IAEA

Safeguards

Development and Implementation Support Programme for Nuclear Verification 2024–2025

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STR-405
January 2024

Foreword

As we look to the opportunities and challenges of the new biennium, I am pleased to present the *IAEA Department of Safeguards' Development and Implementation Support (D&IS) Programme for Nuclear Verification, 2024–2025*. This publication connects our goals with Member State Support Programmes' (MSSPs) decision-making processes to guide and support the IAEA in efforts towards evermore effective and efficient safeguards implementation.

In navigating the complexities of international safeguards, our commitment to fresh perspectives and collaboration is fundamental, especially in our partnerships with our MSSPs. Furthermore, tackling the challenges faced by the Department in 2022–2023 saw an extraordinary collective effort on behalf of both my colleagues and our external partners. The support provided by our MSSPs continues to be crucial in overcoming these challenges.

I would like to welcome the States who have established MSSPs since the last publication of the D&IS: Norway and the United Arab Emirates. Diversifying our streams of extrabudgetary contributions through additional MSSPs is not just a strategy; it's a necessity to ensure the sustainability of our mission. To our recently joined MSSPs: thank you for entrusting us with your extrabudgetary contributions. We assure you that these funds will be used prudently to enhance our capabilities. To our well-established MSSPs: please know you have been crucial to our success and that we highly value our longstanding partnerships.

Allow me to underscore a select set of priorities where I see significant potential for MSSPs to play a pivotal role in aiding our efforts. Ensuring industrial safety for the Department's staff members who work in the field, an important endeavour to ensure the well-being of our staff, is at the forefront of our focus. Additionally, the new Gender, Geographic, and Generational Action Project (GAP) represents a significant cultural shift aiming to yield a diverse, motivated, resilient, and sustainable workforce in the Department. Moreover, your valuable support in providing insights into the designs and deployment of small modular reactors within your respective States will significantly enhance our collective knowledge and advance our shared progress in this area.

Reflecting on the significant support provided by MSSPs, I can clearly see that the work carried out by the Department bears the imprint of your contributions. I look forward to continuing these productive and beneficial collaborations into the future.

With sincere appreciation,

Massimo Aparo
IAEA Deputy Director General and
Head of the Department of Safeguards

Contents

Introduction

Background

This publication provides a comprehensive overview of the Development and Implementation Support (D&IS) Programme for Nuclear Verification (hereafter "the D&IS Programme") within the International Atomic Energy Agency's Department of Safeguards. The D&IS Programme seeks to enhance nuclear verification capabilities through collaborative efforts with a diverse range of partners. Emphasizing the commitment to innovation and sustainability, this document is situated within the broader context of the IAEA's nuclear verification mandate.

Objective

The primary objective of this publication is to communicate the 27 safeguards-relevant Development and Implementation Plans to current and potential partners to the Department of Safeguards (hereafter "the Department"). It seeks to engage partners in supporting the Department's efforts to implement Safeguards effectively, efficiently, and innovatively. Additionally, the document aims to inform partners about the Department's resource needs and facilitate discussions on collaborative initiatives that align with the overarching goal of strengthening nuclear verification capabilities.

Audience

The main audiences are the Department's current and future traditional and non-traditional partners. These include:

- Member State Support Programme (MSSP) Coordinators and Delegates
- R&D Organizations
- State and Regional Safeguards Authorities
- Permanent Missions to the IAEA
- Academia
- Foundations
- Non-Governmental Organizations (NGOs)
- Private Sector Entities

Figure 1: Snapshot from the 2020 Member State Support Programme Coordinators' Meeting. This event updates MSSPs on Department priorities and helps align extrabudgetary contributions with IAEA Safeguards.

Scope

The D&IS Programme focuses on two main areas:

- Developing new techniques and technologies to improve the Department's nuclear verification capabilities and
- Deploying, maintaining, or improving existing capabilities.

This scope aims to present a complete picture of ongoing development activities, regardless of funding sources, to allow partners to understand the Department's initiatives comprehensively.

The programme covers both MSSP Tasks and unfunded areas in the Department. It emphasizes the continual improvement of processes, technologies, and training, along with addressing emerging needs through new capabilities. The scope extends to sustaining core capabilities, enhancing technology, and increasing capacity to meet verification demands effectively.

The Department's Strategy Framework

Mission

To deter the proliferation of nuclear weapons.

Strategic Objectives

The Department of Safeguards' four over-arching strategic objectives are to:

1. Detect early the misuse of nuclear material or technology;
2. Provide credible assurances that States are honouring their safeguards obligations;
3. Assist with other verification tasks;
4. Continually improve the Department's capabilities and performance.

For exact wording of the first three strategic objectives, please see the Agency's Programme and Budget.

The Department's Planning Framework

The Department conducts strategic foresight and planning to improve its ability to address emerging challenges, leverage future opportunities, and, in the process, strengthen its organizational resilience in an ever-changing world. The strategic planning framework supports good management of resources through establishing prioritized objectives and areas of focus. Another key element of the Department's strategy framework is the development, maintenance, and enhancement of partnerships.

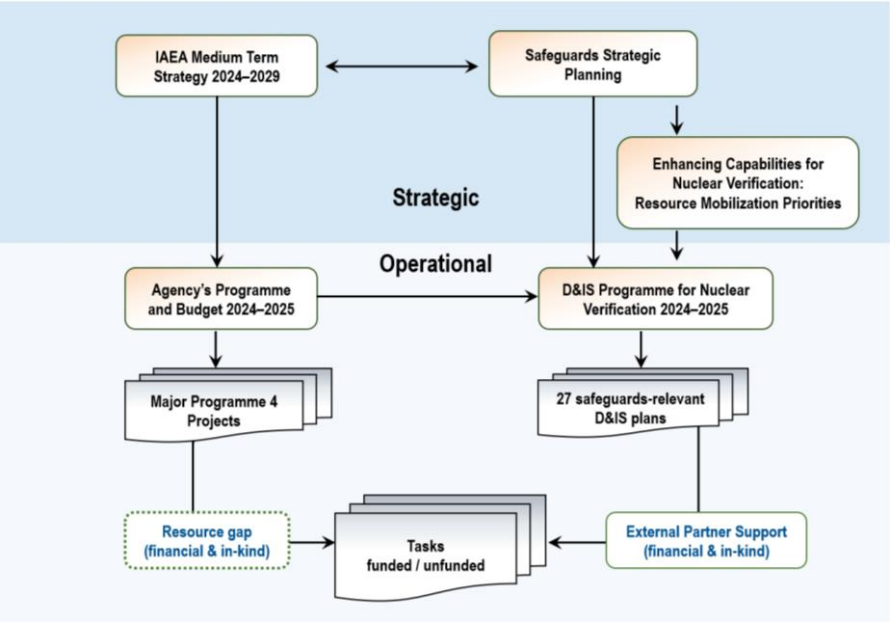


Figure 2: The Department uses these processes and documents to identify and address its resource needs.

The Department's strategic planning framework is comprised of the Agency's Medium Term Strategy and Programme and Budget, and specific to the Department, the strategic planning framework consists of the Department's Strategic Plan, *Enhancing Capabilities for Nuclear Verification: Resource Mobilization Priorities* document, and the D&IS Programme.

Together, these documents connect high-level strategy with required capabilities and associated support needs and D&IS Plans. In so doing, they help ensure that the Department focuses its development efforts and resources where they are most needed, contributing to effective stewardship of limited resources and maximizing the impact of partner support.

Agency's Medium Term Strategy 2024–2029 (GOV/2022/37)


Medium Term Strategy 2024–2029

Introduction

The Agency's statutory objective is to "... seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world' and "... ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose." The Agency has pursued and adapted its programme of work within the framework of its Statute to meet the evolving needs and developmental goals of its Member States.

Over the 80 years of its existence, the Agency has firmly established itself as a unique multidisciplinary organization in the United Nations (UN) system, responsible for international activities concerned with the peaceful uses of nuclear energy. It simultaneously contributes to global peace and security, and the development aspirations of its Member States, including those related to energy security, human health, food security and safety, water resource management and industrial applications. The Agency has risen to the occasion and contributed to addressing many global challenges pertaining to nuclear safety, nuclear security and non-proliferation of nuclear weapons and has played a central role in establishing or strengthening international instruments in these areas. The Agency has responded to Member States' requests for assistance related to verification tasks, including in connection with nuclear disarmament and arms control agreements. The Agency has also responded to Member States' requests for assistance in overcoming the consequences of regional or global medical emergencies, natural disasters, industrial accidents, military conflict endangering nuclear safety, nuclear security and safeguards implementation. In this context, the Agency's support included running its largest assistance to help Member States fight the COVID-19 pandemic and assistance to Ukraine to ensure safety and security, as well as the implementation of safeguards verifications at the nuclear installations.

* * *

The Medium Term Strategy has been prepared through a joint consultation process among Member States and the Secretariat. It covers a period of six years from 2024 to 2029. In line with the Agency's Statute and subject to the decisions and resolutions of the Agency's Policy-Making Organs, which are the basis and the guidance for the Agency's activities, the Medium Term Strategy serves as a strategic direction and roadmap for the Secretariat to prepare the Agency's programme and budget during the period covered by it, by identifying priorities among and within its programmes for three biennia for the achievement of the Agency's statutory objectives in an evolving international environment. The Medium Term Strategy 2024–2029 draws upon the Medium Term Strategy 2018–2023 and may be updated, if deemed necessary by the Board of Governors, adapting to new developments and evolving needs and priorities of Member States.

In fulfilling the Agency's statutory responsibilities, the Medium Term Strategy 2024–2029 identifies strategic objectives that are cross-cutting in nature and that will be attained through a combination of the Agency's six Major Programmes. Several strategic enablers will continue to be applied by the Secretariat across all of the Agency's programmes in order to facilitate the achievement of these strategic objectives.

The *Medium Term Strategy 2024–2029* was prepared through a joint consultation process among Member States and the Secretariat. It provides strategic direction and serves as a roadmap for the Secretariat to prepare the Agency's programme and budget by identifying priorities among and within its programmes for three biennia for the achievement of the Agency's statutory objectives in an evolving international environment.

Find the *Medium Term Strategy 2024–2029* at https://www.iaea.org/sites/default/files/23/02/mts2024_2029.pdf.

Agency's Programme and Budget 2024–2025 (GC(67)/5)

The *Agency's Programme and Budget 2024–2025* describes all approved activities that need to be carried out in 2024–2025. It also contains the approved budget that will be allocated to each of these activities.

Several tasks of the Major Programme 4 (Nuclear Verification) remain unfunded. For the Department, this unfunded part amounts to €86.9 million in 2024–2025, up from €69.1 million in 2022–2023.

Find the *Agency's Programme and Budget 2024–2025* at https://www.iaea.org/sites/default/files/gc/gc67-5.pdf.

Biennium	Unfunded
2024–2025	€86.9 Million
2022–2023	€69.1 Million
2020–2021	€65.6 Million
2018–2019	€45.7 Million

In addition to these unfunded resources (human or material), there is a substantial amount of other resources that cannot be easily tallied but are still essential for effective implementation of the verification mandate. These resources are, for example, new equipment and software resulting from R&D activities performed in Member States, the availability of nuclear facilities for testing or training purposes, and the contributions of external experts.

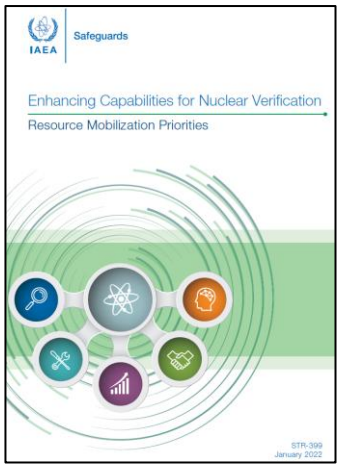
Department's Strategic Plan

The Department's Strategic Plan is a living, internal management and communication tool that describes Departmental priorities across five focus areas:

- Core activities
- Technical capabilities
- Management
- Stakeholders and partnerships
- People and knowledge

Within each focus area, the Department has defined priority objectives (see the Strategic Plan-on-a-Page on page 11). The Department implements its Strategic Plan through priority projects and actions.

Department's Enhancing Capabilities for Nuclear Verification: Resource Mobilization Priorities (RMP) (STR-399)

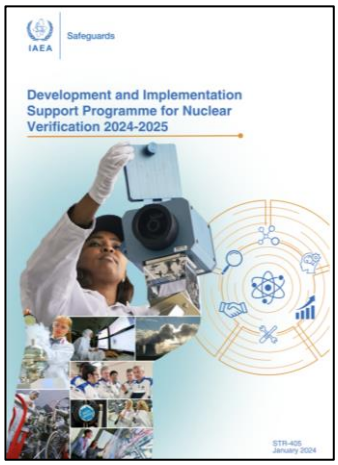


The *Enhancing Capabilities for Nuclear Verification: Resource Mobilization Priorities (RMP)* document communicates a prioritized set of needed capabilities for which the Department is seeking external support and describes the type of support needed. In so doing, it supports the Department in achieving its priority objectives.

Find the electronic version of the RMP document at https://www.iaea.org/sites/default/files/22/02/rmp-2022.pdf.

The 2024-2025 D&IS Programme includes updated top priority capabilities for which the Department is seeking support. The latest top priority capabilities can be found on pages 10–11.

Department's Development and Implementation Support Programme for Nuclear Verification (D&IS Programme) (STR-405) (this document)



The *Development and Implementation Support Programme for Nuclear Verification* (D&IS Programme) is a compilation of 27 nuclear verification-relevant technical Development and Implementation Support (D&IS) Plans crucial to international nuclear verification efforts. These plans, updated biennially, are linked to the Department's strategic planning framework to ensure alignment with overarching objectives. Each D&IS Plan correlates its outcomes and outputs with the Department's focus areas, priority objectives, and resource mobilization priorities.

Find the electronic version of the *D&IS Programme* at https://sprics.iaea.org/api/StaticContent/external/Resources.html (exclusive to SPRICS users at the time of publication, with a near immediate plan to publish on the public iaea.org site).

Department's Strategic Plan-on-a-Page

MISSION
To deter the proliferation of nuclear weapons

STRATEGIC OBJECTIVES
- To detect early the misuse of nuclear material or technology*
- To provide credible assurances that States are honouring their safeguards obligations*
- To assist with other verification tasks*
- To continually improve the Department's capabilities and performance

VISION
IAEA nuclear verification contributes to a secure and peaceful world. The Agency's competence and independence enable it to operate with the trust and support of its Member States and the international community

VALUES
Integrity, professionalism and respect for diversity

Delivering on the Mission – Departmental Priority Objectives

Core Activities

V.1 Strengthen information collection, integration and analysis
V.2 Reinforce State evaluation and consistency in drawing SG conclusions
V.3 Advance State-level safeguards
V.4 Enhance SG effectiveness monitoring and evaluation
V.6 Prepare for new types of facilities and activities

Technical Capabilities

T.1 Strengthen instrumentation capabilities for verification
T.2 Enhance sensitivity, reliability and timeliness in sample analysis
T.3 Ensure resilient, secure and up-to-date SG IT systems
T.6 Enhance remote sensing, monitoring and verification capabilities

Management

M.1 Secure and optimally manage financial resources
M.2 Manage SG assets strategically
M.3 Mature process management and operational discipline
M.4 Increase organizational resilience

Stakeholders and Partnerships

S.1 Communicate proactively and transparently
S.2 Enhance States' safeguards capacity
S.3 Promote safeguards-by-design
S.4 Expand and leverage partnerships

People and Knowledge

W.3 Build and retain organizational knowledge
W.4 Advance workforce diversity, including gender parity

** For exact wording of the three strategic objectives, please see the Agency's Programme and Budget*

Top Priority Capabilities from the Enhancing Capabilities for Nuclear Verification: Resource Mobilization Priorities (RMP) (STR-399)

The Department's top priority capabilities were published in the 2022 document *Enhancing Capabilities for Nuclear Verification: Resource Mobilization Priorities (RMP)* and reviewed by senior Departmental management in early 2024. The 2024 review process was performed to reflect the most pressing present-day resource mobilization priorities. A comprehensive review of all capability needs (including the top priority capabilities) will be carried out in a fully updated RMP in 2026. While all the capabilities reflected in the 2022 RMP remain important to the Department, the following table highlights the 16 capabilities that are of the highest priority as of the beginning of 2024.

* Indicates a prioritized capability

Priority Objective		ID	Change	Capability
V.1	Strengthen information collection, integration and analysis	V.1.C2*	Reworded	Ability to receive/collect, process, analyze and evaluate all safeguards-relevant information efficiently and effectively through innovation, integration, and governance
		V.1.C4*	Reworded and Elevated	Ability to leverage emerging technologies, such as artificial intelligence and machine-learning, for exploiting large volumes of safeguards-relevant data to enhance prioritization, change detection and consistency verification
		V.1.C5*	Elevated	Ability to enhance the sharing, aggregation, visualization and analysis of geo-based information (e.g. verification data, satellite imagery)
V.3	Advance State-level safeguards	V.3.C3*	New	Ability to enhance acquisition path analysis and development of State-level safeguards approaches
V.3	Ensuring preparedness to implement SG	V.6.C2*	Elevated	Ability to implement effective and efficient safeguards for SMRs and microreactors
T.1	Strengthen instrumentation capabilities for verification	T.1.C1*	n/a	Ability to more efficiently verify and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle, including through remote means
		T.1.C5*	n/a	Ability to develop, deploy and maintain new sealing system technologies with improved security and efficiency
		T.1.C12*	New	Ability to expand the use of robotic technology for verification activities
T.2	Enhance sensitivity, reliability and timeliness in sample analysis	T.2.C2*	n/a	Ability to determine age of U and Pu in environmental samples through techniques and evaluation methods
		T.2.C8*	New	Ability to deliver timely environmental sample analysis results through the qualification of new laboratories to the NWAL and by requesting additional capacity from existing NWAL
T.3	Ensure resilient, secure and up-to-date SG IT systems	T.3.C1*	Reworded	Ability to secure information and quickly detect and respond to security events in the Department's information systems using the latest advances in technology such as artificial intelligence

T.6	Enhance remote sensing, monitoring and verification capabilities	T.6.C1	Reworded	Ability to leverage emerging technologies, such as artificial intelligence and machine-learning, to develop and deploy improvements to instrumentation data analysis
M.2	Manage SG assets strategically	M.2.C1*	n/a	Ability to strategically plan, maintain and improve safeguards IT tools, information assets, and associated infrastructure
M.4	Increase organizational resilience	M.4.C2*	n/a	Ability to carry out mission-critical functions – needed for continued delivery of safeguards conclusions – in case of disasters (e.g. disruptive, massive cyber-attack or physical loss of critical infrastructure)
S.2	Enhance States' safeguards capacity	S.2.C1*	n/a	Ability to strengthen the capacity of SSACs/SRAs and monitor and measure progress
W.4	Advance workforce diversity, including gender parity	W.4.C1*	Reworded	Ability to attract and retain a diverse and balanced workforce in terms of geographic origin, gender, and age

MSSP Administration

The collaboration between the Department and MSSPs is administered by the Department's Support Programme Coordination Team (SPCT) in the Division of Concepts and Planning (SGCP) together with MSSP Coordinators. The appointed MSSP Coordinators are the IAEA's main points-of-contact for each MSSP.

Administrative System

SPRICS Support Programme Information and Communication System

The Support Programme Information and Communication System (SPRICS) (sprics.iaea.org) is the repository and information exchange mechanism for the MSSP.

SPRICS stores the latest MSSP Task Proposals, Tasks, meeting information, and general Support Programme information. SPRICS is in IAEA's NUCLEUS Catalogue, along with other scientific, technical, and regulatory systems.

To request access to SPRICS, please contact SPRICSHelp@iaea.org.

MSSP Task Life Cycle

Refer to the visual representation of the MSSP task life cycle on the following page.

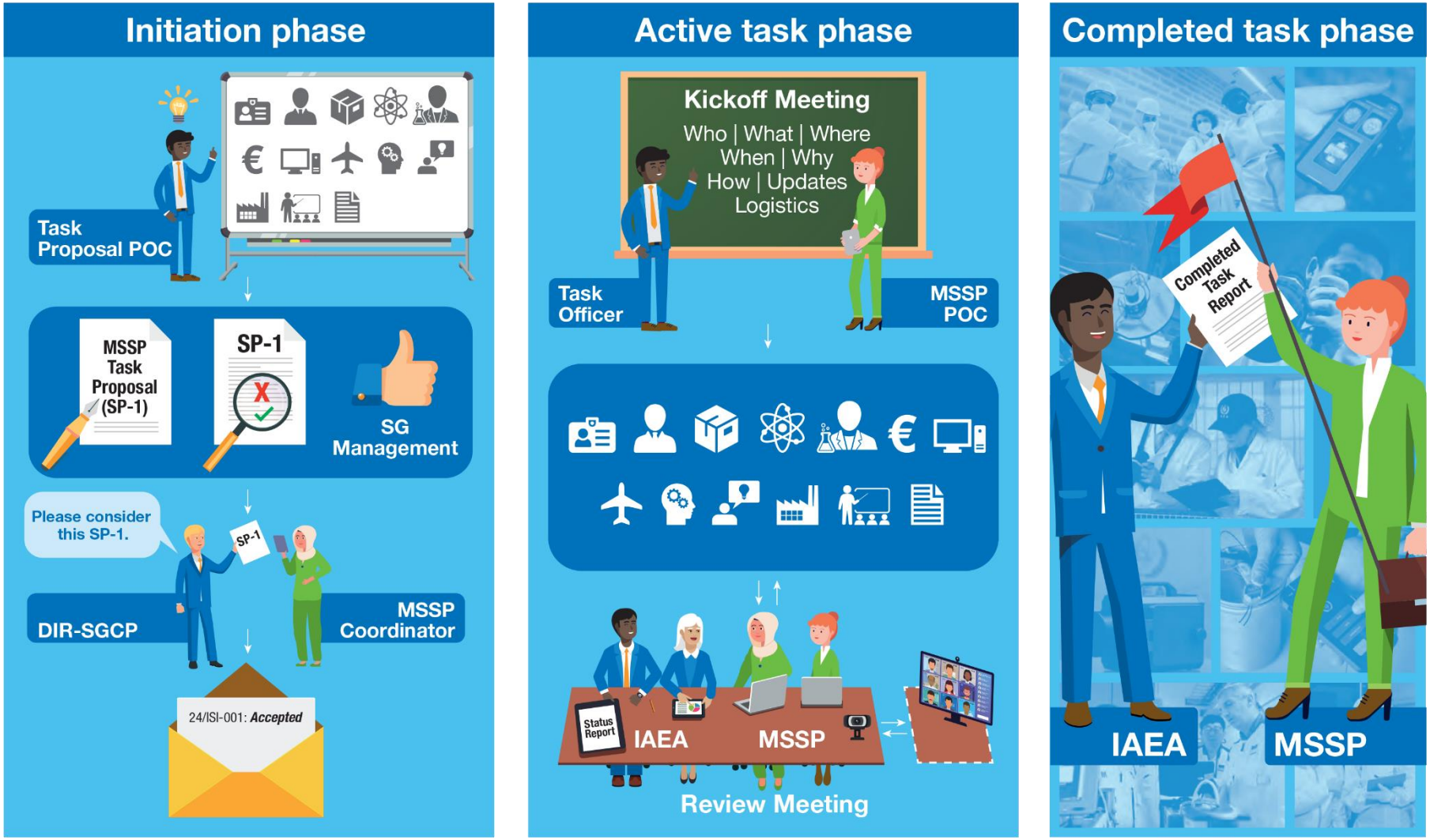
Initiation Phase	Department staff members write MSSP Task Proposals, which are specific requests for support. The SPCT transmits Department-approved MSSP Task Proposals to relevant MSSPs. When a MSSP accepts a MSSP Task Proposal, the Department and the MSSP activate a new MSSP Task and assign an IAEA Task Officer and an MSSP Point of Contact (POC).
Active Task Phase	The Task Officer hosts a kick-off meeting and, in consultation with the MSSP POC, finalizes the task plan. Together, the Department and MSSP execute the task plan, write status reports, and meet at least annually at Annual Review Meetings to discuss progress.
Completed Task Phase	When the Department and MSSP achieve the task objective, the Task Officer documents the MSSP Task outcomes, how outcomes were met, lessons learned, and how the Department is applying the outcomes and outputs.

Programme Oversight, Reporting, and Stakeholder Engagement

The Department conducts annual and semi-annual Support Programme review meetings with individual MSSPs to comprehensively evaluate the status of their Support Programmes and monitor the progress of individual MSSP Tasks. Task Officers, and optionally MSSP Points of Contact (MSSP POCs), write status reports on active MSSP Tasks in preparation for these review meetings. Upon the completion of a MSSP Task, the assigned Task Officer writes a report, which is subsequently submitted to the respective MSSP. All reports and meeting records are archived in SPRICS.

In addition, the biennial MSSP Coordinators' Meeting convenes to assemble MSSPs, MSSP Observers, Member States with an interest in the Programme, D&IS Managers, and Department staff members. This meeting serves as a platform for engaging in discussions that span the overall programme and various topics of interest.

Department's MSSP Task Life Cycle



Member State Support Programmes

As of January 2024, the programme consists of 24 MSSPs, with those established in 2022–2023 appearing in **bold**.

- Argentina
- Australia
- Belgium
- Brazil
- Canada
- China
- Czech Republic
- European Commission
- Finland
- France
- Germany
- Hungary
- Japan
- Netherlands
- **Norway**
- Republic of Korea
- Republic of South Africa
- Russian Federation
- Spain
- Sweden
- Switzerland
- **United Arab Emirates**
- United Kingdom
- United States of America

Observers

- Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC)
- European Atomic Energy Community (Euratom)

D&IS Plans and Managers

The D&IS Programme for 2024–2025 consists of the following 27 D&IS Plans and Managers to meet current and emerging Safeguards needs, with a newly-introduced D&IS Plan and newly-appointed D&IS Managers appearing in **bold**.

Plan ID	Plan Title	Plan Manager
DDGO-001	Overall Safeguards Management and Coordination	Malik DERROUGH
SGAS-001	Destructive Analysis of Nuclear Materials	Mika SUMI
SGAS-002	Environmental Sample Analysis Techniques	Matthew KILBURN
SGAS-003	Analysis Support and NWAL Coordination	Veena TIKARE
SGCP-003	Safeguards Approaches	**Traci NEWTON**
SGCP-004	Strategic Analyses and Partnerships	**Jenni RISSANEN**
SGCP-101	Quality Management	**Gary DYCK**
SGCP-102	Training	Susan PICKETT
SGIM-002	Acquisition and Analysis of Satellite Imagery and Geospatial Data	Marc LAFITTE
SGIM-003	Open Source Information Collection and Analysis	Woan Jin KIM
SGIM-007	Evaluation of Data from ES and Material Characterisation	Mika NIKKINEN
SGIM-008	Statistical Analysis	**Robert BINNER**
SGIM-009	State Declared Information Management	Snezana KONECNI
SGIM-010	**Artificial Intelligence/Machine Learning for Information Analysis**	**Paul SCHNEEWEISS**
SGIS-002	Information Security and Infrastructure	Michael Scott PARTEE
SGIS-003	Safeguards Information Systems and System Usability	Remzi KIRKGOEZE
SGOA-002	Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX)	Christophe CREUSOT
SGOA-003	Fukushima Dai-ichi Safeguards	Glen HORTON
SGOC-001	Chornobyl	Faisal AJJEH
SGVI-001	JCPOA Verification	Andrew CATTON
SGTS-001	NDA Techniques	**Davide PARISE**
SGTS-002	Techniques and Instruments for Sealing and Containment Verification	**Martin MOESLINGER**
SGTS-003	Surveillance Techniques	**Melvin JOHN**
SGTS-008	Instrumentation Technology Foresight	Dimitri FINKER
SGTS-011	Unattended Measurements Techniques	**Mikhail MAYOROV**
SGTS-014	Remote Data Transmission and Processing Systems	Angelo ALESSANDRELLO
SGTS-016	Occupational Health and Radiation Safety	Virginia KOUKOULIOU

New D&IS Plan

Plan ID	Plan Title	D&IS Manager
SGIM-010	Artificial Intelligence/Machine Learning for Information Analysis	Paul SCHNEEWEISS

Plan Title Updates

Plan ID	Previous Plan Title	Updated Plan Title
SGCP-004	Strategic Planning and Partnerships	Strategic Analyses and Partnerships
SGIM-002	Satellite Imagery Analysis	Acquisition and Analysis of Satellite Imagery and Geospatial Data
SGIM-003	Information Analysis	Open Source Information Collection and Analysis

Discontinued Projects

None.

Integration of IT Development within D&IS Plans

Many D&IS Managers incorporate IT development into their plans. In instances where a MSSP provides support for IT development, the D&IS Manager collaborates closely with the D&IS Plan SGIS-003 (Safeguards Information Systems and System Usability) to ensure compliance to the Office of Information and Communication Systems (SGIS) IT governance, standards, and best practices. The alignment of IT development across the Department facilitates the integration, integrity, security, and availability of Safeguards data.

New Plans for the 2024–2025 Biennium

Prior to presenting the new plans, the 2024–2025 D&IS Plan outline is presented to explain each section's contents and significance.

D&IS Plan Outline for 2024–2025

Each D&IS Plan stands alone and has the following sections:

Header Section

The introductory segment features essential information such as the D&IS Plan title, establishment date, D&IS Manager's name, objective, and links to the 2024–2025 Agency Programme and Budget.

Agency Programme and Budget Link(s)

Each D&IS Plan is linked to a corresponding programme, subprogramme, and project outlined in the *Agency's Programme and Budget 2024–2025*. Within this framework, one can access the approved activities and approved budgets. Find the *Agency's Programme and Budget 2024–2025* at https://www.iaea.org/sites/default/files/gc/gc67-5.pdf.

Plan Abbreviations

A list of abbreviations specific to the D&IS Plan is provided for clarity and reference.

Context Highlights

This section is tailored as D&IS Managers selected topics of particular relevance to their D&IS Plans.

Most Needed External Support in 2024–2025

This section presents a summary in table form, outlining the types of external support sought in the 2024–2025 plans. Descriptions of each support type are as follows:

Financial resources	Contribution through direct fund provision.
Expert meeting participation	Consultations and correspondence with experts through, for example, conferences, workshops, and training courses.
Consultants	Professionals under individual contracts (temporary staff assignments or consultancies) to work on short-term projects.
CFE	Cost Free Experts are professionals at the P-3, P-4, and P-5 levels employed by the IAEA under three types of arrangement (Type A, Type B, and Type C). These experts, appointed to meet specialized needs not readily available within the IAEA's staff or budget, may have their salary, benefits, and entitlements covered by the donor State. CFEs operate under specific criteria and are selected through a structured process based on their qualifications and expertise.
JPO	A Junior Professional Officer (JPO) is a young professional gaining on-the-job experience at the P-1 or P-2 level within a scientific, technical, or administrative field. JPO assignments last one to three years, funded by the respective Member State, with candidates selected based on specific criteria and a collaborative process between the IAEA and Member States. JPOs contribute to the IAEA's activities and gain valuable international career experience.
Equipment	Provision or transfer of equipment or other tangible assets, essential for the Department's work on delivering on the Safeguards mission.

Reference materials	A material or substance which is homogeneous and for which one or more values are well established.
R&D	Research and development activities of exploratory or developmental nature, including studies and testing of ideas, methodologies, techniques, and tools and other innovations with potential for Safeguards application.
Facility access	Provision of access to facilities for testing and training purposes.
Training	Learning activities that are specifically designed to educate both Department staff members and State systems of accounting for and control of nuclear material (SSACs) in any and all aspects of Safeguards implementation.
Studies	Provision of research opportunities and materials focused on a wide array of topics, from nuclear energy to safety and security, and from safeguards to nuclear technology and applications.

Plan Resource Mobilization Priority Link(s)

The outcomes of each D&IS Plan are aligned with the Resource Mobilization Priorities (RMP) outlined in the document *Enhancing Capabilities for Nuclear Verification: Resource Mobilization Priorities*. An asterisk (*) designates the top-priority capabilities. Find the electronic version of the RMP document at https://www.iaea.org/sites/default/files/22/02/rmp-2022.pdf.

New Plan for 2024–2025

D&IS Managers describe their vision (outcomes), tangible outputs to achieve those outcomes, applicable RMPs, and the requisite support in their new plans. The *Support Needed* section may discuss internal development activities supported by regular budget funds, with opportunities for external contributions. Prioritized outcomes and outputs are marked with a star (★), and the order of outcomes and outputs does not imply any order of priority unless stated.

DDGO-001: Overall Safeguards Management and Coordination

Established

2018

Manager	Deputy Director General
Malik DERROUGH	Massimo APARO

Objective

Providing support for Department-level projects, programmes, and initiatives that are priorities for the Deputy Director General for Safeguards that also need additional support from Member States for success.

Agency Programme and Budget Links

4.0.0.001 Overall Management and Coordination

4.1.8.002 Integrated Life Cycle Management of Safeguards Assets (ILSA)

Plan Abbreviations

CFE	Cost Free Expert
COMPASS	IAEA Comprehensive Capacity-Building Initiative for SSACs and SRAs
DDGO	Office of the Deputy Director General for Safeguards
DEIA	Diversity Equity Inclusion and Accessibility
GAP	Gender, Geographic, and Generational Action Project
ILSA	Integrated Life Cycle Management of Safeguards Assets
IT	Information Technology
JPOs	Junior Professional Officers
LG-SIMS	Large-geometry secondary ion mass spectrometry
MCIP	Major Capital Investment Plan
OTT	Open Table Talks
SAMO	Safeguards Asset Management Office
SRAs	State Reporting Authorities
SSAC	State Systems of Accounting for and Control of Nuclear Material
TTS	Technical Services Section

Context Highlights

The Office of the Deputy Director General for Safeguards (DDGO) is responsible for overall coordination and management of Department-level projects, programmes, and initiatives. In 2024–2025, the DDGO intends to facilitate improvements to the Department's:

- Life cycle management and strategic recapitalization of critical safeguards assets.
- Internal communications, through further implementation of the Internal Communications Strategy.
- Motivation and effectiveness of Department staff members by fostering a respectful, diverse, and inclusive working environment.

COMPASS was moved to D&IS Plan SGCP-102 (Training).

Integrated Life Cycle Management of Safeguards Assets (ILSA)

As of July 2023, the Department had nearly 54 000 items deployed in over 60 States with a value of over €265 million. The Department recognizes the importance of responsible and sustainable management of its assets and will further improve its asset management capabilities. Under the ILSA

project, the Department created an asset management strategy to provide guidance and ensure consistency for managing the life cycle of all Department assets—from a single LG-SIMS at the Safeguards Analytical Laboratories; to replaceable XCAM batteries contained in surveillance systems all over the world; to internally developed software. This initiative enabled the Department to better foresee funding needs required to maintain, replace, and renew assets.

The Safeguards asset management system was recently assessed to be "Developing" against the ISO55000 series demonstrating the Department has made great progress in the past few years but still has room for improvement. The ILSA project works closest with SGTS Safeguards Asset Management Office (SAMO), but all activities related to life cycle asset management are performed in close collaboration with all Divisions and Offices, primarily SGIS, SGTS, and SGAS.

This D&IS Plan addresses the implementation of the ILSA project itself but does not pertain to the projects funded through the ILSA funding mechanism. The Department will seek support from MSSPs to maintain and continue to improve upon its asset management system, including through CFEs and consultants. Some activities under this project may be carried out by SGTS/TTS.

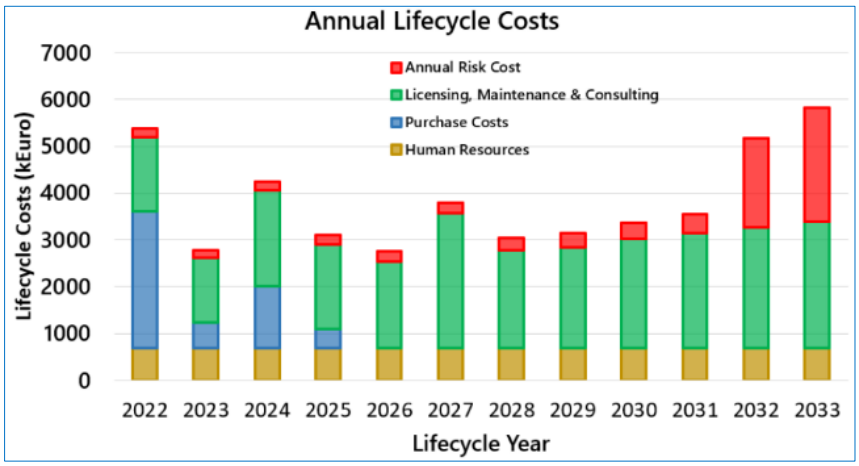


Figure 3: ILSA tracks asset costs from 2022 to 2033, revealing insights into annual risk, licensing, maintenance, consulting, purchase, and human resource expenses.

Communication

As the Department continues to face important challenges, effective communication is essential. In order to facilitate valued, trusted, and efficient internal communication that enhances teamwork and performance, the Department prioritizes strategic internal communication initiatives. The Safeguards Communication Team nurtures a culture of collaboration, teamwork, and information/knowledge sharing, and increases staff trust in leadership and colleagues. Valuable contributions from MSSPs continue to be important to this D&IS Plan's ability to address the Department's communication goals.

Figure 4: What a good communication plan does: informs, engages, and excites.

Respectful, Inclusive, and Diverse Workforce

Organizational culture influences organizational performance and employee motivation and performance. A wide range of research has shown that organizations that recognize and embrace diversity, equality, and inclusion will perform better, see greater staff and stakeholder satisfaction, see increased efficiency, and be more appealing as an "employer of choice." The IAEA, and specifically the Department, operates as a knowledge-based organization founded on leveraging the intellectual capital of its specialists in order to deliver effectively. Maintaining a strong, proactive, and collaborative organizational culture is critical to this.

The IAEA has committed to improving representation of women in professional roles and has developed a gender action plan to support this as part of its project known as the Gender, Geographic, and Generational Action Project, or GAP, to contribute to the broader IAEA plan. The IAEA extended its efforts to encompass all aspects of diversity and inclusion. The Department will seek assistance from MSSPs to support the establishment of an organizational culture that highlights optimal ways of working (encompassing gender, generational and geographic diversity) and which ensures that trust, collaboration, recognition and empowerment are an intrinsic part of the organizational culture at all levels.

Most Needed Extrabudgetary Support in 2022–2023

- ☒ Financial Support
- ☒ Financial Support for IT Development
- ☒ Financial Support for Travel
- ☒ Expert meeting participation
- ☒ Consultants
- ☒ CFEs
- ☒ JPOs
- ☐ Equipment
- ☐ Reference Materials
- ☐ R&D
- ☒ Facility Access
- ☒ Training
- ☐ Studies

Resource Mobilization Priority Links

* Indicates a prioritized capability

M.1.C1	Ability to fully implement data-driven programmatic planning, monitoring and evaluation, to support managerial decision making
M.2.C1*	Ability to strategically plan, maintain and improve safeguards IT tools, information assets, and associated infrastructure
M.3.C1	Ability to maintain an effective departmental communication framework and processes
M.3.C2	Ability to enhance managerial decision-making processes, capabilities and competencies
M.3.C4	Ability to deploy project management approaches to ensure effective execution of strategic priorities and projects
S.1.C1	Ability to deploy data visualization and other methods and techniques to present safeguards findings and performance-related data in a clear and compelling manner
S.2.C1*	Ability to strengthen the capacity of SSACs/SRAs and monitor and measure progress
T.3.C2	Ability to assist SRAs with the creation and submission of accountancy reports and additional protocol declarations with an IT tool
V.4.C3	Ability to better measure and analyse safeguards performance (of the Department and the safeguards system more broadly) through use of analytical and IT tools, including data visualization
W.4.C1*	Ability to attract and retain a diverse and balanced workforce in terms of geographic origin, gender, and age

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: Enhanced foresight and decision support on funding needs and budgeting decisions for replacement of Safeguards assets.

Outputs	1. Asset information dashboards to monitor current status and forecast future needs. 2. Asset management system procedures and updated documentation as necessary to reflect the improvements to the system.

Supporting Resource Mobilization Priorities			
M.3.C4	M.3.C2	M.2.C1*	M.1.C1

Support Needed

In 2022–2023, the ILSA project yielded two significant results: improved cost-benefit analysis for projects, including the postponement of a multimillion-Euro replacement plan, and enhanced accuracy in asset data and forecasts through targeted monitoring and data clean-up measures.

In 2024–2025, the ILSA project and SGTS's Safeguards Asset Management Office (SAMO) will continue to improve on these results through:

1) **Promoting cost-benefit analysis through ILSA funding**. MSSPs may contribute directly to asset recapitalization either through direct contributions to individual projects or through the ILSA Major Capital Investment Plan (MCIP). ILSA MCIP funding will be used strategically with a long-term view on projects with a well-documented and reviewed whole life cycle cost approach and a quantitative risk assessment. The decision to utilize ILSA MCIP funding resides with the DDG-SG. The documented process to receive ILSA funds requires a full project description including a cost benefit analysis with a quantitative risk assessment demonstrating when the assets are needed.

