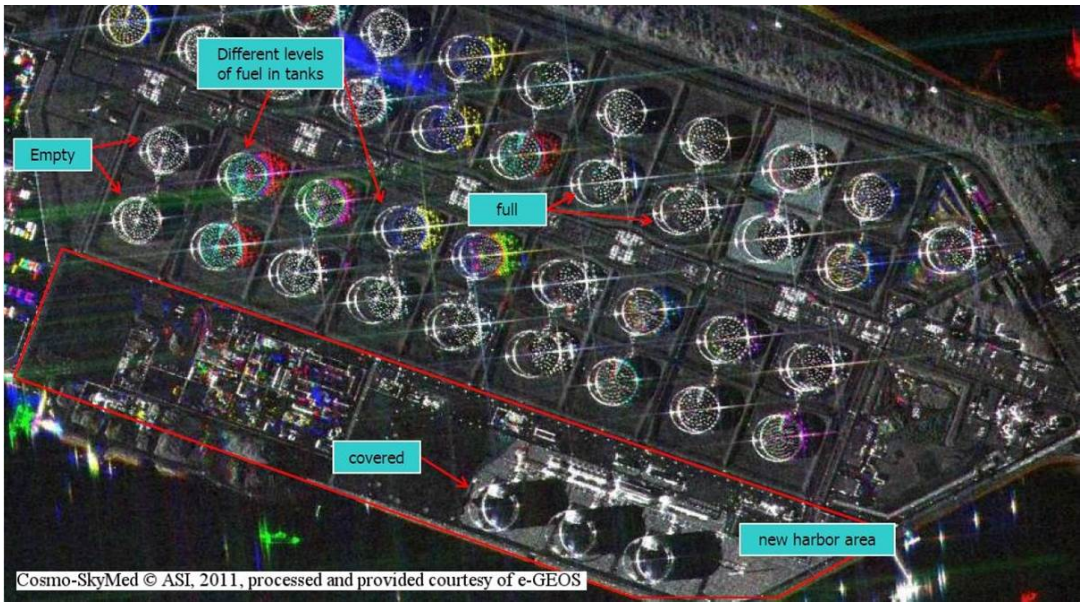

Figure 6. High-resolution SAR image of a fuel tank array

SGIM-003

Information Analysis

Project Manager: SH-ISF

Division: SGIM

1. Overview

This document describes plans for further developing methodologies and processes for the collection of open source information and their implementation. It also guides the development of improved technologies that aid in the collection, analysis, dissemination and management of open source information, including trade and procurement data, within the Department of Safeguards for the period 2016–2017.

During the 2016-1017 biennium, Project SGIM-003 will pursue the following Long-Term Direction:

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 project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
2. Increased ability to detect undeclared nuclear material and activities.	2.1 Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.	H
	2.3 Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.	M
	2.4 Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.	M

SGIM-003 focuses on 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 necessitate 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 2016-2017 biennium, the project's top priorities are:

- Evaluate data analysis methods and computerized tools to aid the analysis and presentation of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions;
- Refine and further integrate scientific and technical literature monitoring processes in support of State evaluation, acquisition path analysis, and in-field activities;
- Further enhance the Rapid News Service tool that was implemented last year to monitor news and streamline information management processes.

2. Background

Open source information, including trade and procurement data, can provide early indications of potentially undeclared nuclear activities. It is now routinely used to verify completeness and consistency of State declarations.

It is important that the collection and analysis of relevant data remain on par with the best of current practice; assistance of Member States and regular verification of the methodologies employed through workshops and in 2014 also through the Safeguards Symposium confirm this.

Open and other sources, such as trade and procurement data, are an important element of an effective safeguards system. Integration of safeguards relevant information from these sources complement States' declarations and information resulting from field activities, enabling a true verification process, including identification of indications that may be obtained on undeclared activities. Such information must be collected, organized, analysed and disseminated in a timely manner in support of the State evaluation process and other safeguards activities. Information is collected from a wide range of open sources, including international and national news media, commercial databases and government reports, and scientific and technical literature. Activities under this project contribute to the information analysis required to support the evaluation of States' nuclear activities provided in the State Evaluation Reports (SERs) and to support activities in the field, such as complementary access. In addition, the IAEA-wide dissemination of open source highlights on a daily basis maintains on-going awareness of safeguards and non-proliferation developments and issues.

The challenges and opportunities for open source information collection are still increasing, the result of an ever expanding world spanning information infrastructure. Meeting these challenges and opportunities effectively in support of drawing soundly-based safeguards conclusions requires on-going development and long-term investment in technology and tools that effectively collect relevant information, filter out 'noise', and organize valuable information in a clear and accessible manner. This project aims to guide and enhance these aspects of information collection, processing, analysis and dissemination.

While the Division of Information Management (SGIM) has the responsibility for developing open source processes, all Divisions within the Department are end users of such information; it is routinely used for the State evaluation process and for support of in-field activities.

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, and improving the technology and tools required.

3. Objectives and Key Achievement Targets

In order to support Project SGIM-003's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations. **(In support of Milestone 2.1)** In addition to existing sources of information, the IAEA seeks to constantly expand and diversify sources of safeguards relevant information upon which to base its analysis as well as fresh ideas how to best present the results of the analysis to support the drawing of safeguards conclusions.	
Continuous improvement of integrated, all source reporting through Member State assistance/ consulting, peer reviews, employment of highly qualified staff, and training.	Ongoing
An improved management system to anchor quality and generate better quantitative data on general open source contributions to the Department of Safeguards.	December 2016

Objective 2.) Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization. **(In support of Milestone 2.3)**	
Selection and implementation of methodologies that help analysis of large, disparate data sets through link analysis and visualization (tailored to SGIM needs, contributing towards collaborative analysis in the Department, and in line with MOSAIC (See SGIS-003)).	July 2016
In conjunction with SGCP-102, implement a new analytic training course for trade and procurement information.	March 2017
Objective 3.) Continuously improve the exploitation of information to the Department: evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in timely drawing soundly-based safeguards conclusions (in close cooperation with SGIS and tailored to both Departmental and SGIM needs). **(In support of Milestone 2.4)**	
Complete planned enhancements to the Rapid News Service tool to monitor news and streamline information management processes.	July 2017
Objective 4.) Identify and obtain specialized support and expertise on specific topics as Departmental needs arise.	

4. Activities

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

Objective 1.) ***Integration of all information available: integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, patent information, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.*** **(In support of Milestone 2.1)**

In addition to existing sources of information, the IAEA seeks to constantly expand the sources of safeguards relevant information upon which to base its analysis to support the drawing of its safeguards conclusions. This work has been on-going since 2008–2009 with regular budget funding and will be continued in 2016–2017. An improved management system, anchoring quality and enhancing quantitative reporting on the contribution made by open sources in support of Safeguards will be developed in 2016. The purpose of the improved management system would be to better track the Section's products. Member State support requested will include assistance in the identification and evaluation of sources (JPN D 1733, ROK D 1213, RUS D 1414).

A continuing issue for 2016–2017 is an increased emphasis on access to regional scientific and technical information, including additional translations of relevant non-English language information (UK D 1728, UK D 1730) and retrieval of information from new media (BEL D 1478, ROK D 1213, RUS D 1414, RSA D 1489, FRA D 1417).

Analysis of scientific and technical literature can provide indications of undeclared nuclear activity, 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 (10/ICA-008), 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. Further work needs to be done on development and implementation of methodologies that help analysis of large, disparate data sets through link analysis and visualization.

This will also complement the related work taking place under Project SGIM-002 *Geospatial Information Analysis*.

Objective 2.) ***Continuously improve the quality of information analysis: develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.*** **(In support of Milestone 2.3)**

New methodologies that help analysis of large, disparate data sets through link analysis and visualization will be developed that meet the needs of SGIM, spanning the entire range of analytical activity from the classification of information sources to efficient and effective information retrieval and may include further work on the development of a suited ontology, taking into account developments towards a common analytical platform in the Department.

Through activities in the past two years, a number of sources for trade and procurement data have been identified and evaluated for use. Support is needed to continue this process (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 Modernization of Safeguards Information Technology (MOSAIC, see SGIS-003) effort.

In order to provide comprehensive, pertinent analysis of safeguards-relevant information to State Evaluation Groups, analytical methodologies, tools and techniques must be further developed and refined, with a particular focus on the use of trade and procurement data. Training in support of such analysis (GER B 1560, FRA B 1768) has proven effective in raising the competence levels of analysts and will continue.

Continued support from Member States to make use of patent classification codes with respect to the Physical Model is needed; respective support from in-house experts has already been provided but not all areas of the Physical Model could be sufficiently covered. A number of new task proposals to cover this need will be issued during the 2016-2017 biennium.

Objective 3.) ***Continuously improve the exploitation of information to the Department: evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in timely drawing soundly-based safeguards conclusions (in close cooperation with SGIS and tailored to both Departmental and SGIM needs).*** **(In support of Milestone 2.4)**

The European Commission Joint Research Centre (JRC in Ispra) has facilitated the release to the Agency of their Rapid News Service (RNS) tool which works together with the European Media Monitor (EMM) to monitor news and create newsletters, aiding therefore an efficient and less time consuming SGIM Daily Highlights production and related article retrieval (EC D 1880). At present, a number of enhancements of RNS are taking place, including a more powerful search engine (faster and with the ability to monitor complete websites instead of just webpages), the introduction of bookmarking of sources by the user (instead of by an administrator only) and improving the user interface. The IAEA and JRC will explore a more effective use of enhanced tools available through JRC for all its information collection.

Objective 4.) ***Identify and obtain specialized support and expertise on specific topics as Departmental needs arise.***

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, FRA D 1417, UK D 1819, 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.

Several new task proposals seeking specialized fuel cycle expertise, either in the form of consultations or reports on Departmentally-specified questions, now provided by a CFE from the UK, will be readdressed towards the end of the 2016-2017 biennium. Member State support in this regard remains indispensable.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[13] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	Continuous improvement of integrated, all source reporting	In addition to existing sources of information, the IAEA seeks to constantly expand the sources of safeguards relevant information upon which to base its analysis as well as fresh ideas how to best present the results of the analysis to support the drawing of its safeguards conclusions. This work has been on-going since 2008–2009 with regular budget funding and will be continued in 2016–2017.	Ongoing
	2	An improved management system	In view of all improvements made, the management system for general open source contributions also needs reviewing in order to anchor quality and generate better quantitative data reflecting the contributions made to the Department.	December 2016
2	3	Further improved analytical methodology	Selection and implementation of methodologies that help analysis of large, disparate data sets through link analysis and visualization.	July 2016
	4	Trade Analysis Portal / OSTEP	Complete the prototype of an integrated portal for trade analysts including the Open Source Trade Exploration Project.	July 2016
	5	Analytic training course	In conjunction with SGCP-102, implement a new analytic training course for trade and procurement information.	March 2017
3	6	RNS completion	Complete planned enhancements to the Rapid News Service tool to monitor news and streamline information management processes.	July 2017

[13] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

SGIM-007

Evaluation of Data from Environmental Sampling and Material Characterisation

Project Manager: Diane Fischer

Division: SGIM

1. Overview

This document describes the plans for developing and implementing new capabilities for assessing results from environmental sampling the characterizing uranium materials within the Department of Safeguards for the period 2016–2017.

During the 2016-2017 biennium, Project SGIM-007 will pursue the following Long-Term Direction:

Enhance the IAEA's ability to structure, organize, 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 project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
2. Increased ability to detect undeclared nuclear material and activities.	2.2 Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools.	H
	2.5 Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results.	M

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 optimizing 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 2016-2017 biennium, the project's top priorities are:

- 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.
- 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.

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.

While the Division of Information Management (SGIM) is responsible for evaluation of environmental sampling and material characterisation data, the Operation Divisions within the Department are end users of such information, incorporating such information for the State evaluation process and for support of in-field activities. In view of advances in 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, as well as quality control of the entire process.

Most of the funding for this data evaluation 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 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 SGAS projects aimed at improving quality and reliability of the laboratory analyses of safeguards samples (SGAS-002 *Environmental Sample Analysis Techniques* and SGAS-003 *Sampling Logistics, Analysis Support and NWAL Coordination*).

3. Objectives and Key Achievement Targets

In order to support Project SGIM-007's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools. **(In support of Milestone 2.2)** 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.	
Obtain the collection of uranium impurity data and fuel burnup inventories from studies completed by Member States for integration into existing SGIM-IFC evaluation libraries.	December 2016
Objective 2.) Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results. **(In support of Milestone 2.5)** 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.	

Complete and deploy the prototype DAVE software for evaluation of trace element and isotopic signatures in uranium samples.	December 2016

4. Activities

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

Objective 1.) ***Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools.*** **(In support of Milestone 2.2)**

In the 2016-2017 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[14] 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, AUL A 1783, RSA A 1790, CAN A 1796, RUS A 1873, EC A1967, UK A 1968 and USA A 1973). Expansion of the MSTAR[15] enrichment application to include multiple streams (side-feed and/or side-product) and coupled cascades would be beneficial, and is under consideration (USA A 1498).

In addition, the IAEA is undertaking two studies in 2016-2017. The first will provide uranium isotopic signature data on commercially available uranium chemicals. The second will examine the detectable signatures related to a post-detonation nuclear event using the typical environmental sampling analytical methods. In addition, 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.

Objective 2.) ***Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results.*** **(In support of Milestone 2.5)**

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 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. The IAEA also seeks to investigate Bayesian statistical techniques to assess detection and/or confidence levels for environmental sampling.

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

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

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017. If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	2016 Technical Meeting on Analysis of Elemental Impurities in Uranium Samples	Second meeting with network laboratories involved with analysis of trace elements in uranium samples, to discuss current and future developments, and to draft recommendations for future actions. Organized in cooperation with SGAS. This was previously planned for September 2015, but was postponed to February 2016.	February 2016
	2	2016 Technical Meeting on Bulk Analysis for Environmental Sampling	Biennial meeting with Bulk Analytical Laboratories of the NWAL, in coordination with SGAS.	November 2016
	3	Second Inter-laboratory exercise on HRGS analysis of ES swipe samples	Inter-laboratory exercise to compare laboratory performance of HRGS analysis of common samples (QC swipe samples). Organized in cooperation with SGAS.	November 2016
	4	Isotopic determination of commercially available uranium chemicals	Commercially available uranium chemicals are used for calibration and QA purposes for a variety of instruments used for measuring uranium. Although the chemicals may be in use in nuclear facility laboratories around the world, the isotopic composition of the uranium is not known, but is generally thought to be DU. Chemicals from a number of vendors have been identified and will be purchased in early 2016. The isotopic composition of the chemicals will be determined by SAL/ESL. The results will be added to the database of known reference materials and documented in a technical paper. This is a joint effort between SGAS and SGIM.	December 2016
	5	Post-detonation signatures	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 are undergoing analysis. The results will be evaluated and documented in a technical	December 2016

			paper.	
	6	2017 Technical Meeting on Particle Analysis for Environmental Sampling	Biennial meeting with network laboratories involved with ES particle analysis, to discuss current and future developments, and to draft recommendations for future actions. Organized in coordination with SGAS.	November 2017
	7	SEM inter-laboratory comparison	In coordination with SGAS, SGIM-IFC will develop the objectives and sample parameters for the first SEM inter-laboratory comparison for particle analysis.	November 2017
2	8	Testing of the iDAVE search engine for assessing origin of uranium ore concentrates (UOC)	Staff assessment of iDAVE capabilities for identifying the origin of UOC through the use of known UOC samples. Initial tests have been completed and functional improvements to the software have been requested. When modifications to the software are made, testing will resume.	December 2016

4.3 Attachments

Figure 1. ES Evaluators collect swipe samples from trinitite rock samples for a study on nuclear post-detonation signatures

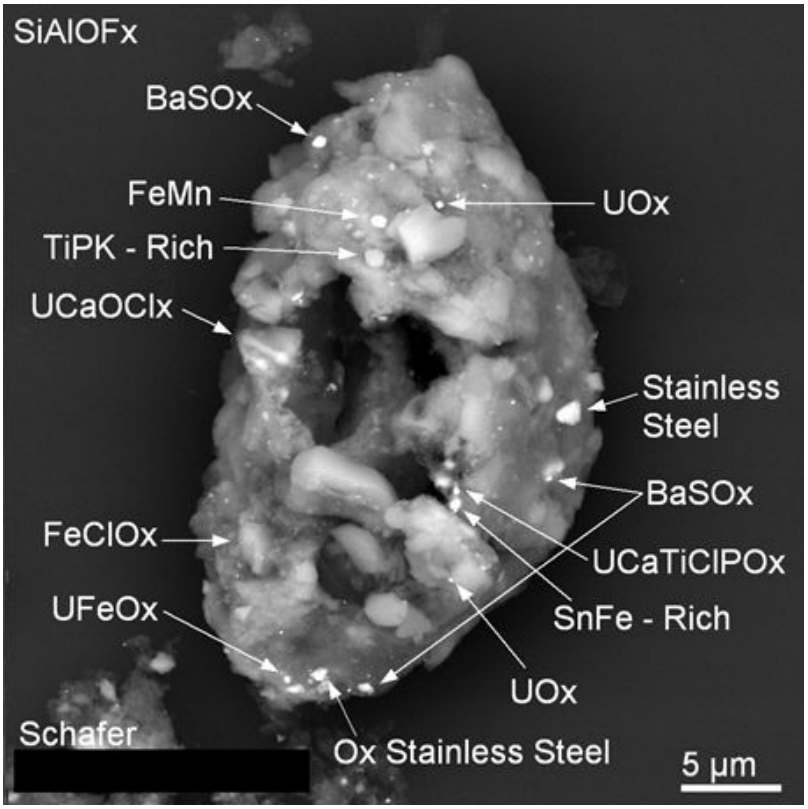

Figure 2. An example of chemical and elemental identification of inclusions in a particle

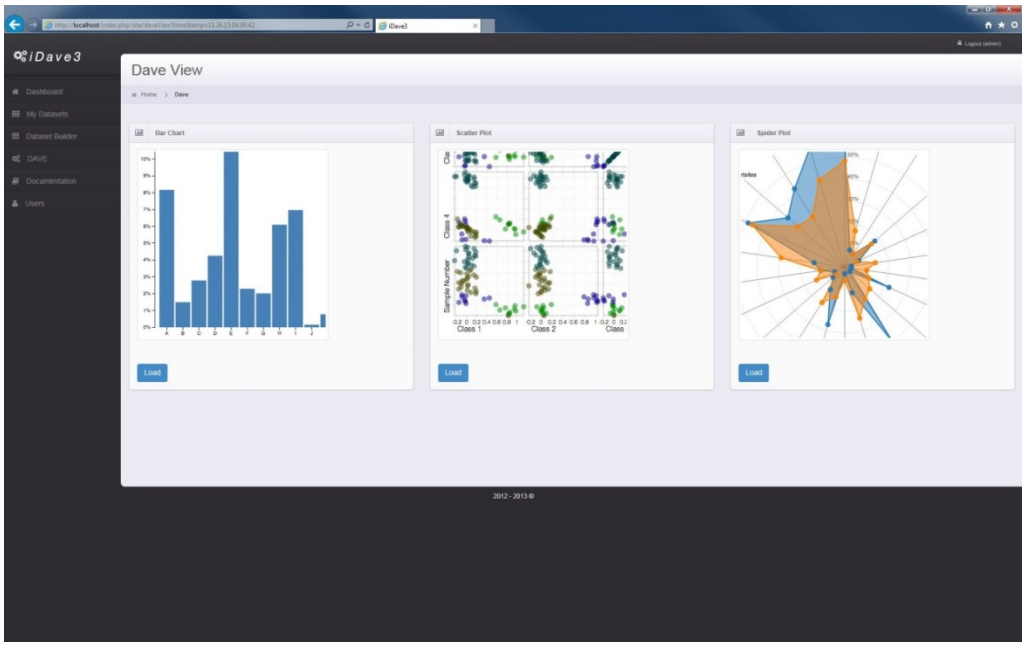

Figure 3. Screen shot of the DAVE application

SGIM-008

Statistical Analysis

Project Manager: Robert Binner

Division: SGIM

1. Overview

This document describes the plans to develop and implement 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 2016–2017.

During the 2016-2017 biennium, Project SGIM-008 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
2. Increased ability to detect undeclared nuclear material and activities.	2.5 Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results.	M

SGIM-008 addresses the development and enhancement of statistical methodologies in support of material balance evaluation, inspection/verification activities, and State-level 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; evaluating, reviewing and harmonizing random inspection schemes; developing an optimized Near-Real Time Accountancy (NRTA) system for plutonium bulk handling facilities (BHF); developing and enhancing data visualization tools for nuclear material flow and acquisition path analysis.

For the 2016-2017 biennium, the project's top priorities are:

- Review and harmonize current random inspection schemes through the development, refinement and documentation of methodologies and processes for implementation; evaluate their effectiveness.
- Review, update and consolidate the algorithms for the determination of measurement error uncertainties from calibration, paired-data, and 3-laboratory data analysis and for evaluating MUF, D, IMUF, and SRD.
- Enhance and further develop analytical methodologies in support of State-level evaluations in the areas of material balance evaluations, 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 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) 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 analyzed in a context of static 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, 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 upgrade existing statistical methodologies, to design new methodologies for the evaluation of verification data from safeguards implementation schemes and/or from innovative nuclear fuel cycle facilities, to develop new computerized evaluation and visualization tools for enhancing and streamlining the evaluation process, and to support the development of optimum random verification schemes.

As such, the end-users 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 heavily reliant on MSSP funding. In particular, Cost Free Experts (CFEs) are being used for methodological development and on support tasks in specific areas such as optimization approaches to inspection/verification design, process simulation software, and intelligent decision analysis support. CFEs may also be engaged for future tasks, for example to explore the use of Bayesian methodologies.