2) **Continued annual updating of asset data and focussing on clean-up measures.** Each spring, the ILSA project manager leads the Department in a data review of the estimated replacement date and estimated replacement cost focusing on the costliest assets and those with the highest risk.

3) **Improving the asset management system** by implementing the recommendations from the ISO55001 assessment. These include improving the asset management key performance indicators and improving risk assessment and better integrating asset management principles into the budget cycle.

4) **Promoting access to asset information**. Underlying all of these efforts is the information on assets. The Department has this information through the Department's asset registry (SEQUOIA) and to aid in its understanding, the Department created PowerBI dashboards to be used by management and SMEs to monitor the status of Department assets. In 2024–2025, these need to be adjusted and made available to all Department staff members.

To implement the above, the Department will require expertise through, inter alia, formal consultancies and informal conversations and provision of documented examples.

The ILSA project is led by a CFE (currently MSSP Task USA X 2468 (Safeguards Technical Specialist (Integrated Life Cycle Asset Management)) who is leaving in 2024, and the Department is seeking a replacement CFE to lead the project.

Further support could be requested from the DDGO and SGTS in the form of:

- Consultants who can provide an ISO 55000 assessment or answer topic-specific asset management questions. These may be formal consultants or informal discussions with SMEs on various topics such as, but not limited to, asset information and tracking, cost-benefit analysis, and replacement planning.
- Enhancements to IT tools to improve the integration of diverse data about Department assets, in close collaboration with D&IS Plan SGIS-003 (Safeguards Information Systems and System Usability).
- Additional training to build expertise.

Continued outcome

Outcome #2: Increased capability for information sharing and greater collaboration.

Outputs	1. Implementation of the Internal Communications Strategy to enhance senior leadership and Department staff member communication capabilities. 2. Coordinated development of published communication to ensure consistency of messages conveyed to Department staff members and to Member States.

Supporting Resource Mobilization Priorities

V.4.C3	M.3.C1	M.3.C2	S.1.C1

Support Needed

Communication in technical organizations require strong connections and coordination between systems, processes, and organizations, which require ongoing learning, training, and mentoring to account for environmental shifts and new technologies. The Department has developed and implemented an Internal Communications Strategy focused on three main pillars:

- Use of internal communication tools, events, and channels.
- Facilitation of vertical and horizontal communication through meetings and reports.
- Establishment of feedback mechanisms.

In 2022–2023, progress was made on each pillar, including the installation and regular update of video screens on all Department floors and in Regional Offices, the regularization of Department meetings, the use of online engagement tools, and the creation of virtual tours of hard-to-reach but in-demand laboratories and facilities.

Furthermore, a Department communication working group convenes on a regular basis to promote further coordination and collaboration across Divisions. Additional emphasis has also been placed on the frequency, prominence, and reporting of meetings, including those at the level of the Deputy Directors General, Directors, Divisions, and Sections, through which to ensure effective information/knowledge sharing at appropriate levels.

In addition to these ongoing efforts, strategic tools and planning are still needed on risk mitigation and crisis communication, communication working group skills, mentoring, and improving accountability.

In-house expertise, provided by a MSSP, currently supports the implementation of these activities based on the Strategic Internal Communication Plan. However, further support is welcome. Additional MSSP resources, including funding for consulting and design expertise would support the development of tools and materials as well as provide advisory support regarding other internal communication challenges.

Continued outcome

Outcome #3: Increased Department staff member engagement and satisfaction.

Outputs	1. Results of spot/pulse surveys and an organizational culture assessment. 2. Facilitation of Department staff member surveys and focus groups regarding communication.

Supporting Resource Mobilization Priority

M.3.C1

Support Needed

Improved internal communication not only promotes appropriate information sharing and coordination beyond Divisions and Sections, but also supports increased engagement of Department staff members in their respective work. The establishment of the Department of Safeguards' Gender, Geographic and Generational Action Project (GAP) (a project related to, but separate from, the IAEA's Gender Parity initiative) is focused on building upon Department staff member feedback for a more comprehensive evaluation of organizational culture with proposals for how the culture and ways of working can be further improved and developed.

With wider opportunities for effective communication and reduced barriers due to inherent biases, Department staff members can more readily share and collaboratively develop solutions in support of verification activities while also finding efficiencies and reducing duplication of work. With an increased level of internal communication, awareness building, and coordination, Department staff members will also more clearly understand Department objectives, priorities, and resources available to support their work.

In addition to the ongoing implementation of the outputs identified above, this D&IS Plan has developed feedback and measurement strategies to assess the impact of communication initiatives. These include spot/pulse surveys, communication surveys, leadership interviews, Department staff member focus groups, and skill-building follow-up. The surveys identify remaining challenges and give the Safeguards Communication Team further steps to consider.

In-house expertise supports the implementation of these activities based on the Strategic Internal Communication Strategy. However, further support is welcome. Additional MSSP resources, including funding for consulting expertise on organizational culture would support the development of feedback and information-sharing mechanisms as well as provide advisory support regarding other cultural and communication challenges, and the Department plans to transmit a new MSSP Task Proposal for GAP in 2024.

New outcome

★ **Outcome #4:** A welcoming and inclusive environment within the Department, where each Department staff member feels valued and part of a supportive community.

Outputs	1. Establishment and successful implementation of the two-year Gender, Geographic, and Generational Action Project (GAP). 2. Increased distribution of current Department staff members, job offers, and applicants along GGG lines. 3. Higher percentage of projects supported by the IAEA that have GGG equality objectives as a significant or main objective.

Supporting Resource Mobilization Priority

W.4.C1*

Support Needed

Departmental Awareness Campaign

The Department is currently focused on improving staff awareness at the intersection of Gender, Geographic, and Generational (GGG) parity through a communication campaign focused on improving staff knowledge around the benefits of diversity, inclusion, and allyship. The Department seeks to complement these activities with in-house events, through the inclusion of external partners and keynote speakers (fee-based), which facilitate dialogue intent on building allyship and improving Department staff member accessibility to adequate support and resources.

Recruitment Efforts

The Department would like to increase recruitment efforts, and in particular those that enable more visibility from a GGG lens, through expanded use of:

- Recruitment events and conference participation, hosted both online and in-person, in many geographic regions.
- New recruitment tools and databases, including the use of subscription fee-based models, to improve reach.
- Cross-Agency recruitment efforts, to increase Agency visibility among different audiences while creating resource efficiencies (cost savings, personnel time, etc.).

Workplace Culture Assessment and Strategy Development

The Department is currently undertaking management-led, small-group meetings—called Open Table Talks (OTTs)—to understand and trend Department staff members' perceptions and experiences. While the output of these OTTs proves helpful to the facilitation of an organizational culture baseline, the Department lacks the appropriate expertise to develop a fully comprehensive culture assessment in-house. Thus, this input will be used, alongside a more structured, expert-driven approach, to complete a Diversity Equity Inclusion and Accessibility (DEIA) Assessment. In particular, the Department expects to use external consultant(s), specifically with expertise

around belonging and psychological reactance, to conduct a DEIA Assessment. The DEIA Assessment will focus on both people and processes, and will subsequently inform the development of a data-driven DEIA Strategy, with external consultant(s) input, that enables the Department to build a culture focused on providing an enabling environment grounded in respect and inclusion.

Phase 1 of GAP, which spans years 2023 and 2024, is focused on building on Department staff member feedback for a more comprehensive evaluation of organizational culture with proposals for how the culture and ways of working can be further improved and developed. Phase 2, which spans years 2024–2025, will be developed on the basis of these findings and will focus on implementing the specific actions of the strategy developed in Phase 1.

SGAS-001: Destructive Analysis of Nuclear Materials

Established

2001

Manager	SGAS Director
Mika SUMI	Steven BALSLEY

Objective

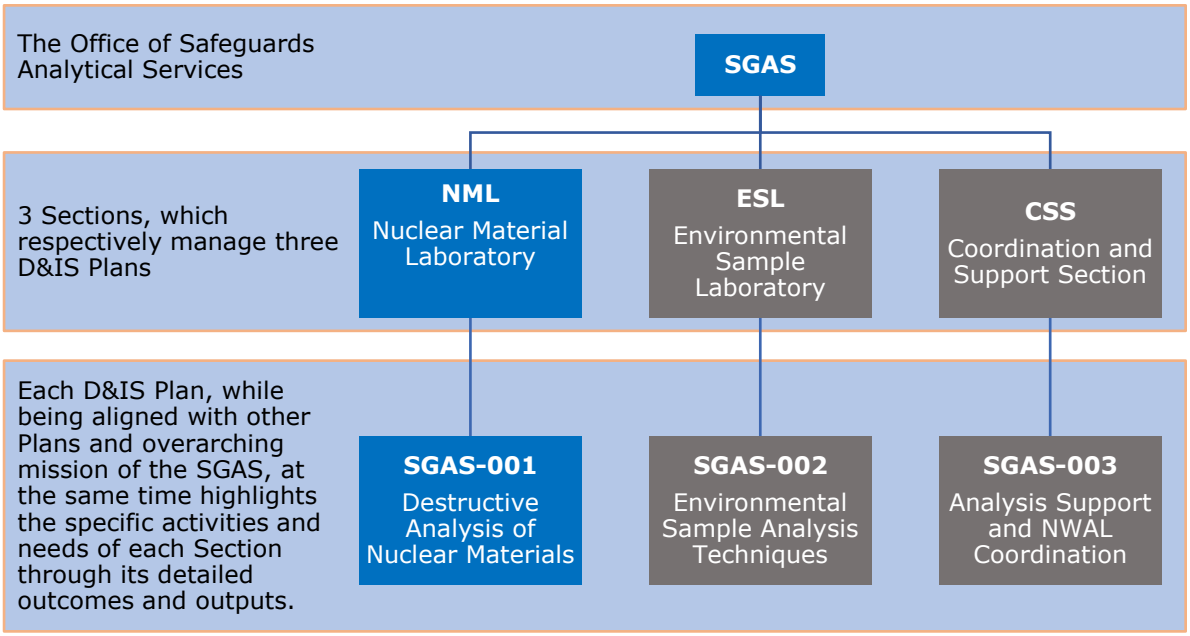
Improving destructive analysis (DA) capabilities and seeking new DA technologies in-house, with SMEs, and with Member State support.

Agency Programme and Budget Link

4.1.7.001 Analytical services and sample analysis

Context for all SGAS D&IS Plans

This text appears at the beginning of SGAS-001, SGAS-002, and SGAS-003 plans.



SGAS-001: Destructive Analysis of Nuclear Materials

Nuclear material sample analysis (also called destructive analysis, or "DA") primarily supports the verification of accountancy and material balance evaluations. Provision of reference materials (RMs), development of new instrumentation and methods for analysis of ever-smaller samples, and the delivery of specialized analytical assistance highlight the support areas to the Nuclear Material Laboratory (NML) via the SGAS-001 D&IS Plan.

Plan Abbreviations

ABACC	Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials
CHKED	Canberra Hybrid K-Edge Densitometry software
COMPUCEA	Combined Procedure for Uranium Concentration and Enrichment Assay
CPC	controlled potential coulometry
CRM	certified reference materials
DA	destructive analysis
DES	decay energy spectroscopy
DU	depleted Uranium
HEU	Highly Enriched Uranium
HKED	Hybrid K-Edge Densitometry
HRGS	high-resolution gamma spectroscopy
IFC	Nuclear Fuel Cycle Analysis Section
ILC	Inter-Laboratory Comparison
LEU	low enriched Uranium
MC-ICPMS	Multi-collector Inductively Coupled Plasma Mass Spectrometry
MEKED	Multi Elemental K-Edge
MEXRF	Multi Elemental X-ray Fluorescence
MMC	magnetic microcalorimeter
MTE-TIMS	Modified-Total-Evaporation Thermal Ionization Mass Spectrometry
NML	Nuclear Material Laboratory
NU	natural Uranium
NWAL	Network of Analytical Laboratories
OSL	On-Site Laboratory
Pu(VI)	Plutonium Six Oxidation State
QC	Quality Control
RRP	Rokkasho Reprocessing Plant
SOFIA	microcalorimetry-based, ultra-high-resolution gamma-spectroscopy system
TES	transition edge sensor
TE-TIMS	total-evaporation thermal ionization mass spectrometry
XRF	X-ray Fluorescence

Context Highlights

How the Department Uses Nuclear Material Sample Analysis Techniques

Destructive Analysis (DA) results of inspection samples (nuclear materials) provided by SGAS are a direct source of independent, validated information that contributes to Safeguards conclusions. The Department relies on the work of this D&IS Plan to assure that its DA capabilities remain efficient, effective, and reliable.

The overall objective is to improve existing DA capabilities and seek new DA technologies through strengthened partnerships with SMEs and MSSP laboratories including the Network of Analytical Laboratories (NWAL) to support in-house activities. The Department continuously seeks ways to improve DA quality (sampling, timeliness of analysis, uncertainty quantification, and robustness) and efficiency (cost control and waste reduction) through advancements in hardware, software, and analytical procedures.

Lastly, certified reference materials (CRMs) are integral to SGAS's Quality Control (QC) programme and Inter-Laboratory Comparison (ILCs) exercises. They are used to regularly calibrate instruments, control analytical processes, and assess the accuracy of analysis.

Anticipated Challenges in 2024–2025

Increasing Demand: The Department is experiencing an increase in requests for high-priority sample analysis and for determination of new chemical and physical attributes of samples. Development and implementation of new sampling and analytical techniques that are optimized for analysis at safeguards analytical laboratories are therefore critical to improve timeliness in analysis and reporting.

Equipment Maintenance: The regular replacement of ageing analytical equipment is also a key to maintaining the Department's analytical capabilities.

Reference materials for Analysis: The growing demand for minor Uranium isotope ratio analysis requests requires isotopic reference materials (RMs) different from the currently available RMs. In addition to requests for verification of in-house working standards (spike solutions and large dried spikes), the Department seeks support to produce and (re)certify nuclear RMs for isotope ratio measurement and assay measurement by isotope dilution analysis. These RMs with new isotopic composition would ensure measurement quality.

On-Site Laboratory (OSL): With the expected restart of the Rokkasho Reprocessing Plant (RRP) by mid-2025, the Department anticipates an accelerated need for specific DA tasks, including the implementation of modernized software for the Hybrid K-Edge Densitometry (HKED) and Plutonium Six Oxidation State (Pu(VI)) spectrophotometry for the OSL in Japan in 2024–2025, preceding the full operation of RRP.

Business Continuity: The Department is actively engaged in business continuity planning, including the implementation of analytical processes for OSL. This planning is undertaken in collaboration with State authorities and the facility operator, ensuring the integration of the Department's proper authentication measures.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☒ Equipment	☐ Training
☐ Financial Support for IT Development	☒ CFEs	☒ Reference Materials	☐ Studies
☒ Financial Support for Travel	☒ JPOs	☒ R&D	
☒ Expert meeting participation		☐ Facility Access	

Resource Mobilization Plan Links

* Indicates a prioritized capability

T.2.C1 Ability to reliably and quickly deliver sample analysis results for special and high priority demands

T.2.C2* Ability to determine age of U and Pu in environmental samples through techniques and evaluation methods

T.2.C5 Ability to assure the quality of the NWAL, including SAL, in environmental sample analysis (specifically particle analysis) using fit-for-purpose quality control and quality assurance methods

T.2.C6 Ability to maintain and further enhance the environmental sampling database and the process models, databases, and tools that support trace elements analysis (material characterisation)

T.2.C8* Ability to deliver timely environmental sample analysis results through the qualification of new laboratories to the NWAL and by requesting additional capacity from existing NWAL

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: Improved analytical techniques, methods, and resources to ensure analytical capabilities at Safeguards Analytical Laboratories including the On-Site Laboratory (OSL) in Japan.

Outputs	1. Replacement of analytical and ancillary equipment in line with the Department's Integrated Life Cycle Management of Safeguards Assets Project (ILSA). 2. Upgrade and enhancements of Canberra Hybrid K-Edge Densitometry software (CHKED) software. 3. Procurement of necessary parts and development of relevant procedures for the Hybrid K-Edge Densitometry (HKED) system sample changer replacement. 4. Implementation of new HKED evaluation software. 5. Evaluation of new instrumentation with regard to the business continuity plan.

Supporting Resource Mobilization Priority	
T.2.C1	T.2.C5

Support Needed

The ability to maintain the capability and capacity of analytical services provided by the Nuclear Material Laboratory (NML) is dependent upon the availability of staff resources and the timely replacement of ageing analytical equipment.

Analytical Equipment at NML in Seibersdorf

The NML in Seibersdorf currently houses glove boxes and fume foods, High Purity Germanium detectors (HPGe), mass spectrometers, alpha spectrometers, Combined Procedure for Uranium Concentration and Enrichment Assay (COMPUCEA) instruments, Davis & Gray potentiometric titrators, high precision analytical balances, leak detectors and microwave systems along with ancillary equipment. The Department has implemented an Integrated Life Cycle Management of Safeguards Assets Project under D&IS Plan DDGO-001 (Overall Safeguards Management and Coordination) to ensure the timely replacement of key analytical infrastructure. In 2024–2025, a key replacement priority is the Wavelength dispersive X-ray fluorescence (XRF). The anticipated cost for the Wavelength dispersive XRF replacement is €220 000.

Supporting Analytical Capabilities at the On-Site Laboratory (OSL) in Japan

Analytical capabilities at the OSL in Japan are aided and improved with the support of multiple Member States. These capabilities must be fully operational before the Rokkasho Reprocessing Plant (RPP) begins commercial operation, which is currently anticipated in mid-2025. To ensure a seamless transition, the Department kindly requests further assistance from Member States, particularly in providing personnel expertise at the OSL.

High-Resolution K-Edge Densitometry (HKED) Systems

HKED is the workhorse analytical technique used at the OSL for determining U and Pu concentrations in highly concentrated sample solutions. There are two HKED systems installed in the OSL that serve as the primary tool for analysing input and product solutions. When the RRP becomes operational, more than 300 IAEA samples per year are expected to be analysed by these HKED systems. Therefore, it is critical to ensure the quality, integrity, and unaltered nature of the HKED results.

HKED operation software

The Department's current HKED operation systems rely on CHKED software version 2.1. The Department is seeking financial support to upgrade this software to version 2.3, and to develop additional enhancements and security features for seamless integration into routine operations. To ensure a smooth transition to the enhanced version of the HKED software, the Department structured this procurement project into multiple phases based on priorities. The initial phase will focus on the software upgrade to the latest version, a critical step to be completed before the plant restart. This phase is estimated to cost $500 000. Subsequent developments will be spread over the following years, with an estimated cost of $1 080 000.

HKED Sample Changer

In order to support high sample throughput at the OSL, each of the two HKED systems is equipped with an automated sample changer. This sample changer is a critical part of the HKED system, and its significant malfunction will have a big impact on Safeguards activities. Currently, the OSL has neither the spare mechanical parts nor the relevant procedures to support the repair or replacement of the HKED sample changers. The Department will seek support from JRC-Karlsruhe and vendors with the development of sample changer replacement procedures, the development of specifications of mechanical parts, and for the building of a spare sample changer assembly for easier troubleshooting and development of necessary maintenance procedures.

HKED spectrum evaluation software

Two HKED spectrum evaluation software packages—the Multi Elemental K-Edge (MEKED) and Multi Elemental X-ray Fluorescence (MEXRF)—were developed at the Oak Ridge National Laboratory (USA) for use by the Department in order to provide an additional independent approach for data evaluation and analysis. Both packages must be tested and evaluated by analysing complex actinide mixtures and mixed U/Pu solutions to ensure quality results. This evaluation will continue to require expert support from several MSSPs with preparation of reference dissolver and product solutions, as well as the software testing including results evaluation and documentation. The fourth HKED workshop and ensuing HKED Inter-Laboratory Comparison (ILC) exercise will be organized in 2024.

Plutonium Six Oxidation State (Pu(VI)) Spectrophotometry

Pu(VI) Spectrophotometry is the second most used analytical technique at the OSL for determination of Pu in less concentrated sample solutions. Particularly for complex spectra obtained on High Active Liquid Waste samples, a suitable software or a validated algorithm for spectrum evaluation is needed to improve Pu concentration determinations. This method needs to be further implemented to assure business continuity of the OSL.

The vulnerability for all addressed analytical activities in this D&IS Plan shall also be assessed to ensure IAEA measurements integrity and authenticity.

Continued outcome

Outcome #2: Improved techniques and methods for independent verification of Pu and U amount in destructive analysis (DA) samples and reference materials.

Outputs	1. Organization of a technical meeting for reference materials. 2. Continued support for the controlled potential coulometry (CPC) system for Pu assay. 3. Support for reference materials and verification of in-house working standards used for DA in the Nuclear Material Laboratory (NML).

Supporting Resource Mobilization Priorities	
T.2.C1	T.2.C5

Support Needed

Following the IAEA 2023 Technical Meeting, "Reference Materials for Destructive Analysis in the Nuclear Fuel Cycle," the Department requests MSSPs to review progress and discuss new certified reference materials (CRMs) needs for DA in the nuclear fuel cycle. The Department will conduct an annual online meeting to review CRM users' needs, which was gathered via a survey and plan to organize technical meetings alongside related events and training opportunities in 2024–2025. MSSP participation is essential for the success of these efforts in advancing DA capabilities.

CPC is a primary analytical method for determining the Plutonium amount content in pure Plutonium solutions. It is integral for verifying the Pu concentration of in-house working standards prepared from Pu CRMs. As a first-principle method for Pu determination, the continual support from Member States is critical for annual instrument calibration, software enhancements, troubleshooting, and routine Department staff member training to assure the operational sustainability for this technique.

The NML continues to request RMs and CRMs from MSSPs for quality control (QC) and calibration of methods and instrumentation. NML also continues to request verification of in-house produced working standards (spike solutions, large dried spikes and minor isotopic standards) from MSSPs.

Also, the Department will seek provision of specific certified or well-characterised reference materials from Member States to conduct a variety of ILC exercises and support internal QC at the NML. It includes working solutions at the On-Site Laboratory (OSL) used for calibration of HKED and spectrophotometry. The Department will seek provision for delivery of reference U/Pu solutions to reduce its own preparation efforts.

Continued outcome

Outcome #3: Improved techniques, methods, and instrumentation to enhance the timely delivery of reliable analytical results.

Outputs	1. Development and deployment of a microcalorimetry system(s) at the Nuclear Material Laboratory (NML). 2. Implementation of the ABACC-Cristallini UF_6 sampling method for collecting safeguards samples from commercial Uranium enrichment plants for analysis at the NML.

Supporting Resource Mobilization Priority	
T.2.C1	T.2.C2*

Support Needed

Microcalorimetry techniques can be applied for decay energy spectroscopy and high-resolution gamma spectroscopy (HRGS) measurements.

Decay Energy Spectroscopy (DES) microcalorimetry system

DES measurement provides high-quality results with a relatively simple sample preparation process and uncertainties that are in the percent to sub-percent range. This type of measurement may be able to provide NML with an additional analytical method for high-precision laboratory analysis of regular U and Pu samples. It can also be potentially used for determining the presence of alpha-emitting radionuclides in very low concentration samples, such as high-active liquid waste. A custom DES design for NML that includes two different types of microcalorimetry sensors (the transition edge sensor (TES) and the magnetic microcalorimeter (MMC)) is being developed with the funding from USSP. Further validation of microcalorimetry performance and refinement of the sample preparation technique are expected before the DES system deployment at NML in 2025. NML will supply appropriate test materials based on inspection samples to the participating laboratories for the validation. Implementation of this method at NML promises to reduce analysis time, improve throughput and timeliness, and reduce chemical separations and radioactive waste generation.

HRGS microcalorimetry system

In addition, a microcalorimetry-based, ultra-high-resolution gamma-spectroscopy system (SOFIA) was developed at the Los Alamos National Laboratory, and validated for use with U and Pu samples. This recently developed system can be used for non-destructive isotopic composition measurements similar to conventional HRGS systems already deployed at NML, but with better performance, and has the potential to reach measurement accuracies between destructive and existing non-destructive assay techniques. The USSP will provide support with adjusting the SOFIA system design for NML needs and will supply the system to NML in 2024. With that new system in operation, NML may be able to use an alternative technique to time-consuming and complex destructive analysis for some sample types.

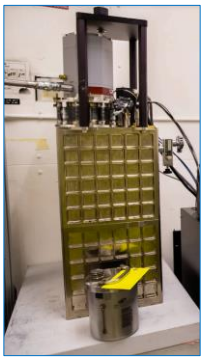


Figure 5: SOFIA microcalorimeter at LANL.

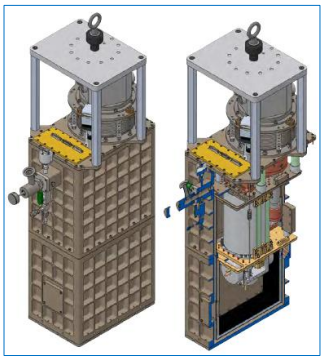


Figure 6: Proposed design for the DES instrument.

ABACC-Cristallini UF_6 sampling

The ABACC-Cristallini UF_6 sampling method was developed and extensively tested by the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC). The Department is currently validating the sampling technique at commercial Uranium enrichment plants. Samples are delivered and analysed at NML to confirm the method performance. The evaluation of the results is jointly reviewed with Operations Divisions and the Nuclear Fuel Cycle Analysis Section (IFC). Practicalities of implementing this sampling method, such as conformance with facility safety procedures, working instructions, training, etc., are taking place at each facility to confirm the method potential to become a routine sampling method for UF_6.

New outcome

Outcome #4: Improved analytical techniques, methods, and quality control measures to reliably perform material characterisation analyses at Safeguards Analytical Laboratories.

Outputs	1. ★ Enhancing the accuracy of Modified-Total-Evaporation Thermal Ionization Mass Spectrometry (MTE-TIMS) of U minor isotope analysis in special samples. 2. Development of a procedure for U minor isotope analysis by using Multi-collector Inductively Coupled Plasma Mass Spectrometry (MC-ICPMS).

Supporting Resource Mobilization Priority		
T.2.C1	T.2.C6	T.2.C8*

Support Needed

MTE-TIMS is an analytical method for the measurement of Uranium isotope ratios in Uranium nitrate solution samples and in dissolved samples (e.g., metals, alloys, oxide powders, oxide pellets, UF_6). In contrast to the TE-TIMS method, the MTE-TIMS method's most significant improvement is in the measurement performance achieved for the minor isotope ratios $n(^{234}U)/n(^{238}U)$ and $n(^{236}U)/n(^{238}U)$. The MTE-TIMS method is installed and routinely used by Network of Analytical Laboratories (NWAL) members. As the range of isotopic compositions in inspection samples has been extending, the Department recognises the need to revise its MTE-TIMS procedure to improve the accuracy of contemporary sample analysis. In particular, new working standards are needed for quality control. Such standards can be produced by blending the existing certified reference materials with the following characterisation of the obtained isotopic composition by qualified NWAL members. Also, assistance in assessment and minimization of interference effects, such as Uranium hydride ions, on the U minor isotopes is required.

MC-ICPMS is an alternative technique that can be used for U isotope ratio measurements including U minor isotopes in destructive analysis (DA) samples. This technique is expected to enhance the throughput of sample analysis and to improve the accuracy of $n(^{234}U)/n(^{238}U)$ ratios measured in depleted Uranium (DU), natural Uranium (NU) and potentially in low-enriched Uranium samples. The Department seeks assistance from Member States in optimizing and assessing the performance of currently available MC-ICPMS instruments for U isotope ratio analysis and, in particular, for minor U isotope analysis. The performance parameters that need to be assessed include the accuracy of the measured isotope ratios $n(^{234}U)/n(^{238}U)$, $n(^{235}U)/n(^{238}U)$ and $n(^{236}U)/n(^{238}U)$ at abundances that are typical for field samples (DU, NU, low enriched Uranium (LEU), Highly Enriched Uranium (HEU)), the detection limits for U-236 in NU, LEU and HEU, the presence of any significant interferences, and sample throughput.

SGAS-002: Environmental Sample Analysis Techniques

Established

2012

Manager	SGAS Director
Matthew KILBURN	Steven BALSLEY

Objective

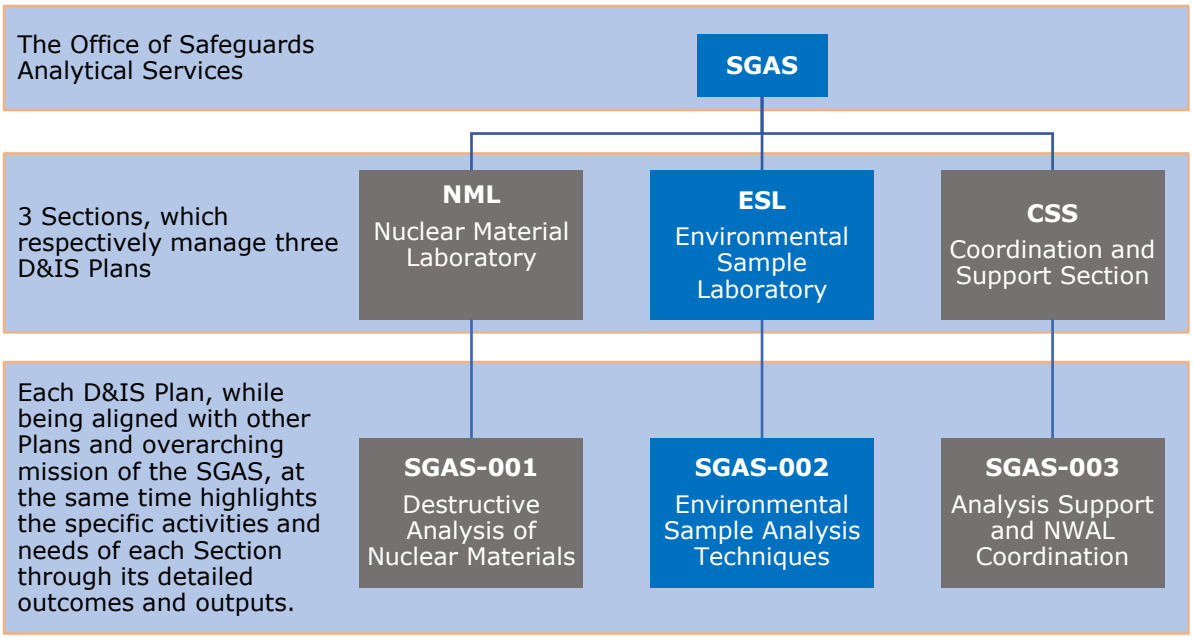
Providing timely, accurate, and precise analytical data from environmental samples collected by IAEA Safeguards inspectors.

Agency Programme and Budget Link

4.1.7.001 Analytical services and sample analysis

Context for all SGAS D&IS Plans

This text appears at the beginning of SGAS-001, SGAS-002, and SGAS-003 plans.



SGAS-002: Environmental Sample Analysis Techniques

Environmental sample analyses are used to indicate the presence or absence of undeclared nuclear materials and activities. SGAS-002 is the vehicle by which the Environmental Sample Laboratory (ESL) develops or acquires new reference materials, analytical methods, and instrumentation with enhanced sensitivity for U and Pu by bulk- and particle-based techniques.

Plan Abbreviations

APM	Automated Particle Measurement
ES	Environmental Sampling
ESL	Environmental Sample Laboratory
FT-TIMS	Fission-track thermal ionization mass spectrometry
HRGS	High-resolution gamma ray spectrometry
ICP-MS	Inductively-coupled-plasma mass spectrometry
IMS	ion mass spectrometry
LA-ICP-MS	laser-ablation inductively-coupled-plasma mass-spectrometry
LG-SIMS	Large-geometry secondary ion mass spectrometry
MC-ICP-MS	multi-collector inductively-coupled-plasma mass spectrometry
NFC	nuclear fuel cycle
NML	Nuclear Material Laboratory
NWAL	Network of Analytical Laboratories
PIC	Pre-Inspection Check
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
SEM	scanning electron microscopy
SIMS	Secondary ion mass spectrometry
TOF-SIMS	Time-of-Flight Secondary ion mass spectrometry

Context Highlights

How the Department uses Environmental Sample Analysis Techniques

Environmental sampling (ES) is a highly effective tool used by the Department to detect the presence (or verify the absence) of undeclared nuclear material and activities. The detection and analysis of Uranium (U) and Plutonium (Pu) isotopes, either in the whole environmental sample (bulk analysis) or in individual micron-sized particles within the sample, requires state-of-the-art analytical instrumentation, highly-skilled staff, and a comprehensive quality management system. To maintain the highest levels of sensitivity and accuracy, the ESL must stay informed of emerging technologies, facilitate development of new technologies and improvements to existing technologies, and continuously strive to improve data quality through the implementation of a robust Quality Assurance/Quality Control (QA/QC) programme. MSSPs continue to provide key support in the development of new technologies, methods, and materials to enhance sensitivity, reliability, and timeliness in sample analysis.

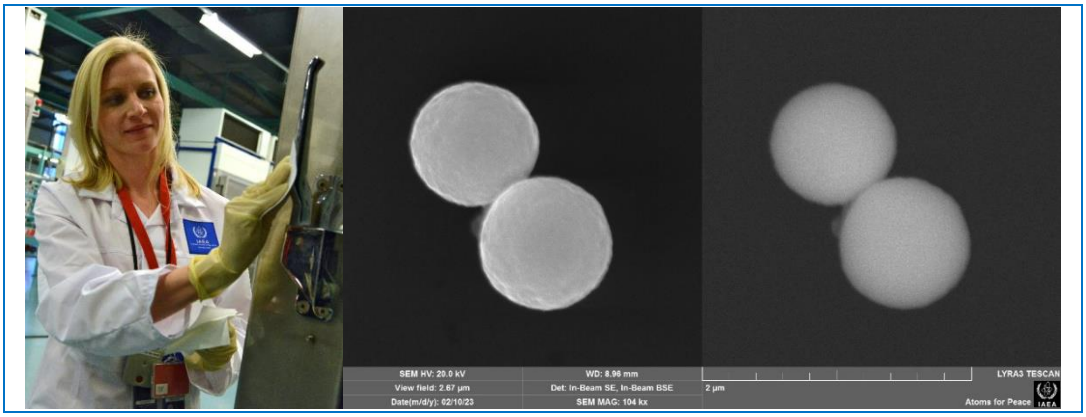


Figure 7: An IAEA Safeguards inspector taking an environmental swipe sample in a facility and the eventual analysis.

Ensuring Robust Analytical Capabilities for Safeguarding Nuclear Activities

It is essential that the Department maintains its ability to provide analytical capabilities to support the independent verification of nuclear activities in an impartial and timely manner. Current ESL capabilities include the bulk analysis of environmental swipe samples by inductively-coupled-plasma mass spectrometry (ICP-MS) and the analysis of particles by large-geometry secondary ion mass spectrometry (LG-SIMS) and scanning electron microscopy (SEM). In 2022–2023, a new LG-SIMS was installed and commissioned using generous donations from Member States, and in 2024–2025, the multi-collector ICP-MS will be replaced. Augmentation of the radiometry screening capabilities is also anticipated in 2024–2025. The regular replacement of ageing analytical equipment is key to maintaining the Department's capabilities and can only be achieved through donations from Member States.

Figure 8: In 2022, a new CAMECA IMS1300-HR LG-SIMS was installed and commissioned using generous donations from Member States.

Advancing Detection and Analysis Methods in Nuclear Safeguards

A key objective of the Department is to enhance the detection of signatures of undeclared nuclear activities found in environmental samples through the development and implementation of new and complementary techniques. As the sensitivity of analytical techniques continues to improve, samples may yield more information about the processes they have undergone, such as using isotopes to determine the age of a material or the presence of characteristic elements to indicate specific processes in the nuclear fuel cycle (NFC). As techniques evolve, novel QC materials are needed to calibrate instruments and check data accuracy, trueness, and precision.

Challenges and Innovations in Quality Control for Environmental Sample Analysis

Assuring the accuracy of data obtained through ES analysis requires the implementation of robust quality control (QC) measures, both within the ESL and across the Network of Analytical Laboratories (NWAL). Reference materials and standards are used to calibrate instruments and provide traceability and to assess the reliability and performance of analytical laboratories. Although there has been much progress in the fabrication of new reference materials applicable to ES in the past few years, the limited availability continues to be a factor. The production of particulate and bulk QC material is both costly and time consuming due to the complexity of fabricating raw materials with a well-constrained and homogeneous composition. Preparing swipes from these materials that resemble inspection samples provides an additional challenge, requiring specialized production facilities and meticulous characterisation.

Figure 9: The careful preparation of reference materials for ES particle analysis.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☒ Equipment	☐ Training
☐ Financial Support for IT Development	☒ CFEs	☒ Reference Materials	☐ Studies
☒ Financial Support for Travel	☒ JPOs	☒ R&D	
☒ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

T.2.C1 Ability to reliably and quickly deliver sample analysis results for special and high priority demands

T.2.C2* Ability to determine age of U and Pu in environmental samples through techniques and evaluation methods

T.2.C3 Ability to detect NFC materials and determine nuclear activities based on elemental and morphological analysis of particles in environmental samples, with emphasis on the recognition of anthropogenic particles using scanning electron microscopy techniques

T.2.C4 Ability to perform mixed U-Pu particle analysis, including screening, isotopic and elemental composition analysis

T.2.C5 Ability to assure the quality of the NWAL, including SAL, in environmental sample analysis (specifically particle analysis) using fit-for-purpose quality control and quality assurance methods

T.2.C8* Ability to deliver timely environmental sample analysis results through the qualification of new laboratories to the NWAL and by requesting additional capacity from existing NWAL

New Plan for 2024–2025

★ Indicates top priority

♻ Continued outcome

Outcome #1: Maintain the ability to reliably perform analysis of environmental samples at Safeguards Analytical Laboratories.

Outputs	1. Replacement of analytical and ancillary equipment in line with the Department's Integrated Life Cycle Management of Safeguards Assets (ILSA) Project. 2. Parallel operation of the IMS 1280 and IMS1300HR large-geometry secondary ion mass spectrometry (LG-SIMS) instruments for ES particle analysis.

Supporting Resource Mobilization Priority	
T.2.C1	T.2.C8*

Support Needed

The ability to maintain the capability and capacity of analytical services provided by the Environmental Sample Laboratory (ESL) is dependent upon the availability of staff resources and the timely replacement of ageing analytical equipment.

The ESL currently maintains highly sophisticated mass spectrometers, microscopes, and screening tools, along with ancillary equipment, with a total replacement value of approximately €15 million. The Department has implemented the ILSA Assets Project under D&IS Plan DDGO-001 (Overall Safeguards Management and Coordination) to ensure timely replacement of key analytical infrastructure. In 2024–2025, the ESL will replace its multi-collector inductively-coupled-plasma mass spectrometry (MC-ICP-MS), used for the isotopic analysis of bulk environmental samples, using €1 000 000 already pledged by a Member State. In addition, updating the high-resolution gamma spectroscopy capability for the screening of ES is also required. This involves a cosmic veto background reduction system for the existing High-resolution gamma ray spectrometry (HRGS) in the ESL and a new well-type high-purity germanium detector (HPGe) for the Nuclear Material Laboratory (NML), with a combined anticipated cost of around €150 000.

To enhance the Department's capacity for environmental sample particle analysis, it is essential to implement simultaneous operation of the IMS 1280 and IMS1300HR LG-SIMS instruments. This parallel operation will significantly improve the throughput, timeliness, and efficiency of analyses, contributing to the Department's ability to meet nuclear verification requirements.

Therefore, to achieve this outcome and these outputs, the Department requires staff augmentation through CFEs and JPOs or funding of extrabudgetary posts. This could also be seen as an opportunity to train staff from prospective Member State laboratories undergoing qualification to join the Network of Analytical Laboratories (NWAL).

Continued outcome

Outcome #2: Improved techniques, methods, and equipment to detect signatures of undeclared nuclear activities in environmental samples.

Outputs	1. ★ Implementation of a procedure for the age determination of particles using large-geometry secondary ion mass spectrometry (LG-SIMS). 2. Development and implementation of a methodology to detect nuclear fuel cycle (NFC) materials and determine nuclear activities based on the elemental and morphological analysis of particles in environmental samples, in particular using scanning electron microscopy (SEM) techniques to determine anthropogenic origin of particles. 3. Development of a procedure for the analysis of Pu and mixed U/Pu particles in environmental samples using laser-ablation inductively-coupled-plasma mass-spectrometry (LA-ICP-MS), LG-SIMS, or other techniques. 4. ★ Development of a rapid particle screening method for Pre-Inspection Check (PIC) sample analysis.

Supporting Resource Mobilization Priorities		
T.2.C2*	T.2.C3	T.2.C4

Support Needed

Determining the age of particles, or more specifically the time since last separation or irradiation, is key to understanding the timing of activities within a facility. The Environmental Sample Laboratory (ESL) will implement a methodology using LG-SIMS for particle age determination using the decay of 234U-230Th. However, before the emerging technology can be used in drawing Safeguards conclusions, the Department requires assessment, validation, and technical support, including potential assistance, travel to laboratories, and access to reference materials.

An important requirement of Department Safeguards evaluators is to identify materials in ES that are indicative of processes within the NFC using a combination of the physical, elemental, and isotopic properties in individual particles. The development of SEM, Time-of-Flight Secondary ion mass spectrometry (TOF-SIMS) and other techniques to characterise different types of NFC materials and how they appear as particulate material in environmental samples is required. Collaboration with experts, technical assistance, travel to laboratories, and access to reference materials are crucial for this development.

Department Safeguards evaluators also require the capability to analyse U and Pu isotopes in particles containing both U and Pu. The ESL has been developing a technique to analyse U/Pu mixed particles using laser-ablation Inductively-coupled-plasma mass spectrometry (LA-ICP-MS) to complement the traditional Fission-track thermal ionization mass spectrometry (FT-TIMS) approach provided by the NWAL. Although this technique shows some promise, there are some technical limitations that need to be addressed to improve and enhance the accuracy of the measurement results. The ESL is aware of a number of other Member State laboratories also developing a capability in LA-ICP-MS and LG-SIMS and seeks technical collaboration, R&D support, and access to reference materials to address technical limitations and enhance measurement accuracy.

Another top priority is the ability to rapidly screen PIC samples for particles as outlined in D&IS Plan SGIM-007 (Evaluation of Data from ES and Material Characterisation). A sensitive, high-throughput approach, such as the Automated Particle Measurement (APM) capability of secondary ion mass spectrometry (SIMS), would be required.

To achieve these outputs, the ESL seeks further collaboration with experts from Member States. Support in terms of technical expertise, cooperation, travel to laboratories, and the provision of reference materials would greatly contribute to the success of these initiatives.

Continued outcome

Outcome #3: Improved reliability of analytical results through the provision of reference materials for internal and external Quality Assurance/Quality Control (QA/QC) programmes.

Output	1. ★ Delivery of new, well-characterised reference materials to be made available for internal and external QA/QC programmes.

Supporting Resource Mobilization Priority

T.2.C5

Support Needed

Access to well-characterised reference materials is key to assuring the quality of analytical results produced by the Network of Analytical Laboratories (NWAL). An external QC programme for the NWAL has been implemented under D&IS Plan SGAS-003 (Analysis Support and NWAL Coordination) utilising materials provided by the Environmental Sample Laboratory (ESL) and MSSPs through this Plan. D&IS Plan SGAS-002 (Environmental Sample Analysis Techniques) currently has MSSP Tasks for QC particle production with the EC SP, FRESPAS, GER SP, and USSP, and bulk QC swipes are produced by both ESL and the United States Department of Energy. The Department requests Member States to ensure the sustained availability of resources to support the continuous production of valuable reference materials for environmental sample analysis.

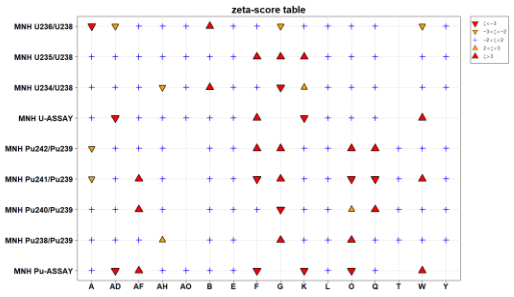
In addition, IAEA Technical Meetings and Working Group meetings provide important forums for experts to review requirements, exchange expertise, and provide guidance on technical aspects of QC material production. Through these forums, the Department aims to remain informed of potential new sources of reference materials that can contribute to the advancement of environmental sample analysis activities. The Department strongly encourages Member States to actively participate in these meetings.

SGAS-003: Analysis Support and NWAL Coordination

Established	
2012	
Manager	**SGAS Director**
Veena TIKARE	Steven BALSLEY

Objective

Enhancing the effectiveness and efficiency of the Network of Analytical Laboratories' (NWAL) sample analysis capabilities, capacity, quality, and timeliness to support IAEA's verification mission.

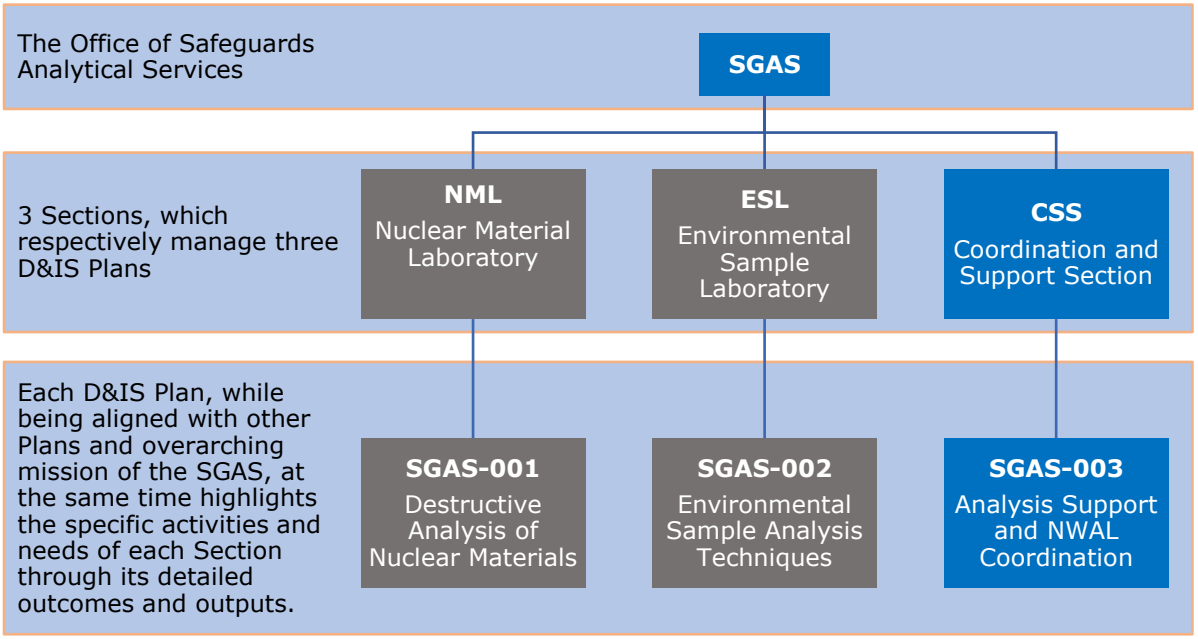


Agency Programme and Budget Link

4.1.7.001 Analytical services and sample analysis

Context for all SGAS D&IS Plans

This text appears at the beginning of SGAS-001, SGAS-002, and SGAS-003 plans.



SGAS-003: Analysis Support and NWAL Coordination

The Network of Analytical Laboratories (NWAL), which consists of the IAEA's laboratories, NML and ESL, as well as 25 laboratories around the world, analyses all samples and furnishes quality control (QC) services for both nuclear material (NM) and environmental samples (ES). Through SGAS-003, the Coordination and Support Section (CSS) manages the capacity and scope of NWAL services to the Department. SGAS-003 also supports the development of custom, laboratory-specific software that is used to enhance the efficiency and reliability of operations.

Plan Abbreviations

AFTAC	Air Force Technical Applications Center (USA)
ANSTO	Australian Nuclear Science and Technology Organization
AWE	Atomic Weapons Establishment (UK)
CEA	Commissariat à l'Energie Atomique et aux Energies Alternatives (France)
CETAMA	Commission d'Etablissement des Methodes d'Analyses (France)
CIAE	China Institute of Atomic Energy
CSS	Coordination and Support Section
CVŘ	Centrum Výzkumu Řež (Czech Republic)
EC-JRC	European Commission, Joint Research Centre
EK-CER	Centre for Energy Research (Hungary)
ES	Environmental Sampling
ESEE	Environmental Sampling Environment Enhancement
ESL	Environmental Sample Laboratory
FJZ	Forschungszentrum Jülich (Germany)
FT-TIMS	fission-track thermal ionization mass spectrometry
IFC	Nuclear Fuel Cycle Analysis Section
ILC	Inter-Laboratory Comparison
IRD	Instituto de Radioproteção e Dosimetria (Brazil)
JAEA	Japan Atomic Energy Agency
KAERI	Korea Atomic Energy Research Institute
KRI	Khlopin Radium Institute (Russian Federation)
LANIE	Laboratoire d'Analyses Nucléaires Isotopiques et Elémentaires (France)
LANL	Los Alamos National Laboratory (USA)
LG-SIMS	Large-geometry secondary ion mass spectrometry
LIMS	Laboratory Information Management System
LLNL	Lawrence Livermore National Laboratory
LMA	Laboratory for Microparticle Analysis (Russian Federation)
MTE	modified-total-evaporation
NBL-PO	New Brunswick Laboratory Program Office
NM	Nuclear Material
NML	Nuclear Material Laboratory
NWAL	Network of Analytical Laboratories
ORNL	Oak Ridge National Laboratory (USA)
PNNL	Pacific Northwest National Laboratory (USA)
QA/QC	quality assurance/quality control
QC	quality control
SAL	Safeguards Analytical Laboratory
SALIMS	Safeguards Analytical Laboratory Information Management System
SRNL	Savannah River National Laboratory (USA)
TIMS	thermal ionization mass spectrometry
US DOE	United States Department of Energy
UWA	University of Western Australia

Context Highlights

IAEA Safeguards inspectors collect NM and ES samples during field activities, which are then analysed by the NWAL.

NM sample analysis primarily supports the verification of material accountancy and material balance evaluations used to assess Member State declarations of NM holdings. Currently, all NM samples are analysed at IAEA's laboratory, NML. The other NWAL members provide QC and back-up functions for these samples.

Environmental sample analysis is used to detect undeclared NM and activities. Environmental Sampling (ES) is generally analysed by two methodologies: bulk and particle analysis. Bulk analysis determines the total amounts of Uranium (U) and Plutonium (Pu), together with their average isotopic compositions in the entire samples. Particle analysis measures the U and Pu isotopic composition of individual particles, and when required, elemental composition and morphological attributes of nuclear and non-nuclear materials involved in nuclear activities. Particle analysis also includes age determination of individual U particles.

The NWAL analyses NM and ES samples and provides results to the Department Safeguards data evaluators (see D&IS Plan SGIM-007 (Evaluation of Data from ES and Material Characterisation). The Department Safeguards data evaluators then draw conclusions about the correctness and completeness of State declarations based on these analysis results and other relevant information. Thus, it is vitally important that the quality and impartiality of the field sample analysis results are of the highest standards.

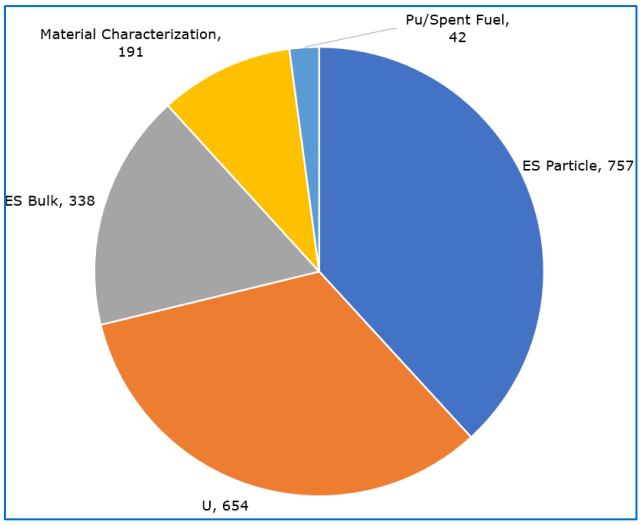


Figure 10: Numbers of NM and ES Samples analysed in 2022, with a total of 1 992.

How the Department uses the work of Analysis Support and NWAL Coordination

SGAS CSS administers and coordinates sample analysis by the NWAL, assures analysis impartiality, and administers a rigorous QC programme. The NWAL QC programme relies heavily on Inter-Laboratory Comparison (ILC) exercises to confirm the quality of analytical results across the NWAL so that analysis results can be interpreted with appropriate confidence. Lastly, certified reference materials are integral to SGAS's QC programme. They are used to regularly calibrate instruments and processes and assess the accuracy of analysis.

Priorities

In pursuit of efficient, high-quality analyses, this D&IS Plan relies on the support of MSSPs to address the following overarching priorities for ES:

1. Provide timely, accurate analysis of ES and NM samples by the NWAL.
2. Expand the overall capacity of the NWAL for the analysis of environmental samples while maintaining high-quality analysis.
3. Support assessment of NWAL member capabilities by participating in ILC exercises organized by SGAS and others.
4. Provide a variety of highly-specialized reference materials to support the NWAL QC programme and internal QC at the laboratories.

Crucial Role of the Network of Analytical Laboratories (NWAL)

SGAS CSS collaborates extensively with the NWAL to communicate the unique analytical requirements of the Department, achieve an optimal balance between the Department's in-house laboratory capabilities and those of the external NWAL members, and foster a collegial working relationship between all NWAL members.

SGAS CSS takes on the crucial responsibility of receiving and distributing samples for analysis while ensuring sample anonymity and transport safety and tracks their progress from collection to reporting of results (**priority #1**).

The NWAL consists of the Agency's Safeguards Analytical Laboratory (SAL), which in turn consists of the Environmental Sample Laboratory (ESL) and Nuclear Material Laboratory (NML) in Seibersdorf, Austria, in addition to 25 external laboratories representing 12 Member States and the European Commission.

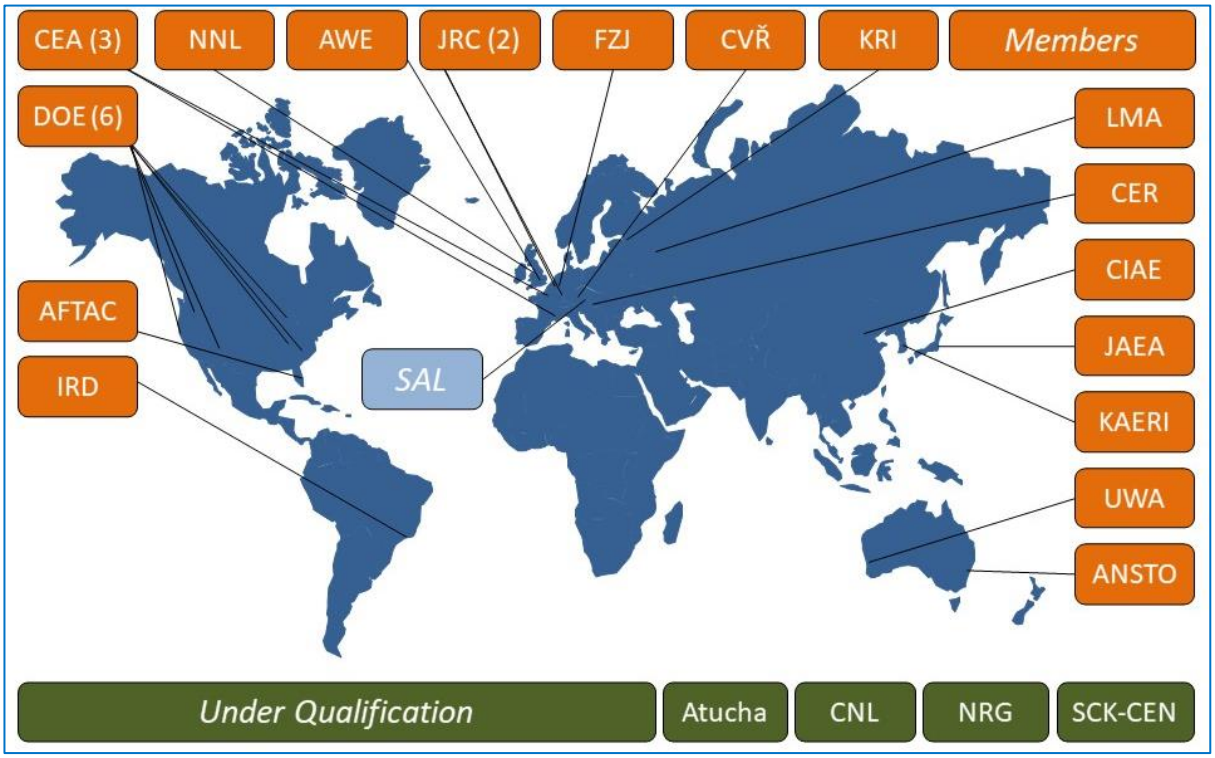


Figure 11: As of May 2023, the composition of the Network of Analytical Laboratories (NWAL), showcasing the Safeguards Analytical Laboratory alongside 25 globally distributed laboratories.

Particle analysis of environmental samples relies on 10 qualified NWAL members, without whom the Department's mission would face significant challenges:

- Safeguards Analytical Laboratory, SAL/ESL, IAEA
- University of Western Australia (UWA), Australia
- China Institute of Atomic Energy (CIAE), China
- European Commission, Joint Research Centre (EC-JRC) Karlsruhe, EC
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), France
- Japan Atomic Energy Agency (JAEA), Japan
- Korea Atomic Energy Research Institute (KAERI), Republic of Korea
- Laboratory for Microparticle Analysis (LMA), Russian Federation
- Atomic Weapons Establishment (AWE), UK
- Air Force Technical Applications Center (AFTAC), USA

In addition, Centrum Výzkumu Řež (CVŘ), Czech Republic is qualified to irradiate ES particle samples for analysis by fission-track thermal ionization mass spectrometry (FT-TIMS).

Bulk analysis of environmental samples is carried out by 11 NWAL members, reinforcing the critical role NWAL plays in the Department's operations:

- Safeguards Analytical Laboratory, Environmental Sample Laboratory (SAL/ESL), IAEA
- Australian Nuclear Science and Technology Organization (ANSTO), Australia
- Instituto de Radioproteção e Dosimetria (IRD), Brazil
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), France
- Japan Atomic Energy Agency (JAEA), Japan
- Korea Atomic Energy Research Institute (KAERI), Republic of Korea
- Khlopin Radium Institute (KRI), Russian Federation
- Four laboratories of the United States Department of Energy (US DOE), USA:
    - Los Alamos National Laboratory (LANL)
    - Lawrence Livermore National Laboratory (LLNL)
    - Oak Ridge National Laboratory (ORNL)
    - Pacific Northwest National Laboratory (PNNL)

While the IAEA NML currently conducts all **NM sample analyses** for material accountancy verification purposes, the NWAL's support is indispensable for quality assurance and as a contingency in the event of NML's unavailability. Four laboratories are qualified by the Department to analyse NM Safeguards samples:

- Safeguards Analytical Laboratory, Nuclear Material Laboratory (SAL/NML), IAEA
- European Commission, Joint Research Centre, Karlsruhe, EC
- CEA Laboratoire d'Analyses Nucléaires Isotopiques et Elémentaires (LANIE), France
- US DOE Savannah River National Laboratory (SRNL), USA

In addition to accountancy analyses, various other NM analyses (including materials characterisation) are occasionally required to ensure the accuracy and completeness of Member State declarations. While the IAEA NML is equipped to perform many of these analyses, the invaluable support provided by several laboratories, including EC-JRC/Karlsruhe, CEA in France, NNL Preston Laboratory in the UK, and LANL, LLNL, ORNL, and PNNL of the US DOE, cannot be overstated.

Analysis of heavy water samples is performed by the Centre for Energy Research (EK-CER), Hungary.

Lastly, 10 NWAL members provide reference materials and QC services:

- Safeguards Analytical Laboratory, Environmental Sample Laboratory (SAL/ESL) and Nuclear Material Laboratory (SAL/NML), IAEA
- European Commission Joint Research Centre (EC-JRC) Geel, EC
- European Commission Joint Research Centre (EC-JRC) Karlsruhe, EC
- Commission d'Etablissement des Methodes d'Analyses (CETAMA), France
- Forschungszentrum Jülich (FJZ), Germany
- KRI, Russian Federation
- Four laboratories of the US DOE, USA:
    - Lawrence Livermore National Laboratory (LLNL)
    - New Brunswick Laboratory Program Office (NBL-PO)
    - Pacific Northwest National Laboratory (PNNL)
    - Savannah River National Laboratory (SRNL)

Expanding the NWAL

Seventeen different NWAL members apply one or more methods to analyse environmental samples. While their cumulative capacity of approximately 1 000 analyses per year had been sufficient for many years, clear limitations are now apparent due to the steady increase in analytical demand. Over the past decade, the number of environmental sample analyses has increased by about 60%. This rise is attributable to both a higher number of samples collected by IAEA Safeguards inspectors as well as an increase in the number of independent analyses performed on some samples. Conversely, the capacity of the network has remained largely static during this time. Furthermore, no laboratories are currently qualifying to analyse environmental samples.

The result is that the Department now faces a capacity shortfall, which has begun to impact the overall processing time for environmental samples. The Department is actively seeking to increase the analysis capacity of the NWAL by identifying new laboratories to start the qualification process to join the NWAL and support ES analyses. The Department is also requesting that existing members analyse more ES samples **(priority #2)**. Without additional ES analysis capacity, the progress in timely ES analyses witnessed in recent years would be at risk.

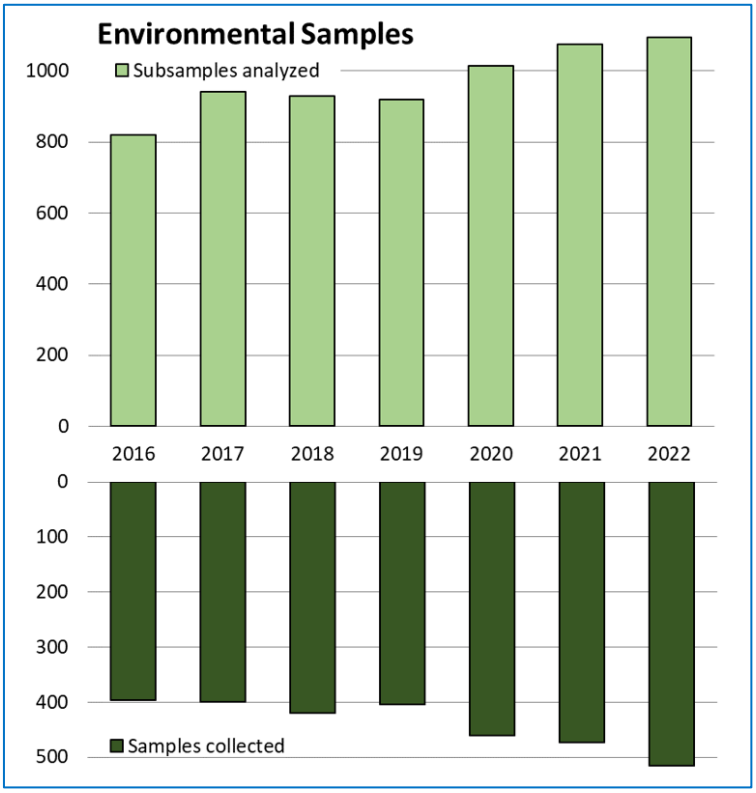


Figure 12: Environmental samples analysed and collected from 2016 to 2022.

Currently, three laboratories in Belgium, Canada, and the Netherlands are under qualification for the analysis of NM samples for accountancy purposes, and the Department is currently not seeking extra capacity in this area. In addition, a laboratory in Argentina is under qualification for heavy water sample analysis.

The Quality Management Programme

SGAS CSS has established a comprehensive quality management programme, which includes regular ILC exercises covering the major Safeguards analytical techniques to confirm consistent quality of analytical results across the NWAL and assess the quality of all supporting infrastructure, such as IT tools used for tracking samples, collecting, and managing all associated data and metadata.

The Department seeks support from NWAL members to maintain the high quality of analytical data (priority #3) by contributing to ILC exercises organized by SGAS or participating in the external proficiency testing programmes conducted by JRC/Geel, CETAMA, and NBL-PO. Moreover, the Department seeks highly-specialized certified or well- characterised reference materials (**priority #4**) from Member States to conduct a variety of ILC exercises and support internal QC at NWAL laboratories.

Most Needed External Support in 2024–2025

☒ Financial Support	☐ Consultants	☐ Equipment	☒ Training
☒ Financial Support for IT Development	☒ CFEs	☒ Reference Materials	☐ Studies
☐ Financial Support for Travel	☒ JPOs	☐ R&D	
☒ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

T.2.C1 Ability to reliably and quickly deliver sample analysis results for special and high priority demands

T.2.C2* Ability to determine age of U and Pu in environmental samples through techniques and evaluation methods

T.2.C3 Ability to detect NFC materials and determine nuclear activities based on elemental and morphological analysis of particles in environmental samples, with emphasis on the recognition of anthropogenic particles using scanning electron microscopy techniques

T.2.C4 Ability to perform mixed U-Pu particle analysis, including screening, isotopic and elemental composition analysis

T.2.C5 Ability to assure the quality of the NWAL, including SAL, in environmental sample analysis (specifically particle analysis) using fit-for-purpose quality control and quality assurance methods

T.2.C6 Ability to maintain and further enhance the environmental sampling database and the process models, databases, and tools that support trace elements analysis (material characterisation)

T.2.C7 Ability to reliably manage and deliver safeguards analytical results, e.g. through SGAS laboratory information management system (LIMS)

T.2.C8* Ability to deliver timely environmental sample analysis results through the qualification of new laboratories to the NWAL and by requesting additional capacity from existing NWAL

New Plan for 2024–2025

★ Indicates top priority

New outcome

Outcome #1: Expanded capacity for high-quality environmental sample (ES) elemental and isotopic analyses to support detection of possible undeclared nuclear material (NM) or activities.

Outputs

1. ★Increased capacity of current Network of Analytical Laboratories (NWAL) members.
2. ★Identification and beginning of the qualification of new NWAL members for:
   a. Particle sample analysis by large-geometry secondary ion mass spectrometry (LG-SIMS) and fission-track thermal ionization mass spectrometry (FT-TIMS) of environmental samples (ES).
   b. Bulk analysis of ES samples.

Supporting Resource Mobilization Priorities

T.2.C1	T.2.C2*	T.2.C3	T.2.C4	T.2.C7	T.2.C8*

Support Needed

The escalating demand for ES sample analyses, which has surged by over 60% in the past decade, now surpasses the NWAL's current capacity. To address this challenge, SGAS Coordination and Support Section (CSS) has initiated a formal campaign to secure additional ES analysis capacity. This aims to enlist support from both existing NWAL members and prospective new members, emphasizing the urgent need to bolster the network's capabilities.

The Department is actively engaging with MSSPs to address this pressing issue. **Priority #2** focuses on acquiring greater capacity for bulk analysis and particle analysis of environmental samples, particularly from laboratories employing LG-SIMS and FT-TIMS.

Continued outcome

Outcome #2: Improved reliability of analytical results through the provision of reference materials for internal and external quality assurance/quality control (QA/QC) programmes.

Output	1. Continued support of the Network of Analytical Laboratories (NWAL) and other laboratories for high-quality reference materials.

Supporting Resource Mobilization Priorities

T.2.C1	T.2.C5

Support Needed

Reference materials are indispensable to the SGAS QC programme. They are used routinely to calibrate instruments, trace to ISO standards, and develop analytical methods. For external QC purposes, they are used in Inter-Laboratory Comparison (ILC) exercises **(priority #4)**.

For this last purpose, SGAS is seeking the provision of well- characterised particle reference materials for environmental sample (ES) particle analysis. SGAS Coordination and Support Section (CSS) relies on D&IS Plan SGAS-002 (Environmental Sample Analysis Techniques) to verify and, if needed, characterise reference particles, to confirm they are fit for Safeguards purposes. High-quality particles with specified isotopic composition of U, mixed U-Th, Pu, and mixed U-Pu particles in micro- to milligram quantities are needed to assess the quality of environmental sample analyses.

In parallel, SGAS CSS continues to seek support from laboratories with unique capabilities and/or particular expertise in the production and characterisation and, if possible, certification of reference materials to provide highly-specialized materials for QC purposes such as instrument calibration. These reference materials might be materials certified in U and Pu isotopic compositions and contents, materials for trace element or minor isotope composition of Uranium, for age-dating techniques, and for scanning electron microscopy analyses. These activities are conducted in coordination with D&IS Plans SGAS-001 (Destructive Analysis of Nuclear Materials) and SGAS-002 (Environmental Sample Analysis Techniques).

Continued outcome

Outcome #3: Strengthened quality assurance of the Network of Analytical Laboratories (NWAL) analytical services.

Outputs	1. Conduct an Inter-Laboratory Comparison (ILC) exercise on bulk analysis of environment samples. 2. Conduct an ILC exercise on particle analysis of environmental samples. 3. Conduct an ILC on high resolution gamma spectrometry. 4. Conduct a nuclear material (NM) analysis round-robin exercise. 5. Conduct an ILC on determination of elemental impurities in Uranium oxide matrix materials.

Supporting Resource Mobilization Priority

T.2.C5

Support Needed

ILC exercises provide IAEA Safeguards evaluators with insight into the capabilities of the NWAL to detect elements and isotopes, their abundance, and their relative amounts **(priority #3)**.

The SGAS Coordination and Support Section (CSS) seeks to design and organize ILCs and provide feedback to the NWAL members on the detection and measurement of materials of interest. It also seeks to provide IAEA Safeguards evaluators the understanding required to interpret field-sample analysis data. For this purpose, SGAS CSS requires that NWAL members participate in the IAEA ILC exercises and strongly encourages them to participate in external proficiency testing programmes conducted by JRC/Geel, CETAMA, and NBL-PO. SGAS also requests MSSPs to provide reference materials in various forms, including those deposited on swipes (as described in outcome #2).

Continued outcome

Outcome #4: Modernized distribution of Safeguards samples to the Network of Analytical Laboratories (NWAL).

Output	1. A re-engineered IT application for coordination of the NWAL (NWAL Hub), which is used to track sample assignment, shipping, analysis, reporting and payment, as well as full integration of this application into the existing SGAS Laboratory Information Management System (LIMS) architecture.

Supporting Resource Mobilization Priorities

T.2.C1	T.2.C6	T.2.C7

Support Needed

The NWAL sample coordination project is sponsored by USSP and started on 3 January 2023 with the onboarding of the Associate Laboratory IT Systems Analyst (extra budgetary position) recruited to support the IT development effort.

The Associate Laboratory IT Systems Analyst is the technical lead and main developer in charge of re-engineering the NWAL coordination application into a modern IT tool called the NWAL Hub, testing and documenting the NWAL Hub, and ensuring its proper integration into the SGAS LIMS architecture and the SGIM Nuclear Fuel Cycle Analysis Section's (IFC) Environmental Sampling Environment Enhancement (ESEE). This project therefore contributes to the wider Safeguards Analytical Laboratory Information Management System (SALIMS) upgrade project. The NWAL coordination project is on track to be completed by the end of 2024.

Once this is completed, launching of a new project is considered to streamline and automate processing of data from modified-total-evaporation (MTE) analyses of DA samples by thermal ionization mass spectrometry (TIMS). Evaluation of TIMS-MTE data involves many complex steps including calculation of measurement uncertainties and production of quality control (QC) charts and the level of effort of required IT development is, at the minimum, one full-time IT developer for one year. It is therefore foreseen that a new Temporary Appointment request will be submitted to the USSP.

SGCP-003: Safeguards Approaches

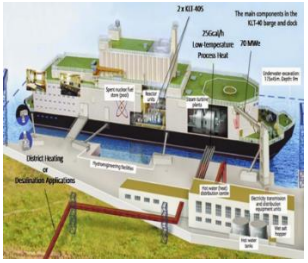
Established

2001

Manager	SGCP Director
Traci NEWTON	Kory SYLVESTER

Objective

Developing, modelling, and demonstrating concepts and approaches to meet evolving Safeguards challenges.



Agency Programme and Budget Link

4.1.1.002 Safeguards approaches and concepts

Plan Abbreviations

APA	Acquisition Path Analysis
CCA	Concepts and Approaches Section
DIQ	Design Information Questionnaire
IMSR	Integral Molten Salt Reactor
SLA	State Level Approach
SMR	Small Modular Reactor

Context Highlights

D&IS Plan Challenges

The increasing global interest in new nuclear technologies to meet future energy demands places greater pressure on the Department. The Department must find improved resource optimization methods while still maintaining effective international safeguards. It is critical that the Department continues to identify additional opportunities for optimization methods, with the assistance of MSSPs, to prepare for implementation of Safeguards on new types nuclear materials, processes, and facilities before they come online, while also enhancing and optimizing existing methodologies and techniques.

How SG Approaches contributes to the verification of nuclear material and facilities for peaceful purposes

MSSP Tasks have provided valuable assistance in the development of Safeguards approaches and the provision of updated resources and guidance on nuclear fuel cycle technologies. In addition, this assistance has extended to the development of guidance for implementing Safeguards measures for Small Modular Reactor (SMR) reactor designs, enabling the Department to prepare for efficiently implementing Safeguards for new technologies even before the construction of these facilities begins.

Significant Achievements in 2022–2023 Resulting from MSSPs

With MSSP assistance, the Department has successfully created Safeguards guidance for decommissioned facilities and is nearing completion for post-accident facilities. MSSPs have also played a crucial role in improving State Level tools and methodologies that are already in use for Acquisition Path Analysis (APA) and State Level Approach (SLA) development.

The Concepts and Approaches Section (CCA) relies considerably on CFEs, as the filling of regular posts has been difficult. The CFEs assist in filling those gaps in existing resources, and towards ensuring that the Department meets its objectives.

Future Research and Development Projects

The Department is actively monitoring ongoing pilot facilities and projects in Member States that hold the potential to contribute significantly to the development and testing of new Safeguards methodologies and equipment for nuclear material verification at advanced reactors.

Currently, SGCP is initiating a in partnership with CAN SP (MSSP Task Proposal 23/GCP-001 (Assessment of High-Fidelity Operational Monitoring for Safeguarding Advanced Reactors)), leveraging Canadian facilities and expertise to develop and test simulators for monitoring nuclear material flows.

Simultaneously, the Department is aware of numerous Member States' plans to construct pilot plants or test loops for the evaluation of emerging technologies.

These developments open up opportunities for potential collaboration between the Department and Member States in various testing scenarios. Such collaborations could play a pivotal role in shaping future Safeguards guidance for innovative nuclear fuel cycle facility designs.

In addition, the Department is exploring the possibility of establishing specialized workshops for innovative reactor designs. These workshops aim to serve as a platform for international SMR vendors, providing them with insights into international Safeguards, an avenue to discuss common concerns specific to technology types, explore potential solutions, and access additional information and resources related to safeguards, safety, security, and safeguards by design.

Advanced Reactors and Geological Repositories

The considerable expansion of SMR designs worldwide has prompted the Department to maintain a stance in its preparedness for future Safeguards implementation. Consequently, the Department is monitoring the global progress of SMRs to gain insights into the anticipated start of construction activities. The simultaneous construction of a substantial number of SMRs presents an increased demand for resources to facilitate safeguarding measures.

In light of these considerations, it is imperative that the Department formulates a strategic framework and proactively explores potential avenues to optimize the implementation of Safeguards before the construction of these new facilities starts. This proactive approach is essential to ensure the effectiveness of Safeguards protocols and resource allocation.

The Department is currently in the process of broadening the scope of subtasks within the Safeguards by Design for SMRs programme, with the inclusion of new reactor designs on the horizon. Several MSSPs have expressed tentative interest in nominating such designs for consideration. The Department acknowledges the challenges faced by some MSSPs in nominating vendors, which, in turn, restricts the range of advanced reactors available for use as model cases and limits the Department's potential for accruing experience from diverse sources. The Department would wish that these challenges not impede the ability to collaborate with motivated vendors outside the MSSP framework.

Floating reactors present a particular set of concerns due to their mobile nature, and the Department is closely monitoring these marine application developments. Currently MSSP Task RUS C 2400 (Safeguards by Design for Small Modular Reactors) specifically addresses this area. Although this MSSP Task is still in its initial phases, it has given the Department the opportunity to begin identifying potential challenges, particularly in regard to legal reporting requirements and the distinct nuclear material flows associated with these installations. The Department has begun to formulate preliminary strategies to address these concerns. However, it is evident that further engagement with marine-based examples would significantly enhance the Department's efforts in this domain.

Figure 13: A visual spectrum of some advanced reactor designs monitored by the Department.

State of the Physical Model

Compilation of expert information for the Physical Model volumes is almost finished. However, the Department is currently streamlining its information dissemination methods and seeks a resource capable to revitalize traditional approaches for conveying complex information into actionable formats. Ideally, the Department seeks a CFE or JPO with adept editing skills and a thorough background in

the nuclear fuel cycle. This unique expertise would enable the CFE or JPO to tailor the textual content within the volumes to align with the specific technical nuances of the subject matter.

Furthermore, the presence of such a technical editor could offer valuable contributions to the Department's Safeguards by Design work. He or she could actively participate in consultancy meetings and play a pivotal role in the compilation of technical assessments provided by SMEs.

Most Needed External Support in 2024–2025

☐ Financial Support	☐ Consultants	☐ Equipment	☐ Training
☐ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☒ Financial Support for Travel	☒ JPOs	☒ R&D	
☒ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

M.4.C3	Ability to maintain awareness of changes in the nuclear landscape and associated impact on safeguards implementation, including the impact of emerging technologies and non-State actors
S.3.C1	Ability to identify and address the needs of designers and operators of modified or new facilities in the early preparation for efficient implementation of safeguards
T.1.C3	Ability to more effectively and efficiently verify spent fuel from on-load reactors
V.3.C1	Ability to derive verification intensities and frequencies from performance targets and to determine detection probabilities
V.3.C2	Ability for safeguards information systems to assist analysts in identifying significant changes in a State's nuclear fuel cycle, which may trigger a need to update the APA, SLA, and AIP
V.3.C3*	Ability to enhance acquisition path analysis and development of State-level safeguards approaches
V.4.C2	Ability to comprehensively evaluate, record, and document safeguards effectiveness at the State level
V.6.C1	Ability to implement effective and efficient safeguards for geological repositories
V.6.C2*	Ability to implement effective and efficient safeguards for SMRs and microreactors
V.6.C4	Ability to perform process monitoring and associated data analysis for safeguarding facilities, particularly advanced reactors with liquid or pebble fuel

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: Improved ability to fully implement the State Level Concept through the development of internal guidance and tools for the development of State Level Approaches.

Output	1. Internal guidance and tools for developing and updating State Level Approaches (SLAs), methodology, and for assessing acquisition path steps, including a State's technical capability to develop nuclear fuel cycle technologies and facilities as well as nuclear material diversion and facility misuse scenarios.

Supporting Resource Mobilization Priorities		
V.3.C1	V.3.C2	V.4.C2

Support Needed

All consultancy meetings concerning each of the selected seven nuclear fuel cycle technologies have been completed with the remaining compilation of the meeting proceedings now being compiled internally. No immediate support is requested from MSSPs at this time. The internal guidance documents for the current subtasks covering seven different nuclear fuel cycle technologies are expected to be completed in 2024. The Department will initiate additional subtasks should additional technologies need assessing.

Continued outcome

Outcome #2: Increased ability to detect undeclared nuclear material and activities through an updated and improved of the Physical Model.

Output	1. A completed version of the Physical Model, which would contain Volumes 1–3 and 5–11, which covers the following fuel cycle steps and their respective technologies: Volume 1 (Mining and ore processing) Volume 2 (Conversion) Volume 3 (Uranium enrichment) Volume 5 (Fuel fabrication) Volume 6 (Reactor and neutron sources) Volume 7 (Heavy water) Volume 8 (Reprocessing and recycling of spent fuel) Volume 9 (Spent fuel management) Volume 10 (Radioactive waste) Volume 11 (Hot cells)

Supporting Resource Mobilization Priorities

V.3.C2	V.6.C1	M.4.C3	T.1.C3	V.3.C3*

Support Needed

The Physical Model serves as a technical resource for Department staff members involved in Safeguards activities such as State evaluation, acquisition path analysis (APA), and State Level Approach development and training. It needs to be continually updated to ensure that the lists of signatures and indicators of nuclear fuel cycle activities are complete and that the weighing of the indicators is accurate with respect to any evolution in fuel cycle technology.

The Department has compiled information for all subtasks and is now in the process of editing the draft volumes. Support needed would be primarily for a technical editor to assist in preparing the volumes for finalization.

The Physical Model should be organized and accessible in such a way that it facilitates analysis by State Evaluation Groups. During the internal review of the volumes to improve consistency and coherence of all the volumes, MSSP experts may be contacted for targeted support.