3. Objectives and Key Achievement Targets

In order to support Project SGIM-008's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objective:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results. **(In support of Milestone 2.5)** 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.	
Review and harmonize current random inspection schemes (including short notice random inspections (SNRIs)) and develop methodologies to evaluate their effectiveness. Publish the results, including procedures for their practical implementation, in a technical document. (See also SGCP-003)	December 2016
Review, update and consolidate the algorithms for the determination of measurement error uncertainties from operator-inspector paired-data, 3-laboratory data, and calibration data. Publish the methodology in a set of technical documents and upgrade the software application for its implementation.	December 2016
Review, update and consolidate the methodologies applied to the evaluation of MUF, D, IMUF, and SRD in the context of material balance evaluation. Publish the methodologies in a technical document and implement the relevant analytical software.	July 2017
Develop standardized methodologies for calculating detection probabilities achieved through verification activities on facility and State levels. Publish the methodologies in a technical document.	December 2017
Further develop and implement data visualization software for nuclear material flow analysis, and develop additional capabilities to the software to represent acquisition path analysis results, verification requirements and achieved verification results, using structured nuclear material accountancy and verification data. (See also SGIS-003)	July 2016 (initial production development) July 2017 (additional enhancement)

Develop a harmonized NRTA system in line with the requirements for the overall Rokkasho Reprocessing Plant (RRP) and J-MOX projects.	Target for RRP: December 2016
Develop Bayesian approaches making use of historical verification data in the evaluation of safeguards information, and publish guidance in a technical document.	December 2017
Demonstrate feasibility of intelligent systems for analyzing non-quantitative data, eliciting analyst conclusions, and aggregating analyst conclusions across multiple disparate data sources in order to assist analysts in articulating the level of confidence in their assessments. Publish study results and recommendations in a technical document. (See also SGIS-003)	December 2017
Investigate accountancy and measurement requirements and gather experience with factors affecting material balance evaluation at pyro-processing facilities. (See also SGCP-003)	December 2017

4. Activities

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

Objective 1.) ***Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results.*** **(In support of Milestone 2.5)**

Many of the standard analytical processes (error estimation algorithms, material balance methodologies and statistical tests) were developed 20-30 years ago. In light of the advancements in IT technology and statistical concepts these processes are in need of review and enhancements.

The planned activities to meet each of the Key Achievement Targets are:

Review and harmonize current random inspection schemes (including SNRIs) and develop methodologies to evaluate their effectiveness. Publish the results, including procedures for their practical implementation in a technical document.

This target will be met through in-house development work, support from a MSSP task (GER D 1925), and through regular budget resources (SGIM-IFC staff and consultancy). The various random inspection schemes applied for safeguards verification activities (e.g., SNRIs, RIIs, UIs, random PIVs) need to be methodically evaluated by quantifying their effectiveness in terms of achieved detection probabilities. The schemes also need to be harmonized in terms of standardized requirements for meeting their technical objectives. This work will be performed in consultation with SGCP to achieve a uniform standard for implementing particular random inspection schemes throughout the department.

Review, update and consolidate the algorithms for the determination of measurement error uncertainties from operator-inspector paired-data, 3-laboratory data, and calibration data. Publish the methodology in a set of technical documents and upgrade the software application for its implementation.

This target will be met through in-house development work and through regular budget resources (SGIM-IFC staff and consultancy). A consultant has developed prototype software determining the optimal error estimates from operator-inspector paired measurement data and 3-laboratory data (OPTANOVA). It will be thoroughly tested by simulation studies, and the error estimation methodology will be thoroughly reviewed. If necessary, it will be enhanced or expanded by additional estimators. After this thorough review and testing, the software is intended to be put into routine use for error estimate calculations.

Review, update and consolidate the methodologies applied to the evaluation of MUF, D, IMUF, and SRD in the context of material balance evaluation. Publish the methodologies in a technical document and implement the relevant analytical software.

This target will be met through in-house development work through major support from extrabudgetary staff and through regular budget resources (SGIM-IFC staff). The basic statistical tests employed in material balance evaluations to judge the statistical significances of MUF, D, IMUF, and SRD have been unchanged for over 20 years.

In light of the re-engineering project for statistical analysis software which is beginning in November 2015, the methodologies and statistical tests associated with evaluating the material balance and determining achieved detection probabilities will be thoroughly reviewed and enhanced.

Develop standardized methodologies for calculating detection probabilities achieved through verification activities on facility and State levels. Publish the methodologies in a technical document.

This target will mainly be met through regular budget resources (SGIM-IFC staff and consultancy). Additional task proposals to meet this target will be prepared and issued during the 2016-17 biennium. No standardized methodology for calculating achieved detection probabilities at facility or State level through verification activities exists. Especially in light of the development of performance targets for evaluating the effectiveness of State-level approaches, such standardized methodologies will be developed and documented.

Further develop and implement data visualization software for nuclear material flow analysis, and develop additional capabilities to the software to represent acquisition path analysis results, verification requirements and achieved verification results, using structured nuclear material accountancy and verification data.

This target will mainly be met through in-house development work (SGIM-IFC staff and consultancy). Prototype visualization software for nuclear material flows at the State level has been developed by SGIM-IFC, and additional capabilities for this software will be developed. These include animation capabilities to show flows over selected time periods, selection of nuclear material types to display, customization of the layout of displayed facilities, display of additional information such as applied verification levels and achieved detection probabilities, and overlaying results of acquisition path analysis.

Develop a harmonized NRTA system in line with the requirements for the overall Rokkasho Reprocessing Plant (RRP) and J-MOX projects.

This target will be met through in-house development work. Due to the very uncertain time-frame regarding the start-up of RRP and of J-MOX, the amount of resources available for this task are currently limited. Additional support from Member States may be needed and relevant task proposals will be issued depending on the projected start-up dates for these facilities. This task also complements related work taking place for project SGOA-002 (Safeguards System for JNFL MOX Fuel Fabrication Plant) under task UK D 1878.

Develop Bayesian approaches making use of historical verification data in the evaluation of safeguards information, and publish guidance in a technical document.

This target will be met through support by MSSP tasks, for which task proposals will be prepared and issued during the 2016-17 biennium.

Investigate 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. Publish study results and recommendations in a technical document.

This target will be met through a support task (BEL D 1927), and by demonstrating the feasibility of intelligent systems which apply fuzzy logic for analyzing non-quantitative data, eliciting analyst conclusions and aggregating them across multiple disparate data sources in order to assist analysts in articulating the level of confidence in their assessments.

Investigate accountancy and measurement requirements and gather experience with factors affecting material balance evaluation at pyro-processing facilities.

This task will be met by maintaining SGIM-IFC's liaison with the Joint Fuel Cycle Study SSWG, exchanging process, accountancy and measurement information from the integrated recycling tests (IRT) and other experiments conducted under the JFCS, and documenting the outcomes. This task also complements related work taking place for Project SGCP-003 *Safeguards Approaches*.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[16] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	Development of evaluation methodologies for random inspection schemes	The various random inspection schemes applied for safeguards verification activities (e.g., SNRIs, RIIs, UIs, random PIVs) need to be methodically evaluated in terms of quantifying their effectiveness in terms of achieved detection probabilities and harmonized in terms of standardized requirements.	December 2016
	2	Review, update and consolidate the algorithms for the determination of measurement error uncertainties from operator-inspector paired-data	Software for error estimation has been developed and will be modified and enhanced through a SSA consultancy (OPTANOVA methodology consultancy).	December 2016
	3	Review, update and consolidate the methodologies applied to the evaluation of MUF, D, IMUF, and SRD in the context of material balance evaluation	The methodologies and statistical tests associated with evaluating the material balance and determining achieved detection probabilities are being thoroughly reviewed and enhanced.	July 2017

[16] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

	4	Development of visualization software for State Nuclear Material Flow (Snakey)	The Snakey software generates state nuclear material flow diagrams, depicting all NM flows for a specified time period between all facilities in a State by material type and magnitude. Various enhancements to the software (including animation capabilities to show flows over selected time periods, selection of nuclear material types to display, customization of the layout of displayed facilities, display of additional information such as applied verification levels and achieved detection probabilities, and overlaying results of acquisition path analysis) are under development.	July 2017
	5	Development of NRTA system for the Rokkasho Reprocessing Plant (RRP) and J-MOX projects in line with the projected start-up dates for these facilities	Develop a harmonized NRTA system for RRP and J-MOX.	December 2016 (for RRP)

SGIM-009

State Declared Information Management

Project Manager: Alain Rialhe

Division: SGIM

1. Overview

This document describes the plans for developing and implementing the process and methodologies to collect, analyze and manage State declared information within the Department of Safeguards for the period 2016–2017.

During the 2016-1017 biennium, Project SGIM-009 will pursue the following Long-Term Direction:

Enhance the IAEA's ability to collect, manage, analyze 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 project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
2. Increased ability to detect undeclared nuclear material and activities.	2.1 Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.	H
	2.4 Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.	M
8. Ability to use safeguards information in a fully integrated, secure environment, maintained and available to all who need it according to their role.	8.1 Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State.	H
	8.2 Create links between exemptions and terminations of nuclear material with the nuclear material accounting database to allow automatic checking of State reporting.	H
9. Ability to communicate secure, authentic information that is fully compatible with ISE between the IAEA, SRAs and inspectors/equipment in the field.	9.1 Develop 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.	M
	9.2 Deploy secure and authenticated communications between the IAEA and SRAs.	M
13. Ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s).	13.2 Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility.	M

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 and the IAEA and on integrating different information sources to detect inconsistencies in nuclear programs and States' declarations in support of the State evaluation process. The rapidly expanding volume of safeguards-relevant information, as well as the constantly changing IT environment, pose 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 2016-2017 biennium, the project's top priorities are:

- Update and deploy tools and methodologies for States to collect, store and submit State declaration information.
- Improve the tools and methodologies for information exchange between States and the IAEA by implementing a web-based portal for the online submission of State declared information by SRAs.
- Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of State declared information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.
- Continue efforts with Member States to enable provision of digital state-declared spatial information using standard, compatible formats, which allow the IAEA to directly ingest this information into existing and evolving information systems.

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 during recent years to develop proper analytical methods in support of safeguards activities.

Key attributes of the IAEA's operating environment include communication with a diverse set of State authorities. This has necessitated different means of communication with secure, reliable and efficient transfer of information.

Over the past several years, information technology has changed drastically. This opens up new avenues for more efficient exchange and management of information in an environment of increased concerns regarding information security. This change has impacted the design of the IAEA's secure IT platform '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 *Safeguards Information Systems and System Usability* and SGIS-002 *Information Security and Infrastructure*.

Some major recent achievements in that context include the successful migration of data and analysis codes from a mainframe based IT system to a distributed server architecture that has a more modern 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 domains in the Division of Information Management (SGIM) and interlaces with the Department's verification activities.

Most of the funding for declared information management comes from the Department's regular budget. 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 *Safeguards Information Systems and System Usability*.

3. Objectives and Key Achievement Targets

In order to support Project SGIM-009's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date

Objective 1.) Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations. **(In support of Milestone 2.1)**	
Make available all State declared data, the associated authority data and related analytical assessments (including AP information and GIS data) on one common platform for analysts.	December 2017
Objective 2.) Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions. (**In support of Milestone 2.4**)	
Develop a methodology and tool that utilizes deterministic and heuristic methods for identifying safeguards relevant issues within a large stream of diverse but related information.	December 2017
Objective 3.) Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State. (**In support of Milestone 8.1**)	
Enable reliable, electronic availability of data items contained in verbose documents such as subsidiary arrangements and facility attachments.	December 2017
Objective 4.) Create links between exemptions and terminations of nuclear material with the nuclear material accounting database to allow automatic checking of State reporting. **(In support of Milestone 8.2)**	
Objective 5.) Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file. **(In support of Milestone 9.1)**	
Deploy the updated software packages PR (Protocol Reporter) software for Additional Protocol declarations and QCVS (Quality Control Verification Software) for nuclear material accountancy reports to SRAs.	December 2017
Develop and implement a framework to enable States to provide digital, GIS-ready site maps attached to additional protocol declarations under Article 2.a.(iii) declarations in close collaboration with SGIM-002.	December 2017
Objective 6.) Deploy secure and authenticated communications between the IAEA and SRAs. **(In support of Milestone 9.2)**	
Develop and implement a means of secure, electronic two-way communication (as a web-based portal) between the IAEA and the relevant State Authorities.	December 2017
Objective 7.) Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility**. (In support of Milestone 13.2)**	
Increase the quality and availability of training material and tools for SRAs in the context of State declared information provision, including for remote training delivery.	December 2017

4. Activities

Most of the following activities will be performed by Safeguards Department personnel with regular budget support. Further assistance will be required from Member State Support Programs for some activities.

Objective 1.) ***Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.*** **(In support of Milestone 2.1)**

In the coming biennium, the IAEA will work to provide efficient access to data sources that enable analysts to cross reference and integrate information items in a flexible and powerful manner. This can be achieved by running ad-

hoc SQL queries against data sources and processing the query results in a general purpose programing environment. This work is expected to be pursued with regular budget resources.

The successful implementation of this activity requires the identification and implementation of efficient low-level tools and related staff training.

Objective 2.) ***Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.*** **(In support of Milestone 2.4)**

In 2016-2017, the IAEA will train staff in statistical and semantic methodology for all-source information analysis and introduce suitable tools. Project SGIM-009 will work with Project SGCP-102 towards this objective.

Objective 3.) ***Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State.*** **(In support of Milestone 8.1)**

In 2016-2017, Project SGIM-009 will work to develop and implement an ontology that covers safeguards information that is drawn from disparate sources. This activity spans the entire range of analytical activity from the classification of information sources and information items to the practical implementation of an efficient and effective means of information retrieval. This work is expected to be pursued with regular budget resources in collaboration with SGIS.

Objective 4.) ***Create links between exemptions and terminations of nuclear material with the nuclear material accounting database to allow automatic checking of State reporting.*** **(In support of Milestone 8.2)**

SGIM-009 will develop and deploy 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.

Objective 5.) ***Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file.*** **(In support of Milestone 9.1)**

Ongoing activity under this objective focuses on the upgrade of software tools for preparing AP declarations and nuclear material accounting reports. The 'Protocol Reporter' software, which is intended to assist States in the creation, management and submission of declarations pursuant to their obligations under the Additional Protocol, is currently developed with MSSP support but additional support for the testing phase will be required. The re-development or substantial update of the 'QCVS' software, which is distributed to 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.

To date, four MSSPs have accepted the Digital Declaration Site Maps (DDSM) task. Significant progress has been realized with each of these MSSPs. Under GER D 1983, the IAEA established a framework document specifying the requirements for providing digital declaration site map data in a geospatial format as an attachment to the 2.a.(iii) declaration in close collaboration with the SGIM-002. Using the specifications outlined in the framework document, Germany (GER D 1983) and Canada (CAN D 1967) each successfully submitted digital declaration site maps. The submitted information gave the IAEA the opportunity to evaluate the ability of site operators to follow the specifications in accordance with declaration submissions and the IAEA's site plans. As a result of these submissions, the IAEA provided feedback about the submissions, and subsequently edited the framework document based on findings and lessons learned from the process. For Germany, a regular budget contract was established with the University of Bonn to create digital site maps for the majority of German NFC sites. The resulting datasets may be used by site operators for future declaration submissions and will increase the motivation of site operators to modernize their processes for generating site maps. The IAEA benefited from the data, since the sites are now accurately represented in the GES. Meetings were held with both Finland (FIN D 1996) and Japan (JAP D 1995) to select candidate sites and begin this same process.

A continuing need for 2016-2017 is to optimize the process of submitting digital declaration site maps. As an example, feedback provided to Canada on their initial digital submission will be incorporated into their 2016 digital declaration. Additionally, the site operator provided valuable feedback on the framework document which will be incorporated into the document. In Finland, one of the two operators committed to the task is currently planning the construction of their first NPP and the operator is expected to utilise the benefits of the DDSM task when designing their initial reporting activities. Both Finnish operators and SRA (STUK) are currently developing their processes for digital data submission, and they will deliver their first digital declaration site maps in 2016. Finland has also shown interest in expanding the task to include all their NFC sites under the 2.a.(iii) declaration. The IAEA is working with site operators to better understand their existing systems and methods to convert the data to a compatible format with the GES.

Another challenge for the next biennium is to establish a capability for SRAs to review, approve, store and submit (to the IAEA) digital declaration site maps. This must consider confidentiality issues, highly secure electronic transmission, standardization, etc. and will be addressed in future stages. Germany has designated two additional sites for this task and is currently working with the site operators on the submissions. Additionally, Germany and Finland will be in communication with EURATOM to document the feasibility of EURATOM accepting the site maps through the Additional Protocol submission process and software. The IAEA acknowledges that the implementation process of a digital declaration framework depends very much on the situation in each State. A workflow and implementation procedure tailored to the specific requirements of the respective State is probably necessary. Accordingly, the IAEA seeks acceptance from more States to enable it to refine the specifications and streamline the processes to establish a longer-term, generic requirements for digital declaration site maps (15/ISI-001). (See *2014 Safeguards Symposium Paper EPR #720* and *S02-07*).

Objective 6.) ***Deploy secure and authenticated communications between the IAEA and SRAs.*** **(In support of Milestone 9.2)**

Ongoing activity under this objective aims to upgrade the paper based communications and the (one-way) electronic communication through encrypted email attachment. A 'State Declarations Portal' feasibility study is currently under analysis by IAEA Staff, but further MSSP support is required for the requirements elicitation and the shaping and testing of the final solution, as a web-based portal, for the online submission of State declared information by SRAs to the SGIM Declared Information Analysis Section (SGIM/ISD).

An SDP MOSAIC project will start in 2016, which will include four phases: proof of concept, initial SRA trial period and SDP enhancement, extended trial period and full SDP implementation.

Objective 7.) ***Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility.*** **(In support of Milestone 13.2)**

The IAEA is currently in the process of updating software products that are distributed to Member States, and developing new means of communication with State Authorities via the State Declarations Portal. As a result, an activity to develop new, appropriate training materials is urgently required. In order to support SRA training 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 new or updated training contents as well as for remote delivery methods. It is expected that new task requests will be pursued to address these objectives in the 2016-2017 biennium.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[17] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

[17] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

SGIS-002

Information Security and Infrastructure

Project Manager: Michael Scott Partee

Division: SGIS

1. Overview

This document describes the plans for developing and implementing Information Security and Infrastructure within the Department of Safeguards for the period 2016–2017. During the creation of this plan, the information security projects within MOSAIC and the IAEA's Five Year Security Roadmap were also considered to ensure that SGIS-002 represents the Department's specific information security and infrastructure needs for the biennium.

During the 2016-2017 biennium, Project SGIS-002 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
8. Ability to use safeguards information in a fully integrated, secure environment, maintained and available to all who need it according to their role.	8.1 Implement a set of solutions to automate and improve the detection of events, system anomalies, and activities in the Department's information systems – particularly in the case of the Integrated Safeguards Environment (ISE).	H
9. Ability to communicate secure, authentic information that is fully compatible with ISE between the IAEA, SRAs and inspectors/equipment in the field.	9.3 Deploy secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices.	M
	9.4 Ensure the Department's ability to recover from an IT failure.	H

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 2016-2017 biennium, the project's top priorities are:

- Implement a set of solutions to automate and improve the detection of events, system anomalies, and activities in the Department's information systems – particularly in the case of the Integrated Safeguards Environment (ISE).
- Attain independent assessments of specific solutions for risk and vulnerabilities; supplement internal capacity to perform comprehensive or targeted penetration tests in efforts to improve the Department's security configurations and system designs.
- 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 virtualized computing technologies and sandboxing 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 2016-2017 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 and information exchange opportunities.

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

3. Objectives and Key Achievement Targets

In order to support Project SGIS-002's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/ or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Implement a set of solutions to automate and improve the 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 Milestone 8.1)** Under this objective, the Department will leverage nascent 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.	
Develop baselines of information system activities in the Department's secure computing environments in order to then build detection capabilities for anomalous behaviours which could indicate compromise or misuse.	March 2017
Create a "big data" platform for the long-term storage and subsequent reporting to improve security measurements, correlations, incident review, and threat intelligence capabilities in the Department's secure network.	December 2017

Objective 2.) Obtain independent assessments of specific solutions for risk and vulnerabilities as well as to supplement internal capacity to perform comprehensive or targeted penetration tests in efforts to improve the Department's security configurations and system designs.	
Perform vulnerability assessments and penetration tests in order to identify potential issues with system configurations, to design solutions, and to verify security controls.	Ongoing
Assess the maturity level of the Secure Software Development Lifecycle in place within the Department and provide an improvement guide based on risk.	March 2016
Objective 3.) 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.	
Provide internal misuse training for Departmental IT security staff.	2016
Train 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.	2016-2017
Conduct a training course on utilizing encryption and other cryptographic techniques in services-oriented application development projects.	May 2016
Objective 4.) Add endpoint and server security protection capabilities of the Department's IT infrastructure with additional security functions through the use of virtualized computing technologies and sandboxing techniques. **(In support of Milestone 8.1)**	
Investigate the use of automated dynamic analysis of email and web content to detect suspicious network traffic, file modifications, or configuration changes within the Department's in-house email system.	September 2016
Identify and implement a solution to mitigate threats from the use of web browsing on the Department's computers through the use of non-persistent, virtualized computing resources.	April 2017
Create secured, thin-client access to the Department's networking resources based on virtualized desktop computing technology.	December 2017
Objective 5.) Deploy secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices. **(In support of Milestone 9.3)**	
Objective 6.) Ensure the Department's ability to recover from an IT failure. **(In support of Milestone 9.4)**	
Design, implement and test IT infrastructure to ensure the operational continuity of core IT services to the Department of Safeguards. Build in 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.	May 2017
Objective 7.) Support 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 Milestone 8.1)** This objective 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.	

4. Activities

Most of the following activities will be performed by Safeguards Department personnel. Further assistance will be required for Member State Support Programmes for some activities. This is especially true in terms of timeliness and, in some cases, expertise that may reside outside of the IAEA.

Objective 1.) ***Implement a set of solutions to automate and improve the 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 Milestone 8.1)**

In the previous two biennia, MSSPs have supported the development of the Department's incident detection and digital forensics capabilities through a combination of training and a task to enhance IT forensics capabilities (ESP D 1921). Through this task, the Department gained advanced expertise in working with an information security environment. In 2016-2017, the Department seeks to improve and expand this capability through the introduction of several new tasks, which will be mapped to specific achievement targets. These efforts will work in concert with the IAEA's overall efforts to increase event detection capabilities throughout the IAEA.