The Department is actively seeking a JPO to technically edit and digitize the Physical Model. This critical initiative aims to transform the existing documentation into a coherent, consistent, and easily accessible digital format on the appropriate platform. Enabling Department staff members to access the content from any location and facilitating efficient updates by the CCA, a digital version would yield substantial benefits. The transition to digital documentation would streamline accessibility, reduce time, costs, and paper consumption associated with traditional hard copy document management. Importantly, as a staff member, a JPO would have the necessary permissions to handle Safeguards Confidential information related to the Physical Model, unlike, for example, a consultant. No MSSP has yet accepted MSSP Task Proposal 20/CCA-002 (Junior Professional Officer - Editing of the updated Physical Model), and the Department is actively seeking and welcoming the necessary support for this crucial endeavour.

Continued outcome

★ Outcome #3: Enhanced ability to safeguard new types of facilities through development of Safeguards concepts and approaches for pyroprocessing plants and small modular and/or Gen IV reactors.

Outputs	For each of the subtasks, to prepare a model Safeguards approach in the form of a Safeguards Technical Report for the identified facility design: 1. Model Safeguards approach for a pyroprocessing plant proposed by the ROK SP. 2. Model Safeguards approach for a transportable (floating) nuclear power plant (RITM-200M) proposed by RUS SP.

	3. Model Safeguards approach for a pebble–bed modular reactor (HTR-PM) proposed by the CPR SP. 4. Model Safeguards approach for a passive small modular pressurized light water reactor (SMART: System-integrated modular advanced reactor) proposed by the ROK SP. 5. Model Safeguards approaches for NUWARD proposed by FRESPAS. 6. Model Safeguards approaches for Moltex Stable Salt Reactor Wasteburner 300 (SSR-W300) of Moltex proposed by the CAN SP. 7. Model safeguards approaches for the Integral Molten Salt Reactor (IMSR) of Terrestrial Energy Inc. (TEI) (a Canadian advanced nuclear reactor company) proposed by the CAN SP. 8. Model Safeguards approaches for two micro modular reactors for district heating proposed by the FIN SP. 9. Model Safeguards approaches for SMRs (types to be decided) to be proposed by the USSP. 10. Model Safeguards approaches for emerging nuclear fuel cycle technologies and SMRs that are proposed by other Member States. 11. Workshop on Safeguards needs for SMRs and microreactors for Member States and SMR vendors.

Supporting Resource Mobilization Priorities		
V.6.C2*	V.6.C4	S.3.C1

Support Needed

This work is ongoing and expanding, with several new small modular reactor (SMR) designs expected to undertake Safeguards by Design in the near future.

Additional support is sought to prepare and present workshops on Safeguards needs for SMRs and microreactors, with the expected participation of vendors as well as Member State R&D delegates. The objective for the Department would be to better understand and prioritize any foreseen gaps in its capabilities, leading to targeted expansion of its Safeguards by Design engagement with Member States.

The objective for the Member State participants would be to better understand their Safeguards obligations and the Agency's needs in implementing Safeguards on advanced reactors, potentially leading to follow-up Safeguards by Design engagement.

Continued outcome

Outcome #4: Improved ability to verify facilities under the decommissioning phase through the development of Safeguards implementation guidelines and concepts.

Output	1. Safeguards guidelines for post-accident facilities.

Supporting Resource Mobilization Priority
S.3.C1

Support Needed

The focus of 2022–2023 was on completing the Design Information Questionnaire (DIQ) template and the Safeguards guideline for facilities undergoing decommissioning. Currently, the only active subtask pertains to the development of Safeguards guidelines for post-accident facilities, with the concluding consultancy meeting taking place in April 2023. Despite the challenges posed by the Covid-19 pandemic, MSSPs have played a crucial role in maintaining progress.

The final draft of the Safeguards guidance for post-accident facilities is currently in preparation and is anticipated to be ready for final approval by early 2024. Looking ahead, the Department may seek continued support in the form of expertise during workshops focused on the implementation of Safeguards at decommissioned and post-accident facilities.

SGCP-004: Strategic Analyses and Partnerships

Established

2018

Manager

Jenni RISSANEN

SGCP Director

Kory SYLVESTER

Objective

Enhancing the Department's preparedness and nuclear verification capabilities through strategic analyses; coordination of external support from partners; and stakeholder engagement.

Agency Programme and Budget Link

4.1.1.001	Strategic planning and coordination

Plan Abbreviations

MSSP	Member State Support Programme
RMP	Resource Mobilization Priority
SPRICS	Support Programme Communication and Information System
S&T	Science & Technology

Context Highlights

D&IS Plan Title Change

The D&IS Plan title has changed from "Strategic Planning and Partnerships" to " Strategic Analyses and Partnerships," a change that highlights the essence of activities in this domain.

Importance of the Strategic Analyses and Partnerships Plan

The Department's strategic analysis and partnership activities support preparedness for the future through continuous monitoring and analysis of the operating environment and prudent management of resources by establishing and communicating the Department's priorities to partners for which external resources and other support are most needed.

In the face of budget constraints and a growing workload, strategic analysis is indispensable for effective anticipation of needs and allocation of resources so that limited resources are prudently prioritized to meet the Department's objectives. By facilitating both traditional and non-traditional partnerships[1], this D&IS Plan fosters collaboration, resource mobilization, and the sharing of expertise, thereby strengthening the Department's ability to fulfil its mission.

Strategic Analyses and Foresight

Recent years have demonstrated the ever-changing and increasingly turbulent and complex operating environment in which the Department carries out the Agency's nuclear verification mission. Internally, a review of the Department's past strategic analyses confirms the value of strategic foresight and the continuous monitoring and analysis of the operating environment and the associated challenges and opportunities. Externally, positive feedback was received for the 'Anticipating the Future' track at the 2022 Symposium, indicating appreciation for 'futures thinking' by the wider safeguards community.

Therefore, the Department will seek to further strengthen strategic analysis and foresight to better anticipate and prepare for forthcoming challenges and opportunities by preparing operating environment and other analyses in support of decision making, and by monitoring emerging technologies and offering Department staff members opportunities to engage with external Science and Technology (S&T) and other experts. The Department will seek to learn from best practices in the field of strategic foresight by interacting with foresight practitioners and seeking professional development opportunities for its staff members in this area.

[1] Non-traditional partners and donors are entities including but not limited to civil society organizations, foundations, international financial institutions, academia, media, private sector entities and/or individuals.

Building and Deepening Partnerships

The importance of partnerships, with both traditional and non-traditional, is further growing in light of the constraints placed by the increasingly strained budgets, particularly for activities aimed strengthening Safeguards effectiveness and efficiency.

The Department made tangible progress in enhancing its partnerships in 2022–2023. The Department has broadened the pool of donors and partners, having added three new MSSPs (Switzerland, UAE, and Norway) in recent years and concluded partnership agreements with eight non-traditional partners for in-kind support.

The Department will continue to seek new MSSPs and look for opportunities to deepen collaboration with all partners. Support from MSSPs in particular will grow in importance, with regular budgets prioritized towards funding statutorily mandated (obligatory) Safeguards activities while activities aimed at strengthening nuclear verification capabilities are being increasingly funded through extrabudgetary means. Engagement with experts from the Department's non-traditional partners can provide opportunities for exchange of ideas and deepening professional knowledge.

Safeguards Symposium: Fostering Global Collaboration and Advancing Safeguards

In the pursuit of deepening collaboration, the Department organizes a Symposium on International Safeguards every four years to bring together global stakeholders. It is an opportunity for regulatory authorities, the research and development (R&D) community, industry, and civil society to identify challenges and opportunities for IAEA Safeguards, showcase research, share ideas, and build partnerships. This quadrennial convening not only provides a platform for the community to identify challenges and opportunities but also serves as a forum for showcasing cutting-edge research, fostering dialogue, and cultivating partnerships.

Figure 14: Scenes from the 2022 Symposium on International Safeguards.

Coordination of MSSP Contributions

Effective coordination of MSSPs ensures a transparent and streamlined transfer of contributions, minimizing administrative efforts for both the Department and contributing Member States. This is particularly important when it comes to in-kind activities (still a majority of the support the Department receives), which have a greatly increased risk of failure if there is insufficient communication. Effective MSSP coordination is a key enabler for every plan within this D&IS Programme.

Looking ahead, the focus for 2024–2025 is on establishing a more comprehensive framework for introducing newly-established MSSPs into the Department and directing their support to the most pressing needs.

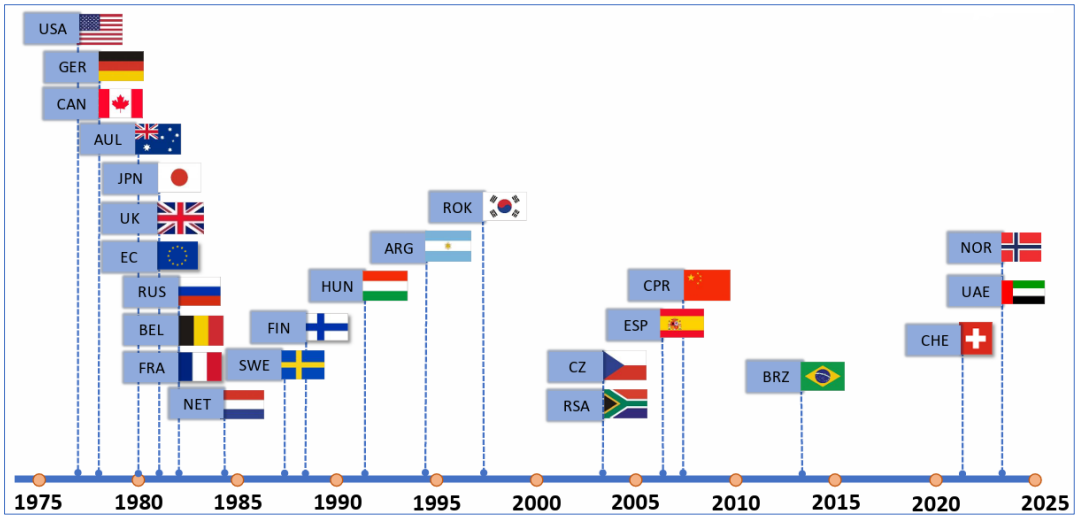


Figure 15: Timeline showcasing the establishments of the current MSSPs.

The Role of CFEs and JPOs in the Department of Safeguards

One of the most valuable contributions that any MSSP can make to the Department is the service of a Cost Free Expert or Junior Professional Officer. These Department staff members, whose costs are borne by the donor, deliver results on a daily basis in Divisions and Offices in which they work, and help develop the next generation of Safeguards professionals. These CFEs and JPOs are particularly crucial resources for driving forward the activities and objectives outlined in this D&IS Programme.

The Department uses a demand-driven process to identify specific technical needs within Divisions that could be addressed with the work of CFEs or JPOs. While the number of CFEs and JPOs has been relatively steady for many years, a key priority in 2024–2025 is to attempt to diversify the base of Member State donors that provide them while retaining a focus on targeting specialized roles and activities for which regular budget is unavailable.

Advancing the Support Programme Information and Communication System (SPRICS) for Streamlined Support Programme Coordination

As the fundamental administrative platform for coordinating extrabudgetary contributions from MSSPs, SPRICS has undergone significant advancements, but it's imperative to continually evolve the system to align with the dynamic needs of current users. The Department, however, faces financial constraints which hinder the allocation of funds for dedicated IT developers to many of its applications, including SPRICS. To address this challenge and leverage strong MSSP interest in improvements, the team will aim to transmit a new MSSP Task Proposal to raise funds so that it can realize substantial planned improvements. The overarching objective of the Support Programme Coordination Team (and by extension SPRICS), is to alleviate administrative burdens on stakeholders so that experts on both sides can focus on delivering results in a transparent, well-documented manner.

Conclusion

This D&IS Plan is a key enabler for the Department to anticipate needs, mobilize resources, and build collaborative partnerships to successfully achieve its nuclear verification mission.

Most Needed External Support in 2024–2025

☐ Financial Support	☐ Consultants	☐ Equipment	☒ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☒ Financial Support for Travel	☒ JPOs	☐ R&D	
☒ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

The work of SGCP-004 serves as an enabler for all of the Department's resource mobilization priorities, and this Plan links to the following specific RMPs:

M.1.C1	Ability to fully implement data-driven programmatic planning, monitoring and evaluation, to support managerial decision making
M.2.C1*	Ability to strategically plan, maintain and improve safeguards IT tools, information assets, and associated infrastructure
M.3.C2	Ability to enhance equipment reliability through improvements to the Safeguards Equipment Management System and monitoring of equipment performance
M.3.C3	Ability to assess and improve the implementation efficiency of the Department's system of processes, procedures and supporting tools
M.3.C4	Ability to deploy project management approaches to ensure effective execution of strategic priorities and projects
M.4.C3	Ability to maintain awareness of changes in the nuclear landscape and associated impact on safeguards implementation, including the impact of emerging technologies and non-State actors
S.1.C2	Ability to more clearly and effectively communicate the value and importance of IAEA safeguards, and to reach a broader audience
W.3.C2	Ability to further develop the expertise of the Safeguards Department's workforce and train the next generation of safeguards experts
W.4.C1*	Ability to attract and retain a diverse and balanced workforce in terms of geographic origin, gender, and age

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

★ Outcome #1: Improved Department ability to monitor, identify, and adjust to changes in the operating environment in a timely manner.

Outputs	1. Operating environment and other analyses through briefings, presentations, and reports that foster strategic awareness and informed decision making. 2. Emerging technologies analyses and workshop(s) and associated deliverables (e.g., reports, multimedia products).

Supporting Resource Mobilization Priorities

M.1.C1	M.3.C2	M.4.C3

Support Needed

Operating Environment Analyses: This output aims to foster strategic awareness and support for Department senior management for informed decision making. To successfully undertake this work, the Department requires JPOs and CFEs to scan the Agency's operating environment, identify and analyse challenges and opportunities, and prepare and present these analyses to senior management. The Department is requesting the continuation of MSSP Tasks GER X 2720 (CFE - Strategic Analyses and Partnerships Officer) and RUS X 2662 (JPO - Associate Coordination Officer (Safeguards Symposium)).

Emerging Technologies Analyses: This output aims to identify and evaluate emerging technologies of relevance to Safeguards, by increasing opportunities for Department staff members to engage with and learn from external Science & Technology (S&T) experts. To accomplish this, the Department seeks partner support for the provision of external expertise, including a dedicated CFE on emerging technologies, currently being requested under MSSP Task Proposal 22/CPC-002 (CFE - Emerging Technologies Expert) that is not yet accepted by any MSSP. The Department also requests support to sponsor the participation of expert speakers and facilitators at Department events, such as at the Emerging Technologies Workshop(s) and other relevant meetings, and the sharing of knowledge through studies, research, and collaboration. Member States are also invited to support effective communication (e.g., multimedia) of the results of the analyses and events for the benefit of both Department staff members and the wider safeguards community.

New outcome

★Outcome #2: Increased volume and diversity of support to the Department through new and existing partnerships.

Outputs	1. At least two newly-established MSSPs. 2. An increase of at least 20% of total extrabudgetary financial contributions from MSSPs to D&IS activities as compared to 2022–2023. 3. Provision of in-kind contributions (e.g., research, expertise) from non-traditional partners in support of the Department's needs.

Supporting Resource Mobilization Priorities

M.2.C1*	M.4.C3	W.4.C1*

Support Needed

To establish at least two new MSSPs and increase total extrabudgetary financial contributions to D&IS activities by 20% or more compared to 2022–2023, it is imperative to make substantial progress across all specified outcomes and outputs within the 2024–2025 D&IS Programme. This necessitates an augmentation of external support through partnerships. To strengthen the Department's reputation for independence and mitigate risks associated with dependency on a few major donors, diversifying the existing donor base is of equal importance. This pertains particularly to financial contributions and contributions such as CFEs and JPOs.

Current MSSPs and non-traditional partners are invited to identify opportunities for new collaboration in line with the needs expressed in the *Enhancing Capabilities for Nuclear Verification - Resource Mobilization Priorities* (RMP) document and this D&IS Programme. Additionally, they are encouraged to support existing partners in persuading their sponsors and key decision makers

that support to the Department is a good investment for international security and global nuclear risk reduction.

Additional outreach efforts with the support of existing partners should be undertaken in 2024–2025 to fully leverage any momentum gained from recent new MSSPs and to deepen collaboration with non-traditional partners.

Modified outcome

Outcome #3: Proactive, timely, and responsive coordination with the Department's partners about extrabudgetary support needs.

Outputs	1. A published update to the 2022 *Enhancing Capabilities for Nuclear Verification - Resource Mobilization Priorities (RMP)* document. 2. Deployment of substantive new Support Programme Information and Communication System (SPRICS) capabilities, including user dashboards and additional functionality requested by SPRICS users. 3. Delivery of improved meeting packages and MSSP Task Proposals.

Supporting Resource Mobilization Priorities	
M.3.C3	S.1.C2

Support Needed

Update of the RMP document: The RMP document identifies and communicates the set of needed capabilities that are of the highest priority to the Department and especially reliant on external support. In so doing, the document supports effective resource mobilization. The Department will develop an updated RMP for the 2026 MSSP Coordinators' Meeting. Resources permitting, the Department's aim is to develop the RMP into a living online resource to communicate the Department's evolving needs for external support. An online RMP has the potential not just to better communicate the Department's needs to traditional and non-traditional partners in a timely manner, but also to enable different partners to connect and collaborate in meeting those needs and to track and view contributions and progress towards them. To support the *Enhancing Capabilities for Nuclear Verification – RMP* document, the Department is requesting the continuation of MSSP Tasks GER X 2720 (CFE - Strategic Analyses and Partnerships Officer) and RUS X 2662 (JPO - Associate Coordination Officer (Safeguards Symposium)).

Implementation of SPRICS Capabilities: The Department relies on the valuable contributions of MSSP Tasks JPN F 2700 (CFE - Support Programme Administrator) and USA F 2682 (JPO - Associate Safeguards Support Programme Officer) to ensure the delivery of MSSP services. However, to maximize the potential of these resources and ensure they are fully utilized, IT development resources are needed to implement the backlog of SPRICS change requests and bugs. In 2024–2025, resources for one full-time internal IT developer will likely be requested, at an estimated cost of approximately €160 000 per year for two years. This investment would not only enhance MSSP services and address long-standing SPRICS change requests and bugs (for example, user dashboards, version history, improved graphic user interfaces (GUIs), better formatted MSSP Task Proposals, etc.) but also ensure a more effective stewardship of extrabudgetary contributions.

MSSP-hosted Review Meetings: In-person annual review meetings, such as the inaugural UAE Support Programme Annual Review Meeting, provide an opportunity for the Department to engage with more stakeholders in the Member State, facilitating substantive discussions on specific opportunities for new support activities. In the past, these have taken place approximately once per biennium with many MSSPs, but can only occur with travel support from the host. In 2024–2025, when feasible, this would prove to be a highly-valued and effective means of support to involve a wider audience from Member States in discussions with the Department's experts on enhancing its verification capabilities.

Continued outcome

Outcome #4: Enhanced dialogue among global safeguards stakeholders with increased understanding of common challenges and opportunities and ideas for solutions.

Outputs	1. Participation of Department staff members in external conferences, workshops, and training courses. 2. Engagement of external experts in Department events and programmes (e.g., through a speaker series).

Supporting Resource Mobilization Priorities

M.4.C3	S.1.C2	W.3.C2

Support Needed

Engagement with the global nuclear non-proliferation and verification community, particularly the Agency's non-traditional partners, provide opportunities for fruitful exchange of views and ideas and sharing of knowledge between them and the Secretariat.

Given the constraints of diminishing regular budgets, opportunities for professional development have become increasingly scarce. To address this challenge, the Department is seeking extrabudgetary support. This support would be allocated towards essential needs, such as travel expenses and participation fees related to professional conferences and training events. Additionally, funding is sought for professional certifications, materials, and the possibility of bringing external consultants or experts to the IAEA headquarters as speakers and SMEs. The success of this output is contingent upon securing the necessary support.

Looking ahead to the next scheduled Safeguards Symposium in 2026, the IAEA would again rely on the expertise of professionals, CFEs and JPOs, and financial assistance. Preparations for the next Symposium will begin in 2024–2025.

SGCP-101: Quality Management

Established

2001

Manager	SGCP Director
Gary DYCK	Kory SYLVESTER

Objective

Implementing and enhancing processes and management tools supporting the Department's Quality Management System (QMS).

Agency Programme and Budget Link

4.1.1.003 Process design and quality management

Plan Abbreviations

CPD	Process Design Section
CQM	Quality Management Section
IQA	Internal Quality Audit
QMS	Quality Management System
SGMD	Safeguards Master Data

Context Highlights

Building upon the progress made in 2022–2023, the Department is entering a new phase of its Quality Management System (QMS) evolution. It had focused on establishing the QMS and enhancing process documentation. Now the Department is focusing on comprehensive oversight of Safeguards processes, emphasizing consistency, effectiveness, and efficiency.

The Quality Management Section (CQM), formerly known as the Process Design Section (CPD), is taking on a broader role in administering quality management activities, including process monitoring and improvement. The Department's Internal Quality Audit (IQA) programme has expanded to include systematic assessments, and the Condition Reporting System is being revised to provide a user-friendly system to identify and address a broader range of issues. Additionally, the Department has embraced knowledge management activities and is committed to retaining critical knowledge as part of its Safeguards implementation strategy.

CQM, and by extension this D&IS Plan, supports quality management for the entire Department, including all areas with external quality certification (SGAS and the Equipment Radiation Monitoring Laboratory).

The *Supplementary Document to the Report on The Conceptualization and Development of Safeguards Implementation at the State Level* (GOV/2013/38) [GOV/2014/41], under C.9 Performance Measurement and Quality Management states:

> "The Department of Safeguards' QMS provides regular and routine oversight of the key safeguards processes and their results to ensure impartiality, effectiveness and efficiency of safeguards implementation. It includes standardized Departmental guidelines; uniform processes and well-defined procedures to ensure consistency of approaches across the Department of Safeguards; Divisional and Departmental review and approval processes; and performance review and process improvement through internal quality audits and quality control reviews. Documented internal processes are reviewed periodically using a process improvement methodology, which includes condition reporting whereby nonconforming or potential nonconforming situations are documented and the root causes identified and corrected. Safeguards processes are also periodically audited by auditors from outside of the Department. As part of the QMS, knowledge management activities are being implemented to improve the retention of critical knowledge prior to the separation of staff members from the Department. It also seeks to retain process knowledge in safeguards implementation."

This updated D&IS Plan emphasizes consistency, efficiency, and effectiveness in Safeguards processes. With the support of MSSPs, the Department is committed to achieving its outlined goals. The Department appreciates the collaboration of its partners and stakeholders to enhance Safeguards implementation and operational procedures together.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☐ Equipment	☒ Training
☐ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☐ Studies
☐ Financial Support for Travel	☒ JPOs	☐ R&D	
☐ Expert meeting participation		☐ Facility Access	

Any software needs will be sought through SGIS.

Resource Mobilization Priority Links

M.1.C1 Ability to fully implement data-driven programmatic planning, monitoring and evaluation, to support managerial decision making

M.3.C2 Ability to enhance managerial decision making processes, capabilities and competencies

M.3.C3 Ability to assess and improve the implementation efficiency of the Department's system of processes, procedures and supporting tools

New Plan for 2024–2025

★ Indicates top priority

New outcome

Outcome #1: An active quality culture with increased Department staff member engagement, ultimately leading to improved Safeguards implementation.

Outputs

1. ★ A plan and programme to develop the quality culture within the Department.
2. Tools to increase Department staff member participation in the quality culture through increased reporting of issues arising in the workplace, such as an improved Condition Reporting system.
3. Improved communication within the Department on the value delivered by the Quality Management System (QMS).

Supporting Resource Mobilization Priority

M.3.C3

Support Needed

As the Department aims to enhance the responsibilities of the Quality Management Section (CQM), it will also be extending the involvement of Department staff members in bolstering its QMS. To facilitate this, the assistance of MSSPs is pivotal, and they can contribute in the following ways:

- Offering training programmes focused on cultivating a quality-centric culture within the Department.
- Providing external resources to aid in the execution of quality management activities.
- Providing human resources, including consultants, CFEs, and JPOs, who can actively participate in nurturing a culture of quality.
    - MSSP Task USA X 2620 (JPO - Associate Quality Management Officer (SG)) has contributed to the Assessment of Data Integrity in the Safeguards Master Data (SGMD) System aligned the Department's Asset Management System with QMS principles and provided collaborative document reviews, which underscores a multifaceted and essential role in advancing this D&IS Plan's objectives. A replacement JPO may be sought in 2024–2025.
- Extending support for the development of reporting tools within the Safeguards Information System.

Through these collaborative efforts, the Department can collectively work towards fostering a culture of quality and ensuring the success of its QMS.

New outcome

Outcome #2: Enhanced ability to identify and address opportunities for improvement, ultimately leading to improved Safeguards implementation and ensuring efficient work practices.

Outputs	1. ★ Completed internal quality audits and assessments with improved quality and scope of this programme. 2. Additional tools for continuous monitoring of Department performance, such as automated tracking of performance metrics. 3. Improvements in consistency, effectiveness, and efficiency of work practices though Internal Quality Audit (IQA) follow-up activities.

Supporting Resource Mobilization Priorities

M.1.C1	M.3.C2	M.3.C3

Support Needed

In the pursuit of enhancing the management and performance of work, the Department has strategic plans to further extend the reach and depth of its IQA programme. Specifically, the Department intends to focus on areas such as the effectiveness of Safeguards implementation and the creation of additional tools to monitor key performance indicators.

To realize these objectives, the support of MSSPs would be instrumental, and they can contribute in the following ways:

- Offering training courses for lead auditors to ensure the effective execution of IQA activities.
- Providing qualified human resources, including consultants, CFEs, and JPOs, who can actively participate in the development and implementation of IQA activities. The current JPO, MSSP Task USA X 2620 (JPO - Associate Quality Management Officer (SG)) has been instrumental in bringing new energy and fresh approaches to the Department's internal Quality Management System (QMS).
- Assisting in the development of alternative performance management methodologies that align with Department goals.
- Financial support to purchase audit management software is currently being requested under MSSP Task Proposal 23/CQM-001 (Financial Support to Purchase an Internal Audit Management System). This is essential to streamline and integrate the audit and assessment processes, ensure compliance with ISO standards, facilitate collaboration, and foster continuous improvement within the Department by providing a centralized and efficient platform for managing findings and recommendations.

New outcome

Outcome #3: Improved and expanded formally-documented Department processes, resulting in improved clarity and effectiveness in operational procedures.

Outputs	1. Expanded and updated documentation of Department processes. 2. Increased Department staff member participation in and understanding of Department processes and their documentation.

Supporting Resource Mobilization Priority

M.3.C3

Support Needed

Ongoing efforts to enhance and expand officially-documented Department processes are built upon the foundation of process development capabilities that the Department has cultivated in recent years. To further bolster process monitoring activities, the Department welcomes the valuable assistance of the MSSPs, which can provide support in the following ways:

- Delivering training programmes on formal process design and improvement to enhance the Quality Management Section's (CQM) expertise in this area.

- Offering the expertise and engagement of human resources, including consultants, CFEs, and JPOs, who can contribute to documenting the Department's core processes, specifically the core process of preparing, conducting, and recording analysis of verification activity samples.
- Facilitating financial support to enable Department staff members from other Divisions (process users) to actively participate in process improvement efforts through funded temporary assignments and developmental reassignments. This will foster cross-functional collaboration.

SGCP-102: Training

Established	
2008	
Manager	**SGCP Director**
Susan PICKETT	Kory SYLVESTER

Objective

Providing effective training and learning opportunities to ensure that target audiences can perform their work and implement IAEA Safeguards.

Agency Programme and Budget Links

4.1.1.004	Safeguards staff training and traineeship
4.1.1.005	Training and assistance to SSACs

Plan Abbreviations

COMPASS	Comprehensive Capacity-Building Initiative for SSACs and SRAs
CTR	Section for Safeguards Training
DSA	Daily Subsistence Allowance
FVPS	Field Verifiable Passive Seal
HR	Human Resources
ICAS	Introductory Course for Agency Safeguards
INIR	Integrated Nuclear Infrastructure Review
INSEP	International Nuclear Safeguards Engagement Program
ISSAS	Safeguards and SSAC Advisory Service
LMS	Learning Management System
NPP	nuclear power plant
SDP	State Declarations Portal
SSAC	State system of accounting for and control of nuclear material
TNA	Training Needs Analysis
WCAG	Web Content Accessibility Guidelines
XCVD	neXt generation Cerenkov Viewing Device

Context Highlights

Background

The Section for Safeguards Training (CTR) is responsible for delivering high-quality, comprehensive, and engaging training and capacity building activities. This extends to both Department staff members and State representatives engaged in safeguards implementation, with a core focus on equipping them with the essential expertise to effectively fulfil their responsibilities. As a Section with two Teams—the Staff Training Team and the Member States' Training team—CTR's efficacy is fortified through the collaborative partnership and support extended by MSSPs.

The Department relies on CTR, recognizing its role in not only equipping IAEA Safeguards inspectors, analysts, and personnel with essential training and skill development opportunities, but also in cultivating the distinct proficiencies necessary for effective Safeguards implementation. Furthermore, CTR delivers vital support and guidance to States, facilitating the building, maintaining, and strengthening of their individual systems for their own State systems of accounting for and control of nuclear material.

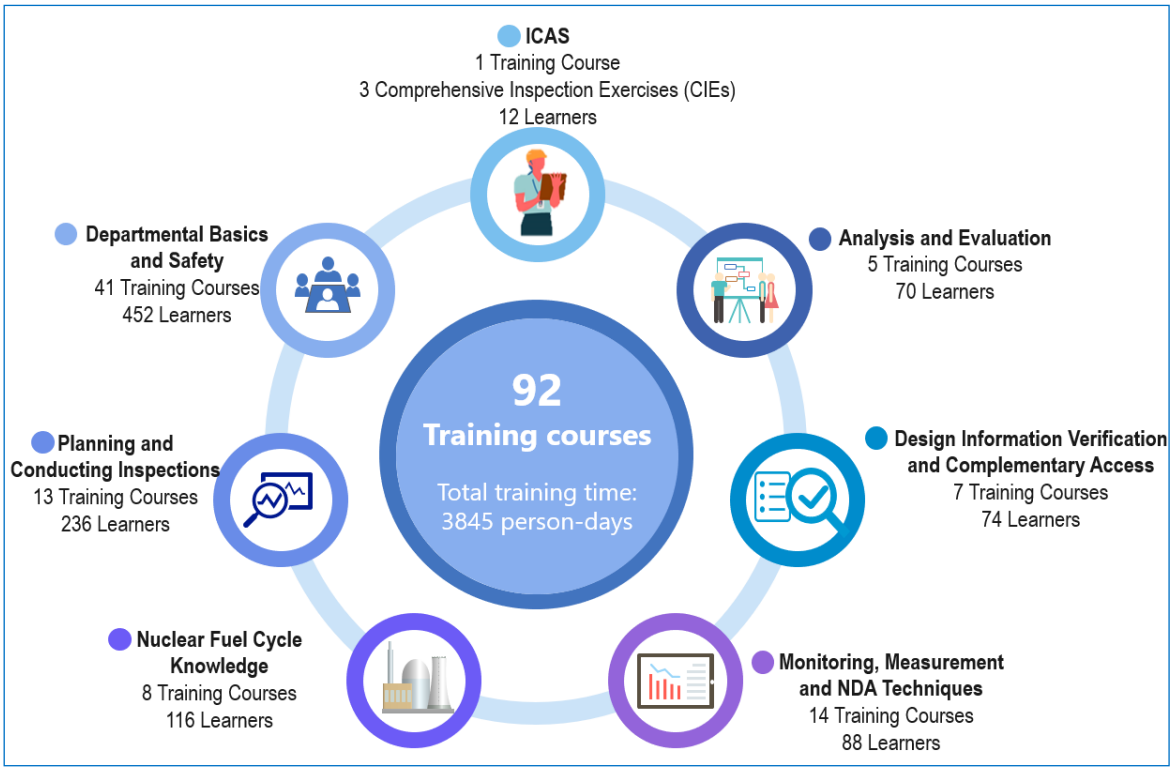


Figure 16: The impact of Staff Training in 2022.

2022–2023 Accomplishments and Milestones

To encapsulate the notable accomplishments spanning 2022–2023, CTR has achieved the following milestones:

- **Staff Training:** More than 60 courses, totaling more than 90 offerings per year, amounting to a substantial 3800+ person-days annually. Additionally, two intensive six-month introductory courses were conducted, tailored to Agency Safeguards, benefitting 29 new IAEA Safeguards inspectors. CTR's contributions further extended to the successful completion of three level-3 evaluations and comprehensive training needs assessments.
- **Member States:** More than 45 annual events, involving over 400 participants. Notably, the introduction of a new webinar series, comprising 10 webinars, attracted an average participation of over 100 individuals from nearly 100 States.
- **E-learning:** The IAEA Open Learning Management System (LMS) platform now boasts a substantial registrant count exceeding 4000+. This initiative saw the creation of 23 new, publicly-accessible training course pages. These include:
    - Six microlearning pages, including:

A concise introduction to the Safeguards Legal Framework	A short history of Safeguards	What is the nuclear fuel cycle?
		

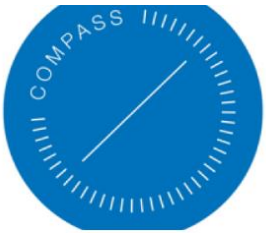
- 13 dedicated e-learning pages, including:

[Everything you need to know about ISSAS! | IAEA]

[Basic Training Course on IAEA Safeguards | IAEA]

[Nuclear Trade: Export Controls | IAEA]

[Basic concepts: Nuclear material accounting in facilities | IAEA]



[Sharing the COMPASS experience | IAEA]

[Safeguards for States Introducing Nuclear Power | IAEA]

[Design Information | IAEA]

[Safeguards Traineeship | IAEA]

[How to use the FLIR identiFINDER 2 for Safeguards Verification | IAEA]

- Four pages hosting past webinars from 2020–2023, including:

Furthermore, with restricted access, a total of 39 assets were introduced, encompassing:

- 11 pages specific to the Comprehensive Capacity-Building Initiative for SSACs and SRAs initiative.
- Three pages dedicated to Communities of Practice (International Nuclear Safeguards Engagement Program (INSEP), Safeguards MSSP Coordination 2022, and MSSP Task Proposal 20/CTR-005 (Online Course Development Consultation).
- Virtual classrooms, supporting in-person training courses (blended approach) in English, Spanish, and Russian.

- **Safeguards Traineeship Programme:** In commitment to nurturing the next generation of Safeguards professionals, CTR conducted two comprehensive nine-month traineeship programmes. These programmes welcomed a cohort of nine participants each year, cultivating the talents of young professionals from States with little or no nuclear fuel cycle. In 2022–2023, the following States were represented: Co-operative Republic of Guyana, Federal Republic of Nigeria, Georgia, Kingdom of Lesotho, People's Democratic Republic of Algeria, People's Republic of Bangladesh, Republic of Cameroon, Republic of Costa Rica, Republic of Madagascar, Republic of Panama, Republic of Tajikistan, Republic of the Sudan, Republic of Yemen, Socialist Republic of Viet Nam, and the United Republic of Tanzania.

Figure 17: 2021 Safeguards Trainees exploring a Czech Republic facility to gain insights into Safeguards implementation within the State.

- **Comprehensive Capacity-Building Initiative for SSACs and SRAs (COMPASS)** activities included 14 SSAC stakeholder outreach events and meetings; 15 physical training courses; more than ten webinars on safeguards-related topics; legal and regulatory training/assistance to all seven pilot States; as well as information management advice to three pilot States. The Agency additionally procured 13 hand-held radioisotope identification devices and nine computers with Safeguards software installed for the pilot States. As a result of these meetings and engagements, the pilot States developed 22 new guidelines and procedures (plus one developed with Agency support) and five national training plans, provided reports to the IAEA through the State Declarations Portal (SDP), and worked to facilitate all activities.

Figure 18: The impact of the COMPASS Pilot Phase.

Briefly, it is valuable to revisit the 2020–2021 biennium for its noteworthy developments. One of the standout goals, written prior to the onset of the Covid-19 pandemic, was to provide accessible training and learning avenues for staff within States. This strategic perspective aimed to ensure that safeguards practitioners could access crucial information and educational resources, facilitating the cultivation of the essential knowledge and skills on demand required for their roles.

While the original plan outlined a modest requirement of three e-learning modules, at present, the Department boasts over 50 dedicated pages and sites. This evolution encompasses not only resources tailored to Member States in multiple languages, but also features specialized pages, which can also be used for staff learning.

Complementing this notable accomplishment is a profound transformation in the Department's support paradigm for Member States. This recalibration is particularly discernible in the intensified focus on needs assessment and the implementation of a bespoke approach. This tailored methodology is evident across various dimensions, encompassing COMPASS initiatives as well as the broader spectrum of support and assistance extended to States.

Contributions of MSSPs to Training and Capacity Building

MSSPs significantly contributed to the successful outcomes of the aforementioned programmes through:

- **Access to Facilities:** Through generous in-kind contributions, MSSPs provide invaluable access to facilities. This enables IAEA Safeguards inspectors and analysts to acquire hands-on, fundamental skills crucial for the effective execution of Safeguards. The opportunity for practical learning is pivotal in enhancing competencies.
- **Human Resources and Expert Support:** The expertise and support of CFEs and JPOs play an indispensable role in advancing both Department staff member and Member States' training. This involves expert guidance for on-site training and Agency-based instructional initiatives. The rapid and decisive response to the request for a CFE in instructional design has yielded immediate and significant results. The appointed CFE has already taken proactive steps in crafting an induction programme tailored for new non-IAEA Safeguards inspectors. Notably, this induction programme has garnered explicit recognition as a high-priority initiative by all Department Directors.
- **Funding and Peer-to-Peer Support for Member States:** A cornerstone of comprehensive Safeguards agreements, the establishment of a State system of accounting for and control of nuclear material (SSAC) necessitates funding. The COMPASS initiative demonstrated the collaborative strength of State-to-State support, bolstered by IAEA collaboration. This collaborative approach facilitates the exchange of best practices, reinforcing State capabilities and thereby fortifying the international non-proliferation regime.
- **Equipment Provision:** Essential to both Department staff member training and Member States' capacity-building efforts, the provision of necessary equipment is of paramount importance. This ensures that training initiatives are conducted seamlessly and effectively, enhancing the overall impact of these endeavours.

Figure 19: A radionuclide detector, the Hm5.

Challenges

In order to provide further context regarding CTR's pursuit of support, it is important to outline its anticipated challenges for the coming 3–5 years. This strategic assessment takes into account a holistic view of the Department's operational landscape, encompassing both internal and external factors:

- **Resource Uncertainty in Annual Programme Planning:** Navigating an environment characterised by resource uncertainties presents an ongoing challenge. Currently, the Department's planning horizon ranges from annual to bi-annual cycles, primarily due to its dependence on external support, including MSSP contributions and the corresponding negotiation dynamics. Member States training non-human resources (HR), which is *entirely* supported by extrabudgetary contributions, as well as human resources allocation, particularly for two CFEs, heavily rely on extrabudgetary support. Department staff member training relies on access to nuclear facilities from Member States, introducing further complexities.
- **Participation and Accountability Hurdles:** Ensuring optimal enrollment, completion rates, and precise targeting of audiences persistently pose challenges for both Department staff member and Member States teams. Key obstacles include the necessity for robust programme enrollment tracking, delays in nominations from regulatory agencies, misalignments between participants and course content, visa-related impediments for international training, and limited internet access at specific training sites. These barriers hinder effective monitoring, participation, and completion in training initiatives.

- **Adapting to Emerging Technology:** The landscape of new nuclear technologies, slated for Safeguards due to their use of nuclear material, including technologies like Small Modular Reactors (SMRs) and accelerator-based systems, necessitates a proactive approach. Not only do novel approaches become requisite, but also the imperative for training Department staff members to master the skills necessary for implementing Safeguards. In parallel, the integration of new verification techniques necessitates synchronized training efforts, wherein close collaboration with SGTS and the Operations Divisions ensures the needs are met in a timely manner.
- **Incorporating Diversity and Inclusivity:** Taking diversity and inclusivity into the development and delivery of training materials poses another notable challenge. Striving to cultivate a training environment that effectively accommodates diverse perspectives and fosters inclusivity requires a thoughtful and strategic approach. Microlearning on accessibility was held and initial changes are being made on CLP4NET.

The Department's proactive assessment of these challenges is instrumental in shaping its approach to the subsequent requests for support to ensure that the training courses can be received by everyone no matter which disability they may be facing, representing as many ethnicities, ages, and cultures.

Time-Sensitive Request: Industrial Safety Training

Since its inclusion in the 2020–2021 D&IS Plan, industrial safety remains a priority. Safety, a commitment across all levels of the Department, underscores the urgent need for an Industrial Safety Training Programme. The gravity of this situation is heightened by the Department's responsibility for the safety of Department staff members who work in the field.

Notable progress has been achieved, including a comprehensive training needs analysis that garnered unanimous support from Department Directors. This support paved the way for the development of an Industrial Safety curriculum. However, the Department has not yet secured the necessary expertise to design and develop the necessary curriculum.