New Task Proposal #1 will request MSSP support to provide tools and expertise to develop a baseline of the events and activities on the Department's computer systems and to then create mechanisms that will alert the Department's security responders to anomalous behaviors.

New Task Proposal #2 will request MSSP support to enhance the existing event collection system and develop interfaces to a "big data" platform to provide additional long-term correlation and review capabilities, as well as to add a layer of security threat intelligence reporting so that event information on the IT systems can be used to build indicators of compromise and threat characteristics.

Objective 2.) ***Obtain independent assessments of specific solutions for risk and vulnerabilities as well as to supplement internal capacity to perform comprehensive or targeted penetration tests in efforts to improve the Department's security configurations and system designs.***

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 2016-2017, 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.

New Task Proposal #3 will request 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.

Objective 3.) ***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.***

Keeping abreast of the latest techniques, tools, threats, and technologies is a major component of ensuring that the Department's IT, software, and equipment development 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 supported such training in the past.

New Task Proposal #4 will request support for an effort to ensure that the Department's incident response teams can participate in the Forum of Incident Response and Security Teams (FIRST) – a collective of the world's leading IT security incident response teams in which the IAEA is seeking membership. Membership in FIRST would help to ensure that the IAEA's incident responders are accepted as trusted members of the world's security incident response teams and, as such, gain access to the latest internet-based threat information in real time.

New Task proposal #5 will request that MSSPs provide or sponsor internal misuse techniques training for the Department's security and systems development teams. The intentional or unintentional misuse of safeguards information within the secure information systems poses the greatest risk of unwanted destruction, unauthorized

disclosure, and detrimental alteration to such information. Using new techniques and tools to detect and immediately respond to such misuse is a primary area of mastery for the Department to achieve in order to use safeguards information in an integrated and secure environment.

New Task Proposal #6 will request support 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, but the commercial arrangements necessary to provide such training are negotiated and established in order to provide cost-effective training for larger target groups. This serves the overall training needs of the IAEA well. However, such arrangements do not cover rapid developments, niche markets, and stretch capabilities that are often necessary for the Department's staff members, who are 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,

New Task Proposal #7 The Safeguards Security Model project will necessitate that developers, systems engineers, network engineers, equipment engineers, service desk, and other IT staff are trained in cryptographic techniques. This request would seek targeted training in cryptography techniques for various audiences in order to ensure that needed capabilities are within the Department's IT staff members' expertise and knowledge.

Objective 4.) ***Add endpoint and server security protection capabilities of the Department's IT infrastructure with additional security functions through the use of virtualized computing technologies and sandboxing techniques.*** **(In support of Milestone 8.1)**

The development of the Integrated Safeguards Environment was a positive step forward for the Department's information security. However, the Department retains a computing environment which requires internet access for accessing web-based resources and internet email. Therefore, the systems on this network are exposed to internet-based threats and, given the risk this poses to safeguards information, additional mitigating measures must be put in place.

New Task Proposal #8 will request MSSP support to investigate the use of automated dynamic analysis of email and web content run in a sandbox to detect suspicious behavior, including attempts to illicitly generate network traffic, create or modify files, or change configurations. This effort would then provide implementation assistance for the highest value solution to protect the Department's in-house email system.

New Task Proposal #9 will request support 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.

New Task Proposal #10 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.

Objective 5.) ***Deploy secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices.*** **(In support of Milestone 9.3)**

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.

New Task Proposal #11 will request MSSP support 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.

Objective 6.) ***Ensure the Department's ability to recover from an IT failure.*** **(In support of Milestone 9.4)**

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.

New Task Proposal #12 will request support for business continuity and disaster recovery expertise and guidance to aid in successfully delivering this objective. 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.

New Task Proposal #13 requests Member States' support to 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.

Objective 7.) ***Support 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 Milestone 8.1)**

Provide or support consultations, assessments, and expert engagements to provide assurance for project deliverables in the authorization management, information classification, and information access management areas.

New Task Proposal #14 seeks contributions from Member States to provide 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

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[18] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

[18] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

SGIS-003

Safeguards Information Systems and System Usability

Project Manager: Gregg Whitaker

Division: SGIS

1. Overview

This document describes the plans for developing and implementing an integrated information technology (IT) system to support the safeguards implementation processes within the Department of Safeguards for the period 2016–2017.

During the 2016-1017 biennium, Project SGIS-003 will pursue the following Long-Term Direction:

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 project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
2. Increased ability to detect undeclared nuclear material and activities.	2.1 Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.	M
	2.3 Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.	M
	2.4 Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguard conclusions.	M
8. Ability to use safeguards information in a fully integrated, secure environment, maintained and available to all who need it according to their role.	8.1 Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State.	H
9. Ability to communicate secure, authentic information that is fully compatible with ISE between the IAEA, SRAs and inspectors/equipment in the field.	9.1 Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file.	M

SGIS-003 aims to modernize safeguards IT systems to become a strategic enabler for safeguards implementation by enhancing existing safeguards IT capabilities and developing new capabilities, while strengthening the protection of safeguards information. The modernization efforts help to achieve efficiencies and improve effectiveness of

safeguards implementation, establish basis for improved communication with State/regional authorities, improve institutional memory and rely more on electronic documentation and signatures.

For the 2016-2017 biennium, the project's top priorities are:

- Integrate all safeguards relevant data and improved applications to better support safeguards implementation processes.
- 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 will be replaced with a modern systems in a secure environment. The project enhances existing safeguards capabilities and helps to develop new capabilities, while ensuring the protection of safeguards information.

MOSAIC will bring widespread and tangible benefits throughout the IAEA Department of Safeguards, and will help to process data and manage information in ways that have not been possible on the old system. A modern and secure IT platform will better align IT tools with safeguards implementation processes, among other things, lead to improved efficiency and effectiveness of safeguards implementation activities.

Activities under this project include support for all in-field activities with improved reporting tools; the simplification of data entry and automated report generation; the integration of all safeguards relevant data and improved applications; enhanced analytical capabilities; the digitization of content and optimization of internal processes with enhanced document management, workflows and electronic verification packages; improved connectivity with headquarters for staff working in the field; improvements to a 'virtual workspace' for staff to share information and work collaboratively; the prevention of unauthorized access to information; and new systems to facilitate State-IAEA cooperation.

Significant progress has been achieved with the deliverables produced by the recent Mainframe Migration project that is of direct use to Project SGIS-003, and serves as a firm foundation upon which new capabilities and the enhancement of existing capabilities can be built. All the mainframe applications have now been re-engineered and replaced with new, modern software applications that are available in the Integrated Safeguards Environment (ISE). During this process, over 60 million records were migrated from the old system to the new more scalable ISE. The mainframe has been decommissioned, and ISE is the primary working environment for secure access to operational safeguards data and applications.

Resources for this effort are needed now to support the current and new MOSAIC projects starting in 2016 that will continue throughout mid-2018. SGIS-003 will be conducted in close cooperation with all stakeholders, particularly with interrelated projects in the Division of Information Management (SGIM) 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 as well as the Member States.

3. Objectives and Key Achievement Targets

In order to support Project SGIS-003's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations. **(In support of Milestone 2.1)** The evolution of safeguards implementation requires new business capabilities to be developed and existing capabilities to be enhanced by information technology. Further integration of safeguards data will 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.	
Provide a generic solution for the assembly and processing of electronic verification packages with electronic content of all associated evidence used for the evaluation of in-field verification activities.	December 2016
Develop new capabilities in support of the State Evaluations process.	December 2017
Integrate and enable visualization of safeguards information with geographical data in a user friendly manner.	December 2016
Objective 2.) Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization. **(In support of Milestone 2.3)** 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.	
In a common/collaborative platform, integrate all safeguards relevant data such as state declarations, collection of open source information, results of verification activities and other available sources of Safeguards (SG) relevant data.	July 2017
Extend the collaborative analytical platform to support structured analysis of all safeguards relevant data against the Physical Model.	December 2017
Support analysis of acquisition/diversion path analysis for the development of State-level Approaches.	December 2017
Develop enhanced analytical capabilities for the integration of nuclear fuel cycle tools with the analysis of open source and acquisition path analysis.	December 2017
Objective 3.) Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State. **(In support of Milestone 8.1)** The environment for hosting modernized applications where information is integrated, available, and accessible is essential. The evolution of ISE to further enhance security, while at the same time improving its usability, demands a central repository for all state related data that will improve the support for information retrieval and analysis in all business processes.	

Enhance the usability of the State File with an integrated view of all information related to a State, including documents and information residing in other systems.	December 2017
Integrate the Complementary Access (CA) data with other inspection verification activities where the collected information can be processed, analyzed, compared, and evaluated.	December 2017
Provide support for the management of technical objectives and applicable safeguards measures.	December 2017
Objective 4.) Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file. **(In support of Milestone 9.1)** New functionality is needed to manage the processing of State-supplied data and the evaluation of the data for completeness and correctness. Enhancing the hardware and software systems support the integration of data and reduce the effort required to compile information for the State Evaluation process.	
Increase the efficiency of the declared data processing and analysis process.	July 2016
Integrate all Safeguards State declarations in ISE to ensure completeness and correctness of the information.	December 2016
Improve communications and the electronic exchange of State-supplied data between HQ and Member States.	December 2017
Improve the capability to evaluate verification activities and prepare the Safeguards Implementation Report (SIR) and the Data Evaluation Report DER.	June 2016

4. Activities

Funding and resources for much 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 all of the project's objectives listed below. Project governance and management of the activities are performed by Safeguards Department personnel.

Assistance from Member States (UK D 1449, GER D 1455, FRA D 1676, CZ D 1512, AUL D 1481, USA D 1461) in support of the ISIS Re-engineering Project (IRP) and Mainframe Migration established the foundation for the integration of data. While support continues from regular budget and some Member State Support Programmes (JNT D 2100 CAN, JNT D 2106 USA, JNT D 2107 ROK & JNT D 2171 UK), additional funding and resources are required to avoid delays.

Objective 1.) ***Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.*** **(In support of Milestone 2.1)**

For 2016-2017, the MOSAIC project is aligned with the safeguards priority for integrated information systems and includes the following activities:

- Automate the assembly and processing of verification data and other SG data to improve the quality of documentation, eliminate paper copies, and reduce the processing time to plan, report, review and approve in-field activities;
- Develop applications in support of the preparation of State Evaluation Reports (SERs); and
- Develop a system to visualize information (when geo-location matters) accessible in a user-friendly manner through a geographical map or image.

Objective 2.) ***Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.*** **(In support of Milestone 2.3)**

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. ISE is hosting the safeguards portal (SG Portal project), promoting collaboration and the implementation of new analytical processes.

The Collaborative Analysis Platform project provides an analytical platform designed to integrate multiple data and information sources to enable "all-source" analysis. It will facilitate the performance of information-related tasks at a speed and scale that was not possible in the past – increasing the effectiveness and efficiency of IAEA staff activities. The ability to establish relationships between information from multiple sources, across time, and over ever-increasing volumes of information, will ensure that safeguards analytical products are produced with greater correctness and completeness.

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.

Specifically, MSSPs can assist the project with resources that:

- Develop the capabilities to integrate multiple data and information sources to enable all-source analysis with a fast, comprehensive review of all Safeguards-relevant data, including Additional Protocol (AP) declarations and open-source data linked to the Physical Model.
- Provide a comprehensive solution to support integrated analysis of all SG relevant data; Support Acquisition/Diversion Path Analysis with new reports and visualization tools for the development of State-Level Approaches and the reduction of the manual effort to perform acquisition path analysis.
- Develop applications for the integration of nuclear fuel cycle tools with analysis of acquisition paths.

These activities represent a collaborative effort with activities of projects SGIM-002 *Geospatial Information Analysis* and SGIM-003 *Information Analysis*.

Objective 3.) ***Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State.*** **(In support of Milestone 8.1)**

ISE is a highly secure and modern infrastructure allowing the centralization of all safeguards information. It provides a Service Oriented Architecture platform on which all software supporting safeguards business processes can be developed.

The Electronic State File (eSF) is intended to be a platform for the upload, organization, maintenance, analysis, and evaluation of non-structured, safeguards relevant documents and information. The eSF supports the entire safeguards process to varying extents, including the planning of field and headquarters activities, the capture and archiving of non-structured information collected in the field or generated during headquarters activities, the analysis of safeguards relevant information, and the continuous State evaluation process.

In particular, 2016-2017 planned activities include:

- Enhance 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.
- Modernize the current Complementary Access systems (CA) and integrate with the system for reporting other in-field verification activities (e.g. inspection/DIV).
- Develop new capabilities to record and manage safeguards technical objectives and applicable safeguards measures.

These activities represent a collaborative effort with activities related to SGIS-002 *Information Security and Infrastructure*.

Objective 4.) ***Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file.*** **(In support of Milestone 9.1)**

The State Supplied Data Handling (SSDH) system supports the processing, dissemination and analysis of safeguards declarations provided by States to the IAEA, particularly Nuclear Material Accounting (NMA) declarations. SSDH went live on 15 May 2015 as the primary operational system for handling NMA declarations, replacing the legacy mainframe system.

The need to re-engineer the software related to the review and analysis of state supplied data by safeguards staff is essential. In support of a Departmental core process (receiving, processing and analyzing AP declarations), the goal is to ensure completeness and correctness of the State-supplied AP information through enhanced tools for the review and analysis of AP declarations.

In particular, some of the following activities to develop new and enhance existing capabilities in support of State declarations include:

- Modernize the current AP System and integrate it into ISE where all State declarations are processed, analyzed, compared, and evaluated to ensure completeness and correctness of the information. Improve the review and evaluation process by increasing the granularity and quality of the available AP information to save information analysts' time in preparing analytical reports.
- Enhance existing capabilities to process State supplied data with a data processing dashboard providing clear status information on data workflows and errors occurring during quality control.
- Develop new capabilities for the secure electronic exchange of data with States.
- Enhance the functionality to review and access evaluation data to a larger group of users in support of the Facility Evaluation process and preparation of the SIR/DER.

These activities represent a collaborative effort with activities related to SGIM-009 *State Declared Information Management*.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[19] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

[19] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

SGOA-002

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

Project Manager: Christophe Creusot

Division: SGOA

1. Overview

This document describes the 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 2016–2017.

During the 2016-2017 biennium, Project SGOA-002 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
5. Deploy equipment at facilities to meet safeguards requirements.	5.1 Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation).	L
	5.2 Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities.	M
	5.3 Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities.	M
	5.4 Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.	M
	5.5 Develop methods to verify fresh fuel in shipping containers without opening the containers.	M
	5.6 Develop improved NDA instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.	M
	5.7 Develop more sensitive and less intrusive alternatives to existing NDA instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage.	H
	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.	M

SGOA-002 addresses the development and implementation of the J-MOX safeguards systems. It includes the development of joint use equipment, data collection system and evaluation software which is monitored through the J-MOX Joint Technical Committee (JTC) with all stakeholders including Japanese State Authorities and operator. The development has been almost entirely on stand-by since 2013 as a result of the delays in the construction of the facility and the uncertainties regarding the future operation of this plant.

Should Japan provide an updated J-MOX construction schedule before or during the 2016-2017 biennium, the project's top priorities will be:

- Develop/consolidate a safeguards approach in line with the State-level Approach.
- Develop/manufacture equipment necessary to support the safeguards approach.
- Define the requirements specification and architecture for integrated data collection and evaluation system.
- Developing the plan and procedures for Design Information Verification (DIV) during the construction and commissioning phases of the facility.

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 two main buildings. Construction is currently awaiting further authorization by the safety authorities. The safety review is performed based on updated safety regulations promulgated as a consequence of the major accident at Fukushima in 2011, which might impact the current design of J-MOX. In November 2015, Japan provided an updated starting date for J-MOX commercial operation in 2019 instead of 2017. 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 remains largely unchanged from the previous biennial plan.

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

It is expected that most of the funding for development and implementation of the safeguards systems for J-MOX will come from the Department's regular budget. 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. Objectives and Key Achievement Targets

In order to support Project SGOA-002's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Deploy equipment at facilities to meet safeguards requirements. **(In support of Capability 5)** The following key achievement targets will depend on Japan's provision of an updated J-MOX construction and commissioning schedule and confirmation about the future operation of the plant. 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. DIV will proceed according to construction schedule.	
Develop a safeguards approach for J-MOX, based on the basic elements agreed with Japan, and start the preparation of procedures for implementation.	Date unconfirmed
Design, test and install safeguards equipment (NDA, C/S) that provide high quality, independent and reliable results.	Date unconfirmed
Design, test and implement an integrated data collection and evaluation software for J-MOX, using synergies with the RRP Information System.	Date unconfirmed

Establish and implement DIE/DIV procedures that assure that the facility is constructed and will operate as declared, while ensuring that the safeguards approach remains adequate and robust. Carry out DIE/DIV activities from construction to MOX commissioning phases.	Date unconfirmed

4. Activities

The following projected activities include those funded by the IAEA regular budget and those expected to be funded by Member State Support Programmes (MSSPs).

Objective 1.) ***Deploy equipment at facilities to meet safeguards requirements.*** **(In support of Capability 5)**

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 Measurements Techniques*; and SGTS-014 *Remote Monitoring and Data Processing System*.

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

The conceptual design of the Advanced Material Accountancy Glove Box (AMGB) system, one of the key NDA systems developed by the IAEA for J-MOX, has been peer-reviewed under the task USA A 1801. A prototype of the AMGB verification NDA system was produced in 2010 and was tested at the JRC-Ispra in 2011/2013 under the task EC A 1778. A peer review of a conceptual design for rods verification system was carried out in 2015 under the same task.

Initial tests were performed in Japan under the task JPN A 1721 to evaluate the potential use of new generation detectors (i.e. EMC-HPGe, CZT, and liquid scintillator neutron detectors) for J-MOX, as well as the long-term testing of the EMC-HPGe in 2013.

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.

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

The development and implementation of an integrated data collection and evaluation system for J-MOX (named 'JADE') 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 in order to provide future assistance for the design, development, procurement, testing and installation of the JADE system. Sub-tasks will be defined as needs arise.

Most of the above tasks were in stand-by in 2014-2015 and will be re-activated when an updated J-MOX construction and commissioning schedule and confirmation about the future operation of the plant is received.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[20] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.3 Attachments

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

Figure 2. Testing of the AMGB prototype

[20] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

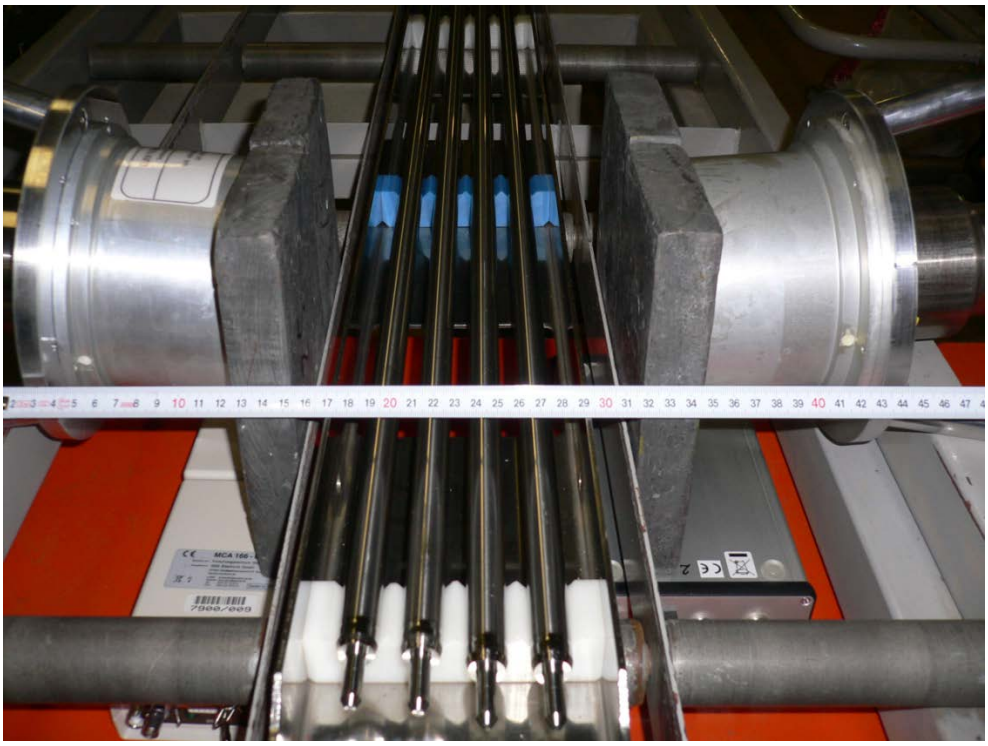

Figure 3. Testing of the liquid scintillators with MOX fuel rods

SGOA-003

Fukushima Dai-ichi Safeguards

Project Manager: Davis Hurt

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 2016–2017.

During the period 2016-1017, Project SGOA-003 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
2. Increased ability to detect undeclared nuclear material and activities.	2.4 Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of data in order to assist in drawing soundly based safeguards conclusions.	M
12. Ability to take on technical challenges and opportunities, and emerging tasks.	12.1 Assist Chernobyl, Fukushima and DPRK related activities as requested.	M

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 2016-2017, the project's top priorities are:

- Maintain a reliable safeguards monitoring 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.
- 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 the meltdown 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 2015, 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. Objectives and Key Achievement Targets

In order to support Project SGOA-003's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Identify and obtain specialized support and expertise on monitoring systems capable of providing credible assurance that nuclear material is not removed from the damaged facilities. (See also SGIM-002)	
Design, develop and deploy reliable and effective monitoring systems using surveillance devices, radiation detectors or other methods.	December 2017
Objective 2.) Identify and obtain specialized support and expertise on technical options for in-situ verification of currently inaccessible material. (See also SGIM-002)	
Design and develop 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 2016
Objective 3.) Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of data in order to assist in drawing soundly based safeguards conclusions. (See also SGIM-002) **(In support of Milestone 2.4)**	
Develop integrated review software tools to analyse data from the radiation monitoring system and the surveillance equipment at Fukushima Dai-ichi site.	July 2017

4. Activities

Most of the following activities will be performed by Safeguards Department personnel with regular budget support. Further assistance will be required from Member State Support Programmes for some activities.