Previous requests have not yet aligned with the priorities of any MSSP, prompting the Department to explore alternative solutions. As the Department embarks on the new biennium, it seeks to gauge MSSP interest in contributing to and supporting Industrial Safety Training.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☐ Equipment	☒ Training
☐ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☐ Studies
☒ Financial Support for Travel	☒ JPOs	☐ R&D	
☐ Expert meeting participation		☒ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

M.2.C1*	Ability to strategically plan, maintain and improve safeguards IT tools, information assets, and associated infrastructure
M.3.C1	Ability to maintain an effective departmental communication framework and processes
M.3.C2	Ability to enhance managerial decision making processes, capabilities and competencies
M.3.C4	Ability to deploy project management approaches to ensure effective execution of strategic priorities and projects
M.4.C1	Ability to enhance working practices, leveraging Covid-19 lessons learned (e.g. information architecture, secure cloud services, secure virtual meeting environment)
S.1.C2	Ability to more clearly and effectively communicate the value and importance of IAEA safeguards, and to reach a broader audience
W.3.C1	Ability to train inspectors on spent fuel measurement techniques inside facilities
W.3.C2	Ability to further develop the expertise of the Safeguards Department’s workforce and train the next generation of safeguards experts
W.3.C4	Ability to effectively utilize knowledge and expertise already existing with the Department
W.3.C5	Ability to preserve and disseminate critical organizational knowledge to overcome staff turn-over and other associated challenges

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: Competent and confident SSAC staff members with the knowledge and skills to effectively implement safeguards and fulfil Safeguards obligations.

Outputs

1. **SSAC Support:** On-demand national and international courses conducted annually per State request, typically four to five courses per year; update of relevant IAEA Service Series references.
2. **E-learning:** Ongoing elearning.iaea.org site development, updates, and maintenance, coupled with video content creation, ensuring accessible on-demand learning for SSAC staff.
3. **Webinar Series for 100 States:** Curated based on States' and Operations Divisions' input, delivering topical interactive sessions.
4. **Comprehensive Capacity-Building Initiative for SSACs and SRAs (COMPASS) Implementation:** Executed comprehensive workplans for the four COMPASS States, blending virtual and in-person training, fellowships, and other engagements.
5. **IAEA Safeguards and SSAC Advisory Service (ISSAS):** One to two annual ISSAS Missions, addressing Member States' requests, extending beyond COMPASS' scope.

Supporting Resource Mobilization Priorities

M.2.C1*	W.3.C2	M.4.C1

Support Needed

The Department's crucial support and assistance to Member States are exclusively sustained through extrabudgetary funding. Presently, all funding for Member State support assistance comes from International Training Courses. These encompass five to six international SSAC courses, supported by the USA, Japan, and ROK. The collaboration and financial support of these MSSPs remain indispensable. The Department warmly welcomes the prospect of further expanding this impactful programme to accommodate the evolving needs of Member States, with not only training courses, but also online learning for continual access, ISSAS missions and COMPASS support, as well as support to other IAEA missions.

National Engagements (training programmes, learning opportunities)

Between 2022–2023, over 25 national and international training events (both virtual and in-person) were held. CTR's innovative approach integrates in-person curriculum offerings with virtual training modules, webinars, and personalized one-on-one engagements. An annual projection anticipates an average of five to six in-person national and international IAEA training courses.

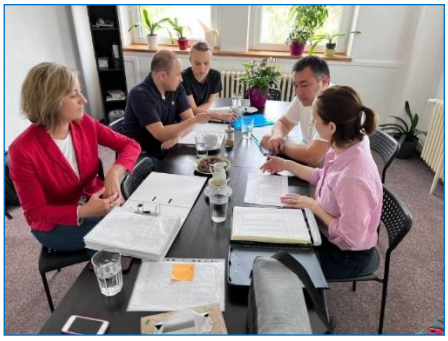


Figure 20: An IAEA workshop in Uzbekistan.

These training initiatives necessitate a consistent financial commitment. An estimated €160 000–180 000 is annually dedicated to sustain these training events. Each training course ranges between €35 000–50 000 and covers critical components such as travel and Daily Subsistence Allowance (DSA) for instructors and any requisite logistical support.

Online Learning

The online learning element of MSSP support serves as a cornerstone, facilitating accessible and comprehensive learning avenues. This encompassing approach caters not only to SSAC staff but also extends to Department staff members. The Department's envisioned roadmap entails a series of strategic enhancements:

- Revamped Graphic Design in alignment with IAEA visual identity and adherence to level AA of the Web Content Accessibility Guidelines (WCAG).
- A revision of existing pages with a pursuit of accessibility standards at level AA to enhance the inclusivity and usability of the Department's offerings.
- A comprehensive update of the Basic Training Course on IAEA Safeguards, ensuring its continued relevance and efficacy.
- Localization efforts to render select publicly-available pages in Spanish, French, and Russian, promoting a globally accessible learning environment.

The Department seeks €50 000 to develop CLP4NET, including requisite learning modules and video content. Furthermore, a budget of €150 000 is imperative to secure the services of a skilled instructional designer at the P3 level, spanning the crucial period from 2024 to 2027.

COMPASS

An annual allocation of €800 000 is necessary to support essential staff expenditures and implement national support programmes to include ISSAS missions, training initiatives, provision of essential equipment, and SME assessments of guidelines.

In-kind support has been requested and is needed in such forms as hands-on training either in COMPASS States or in partner States; training webinars; the development of processes and procedures to implement safeguards; and national training plans to sustain SSAC capacities.

ISSAS Missions

In addition to COMPASS States, CTR estimates one additional ISSAS mission per year. The Director General and DDGO endorse ISSAS missions as an avenue for States to assess their SSACs. This assessment develops a clear follow-up plan that can be used to target support for capacity development. MSSPs provide vital extrabudgetary support, facilitating the execution of ISSAS missions. This collaborative effort has culminated in successfully completed missions in People’s Republic of Bangladesh and the Republic of Türkiye. Beyond the COMPASS framework, projections expect one additional ISSAS mission annually. To make this a reality, a funding allocation of €35 000 is necessary to fortify safeguards capabilities in States.

Human Resources (CFEs)

CTR’s efficacy is tied to the contributions of the CFEs within the Member State Training Team. Two CFEs from USA and Japan ensure coordination and execution of Member States training, working in tandem with Integrated Nuclear Infrastructure Review (INIR) missions and drive Member States' training initiatives to new heights.

Programme	Funding	In-kind
National engagements	€160 000–180 000 for five to six national courses per needs from Member States	In-kind support for facility and training.
Online learning	€150 000 annually for staff	
	€50 000 to develop CLP4NET	Translation support.
COMPASS	€800 000	Hands-on training; training webinars; technical visits, processes and procedures support for States; and national training plans to sustain SSAC capacities.
ISSAS	€35 000 annually	Participation of experts from Permanent Missions.
Update of Service Series document	Provision of a consultant or extrabudgetary staff to coordinate and implement the update of IAEA Service Series on Safeguards Implementation (either in-kind or funded).	

Continued outcome

Outcome #2: Knowledgeable and skilled departmental staff members who can plan, conduct, and evaluate safeguards activities.

Outputs

1. ★ Secured access to a facility(ies) for 10 high-priority training courses per year for the next five years.
2. A comprehensive Safeguards Training Programme.
3. ★ An industrial safety curriculum.
4. Process or guideline on accountability for training Department staff members, Member States, and MSSPs.
5. Training courses to address new verification technologies.

Supporting Resource Mobilization Priorities

W.3.C1	W.3.C2	W.3.C4	W.3.C5

Support Needed

1. **Facility Access:** This critical requirement continues from the last biennium. In-person training at nuclear facilities remains an essential tool to ensure the Department integrates the knowledge, skills, and abilities to fulfil the verification mission. While prioritisation and assessment of risks to hosts and participants have now become part of the planning and decision-making process, facility access remains an absolutely indispensable, essential need. As examples, the Department currently relies on one single facility for Cherenkov spent fuel verification training and two facilities for fuel fabrication verification training, which limits the opportunities for IAEA Safeguards inspectors to train on these fundamental skills. The Department hires between 10–20 IAEA Safeguards inspectors each year, which requires between two and five facilities for the comprehensive inspection exercise (a one-week practical exercise at a nuclear power plant (NPP)) every year. Facilities located closer to Vienna are preferred to reduce travel costs, which further restricts availabilities.
2. **A Comprehensive Safeguards Training Programme:** This critical requirement continues from the last biennium. The Department now has an expert in instructional design consistently apply the Systematic Approach to Training. The expert has already delivered on key elements of the programme and initiated the development of an induction programme for all Department staff members. Finally, continued support is needed for this as well as MSSP Tasks USA B 2436 (JPO - Associate Training Officer) supporting the evaluation of training effectiveness and USA B 2559 (CFE - Nuclear Instrumentation Training Expert).
3. **Industrial Safety:** The Department initiated this endeavour by conducting a training needs analysis. Looking forward, the next objective is to develop the curriculum, which may incorporate elements from existing commercial training resources and will integrate with the Training Programme. The support extended by the USSP has proven invaluable.
4. **Accountability in training:** Ensure timely visa decisions with a target of two weeks prior to the start of the training course; as a component of the Learning Management System (LMS), a process to monitor attendance and provide necessary statistics.
5. **New technology verification new technologies:** Training courses developed to address new verification technologies, such as the neXt generation Cerenkov Viewing Device (XCVD) or the Field Verifiable Passive Seal (FVPS) would require MSSP support.

In order to attain the outputs and achieve the outcome, the Agency needs continued MSSP support for the 95 active MSSP Tasks. This includes current CFEs and JPOs.

Support Required

- Continued access to nuclear facilities for in-person training.
- Continued provision of a CFE with proficiency in instructional design.
- Support to lead the Department's industrial safety training efforts, encompassing needs analysis and curriculum development.
- Continued support for the Department staff member training courses and associated expertise.

New outcome

Outcome #3: Enhanced engagement, knowledge dissemination, and skill augmentation.

Output	1. A custom Department Learning Management System (LMS).

Supporting Resource Mobilization Priorities

M.2.C1*	M.3.C1	M.3.C2

Support Needed

The Department is integrating its training processes into the IAEA-wide Oracle-based LMS, but certain technical limitations have impeded a seamless alignment with the Department's unique needs. To bridge this gap, the Department continues to refine and harmonize training processes to achieve proper recording and monitoring of Department staff member training.

This work has required migration of existing training data, development of specific workflows for selection of course participants, testing of functionalities, and development of training and documentation not provided by the supplier.

Goals

By the end of 2025, the Department plans to input training data into the LMS in order to eliminate the reliance on disparate systems, effectively centralizing the location of course access and enrolment. The Department has a reliable, granular reporting function available to analyse the effectiveness of the training programme. The Department uses the LMS to manage most training processes, particularly the nomination and selection of candidates for training courses.

Support needed

Approximately €125 000 for a one-year consultant engagement to help the Department optimize its use of the LMS, in particular, enhancing its reporting capabilities to have an efficient and meaningful data extraction method that would better inform decision making and automating the course nomination process within the LMS framework.

Continued outcome

Outcome #4: Increased knowledge of safeguards and aspects of the nuclear fuel cycle in Member States with limited or no nuclear fuel cycle technologies.

Outputs	1. Annual implementation of the Safeguards Traineeship Programme. 2. Implementation of the next IAEA Safeguards Mid-Career Leadership Programme.

Supporting Resource Mobilization Priorities

W.3.C2	S.1.C2	M.3.C2	M.3.C4

Support Needed

Continuing the Department's strategic pursuit, the Safeguards Traineeship Programme for Young Graduates and Junior Professionals remains a pillar. By equipping trainees with specialized knowledge in Safeguards implementation and fostering a comprehensive understanding of the peaceful applications of nuclear techniques, the Department empowers them to implement safeguards within their respective States.

Running for over 40 years, this programme is now conducted annually with a cohort of nine participants. The application process ensures a balanced representation of genders, fostering a diverse pool of talent that enriches the collective perspective. This expansion has incurred elevated costs, necessitated by factors such as stipends, travel expenses, and the rising cost of living. The programme continues to ensure a broad diversity of participants and the application process secured gender parity.

In 2022, the IAEA Safeguards Mid-Career Leadership Programme was introduced. This programme, available both in-person and online, empowers mid-career professionals from Member States with practical leadership acumen. The Department's practical approach provided the opportunity for these professionals to draft an SSAC plan to navigate complex challenges and foster effective leadership within their roles.

- With an estimated total cost of €550 000, of which €400 000 is requested from MSSP, to support critical aspects of the Traineeship Programme is requested. These funds will sustain

trainees' travel and sustenance, facilitate the comprehensive 6-week nuclear fuel cycle training, and the 4-week nuclear physics and nuclear fuel cycle curriculum at the Atominstitut in Vienna. Additionally, the Traineeship Coordinator, who is hired on a yearly basis to coordinate the programme, relies on this support to orchestrate seamless execution.

- Facility access, State experience, and training is essential to the programme and is currently provided by EC, HUN, CZ, and FIN SPs. More facilities would be a welcome form of support.
- The Department plans to host the "Introduction to IAEA and Safeguards" programme at the IAEA headquarters again after a successful 2022 iteration with 36 participants from 32 States who attended the 2-week training, sponsored jointly by the United States and European Union. This initiative, with the participation of the Director General, targets young professionals from States with nuclear programmes. The aim is to provide them with foundational insights, facilitated through a two-week training course. To realize this goal, the Department seeks funding ranging from €150 000 to €175 000.
- The IAEA plans to offer a Mid-Career Leadership Programme to professionals building on the 2022 offering to COMPASS Pilot States. An estimated budget of approximately €100 000 will be essential, contingent upon the final programme design.

Programme	Funding	In-kind
Traineeship	€400 000	In-kind support for facility and training.
Introduction to IAEA and Safeguards	€150 000–175 000	
Mid-Career Leadership Programme	€100 000 will be essential, contingent upon the final programme design.	In-kind support possible if offered jointly with a Member State.

SGIM-002: Acquisition and Analysis of Satellite Imagery and Geospatial Data

Established

2001

Manager	SGIM Director
Marc LAFITTE	Stephane BAUDE

Objective

Acquiring, processing, analysing, and exploiting satellite imagery and geospatial information to support nuclear verification activities.

Agency Programme and Budget Link

4.1.5.003 State infrastructure analysis

Plan Abbreviations

AI	Artificial Intelligence
AP	Additional Protocol
DL	Deep Learning
EO	Earth Observation
ESA	European Space Agency
GIS	Geographic Information System
HSI	Hyperspectral Imaging
ISI	State Infrastructure Analysis Section
LOF	Location Outside Facility
MWIR	Mid-Wave-Infrared
ML	Machine Learning
MS	Multi Spectral
PAN	Panchromatic
SAR	Synthetic Aperture Radar
SOM	Structured Observation Management
SWIR	Short-Wave Infrared
TIR	Thermal Infrared Imagery

Context Highlights

D&IS Plan Title Change

The D&IS Plan title has changed from "Satellite Imagery Analysis" to "Acquisition and Analysis of Satellite Imagery and Geospatial Data," a change that highlights the essence of activities in this domain.

Importance of Satellite Imagery Analysis to the Department

For over two decades, analysis derived from satellite imagery and geospatial data has given invaluable contributions to the enhancement, effectiveness, and efficacy of Safeguards implementation. Analysis and assessment derived from satellite imagery have become an essential component of "other relevant information," which strengthens the credibility of Safeguards conclusions and leads to better decision making when it comes to assessing the correctness and completeness of Member States' declarations. The experience gained by IAEA Safeguards experts throughout the years plus the continuous development in new space-borne sensors and remote sensing technologies (and techniques) have opened up new perspectives for the information analysis component of the strengthened Safeguards system.

A Growing Demand

The demand for satellite imagery analysis continues to significantly evolve and grow. As a result, the dissemination of geospatial information has also become essential for the Department and beyond regarding decision-making capacity, raising awareness, collaborative analysis, and in general, the synergy of Safeguards-relevant information.

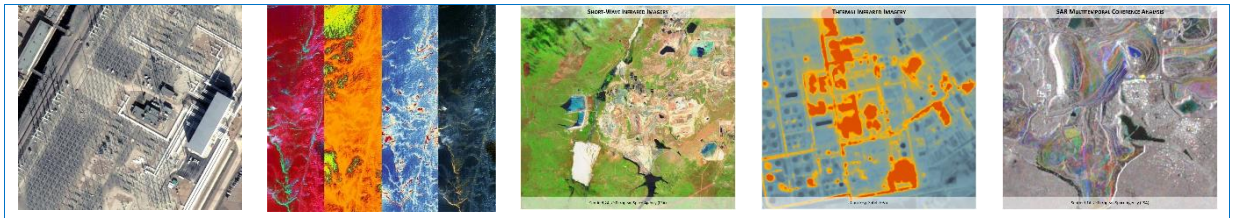
Advancements in Earth Observation Through New Sensor Technologies

With the development of small satellites and the arrival of new actors in the space launch business, Earth observation is growing and evolving at an exceptional pace. Hundreds of new sensors have been recently placed into orbit or are ready to be launched. These constellations of new sensors provide unprecedented new capabilities, in particular regarding spectral analysis (electro-magnetic spectrum) or temporal resolution. Spectral analysis is a promising source of information. New constellations of satellites include enhanced capabilities to acquire mid- to high-resolution Short-Wave Infrared (SWIR) or mid-resolution hyperspectral imagery (HSI). Heat release is one of the main characteristics (evidence) of industrial processes taking place (operation). For addressing this new imagery source, recently launched high-resolution mid-wave-infrared (MWIR) sensors will provide the Department with the unique ability to detect, measure, and assess heat release.

Figure 21: Modified Copernicus Sentinel-1 SWIR data, processed with Earth Observation (EO) Browser (13 Aug 2023) by European Union.

Enhancing Analyst Expertise for Advanced Sensor Utilization

Improvement of new sensors, and in particular of advanced spectral capabilities, requires extensive knowledge and expertise of IAEA Safeguards imagery analysts to effectively and expertly exploit all available imagery data. Maintaining and enhancing existing capabilities is crucial to exploiting new types of imagery. The analysis of imagery acquired by multiple sensors (spatial and/or spectral resolution) requires comprehensive image processing and imagery analysis knowledge and expertise.



Visible (Panchromatic (PAN) + Multi spectral (MS))	Hyperspectral (HSI)	Short-Wave Infrared (SWIR)	Mid-Wave Infrared (MWIR)	Synthetic Aperture Radar (SAR)

Figure 22: Five different types of remote sensing technologies and data used in satellite imagery analysis.

Challenges

Current and upcoming challenges are mainly related to the availability of very large volumes of satellite imagery. The significant growth of satellite imagery analysis requests in support of the State Evaluation process and the more complex nature of these requests necessitates the development of artificial intelligence (AI). More specifically, machine learning (ML) and deep learning (DL) techniques are required to support satellite imagery collection, processing, analysis, and dissemination to enhance analytical assessments and multimodal data discovery. A robust IT infrastructure and human resources (recruitment of highly skilled experts, business continuity versus the IAEA rotation-policy) are critical to exploit and assess information derived from satellite imagery and geospatial data and to cope with analytical requests for at least 189 States and more than 1 353 nuclear sites, facilities, and locations outside facilities (LOFs) under Safeguards[2].

[2] Find the IAEA Safeguards in 2022: Verifying the peaceful use of nuclear material infographic, the source for these figures.

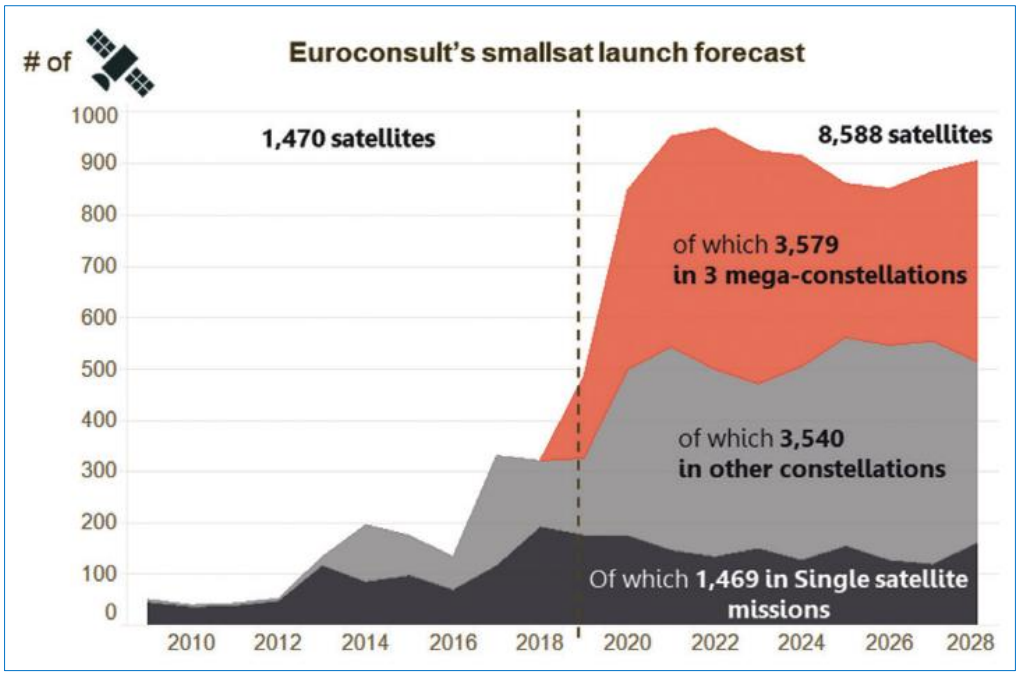


Figure 23: Smallest Launch Forecast until 2028. Source: Euroconsult's Prospects for the Small Satellite Market, 5th Edition.

Guiding Principles and Objectives for 2024–2025

It is important to acknowledge the principles that have defined the Department's path in using satellite imagery. These consistent principles encompass the Department's commitment to enhance safeguards, embrace innovation, and cultivate expertise over the past 20+ years. In addition, it continues to shape the Department's approach as it adapts to the evolving landscape of Earth observation (EO).

The extrabudgetary needs for 2024–2025 can be categorized into three key outcomes:

- Front-end (Acquisition and Pre-processing)
- Analysis
- Back-end (Dissemination and Integration)

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☐ Equipment	☒ Training
☐ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☐ Studies
☒ Financial Support for Travel	☒ JPOs	☐ R&D	
☒ Expert meeting participation		☒ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

M.3.C2	Ability to enhance managerial decision-making processes, capabilities and competencies
S.1.C1	Ability to deploy data visualization and other methods and techniques to present safeguards findings and performance-related data in a clear and compelling manner
T.6.C3	Ability to leverage new types of space-borne sensor data from open sources, including the processing of synthetic aperture radar data, analysis of multi/hyperspectral data, thermal imagery
V.1.C2*	Ability to receive/collect, process, analyze and evaluate all safeguards-relevant information efficiently and effectively through innovation, integration, and governance
V.1.C4*	Ability to leverage emerging technologies, such as artificial intelligence and machine-learning, for exploiting large volumes of safeguards-relevant data to enhance prioritization, change detection and consistency verification
V.1.C5*	Ability to enhance the sharing, aggregation, visualization and analysis of geo-based information (e.g., verification data, satellite imagery)

W.3.C2 Ability to further develop the expertise of the Department of Safeguards' workforce and train the next generation of safeguards experts

W.3.C4 Ability to effectively utilize knowledge and expertise already existing with the Department

W.3.C4 Ability to effectively utilize knowledge and expertise already existing with the Department

W.3.C5 Ability to preserve and disseminate critical organizational knowledge to overcome staff turn-over and other associated challenges

New Plan for 2024–2025

★ Indicates top priority

New outcome

Outcome #1: Enhanced data acquisition, improved data pre-processing, and enabled early warning/indicators, ultimately making processes more efficient and reliable.

Outputs	1. Broader, diversified (objectivity, independence, and availability), and easier access to all relevant commercial satellite imagery with different characteristics (spatial, spectral, and temporal). 2. ★ Enhance pixel consistency processing (analysis ready data) and geo-visualisation accuracy to enable further implementation of machine learning (ML) algorithms. 3. Implementation of new technologies (e.g., automatic data selection and ordering by using APIs) to support the selection and prioritization of the most relevant imagery (big data). 4. Enforcement of data quality (accuracy and reliability) and improvement of procedures for data acquisition and quality control processes. 5. Implementation of new technologies (e.g., ML) to support SMEs with indicators of activities and infrastructure changes, i.e., primarily using automatic change detection algorithms.

Supporting Resource Mobilization Priorities

T.6.C3	V.1.C2*	V.1.C4*	V.1.C5*

Support Needed

The number and capabilities of Earth observation (EO) satellites have steadily increased over the past two to three decades. Presently, EO activities are primarily motivated by the desire for a deeper understanding of the planet and its environment, as well as the necessity for global situational awareness to inform decision making.

Recent advances in sensors, techniques, and applications offer substantial potential to enhance the Department's current capabilities. However, the Department's capacity to explore, develop, and implement these new technologies is constrained by limited resources and a high volume of imagery analysis requests. To address these limitations, the Department seeks support from MSSPs, which could encompass the following:

Financial Support: | Travels: | Reference Materials: | Training: | Consultants-CFE/JPO: | Equipment | R&D | Facility Access | Studies

- Providing access to specific datasets (imagery, maps, vectors).
- Facilitating cooperation on innovative topics and novel technologies, in particular satellite imagery-related ML or computer vision techniques.
- Providing technical expertise and supporting the development of a platform to aggregate the discovery (search and query) across a broad range of suppliers' archive catalogues.
- Developing ML, deep learning (DL), and computer vision-associated technologies to analyse annual infrastructural changes at nuclear-related facilities (with primary emphasis on Additional Protocol (AP)-declared facilities) and detect inconsistencies with AP declarations (text and site plans) to improve AP verification processes (in coordination with D&IS Plan SGIM-010 (Artificial Intelligence/Machine Learning for Information Analysis).

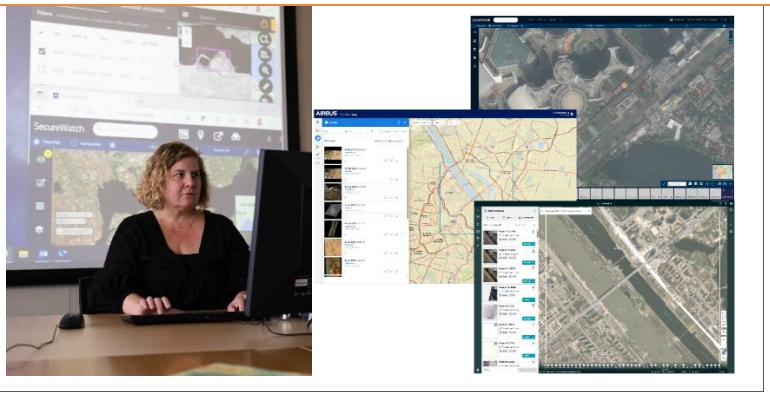


Figure 24: A Satellite Imagery Analyst navigating image catalogues for in-depth analysis.

SATELLITES	EGEOS	KONGSBERG	
AIRBUS	ALOS-2	Aleph-1 (Satellogic)	Sentinel 1A/B
Pleiades 1A, B	ALOS-3	ALOS AVNIR	Sentinel 2A/B
Pleiades NEO	Beijing 3 (constellation)	ALOS-PRISM	Sentinel 3A/B
SPOT 6, 7	CBERS-04	ALOS-2	Sentinel 5P
TerraSAR-X/TanDEM-X/PAZ	COSMO-SkyMed	ASTER	CNES
Aisat-1b	COSMO-SkyMed NG	DEIMOS-2	SPOT 1-4
KazSTSAT (DMC)	EROS-B	EROS-B	SPOT 5
Vision 1 Satellite (Satellite S1-	EROS-C	Gaofen-1	PLANET.
BLACKSKY	GAOFEN 1/6	Gaofen-2	PlanetScope (Dove)
Pathfinder	GAOFEN-2	Gaofen-3	PlanetScope (SuperDove)
Global (Gen-2)	GAOFEN-3	GaoFen-6	RapidEye
Next Gen (Gen 3)	Gaofen-7	Jilin-03 "Gaofen" 03B-1,2,3,4,5	
MAXAR	Gaofen-7-02	GHGSat	
IKONOS	SAOCOM	Hyperion	
QuickBird	SuperView1/2 (GaoJing-1)	ICEYE	Skysat-1-21
WorldView-1	TeLEOS-1	Jilin	
WorldView-2	TRIPLESAT 1-4	Jilin-1 / GP01/02	
GeoEye-1	EUSI	Jilin-1 "Gaofen"02A/02B	
WorldView-3	Albedo	Jilin-1 "Gaofen" 03A	SPACEWILL
WorldView-4	Satellogic Aleph (ÑuSat)	Jilin-1/J1GXA	CBERS-04
WorldView Legion	GAF	Jilin-1KF01B " Nei Mongol-1	Gaofen-1
CAPELLA SPACE	Cartosat-1	Jilin-1 "Shipin"-3/4/5/6/7/8	Gaofen-2
Capella-2		Jilin-1 "Gaofen" 03C-GF01/03	Gaofen-3
Capella-3 + Capella-4	Cartosat-2E	Jilin-1 "Shipin"-SP03/08	GaoFen-6
Capella-6		KOMPSAT-2	Gaofen-7 (GF-7)
Capella-5		KOMPSAT-3	Gaofen-7-02
Capella-7 + Capella-8	Cartosat-3	KOMPSAT-3A	Geneo
CLOUDFERRO	GEOSAT	PRISMA	GF-5
Jilin	DEIMOS 2	PROBA CHRIS	Mantis
KazEOSat	DEIMOS 1	RADARSAT-2	Phisat2
KOMPSAT-5		RapidEye	SuperView1/2
S2GL	USGS	SuperView1/2	Ziyuan-3/ ZY-3 and ZY-3-02
SMSOS	Landsat-4/5	SuperView3/4	Ziyuan-1/ ZY1-02
	Landsat-7	Vision-1	
	Landsat-8		

Figure 25: IAEA's satellite imagery access portfolio.

Modified outcome

Outcome #2: Stronger satellite imagery and geospatial analysis capabilities; enhanced skills and knowledge to deliver more effective and comprehensive assessments.

Outputs

1. ★Maintained awareness and understanding of cutting edge satellite imagery and geospatial analysis technologies, methodologies, and applications.
2. ★ Stronger analyst skills to improve analytical capabilities.
3. ★ Sustained and enhanced understanding of NFC signatures and the associated key indicators for the analysis of all types of satellite imagery.
4. A most effective contribution of satellite imagery, remote-sensing, and geospatial analysis techniques and technologies to Safeguards implementation.
5. ★ More systematic integration of in-depth spectral analytics derived from Short-Wave Infrared (SWIR), Mid-Wave Infrared (MWIR), Synthetic Aperture Radar (SAR), Multi Spectral (MS), and Hyperspectral Imaging (HSI) satellite imagery into analytical products.

Supporting Resource Mobilization Priorities

W.3.C2	W.3.C4

Support Needed

The number and capabilities of Earth Observation (EO) satellites have steadily increased over the past two to three decades. It is essential for the Department's imagery and geospatial analysts to receive regular training. These training courses permit them to understand and effectively utilize

the features of new sensors, techniques, and applications. It also enables them to integrate these new techniques and developments into their daily satellite imagery analysis work.

In the present landscape, proficiency in various advanced skills, including programming, geospatial technologies, and processing of infrared and SAR data, is necessary to ensure the proficient exploitation of satellite imagery. This expertise is critical for delivering accurate and comprehensive analytical assessments across the Department.

Upholding and strengthening Department SME skills and knowledge is of utmost importance. Historically, the Department has sought support from MSSPs in the following areas:

Financial Support: | Travels: | Reference Materials: | Training: | Consultants-CFE/JPO: | Equipment | R&D | Facility Access | Studies

- Employing personnel with strong technical backgrounds and experience in satellite imagery analysis of nuclear infrastructures and geospatial analysis.
- Delivering and facilitating specific training courses (remote sensing, Geographic Information System (GIS), image processing, Python, Elastic, etc.) or supporting the organization of ad-hoc workshops/technical meetings.
- Training on SWIR, MWIR, Thermal Infrared Imagery (TIR), and SAR imagery and analysis techniques.
- Sharing access to HSI libraries (nuclear-related features).
- Facilitating onsite familiarization visits to nuclear fuel cycle-related sites (mines including in situ leaching, conversion, enrichment, reactors of different types, heavy water production plants, spent fuel, waste storage, phosphate processing plants, etc.), nuclear-powered naval vessels, and supporting facilities.
- Gaining knowledge from international SMEs in the realms of remote sensing imagery techniques, artificial intelligence (AI) applied to satellite imagery, geospatial analysis, data management, etc.
- Supporting attendance at international conferences and seminars.
- Offering or strengthening cooperation/partnerships with national laboratories or universities.
- Developing and implementing a system for structured observation management (SOM).

Figure 26: A Satellite Imagery Analyst pointing to foundation data (geospatial data).

- Contributing to the enhancement of current foundational data schema, optimizing workflows and processes, and developing ad-hoc tools for data quality performance and associated governance.

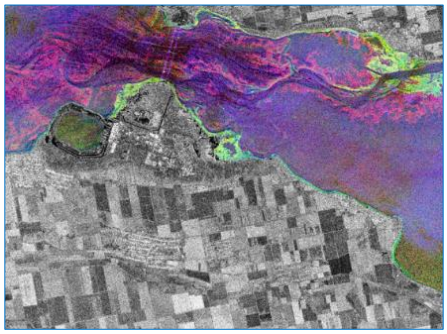


Figure 27: Coherence Change Detection – Sentinel-1 – European Space Agency (ESA) (July 2023).

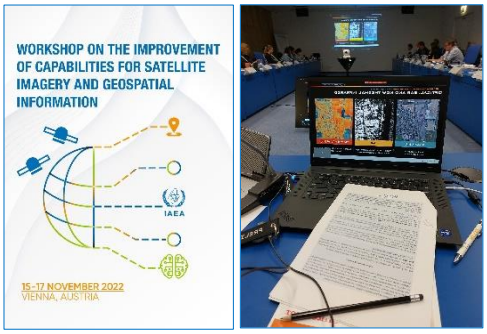


Figure 28: 2022 Workshop organized by the Department's State Infrastructure Analysis Section.

Modified outcome

Outcome #3: Enhanced dissemination and sharing of geospatial information for improved knowledge building, collaboration, and understanding.

Outputs

1. ★ Enhance the capture of Safeguards-relevant geospatial information from satellite imagery (structured observation management (SOM)) and the retention of historical knowledge (infrastructure changes).
2. ★ Boost the synergy and dissemination of geospatial data, including satellite imagery and geospatial analysis.
3. Enhance IT infrastructure to cope with the growing volume of data.

Supporting Resource Mobilization Priorities

W.3.C4	W.3.C5	S.1.C1	V.1.C2*	M.3.C2

Support Needed

Access to information has become critical, while the contribution of geospatial information to Safeguards implementation, including the drawing of Safeguards conclusions, has grown significantly. Today, there is a need to optimize and structure the capture of satellite imagery observations (key features) and in particular infrastructure changes from satellite imagery and to explore interactive or dynamic ways to disseminate the information. Specific tools (e.g., Geographic Information Systems (GIS)) enable the circulation, but also the management and synergy of the information to strengthen collaborative analysis capabilities and contribute to the drawing of Safeguards conclusions by:

Financial Support: | Travels: | Reference Materials: | Training: | Consultants-CFE/JPO: | Equipment | R&D | Facility Access | Studies

- Supporting the development of web-based geospatial software and applications based on geospatial cutting-edge technologies (servers) including Esri, Elastic, etc.
- Supporting the development and implementation of a geospatial collaborative platform offering the capability to ingest, manage, discover, and display (or view) all types of geospatial and Safeguards-relevant information (including satellite imagery and facility site plans).
- Enhancing cooperation with other areas of competence across the Department in terms of data exchange and provision of GIS support.
- Acquiring more computational power in order to enhance image processing capabilities.
- Enhancing geospatial capabilities to improve data management, data standardization, enterprise GIS, and data dissemination.
- Enhancing computational capabilities (software, hardware, and automatization) to enable security standards, updated IT infrastructure to assure compatibility with IAEA requirements, speedup or replacement of manual processes by using adequate scripts, and dedicated artificial intelligence/machines learning (AI/ML), and computational power by maintaining and upgrading system and server capabilities.

Figure 29: Increasing computational capabilities for the Department's State Infrastructure Analysis Section (ISI) with additional servers.

SGIM-003: Open Source Information Collection and Analysis

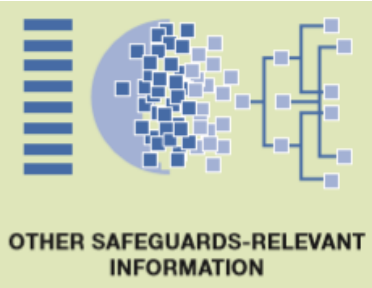
Established

2001

Manager	SGIM Director
Woan Jin KIM	Stephane BAUDE

Objective

Collecting, analysing, and integrating information from disparate sources to detect possible inconsistencies in States' declarations.



Agency Programme and Budget Link

4.1.5.004 Information collection and analysis

Plan Abbreviations

APA	Acquisition Path Analysis
CFE	Cost Free Expert
SGIM-ISF	Division of Information Management - State Factor Analysis Section
JPO	Junior Professional Officer
NFC	Nuclear Fuel Cycle
OSIS	Open Source Information System
OSIS-ST	Open Source Information System - Science & Technology
SLA	State Level Approach

Context Highlights

D&IS Plan Title Change

The D&IS Plan title has changed from "Information Analysis" to "Open Source Information Collection and Analysis," a change that highlights the essence of activities in this domain.

Role and Significance of Open Source Information Collection and Analysis to Safeguards

The State Factor Analysis Section (ISF) is responsible for the collection, validation, evaluation, analysis, and dissemination of Safeguards-relevant open source information for the Department. This happens daily as an essential component of performing continuous State Evaluation and supporting Safeguards implementation.

The range of analytical products and technical support provided by SGIM-ISF for State Evaluation Groups is a key input to all four fundamental processes of the Department:

1. Collection and evaluation of all safeguards-relevant information;
2. Development of a safeguards approach for a State;
3. Planning, conduct and evaluation of safeguards activities; and
4. Drawing of safeguards conclusions.

The key focus continues to be the assessment of the completeness and correctness of State Declarations in order to identify possible undeclared nuclear material and activities.

It is also critical that the risk to proliferation coming from the advances in technology and accelerated availability of knowledge through globalisation be addressed effectively. SGIM-ISF analysis assists the Department in maintaining an ongoing awareness of global safeguards and non-proliferation developments and in the timely identification of issues.

One of the examples that reaches all Department staff members and senior management is the daily *Open Source Highlights* newsletters bringing the most Safeguards-relevant news and international developments in the nuclear fuel cycle (NFC) and related technology.

Figure 30: The SGIM Open Source Highlights is delivered to Department staff members and senior management inboxes each working day.

Efficient and Effective Information Collection and Analysis

With the volume and variety of available Safeguards-relevant information continuing to increase, the strategy for SGIM-ISF is focused around the identification, implementation, and use of the most updated data collection, validation, and information analysis methodologies, techniques and tools. This ensures that the information is maintained and utilized transparently and consistently. The continued development and introduction of new methods, processes, and tools is a priority area.

Acquisition Path Analysis (APA) and Development of the State-level Approach (SLA)

The use of APA and the development of the SLA within the Department has brought an increased demand for and focus on the contribution of analytical activities at IAEA headquarters.

In order to support the non-discriminatory and transparent assessment of all State-specific factors that are considered in the APA and the development of State-level approaches, it is crucial to implement well-developed analytical processes and information management strategies.

SGIM-ISF is responsible for the production and development of analytical products to support the conduct of APA, development of SLA, and contributes to the evaluation of States' compliance in a non-discriminatory manner. These products are designed to provide factual and consistent assessment of all State-specific factors including States' NFC and related technical capabilities.

Importance of Extrabudgetary Support to Information Analysis and Management

Drawing Safeguards conclusions at the State-level through the analysis of all Safeguards-relevant information requires constant improvement to the analytical processes and tools, and the maintenance and development of Department staff members' knowledge and expertise.

SGIM-ISF has benefitted extensively from the support of MSSPs in the past, and the need for continued extrabudgetary support is now more important than ever.

Support continues to be required in a variety of areas, including funding to allow access to new streams of Safeguards-relevant information, assistance in the development of new methodologies for information collection and analysis, staff training, and the ongoing provision of human resources in the form of CFEs, JPOs, and ad hoc specialised technical consultancies.