Objective 1.) ***Identify and obtain specialized support and expertise on monitoring systems capable to provide reasonable assurance that nuclear material is not removed from the damaged reactors.***

In 2015, 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. 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.

Objective 2.) ***Identify and obtain specialized support and expertise on technical options for in-situ verification of currently inaccessible material.***

Currently, the verification of the spent fuels from Unit 4 (a damaged facility) has been performed at a nearby spent fuel storage facility where the spent fuels are temporarily stored. 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.

Objective 3.) ***Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of data in order to assist in drawing soundly based safeguards conclusions.*** **(In support of Milestone 2.4)**

Data from the installed outdoor cameras and radiation monitor equipment (gamma/neutron detectors) are acquired continuously. Currently, the evaluation is performed based on the review of the data from each camera and detector independently. Developing new tools to integrate the analysis of all the data would improve the confidence of the safeguards assessment.

4.1 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)

SGOC-001

Chernobyl

Project Manager: Sigitas Kurselis

Division: SGOC

1. Overview

This document describes the plans for developing and implementing Project SGOC-001, *Chernobyl* within the Department of Safeguards for the period 2016–2017.

During the 2016-1017 biennium, Project SGOC-001 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

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

The purpose of SGOC-001 (hereinafter "Chernobyl 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 Spent Fuel (SF) Storage Facility 2 and the associated conditioning facility (ISF-2), and the New Safe Confinement (NSC) to be placed over the Shelter covering ChNPP Unit 4. All three facilities are planned to start operation in 2017, while testing will start in 2016. The IAEA's obligation is to ensure that safeguards are applied, in accordance with the terms of the safeguards agreement, on all source or special fissionable material at these facilities (INFCIRC/550), while avoiding undue interference in the operation of the facilities.

For the 2016-2017 biennium, the project's top priorities are:

- Finalize the update of the State-level safeguards approach (SLA) for Ukraine, which will include facilities under this project.
- Complete the installation and authorization of safeguards equipment for verification use.
- Install hardware and software for data collection, on-site review, remote transmission to the IAEA and analysis.

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 required technical details of the equipment to be installed to apply safeguards.

3. Objectives and Key Achievement Targets

In order to support Project SGOC-001's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objective	Expected Completion Date
Objective 1.) Finalize the update of the State-level safeguards approach (SLA) for Ukraine.	
Update the State-level approach for Ukraine covering:	
SF transfer from the wet storage at ChNPP to the ISF-2 conditioning facility.	June 2016
Flow of nuclear material inside the conditioning facility.	June 2016
Transfer of spent fuel from the conditioning facility to the dry storage.	June 2016
The dry spent fuel storage.	June 2016
Activities at the NSC.	June 2016
Objective 2.) Complete the installation and authorization of safeguards equipment for verification use.	
Complete installation and authorization for safeguards equipment for verification use for ISF-2.	August 2016
Complete installation and authorization for safeguards equipment for verification use for NSC.	Early 2017
Objective 3.) Install hardware and software for data collection, on-site review, remote transmission to the IAEA and analysis.	

4. Activities

Most of the following activities will be performed by Safeguards Department personnel with regular budget support. Further assistance will be required from Member State Support Programmes for purchase of equipment. Assistance from the US Support Program (USA E 1361 and USA E 1445) may be used for this purpose.

Objective 1.) ***Finalize the update of the State-level safeguards approach (SLA) for Ukraine.***

A preliminary safeguards approach was prepared in 2005-2006. However, taking the broader conclusion for Ukraine into account (drawn since 2010) and the recent simplification of the nuclear material flow in the processing facility, a new simpler safeguards approach was developed. In August 2015, the principles of the safeguards approach to be applied during transfer to the ISF-2 were presented to the TRC and were approved. It will be incorporated in the updated SLA for Ukraine. SLA updating is in progress and should be completed in June 2016.

Objective 2.) ***Complete the installation and authorization of safeguards equipment for verification use.***

For ISF-2: an integrated monitoring system, which consists of surveillance and radiation detection devices with neutron and gamma detectors that may operate in unattended mode, is to be adopted as part of the safeguards measures. These measures include mobile systems on railcar and on canister trolley as well as fixed systems in the spent fuel processing area. 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, including in the conditioning facility. For this purpose, site-specific methods and instruments will be applied. Instruments shall be installed before the cold testing of the facility; installation is foreseen between July, and September of 2016.

For 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 containment and surveillance (C/S) and NDA devices was upgraded in 2013 and will continue to be used until NSC is in place and new monitoring equipment is installed. The new equipment shall cover removal points of the NSC the same way as for the existing shelter. Installation shall be done in early 2017.

Objective 3.) ***Implement hardware and software for data collection, on-site review, remote transmission to the***

IAEA and analysis.

The concept of the safeguards measures adopted for ISF-2 is based on an integrated remote monitoring (RM) system that comprises a surveillance device and radiation monitor with neutron and gamma detectors. In order to draw a safeguards conclusion, time synchronized surveillance and monitoring records must be correlated for a multitude of different cameras, radiation detectors and other measures and compared with operator's records. It is intended to integrate this RM system into the existing Chernobyl NPP RM system.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[21] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	Acquisition path analysis	To update the State-level approach, acquisition path analysis shall be done beforehand.	March 2016
	2	State-level approach	State-level approach to be updated to include new facilities.	June 2016
2	3	Equipment infrastructure requirements	For equipment procurement and installation, infrastructure requirements are to be developed.	December 2015

[21] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

4.3 Attachments

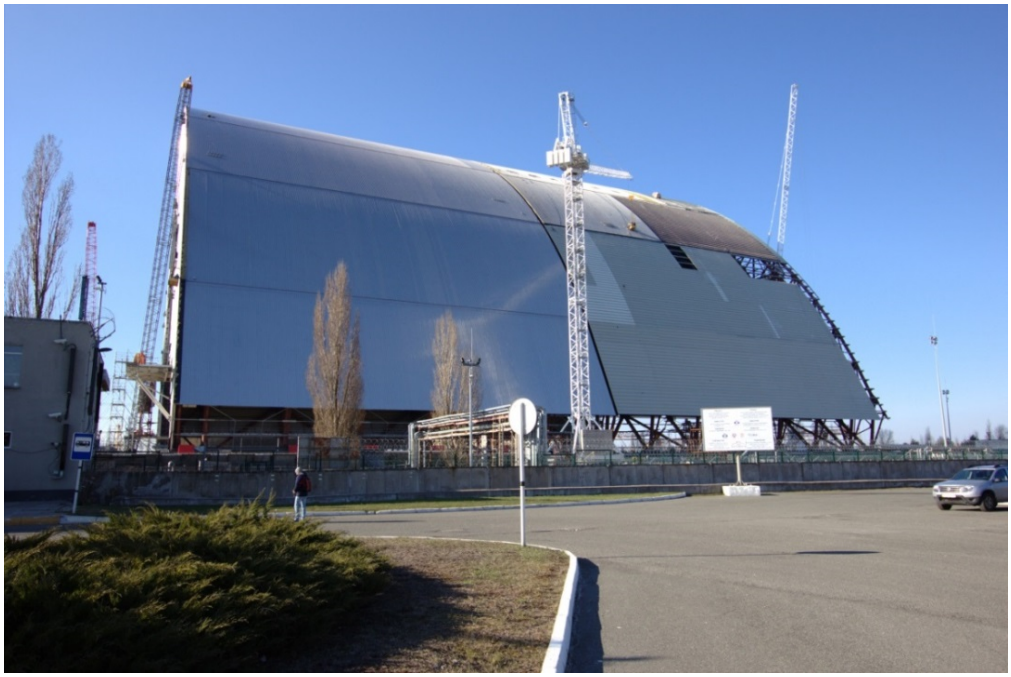

Figure 1. Chernobyl New Safe Confinement, April 2015

Figure 2. ISF-2 Conditioning Facility

Figure 3. ISF-2 Dry Storage

SGVI-001

JCPOA Implementation

Project Manager: Andrew Catton

Division: SGVI

1. Overview

This document describes the Member State support plans for the Joint Comprehensive Plan of Action (JCPOA) Implementation Project within the Department of Safeguards for the period 2016–2017.

During the 2016-2017 biennium, Project SGVI-001 will pursue the following Long-Term Direction:

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

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

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

SGVI-001 addresses the potential need for additional resources to ensure the effective and credible implementation of the JCPOA. The project is being initiated this biennium, but its full scope remains to be determined. The project is intended to host resource requests and activities that are primarily for JCPOA implementation, and will also serve as a focal point for descriptions of development activities (both internal and external) being conducted or coordinated under other D&IS Projects that have a JCPOA-related dimension or application.

For the 2016-2017 biennium, the project's top priority is:

- Identify assistance that may be required from MSSPs to assist with the implementation of the JCPOA, particularly in the areas of:
  - Software and analytical tools (in cooperation with SGIS-003 *Safeguards Information Systems and System Usability* and SGIM-003 *Information Analysis*);
  - Specialized training (in cooperation with SGCP-102 *Training*); and
  - Unattended monitoring equipment (in cooperation with multiple SGTS Projects).

2. Background

On 14 July 2015, the E3/EU+3 and the Islamic Republic of Iran signed the Joint Comprehensive Plan of Action (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 implement the Additional Protocol (AP) to its safeguards agreement with the IAEA, as well as extra nuclear-related commitments, which are known as transparency measures. Under the AP, already in force in 120 of 174 states with Comprehensive Safeguards Agreements (CSA), States grant the IAEA expanded rights of access to information and sites. By enabling the IAEA to obtain a much fuller picture of such States' nuclear programmes, plans, nuclear material holdings and trade, the AP helps the IAEA to provide much greater assurance of the absence of undeclared nuclear material and activities in those States.

As part of the transparency measures, 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 CSA and AP and will help the IAEA to have a better understanding of Iran's nuclear programme.

3. Objectives and Key Achievement Targets

In order to support Project SGVI-001's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objective:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Develop options and approaches for possible future mandates as required or requested that respect sensitive and proprietary information. **(In support of Milestone 11.1)** With the adoption of the JCPOA, the IAEA's workload will increase; MSSPs may be called upon to assist with particular support aspects of the verification and monitoring of Iran's nuclear related-commitments.	
Identify areas in which MSSPs could assist in the implementation of the JCPOA.	December 2016

4. Activities

Funding and resources for most of the Project's activities will be supported by the regular budget. Member State Support Programmes may be requested to provide assistance in particular areas of need.

Objective 1.) ***Develop options and approaches for possible future mandates as required or requested that respect sensitive and proprietary information.*** **(In support of Milestone 11.1)**

Discussions within the Office for Verification in Iran (SGVI) are currently underway to identify areas in which MSSPs could assist in the implementation of the JCPOA. Some forthcoming needs are likely to be specialized, although may have some spin-off application outside of the JCPOA context. In such cases, requests for support will be undertaken through this Project. In other cases, activities may be pursued in the framework of other projects that are primarily targeted at JCPOA-related needs (e.g. specialized training), and will thus be cross-referenced in this project's documentation to provide Member State Support Programmes with a complete picture of relevant D&IS work.

Current proposals for areas of MSSP support under consideration include:

Natural Language Processing

The IAEA Department of Safeguards has been developing an automated natural language processing (NLP) and a big-data analytic capability prototype to help manage the challenge posed by the rapid growth of digital, safeguards-relevant information in open sources. In order to proceed, 'training sets' representing the various sub-chapters of the IAEA Physical Model are needed to provide a basis for categorization of new information. The purpose of this task would be to establish a mechanism whereby MSSPs can provide the Department with both training data and testing sets for subsequent utilization by NLP engines in a multilateral and transparent manner. This work is to be carried out in close collaboration with Project SGIS-003 *Safeguards Information Systems and System Usability* and Project SGIM-003 *Information Analysis*.

Analytic Tools (Hardware, software, data, etc.)

SGVI is currently considering additional hardware and software requirements for the JCPOA to meet the unique analytical challenges of the JCPOA, including the tracking of thousands of individual components and evaluation of nuclear related procurements. Specific requests, whether through MSSP contributions or efforts in-kind are to be developed in the coming year and will be coordinated with Project SGIS-003 *Safeguards Information Systems and System Usability* and Project SGIM-003 *Information Analysis* as appropriate.

Training

Technological and analytical training in the form of courses and workshops would greatly assist the SGVI with better understanding various technologies critical to the successful implementation of the JCPOA. Such topics would likely include, for example, training on the specific subjects contained in Annex I Section T of the JCPOA, as well as stable isotope enrichment. These activities will likely be initiated under Project SGCP-102 *Training*, but projections on specialized needs and applications of JCPOA-specific training will be described in this project's plans and reports.

Specialized Equipment

Specialized equipment for the implementation of the JCPOA-specific verification mandate is likely to be required, and support in this regard may be requested from MSSPs (e.g. for monitoring centrifuge production, detecting undeclared heavy water production, measurement of irradiated fuel items). These requests will be coordinated with the applicable SGTS Projects, such as SGTS-001 *NDA Techniques*, SGTS-002 *Techniques and Instruments for Sealing and Containment Verification*, SGTS-003 *Surveillance Techniques*, SGTS-011 *Unattended Measurement Techniques*.

4.1 Attachments

Figure 1. Iran Talks in Vienna, 14 July 2015

Figure 2. Iran Talks in Vienna, 14 July 2015

SGTS-001

NDA Techniques

Project Manager: Mikhail Mayorov

Division: SGTS

1. Overview

This document describes the plans for developing and implementing non-destructive assay (NDA) methods and systems for the assessment and verification of nuclear material and instrumentation associated with other inspector field activities such as design information verification and complementary access, within the Department of Safeguards for the period 2016–2017.

During the 2016-2017 biennium, Project SGTS-001 will pursue the following Long-Term Direction:

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 project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
2. Increased ability to detect undeclared nuclear material and activities.	2.2 Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools.	H
	2.6 Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations.	H
5. Ability to provide credible assurances that nuclear material used in non-proscribed military activities, specifically naval propulsion, is not used for the production of nuclear weapons or other nuclear explosive devices.	5.6 Develop improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.	M
	5.7 Develop more sensitive and less intrusive alternatives to existing instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage.	H
	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.	M
6. Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products.	6.1 Implement an improved cost/benefit assessment methodology for the design and operation of safeguards equipment.	M

In 2016-2017, Project SGTS-001 will continue to take advantage of natural 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 the 2016-2017 biennium, the project's top priorities are:

- Develop, evaluate and authorize a system for partial defect verification of fresh-fuel that does not require a priori information about the concentration of burnable poison.
- Develop, evaluate and authorize tomography systems capable of performing genuine partial defect tests on inhomogeneous and impure nuclear material and spent fuel.
- Establish a pool of 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 (in cooperation with SGTS-008).
- Conduct a feasibility study of nuclear material assessment with in-field alpha spectrometry.
- Enhance the functional performance and extend the area of use of existing NDA instruments, such as COMPUCEA (See Project SGAS-001 *Destructive Analysis of Nuclear Materials*), FDET and DCVD.
- Re-engineer the software package for IMCA-based applications to improve usability and maintainability.

2. Background

The IAEA's toolbox of instruments supporting safeguards implementation is very extensive and currently includes over 60 varieties of NDA devices and systems. However, even with such a large toolkit, there are assessment and verification scenarios in which application of the available NDA instruments and methods has faced limitations. Some methods, such as the fork detector irradiated fuel measuring system (FDET) have been used routinely as the "best available method" in the absence of authorized systems for partial defect test of spent fuel. It is understood that the status of being "the best available method" has been granted on a temporary basis and should encourage and motivate research and development efforts in the identified problematic technical areas.

In the forthcoming biennium, Project SGTS-001 will explore several options to mitigate outstanding verification challenges. This activity alone, as well as efforts towards continuous, incremental improvement of the functional and technical performance, maintainability and usability of the pooled NDA systems, will dominate the NDA D&IS portfolio in 2016-2017.

3. Objectives and Key Achievement Targets

In order to support Project SGTS-001's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and / or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations. **(In support of Milestone 2.6)**	
In accordance with the safeguards equipment authorization guidance document, select, evaluate, customize and authorize a hand-held Raman spectrometry-based chemical compounds identification device.	December 2016
Objective 2.) Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools. **(In support of Milestone 2.2)**	
Develop a prioritized list of NFC indicator and signature materials to be contributed by Member States.	March 2016
Create repositories of basic NFC indicator and signature materials and create or adapt the relevant infrastructure for carrying out experimental tests with such materials. Comprehensively characterize collected materials.	June 2017

Begin experimental tests of instrumentation using the created repository of dual-use materials and testing infrastructure.	December 2017
Perform feasibility studies and a pilot deployment of in-field alpha spectrometers for nuclear material identification and isotopic composition analysis; establish the necessary procedures for application of the methodology within the Department of Safeguards.	December 2017
Objective 3.) Develop improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition. **(In support of Milestone 5.6)**	
Develop a methodology for, and perform the evaluation of, the Compact Gamma Tomography System which was procured in 2015, with the goal of authorizing the system for inspection use.	December 2016
Objective 4.) 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. **(In support of Milestone 5.7)**	
Improve PGET by shortening the acquisition time from hours to a few minutes and by adding the capability to detect neutrons; perform tests of PGET with a range of different fuel types; develop operating procedures for PGET; pursue authorization of PGET for application in attended mode.	December 2017
Objective 5.) 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. **(In support of Milestone 5.8)**	
Re-design the data acquisition system of the FNCL to improve usability; successfully complete performance evaluation and pursue authorization of the instrument.	October 2016
Objective 6.) Implement an improved cost/benefit assessment methodology for the design and operation of safeguards equipment. **(In support of Milestone 6.1)**	
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.	December 2017
Procure the services required for re-design of software applications in such a way as to enable in-house maintenance and support.	December 2017

4. Activities

Most of the following activities will be performed by Safeguards Department personnel. Further assistance will be required from Member State Support Programmes for some activities.

Objective 1.) ***Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations.*** **(In support of Milestone 2.6)**

In support of Objective 1, the IAEA will select, evaluate and authorize the Raman spectrometry-based material identifier for in-field verification activities, 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 order to optimize the cost of development, preference will be given to a commercial-off-the-shelf solution.

The instrument toolbox for on-site detection of non-radiation signatures is under development, with the expected completion of development and authorization by the end of 2016. Through several performance evaluations (notably the International Workshop on Demonstration of Technologies for Detection and Identification of Nuclear Fuel Cycle Indicator Materials, held 24-27 November, 2014 (EC A 0860)), two technologies have been selected. Firstly, laser-induced breakdown spectrometry (LIBS) is being developed (CAN A 1855). Secondly, Raman spectrometry is being used to analyze on-site materials for elemental and chemical composition, but an instrument utilizing Raman spectrometry is yet to be selected.

The instrument will be selected, evaluated and authorized under an internal task in close cooperation with the EC Support Programme (EC A 0860).

Objective 2.) ***Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools.*** **(In support of Milestone 2.2)**

In support of Objective 2, the IAEA will create repositories of reference nuclear fuel cycle materials and evaluate the practicality of performing nuclear material assessment with in-field alpha spectrometry.

As described above, the IAEA is building up a pool of instruments for detection of non-radiation NFC signatures. One of them has been developed under a MSSP task (CAN A 1855), while others are commercial-off-the-shelf solutions. To fully adapt the instruments to safeguards needs, a variety of dual-use substances are needed, both for testing and incorporation into the on-board identification libraries.

This objective is tightly linked to the IAEA's ability to select, evaluate and customize instruments for detection of NFC signatures. While there is an extensive collection of nuclear material samples at the IAEA's Safeguards Analytical Laboratories, there exist only a very limited number of well-characterized samples representing a variety of dual-use non-radioactive substances specific to the nuclear fuel cycle.

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 NFC 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.

Alpha spectrometry for determination of uranium isotopes at various concentration levels and various isotope ratios is appropriate for a number of applications, in particular where accuracy of gamma spectrometry is insufficient and mass spectrometry is not a practical option (due to the required timeliness of the analysis results). This method could be an option for partial defect of thorium concentrates, as well as in-situ spectrometry of plutonium isotopes (gross defect) for attribute tests of open samples.

Objective 3.) ***Develop improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.*** **(In support of Milestone 5.6)**

In support of Objective 3, the IAEA will authorize a compact gamma-tomography system for assessment of nuclear waste.

At present, there are essentially two options for the assessment of isotopic analysis of nuclear material. They are the methods based on either mass or gamma spectrometry. The first group targets the relative accuracy of less than 0.5 %, while gamma spectrometry allows for accuracy to be within several percent.

If the accuracy of gamma spectrometry is insufficient and the shipment of DA samples to HQ remains a less preferred option due to the time and effort it requires, in-field DA sample analysis could be performed. Portable mass spectrometers are not yet available to the IAEA, but Combined Product Uranium Concentration and Enrichment Assay (COMPUCEA) has been successfully used at several conversion and fuel fabrication facilities.

An alternative option could be alpha-spectrometry of the DA sample. This appears to be a promising method for uranium enrichment measurements with an intermediate accuracy of about 1.0%.

Since the IAEA has limited experience in this regard, MSSP support will be particularly important.

One current verification challenge is 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. In 2015, the IAEA procured a Compact Gamma Tomography System. The instrument offers the capability to assay objects in three dimensions, thus significantly reducing the uncertainties associated with knowledge of the matrix and the distribution of nuclear material. Isotopic composition analysis is performed by high-resolution gamma spectrometry with an electrically cooled HPGe detector at the level of

individual voxels in the inspected object.

Successful implementation of this technology requires expertise in tomography and extensive tests. The expertise has been provided through the US SP, but the performance evaluation and authorization of the method will be pursued within the next biennium under an internal task.

Objective 4.) ***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.*** **(In support of Milestone 5.7)**

In support of Objective 4, the IAEA will re-design, evaluate, and authorize the Passive Gamma Emission Tomography system for partial and bias defect testing on spent fuel. Passive Gamma Emission Tomography (PGET) is the only existing technology that can detect the diversion of spent fuel at the pin level (in the most generic case), a capability that is of particular interest to the IAEA in forthcoming and foreseeable situations (e.g. prior to the transfer of spent fuel assemblies into a repository). The availability of PGET will improve the effectiveness of verification and will complement DCVD and FDET when the use of the latter instruments is not possible or not practical.

The IAEA considers tomography-based NDA systems as a key component of nuclear verification activities in the medium and long term. The technology was customized for the IAEA verification activities completed in 2015 (JNT A 1510).

Analysis of PGET design options has shown that the performance of the prototype can be significantly improved by introduction of an online energy calibration feature, shortening acquisition time from hours to minutes by the application of parallel reading of data from all 208 CdTe detectors, and by enabling the detection of neutrons. Moreover, the IAEA intends to consolidate all design documentation and IP rights in such a way as to be able to immediately order the device as a "turnkey" solution. The work is being implemented under an internal task.

The tests of the re-designed PGET will be performed with FIN SP support (FIN A 1997). PGET calibration, followed by tests at Loviisa and Olkiluoto NPPs in 2016 and 2017, will be followed by authorization of the PGET for nuclear verification. Software for tomography image reconstruction and analysis is also being developed under an internal task in close cooperation with the JNT A 1955 team (Unattended Gamma Emission Tomography for Partial Defect Detection).

Finally, the data acquisition system being developed under an ongoing IAEA contract is seen as a scalable platform for future tomography-based applications for nuclear verification.

Objective 5.) ***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.*** **(In support of Milestone 5.8)**

In support of Objective 5, the IAEA will evaluate and authorize the Fast Neutron Uranium Collar for partial defect testing on fresh fuel.

The IAEA's experience in the verification of burnable poison fuel is based on either the application of the Uranium Neutron Collar (UNCL) in its thermal mode with subsequent correction of the declared concentration of burnable poison; or use of UNCL in its fast mode. The first approach has a strong intrinsic inconsistency: for the verification of the declared amount of fissile material, the IAEA accepts as a given the declaration of burnable poison concentration, which cannot be verified independently and which strongly affects the result of verification. While it is a robust, reliable and relatively accurate instrument with RSD of about 5-7%, the second approach – the use of UNCL in fast mode – requires a significantly longer acquisition time of about one hour for both passive and active measurements for verification of a single fuel assembly.

Since 2012, the IAEA, in cooperation with its Member State Support Programmes, (NET A 1958, UK A 1951 and EC A 1362) has been pursuing 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.

Under an internal task in 2016, the prototype will undergo re-design towards improvement of its usability in the field and performance optimization for PWR and WWER-1000 fresh fuel. With EC SP support (EC A 1362), FNCL performance will be evaluated in Q2 of 2016 at ITU with a mock-up of PWR fuels in different configurations in a wide range of ^{235}U linear mass densities and Gd- burnable poison concentrations. Authorization of the FNCL will be pursued in Q4 of 2016.

Objective 6.) ***Implement an improved cost/benefit assessment methodology for the design and operation of safeguards equipment.*** **(In support of Milestone 6.1)**

In support of Objective 6, the IAEA will enhance the performance and sustainability of existing NDA instruments. Collectively, this group of tasks will extend the area of applications for the existing instruments and methods (COMPUCEA for UF_6), improve their verification accuracy (DCVD and FDET), and also allow the IAEA to maintain and sustain the key software application, used for collection and interpretation of safeguards data (IMCA software, DCView and Isotopic Composition Analysis Software).

Some recently developed and authorized systems continue to undergo development that enhances the instruments' performance and extends their area of use. Some were developed and authorized decades ago and are difficult to maintain and support.

In the 2016-2017 biennium, this project will work to extend the area of COMPUCEA application towards UF_6 enrichment. COMPUCEA is a portable analytical system for uranium elemental assay and ^{235}U enrichment measurement in pellets, powders, scrap and other uranium-bearing materials, with the accuracy of the method meeting the ITV2010 requirements for destructive assay (DA) measurements. The task will be performed internally in cooperation with the IAEA's Safeguards Analytical Laboratories (See Project SGAS-001 *Destructive Analysis of Nuclear Materials*).

During the previous biennium, the performance of the ICVD (developed over 30 years ago) has been critically assessed. There have been two motivations for this undertaking. First is the natural progress in development of high-sensitive low-noise multichannel plate-based image intensifiers. Second, spent fuel under safeguards is getting older, which makes verification more and more difficult. Results of investigations indicated that for approximately 25% of the ICVDs in the existing NDA pool that were procured decades ago, performance can be significantly improved by the replacement of image intensifiers (Fig.1). It was also found that image and particularly video recording features could be very useful options. Under an internal task, the IAEA plans to build (or customize existing COTS devices, if practical) and authorize a new Cherenkov Viewing Device with the above features.

The other task is to upgrade the Digital Cerenkov Viewing Device's (DCVD) data collection and analysis software, called DCView. There will be a number of new features improving the maintainability and usability of the software, such as the ability to interface with the new DCVD hardware (the camera presently supported by DCView is not in production anymore) or enable an automated process of data analysis, preparation of historical data, and reporting. However, the most important improvement will be associated with development and implementation of the advanced prediction models for Cherenkov radiation emission in spent fuel performed by the SWE SP and CAN SP (JNT A 2009). Cerenkov light intensity is mainly driven by the burn-up and cooling time of the fuel, but there are second-order effects that can make significant contributions under some conditions. They are initial fuel composition, irradiation history and fuel design. In addition, fuels in the same population with emission intensities that differ by several orders of magnitude can be stored in close proximity to one another. In this case, cross talk cannot be ignored and must be estimated and corrected for. The new model will take all those effects into account.

Similar work will be performed under an internal task that may potentially enhance performance of the FDET for partial defect test verifications. Assessment of SCALE/ORIGEN/ORELLA depletion code accuracy to predict FDET inspection data will be performed on the basis of an absolute comparison of the estimated from declaration and observed data. Depending on the evaluation results, a new SP-1 may be raised to obtain US SP support to close identified gaps.

In collaboration with the US SP (USA A 2094) this project is pursuing the development of an integrated data acquisition and analysis software application to work with the InSpector-2000, MMCA-527 and possibly other multi-channel analyzers that are available on the market. The application incorporates the functionalities of multiple existing data analysis codes in one package. The latter includes codes, such as those used for uranium and plutonium spent fuel attribute tests: MGA/MGAU, FRAM, NaIGEM, LabRod and LabPel. The new software package will integrate and provide a common unified graphical user interface for 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, depending on emerging safeguards needs.

The IAEA will continue to review and improve the complementary access toolkit for inspectors. With the Portable Radionuclide Identification Pager FLIR nanoRaider, the CA toolkit acquired a powerful pocket-size instrument for gamma and neutron detection and radionuclide identification with medium-resolution gamma spectrometry. In

2016-17, the IAEA envisions establishment of a modular approach to the CA toolbox where selection of instruments from the larger range of options for a particular mission could be tailored to the specific task(s) and the type of facility. This work will be done in cooperation with Project SGTS-008.

According to the IAEA Equipment Management Information System, at present there are 7 261 NDA systems and core components available for Safeguards assessment and verification. Annually (data as of 2014), some 900 NDA systems involving some 2 000 components are prepared for deployment in the field. Functionality testing of the same kind of equipment, such as the HM-5, takes a lot of resources, but is rather simple in nature and hence, could be fully automated. As this is seen as one of the areas in which to improve the efficiency of routine operations, the IAEA intends to develop and deploy a robotic test station to perform functionality testing of selected NDA systems in a round-the-clock regime, thereby freeing resources for non-routine NDA activities.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[22] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1,2	1	Selection, evaluation and authorization of Raman spectrometry based material identifier for CA missions	Selection and evaluation of a COTS solution for material identification will be performed, followed by authorization of the selected instrument for in-field verification activities in the Department of Safeguards.	December 2017
3	2	Performance evaluation and authorization of Compact Gamma Tomography System for nuclear waste assay	The IAEA should develop a methodology and perform evaluation of the Compact Gamma Tomography System that has been procured with extrabudgetary funds in 2015, with the goal of fully authorizing the system for inspection use.	December 2016
4	3	Re-design of PGET Data Acquisition System	In close cooperation with FIN SP task 1997 'PGET implementation support' the IAEA will procure necessary services, works and components to replace the old and inefficient Data Acquisition System that was built more than 10 years ago. The objective is to reduce data collection time from 3-3.5 hours to 100-300 seconds by replacing the existing sequential readout scheme with parallel readout electronics and the introduction of new features.	December 2016

[22] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

	4	Development and validation of PGET image reconstruction and analysis software	In close cooperation with US Support Programme task JNT A 1955 , FIN Support Programme task FIN A 1997 and 1354, define the functional and performance requirements, coordinate, implement, test and integrate the software for PGET image reconstruction and analysis.	August 2016
5	5	Performance evaluation and authorization of the fast neutron uranium collar for partial defect test on fresh fuel	The objective of this task is to (1) evaluate performance of the existing prototype of the fast neutron uranium collar (FNCL) which may be a solution to improve effectiveness for determination of ^{235}U mass density in fresh fuel assemblies containing burnable poisons and (2) eventually authorize the FNCL for inspection use. The outcome of this project can be extended to the applications in some other challenging areas such as the assay of U waste with unknown matrix.	June 2016
6	6	Development of New Generation of CVD	The goal of this task is to develop a concept design of an upgraded handheld Cherenkov viewing device. The upgraded instrument should increase the sensitivity of the current device and include recording functions.	December 2016
6	7	Assessment of accuracy of SCALE/ORIGEN/ORELLA depletion codes to predict FDET inspection data	The IAEA is pursuing development of the concept of advanced data evaluation for FDET spent fuel verification, based on prediction of the expected gross gamma neutron, as well as measurement and comparison of prediction and observable values. In this task, a batch of FDET data, provided by Operations, will be compared with predictions of various depletion codes. Depending on the outcomes of the task it may support authorization of FDET for method F.	June 2016

4.3 Attachments

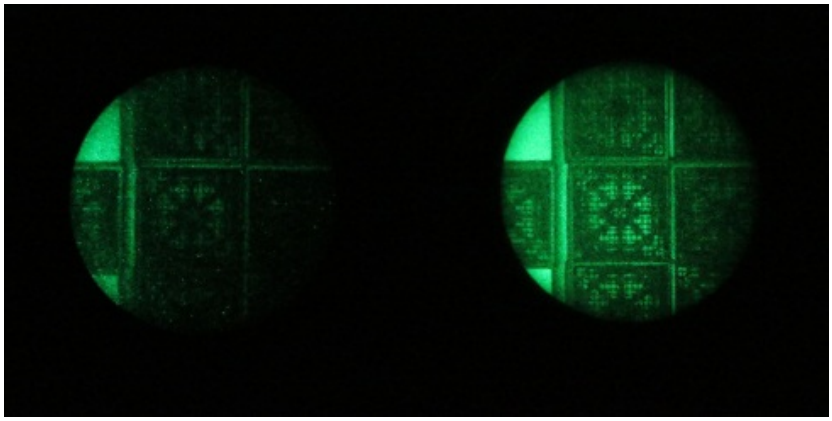

Figure 4. Spent fuel image taken with a traditional (left) and improved (right) ICVD

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 2016–2017.

During the 2016-2017 biennium, Project SGTS-002 will pursue the following Long-Term Direction:

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 project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
5. Deploy equipment at facilities to meet safeguards requirements.	5.1 Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation)	L
	5.2 Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities.	M
	5.3 Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities.	M
	5.4 Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.	M
	5.5 Develop methods to verify fresh fuel in shipping containers without opening the containers.	M
	5.6 Develop improved NDA instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.	M
	5.7 Develop more sensitive and less intrusive alternatives to existing NDA instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage.	H
	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.	M
6. Ability to acquire and deploy safeguards equipment that is	6.1 Implement an improved cost/benefit assessment methodology for the design and operation of safeguards	M

sustainable, standardized and modular, with increased use of commercial off-the-shelf products.	equipment.	
	6.2 Develop neutron counting systems reducing the use of ^{3}He or offering equivalent functional and technical alternatives.	M

In 2016-2017, 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 for maintaining continuity of knowledge (CoK) of nuclear material in containers, detection of diversion through pathways, and tampering of IAEA's equipment. The project also works to ensure the integrity and authenticity of instrument data used to draw safeguards conclusions. 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 2016-2017 biennium, the project's top priorities are:

- Modernize, sustain and improve the tamper resistance of sealing systems throughout their lifetime.
- Develop a new generation of active seal called the Active Optical Loop Seal (AOLS).
- Develop and deploy a new glass seal (GLAS) to be used in applications for which metal seals are currently utilized.
- Continue to improve the overall security of safeguards instrumentation to the dynamic threat landscape.

2. Background

Secure containment is essential to all safeguards approaches. Containment systems are needed in every type of nuclear facility in the fuel cycle. Therefore, a key objective remains modernizing and sustaining containment systems throughout their lifetime, and continually improving tamper resistance. It is likewise important to continuously identify and mitigate the vulnerabilities of safeguards equipment and data derived from equipment.

One key current priority for the project is the development of a new generation of active seal called the Active Optical Loop Seal (AOLS) which is jointly developed with the JRC under EC E 1849. The AOLS will be the first active seal with an open hardware and software architecture. This allows the IAEA to more stringently assess the seals security as well as allowing for changes to the AOLS' functionality in order to meet the widest range of containment scenarios. A unique feature of the AOLS is its implementation of asymmetric cryptography. This will improve the management of cryptographic keys, ease the burden on inspectors to carry USB tokens, and significantly improve security.

A second high priority is the development of the glass seal (GLAS). The IAEA has received preproduction prototypes for field testing which is scheduled for Q2 2016. Unlike the metal seal, the glass seal has few 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.

One aspect of the current operating environment that remains particularly challenging for containment is the growing number of dry storage casks (DSCs). Over the next 10 years, it is projected that the number of DSCs could increase by a factor of two to three. A significant percentage of inspector resources are currently being used for verifying DSCs. Without improvements in containment inspectors resources will be stretched thin by the verification of DSCs in the future. Therefore, there is a strong focus at present on the development of DSC sealing technologies that decrease efforts.

Project SGTS 002 coordinates regularly with SGIS-002 *Information Security and Infrastructure* on data security issues.

3. Objectives and Key Achievement Targets

In order to support Project SGTS-002's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium, and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Modernize and sustain sealing systems used in safeguards and increase their tamper resistance.	
Develop and deploy the Active Optical Loop Seal (AOLS).	December 2017
Field test the glass seal (GLAS).	June 2016
Develop and deploy the AOLS / EOSS Reader.	December 2016
Develop and deploy the GLAS reader.	December 2016
Objective 2.) Develop and maintain sealing systems for facility specific applications.	
Create a version of the Ultrasonic Optical Sealing Bolt (UOSB) for more effectively implementing joint-use arrangements.	December 2017
Determine whether technical challenges can be overcome to improve the usability of the UOSB Handheld Reader.	December 2017
Objective 3.) Improve and expand techniques, tools and procedures for containment verification.	
Initiate an MSSP task to examine the effectiveness of visual inspections of casks in cases where CoK is lost.	December 2017
Objective 4.) Research, develop, and implement new and novel technologies that can be applied for secure sealing and containment verification systems.	
Identify and develop solutions for:	
• *Tampering Indicating Covers (TIC1)*	December 2016
• *Tampering Indications of Cables (TIC2)*	December 2017
• *Tamper Indication of Cabinets (TIC3)*	December 2017
Objective 5.) Expand and improve capabilities to identify and mitigate the vulnerabilities of safeguards equipment and data derived from equipment.	
Establish an assessment centre for safeguards instruments and their use based on attacking and defending security teams.	December 2017
Objective 6.) Act as focal point to increase data security of safeguards equipment.	

4. Activities

Funding and resources for some 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. Many activities are supported by regular budget sources.

Objective 1.) ***Modernize and sustain sealing systems used in safeguards and increase their tamper resistance.***

Active Optical Loop Seal (AOLS)

The Active Optical Loop Seal (EC E 1849) will be the first active seal with an open hardware and software architecture. This allows the IAEA to more thoroughly assess its security and change functions to meet the wide range of 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.

AOLS / EOSS Reader – (internal development)

The IAEA requires a reader for the AOLS that is reliable, ergonometric for inspectors to use in contaminated environments, and based on open standards that are compatible with other hardware platforms. Further, the paperless environment requires XML output that allows for the seamless extraction of instrument data into inspection reports. It is also worth noting that the EOSS readers have reached the end of their lifecycle. As an efficiency measure the IAEA will seek to integrate reading EOSS seals into one new platform allowing inspectors to carry less equipment.

Glass Seal (GLAS) – (internal development)

Glass seal pre-production prototypes have been received, and field testing will begin no later than Q2 2016. As the vast majority of safeguards applications can in principle benefit from the implementation of the glass seal, the IAEA will evaluate this seal in as wide a range of field applications as possible.

Glass Seal Reader - (internal development)

In order to facilitate inspector needs in the field, the development of the glass seal reader will focus on two platforms. Firstly, the iReader will be expanded to read the glass seal. The iReader has been extremely successful for verifying Cobra seals. In a second phase of development, a compact USB camera attachment will be constructed so that the AOLS/EOSS reader can read the GLAS. The two developments have the possibility to create an all-in-one reader that minimizes the amount of equipment carried by inspectors in the field.

Unattended Proximity Seal for Casks (UPSC)

The IAEA seeks an active sealing system that provides a measure of confidence that CoK has been maintained on nuclear material casks during shipment without the need for an IAEA inspector to verify either attachment or detachment. To clarify, there are a number of bilateral or multilateral agreements, such as with weapon States, which restrict the presence of inspectors at the loading and unloading of casks. Nonetheless, the IAEA still requires a measure of CoK during transport. The UPSC is intended to provide that confidence despite the inspector restriction. This type of sealing system poses significant technical and security challenges, but preliminary evaluations appear promising.

Objective 2.) Develop and maintain sealing systems for facility specific applications.

Universal UF_6 Reader (UF_6R)

The IAEA seeks to support 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). More than one hundred thousand UF_6 cylinders are currently in worldwide use with annual movements numbering in the thousands. Currently, cylinders do not have standardized and/or machine readable permanent labels. The IAEA has proposed the format of a stainless steel label (as shown below). This label would be machine readable at a distance as well as authenticatable to high certainty at short range. As both features would be valuable in reducing IAEA inspection efforts, the IAEA intends to provide technical assistance to this effort as the development proceeds. However, the main IAEA focus will remain on the authentication techniques which take advantage of successes with the Laser Mapping of Cask Verification (LMCV – EC E 1549).

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.

UOSB Handheld Reader (UBRD)

Currently, the reader for the UOSB can be cumbersome to use as UOSBs are often installed on casks that have heights of five meters or more. For safety and effectiveness, a more streamlined reader is required. However, there are a number of technical challenges which must be overcome. This will be pursued with assistance from task EC E 2008.

Objective 3.) Improve and expand techniques, tools and procedures for containment verification.

Effectiveness of Visual Cask Inspections

Should a seal be damaged or inadvertently removed on a closed and welded cask, CoK could be lost. In such a scenario, inspectors currently have few options to verify the contents. The IAEA seeks to quantify, if possible, the effectiveness of visual inspections of casks to recover CoK. In addition, the IAEA would like to identify other mitigating techniques that can assist the inspector in recovering CoK, perhaps including ultrasonic or laser mapping. MSSP assistance will be solicited in this regard during 2016-17.

Objective 4.) Research, develop, and implement new and novel technologies that can be applied for secure sealing and containment verification systems.

Tamper Indicating Covers (TIC1) – (internal development)

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 requires a higher degree of tamper indication for enclosures, which must be assessed by a robust design review. This activity will be pursued during the 2016-17 biennium and will also include enclosures for the transport of samples.

Tamper Indication of Cables (TIC2) – (internal development)

The replacement of tamper indicating conduit would greatly decrease the cost and complexity of UMS systems. The IAEA seeks a solution for electronic cables by a module with 30 or more channels. In addition, analysis software must be developed that can identify a number of attack scenarios with a minimum of false negatives and positives.

Tamper Indication of Cabinets (TIC3) - (internal development)

The IAEA seeks a device that actively indicates whether the inside of a equipment cabinets have been breached by an attacker. Video surveillance in this case can be ineffective as cabinets must be kept cool and dark. Therefore, simple to install, low-power, and maintenance-free techniques will be explored.

Objective 5.) Expand and improve capabilities to identify and mitigate the vulnerabilities of safeguards equipment and data derived from equipment.

Vulnerability Assessment

Assess and identify vulnerabilities so that they may be mitigated to a level at which it is practically impossible to defeat the following systems:

- Active Optical Loop Seal and Reader
- Tamper Indicating Covers

The IAEA may request MSSP assistance for this work, particularly through task EC E 2008.

Objective 6.) Act as focal point to increase data security of safeguards equipment.