Most Needed Extrabudgetary Support in 2024–2025

☒ Financial Support	☒ Consultants	☐ Equipment	☒ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☒ Financial Support for Travel	☒ JPOs	☒ R&D	
☐ Expert meeting participation		☒ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

S.1.C1 Ability to deploy data visualization and other methods and techniques to present safeguards findings and performance-related data in a clear and compelling manner

V.1.C2* Ability to receive/collect, process, analyze and evaluate all safeguards-relevant information efficiently and effectively through innovation, integration, and governance

V.1.C3 Ability to efficiently process and interpret multi-lingual safeguards-relevant information, including within the Agency's secure air-gapped network

V.1.C4* Ability to leverage emerging technologies, such as artificial intelligence and machine-learning, for exploiting large volumes of safeguards-relevant data to enhance prioritization, change detection and consistency verification

V.1.C7 Ability to effectively maintain situational awareness of safeguards-relevant nuclear trade activities and developments

V.4.C3 Ability to better measure and analyse safeguards performance (of the Department and the safeguards system more broadly) through use of analytical and IT tools, including data visualization

W.3.C2 Ability to further develop the expertise of the Safeguards Department's workforce and train the next generation of safeguards experts

W.3.C4 Ability to effectively utilize knowledge and expertise already existing with the Department

New Plan for 2024–2025

★ Indicates top priority

The four areas listed below all bear the same level of high priority. An overall strengthening of the effectiveness and efficiency of open source information collection, analysis, and management can only be realised if all elements of the plan progress in parallel.

Modified outcome

Outcome #1: Maintain sufficient resources to support the collection and analysis of available Safeguards-relevant open source information.

Outputs	1. Timely conduct of daily information collection and analysis and delivery of analytical products. 2. Timely provision of scientific and technical expertise and analytical products. 3. Evaluation of nuclear fuel cycle (NFC) modelling codes.

Supporting Resource Mobilization Priorities	
V.1.C2*	W.3.C2

Support Needed

CFEs and JPOs

The continued support of MSSPs in the provision of CFEs and JPOs form an essential part of the State Factor Analysis Section's (SGIM-ISF) ongoing strategy to maintain and expand its skills and competence base.

SGIM-ISF benefits from the provision of a number of CFEs and JPOs through MSSP Tasks currently sponsored primarily by FRA, ROK, and US SPs. Their provision brings skills or expertise in open source analysis, specific areas of NFC-related science and technology, along with nuclear trade, procurement and regulatory expertise, often with the bonus of additional languages capabilities.

The placement of JPOs within the SGIM-ISF also has positive benefits for MSSPs and the Department as a whole, since it provides a mechanism to train and provide experience to the next generation of safeguards professionals.

Technical Support and Consultancies

Given the breadth of scientific and technical disciplines covered by the NFC, SGIM-ISF has the constant work of maintaining its expertise across all these areas. SGIM-ISF recognises the importance of the support it currently receives from MSSPs. Such support can be provided in a number of ways, for example:

- **Technical Consultancies:** Inputs from technical specialists and consultants continues to play a significant role in enhancing the Department's ability to carry out technical analysis to support the evaluation of specific NFC and related technology areas. It is important that future support will increase and build on that support currently provided through MSSP Tasks USA D 1126 (Consultant - Assistance on Information Collection and Information Systems) and UK D 1819 (Nuclear Fuel Cycle Specialist Assistance).
- **Fuel Cycle Modelling Codes:** SGIM-ISF plans to trial the use of NFC modelling codes. Initial plans involve support under MSSP Task UK D 1819 (Nuclear Fuel Cycle Specialist Assistance) for the use of ORION, a systems dynamics fuel cycle code developed and maintained by the National Nuclear Laboratory in the United Kingdom. Addressing such needs will be closely coordinated, inter alia, with D&IS Plan SGIM-007 (Evaluation of Data from Environmental Sampling and Material Characterisation).

Modified outcome

Outcome #2: Expansion of the number and diversity of sources of Safeguards-relevant open source information.

Outputs	1. Continued provision of consolidated and translated collections of Safeguards-relevant information not published in English. 2. Identification and acquisition of new sources and streams of Safeguards-relevant information. 3. New sources of open source information available through paid subscription services and databases.

Supporting Resource Mobilization Priorities

V.1.C2*	V.1.C3	V.1.C7

Support Needed

Information Collection from Sources not Published in the English Language

The increased access to regional and State-specific, Safeguards-relevant open source information brings the challenge of identifying and translating information that is not published in English.

Future support is sought to expand the diversity of non-English streams of open source information. This can be achieved through the provision of support in one or more aspects of the collection and translation of Safeguards-relevant open source information.

The State Factor Analysis Section (SGIM-ISF) already greatly benefits from support to this activity, namely under MSSP Tasks UK D 1728 (Regional Information Collection Centre-East Asia) and UK D 1730 (Regional Information Collection Centres), HUN D 1919 (Collection and Analysis of Nuclear Trade Related Information to Strengthen Safeguards), JPN D 1733 (Provision of Open Source Information), ROK D 1213 (Provision of Open Source Information), and UK D 1916 (Improving the Analysis of Trade Data for Safeguards Relevant Proliferation Activities).

Identification and Acquisition of New Sources and Streams of Safeguards-relevant Information

SGIM-ISF makes continuous efforts to identify new potential sources of information and will transmit new MSSP Task Proposals at the appropriate time. In addition, support is welcomed in the form of suggestions from MSSPs for the provision of potentially relevant new sources.

Purchased Subscription Services

SGIM-ISF seeks to ensure the broadest possible set of Safeguards-relevant open source information to support the State Evaluation Process. Therefore, SGIM-ISF continues to request funding to secure access to paid subscription databases and publications. Such support will continue to be essential in 2024–2025.

A number of sources of global news coverage, trade and procurement data, as well as science and technology publications have been previously identified and support for their procurement is currently provided through MSSP Tasks EC D 1662 (Improving Analysis of Nuclear Trade-Related Information) and ROK D 2717, SWE D 2681, UK D 2666, and USA D 2606 (Transactional Trade Data and Open Source Data for Enhanced State Evaluation).

In 2024–2025, in addition to a continuation of current support, further assistance is sought to expand access to additional paid subscription services and databases.

Modified outcome

Outcome #3: Enhanced competence and capabilities of Safeguards Information Analysts.

Outputs	1. Bespoke training courses and workshops designed to support information analysts in maintaining and gaining relevant skillsets and capabilities for the analysis of Safeguards-relevant open source information. 2. Technical visits and seminars designed to increase the knowledge and first-hand experience of IAEA Safeguards information analysts of specific nuclear fuel cycle (NFC) facilities, and nuclear related technology/industry. 3. Participation at relevant technical meetings, conferences, and events.

Supporting Resource Mobilization Priorities

V.1.C2*	W.3.C2	W.3.C4

Support Needed

Due to the technical and specialised nature of the analytical work carried out in SGIM-ISF, there is a strong need for the development of customized learning and development opportunities for the Section's analysts.

Dedicated Analytical Skills Training and Workshops for Analysts

Support is required from MSSPs in identifying, designing, conducting, and/or funding specialized training events focused on the latest open source information collection and analysis tools and techniques. Where appropriate, work will be carried out in conjunction with the Section for Safeguards Training.

Support is requested from MSSPs where suitable training courses and services are identified as already being available from, or could be developed in conjunction with external suppliers.

Dedicated Technical Visits and Seminars for Analysts

MSSPs will be requested to support increased technical training and familiarisation for SGIM-ISF staff in specific areas of the NFC and supporting infrastructure. This may be through organized technical visits to facilities or locations or through the organisation of bespoke technical seminars and events either at IAEA headquarters or elsewhere.

For example, training through MSSP Task GER B 1560 (Nuclear Trade Analysis Related Support and Training for Trade and Technology Analysis Unit) has proven effective in raising the competence levels of SGIM-ISF analysts and Department staff members from other Divisions.

Participation in Technical Meetings, Conferences, and Events

Attendance at selected technical meetings, conferences, and events bring many positive benefits including the development and awareness of Department staff members with latest developments in areas such as nuclear nonproliferation, the NFC, and aspects of nuclear trade and procurement. Such events also provide useful and valuable sources of Safeguards-relevant information.

SGIM-ISF will assess which events where attendance by Department staff members would bring positive benefits and make appropriate proposals to MSSPs for financial support.

Modified outcome

Outcome #4: Enhanced capabilities to address challenges in information management through the development of optimized processes, methodologies, and tools.

Outputs	1. Improved capability in the automated identification and collection of Safeguards-relevant open source information from online data sources including data from disparate sources such as social media and network. 2. Enhancement to the processing, analysis, and management of Safeguards-relevant open source information including knowledge management. 3. Development of an analytical environment for the integration and analysis of information from multiple data sources, and the reporting and management of analytical results and products. 4. Assessment of advanced analytical methodology, techniques, and tools for different types and sources of open source information, including global trade data and science and technology publications.

Supporting Resource Mobilization Priorities

S.1.C1	V.1.C2*	V.1.C3	V.1.C4*	V.D.C3	W.3.C4

Support Needed

SGIM-ISF has driven the development of its core open source collection and processing systems—the Open Source Information System (OSIS) and the Open Source Information System - Science & Technology (OSIS-ST)—based on over 30 years of experience in open source information collection and analysis. OSIS and OSIS-ST automate the collection of Safeguards-relevant open source information and support validation processes, increasing transparency in the analytical process. The collection provides basis for the information analysis required by the Department's core processes including State evaluation and development of SLAs.

Enhancement to Current Tools and Evalution of New Methodologies, Techniques and Tools

SGIM-ISF needs to continue to assess, and implement where appropriate, enhancements to its existing processes, methodologies, tools, and methodologies for collecting, processing, and managing Safeguards-relevant open source information. In addition, it is important to identify new tools and techniques that can support other aspects of information management including supporting analysis with the establishment of an analytical environment compliant with needs of the Department including consistency analysis (core component of the State Evaluation) and knowledge management such as structured knowledge retention in spite of Department staff member rotation.

Support from MSSPs is sought in the provision of assistance in enhancing existing tools and evaluating new tools and techniques that could directly support all aspects of information management. For instance, the existing tools (e.g., OSIS) will need to be extended and updated to address the continuing challenge of globalization (e.g., Nuclear Trade Data) and improve the use of open source by other areas of competence (e.g., geospatial information, in coordination with D&IS Plan SGIM-002 (Acquisition and Analysis of Satellite Imagery and Geospatial Data).

Future effort includes the examination and investigation of new methodologies that assist with the collection and analysis of large, disparate datasets, including social media and networks. There is a need to assess the overall usefulness of such information as part of the Safeguards analytical process and identify the particular cases where the use of such data can provide positive benefits.

Where applicable, these efforts will be closely linked with MSSP support being requested under D&IS Plan SGIM-010 (Artificial Intelligence/Machine Learning for Information Analysis).

SGIM-007: Evaluation of Data from Environmental Sampling and Material Characterisation

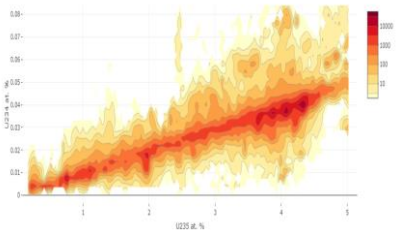
Established

2008

Manager	SGIM Director
Mika NIKKINEN	Stephane BAUDE

Objective

Evaluating environmental sampling (ES) and material characterisation data to detect undeclared nuclear material and activities.



Agency Programme and Budget Link

4.1.5.002 Nuclear fuel cycle information analysis

Plan Abbreviations

ES	environmental sampling
ESDB	Environmental Sampling Database
ESEE	Environmental Sampling Environment Enhancement
NWAL	Network of Analytical Laboratories

Context Highlights

Background: Environmental Sampling in Safeguards Verification

Environmental sampling has been a core part of Safeguards verification for 30 years. The Department has amassed a substantial knowledge repository for evaluation purposes that is used daily for contributing to Safeguards conclusions. A central part of the knowledge base is the Environmental Sampling Database (ESDB), which hosts extensive data collected throughout the years of environmental sampling (ES) implementation in a structured and easily accessible manner.

Environmental Sampling Environment Enhancement (ESEE) Project Update and Goals

In the realm of environmental data management, the ESEE Project stands as the most important and urgent need—an enduring, long-term initiative that requires crucial support for its sustained success.

The Environmental Sampling (ES) Evaluation Environment is designed for assessing and analysing environmental samples that IAEA Safeguards inspectors take in the field. Its primary objective is to evaluate and acquire data from a variety of environmental samples. Tasked with the comprehensive management and processing of data pertaining to environmental samples, this environment plays a pivotal role in ensuring the precision and effectiveness of the evaluation process.

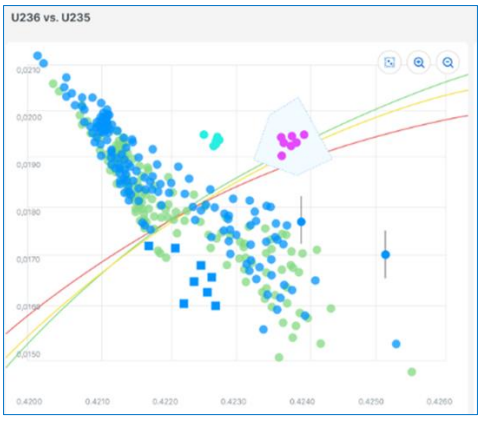


Figure 31: An ESEE Sneak Peek: Enhanced plotting capabilities for ES evaluations.

The ESEE Project's objective is to enhance the ES Environment, presently dependent on outdated Oracle technology. The existing system's limitations in supporting advanced analytical methods result in a labor-intensive reporting procedure. This necessitates a shift to a new platform, the incorporation of nuclear data modeling tools, and adherence to current Safeguards IT standards.

The Department launched the ESEE Project in 2022–2023 as an initiative to re-engineer the core data repository, implement report generation workflows, and ensure the adaptability of ES data management tools, with a focus on using MS SQL Server and the .NET framework for long-term sustainability.

The primary objective in 2024–2025 is to successfully complete the new ES evaluation platform—ESEE—which is essential to managing the growing sample volume and rapidly drawing conclusions for facilities with complex nuclear fuel cycles.

The invaluable support received from MSSP extrabudgetary funding for the ESEE Project has been pivotal in advancing this work. Additionally, resources in the form of JPOs (MSSP Tasks USA D 2580 and USA D 2328: JPO - Associate Data Evaluation Officers) have played a crucial role in business process mapping and software testing. Therefore, the possibility of having JPOs and/or CFEs to continue to support this endeavour would be greatly appreciated.

Enhancing the Department's Understanding of Nuclear Material Behavior and the ES Data Analysis

Understanding the behaviour of nuclear materials and impurities in different nuclear processes, such as irradiation, reprocessing, and enrichment is crucial when examining traces found in environmental samples. The Department would greatly value improvements to its nuclear fuel burn-up library and the development of more comprehensive models to illustrate the behaviour of Uranium isotopes in the enrichment process. Additionally, there is a need for enhanced data mining techniques to identify similar findings within the ES data. The exploration of new approaches that aid evaluators in these areas is highly sought after.

Most Needed External Support in 2024–2025

☐ Financial Support	☐ Consultants	☐ Equipment	☐ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☐ Studies
☐ Financial Support for Travel	☒ JPOs	☒ R&D	
☒ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

V.1.C1 Ability to synthesize and evaluate disparate sets of verification data from the field through data analysis methods and tools

T.2.C6 Ability to maintain and further enhance the environmental sampling database and the process models, databases, and tools that support trace elements analysis (material characterisation)

New Plan for 2024–2025

★ Indicates top priority

♻ Continued outcome

★ Outcome #1: Enhanced environmental sampling (ES) evaluation environment.

Outputs

1. An available Environmental Sampling Environment Enhancement (ESEE) toolbox with data evaluation, reporting, and integration of some nuclear modelling tools.
2. A more efficient ES evaluation process, resulting in a measurable reduction in evaluation time, which will allow the Department to keep evaluation times below 30 days despite the increasing number of samples.
3. Consistent completion of ES reports without the need for excess manual work.

Supporting Resource Mobilization Priorities

V.1.C1	T.2.C6

Support Needed

To ensure the success of the ESEE project, which represents a significant overhaul of environmental sample evaluation in 25 years, the Department anticipates the need for support from MSSPs. This support could encompass various aspects:

1. **Human Resources:** Involving JPOs and CFEs significantly enhances the Department's capabilities. These highly-skilled professionals actively contribute to both the development and testing phases of the project, ensuring that the new ES evaluation platform meets the highest standards in terms of quality and functionality. However, at this moment, the

Department is facing challenges in securing a CFE - Safeguards Information Analyst (Environmental Sampling) (MSSP Task Proposal 21/IFC-004). Without additional professional human resources, the Department may regrettably need to delay certain crucial work for Safeguards verification due to higher-priority requests. Furthermore, given the current workload relative to the available human resources, the professionals in the Section have very limited time to allocate to the development of state-of-the-art statistical analysis tools. Such tools are essential to align with evolving Safeguards concepts and to enhance both the Section's efficiency and the Department's capabilities for detection. The Department kindly seeks understanding and assistance in addressing these resource constraints, as it is committed to continuously improving its processes. MSSP support in this regard would be highly valued.

2. **Financial Support:** Given the scope and scale of the project, substantial extrabudgetary funding from MSSPs is paramount to cover the costs associated with software development, infrastructure enhancement, and the procurement of necessary tools and technologies. This financial support will play a pivotal role in the successful implementation of the project.
3. **Technical Expertise:** MSSPs can provide technical expertise via SMEs who can offer insights and guidance on the project's technical aspects. Their knowledge and experience will be instrumental in overcoming challenges and optimizing the project's outcomes.

This collaborative effort will contribute to the successful implementation of the project and the continued effectiveness of Safeguards verification processes.

New outcome

Outcome #2: Updated nuclear fuel cycle analysis tools and results.

Outputs	1. An environmental sampling (ES) nuclear model library completed with various new spent fuels, target irradiations, and Uranium enrichment cases. 2. Tools for nuclear fuel irradiation and enrichment that are regularly updated and maintained as new versions become available. 3. ES evaluators trained on the newly-developed tools that are accessible through Environmental Sampling Environment Enhancement (ESEE) to improve evaluation efficiency.

Supporting Resource Mobilization Priorities	
V.1.C1	T.2.C6

Support Needed

To achieve this outcome, the Department needs MSSP support to provide and/or run the models, provide new versions of modelling tools, and provide training of Department staff members to use the data and tools.

Enhanced ES Nuclear Model Library: In order to expand the ES nuclear model library and gather data on various types of spent fuel, on target irradiations, and on Uranium enrichment cases, the Department requires substantial MSSP support. This support could include the provision and integration of new data, the development of models, and the regular update of existing information to ensure the library remains current.

Regular Updates for Fuel Irradiation and Enrichment Tools: To keep nuclear fuel irradiation and Uranium enrichment tools current and effective, continuous support from MSSPs is essential. This includes the provision of new versions of modelling tools and ongoing maintenance to address emerging challenges and developments in the field of nuclear fuel cycle analysis.

Training Courses: To facilitate the adoption of new tools and streamline the evaluation process, MSSP support is needed for comprehensive training courses. Additionally, the Department requires assistance in tailoring such training courses to address the needs of environmental sample evaluators. This may involve also the Network of Analytical Laboratories (NWAL) members as ESEE development may change the way the laboratories communicate with the Department.

Financial Support: Furthermore, given the complexity and resource-intensive nature of these initiatives, the Department seeks MSSP support to fund the development and operation of these models, which is crucial for their sustained functionality and reliability.

Assistance in these areas would significantly contribute to the advancement of verification capabilities and the overall mission of the Department.

SGIM-008: Statistical Analysis

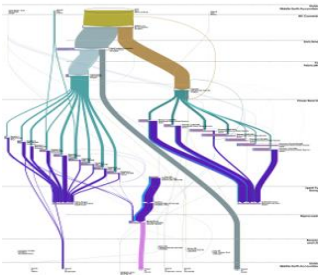
Established

2001

Manager	SGIM Director
Robert BINNER	Stephane BAUDE

Objective

Developing statistical and probabilistic methodologies to design and evaluate safeguards approaches and activities and optimize resources.



Agency Programme and Budget Link

4.1.5.002 Nuclear fuel cycle information analysis

Plan Abbreviations

APA	Acquisition Path Analysis
DA	Destructive Analysis
ESARDA	European Safeguards Research and Development Association
IMUF	Inspector estimate of MUF
ITV	International Target Values
JMOX	Japan Nuclear Fuel Ltd. MOX Fuel Fabrication Plant
MBE	Material Balance Evaluation
MUF	Material Unaccounted For
NDA	Non-Destructive Assay
NRTA	Near Real-Time Accountancy
SME	Subject Matter Expert
SLA	State-level Safeguards Approach
SLAIP	State-level Safeguards Approach Implementation Plan
SRD	Shipper-Receiver Difference
STEPS	Statistical Evaluation Platform for Safeguards
STR	Safeguards Technical Report
TO	Technical Objectives
UQ	Uncertainty Quantification
WG DA	ESARDA Working Group on Standards and Techniques for Destructive Analysis

Context Highlights

The Multifaceted Role of Statistical Analysis in Nuclear Safeguards

Statistical analysis serves several crucial objectives in nuclear safeguards. It identifies anomalies and discrepancies within nuclear facilities by comparing observed data with established patterns. It provides an objective assessment of the accuracy of declared nuclear material quantities, enhancing the verification process by determining whether reported figures align with actual measurements and thus contributing to one of the central objectives of Safeguards: diversion detection. Moreover, statistical tools efficiently allocate the Department's limited resources, concentrating verification activities where the likelihood of uncovering irregularities is highest. They also evaluate risk, estimating probabilities and uncertainties to inform decision-making, enabling the Department to prioritize actions based on potential consequences. Lastly, through historical data and ongoing monitoring, statistical analysis facilitates the refinement of Safeguards strategies over time, ensuring they adapt to evolving threats and vulnerabilities. In essence, statistical analysis forms the

cornerstone of effective and efficient Safeguards, safeguarding the peaceful use of nuclear materials and deterring their diversion.

Statistical Methodology Scope Expansion

Statistical methodologies for Safeguards have a long history. These methodologies are rooted in a criteria-driven, facility-based approach with clear criteria, which has traditionally formed the basis for the Department's conclusions on diversion detection.

While the fundamental principles and approaches of statistical methodologies remain generally applicable in the framework of a State-level evaluation, there is a need for expansion. Previously, these methodologies were primarily focused on material balance areas (MBA) within specific facilities. However, the evolving landscape requires a broader perspective. This expansion encompasses the analysis of nuclear material flows, inventories, and balances for an entire State.

Furthermore, it takes into account the increasing use of random inspection schemes within State-level Approaches (SLAs). This shift poses new challenges for the statistical analysis of data collected under these schemes. It also emphasizes the importance of achieving specific performance targets as an integral part of the process.

In addition to this complex endeavour, which poses various methodological challenges, there is a need for innovative approaches to:

- Manage the growing volume of diverse data effectively.
- Optimize the distribution of limited resources for statistical analysis and verification.
- Ensure alignment with the technical objectives (TOs) defined the in State-level Safeguards approaches.
- Develop probabilistic methods for quantifying the attainment of State-level performance targets.

Additionally, it is critical to consolidate and cross-reference statistical evaluation results from State-declared and verification data with information from other sources.

Framework for Statistical Methodologies Support

In 2013, the Department launched the biennial International Technical Meeting on Statistical Methodologies for Safeguards. Its mission was to gather global expertise to address current gaps and questions, draft recommendations, and build a network of specialists. This initiative aimed to address the challenge of limited Department staff member availability, primarily occupied by core production activities like generating analytical reports and supporting Operations Divisions.

The needs of the Department, as outlined during these meetings, revolve around a high-level structure centred on the review and upgrade of uncertainty quantification (UQ) methods as a fundamental step. Subsequently, the emphasis is on the advancement and refinement of random verification schemes and data evaluation methodologies.

MSSPs that accept MSSP Task Proposal 21/IFC-002 (Statistical Methodology Development) play a pivotal role in developing and refining the Department's statistical methodologies. This encompasses the development of UQ (including development of Bayesian techniques), random verification schemes, including sampling plans and random inspections, and data evaluation methodologies, with a particular focus on State-level evaluation requirements as part of the newly implemented State-level Safeguards Approach Implementation Plan procedures (SLAIPs).

Furthermore, the continued support of CFEs and JPOs remains essential for effectively addressing these needs. The dedication of regular budget staff resources to production work leaves limited capacity for guiding and supporting methodological R&D in most of the areas.

IT and Statistical Methodologies

Considerable progress was made in the field of IT and statistical methodologies since they were first applied to safeguards several decades ago. The implementation of newly developed and enhanced methodologies take advantage of, and in general also require, updated IT capabilities.

The fundamental statistical evaluation tools for UQ and material balance evaluation (MBE) have been migrated to an updated IT platform called the Statistical Evaluation Platform for Safeguards (STEPS) over the past decade. Simulation studies, newly developed and enhanced data visualization applications, detection probability and sample size calculations, and advanced UQ methodologies likewise will all require state-of-the art IT capabilities.

Most Needed External Support in 2024–2025

☐ Financial Support	☐ Consultants	☐ Equipment	☐ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☒ Financial Support for Travel	☒ JPOs	☒ R&D	
☐ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

V.3.C1 Ability to derive verification intensities and frequencies from performance targets and to determine detection probabilities

V.3.C3* Ability to enhance acquisition path analysis and development of State-level safeguards approaches

V.4.C1 Ability to leverage statistical methodologies to evaluate verification data, to assess verification performance (detection probability, timeliness and deterrence) and the associated level of confidence, at the facility and State levels

V.4.C2 Ability to comprehensively evaluate, record, and document safeguards effectiveness at the State level

V.4.C3 Ability to better measure and analyse safeguards performance (of the Department and the safeguards system more broadly) through use of analytical and IT tools, including data visualization

V.6.C3 Ability to implement effective and efficient safeguards at J-MOX

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

★Outcome #1: Enhancing Safeguards capabilities by implementing more effective and efficient verification activities based on standardized methodologies for calculating detection probabilities at both facility and State levels, including developing associated sample plan methodologies.

Outputs

1. Development of simulation-based methodology software with the capability to estimate detection probabilities up to the State level, accommodating non-Gaussian uncertainty distributions and considering all diversion strategies.
2. Development of optimized sampling plans achieving a defined detection probability in order to maximize efficiency of verification activities.
3. Development of prototype IT tools to facilitate the implementation of detection probability calculations and sampling plan methodologies.

Supporting Resource Mobilization Priorities

V.3.C1	V.4.C1	V.4.C2

Support Needed

To achieve the desired outcome, which entails enhancing the efficiency and effectiveness of verification activities through standardized methodologies for calculating detection probabilities at both facility and State levels, the Department requires comprehensive support.

The outputs include the development of simulation-based methodology software that can estimate detection probabilities up to the State level, accommodating non-Gaussian uncertainty distributions and considering various diversion strategies. The Department also seeks to create optimized sampling plans to maximize the efficiency of verification activities. Additionally, the Department aims to develop prototype IT tools to facilitate the implementation of detection probability calculations and sampling plan methodologies.

This support aligns with the MSSP Task Proposal 21/IFC-002 (Statistical Methodology Development), specifically under sub-activity #3. This task addresses the need for developing simulation tools capable of accurately determining achieved detection probabilities during Safeguards verification activities. It encompasses methodological development work to calculate detection probabilities without the traditionally applied simplifying assumptions, such as equal amounts diverted from each falsified item, Gaussian uncertainty distributions, and detection

probabilities calculated on a per-stratum basis. Furthermore, it includes the development of IT tools that can implement these methodologies.

Additionally, the Department requires further research and development (R&D) efforts and IT tool development to leverage the detection probability calculations for optimizing sample size calculations. This process will enable the Department to efficiently achieve the desired detection probabilities while using the minimum verification resources necessary.

In conjunction with the external MSSP support outlined above, the Department acknowledges the essential role of CFEs and JPOs. Their guidance and expertise will be instrumental in driving these development efforts. Regular budget staff resources are currently fully engaged in core production activities, making it challenging to allocate the necessary resources for these initiatives.

By combining external and internal support, the Department aims to effectively address the outcome, improving Safeguards capabilities. MSSP assistance will significantly contribute to the mission.

Continued outcome

★**Outcome #2:** Enhancing the effectiveness and efficiency of safeguards implementation by further improving and harmonizing random verification schemes, including sampling plans and random inspection schemes, and methodologies to evaluate their effectiveness.

Outputs	1. Further development and documentation of advanced sampling plans (e.g., stemming from detection probability simulation results) to be included in the upcoming revision of *STR-381: Safeguards Technical Report - Statistical Methods for Verification Sampling Plans*. 2. Development of a prototype software application that integrates the sampling plan procedures outlined in documents such as STR-381. 3. Documentation detailing the practical implementation of sampling plans to be incorporated into the *Inspector Handbook*. 4. Development and documentation of a standardized set of random inspection schemes, complete with standard evaluation methodologies and tools, to establish a foundational framework for implementing and evaluating such schemes in State-level Approaches (SLAs).

Supporting Resource Mobilization Priorities

V.3.C1	V.4.C1	V.4.C2

Support Needed

MSSPs who accept MSSP Task Proposal 21/IFC-002 (Statistical Methodology Development) provide essential support for achieving the intended outcome. In this regard, sub-activity #1 of the MSSP Task involves consulting and peer review of statistical methodologies for sampling plans, material balance evaluation (MBE), and uncertainty quantification (UQ) outputs. It is of great interest to the Department to maximize efficiency in the implementation of verification activities while achieving necessary effectiveness to meet performance targets.

This support addresses various verification needs, including specialized sampling plans tailored to certain parameters such as time or cost, follow-up sampling plans, and those designed for particular diversion scenarios. Additionally, it aids in developing random inspection schemes that effectively achieve the required frequency targets within State-level Approaches while considering constraining parameters like the maximum number of inspections or scheduling limitations.

In addition to the support provided through MSSP Task Proposal 21/IFC-002, assistance from CFEs and JPOs is indispensable for guiding and facilitating these development efforts. Given that the regular budget staff members are fully occupied with production work, this additional support is essential to meet objectives effectively.

New outcome

Outcome #3: Enhanced nuclear Safeguards capabilities and improved Safeguards practices and decision-making through advanced simulation and visualization methodology and IT tools.

Outputs	1. Development of the Nuclear Solar System (NSS) with a practical, non-confidential nuclear material flow simulation platform for a fictional group of States. 2. Further development of the SNAKEY nuclear material flow visualization tool, incorporating additional data layers that provide visual information on Acquisition Path Analysis (APA) and verification results.

Supporting Resource Mobilization Priorities

V.4.C1	V.4.C3	V.3.C3*

Support Needed

MSSP Task Proposal 21/IFC-002 (Statistical Methodology Development) addresses the necessary support for achieving the outcome through sub-activity #4 of this MSSP Task, involving other research and collaboration as needed.

In the context of statistical methodology development, it's essential for SMEs to access representative nuclear material accountancy and Safeguards verification data. However, the confidentiality of such data often hinders sharing. The Nuclear Solar System (NSS) aims to address this challenge by generating accountancy and verification datasets that mimic Safeguards data while maintain confidentiality. Support is needed to develop simulation techniques that simulate the statistical properties of real data, making it impossible to extract the underlying real data. The complete development of NSS, a nuclear material flow simulation system, will produce simulated, yet non-confidential data, covering both nuclear material accountancy and verification data for a fictional set of States. NSS will also facilitate external parties like MSSP SMEs in testing newly-developed statistical methodologies using realistic yet fictional data.

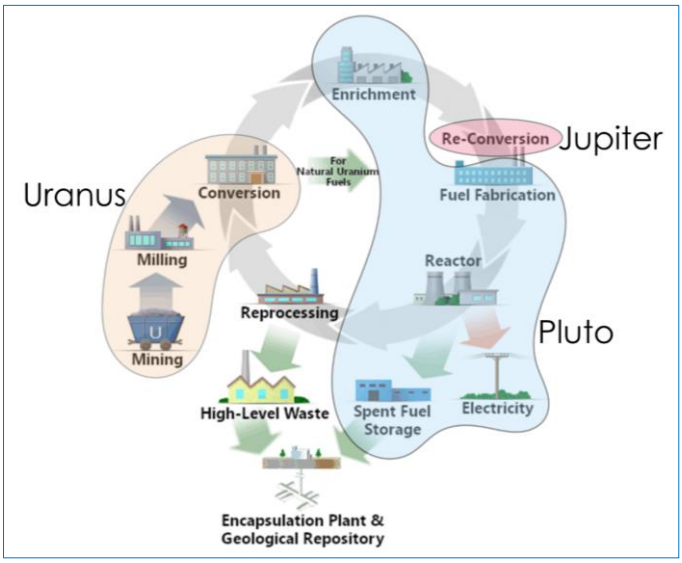


Figure 32: The Nuclear Solar System (NSS) is being designed to generate accountancy and verification datasets that mimic Safeguards data while protecting confidentiality.

For the further development of SNAKEY, the Department requires support to develop and implement additional visualization layers beyond the original nuclear material flow layer. These additional layers will provide visual information on APA, verification measurements, and performance targets. This will enable the Department to prioritize MBE activities, flag the need to intensify the focus on other technical objectives (TOs), and streamline acquisition strategies. While initial conceptual development will be carried out with in-house resources, additional extrabudgetary support will be identified as the work progresses.

In addition to MSSP Task Proposal 21/IFC-002, the Department requires CFEs and JPOs to guide these development efforts. Regular budget staff, occupied with production work, lack the capacity for effective support.

Continued outcome

Outcome #4: Enhanced effectiveness of Safeguards evaluation processes, driven by reviewed, updated, and consolidated methodologies, including Bayesian methodologies, applied to uncertainty quantification (UQ), the evaluation of material unaccounted for (MUF), D Statistic (D), Inspector's MUF (IMUF), and Shipper-Receiver Difference (SRD) in the context of material balance evaluation (MBE) and near real-time accountancy (NRTA).

Outputs	1. A technical document, most likely a Safeguards Technical Report (STR), outlining MBE methodologies and their implementation in relevant analytical software. 2. Technical documentation on the potential applicability of Bayesian statistical methodologies to UQ and MBE. 3. Requirements specification for a harmonized NRTA software system for use as a standardized platform for NRTA evaluation systems at the Rokkasho Reprocessing Plant and at the JMOX plant.

Supporting Resource Mobilization Priorities

V.4.C1	V.4.C3	V.6.C3

Support Needed

To achieve this outcome, this D&IS Plan identifies specific outputs that require support from key initiatives:

Under MSSP Task Proposal 21/IFC-002 (Statistical Methodology Development), the Department is actively working on the development and implementation of improved methodologies for evaluating MBE statistics. These advanced methodologies are currently underway and being integrated into the MBE module of the Statistical Evaluation Platform for Safeguards (STEPS). To ensure that these methodologies are documented and accessible, the Department plans to create a comprehensive technical document (replacing STR-326). Given the extensive nature of this documentation (expected to be similar in length to STR-326, approximately 200 pages), the Department's limited in-house resources necessitate the request for extrabudgetary support.

As part of the Department's ongoing efforts in MSSP Task Proposal 21/IFC-002 (Statistical Methodology Development), it is actively exploring the potential application of Bayesian statistical methodologies to enhance UQ and MBE. This investigation is carried out through subtask #2, and based on the initial findings, the Department anticipates the need for more in-depth studies.

MSSP Task Proposal 17/IFC-001 (NRTA System Documentation and Requirements Gathering) addresses the third output. This focuses on creating comprehensive requirements specifications for a harmonized NRTA software system, intended for use as a standardized platform for NRTA evaluation systems at the Rokkasho Reprocessing Plant and at the JMOX plant and which should be available when the plants become operational. Support for Phase 3, which involves requirements specification for NRTA software, is currently ongoing with MSSPs who have accepted the MSSP Task Proposal. However, as the Department progresses in the software development process, it may identify additional areas where support is required, which could lead to further requests for support.

New outcome

Outcome #5: Enhanced precision in nuclear material measurements, adaptation to technological advances, comprehensive documentation and standardization, and global collaboration through expert engagement.

Output	1. A continuously updated version of STR-368 (Safeguards Technical Report - International Target Values for Measurement Uncertainties in Safeguarding Nuclear Materials), incorporating the latest recommended target values for uncertainty components of Destructive Analysis (DA), Non-Destructive Assay (NDA), and bulk measurement technique.

Supporting Resource Mobilization Priorities		
V.4.C1	V.4.C3	V.6.C3

Support Needed

The European Safeguards Research and Development Association (ESARDA) Working Group on Standards and Techniques for Destructive Analysis (WG DA) introduced the concept of target values to the IAEA and Euratom in the late 1970s. The concept was extended and refined over the years, leading to the International Target Values (ITV), which are regularly updated in the form of Safeguards Technical Reports (STRs) first issued in 1993. Under the ITV-2020 project, the network of international subject matter experts (SMEs) involved in the review of ITV was significantly expanded thanks to the use of a virtual exchange platform. A new set of updated ITVs, including new entries and new tables, was established and the lessons learned from virtual meetings led the Department to create a public ITV CONNECT internet platform accessible through the www.iaea.org and including an extended version of the ITV report (STR-368 R.1.1), an electronic version of the ITV tables linked to narratives describing the documented methods as well as ITV-related resources, e.g., the previous version ITV-2010. A restricted workspace on this platform supports a continuous review of the ITVs by the network of international experts.

The continuous ITV review will regularly take into account advances in the areas of uncertainty quantification (UQ) and verification measurement performance evaluation (VMPE), advances in measurement equipment and analytical techniques, and lessons learned from the preparation and application of the previous ITV updates.

MSSPs play a crucial role in providing essential support by accepting MSSP Task Proposal 23/IFC-003 (Continual Review of the International Target Values (ITV)). This task involves identified SMEs engaged in relevant ITV expert groups. When a MSSP accepts Task Proposal 23/IFC-003, it serves as the catalyst for comprehensive support. This support includes sustained expert collaboration, facilitation of global collaboration tools, access to cutting-edge technology, resource allocation for ITV review, and the establishment of effective feedback channels.

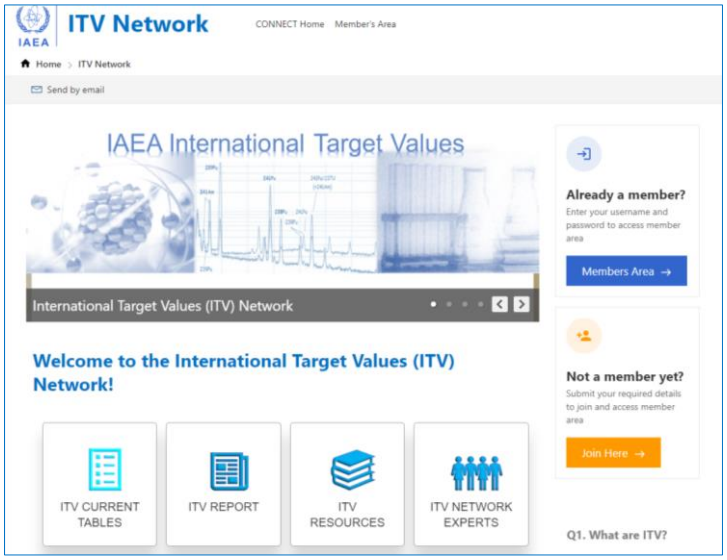


Figure 33: The ITV Network Homepage is a hub for international nuclear measurement professionals working together to keep the International Target Values updated.

SGIM-009: State Declared Information Management

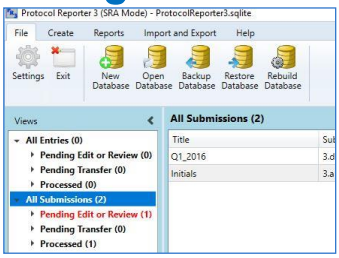
Established

2016

Manager	SGIM Director
Snezana KONECNI	Stephane BAUDE

Objective

Collecting, managing, analysing, and utilizing State declared information.



Agency Programme and Budget Link

4.1.5.001 Declared information analysis

Plan Abbreviations

AI/ML	Artificial Intelligence/Machine Learning
AKL	Acknowledgement
AP	Additional Protocol
APS	Additional Protocol System
CSA	Comprehensive Safeguards Agreement
DA	Data Analysis
ES	environmental sampling
GUI	graphic user interface
ICR	Inventory Change Report
ISD	Declared Information Analysis Section
LFUA	Low Frequency Unannounced Inspection
NDA	Non-Destructive Assay
NMA	Nuclear Material Accountancy
OCR	optical character recognition
QC	quality control
ORNL	Oak Ridge National Laboratory
SDP	State Declarations Portal
SEG	Safeguards Evaluation Group
SER	State Evaluation Report
SGMD	Safeguards Master Data
SQP	Small Quantities Protocol
SRA	State or Regional authority
SSDH-C	State Supplied Data Handling Core (system)
UCVS	Unattended Cylinder Verification System

Context Highlights

SGIM-009's Streamlined Outcomes and Outputs for 2024–2025

In previous biennia, this D&IS Plan was characterised by ambitious numbers of outcomes and outputs. While this ambition has yielded positive outcomes, the Department recognizes the need for a more streamlined strategy in 2024–2025. This shift will allow the Department to allocate resources more efficiently and effectively, ensuring that efforts are concentrated on those initiatives that are both achievable and aligned with core objectives. While some aspects of the plan may still represent a challenge, its priorities are clearly defined.