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 is 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 methodology will be used to ameliorate the risk of the nuclear safeguards instruments being assessed.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017. [23] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	AOLS / EOSS Reader	The IAEA requires a reader for the AOLS that is reliable, simple for inspectors to use in contaminated environments, and is based on a cost-effective platform with highly user-friendly software that is based on open standards and compatible with other hardware platforms. Further, the paperless environment requires XML output that allows for the seamless extraction of instrument data into inspection reports. It is also worth noting that the EOSS readers have reached the end of their lifecycle. As an efficiency measure, the IAEA will seek to integrate reading EOSS seals in this new platform.	December 2016
	2	Glass Seal (GLAS)	Glass seal pre-production prototypes have been received and field testing will begin no later than Q2 2016. As the vast majority of safeguards applications can in principle benefit from the implementation of the glass seal, the IAEA is selecting as wide range as possible to test this seal in the field.	June 2016
	3	Glass Seal Reader	In order to meet the wide range of inspector needs, the development of the glass seal reader will focus on two platforms. First, the expansion of the iReader to read the glass seal, since is it has been extremely successful as a reader for Cobra seals. A second phase will focus on the development of a USB attachment to the AOLS/EOSS reader described above. The two developments will create an all-in-one reader that minimizes the amount of equipment carried by inspectors in the field.	December 2017
4	4	Tamper Indicating Covers (TIC1)	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	December 2017

[23] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

			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.	
	5	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 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.	December 2017
	6	Tamper Indication of Cabinets (TIC3)	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 2017

4.3 Attachments

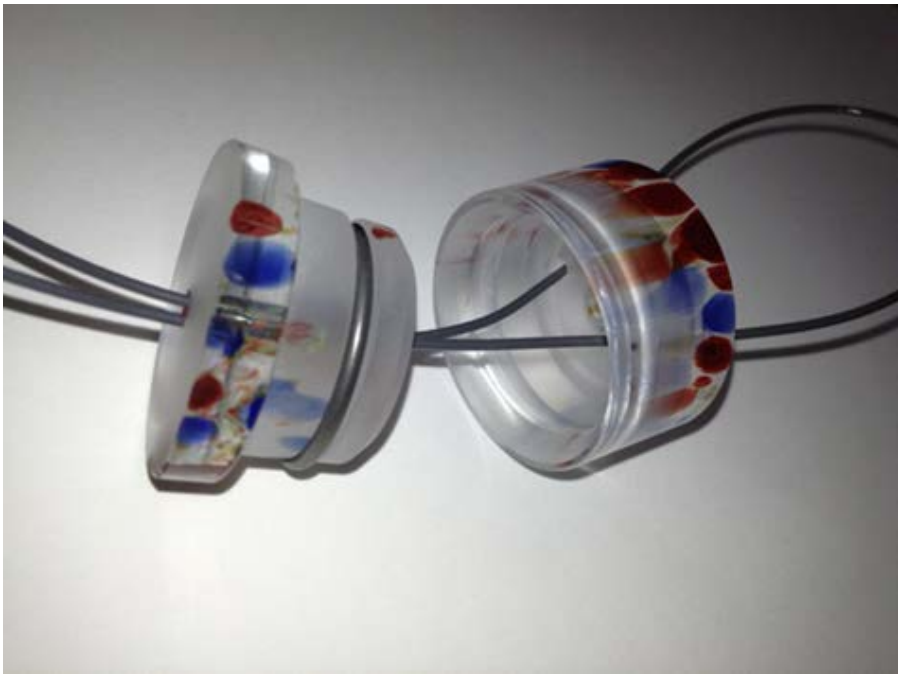

Figure 1. A version of the GLAS, which passed a third party independent vulnerability assessment in 2015

Figure 2. The UOSB installed at a spent fuel storage facility
where it saves significant inspector and facility resources

Figure 3. A prototype of a TIC that integrates fiber optic fibers allowing for use of a Cobra-like seal

Figure 4. The IAEA has proposed the format of a stainless steel label for UF_6 cylinders

SGTS-003

Surveillance Techniques

Project Manager: Martin Moeslinger

Division: SGTS

1. Overview

This document describes the plans for developing and implementing optical surveillance equipment within the Department of Safeguards for the period 2016–2017.

During the 2016-2017 biennium, Project SGTS-003 will pursue the following Long-Term Direction:

Provide advanced surveillance equipment and technologies to improve and optimize Departmental operations and capabilities to effectively carry out the IAEA's safeguards mission.

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
5. Ability to deploy equipment at facilities to meet safeguards requirements.	5.1 Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation).	L
	5.3 Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities.	M
7. Ability to make maximum efficiency savings by the use of remote monitoring of operators' and unattended IAEA equipment.	7.2 Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.	M

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

For the 2016-2017 biennium, the project's top priorities are:

- Develop and authorize new, 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.
- Ensure sustainability of current NGSS technology by implementing updates required by new needs from safeguards inspectors and updated Departmental IT security.

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, 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 regimes. A particular focus of the Project's R&D activities is the development, standardization and modularization of surveillance data analysis techniques to reduce the burden currently presented to safeguards inspectors and 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;
- Authorization of the NGSS-based underwater camera for routine Safeguards use; and
- The development of an NGSS camera module with analog input to support applications where special radiation hardened or operator owned cameras have to be used.

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 *Techniques and Instruments for Sealing and Containment Verification*, SGTS-008 *Novel Technologies in Support of Safeguards Implementation*, SGTS-011 *Unattended Measurement Techniques*, SGTS-014 *Remote Monitoring and Data Processing Systems* and SGTS-015 *Technologies for New IAEA Verification Mandates*.

3. Objectives and Key Achievement Targets

In order to support Project SGTS-003's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Ability to deploy equipment at facilities to meet safeguards requirements. **(In support of Capability 5)** This represents the project's core objective by ensuring that the Department's needs in optical surveillance measures are met with highly effective and cost efficient technologies. In support of this objective, the IAEA constantly benchmarks current technologies and initiates equipment developments as required to address equipment obsolescence, improve effectiveness or to be proactive in regard to emerging security concerns.	
In collaboration with Project SGTS-014, complete the Phase 1 development of new surveillance review software, providing a working prototype for benchmark testing.	December 2016
Objective 2.) Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation). **(In support of Milestone 5.1)**	
Enhance the existing 3DLR laser scanner-based Design Information Verification (DIV) tool to be applicable for routine containment verification tasks.	August 2017
Objective 3.) Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities. **(In support of Milestone 5.3)**	
Assess the applicability of the L2IS Laser Item Identification System in new enrichment plants.	July 2017

Objective 4.) Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements. **(In support of Milestone 7.2)**	
Complete the evaluation and vulnerability assessment of the DCM-A1, next generation analogue camera recording module.	December 2016

4. Activities

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

Objective 1.) ***Ability to deploy equipment at facilities to meet safeguards requirements.*** **(In support of Capability 5)**

Under task FRA E 1818, an evaluation of sophisticated, intelligent surveillance technology based on object recognition and trajectory analysis is being performed. Assessment of the work performed under this task to date confirms the technology's potential to substantially increase the efficiency of surveillance data review. The work accomplished under this task also supports 'In-house Activity #1' and Project SGTS-014 by augmenting specifications and requirements for a new, modular surveillance review software tool.

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. Completion of the assessment and a decision as to whether VideoZoom technology shall be implemented under 'In-house Activity #1' and Project SGTS-014 is planned for July 2016.

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 2016. 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 and enhancements to support changes in the IAEA's data security environment and Public Key Infrastructure (PKI).

Objective 2.) ***Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation).*** **(In support of Milestone 5.1)**

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 2016.

Objective 3.) Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities. (In support of Milestone 5.3)

The L2IS Laser Item Identification System was originally developed under task EC E 1696. L2IS is capable of

monitoring 100% of the real-time flow of UF_6 cylinders at nuclear material bulk handling facilities, like enrichment plants. L2IS is currently authorized for safeguards use at the Rokkasho Enrichment Plant, 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 or nuclear material bulk handling facilities is planned to be completed by July 2017.

Objective 4.) Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements. (In support of Milestone 7.2)

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, are undergoing acceptance testing and vulnerability assessment planned to be completed by December 2016. 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

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[24] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
5	1	Develop new, standardized power modules for surveillance system implementation	Finish the selection and development of a new, standardized low voltage power subsystem for all surveillance equipment, taking full advantage of available commercial-off-the-shelf battery and power supply technology (regular budget).	June 2016
	2	Develop and implement infrastructure for the Department's surveillance laboratories	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	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	XMOS is a surveillance server designed to replace the old DMOS multi-camera system server when upgrading to NGSS technology.	March 2016

[24] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

			XMOS is based on standard NGSS components augmented with an industrial touch screen panel PC and server software developed by SGTS in-house resources.	
	5	Evaluate commercial "smartphone" technology for SG applicability	Demonstrate the applicability of commercial off-the-shelf (COTS) technology to address the need for a miniature, unattended camera for short-term temporary surveillance (Completed). Propose a new task (SP-1) for an SG specific application development for the selected platform with a goal of completion by December 2016.	December 2016
	6	Vulnerability review of SSTDR technology implemented in analog camera NGSS module	The Spread Spectrum Time Domain Reflectometer (SSTDR) implemented in the analog camera NGSS module 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 member state support is sought. A related task proposal (SP-1) will be advertised by March 2016.	Phase 1 to be completed in February 2016
7	7	Develop wireless communication interface for the NGSS camera	Develop a fully integrated WLAN based communication module for the NGSS camera to eliminate the need for data cables in certain SG applications.	April 2016
	8	Execute Phase 1 of the Next Generation Surveillance Review Software development	Funded by regular budget and in cooperation with the EC, a Next Generation Surveillance Review software is being developed. Phase 1 will provide core review capabilities for images from NGSS cameras.	December 2016

4.3 Attachments

Figure 1. XMOS multi-camera server based on Next Generation Surveillance Camera (NGSS) technology

Figure 2. NGSS underwater camera for spent fuel surveillance applications

SGTS-008

Instrumentation Technology Foresight

Project Manager: Dimitri Finker

Division: SGTS

1. Overview

This document describes the plans for developing and implementing Project SGTS-008, *Instrumentation Technology Foresight*, within the Department of Safeguards for the period 2016–2017.

During the 2016-2017 biennium, Project SGTS-008 will pursue the following Long-Term Direction:

Identify, adapt and deploy emerging technical advances in other scientific fields and optimize them for use in safeguards.

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
12. Ability to take on technical challenges and opportunities, and emerging tasks.	12.2 Develop and implement a technology foresight horizon scanning process for external, potentially relevant research and development (R&D) fields.	M

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 2016-2017 biennium, the project's top priorities are:

- Implement ANPS (autonomous navigation and positioning for safeguards) as a means to structure and streamline the workflow of field instrumentation data.
- Develop in situ analysis capabilities.
- Evaluate the use of robotics to assist or automate tasks in the field.
- Upgrade the Complementary Access toolkit for inspectors.

2. Background

Previously, this project was titled "Novel Technologies" and served as a catalyst for the adoption of emerging technologies for safeguards, such as laser-induced breakdown spectroscopy (LIBS) or hand-held Raman instruments. The recently rescoped project will continue to monitor a broad scope of innovations and R&D developments but has renewed the project to focus on the evaluation and implementation of available 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 to address cross-cutting 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. These include indoor positioning and navigation, chemical substance identification, and photogrammetry. 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 customized development efforts;
- Providing resources for related R&D efforts to support the implementation of identified solutions; and
- Supporting the testing and deployment of innovative technologies.

3. Objectives and Key Achievement Targets

In order to support Project SGTS-008's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Develop and implement a technology foresight horizon scanning process for external, potentially relevant research and development (R&D) fields. **(In support of Milestone 12.2)**	
Establish partnerships with new external stakeholders, 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.	December 2017
Issue and distribute a quarterly Technology Preliminary Evaluation Report.	Ongoing
Objective 2.) Implement solutions for gaps identified in technologies currently in use for safeguards and laboratory activities.	
Evaluate and customize commercial in-situ analysis capabilities. Report on results to stakeholders.	December 2016
Identify and deploy a gamma imaging solution addressing at least one specific safeguards scenario.	June 2017
Implement an autonomous navigation and positioning system, included in the standard instrumentation kit used by inspectors for CA and DIV, along with the processing software used to structure and streamline the instrument data workflow.	December 2017
Upgrade the Complementary Access kit with up-to-date technologies; make it modular and compact.	December 2016
Objective 3.) Evaluate identified technologies for possible safeguard applications.	
Conduct a technology demonstration workshop on robotics.	December 2016

4. Activities

Funding and resources for some 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. Most activities are supported by regular budget sources.

Objective 1: ***Develop and implement a technology foresight horizon scanning process for external, potentially relevant research and development (R&D) fields.*** **(In support of Milestone 12.2)**

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. MSSP support in identifying the appropriate stakeholders for each technical area under consideration is important.

Equally important are the internal IAEA experts and inspectors who can support the evaluation, testing and implementation of these innovations for safeguards. This project will establish a process of systematically reaching out to various technical fields to support the identification of relevant innovations. Additionally, to ensure stakeholders are informed of ongoing work and the IAEA's evaluation of various topics, the IAEA will issue quarterly reports on its preliminary evaluation of technical areas of interest.

Objective 2: ***Implement solutions for gaps identified in technologies currently in use for safeguards and laboratory activities.***

Once a technology has been evaluated and shows potential to positively impact the implementation of safeguards, the IAEA will customize solutions and implement them in cooperation with the Divisions of the Department of Safeguards. The focus for this biennium will be on the evaluation of identified commercial in-situ analysis capabilities, their customization for safeguards use and their impact on the user-experience. Improved processing capabilities enable portable instruments to provide near real-time analysis in the field for many situations that previously required time-consuming analysis in a laboratory. Simultaneously, the size and weight of many field instruments are decreasing from portable to hand-held, from hand-held to palm-top and from palm-top to wearable.

Additionally, the IAEA has spent significant effort in 2014-2015 to evaluate and integrate a safeguards-specific solution for autonomous navigation and indoor positioning. This effort will continue during this period with the optimization of the hardware and development of the software, and implementation of this capability with IAEA inspectors.

Objective 3: ***Evaluate identified technologies for possible safeguard applications.***

The IAEA will continue to monitor and evaluate new areas for innovative solutions to address safeguards challenges. As such, the focus for 2016 will be on robotics and the possible solutions this field can provide to complete or 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 their working conditions. The IAEA expects to hold a technology demonstration workshop on this topic in 2016 and MSSP support in organizing and recommending participants will be particularly important.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[25] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	Continuous technology evaluation	1) Continue research and subsequent evaluation of technologies for potential safeguards application. 2) Issue quarterly "Technology Preliminary Evaluation Report".	Ongoing
2	2	Indoor positioning	Implement the IAEA autonomous navigation and indoor positioning system.	December 2016
	3	In situ analysis	Customize and implement chemical identification systems.	June 2017
	4	Instrument data contextualisation	Automate the extraction of the instrument data collected in the field, and enrich them with contextual information.	December 2017
	5	Gamma imaging	Implement a gamma imaging solution for safeguards activities.	June 2017
	6	Complementary Access tools	Upgrade the Complementary Access (CA) kit.	December 2017
3	7	Technology Demonstration Workshop (TDW) on robotics	Conduct a workshop on the application of robotics for safeguards.	December 2016

[25] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

4.3 Attachments

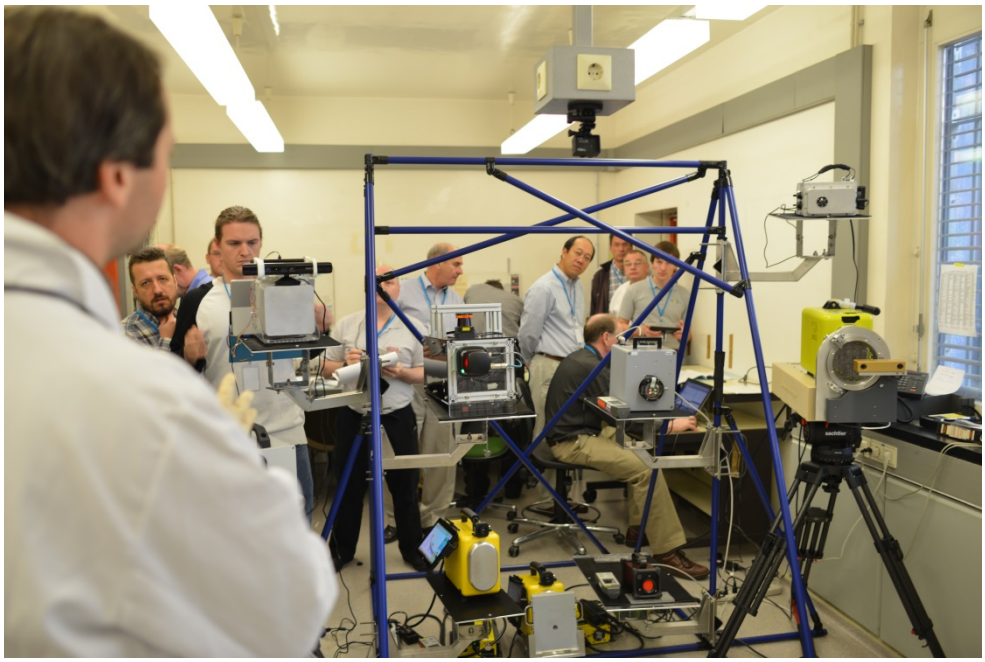

Figure 1. Gamma imaging workshop

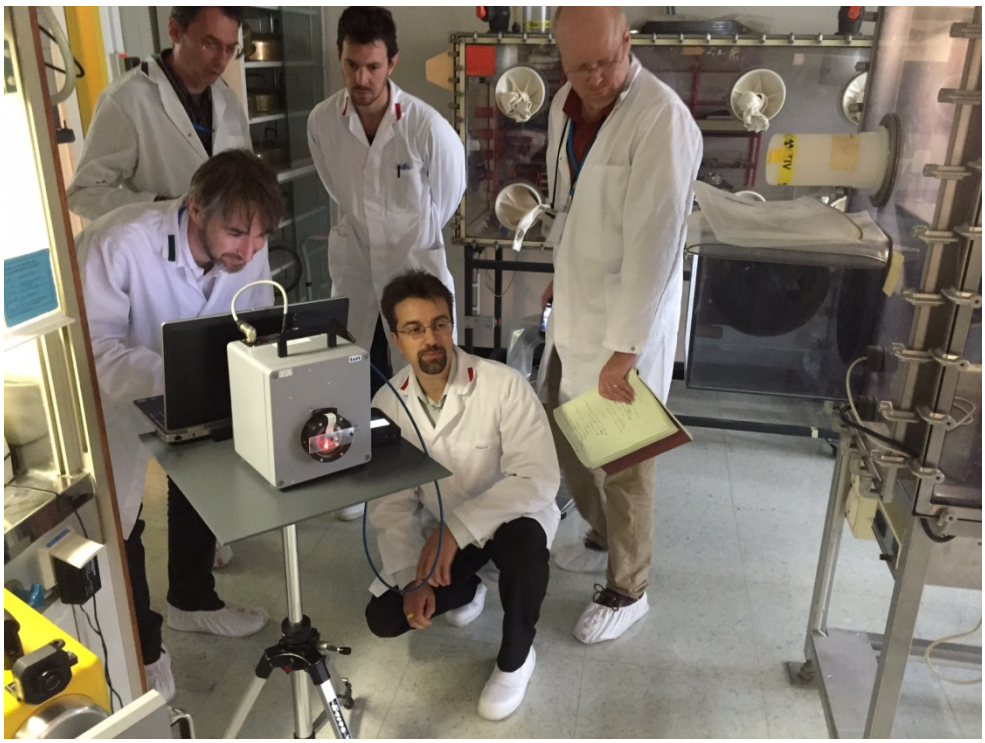

Figure 2. Gamma imaging workshop

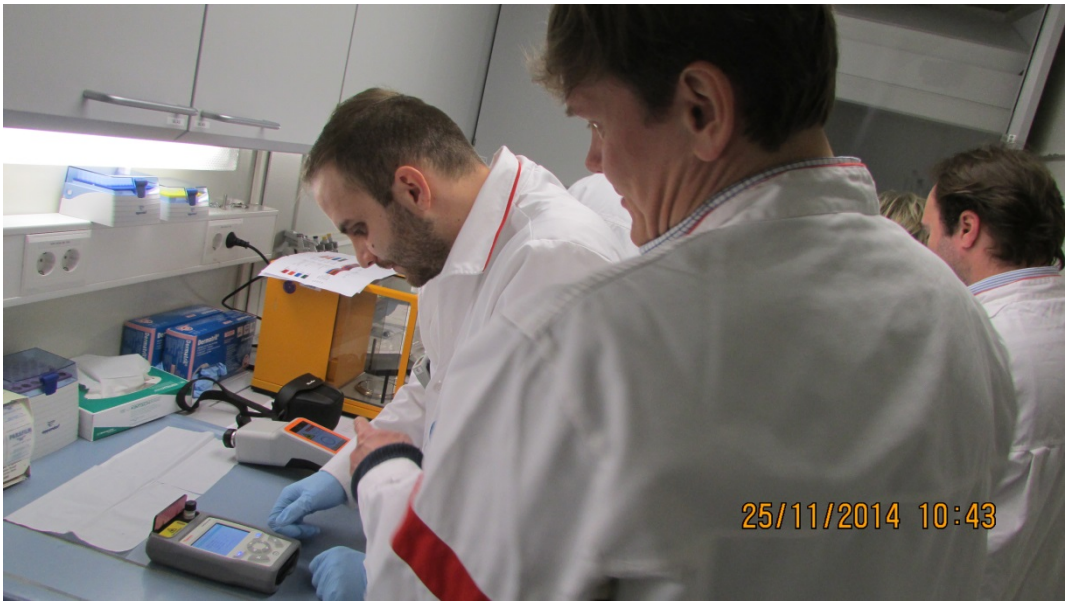

Figure 3. Several hand held chemical identification devices being tested

Figure 4. Mapping with Zeb1

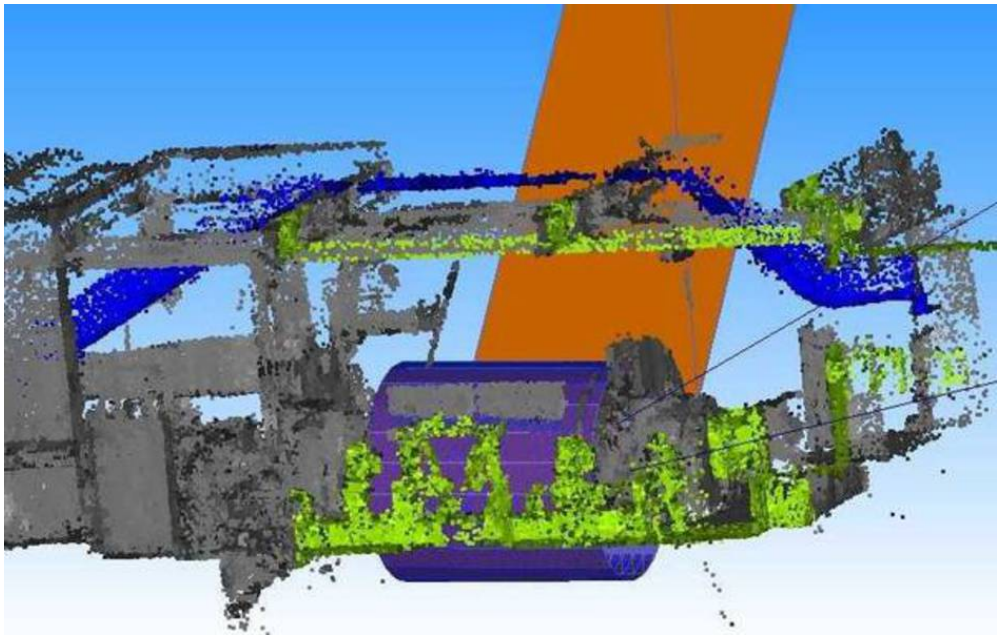

Figure 5. Image generated by Zeb1

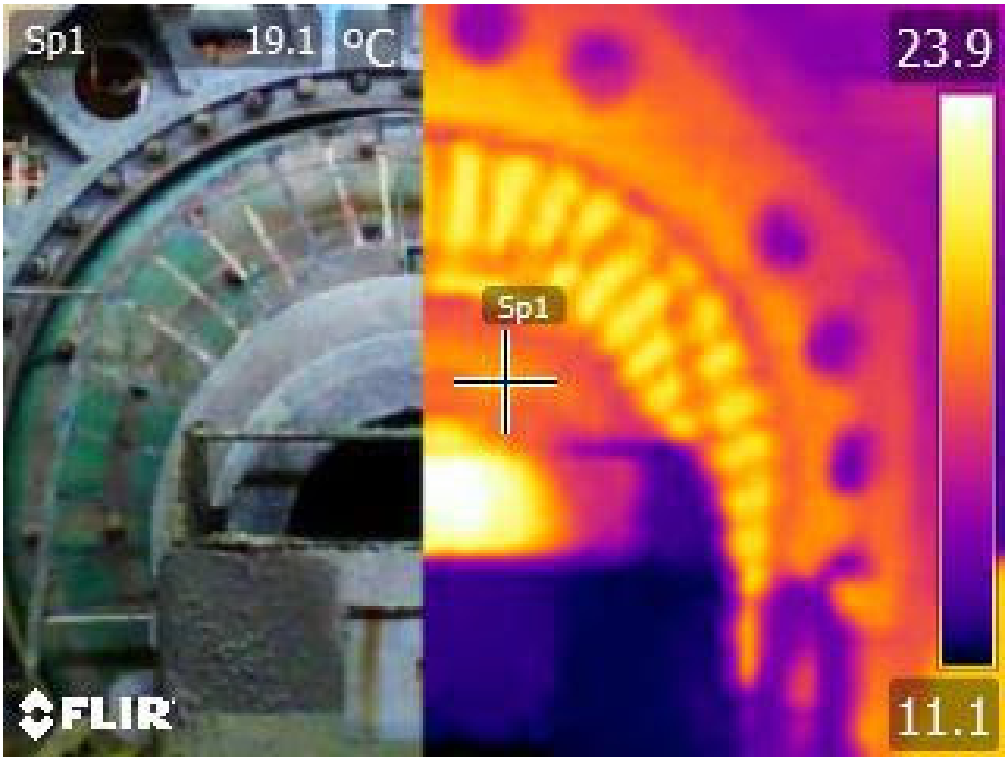

Figure 6. IR Camera

SGTS-011

Unattended Measurement Techniques

Project Manager: Thierry Pochet

Division: SGTS

1. Overview

This document describes the plans for developing and implementing unattended measurement techniques within the Department of Safeguards for the period 2016–2017.

During the 2016-1017 biennium, Project SGTS-011 will pursue the following Long-Term Direction:

Provide optimized unattended measurement techniques that enhance present safeguards equipment methods and capabilities for the detection and monitoring of declared and undeclared nuclear material and activities.

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
5. Ability to provide credible assurances that nuclear material used in non-proscribed military activities, specifically naval propulsion, is not used for the production of nuclear weapons or other nuclear explosive devices.	5.1 Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation).	L
	5.2 Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities.	H
	5.3 Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities.	M
	5.4 Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.	M
	5.7 Develop more sensitive and less intrusive alternatives to existing instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage.	H
6. Increase the proportion of deployed unattended systems that are sustainable, standardized, and modular, with increased use of COTS products.	6.1 Implement an improved cost/benefit assessment methodology for the design and operation of safeguards equipment.	M
	6.2 Develop neutron counting systems reducing the use of ^3He or offering equivalent functional and technical alternatives.	M

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 NDA (Non-Destructive Assay) applications. The former will help meet current and emerging verification challenges in a resource-constrained environment, while the latter will reduce costs, particularly labor 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 non-destructive assay (NDA) methodologies, measurement techniques and sensors for unattended applications, pertinent to safeguards implementation requirements and the required capabilities.
- The development of standard NDA techniques specifically tailored for unattended use.
- The 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 security, power management, and redundancy features for unattended use, in particular to allow secure remote data collection through networks. The development effort must be driven by a standardization approach and a strict cost-effectiveness policy in view of optimizing system maintainability and associated life cycle costs.
- The development and standardization of new generic software for multiple data type collection, review and analysis, which will be compatible with all unattended monitoring system (UMS) data generators. Review and analysis software will provide powerful and sophisticated features for data reduction and interpretation, which will efficiently and effectively assist inspector effort.

For the 2016-2017 biennium, the project's top priorities are:

- Deploy the On-Line Enrichment Monitor (OLEM) at Operations' request.
- Complete the Unattended Cylinder Verification System (UCVS) viability study.
- Complete Phase II of the Unattended Gamma Emission Tomography (UGET) study.
- Develop specifications for the next generation of UMS Data Acquisition module.
- Complete the upgrade of VIFM systems with new ADM2 data acquisition modules.
- Complete the upgrade of all other ageing UMS systems with up-to-date and standardized COTS components.
- Consider a new approach for power management to support the aim of optimizing the life cycle cost of UMS systems.

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 supporting the main end users, which are safeguards inspectors. 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.

The project has supported unattended system use with development and support for new detector systems (MUD2 (Mobile Detection Unit) and F-SEGM (Fiber-optic based Silo Entry Gate Monitor)), new data acquisition (ADM2 (Next Generation Adam Module) development), unattended systems for use in enrichment facilities (OLEM (On-Line Enrichment Monitor) and UCVS (Unattended Cylinder Verification System) prototypes) and difficult to access storage (UGET (Unattended Gamma Emission Tomography) Phase I study).

In the 2016-2017 biennium, these efforts will continue with the continuing development and improvement of existing UMS and the development and implementation of UMS into new application areas.

A number of this project's key 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*, and SGTS-015 *Technologies for New IAEA Verification Mandates*.

3. Objectives and Key Achievement Targets

In order to support Project SGTS-011's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation). **(In support of Milestone 5.1)**	
Improve, evaluate and test upgraded solution monitoring software.	December 2017
Objective 2.) Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities. **(In support of Milestone 5.2)**	
Complete the viability study of the UCVS at an enrichment facility.	June 2016
Objective 3.) Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities. **(In support of Milestone 5.3)**	
Deploy the OLEM at an enrichment facility upon Operations' request.	December 2016
Objective 4.) Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle. **(In support of Milestone 5.4)**	
Develop further the MUD2 capabilities to accommodate different types of sensors and detectors.	December 2016
Complete the upgrade of VIFM systems with new ADM2 data acquisition modules.	December 2017
Complete the upgrade of all other UMS systems.	December 2017
Objective 5.) 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. **(In support of Milestone 5.7)**	
Complete evaluation of gamma-ray emission tomography methodology for unattended use in verification of fuel assembly integrity. This might include Phase II of the Unattended Gamma-ray Emission Tomography (UGET) project, if approved.	December 2017
Objective 6.) Increase the proportion of deployed unattended systems that are sustainable, standardized, and modular, with increased use of COTS products. **(In support of Capability 6)**	
Complete the upgrade of UMS systems with up-to-date and standardized COTS components including data acquisition modules, computers, and power management modules.	December 2017
Complete the upgrade of VIFM systems with new ADM2 data acquisition modules.	December 2017

4. Activities

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

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 bienniums.

Objective 1.) ***Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of***

Pu separation). **(In support of Milestone 5.1)**

The task EC A 1661 currently supports this objective through the development of solution monitoring software for a large reprocessing facility. The task includes the development of reference signatures for about 50 vessels, as well as upgrades to the user interface. So far, reference signatures for 20 of the most important vessels were tested and refined, based on the available data. First versions of several reference signatures developed by the IAEA, with support from JRC-Ispra, and were integrated into the configuration module by a contractor. The first version of the upgraded user interface was delivered by the contractor, and following its testing by the IAEA and JRC-Ispra several corrections/improvements were identified and reported for implementation.

With the shutdown of the Rokkasho Reprocessing Plant (RRP) facility, progress on development has been slowed. Future work will involve a comprehensive analysis of the user interface event-handling function, as well as an analysis of the impact produced by the software upgrades on the evaluation module. This activity is pending the release of the final updated software.

Further work on reference signatures relies on the availability of additional representative data and is therefore pending the re-start of facility operations. According to the current schedule, commercial operation is not expected before April 2016.

In addition, USA A 1351 *Support for Development of the Safeguards System at RRP* is another support task to help the IAEA develop and implement unattended systems.

Objective 2.) ***Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities.*** **(In support of Milestone 5.2)**

and

Objective 3.) ***Develop improved tools and techniques to enable real time flow measurements of nuclear material, including UF_6 at enrichment facilities and Pu at reprocessing facilities.*** **(In support of Milestone 5.3)**

The IAEA is developing a flexible toolbox of technologies that is consistent with its State-level approach to safeguards implementation. The toolbox includes three different unattended measurement systems:

- The On-Line Enrichment Monitor (OLEM), which could provide continuous enrichment measurement for all of the declared gas flowing through unit header pipes.

Phase II of the OLEM project (under tasks UK A 1868 and USA A 1913) started in early 2013. Three prototypes were developed and tested in the URENCO enrichment facility in Almelo, The Netherlands during 2014, and this phase of the OLEM project completed in 2015. Another phase of the OLEM project is being considered for this biennium to develop an addition to the current OLEM to allow for uranium density to be measured without direct pressure measurements (the current version of OLEM relies on splitting pressure signals from existing pressure transducers in the facility).

- The Unattended Cylinder Verification System (UCVS), which 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 viability study of UCVS was started in 2014 under tasks JNT A 1979 EC and JNT A 1979 USA. The first phase, which should be completed by summer 2016, covers refinement of user requirements; development and documentation of preliminary hardware and software design specifications for a flexible field-prototype UCVS; modelling-based assessment of predicted performance over a plausible range of cylinder parameters and diversion scenarios; field-testing of an initial prototype in a low-risk operational environment; comparative evaluation of candidate NDA methods; and development of life-cycle cost estimates. Initial results look positive, and a Phase II will be considered during this biennium to develop a robust prototype for field trial in an enrichment facility.

- The application and verification of joint use data collected at enrichment plants (under SGTS-001).

The study of joint use data from enrichment plants is being conducted under tasks JNT A 1879 EC and JNT A 1879 FRA (under SGTS-001). The purpose of this task was primarily to study the possibilities of using operator sensor data (for example load cell data) for safeguard purposes. The investigation looked into the issues associated with joint use data, data independence, and the possibilities of combining data sources to allow for robust data authentication.

Objective 4.) ***Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.*** **(In support of Milestone 5.4).**

MUD2 systems originally developed for neutron detection will be further developed to detect gamma radiation for counting or spectrometry applications.

The upgrade of all VIFM systems will continue worldwide with the new NGAM data acquisition module. This campaign will last several years, and will be supported by the on-going task CAN E 1530 'VIFM Implementation Support'. The upgrade of all other UMS systems will also continue worldwide with up-to-date standardized COTS components. This campaign will last several years, and will be 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'.

Objective 5.) ***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.*** **(In support of Milestone 5.7)**

The IAEA is interested in pursuing methods to verify spent fuel assembly integrity prior to putting the assemblies in difficult to access storage facilities.

One of the promising technologies that has been explored and continues to be developed is gamma emission tomography (GET). The IAEA has initialized a number of MSSP tasks in this area over the years, with the latest being Unattended Gamma Emission Tomography (UGET) for Partial Defect Detection – Phase I (JNT A 1955 EC, JNT A 1955 FIN, JNT A 1955 SWE, and JNT A 1955 USA), which concluded at the end of 2015. This joint task developed modeling and simulation tools to help explore the operational space to optimize detector geometry and analysis approaches for an optimized GET system. These tools were then used to evaluate the performance envelope of the optimized device against a number of spent fuel assembly varieties and scenarios from short to long cooling times for two primary objectives, either pin diversion or pin by pin burnup verification. A number of questions remain, and further development of software tools would be required for optimal image reconstruction and analysis.

The IAEA is considering a second phase for this task, which will likely focus on additional modeling and simulation scenarios as well as software development. Along with the UGET task, the IAEA is upgrading a GET prototype under the SGTS-001 project, which would benefit from continuation of the UGET task.

Objective 6.) ***Increase the proportion of deployed unattended systems that are sustainable, standardized, and modular, with increased use of COTS products.*** **(In support of Capability 6)**

Project SGTS-011 includes implementation activities that address Capability 6. During the 2014-2015 biennium, UMS continued to develop and implement standard COTS components in the UMS to the extent possible, in order to simplify the maintainability of UMS systems and to minimize component life cycle costs. 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.

In addition to the above current tasks, nine new tasks are proposed for Project SGTS-011 that would be addressed internally with regular budget funding:

- A new preamplifier developed by Los Alamos National Laboratory with improved performance characteristics will be tested in the field in the course of 2016.
- UMS has developed a versatile neutron source housing to allow for accurate testing of UMS neutron detectors. The source housing will be fully operational by February 2016.
- UMS will select and evaluate new generation computers for use in unattended systems (including new operating system versions) by mid-2016.
- UMS will develop an electronic booster of pulse TTL type signals to extend ranges between UMS cabinets and detectors by mid-2016.
- A COTS charge pulse injector has been proposed to facilitate the calibration of nuclear measurement chains in the field during regular maintenance or repair. A final technical specification was proposed to potential vendors in February 2015, and sample devices are being tested. They should be available for field use by June 2016.

- A survey of COTS technologies related to power management has been proposed to support the aim of increasing the maintenance cycles for UMS systems. The technologies will include an uninterruptible power supply in UMS instruments and other measures to extend the cycle of battery replacement. A new concept should be ready for implementation in July 2016.
- The evaluation of a new class of gamma-ray detectors, such as proportional counters and Geiger–Müller tubes, has been proposed to guide the eventual replacement of ion chamber detectors. If the tests are successful, these types of detectors will be added to the IAEA's pool of authorized UMS detectors, becoming available for field implementation by the end of 2016.
- The use of a suitable COTS current to frequency converter (CFC) has been proposed to improve instrumentation performance. When utilized with an ion chamber, the CFC will produce a data acquisition digital pulse input rather than an analogue voltage current proportional to the input. Technical specifications could be submitted to potential vendors by mid-2016, with candidate devices tested for field deployment by the end of 2016.
- UMS will develop 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 by the end of 2017.

4.1 MSSP Development and Implementation Support Tasks

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[26] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
6	1	Data acquisition	Develop next generation data acquisition solution.	December 2017
	2	Power management methods	Asses and evaluate methods for improving the power management of UMS systems.	June 2016
	3	Computers for UMS	Selection and evaluation of new generation computers for UMS including new operating system versions.	June 2016
	4	New preamplifier	Evaluate new preamplifiers for coindence counting applications.	June 2016
	5	New generation of gamma-ray detectors	These detectors must be able to work in pulse mode to replace ion chambers.	December 2016
	6	Current to frequency converter	Evaluate new current to frequency converters to support standardization of data acquisition for ion chambers.	December 2016
	7	Charge pulse injector for calibration purpose	Needed to adjust gain and thresholds on neutron preamplifiers.	June 2016

[26] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

	8	Neutron source and housing	Develop versatile neutron source housing to allow for accurate testing of UMS neutron detectors.	February 2016
	9	Pulse booster	Development of electronic booster of pulse signals to extend ranges between UMS system components.	June 2016

4.3 Attachments

Figure 1. Image of the On-Line Enrichment Monitor (OLEM) developed through the US SP

Figure 2. Image of a prototype Unattended Cylinder Verification Station (UCVS) at a data collection activity

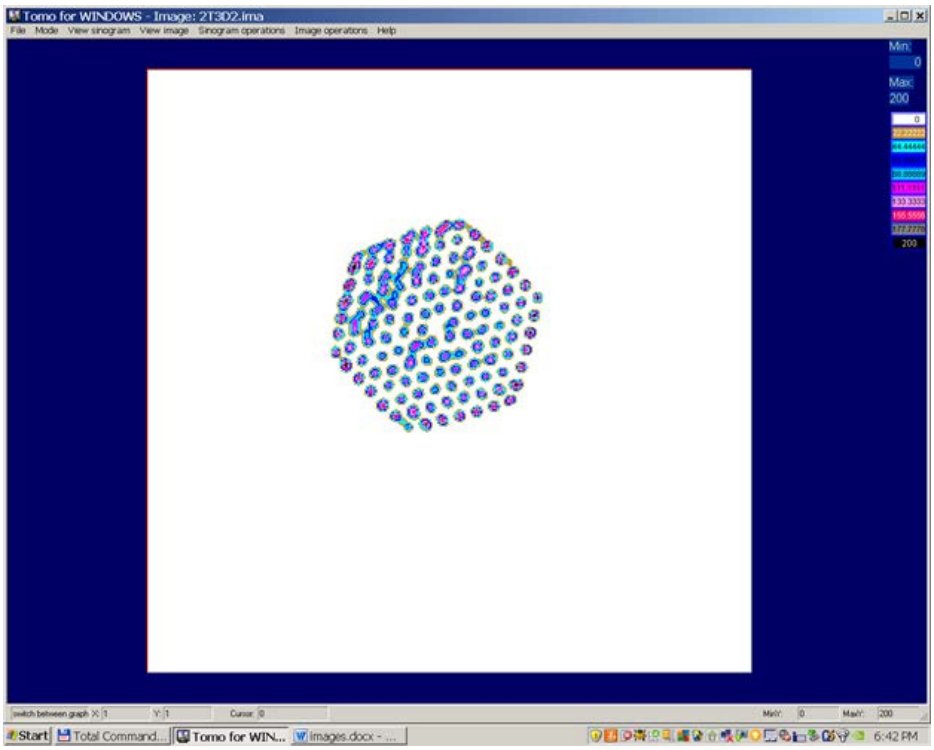

Figure 3. Reconstructed image of a spent fuel assembly from a gamma emission tomography device

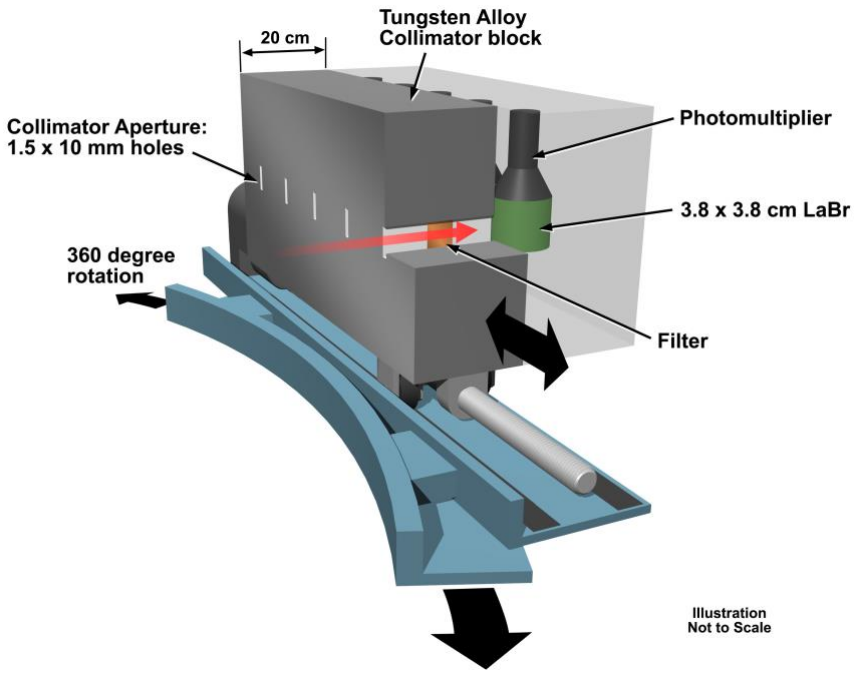

Figure 4. Conceptual design of the Unattended Gamma Emission Tomography (UGET) detector

SGTS-014

Remote Monitoring and Data Processing Systems

Project Manager: Jim Regula

Division: SGTS

1. Overview

This document describes the 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 2016–2017.

During the 2016-2017 biennium, Project SGTS-014 will pursue the following Long-Term Direction:

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 project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

Capability	Milestone	Urgency
7. Ability to make maximum efficiency savings by the use of remote monitoring of operators' and unattended IAEA equipment.	7.2 Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.	M

The purpose of this project is to support the use of remote monitoring and IAEA equipment data processing through the enhancement of hardware and software tools. In the near term, the major challenges this project addresses are the integration of the RM equipment interface RAINSTORM (Real-time And Integrated Stream-Orientated Remote Monitoring), development of NRT (near real time) components at large future facilities and the all-in-one review program, iRAP (Inspector Review and Analysis Platform).

For the 2016-2017 biennium, the project's top priorities are:

- Joint development with EURATOM of the all in one review program iRAP (the top priority for this project in the 2016-2017 biennium).
- Building new NRT (near real time) components for upcoming large facilities.
- Maintenance and expansion of the global RM network, while ensuring data security.

2. Background

Remote monitoring 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, RM grew 10-15% per year in the number of systems connected and data collected. In-house tools such as custom written applications for the transfer of data, parsing of log files, and web status screens (ROOGLE) were developed. Several years ago, it was decided that RM would be the focal point for equipment software development in the Safeguards Department's Division of Scientific and Technical Services (SGTS). This was a major turning point for the unit. Additional programmers were hired and the application areas also expanded. RAINSTORM was developed in house to standardize the RM 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.