Priorities

In order to improve the efficiency and effectiveness of receiving and processing State declarations, most Member States need to adopt the State Declarations Portal (SDP) as a secure platform for communication and provide their reports in electronic and loadable format. This could be achieved with several different initiatives like additional SDP user meetings where the emphasis would be on listening to users and their experiences and providing training courses for the Member States on how to securely send information and reports through SDP. Preparing Nuclear Material Accountancy (NMA) reports in a Code 10 format is a time saving solution as the Declared Information Analysis Section (ISD) spends a lot of effort correcting errors in the NMA reports. A user-friendly platform to enter NMA information in a data exchange format might be one answer for this problem, or a, NMA reporting tool that could generate NMA reports based on the State's data in an IAEA Code 10 format that would be computer loadable. Updating of the Services Series Publications like SS11, SS22, SS33 is needed as they currently do not mention SDP. The Service Series publications are used and shared widely. They are linked to some Safeguards Agreements. In order to improve the format of the reports received from Small Quantities Protocol (SQP) States, the SS22 needs to be updated with templates that will facilitate easer processing of declarations.

Top priorities

- An environment that would allow the Department to access multi-source data via secure APIs. Ability to automatically generate relevant data outputs in multiple formats (flat tables, graphical, etc.) for routine NMA work, for example, State Evaluation Report (SER) contributions.
- Optical character recognition (OCR) or similar tool to convert NMA reports provided in hardcopy to electronic format for fast processing of declarations. In parallel an outreach campaign should focus on moving States reluctant to use modern transmission vehicles.
- A testing database, which would enable ISD to test NMA reports from Member States when they transition from one reporting method to another, for example from Fixed code 10 to the Labelled Code 10 or the XML Code 10 NMA reports.
- The ability to provide a NMA reporter tool, which is often requested from Member States in order to prepare NMA reports.
- Development of PR3 online training materials, which would enable Member States to adopt and utilize PR3 more quickly and efficiently, thus reducing demand on support resources within ISD and increasing the accuracy of Additional Protocol (AP) declarations.
- Strengthening UF_6 batch tracking and monitoring.
- Implementation of advanced data analytics to evaluate and provide high-value reporting on learning resource utilization and effectiveness both internally and to MSSPs.

Impact of CFEs and JPOs on SGIM-009 Plan Success

CFEs and JPOs bring specialized skills and fresh perspectives, and their presence ensures that the Department can maximize this D&IS Plan's potential and achieve its objectives effectively.

MSSP Task USA D 2650 (JPO - Associate State Declarations Portal Officer), already on board, is poised to make a lasting impact in customising the interface to SDP based on user needs. MSSP Task USA B 2648 (CFE - Safeguards Reporting e-Learning Expert) has become integral to the team and is making substantial contributions. The expertise in e-learning solutions enhances the Department's capacity to deliver effective training. The upcoming addition of MSSP Task JPN D 2739 (JPO - Associate State Declarations Analyst) will further strengthen this plan. In 2024–2025, the CFE specializing in Safeguards Information Analysis, particularly in Nuclear Material Accounting, will bolster the Department's analytical capabilities and finetune analytical tools.

Current State of the State Declarations Portal (SDP)

The Department has dedicated significant efforts to enhance Member States' abilities in preparation and transmission of the State declarations since 2016, and the Department takes pride in the establishment of the SDP. While the focus now leans towards maintenance, there remain opportunities for ongoing improvement. The Department encourages permanent missions to actively engage in this process. The SDP facilitates efficient communication between State Authorities, Permanent Missions, and the IAEA, streamlining the exchange of crucial information.

Canada and Switzerland, both early adopters of the SDP, have consistently demonstrated a strong commitment to the SDP. Their prompt and accurate reporting sets a commendable example. Their feedback regarding the SDP has been most helpful to refine the features offered. In addition, financial contributions from MSSPs have enabled the Department to develop needed SDP features like uploading large files on SDP.

The SDP assists Member State in uploading State declarations, but has not prevented States to send their reports in unloadable format. For example, the Department receives images of the reports. The Department needs to focus on improving the efficiency of loading the State declarations and could devote more efforts on the analysis of those reports.

SG Mailbox

The current SG Mailbox, which allows facility operators to securely email "mailbox declarations" to the IAEA, is set for retirement in 2024. This feature will be taken over by the SDP. Facility operators will be able to continue using secure email or submit directly with the SDP. As is the case now for all types of submissions in SDP, a history will be maintained for mailbox declarations. In this case, facility operators will also be able to take advantage of all the features of the SDP.

Quality Control (QC) Online

One of the significant advancements in this D&IS Plan is the implementation of "QC Online," a tool that facilitates real-time database checks for verification reports. QC Online allows for the immediate and comprehensive verification of reports against a live database. This means that as information is submitted, it undergoes automated validation against the most up-to-date data available. This real-time verification ensures the integrity and accuracy of the data, reducing the potential for errors or discrepancies.

While QC Online has been embraced by some Member States, its full potential is yet to be realized by adoption of this option by the State or Regional Authorities (SRAs) prior to submitting their NMA reports. The benefits it offers in terms of data validation and accuracy are invaluable. It would be highly advantageous for more Member States to leverage this tool, as it not only streamlines the verification process but also promotes transparency and accountability.

Challenges

Currently, there remain 20 Comprehensive Safeguards Agreement (CSA) and two INFCIRC/66 type States that continue to submit State declarations in a hardcopy format or in a poor-quality electronic report, which requires Department staff members to manually enter the data. The SQP States reports need manual entry in the IAEA NMA database as there is no prescribed format for the reports. The persistence of hardcopy submissions requires resource-intensive manual data entry, introducing the potential for errors and hampering processing efficiency, highlighting the need for solutions such as OCR technology. Addressing this challenge necessitates exploring innovative solutions, such as possibly enhancing OCR technology. OCR can automate the conversion of hardcopy documents into digital data, significantly reducing manual workload and minimizing the risk of errors.

Opportunities

A great opportunity is working together with the D&IS Plan SGIM-010 (Artificial Intelligence/Machine Learning for Information Analysis)-related projects and the use of AI/ML (Artificial Intelligence/Machine Learning) to enhance effectiveness and efficiency in the processing and analysing State declarations, especially AP declarations.

New SMRs may require new codes for reporting nuclear material transfers. These need to be developed and accepted by the Board of Governors. Working together with SGCP while developing new Safeguards approaches is very important. This will assist the communication with Member States on how to report transfers of nuclear material in the new facilities. The new types of facilities, like nuclear-propelled submarines used by non-nuclear-weapon States, and nuclear material accounting are important parts of developing the Safeguards approach for these facilities in the future.

In collaboration with SGTS and SGCP, strengthening UF_6 batch tracking and monitoring would be an important benefit as they could use global identifiers during annual and interim inventories verification. For that, the Department could test and evaluate 2D barcode readers to read Identifiers in the field, investigate scanning 2D identifiers on cylinders in feed chests and sampling stations during Low Frequency Unannounced Inspections (LFUAs), and provide improvements for manual inventory reconciliation procedures. The Department could use readers to more rapidly locate specific cylinders to resolve questions/irregularities (e.g., discrepancies between reported storage location and actual storage location). The ability to scan barcodes would provide a capability for frequent inventory verification of non-flow cylinders during interim inventory inspections.

Travel Funding Needs for In-Person Interaction

For the successful execution of this plan, the Department requires funding for travel. While virtual tools are helpful, in-person meetings are essential for certain work. Facility access may be required.

- UF_6 Expert Meetings: To discuss UF_6 matters with specialists, in-person meetings are crucial for an effective exchange of insights.

- New reactor technologies meetings with experts to better understand what are the future reporting needs and possibilities.
- NMA User Requirements: The Department needs to meet users to better understand their needs for NMA development.
- User Group Meeting on SDP: In-person discussions with State authorities to help the Department improve the SDP utilisation based on their feedback.
- Meeting with SRAs: Travel supports training sessions for State Authorities developing new capabilities and adoption of advanced reporting schemes.
- Travel for Department staff members (including CFEs and JPOs) to participate in specialised training courses.

Most Needed External Support in 2024–2025

☐ Financial Support	☐ Consultants	☐ Equipment	☒ Training
☐ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☐ Studies
☒ Financial Support for Travel	☒ JPOs	☐ R&D	
☒ Expert meeting participation		☒ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

V.3.C3* Ability to enhance acquisition path analysis and development of State-level safeguards approaches

S.1.C1 Ability to deploy data visualization and other methods and techniques to present safeguards findings and performance-related data in a clear and compelling manner

V.1.C2* Ability to receive/collect, process, analyze and evaluate all safeguards-relevant information efficiently and effectively through innovation, integration, and governance

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: More effective and efficient internal State Declarations Handling System with improved workflows.

Outputs

1. Implementation of a full workflow, including quality control (QC) checks, for Exemption, Termination, and Re-application requests of nuclear material and integration with the Nuclear Material Accountancy (NMA) system to facility matching State NMA reports with requests for exemptions and terminations of nuclear material.
2. ★ Application of enhanced optical character recognition (OCR)/text extraction to reduce manual input of hardcopy declarations while still allowing for robust verification procedures to eliminate data entry errors in the NMA database.

Supporting Resource Mobilization Priority

V.1.C2*

Support Needed

To be able to track exemption requests and OCR/text extraction from reports submitted in hard copies with technical tool solutions is essential for effective utilisation of Department staff members. The outputs listed above contribute to achieving this outcome by providing a proper platform, tools and storage database, and mechanisms for tracking reports and requests from Member States. Ultimately, this promotes a more efficient utilisation of Department assistants and analysts and ensures timely analysis of State declarations.

A MSSP can contribute to provide technical solutions:

- Financial support to invest in analytical tools, such as COTS platforms.
- A consultant or funds to support a consultant who would implement applications for tracking workflows and OCR tools.

Continued outcome

Outcome #2: Improved effectiveness and efficiency of analysis of all State Declared Information (e.g., Nuclear Material Accountancy (NMA), Additional Protocol (AP), Safeguards Master Data (SGMD), etc.).

Outputs	1. ★An integration platform to access multi-source data via secure APIs. 2. Ability to automatically generate relevant data outputs in multiple formats like flat tables, graphical, etc. for routine NMA work, for example, State Evaluation Report (SER) contributions. 3. Development of a new graphic user interface (GUI) that allows Department analysts to work with NMA data intuitively. 4. Easier comparison of Safeguards-relevant data and State declarations and consistency analysis. 5. Ability to tag all locations declared in NMA and AP declarations with geospatial data.

Supporting Resource Mobilization Priorities	
S.1.C1	V.1.C2*

Support Needed

To empower Department staff members with data acumen, tools, secure sharing, and adept management, this plan needs to secure clear guidelines, training materials, proper platform and storage database, and mechanisms for reporting of the analysis of State-declared information. Ultimately, this promotes a more efficient utilisation of Department analysts and ensures provision of Safeguards-relevant information.

Advanced analytics with an analytical integration platform will furnish evidence-based insights, bolstering professional missions. Data-fuelled services significantly enhance analytical capabilities. Technology provides domain experts with powerful tools to swiftly derive trustworthy insights from data, thus optimizing precious analysis time. For example, coordinating the activities with D&IS Plan SGIM-010 (Artificial Intelligence/Machine Learning for Information Analysis) to assist analysis of declared information is very valuable.

MSSPs can contribute to enhancing analytical exchanges by providing:

- Financial support to invest in Safeguards analytical tools.
- A CFE to implement a platform and integrate it with existing databases like the State Supplied Data Handling Core System (SSDH-C) and Additional Protocol System (APS).
- Technical expertise on how to develop one platform.
- Training and capacity building programmes.
- Best practices and industry standards.
- Networking and collaboration opportunities.

Continued outcome

Outcome #3: Improved Nuclear Material Accountancy (NMA) testing and training capabilities.

Outputs	1. ★ Creation of an NMA training and testing database. 2. Creation of a comprehensive set of simulated NMA training data. 3. Tests of future reporting codes to reflect the latest development in SMR and nuclear propulsion.

Supporting Resource Mobilization Priorities	
S.1.C1	V.1.C2*

Support Needed

The Department needs support in several key areas:

- Robust infrastructure for the NMA training and testing database, equipped with the latest technology, secure data storage, and scalability for future needs.
- An NMA Expert to create accurate simulated training data, and maintaining quality and authenticity.
- Clear and comprehensive guidelines are essential, encompassing best practices, standardized procedures, and methodologies for NMA testing and training.
- Adequate support is needed for developing high-quality training materials, including modules, presentations, videos, and reference documents.
- Ongoing management, updates, data validation, and security measures are vital for the NMA database's sustainability and reliability.
- Effective reporting mechanisms are necessary for accurate and efficient reporting by State or Regional Authority (SRA) staff, with user-friendly interfaces and templates to reduce errors.
- Capacity-building programmes, such as training sessions, workshops, and mentoring are crucial for enhancing the skills of SRA staff in NMA testing and reporting.

By addressing these support needs, the Department can ensure effective progress toward the goal of improved NMA testing and training capabilities, gaining the support of Member States in this essential area of nuclear verification. A set of simulated NMA data is needed for Material Balance Evaluation.

Modified outcome

Outcome #4: More efficient information exchange by optimizing external-facing State Declarations Portal (SDP) processes.

Outputs	1. Ability to give near-real-time Nuclear Material Accountancy (NMA) feedback to Member States with on-demand requests for current NMA Book balances. 2. ★ Built-in encryption handling: a. Capability to encrypt and digitally sign all files destined for the IAEA. b. Capability to decrypt and verify digital signatures of files received from the IAEA. 3. Design of a new Acknowledgement System to replace Acknowledgement (AKL) letters. 4. Feature to conduct real-time quality control (QC) verification of Additional Protocol (AP) declarations.

Supporting Resource Mobilization Priorities	
S.1.C1	V.1.C2*

Support Needed

Financial support is crucial to invest in SDP improvements and develop new capabilities. This support will enable the Department to upgrade its infrastructure, software, and security measures, leading to more efficient information exchange and stronger external-facing SDP processes.

Continued outcome

Outcome #5: Competent and confident State Authorities who have the knowledge and skills to effectively submit declarations to the IAEA.

Outputs

1. Translations of e-learning modules into Arabic, French, Spanish, Chinese, and Russian to increase access to more learners.
2. ★ Development of advanced Nuclear Material Accountancy (NMA) and Additional Protocol (AP) e-learning modules to increase knowledge and skills and decrease reliance on Department staff members to provide direct support of these activities.
3. ★ Development of training courses and resources to assist with PR3 adoption and utilization for submitting AP declarations.
4. ★ Implementation of advanced data analytics to evaluate and provide high-value reporting on learning resource utilization and effectiveness.
5. Effective promotion of the Declared Information Analysis Section (ISD) online learning resources to build awareness and enhance their perceived value for learners.
6. Investigation and implementation of emerging technologies and approaches for enhancing the learning experience (e.g., AI tutors, microlearning, social learning, immersive learning, etc.).
7. Outreach sessions with State Authorities to encourage Member States to provide reports in electronic loadable formats.
8. Updated Service Series Documents: SS11, SS22, and SS33.

Supporting Resource Mobilization Priority

S.2.C1*

Support Needed

The Department requests financial support and in-kind contributions. Financial support for outsourced e-learning development will bolster the Department's ability to tackle multiple priorities concurrently and potentially engage external specialists with expertise in innovative learning approaches. In addition, in-kind contributions, particularly in areas such as e-learning, data analytics, or translation services would be immensely valuable in optimizing Department resources and expanding its impact. Partnership in these areas is instrumental in the Department's ongoing mission.

Continued outcome

Outcome #6: Enable creation, validation, and submission of declarations and other State-declared information for State or Regional Authorities (SRAs).

Outputs	
	1. ★ Documented business requirements for a nuclear material Reporting tool/platform that could be used by Member States to prepare and transmit Nuclear Material Accountancy (NMA) reports. 2. An established single client platform/application. 3. An established open-source repository for application code and documentation. 4. Defined governance for collaboration.

Supporting Resource Mobilization Priority

V.1.C2*

Support Needed

The Department requires support in understanding the specific requirements of Member States regarding the NMA reporting platform/tools. Ideally, these tools should allow for real-time Quality Control (QC) verification of Code 10 files in fixed, labelled, and XML formats. Additionally, integration with QC verification of Additional Protocol (AP) declarations may be necessary. Ensuring the capability to encrypt and digitally sign all files intended for submission to the Department is essential. This platform will operate under a well-defined governance structure, promoting effective collaboration. Such a tool will greatly assist State Authorities in preparing NMA reports in alignment with their obligations. MSSP support in this matter is greatly appreciated.

Continued outcome

Outcome #7: Enhanced UF_6 cylinder tracking via unique identifier.

Outputs	
	1. ★ Ability to track individual UF_6 cylinder unique identifiers (UF_6IDs) (ID to be voluntarily provided by Member States). 2. ★ Increased value for Environmental Sampling (ES) Reports from Nuclear Power Plants using UF_6 cylinders. 3. Increased ability to analyse facility operators' measurement systems and data. 4. Preliminary studies based on test data for future adaptation of the database. 5. Simulation of data collection and analysis.

Supporting Resource Mobilization Priorities

V.1.C2*	S.1.C1	V.3.C3*

Support Needed

MSSPs can play a pivotal role in facilitating the integration of UF_6 Unique tags into Department reports. This is an ongoing challenge that has garnered renewed attention within the Department. Meetings have been scheduled with Oak Ridge National Laboratory (ORNL), and additional meetings were held in October 2023. This will be done in collaboration with D&IS Plan SGIM-008 (Statistical Analysis).

The Department is actively ensuring that all relevant stakeholders are informed about this revival. This communication aims to prepare everyone for the work ahead, including preliminary studies based on test data for future adaptation of the database and simulations for data collection and analysis.

This effort necessitates several key actions, including the creation of new tables within the primary Safeguards database for storing voluntarily shared data such as tare weights. The Department must carefully select equipment for ID reading, establish interfaces with both local and global databases, and implement various data matching processes between the existing and new datasets. Additionally, the Department will address requirements related to transit and information pertinent to Non-Destructive Assay (NDA) and Data Analysis (DA).

This work encompasses:

- Strengthening UF_6 batch verification and monitoring.
    - Use global identifiers during annual and interim inventories.

        - Test and evaluate 2D barcode readers to read identifiers in the field.
        - Investigate scanning 2D identifiers on cylinders in feed chests and sampling stations during Low Frequency Unannounced Inspections (LFUAs).
        - Provide improvements for manual inventory reconciliation procedures (examine opportunities to automate portions of the reconciliation process).
    - Use readers to more rapidly locate specific cylinders to resolve questions/irregularities e.g., discrepancies between reported storage location and actual storage location.
    - The ability to scan barcodes would provide a capability for more frequent inventory verification of non-flow cylinders during interim inventory inspections.
- Establishing a database to enable use of existing Department information to strengthen onsite verification activities.
    - Link State-reported batch information in Inventory Change Reports (ICRs) with site-provided cylinder IDs
        - Plan random inspections: IAEA Safeguards inspectors would be able to produce an expected list of received cylinders (from State-reported ICRs) prior to receiving receipt list from operator after arriving at the site.
    - Improve transit matching and enable quicker resolution of transit matching questions/irregularities.
    - Link State-reported cylinder tare weights with onsite information (data marked by cylinder fabricators on cylinder nameplates).
    - Support question resolution by maintaining history of UF_6 batches contained in individual cylinders (enrichments and facilities), e.g., Environmental Sampling (ES) results.
    - Evaluate explanations for the presence of observed cylinders not included on IAEA Safeguards inspector-provided cylinder listings (potential indicator of undeclared operations).
- Supporting Safeguards Evaluation Group (SEG) evaluations with:
    - Monitor changes/fluctuations in State-reported cylinder tare weights (used to verify reported batch quantities).
    - Detect duplicate cylinder reporting across sites or cylinder swaps.
    - Monitor materials flows within and among States.
    - Support acquisition path analysis.
    - Explore methods to better link/associate State-reported batch names with container IDs observed in the field for various analysis including material balance evaluation.
- Exploring benefits resulting from using cylinder identifier in other Department systems (e.g., Unattended Cylinder Verification System (UCVS)).
- Exploring additional Department benefits resulting from methodology for the Department to authenticate the cylinder ID.

SGIM-010: Artificial Intelligence/Machine Learning (AI/ML) for Information Analysis

Established

2024

Manager	SGIM Director
Paul SCHNEEWEISS	Stephane BAUDE

Objective

Leveraging Artificial Intelligence (AI) breakthroughs, including generative AI, for enhanced machine learning (ML) projects in Safeguards information analysis, ensuring responsible development, fostering knowledge sharing with external experts, and incorporating subject matter expertise into data-driven systems.

Agency Programme and Budget Link

4.1.5 Information Analysis

Plan Abbreviations

AI	Artificial Intelligence
AP	Additional Protocol
ESARDA	European Safeguards Research and Development Association
IEEE	Institute of Electrical and Electronics Engineers
INMM	Institute of Nuclear Materials Management
ML	Machine Learning
NLP	Natural Language Processing
PoC	Proof of Concept
SAGSI	Standing Advisory Group on Safeguards Implementation
SAR	Safeguards Advisory Report
SME	Subject Matter Expert

Context Highlights

Harnessing Artificial Intelligence/Machine Learning (AI/ML) for Enhanced Safeguards Information Analysis

The introduction of this newest D&IS Plan responds the urgent requirements arising from various data science activities across different areas of information analysis. It also addresses potential risks for Safeguards associated with recent advancements in AI/ML technologies.

Before initiating the governance and coordination of AI/ML efforts, SGIM conducted Proofs of Concept (PoCs) to assess the potential for Safeguards, which have proven to efficiently determine whether a new technology has the potential to provide benefits in real-world applications before starting further development.

In the Department's initial PoC regarding open source analysis, it successfully demonstrated, that by using the AI/ML-based prioritization, 90% of Safeguards-relevant articles can be found in the top 10% of collected open source articles. This suggests a potential for substantial reduction in the time-consuming work of reviewing Science & Technology publications. Following this, the Department further refined and integrated these results into a production environment.

Additional PoCs in other areas of Safeguards information analysis also demonstrated the potential to increase effectiveness and efficiency in reviewing State declarations, cross-checking consistency between open source information and declarations, supporting the detection of changes in buildings based on satellite imagery, or assisting with particle analysis. These results and benefits of AI/ML for Safeguards were presented at the Safeguards Symposium 2022, at the Institute of Nuclear Materials Management (INMM) and European Safeguards Research and Development Association (ESARDA)

Annual Meeting 2023 and are summarized in the annual United Nations Activities on Artificial Intelligence (AI) Report[3].

Figure 34: SGIM data scientists presenting at the 2022 Safeguards Symposium on the topic of "How Safeguards Benefits from Artificial Intelligence."

Figure 35: SGIM data scientists presenting at the INMM & ESARDA Annual Meeting 2023 on the topic of, "Extracting the signal from the noise."

As information is growing in volume and variety, there is an increasing need for innovative techniques to help analysts distinguish "the signal from the noise." Leveraging both recent breakthroughs and long-established methods in AI/ML, the results of already conducted and ongoing projects demonstrate how data science-based approaches can be applied to the nuclear domain with significant results.

After successfully demonstrating that AI/ML can substantially improve the effectiveness and efficiency of analysing Safeguards-relevant information, SGIM initiated the governance and coordination of various data science activities across different areas of information analysis. Through a strong collaboration between data scientists, analysts, and Subject Matter Experts (SMEs), these efforts incorporate AI/ML in the processes of collecting, evaluating, and analysing Safeguards-relevant information.

SGIM-010 Scope and Focus

This D&IS Plan, established at the Director level, primarily supports SGIM, offering support to all its Sections and related D&IS Plans. This plan does not assume direct influence over AI/ML activities conducted within other Divisions' responsibilities or elsewhere in the Department.

When applied to various categories of information, including State-declared information, IAEA field activity data, open source information, satellite imagery, geospatial information, and third-party information, the implementation of AI/ML requires specific domain expertise. This new D&IS Plan complements all AI/ML initiatives related to information analysis within Safeguards, including some that are already addressed in the existing D&IS Plans falling under the purview of SGIM.

All AI/ML efforts for Safeguards information analysis share common methodologies, opportunities, and challenges. For example, while generative AI offers new opportunities for Safeguards, it also poses the risk of misuse through the creation of fake information in open sources. There is a demand to reliably incorporate expert knowledge into data-driven systems, and there is a need for common guidelines and validation procedures to address the risks posed by new technologies. These topics are coordinated and governed and serve as the primary motivation for requesting extrabudgetary support under this D&IS Plan.

Additionally, it should be noted that in its Safeguards Advisory Report (SAR)-78 report of December 2022, the Standing Advisory Group on Safeguards Implementation (SAGSI) recommended "*that the Department of Safeguards develop a structured framework for tracking advancements in machine learning and artificial intelligence (ML/AI), identifying the most promising use cases for safeguards applications, pilot testing new capabilities and operationalizing those that prove to be successful*." This D&IS Plan addresses this recommendation in relation with Information Analysis, i.e., for Subprogramme 4.1.5 of the IAEA Programme and Budget.

[3] For further details, refer to the official document: "United Nations Activities on Artificial Intelligence (AI) 2022" available at https://www.itu.int/dms_pub/itu-s/opb/gen/S-GEN-UNACT-2022-PDF-E.pdf.

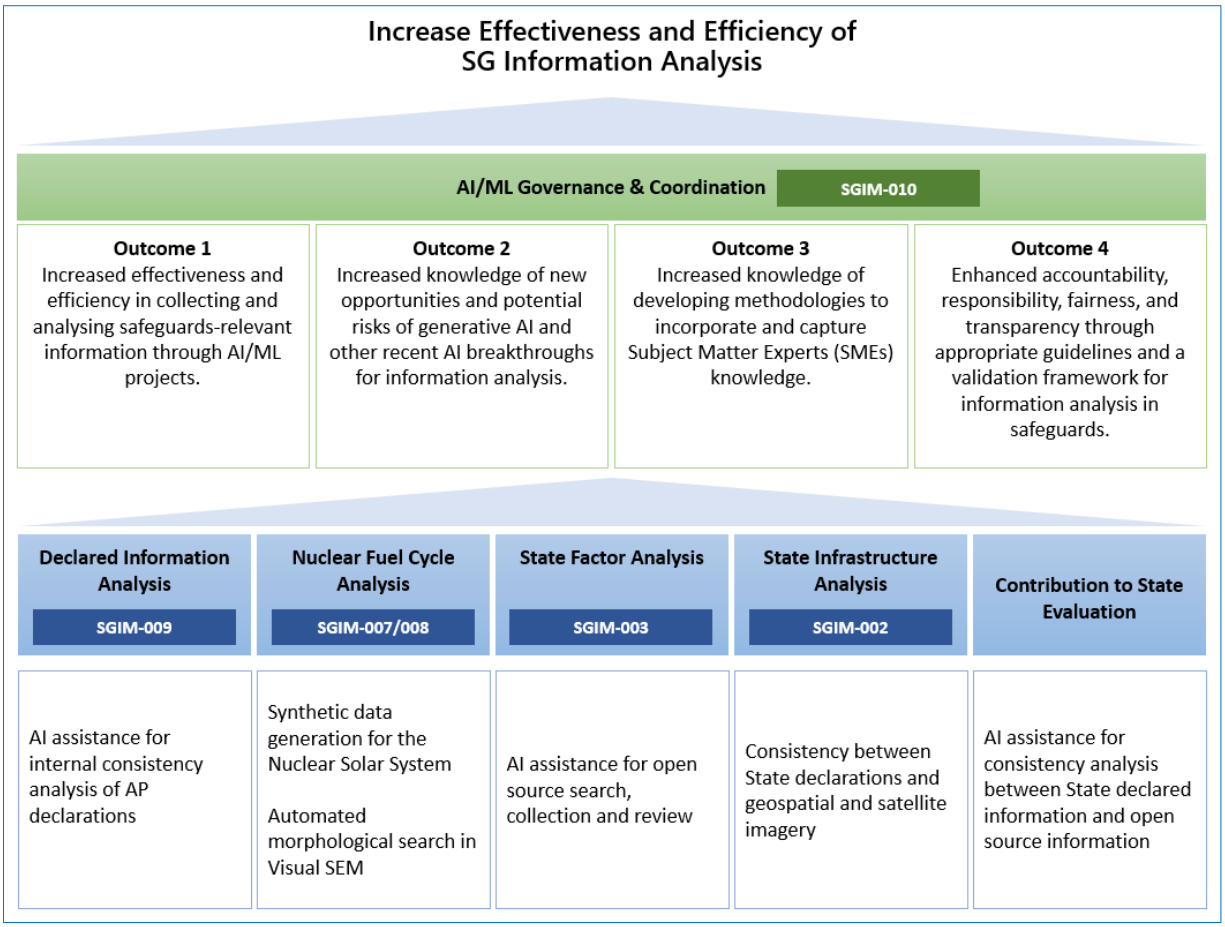


Figure 36: The Department's AI/ML governance and coordination to enhance all areas of Safeguards information analysis.

Managing Data Growth Challenges: Leveraging Technology for Efficient Analysis

There is broad agreement that digital data grows exponentially each year. Internally, the amount of information accumulated from decades of Safeguards implementation demands efforts to ensure that such information continues contributing to efficient and effective analysis.

Externally, the increasing number and variety of sources, websites, and media types present new challenges for the Department. Due to the gap between the availability of resources and the vast increase in potentially relevant information, there must be a balance between the benefits of considering a wide dataset and the resources required for collection and analysis. To overcome this challenge, new technologies are needed to assist analysts in their daily work and ensure that relevant information is easily available.

AI Breakthroughs and Safeguards: Balancing Potential With Responsibility

Since the introduction of the so-called deep learning algorithms in 2012, tremendous AI success in a variety of application domains has been demonstrated. The rapid evolution of ML models over the last 10 years has led to new modalities of applications and marked improvements in fields such as image processing, computer vision, machine translation, speech recognition, natural language processing, and many others. Recent progress, especially in the fields of natural language processing and computer vision, is characterised by impressive innovations like large language models, vision transformers and generative AI. Future work on current projects demands constant assessment to determine if the latest methods are applicable to Safeguards information analysis work. Modern AI/ML methods not only have the potential to significantly enhance the Department's capabilities, but also underscore the need for guidelines, validation procedures, transparency, responsible use, and a strong collaboration with analysts and SMEs.

AI/ML Projects Demonstrating the Potential Enhance All Areas of Safeguards Information Analysis

Highlighted below are AI/ML projects that have either been incorporated into productive workflows or serve as PoCs, successfully illustrating the potential of AI/ML for Safeguards.

AI/ML Project: AI Assistance for Open Source Search, Collection, and Review

AI/ML assists Safeguards analysts by prioritizing open-source information relevant to nuclear fuel cycle technologies and their significance for Safeguards. A recent integration of an AI/ML component into a production environment has shown its capability to efficiently prioritize open-source information. As a result, 90% of articles relevant to Safeguards are found within the top 10% of the collected open source articles. This D&IS Plan complements the needs outlined in SGIM-003 (Open Source Information Collection and Analysis).

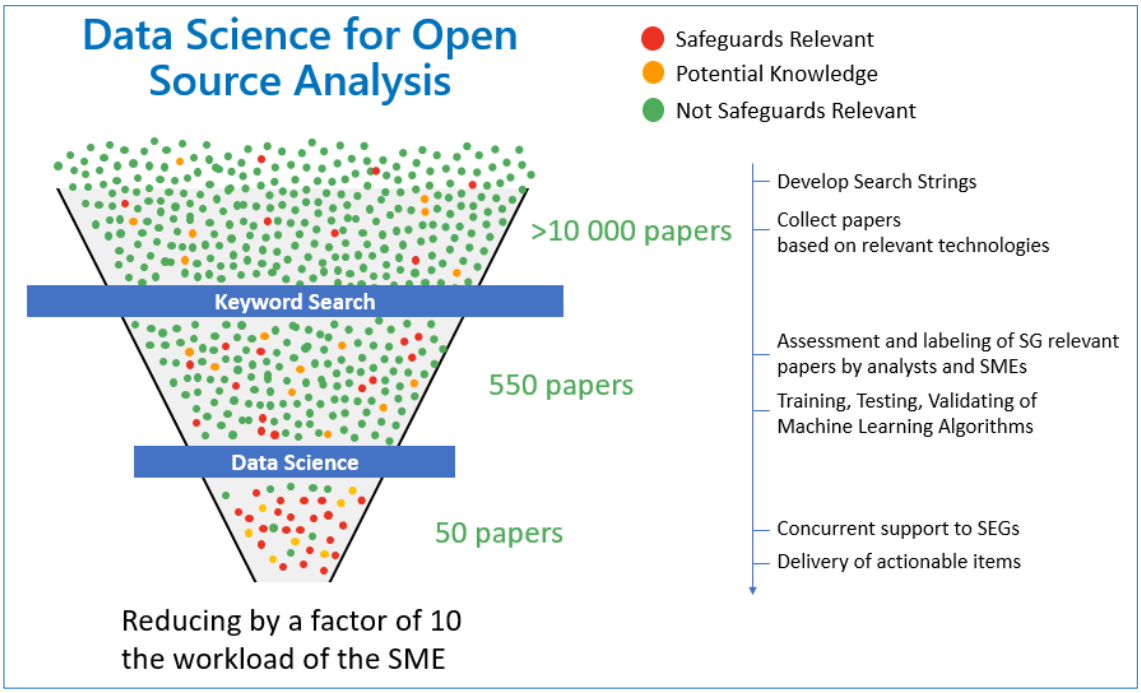


Figure 37: Leveraging Data Science for Open Source Analysis to streamline information overload. The approach reduces SME workload by a factor of 10.

AL/ML Project: AI assistance for internal consistency analysis of Additional Protocol (AP) declarations

In the annual review of specific articles under the AP, data science techniques are being used to identify new research content. Preliminary evaluations have shown that for some States, less than 30% of their declarations contain new research. These tools also help verify the completeness and consistency of State declarations by comparing them to research projects from partner States. This highlights the potential of data science in this work. Therefore, this D&IS Plan complements the needs outlined in D&IS Plan SGIM-009 (State Declared Information Management).

AI/ML Project: AI Assistance for Consistency Analysis Between APS and Open Source Information

Data science assists with consistency analysis, helping analysts assess whether a State's declarations align with Safeguards-relevant information from open sources. By categorizing validated open source information and State declarations according to research entities and nuclear fuel cycle technologies, data science provides a structured understanding, assisting analysts in identifying potentially undeclared research, therefor, this D&IS Plan contributes to the State evaluation process.

AI/ML Project: Pre-review of 2.a(iii) State Declarations Based on Satellite Imagery and Geospatial Information

Reviewing 2.a(iii) declarations requires manual comparisons with satellite imagery, but deep learning offers the potential to greatly enhance the processing of this data for the Department's State Infrastructure Analysis Section. Although only a fraction of the existing facilities is currently reviewed due to limited resources, a computer-assisted system can increase review efficiency. PoC tests have successfully employed semantic segmentation to detect changes in buildings

within satellite imagery. Therefore, this D&IS Plan complements the needs outlined in D&IS Plan SGIM-002 (Acquisition and Analysis of Satellite Imagery and Geospatial Data).

AI/ML Project: Synthetic Data Generation for the Nuclear Solar System

The "Nuclear Solar System" simulates an artificial nuclear fuel cycle, supported by a ML model that generates synthetic data streams based on real data. Highlighted in recent studies, such synthetic data is crucial for AI when original data is limited or needs anonymization. This data not only facilitates training within a simulated nuclear fuel cycle but also enables external sharing, offering value for analysts, partners, and various test scenarios. Therefore, this D&IS Plan complements the needs outlined in D&IS Plan SGIM-008 (Statistical Analysis).

AI/ML Project: Automated Morphological Search in Visual SEM

In response to the growing volume of diverse environmental samples, Visual SEM was developed, a software utilizing ML for particle analysis. It compares elemental compositions of samples globally with IAEA databases, enabling insights into particle origins and associated nuclear activities. This analytical environment is especially valuable for nuclear forensics evaluators comparing detected materials with declared nuclear materials and activities. Therefore, this D&IS Plan complements the needs outlined in D&IS Plan SGIM-007 (Evaluation of Data from Environmental Sampling and Material Characterisation).

Unlocking AI/ML Potential for Safeguards: A Call for Extrabudgetary Support

While SGIM already offers services and tools for information analysis based on modern AI/ML algorithms, there is a strong need for extrabudgetary support. The significant potential AI/ML holds for Safeguards, and the rapid pace at which AI/ML has developed recently, underscores the demand for additional resources. Extrabudgetary support will not only enhance existing ML projects and discover new opportunities, such as generative AI, but also help identify and address risks by establishing guidelines and validation procedures for the responsible use of AI/ML applications in the analysis of Safeguards-relevant information.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☐ Equipment	☐ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☒ Financial Support for Travel	☒ JPOs	☒ R&D	
☒ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

V.1.C2* Ability to receive/collect, process, analyze and evaluate all safeguards-relevant information efficiently and effectively through innovation, integration, and governance

V.1.C4* Ability to leverage emerging technologies, such as artificial intelligence and machine-learning, for exploiting large volumes of safeguards-relevant data to enhance prioritization, change detection and consistency verification

V.4.C2 Ability to comprehensively evaluate, record, and document safeguards effectiveness at the State level

M.2.C1* Ability to strategically plan, maintain and improve safeguards IT tools, information assets, and associated infrastructure

Plan for 2024–2025

★ Indicates top priority

New outcome

Outcome #1: Increased effectiveness and efficiency in collecting and analysing Safeguards-relevant information through Artificial Intelligence/Machine Learning (AI/ML) projects.

Outputs

1. Feedback report on current AI/ML project methodologies to pinpoint potential enhancements related to model accuracy, usability, explainability, and transparency.
2. ★ Comprehensive results from experiments on specific data science work, showcasing the comparative efficacy of alternative methodologies and approaches.
3. Technical meeting with external experts to enhance the capabilities of SGIM data scientists by imparting knowledge on modern approaches in Natural Language Processing (NLP), information retrieval, and computer vision.
4. ★ Training courses designed to equip analysts with fundamental knowledge in AI/ML, specifically tailored to address the unique challenges and requirements of Safeguards information analysis.

Supporting Resource Mobilization Priorities

V.1.C2*	V.1.C4*	V.4.C2	M.2.C1*

Support Needed

SGIM data scientists have integrated AI/ML technologies into Safeguards information analysis, including open-source information support. Proofs of Concept (PoCs) demonstrated successfully the potential of AI/ML in areas like satellite imagery analysis, evaluation of State-declared information, and assistance in identifying undeclared research, among others.

Nevertheless, the highly active research field of AI/ML offers numerous methods and tools to address business challenges. To ensure that analytical capabilities remain up-to-date, the following activities are recommended:

- Engaging in discussions on current AI/ML methodologies with external experts or researchers.
- Documenting alternative approaches that aim to improve model accuracy, usability, explainability, and transparency.
- Organizing workshops to address specific data science topics in current projects, including model robustness, domain adaptation, model explainability, and evaluation metrics.
- Conducting experiments to demonstrate alternative methodologies and approaches.
- Establishing knowledge exchange between SGIM data scientists and external experts to ensure the most appropriate approaches are being employed in assisting analysts with the analysis of Safeguards-relevant information.
- Offering AI/ML training courses tailored for safeguards information analysis, aimed at equipping analysts with foundational techniques, addressing AI concerns, and enabling them to identify and assist in designing AI/ML use cases.

Therefore, an MSSP can contribute with:

- **Human Resources:** Providing CFEs and JPOs with a strong academic background in AI/ML, NLP, or computer vision to conduct experiments to test alternative AI/ML methodologies.
- **Consultants:** Supporting collaboration with international AI experts to exchange and reflect on current AI/ML approaches.
- **Expert meeting participation:** Sharing technical expertise to identify and discuss alternative approaches of AI/ML currently used in AI/ML projects. Support with the design of an AI/ML training programme tailored for Safeguards information analysis.
- **Expert meeting participation/R&D:** Workshop or research on specific challenges identified in current projects, such as model robustness, domain adaptation of pre-trained models, model explainability, and suitable evaluation metrics.

New outcome

Outcome #2: Increased knowledge of new opportunities and potential risks of generative artificial intelligence (AI) and other recent AI breakthroughs for information analysis.