Over the recent years, the Department of Safeguards has had difficulty maintaining existing review programs for equipment data because they are numerous and the IAEA did not have access to the source code lacking IP (intellectual property) rights. An attempt was made at obtaining 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. Currently, iRAP version 2.0 has been released and can be used to review and analyze data from any of the Department's Unattended Monitoring Systems (UMS). Future iRAP capabilities will also include review of surveillance and electronic seals, INCC (IAEA Neutron Coincidence Counting) integration, and the importing of operator declarations.

Future large facilities such as geologic repositories will require NRT (near real time) data processing and red/green status lights for the operator. This will mean new tools will have to be developed based on safeguards equipment event detection and state of health (SoH) monitoring. The Remote Monitoring Team (RMT) plans to build a NRT test bed during the upcoming biennium.

The RM global network is estimated to be approximately 90% complete, with some geographic areas still unrepresented. The IAEA predicts that most of these regions will be connected to RM by the end of the biennium. Along with expansion, the security of the network is of the highest concern. New VPN technologies will continue to be tested, which will also include outside security audits.

Finally, the RMT is releasing the first iOS app in the Department of Safeguards, which shows the status of all RM systems in a read-only display. The IAEA intends this to evolve 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. MSSP support may be requested 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. Objectives and Key Achievement Targets

In order to support Project SGTS-014's long-term direction and associated capabilities and milestones from the Long-Term R&D Plan, 2012-2023, activities have to be initiated, continued and/ or finalized during the 2016-2017 biennium and can be structured under the following objectives:

Objectives and Key Achievement Targets	Expected Completion Date
Objective 1.) In collaboration with EURATOM, develop and implement an all-in-one review program.	
Complete and deploy a version of iRAP that includes surveillance, seals, operator declaration integration, and reporting tools.	December 2016
Objective 2.) Assist with preparations to safeguard new large facilities by building new NRT components to support remote monitoring.	
Objective 3.) Expand and maintain the global RM network while ensuring data security.	
Objective 4.) Improve the efficiency of facility inspections by introducing iOS-based apps, initially to monitor RM system status.	
Launch a prototype iOS-based (or similar) inspector tool for field use to assist with common tasks.	July 2017

4. Activities

Most of the following activities will be performed by Safeguards Department personnel with regular budget funding. Further assistance will be required from Member State Support Programmes for some activities.

Objective 1.) ***In collaboration with EURATOM, develop and implement an all-in-one review program.***

With the delivery of iRAP version 2.0, all UMS systems can be reviewed. There are, however, still gaps to be filled before the application is authorized for use by inspectors. Facility configurations need to be prepared, the graphics package needs updating, performance will need to be improved with the addition of RMT algorithms, INCC will need to be integrated into the system, and reporting tools must include safeguards requirements. There are work packages or studies currently pending to address all of these concerns. The majority of software development is done by an outside contractor, paid through the regular budget. Many of these development work packages will be evenly distributed between the IAEA and EURATOM.

By the first half of 2016, work will begin on integrating surveillance and electronic seals into the program. The surveillance unit has been relying on older GARS technology for the past several years, meanwhile looking for alternatives. The IAEA currently intends for iRAP to be the future singular surveillance review application.

Objective 2.) ***Assist with preparations to safeguard new large facilities by building new NRT components to support remote monitoring.***

When special verification within a facility process flow is required 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 reverification 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.

This is a new concept in remote data processing. It is one in which RMT has already built tools (SoH analysis and ROOGLE), but many additional components will have to be designed and developed. Examples include components to send and receive timely, authenticated feedback, components to provide immediate SoH analysis for a certain device over a given time period, and custom made docking stations for linking devices and exchanging messages.

To date, no support from MSSPs has been requested in this area. Initial work will be done in-house with regular budget support. However, several new task proposals seeking specialized programming or hardware expertise could be anticipated during the 2016-2017 biennium. MSSP support in this regard may be important.

Objective 3.) ***Expand and maintain the global RM network while ensuring data security.***

Expansion of the RM network continues, with the 25th Member State added in October of 2015; an RM site survey to an additional Member State will be performed in December 2015. The IAEA anticipates expansion into the remaining geographic areas, which have been historically resistant to RM, to be completed by the end of the 2016-2017 biennium.

Of higher priority is the security of the infrastructure; great efforts will continue to be made to identify and test the most secure VPN technologies. These include both proprietary and open source, ethernet-based and wireless, and smaller more industrial form factors.

The IAEA also anticipates the continuation of security audits or penetration tests by outside consultants as a very useful tool for gauging the current effectiveness of its security. MSSP support has been important in the past (USA E 1735, CAN E 1931); RMT anticipates that future support will be requested.

Objective 4.) ***Improve the efficiency of facility inspections by introducing iOS-based apps, initially to monitor RM system status.***

ROOGLE is a read-only web-based application, developed in-house, that displays the latest status of all systems under RM. It has been operational for over six years. It has recently been ported to iOS where it is being beta-tested on the iPhone/iPad platform (an IAEA standard). These types of apps may expand in the next biennium because these devices will be carried by all inspectors and many routine inspection tasks could be automated on them. Examples include a metal seal log for tracking attaching/detaching seals, a bar code scanner for inventory control, 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

A list of active and standby MSSP development and implementation support tasks, updated quarterly, can be accessed at Overview: General File > Development and Implementation Support Programme > 2016-2017.[27] If you have trouble logging into SPRICS, please contact SPRICShelp@iaea.org.

4.2 In-house Development Activities

Objective	Activity #	Activity Title	Description	Expected Completion Date
1	1	iRAP Development	Limited in-house development will occur, as iRAP matures into an all-in-one equipment review tool.	December 2017
2	2	NRT at large future facilities	Extension of in-house development is planned to build near real-time software systems for the unique requirements posed by these facilities.	December 2018
4	3	iOS software development	In-house iOS software is currently under development to replicate ROOGLE for the iPhone. Further development could take place in linking portable equipment.	December 2017

[27] Use link below to access folder
https://sprics.iaea.org/Sprics/Role%20based%20access%20file/Forms/AllItems.aspx?RootFolder=%2fSprics%2fRole%20based%20access%20file%2f%5fDevelopment%20and%20Implementation%20Support%20Programme%2f2016%2d2017%2fMSSP%20Development%20and%20Implementation%20Support%20Task%20Tables&FolderCTID=&View=%7bCA6F24D5%2d4576%2d4E12%2d9D51%2d5A54D2E3FDA5%7d

4.3 Attachments

Figure 1. Touch-screen application developed for Next Generation Surveillance System (NGSS) camera

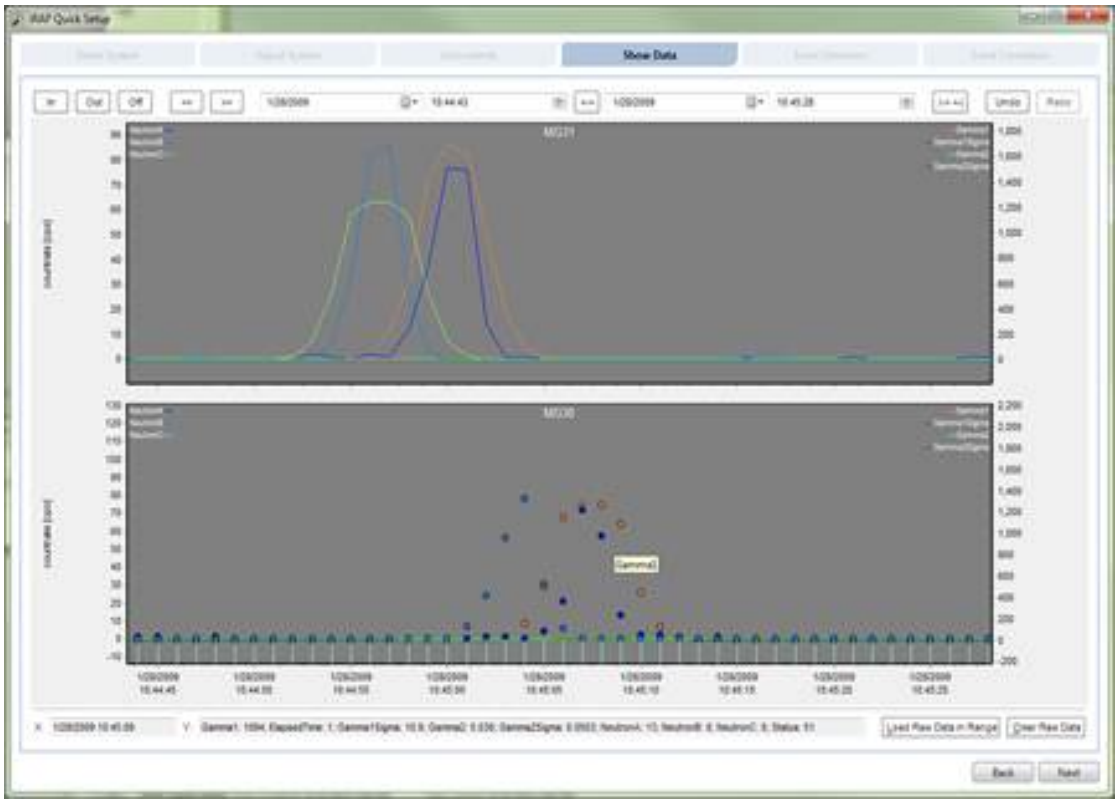

Figure 2. Screen shot of iRAP

SGTS-015

Technologies for Possible New IAEA Verification Tasks

Project Manager: Kenneth Baird

Division: SGTS

1. Overview

This document describes the plans for developing and implementing, as needed, tools for possible future IAEA Verification activities within the Department of Safeguards for the period 2016–2017.

During the 2016-2017 biennium, Project SGTS-015 will pursue the following Long-Term Direction:

Make ready for implementation instruments and measurement techniques and tools needed to support new IAEA verification mandates.

The project supports the Long-Term R&D Plan, 2012-2023, particularly with regard to achieving:

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

SGTS-015 addresses the development of instruments and measurement techniques needed to support the implementation of future IAEA verification mandates.

2. Background

This project was initiated in the 2011-2012 biennium in order to develop the technical tools needed for future foreseen verification activities that the IAEA could be called upon to implement.

Initially, in accordance with the formal request received from the authorities of the United States of America and the Russian Federation, the Department of Safeguards actively participated in the elaboration of the Russia-US-IAEA agreement defining verification measures to be performed by the IAEA under the US-Russia Plutonium Management and Disposition Agreement (PMDA) ('Agreement between the Government of the United States of America, and the Government of the Russian Federation, concerning the Management and Disposition of Plutonium Designated as no longer required for Defense Purposes and Related Cooperation').

While the implementation of this specific agreement is currently on hold, the Department of Safeguards maintains this project as a 'placeholder' for future activities in this area.

3. Objectives and Key Achievement Targets

No specific objective or key achievement targets are defined in this plan, as the activities required of the IAEA arising from the PMDA are, at the moment, unclear.

4. Activities

It is envisaged that future funding and resources for most of the project's D&IS activities will be provided by extrabudgetary funds. Some activities, having applications for both traditional and future IAEA mandates, would be supplemented by regular budget sources.

Appendix

Table of Long-Term R&D Plan capabilities and milestones with corresponding D&IS Projects and objectives

Long Term Capabilities	Milestones	Urgency	Projects and Objectives
1. Ability to fully implement the State-level concept for the planning, conduct and evaluation of safeguards.	1.1 Develop safeguards policy, guidelines and processes to more fully implement the State-level concept.	H	SGCP 101 Objective 1 SGCP 102 Objective 1
	1.2 Prepare additional guidance for the ongoing development of State-level safeguards approaches: • The use of State-specific factors • Acquisition path analysis • The specification of options for Headquarters and in- field activities required to meet the technical objectives • The link between the State evaluation process and development of SLAs and AIPs.	H	SGCP 003 Objective 1 SGCP 102 Objective 1
	1.3 Develop additional tools to support the development of State-level safeguards approaches: • The analysis, representation, and prioritization of acquisition paths • The planning of safeguards activities • The assessment of overall safeguards effectiveness • The determination of technical objectives.	M	SGCP 003 Objective 2 SGCP 102 Objective 1
	1.4 Develop approaches to more fully utilize SRA data and verification findings, where appropriate, to achieve efficiencies.	H	SGCP 003 Objective 3 SGCP 102 Objective 1
	1.5 Develop safeguards guidance for States, including web-based versions, addressing topics such as: • Regulatory authority • Design information • Inspections and complementary access • Imports and exports.	M	SGCP 003 Objective 4 SGCP 102 Objective 1
2. Increased ability to detect undeclared nuclear material and activities.	2.1 Integrate information sources, including satellite imagery, electronic data (including images), technical and academic literature, trade data, etc., to detect inconsistences in nuclear programmes and States' declarations.	M	SGCP 102 Objective 2 SGIM-003 Objective 1 SGIM 009 Objective 1

			SGIS 003 Objective 1
	2.2 Develop elemental and isotopic signatures of nuclear fuel cycle activities and processes (e.g. uranium conversion and laser enrichment), and apply them to analysis of environmental sampling and destructive analysis of nuclear material using mathematical, statistical and graphical tools.	H	SGCP 102 Objective 2
			SGIM 003 Objective 1
			SGIM 007 Objective 1
			SGTS 001 Objective 2
	2.3 Develop analytical methodologies, tools, and techniques for 'all source analysis', including the update of the 'Physical Model', to detect signatures of undeclared activity, and improve analysis of nuclear fuel cycles, including weaponization.	M	SGCP 102 Objective 2
			SGIM 002 Objective 1
			SGIM 003 Objective 2
			SGIS 003 Objective 2
			SGCP 003 Objective 5
	2.4 Evaluate data analysis methods and computerized tools to aid the analysis of the large amount of all-source information in order to support the State evaluation process and assist in drawing soundly-based safeguards conclusions.	M	SGCP 102 Objective 2
			SGIM 002 Objective 1
			SGIM 003 Objective 3
			SGIM 009 Objective 2
			SGOA 003 Objective 3
	2.5 Develop statistical methodologies and mathematically based approaches to optimize safeguards verification approaches and evaluation of results.	M	SGCP 102 Objective 2
			SGIM 007 Objective 2
			SGIM 008 Objective 1
	2.6 Develop instruments and associated techniques to detect the establishment and operation of nuclear fuel cycle activities, for example by detecting process emanations.	H	SGCP 102 Objective 2
			SGTS 001 Objective 1
3. Ability to safeguard new types of facility.	3.1 Develop generic safeguards approaches for: • Pyroprocessing plants • Other new reprocessing technologies • Laser enrichment plants	 M L M	SGCP 003 Objective 6

	• Other new enrichment technologies • Small modular and/or Gen IV reactors.	L M	
	3.2 Develop tools and techniques to characterize: • Fissile content in metal mixtures containing the actinides Np, Am and Cm during pyroprocessing • Fuel types for Gen IV reactors containing minor actinides. • Seismic signals in geological repositories.	M L M	SGCP 003 Objective 7
	3.3 Develop training to reflect the approaches and equipment for safeguarding new types of facility, including consulting with States developing such facilities to help assess what training is required.	L	SGCP 102 Objective 3
	3.4 Develop a mechanism to enable safeguards to be considered early in the facility design process.	M	SGCP 003 Objective 8
4. Ability to provide credible assurances that nuclear material used in non-proscribed military activities, specifically naval propulsion, is not used for the production of nuclear weapons or other nuclear explosive devices.	4.1. Consult with Member States with established naval nuclear propulsion programmes for development of future verification arrangements in this area.	H	SGCP 003 Objective 9
	4.2 Develop concepts, tools, and measures to enable the IAEA to design a verification approach for nuclear material destined for, and returned from, naval propulsion.	M	--
	4.3 Develop an approach to provide credible assurance that nuclear material being used in naval propulsion is not used for the production of nuclear weapons or other nuclear explosive devices.	M	--
5. Ability to deploy equipment at facilities to meet safeguards requirements.	5.1 Develop improved tools and techniques to detect misuse of reprocessing plants (real time detection of Pu separation).	L	SGOA 002 Objective 1 SGTS 003 Objective 1 SGTS 003 Objective 2 SGTS 011 Objective 1
	5.2 Develop tools and techniques to enable timely, potentially real time, detection of HEU production in LEU enrichment facilities.	H	SGOA 002 Objective 1 SGTS 003 Objective 1 SGTS 011 Objective 2
	5.3 Develop improved tools and techniques to enable real time flow measurements of nuclear	M	SGOA 002 Objective 1

	material, including UF_6 at enrichment facilities and Pu at reprocessing facilities.		SGTS 003 Objective 1
			SGTS 003 Objective 3
			SGTS 011 Objective 3
	5.4 Develop appropriate safeguards equipment to establish and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle.	M	SGOA 002 Objective 1
			SGTS 003 Objective 1
			SGTS 011 Objective 4
	5.5 Develop methods to verify fresh fuel in shipping containers without opening the containers.	M	SGOA 002 Objective 1
			SGTS 003 Objective 1
	5.6 Develop improved NDA instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.	M	SGOA 002 Objective 1
			SGTS 001 Objective 3
			SGTS 003 Objective 1
	5.7 Develop more sensitive and less intrusive alternatives to existing NDA instruments to perform partial defect test on spent fuel assembly prior to transfer to difficult to access storage.	H	SGOA 002 Objective 1
			SGTS 001 Objective 4
			SGTS 003 Objective 1
			SGTS 011 Objective 5
	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.	M	SGOA 002 Objective 1
			SGTS 001 Objective 5
			SGTS 003 Objective 1
6. Ability to acquire and deploy safeguards equipment that is sustainable, standardized and modular, with increased use of commercial off-the-shelf products.	6.1 Implement an improved cost/benefit assessment methodology for the design and operation of safeguards equipment.	M	SGTS 001 Objective 6
			SGTS 011 Objective 6
	6.2 Develop neutron counting systems reducing the use of ^{3}He or offering equivalent functional and technical alternatives.	M	SGTS 011 Objective 6

7. Ability to make maximum efficiency savings by the use of remote monitoring of operators' and unattended IAEA equipment.	7.1 Develop minimally intrusive techniques that are both secure and authenticated to enable the use of operator's systems, instruments and process monitoring for cost effective safeguards implementation.	H	--
	7.2 Conduct improved intrusiveness and vulnerability analysis on current and future use of unattended systems, particularly to address any new threats resulting from technology advancements.	M	SGTS 003 Objective 4
8. Ability to use safeguards information in a fully integrated, secure environment, maintained and available to all who need it according to their role.	8.1 Develop a fully integrated, secure safeguards data environment (ISE), including all State reports under a safeguards agreement and declarations under an additional protocol, and an electronic State file containing all safeguards-relevant information about each State.	H	SGIM 002 Objective 2
			SGIM-009 Objective 3
			SGIS 002 Objective 1
			SGIS 002 Objective 4
			SGIS 002 Objective 7
			SGIS 003 Objective 3
	8.2 Create links between exemptions and terminations of nuclear material with the nuclear material accounting database to allow automatic checking of State reporting.	H	SGIM 009 Objective 4
9. Ability to communicate secure, authentic information that is fully compatible with ISE between the IAEA, SRAs and inspectors/equipment in the field.	9.1 Develop updated software tools for use by SRAs in creating and submitting accountancy reports and additional protocol declarations, supporting the further integration of State declared information within the electronic State file.	M	SGIM 009 Objective 5
			SGIS 003 Objective 4
	9.2 Deploy secure and authenticated communications between the IAEA and SRAs.	M	SGIM 009 Objective 6
	9.3 Deploy secure and authenticated communications between inspectors in the field and IAEA headquarters/regional offices.	M	SGIS 002 Objective 5
	9.4 Ensure the Department's ability to recover from an IT failure.	H	SGIS 002 Objective 6
10. Ability to provide analytical services through the NWAL to support verification requirements.	10.1 Utilise the expanded NWAL, in order to: • Provide external quality control and reference materials • Provide technical expertise.	H	SGAS 001 Objective 1
			SGAS 002 Objective 1
			SGAS 003 Objective 1

	10.2 Develop techniques, methods and equipment to detect signatures of nuclear activities in environmental samples including: • Age determination of U and Pu relevant to the origin of nuclear materials • Analysis of impurities relevant to the origin of source materials • Particles morphology for identifying operational processes • Reliably finding smaller particles of interest in an excess of background material.	H	SGAS 002 Objective 2
	10.3 Develop and implement techniques for determination of new chemical and physical attributes for strengthening safeguards verification using nuclear material samples. Improve capability to characterize nuclear material and verify its origin e.g.: • Age determination • U speciation. • Analysis of U impurities.	H	SGAS 001 Objective 2
11. Ability to deal with new mandates.	11.1 Develop options and approaches for possible future mandates as required or requested (e.g. fissile material cut off treaty, arms control) that respect sensitive and proprietary information.	L	SGVI 001 Objective 1
12. Ability to take on technical challenges and opportunities, and emerging tasks.	12.1 Assist with Chernobyl, Fukushima and DPRK related activities as requested.	M	SGCP 003 Objective 10
			SGOC 001 Objective 1
			SGOC 001 Objective 2
			SGOC 001 Objective 3
	12.2 Develop and implement a technology foresight horizon scanning process for external, potentially relevant R&D fields.	M	SGTS 008 Objective 1
			SGCP 003 Objective 10
13. Ability to deploy the required expertise and skills to continue to fulfil the IAEA's mandate(s).	13.1 Develop training tools using advanced methods such as virtual reality, immersive learning systems and web-based training: • Develop prototype virtual reality systems, test and evaluate performance • Include immersive learning for all types of fuel cycle facilities • Develop web-based tools for specific safeguards equipment • Develop signal (neutron/gamma) simulators to generate responses from equipment during training.	M	SGCP 102 Objective 4
			SGCP 102 Objective 5

	13.2 Develop training material and remote delivery methods to support SRA training with reduced costs and increased accessibility.	M	SGIM 009 Objective 7
			SGCP 102 Objective 4
			SGCP 102 Objective 6

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16-09031