Outputs

1. ★ Hosting of a technical meeting with SGIM data scientists to identify and document new applications of generative AI and other recent AI breakthroughs for Safeguards, and potential risks conflicting with IAEA agreements, security regulations, or Safeguards guidelines.
2. Implementation of a Proof of Concept (PoC) and guidelines to increase awareness and information validation capabilities.
3. ★ Implementation of two or more Proofs of Concept (PoCs) for selected applications to demonstrate technical feasibility and address identified risks.
4. Attendance at academic or industrial conferences focused on the applications of modern Natural Language Processing (NLP) methods, generative AI, large language models, and computer vision.

Supporting Resource Mobilization Priorities

V.1.C2*	V.1.C4*	V.4.C2	M.2.C1*

Support Needed

This outcome aims to identify new opportunities emerging from the latest AI/machine learning (ML) breakthroughs, like generative AI, large language models, and vision transformers. Although these methods have received significant attention in several industries, the Department's focus is on analysing Safeguards-relevant information and its inherent risks and challenges. Efficient support for Safeguards requires close collaboration with safeguards experts through workshops or working groups. PoCs will demonstrate the feasibility of proposed applications. Another essential output is ensuring that SGIM data scientists are able to attend key conferences on generative AI, large models, and computer vision to stay up-to-date.

To achieve these objectives, the following activities are planned:

- Developing PoCs to demonstrate the benefits of new technologies for Safeguards, while also addressing emerging risks, such as the increasing prevalence of generated fake information.
- Integrating successfully conducted PoCs into existing tools or developing new prototypes that leverage the capabilities of generative AI, large language models, and methods from the field of computer vision.
- Organizing workshops to bring together experts in generative AI, large language models and computer vision with experts to identify new opportunities and potential risks for Safeguards.
- Enhancing the capabilities of SGIM data scientists to apply generative AI, large language models, or vision transformers by attending external training courses or conferences.
- Organization of training courses to raise awareness of the potential misuse of AI-generated content in open sources, such as "deep fakes." This ensures that validation of information takes into account the potential risks posed by emerging generative AI technologies.

Therefore, an MSSP can contribute with:

- **Human Resources:** CFEs and JPOs can provide technical support for the development of PoCs or prototypes to demonstrate the feasibility of proposed applications.
- **Consultants:** Supporting collaboration with international experts to help with the identification of new opportunities using generative AI, large language models, or vision transformers.
- **Expert meeting participation:** Sharing best practices and experiences from projects that leverage generative AI, large language models, or vision transformers.
- **Financial Support:** Enabling SGIM data scientists to attend relevant conferences.
- **Financial Support for AI tool Development:** Integration of new AI capabilities based on generative AI, large language models, and vision transformers into existing processes or tools.

New outcome

Outcome #3: Increased knowledge of developing methodologies to incorporate and capture Subject Matter Experts (SMEs) knowledge.

Outputs	1. ★ Identification of methods to systematically capture SME knowledge to ensure the long-term preservation of their expertise, utilizing techniques such as ontologies, knowledge graphs, and rule-based methodologies. 2. Outlined methods that integrate SME knowledge into data-driven strategies. 3. ★ Development of Proofs of Concept (PoCs) to showcase how integrating SME knowledge can enhance accuracy and interpretability of data-driven methods.

Supporting Resource Mobilization Priorities		
V.1.C4*	V.4.C2	M.2.C1*

Support Needed

Many Department SMEs possess invaluable expertise in various aspects of the nuclear fuel cycle, and they play a crucial role in advancing IAEA goals. Their expertise is captured in collected literature, multimedia resources, rulesets, reports, and more. For data-driven approaches, this knowledge should be represented in structured formats, like knowledge graphs or rule-based methodologies. Once the knowledge is structured, methods are needed to incorporate them into data-driven algorithms. Such approaches, often termed "knowledge-infused learning," represent a relatively new field but hold the potential to greatly enhance the effectiveness and efficiency of analysing Safeguards-relevant information.

To achieve these objectives, the following activities are required:

- Identification of internal, Department sources that contain valuable SME knowledge of different fields of the nuclear fuel cycle.
- Review of technologies that are suitable to represent SME knowledge in Safeguards in a structured and reusable way.
- Development of PoCs that demonstrates the representation and retrieval of SME knowledge.
- Exploration of data science approaches that enable the integration of SME knowledge into data-driven systems.

Therefore, an MSSP can contribute with:

- **Human Resources:** CFEs and JPOs can provide technical support in the development of PoCs to demonstrate the feasibility of the suggested approaches.
- **Consultants:** Supporting close collaboration with experts for advice on suitable methods of representing and using expert knowledge for data-driven approaches.
- **Training Courses:** Knowledge transfer in knowledge representation techniques, such as ontologies or knowledge graphs.
- **Expert meeting participation:** Workshops with experts with strong academic backgrounds in "knowledge-infused learning" to discuss ways to incorporate expert knowledge into data-driven systems.
- **R&D:** Research and evaluation of data science approaches that can integrate expert knowledge into data-driven algorithms.

New outcome

Outcome #4: Enhanced accountability, responsibility, fairness, and transparency through appropriate guidelines and a validation framework for information analysis in Safeguards.

Outputs	1. A review and categorization of existing responsible artificial intelligence (AI) frameworks and an analysis of their relevance and suitability for information analysis in Safeguards. 2. ★ Guidelines for the responsible use of AI and validation procedures tailored to the specific needs of Safeguards, emphasizing transparency, fairness, non-discrimination, and compliance with IAEA agreements and governance standards. 3. Recommendations on how the proposed guidelines and validation procedures can be integrated into specific data science practices, including algorithm design, model explainability, and bias assessments.

Supporting Resource Mobilization Priority

M.2.C1*

Support Needed

The latest advances in generative AI and large language models offer significant potential to improve the effectiveness and efficiency of analysing Safeguards-relevant information. However, they also bring new challenges regarding their responsible use. While several reference frameworks exist (e.g., the Institute of Electrical and Electronics Engineers' (IEEE) CertifAIEd and the United Nations' Principles for the Ethical Use of AI), their applicability to Safeguards requires assessment.

While SGIM already incorporates principles of transparency, accountability, non-discrimination, and privacy, the following activities are required to establish comprehensive guidelines and validation procedures for AI developments regarding Safeguards-relevant information analysis:

- Collecting and reviewing existing responsible AI frameworks, such as IEEE CertifAIEd and Principles for the Ethical Use of AI in the United Nations System.
- Assessing if those guidelines are applicable for the analysis of Safeguards-relevant information.
- Developing guidelines and validation procedures for the responsible use of AI tailored to the specific needs of the Department.
- Suggesting specific data science practices to align with these tailored guidelines.

Therefore, an MSSP can contribute with:

- **Human Resources:** CFEs and JPOs that provide support for the development of Proofs of Concept (PoCs) to demonstrate how data science methods can incorporate the proposed guidelines for the responsible use of AI, e.g., by prioritizing transparency, non-discrimination, accountability, or privacy, especially in the context of generative AI and large language models.
- **Consultants:** Consultants that provide technical expertise to recommend data science practices aligned with proposed guidelines and conduct a thorough review and evaluation of current considerations for the ethical use of AI in analysing Safeguards-relevant information.
- **Reference materials:** Providing documents and/or studies about existing reference frameworks that are relevant for the development of responsible AI guidelines for information analysis in safeguards.
- **R&D:** Research specific data science topics related to responsible use of AI, including the detection and mitigation of model bias, explanation of model predictions, etc.

SGIS-002: Information Security and Infrastructure

Established

2010

Manager	SGIS Director
Michael Scott PARTEE	John COYNE

Objective

Ensuring the confidentiality, integrity, and availability of the information entrusted to the Department.

Agency Programme and Budget Link

4.1.9.003 Security

Plan Abbreviations

AI	Artificial Intelligence
DR	Disaster Recovery
PKI	Public Key Infrastructure

Context Highlights

Areas of greatest risk

The 2024–2025 D&IS Plan for Information Security and Infrastructure focuses on the current areas of greatest risk concerning the Department's information while reserving capacity for understanding and reacting to future threats. This approach maintains an equilibrium, ensuring a continuous stream of solutions that defend the Department's information against unauthorized disclosure, alteration, or destruction while ensuring that the present threats and vulnerabilities are managed with an understood level of risk.

In its annual assessment of the top information security risks, the Department identified the following risks and threats that can be shared in this D&IS Plan:

- Advanced and persistent cyber threat actors targeting the Department's information assets.
- Increased cybercrime activity due to the proliferation of new attacks techniques including more advanced phishing tactics; business email compromise attacks; impersonation attacks; and many types of social engineering attacks including those powered by artificial intelligence (AI).
- Lack of sufficiently developed capabilities to combat new attack techniques and the most advanced types of attacks such as file-less malware and "living off of the land" style tactics.
- The ability to attract and retain a sufficiently skilled and diverse workforce.
- The increased profile of the IAEA and the Department on the global stage has resulted in renewed interest by "hacktivist" groups seeking to discredit global nuclear Safeguards activities and a corresponding interest in compromising the integrity and confidentiality of the Department's information.
- Aging facilities at IAEA headquarters leading to unintended interruptions in information services, staff locations, and increased vulnerabilities and reliability issues in the physical security system.

The Department also encounters numerous risks and threats that cannot be elaborated upon in this D&IS Plan, either due to high sensitivity or their relatively lower criticality. Nevertheless, effective management of these concerns is imperative.

SGIS-002 Highlights from 2022–2023

In 2022–2023, the Department strengthened its information security, business continuity, and disaster recovery (DR). These accomplishments were made possible through the collaboration and substantial resources from MSSPs.

A focal accomplishment emerged as the Department devised and enacted an array of security operations procedures, formatted as "run books," (a reference guide for Department staff members to follow in order to manage specific scenarios) written to address the most probable cyber-attack

scenarios. Through collective efforts with other projects and activities, the Department established foundational DR capabilities in Seibersdorf and began the initial testing to improve the capability to continue operations in the Integrated Safeguards Environment (ISE) in the case of a severe disruption of the IT systems at IAEA headquarters.

Moreover, the Department capitalized on MSSP support to facilitate knowledge enrichment, skills development, cyber threat intelligence, and the exchange of threat-related insights, which enabled the Department to stay ahead and protect its digital assets and operations.

A pinnacle achievement was upgrading the physical security management system. The security landscape of the Department's IT environments was further improved through ongoing security assessments, vulnerability management, and threat assessment practices. This contributes to a comprehensive security strategy that protects assets, data, operations, and reputation, while also ensuring compliance with regulations and minimizing potential risks and disruptions.

Priority Activities in 2024–2025

While the core threats and vulnerabilities faced by the Department persist in a manner similar to the preceding biennium, there has been a shift in emphasis. This adjustment is a result of accomplished initiatives that effectively mitigated certain risks, driven by the Department's informed response to evolving threat and vulnerability intelligence.

The Department intends to focus on several of the highest information security risks:

- Persistent and targeted cyber intrusions and cybercrime orchestrated by continuously evolving and progressively adept threat actors.
- Aging facilities and infrastructure at IAEA headquarters, including the physical security system.
- Inadequate DR capabilities potentially compromising the fulfilment of BC requirements.
- Challenges in sourcing, recruiting, and retaining skilled professionals in the field of cybersecurity and information technology.
- Lack of well-defined security polices, established processes, and effective tools tailored to emerging computing paradigms like artificial intelligence and cloud service management to defend against new types of attacks that leverage artificial intelligence techniques.
- Environmental, kinetic, and health risks related to extraordinary safeguards circumstances, such as conducting activities in conflict zones and endemic infection scenarios.

The Department's strategic objectives to address these risks include:

- Enhancing and expanding endpoint detection and response capabilities to effectively cover the extensive array of the Department's mobile computing devices.
- Identifying and remediating vulnerabilities in the Department's information systems, as well as its associated development and operational endeavours through improved tools, processes, and the augmentation of skills and knowledge among the responsible Department staff members.
- Maintaining and increasing cooperation with cybersecurity practitioners across the Agency, Vienna Based Organizations, international entities, and Member States to establish robust security controls, foster mutual assistance, and facilitate the exchange of current cyber threat intelligence.
- Applying a diverse array of resources through both traditional and non-traditional partnerships including expert engagements, CFEs, JPOs, and consultants to complement the Department's world-class, diverse cybersecurity team, and to ensure the team has the essential skills and capabilities for conducting efficient and effective cybersecurity operations.
- Ensuring the continuous improvement of BC capabilities through collaborating with a full spectrum of practitioners as well as iteratively improving the full development and testing of DR capabilities in Seibersdorf and Regional Offices.
- Implementing targeted improvements in cybersecurity operations and security platforms based on realistic threat and risk scenarios while examining the emerging and prospective threats and vulnerabilities and formulating the necessary remediation activities to address these evolving challenges.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☐ Equipment	☒ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☒ Financial Support for Travel	☒ JPOs	☒ R&D	
☒ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

M.2.C1* Ability to strategically plan, maintain and improve safeguards IT tools, information assets, and associated infrastructure

M.4.C2* Ability to carry out mission-critical functions – needed for continued delivery of safeguards conclusions – in case of disasters (e.g. disruptive, massive cyber-attack or physical loss of critical infrastructure)

T.3.C1* Ability to secure information and quickly detect and respond to security events in the Department's information systems using the latest advances in technology such as artificial intelligence

W.4.C1* Ability to attract and retain a diverse and balanced workforce in terms of geographic origin, gender, and age

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: Information security risk mitigation through an effective information security management system and security operations.

Outputs

1. Addition of automated detection and response capabilities that integrate into the Department's security operations.
2. The operation and continuous improvement of an information security programme that focuses on the Department's risks and adapts to the continuously-evolving technological and threat environments.
3. Establishment of a robust framework for risk, threat, and technical security controls guided by strategies to mitigate targeted cyber intrusion and bolstered by at least three security assessments per year.
4. Establishment of a security awareness programme with 90% of Department staff member participation and a phishing awareness training course and testing to achieve a 5% reduction in "click rates."

Supporting Resource Mobilization Priorities

T.3.C1*	M.4.C2*	W.4.C1*

Support Needed

The Department's combination of a mobile workforce, specialized mission, and unique range of cyber threats poses a challenge for those responsible for operating the supporting IT systems. A significant area of concern lies in the vulnerability of mobile computers carried by virtually all Department staff members, especially inspectors and technicians engaged in global operations. Addressing this risk compels the Department to invest in an advanced endpoint detection and response solution. A solution will fortify the existing security operations capabilities, bridging critical gaps in cyber-attack prevention and detection.

To this end, the Department intends to procure a solution and establish a comprehensive programme to optimize its configuration, integrate with existing cybersecurity tools, and tune for timely and effective alerting. This solution will introduce cutting-edge technologies to the Department's security operations that are, at present, unavailable. Procuring this solution and ensuring its optimal deployment may necessitate additional budgetary allocation, as well as potential expert engagements, JPOs, or CFEs.

In addition to this most critical area of risk, the overall Department information security management system is in place and operating in order ensure that security activities are conducted as an intrinsic part of IT development and operational processes as appropriate. Central to this system are the policies and procedures that underpin the tools, technologies, tactics, and personnel responsible for creating, managing, and safeguarding the Department's information

technology solutions. Expert engagements to help refine realistic threat scenarios and define threat actors, as well as develop incident response procedures been effective in the past, and such support may be requested in 2024–2025. Additionally, tools to support these security processes can be costly, and the Department may seek financial support and expert engagements to procure, configure, and train the Department's security practitioners on their use.

Aligned with its information security strategy, the Department emphasizes the vital security controls to counter the risks posed by targeted cyber intrusions. One of the key elements of this strategy is finding and removing vulnerabilities from the Department's information technology environments. While automated vulnerability discovery processes are already in place, their effectiveness is further augmented through a regular series of security assessments. These assessments are often conducted by third party experts and sponsored through Member State support, and the Department intends to continue to seek support. Specifically, seeking assistance for conducting a minimum of three targeted or comprehensive security assessments annually, through avenues such as expert engagements or financial support, remains a priority.

Recognizing that Department staff members play a pivotal role in upholding the confidentiality and integrity of its information, the Department invests in robust security awareness initiatives and tools. This investment ensures that they possess the necessary knowledge to handle entrusted data from Member States. The Department seeks to improve and expand security awareness offerings by continuing to refine the standard email phishing awareness programme; developing smaller scale and highly targeted awareness briefings and material for specific target audiences; enhancing or redesigning online information classification, handling, and protection courses; and engaging in "whole house" IAEA-wide security awareness activities. Such improvements would necessitate extrabudgetary resources as well as potential expert engagements in the form of meetings or leveraging existing CFE arrangements for information security awareness in the Agency.

Continued outcome

Outcome #2: Increased trust in the Department's information and systems through improved security engineering and enhanced solutions for secure communications, data protection mechanisms, and data exchange.

Outputs	1. ★ Continuous improvement of the Department's software development security practices through investment in Department staff members' skills; refined processes surrounding the secure development life cycle; and tools that identify and correct security issues in the Department's code. 2. The implementation of a public key infrastructure (PKI) solution that provides the integrity and confidentiality controls necessary for Department information and is resilient for current and future attack scenarios, with resilience against a simulated "post-quantum" attack including "post quantum" computing. 3. Secure communications solutions for in-field activities and remote office work that protect highly-confidential information. 4. Formulation and implementation of realistic security measures for future technologies, including Artificial Intelligence (AI), cloud computing, strategies, and techniques to detect and to defend against new types of attacks that leverage cutting edge technologies such as deep fakes and autonomous robotic attackers.

Supporting Resource Mobilization Priorities	
T.3.C1*	M.2.C1*

Support Needed

Support for the Continued Improvements to Software Security: To sustain the ongoing advancements in software security, extrabudgetary funds are essential for procuring necessary tools and training. The Department is committed to progress across all aspects of this critical domain and supporting the individuals responsible for these efforts. However, further assistance will be required, including funding for comprehensive training initiatives, facilitating expert exchanges, and acquiring and maintaining essential tools.

Enhancing the Agency's PKI: The Agency's PKI, which is the root of trust for many of the sensitive cryptographic activities in the Department, underwent a complete upgrade in 2022–2023. The Department expects that many systems will be required in the near future that will use trusted and strong cryptography to protect the confidentiality and integrity of the Department's data. The integration of such systems with the existing root of trust may require collaborations with Member States through expert exchanges, financial support for acquiring tools, and engagement of professionals to guide the integration work. Additionally, the PKI system faces a future threat in the form of quantum computing, potentially undermining improperly implemented or inadequate ciphers and algorithms. A study or R&D effort related to "post-quantum" computing would be beneficial, and the Department would coordinate and leverage such initiatives for broad applicability across its systems.

Advancing Secure Communications Solutions: Given the diverse secure communications requirements of the Department, including high-stakes person-to-person interactions within high-information security threat environments, continuous enhancements and increased efficiency are imperative. The Department intends to explore areas of high-security communications and seeks support from Member State experts, both in terms of expert engagements and financial support, to pilot and implement potential solutions.

Adapting to Emerging Technology Paradigms: Future and present computing paradigms, as well as nascent and fast-evolving technology fields, compels the Department to prepare for change and adapt its approach to delivering and securing information technology services. The Department must adapt its protections to address new threats, such as quantum computing and artificial intelligence-based attacks, and it must also explore comprehensive security frameworks for emerging computing and information delivery models, such as cloud-based services and how they can be safely utilized in the Department's business process without subjecting Safeguards information to the risk of unauthorized disclosure or alteration. The Department intends to seek expert engagements in several potential forms, such as CFEs, consultants, and expert engagements. The Department may also seek extrabudgetary support for activities to define and deploy the necessary security controls to mitigate these risks.

Continued outcome

Outcome #3: Increased trust in the Department through enhanced physical security and environmental security solutions.

Outputs	1. ★ Delivery/implementation of the physical security management system refresh work packages at IAEA headquarters. 2. Assessments of the physical security tools in the Tokyo and Toronto Regional Offices.

Supporting Resource Mobilization Priority

T.3.C1*

Support Needed

In 2022–2023, a collaborative effort involving the Department and multiple stakeholders across the Agency was initiated to address the risks associated with the aging system responsible for managing physical access control, alarms, and video tools within IAEA headquarters' access control and monitoring system. Following a thorough assessment, it was determined that the most cost effective and best course of action to improve the system was to refresh the existing system rather than a complete replacement. The project was divided in two phases: addressing immediate and essential requirements and outlining a phased strategy for replacing aging physical components.

The essential package of upgrades has been successfully funded and executed. However, the longer-term process of replacing aging physical components will begin in 2024. In order to complete this work, the Department will actively seek extrabudgetary support.

As part of both the refresh project's lessons learned analysis and the Department's ongoing commitment to management of its physical security system, a comprehensive review of the physical security systems in regional offices is planned. This review aims to ensure the sustained effectiveness of these systems over the long term while also optimizing resource allocation like hardware, software, and personnel.

Continued outcome

Outcome #4: Securely enabling the Business Continuity of the Department through the provision of reliable, resilient, and highly available IT infrastructure even during a disruptive event.

Outputs	1. Iterate on the Disaster Recovery (DR) capabilities in Seibersdorf to expand the capabilities and improve the efficiency and effectiveness of its DR solutions testing and learning. 2. Establishment of a fully equipped alternative facility for the Tokyo Regional Office that is fully prepared for use in the event of the Tokyo office's unavailability as well as the identification of potential alternative arrangements for other facilities. 3. Effective and secure business continuity capabilities for in-field activities in high-threat environments.

Supporting Resource Mobilization Priorities	
T.3.C1*	M.4.C2*

Support Needed

The Department is dedicated to expanding and testing the capabilities of the DR environment in Seibersdorf. This endeavour may require enlisting expert engagements and securing financial support.

The Department's alternate arrangements in already-identified locations for regional offices will be supplied with the necessary infrastructure and procedures, which will also be assessed for security and improved as needed. To ensure this, the Department may require information exchanges with Member State experts and financial resources for adequate training and assessment activities. Additional alternate locations may also be explored for regional office and arrangements for which none exist, which may require assistance from Member States with the effort to identify suitable hosting parties for these arrangements.

The Department will continue to collaborate with stakeholders and practitioners across the Agency, the United Nations system, and with Member States. This aims to augment the Department's ability to sustain operational continuity and safeguard both personnel and information in high-risk environments. In addition to information exchanges and expert engagements, the Department may seek financial support to bolster these efforts, aligned with the overarching "whole house" approach to coordinated activities.

SGIS-003: Safeguards Information Systems and System Usability

Established

2014

Manager	SGIS Director
Remzi KIRKGOEZE	John COYNE

Objective

Securely enabling the operation of the Department through the provision of IT applications and IT equipment that are maintained, enhanced, and/or developed.

Agency Programme and Budget Links

4.1.9.001	ICT Development
4.1.9.002	ICT infrastructure and support

Plan Abbreviations

AI/ML	Artificial Intelligence/Machine Learning
APA	Acquisition Path Analysis
CASCADE	Centralized Automated System for Correlated Analysis and Data Evaluation
IRAP	Integrated Review and Analysis Platform
ISE	Integrated Safeguards Environment
ISP	Integrated Scheduler Planner
IT	Information technology
NAMIS	Neptunium and Americium Information System
NMA	Nuclear Material Accountancy
QC	Quality Control
SEEIS	Safeguards Effectiveness and Evaluation Information System
SGIS	Office of Information Systems
SIR	Safeguards Implementation Report
SLA	State Level Approach
SMT	Service Management Tool
SNRI	Short Notice Random Inspections
SSAC	State Systems of Accounting for and Control of Nuclear Material
SSDH	State Supplied Data Handling

Context Highlights

Safeguards Information Systems and System Usability Update

The Department's IT landscape continues to evolve. With over 30 applications, the Department maintains data consistency, drives high-quality outputs, and streamlines staff time management. The focus now includes deeper integration of applications, digital transformation, and automation of work while maintaining a rigorous cost-benefit analysis. IT remains central to the Department's business operations, supporting efficiency and value delivery to its users.

The importance of Information Technology (IT) to the Department of Safeguards has never been greater in a time when technological advances are reshaping the landscape of modern-day business. IT is not merely a support function; rather, it is the hub around which the daily operations revolve, empowering the Department to increase its productivity, boost its decision-making, and ultimately provide great value to Department users.

Enhanced IT Landscape: Over 30 Applications, Improved Efficiency

The Department has over 30 applications. These applications have increased data consistency across IT applications and applications, produced higher-quality outputs, and enabled more efficient staff time management in the Department. The Office of Information Systems (SGIS) aligns fundamental Department processes with the management of IT application domain processes, including State-Cooperation, Verification, Analysis, and Services. In past years, the Department has continued to enhance these applications and created new ones to support Department processes and increase the effectiveness and efficiency. The domain processes outlined in 2022–2023 enable SGIS to adapt quickly to the changing requirements of Department staff members.

Future Focus: Integration, Digital Transformation, and Efficiency

In previous years, the Department has continued to enhance these applications and developed new ones to support all Department processes to further increase its efficiency and effectiveness. The domain processes outlined in the 2020–2021 Keeping Safeguards IT Updated implementation plan allows SGIS to be agile in meeting the evolving needs of Department staff members. In the coming years, the Department would like to focus more on integration of applications, digital transformation of the Safeguards processes, reduction of manual data entry, and automation of repetitive work.

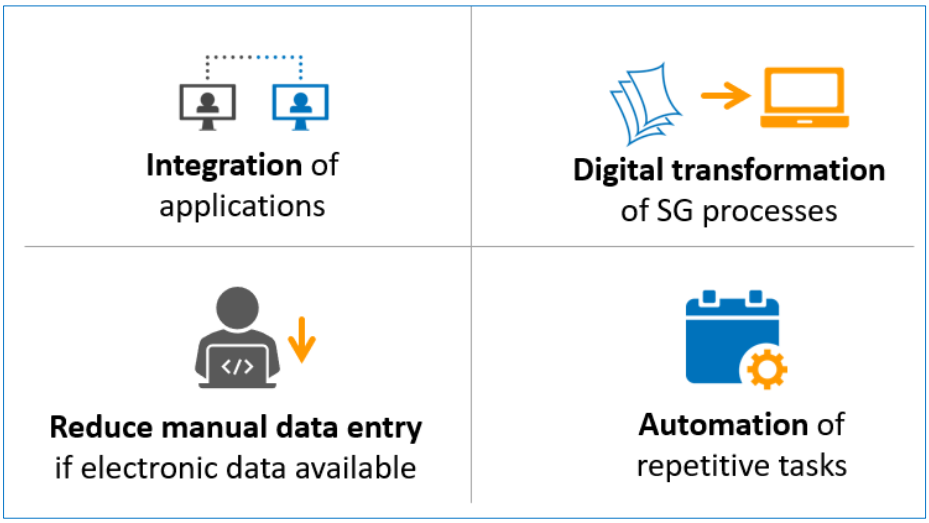


Figure 38: Strategic IT Focus Areas: Integration, Digital Transformation, Efficiency, and Automation.

IT Value Delivery: Cost-Benefit Analysis and Benefit Tracking

During the development of new features and the enhancement of existing ones, the Department will ensure IT value delivery with cost benefit analysis and tracking benefit realization.

As the Department embarks on the path of developing new features and enhancing existing ones, the top priority is optimizing IT value delivery. To achieve this, the Department will diligently conduct cost-benefit analyses as an integral part of its decision-making process.

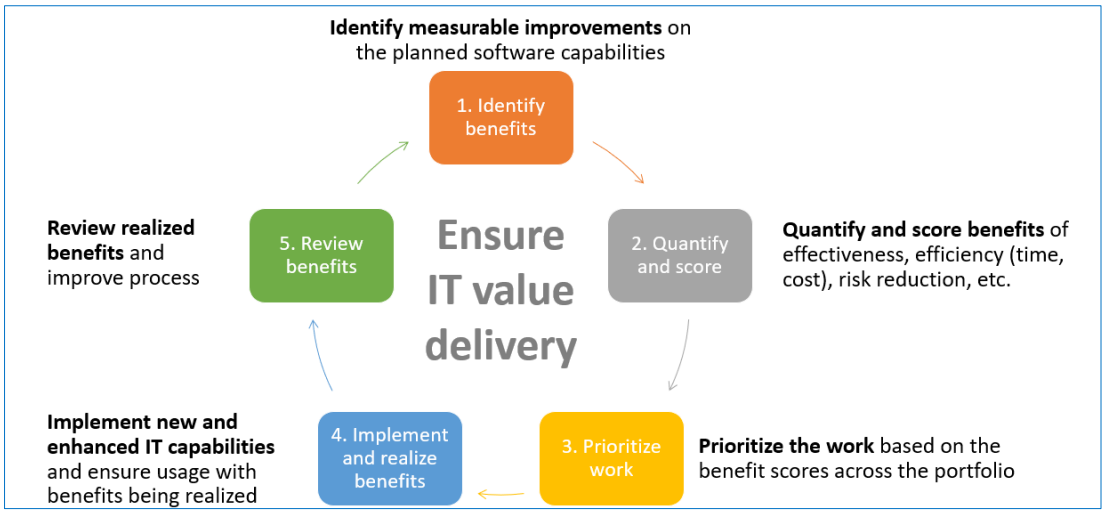


Figure 39: The Life Cycle of Ensuring IT Value Delivery: Identifying, Quantifying, Prioritizing, Implementing, and Reviewing Benefits.

The Imperative of Innovative Technology Adoption and Extrabudgetary Support

Implementing advanced information and communication technology is a fundamental requirement for achieving strategic objectives within the Department. In this ever-evolving technological landscape, it's essential that the Department maintains an advanced technological framework. By embracing these innovations, the Department creates a robust foundation for improved efficiency, flexibility, and adaptability across the entire organization. These technologies provide the Department with data-driven insights that enhance security measures, improve user experiences, and inform decision-making processes. The adoption of innovative practices isn't about personal preference but is instead an essential prerequisite for fostering a culture of continual progress.

However, these goals cannot be fully realized within the existing budget constraints. The regular budget allocation primarily aims to supports operational needs, ensuring that the Department has access to the necessary IT tools to fulfil its mission. However, it does not cover the entire cost. The better the Department works, the more effectively it utilizes the contributions from Member States, both through the regular budget and extrabudgetary support. Therefore, the Department seeks extrabudgetary support to:

- Advance the development of the environment for the efficient development, training, and execution of Machine Learning (ML) Models tailored to various use cases within the Department.
- Conduct a comprehensive analysis of Safeguards data repositories, data flows, and data governance to identify opportunities for enhancing data efficiency.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☐ Equipment	☐ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☒ Financial Support for Travel	☒ JPOs	☐ R&D	
☐ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

M.1.C1	Ability to fully implement data-driven programmatic planning, monitoring and evaluation, to support managerial decision making
M.2.C1*	Ability to strategically plan, maintain and improve safeguards IT tools, information assets, and associated infrastructure
M.2.C2	Ability to enhance equipment reliability through improvements to the Safeguards Equipment
M.3.C3	Ability to assess and improve the implementation efficiency of the Department's system of processes, procedures and supporting tools
M.4.C1	Ability to enhance working practices, leveraging Covid-19 lessons learned (e.g. information architecture, secure cloud services, secure virtual meeting environment)
V.3.C3*	Ability to enhance acquisition path analysis and development of State-level safeguards approaches

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: Increased efficiency of Safeguards processes through consolidation and integration of current IT systems.

Outputs

1. Implementation of robotic process automation for office work.
2. An assurance that all Safeguards equipment produces data in an agreed, future-proof standard format so that data, whether collected manually by inspectors or received remotely, will flow through extractable metadata into the respective target systems, eliminating the need for manual file handling.
3. A defined standard format for Operator Data Declarations, encompassing Operator General Ledgers, Operator Inventory, and real-time verification processes, similar to Nuclear Material Accountancy (NMA) reports through Code 10.
4. Implementation of a Safeguards Message Bus that will enable alternative integration patterns, such as 'publish-subscribe,' making integrations easier to maintain.
5. A Safeguards Service Registry that enables the registration of services and reusable components, centralizes the registration, documentation, and discoverability of all services.
6. A searchable, well-documented data platform that ensures the availability of a robust data platform to support analytical needs for complex data analysis.

Supporting Resource Mobilization Priorities

M.2.C1*	M.2.C2

Support Needed

In line with the goal to enhance efficiency in Safeguards processes through the consolidation and integration of current IT systems, the Department will take the following steps:

- **Process Automation:** The Department will identify repetitive, rule-based, and time-consuming office work and processes. After prioritizing them based on their potential for automation and the benefits it would bring, the Department will develop bots or scripts to automate the selected processes, for example, quality assurance processes of received data.
- **Integrated Review and Analysis Platform (IRAP) Configuration:** The plan is to configure the IRAP system to analyse data obtained from Unattended Monitoring Systems at advanced facilities. IRAP will analyse the measured data from a multi-sensor system and compare the results with item movement declarations provided by the facility operator.
- **IT Service Registry:** The goal is to extend the documentation for all existing IT services, including applications, infrastructure, and software components. Additionally, the Department will implement a process for regularly updating and maintaining the IT Service Registry to centralize the registration, documentation, and discoverability of all services.

- **Data Integration:** The focus is on elevating data integration by creating a data mapping strategy that aligns data schemas and structures across different sources to ensure compatibility. The Department also intends to establish data governance policies to effectively manage, document, and catalogue data.

These activities have received support under MSSP Tasks GER D 2626, CAN D 2660, UK D 2465, USA D 2419 (Keeping Safeguards IT Updated), USA D 2460 (Updating software to support Safeguards review of IAEA Technical Assistance), and USA A 2336 (Expert - User Experience Developer). However, to successfully consolidate and integrate IT systems, the Department is seeking extrabudgetary support in terms of CFEs, JPOs, and financial assistance. MSSP support is instrumental in achieving these essential enhancements, which will ultimately lead to increased efficiency in Safeguards processes.

Continued outcome

Outcome #2: Extended support of Safeguards processes through new IT capabilities.

Outputs	1. A Safeguards Implementation Evaluation Software that facilitates the continuous evaluation of Safeguards implementation activities, ensuring alignment with State Level Approach (SLA) targets and incorporates Safeguards issues to guarantee the satisfactory execution of compensatory measures when issues arise. 2. A standardized Safeguards statistical toolset to be used across all Safeguards processes that includes updated and enhanced algorithms, offering both online and offline accessibility, and compatibility with facility resident software. 3. Integrated Artificial Intelligence/Machine Learning (AI/ML) models in Safeguards applications using the existing AI/ML platform by identifying use cases and developing models.

Supporting Resource Mobilization Priorities			
M.1.C1	M.2.C1*	M.3.C3	V.3.C3*

Support Needed

In pursuit of this outcome, the Department aims to deliver the following detailed outputs:

Data Processing Support for Operator Data

- Enable the processing of Operator LIIs in different formats.
- Configure data processing for all major bulk handling facilities.
- Integrate SSDH to load ICRs for comparison of reports and records.
- Support Short Notice Random Inspections (SNRI).

SGTS Electronic Work Plan (eWP)

- Plan SGTS in-field work activities alongside trip information in the Integrated Scheduler Planner (ISP).
- Ensure that the SGTS work plan is reviewed simultaneously with the trip.
- Incorporate reported incidents and issues documented through the Service Management Tool (SMT).
- Integrate Technical Travel Reports into ISP to report on performed activities.

Nuclear Material Accountancy (NMA) Code 10 Quality Control (QC)

Provide in-browser QC of NMA Code 10 files to reduce errors in declarations and processing time for NMA declarations.

SG Mailbox

- Integrate with the security model and Centralized Automated System for Correlated Analysis and Data Evaluation (CASCADE) to facilitate the retirement of the current SG Mailbox system.
- Provide information to users through CASCADE (Integrated Safeguards Environment (ISE) and SG LAN).

Expansion of the State Systems of Accounting for and Control of Nuclear Material (SSAC) Questionnaire
Expand the new SSAC questionnaire with information from relevant systems to aid users in answering questions effectively.

State Supplied Data Handling (SSDH) Extension
Extend the SSDH system to support Neptunium and Americium declaration information in order to retire the current Neptunium and Americium Information System (NAMIS).

Data Analysis (Data Cube)
- Further develop the Data Analysis (data cube) to support Safeguards Implementation Report (SIR) analysis, enhancing support for Operations.
- Reduce analysis time and increase the completeness of Safeguards knowledge.

SLA Functionality Extension
- Restructure the current model to define performance targets per acquisition step to ensure all technical objectives are met.
- Generate statistics and reports on Acquisition Path Analysis (APA) and SLA information.
- Support SEGs and Operations Divisions in tracking and analysing APA and SLA information and processes.
- Adapt the Safeguards Effectiveness Evaluation System to the new structure of performance targets.
- Supply the Safeguards Effectiveness and Evaluation Information System (SEEIS) with intensity criteria for evaluation.
- Implement quality control for the Annual Implementation Plan and activity randomization.

These activities have received support under various MSSP Tasks, including UK D 2465, USA D 2419 (Keeping Safeguards IT Updated), USA D 2460 (Updating software to support Safeguards review of IAEA Technical Assistance), and USA A 2336 (Expert - User Experience Developer).

To successfully achieve these outcomes and outputs, the Department seeks additional support in the form of CFEs, JPOs, financial assistance for consultants, funding for training, and participation in expert meetings. This collaborative effort will drive progress and innovation within Safeguards processes, ultimately advancing its mission.


Continued outcome

Outcome #3: Enabled digital transformation.

Outputs	1. Integration of automation and Artificial Intelligence (AI). 2. A comprehensive case study investigating cloud capabilities.

Supporting Resource Mobilization Priorities			
M.1.C1	M.2.C1*	M.3.C3	M.4.C1

Support Needed

The plan is to:
- Identify key business processes that can benefit from automation and AI.
- Develop use cases and pilot projects to demonstrate the value of these technologies.
- Integrate them into existing workflows gradually.

In the interest of innovation and operational efficiency, the Department wants to start a proof of concept (PoC) to investigate the potential of cloud technology. The major goal is to validate the feasibility and benefits of incorporating cloud capabilities into the existing infrastructure. Key Components of the PoC will be cost-benefit analysis, scalability and performance, data security, and operational efficiency.

The primary achievements from this PoC would include:
- **Validation of Cloud's Feasibility:** The PoC will determine if cloud technology is a practical fit for the Departments' unique requirements.

- **Quantified Benefits:** The Department will provide a quantified assessment of the benefits in terms of cost savings, improved performance, and data security.
- **Risk Mitigation:** Identifying potential challenges and risks will enable the development of risk mitigation strategies.
- **Data Security Assurance:** Ensuring that cloud technology aligns with Department data security and compliance standards is of utmost importance.

The Department requires support in the form of CFEs, JPOs, financial support for consultants, funding for training, and participation in expert meetings.

To enable the Department's digital transformation initiatives and achieve the desired outcome, the following support would be essential:

- **Integration of Automation and AI:** The Department's goal is to identify key business processes suitable for automation and AI enhancements, and the Department intends to develop use cases and pilot projects that showcase the value these technologies can bring. This approach allows us to gradually integrate automation and AI into existing workflows.
- **Comprehensive Case Study on Cloud Capabilities:** The Department aims to explore cloud capabilities to determine their efficiency for hosting Safeguards processes and consider full life cycle costs. The case study will include a thorough business analysis and a medium-term cost/benefit evaluation, factoring in various licensing models. The primary takeaways from this study will include validating the feasibility of cloud technology, quantifying benefits, identifying potential challenges, and ensuring data security compliance.

To achieve these objectives, the Department seeks support of CFEs, JPOs, financial resources for expert consultants, funding for training, and participation in expert meetings.

By providing the necessary support, the Department can ensure a successful digital transformation, enhancing the efficiency and effectiveness of Safeguards processes. This, in turn, will help the Department better fulfil its mission and uphold the highest standards of data security and operational efficiency.

SGTS-001: Non-Destructive Assay (NDA) Techniques

Established

2006

Manager	SGTS Director
Davide PARISE	Alexey ANICHENKO

Objective

Pursuing development of non-destructive assay (NDA) systems and techniques to improve verification capabilities, reduce deficiencies and vulnerability of current systems and techniques, and address new Safeguards needs.

Agency Programme and Budget Links

4.1.6.001	Provision of Safeguards Instrumentation and Services
4.1.6.002	Development of Safeguards Instrumentation

Plan Abbreviations

CTGS	Compact Tomographic Gamma Scanner
CZT	Cadmium Zinc Telluride
DA	Destructive Assay
DD	Deuterium-Deuterium
FABIA	Fieldable Atomic Beam Isotopic Analyzer
FFA	fresh fuel assemblies
FNCL	Fast Neutron Coincidence Collar
HM-6	Hand Held Monitor Version 6
IFAD	In-Field Alpha Spectrometry (system)
JUE	Joint Use Equipment
KINAC	Korea Institute of Nuclear Nonproliferation and Control
LANL	Los Alamos National Laboratory (USA)
MCAT	Multichannel Analyser - Touch (software that supports NDA measurements)
MCCM	MCAT-based Cadmium Zinc Telluride Module
MGA/MGAU	Multi-Group Analysis/Multi-Group Analysis code for Uranium
MTR	Materials Test Reactor
NDA	Non-Destructive Assay
OFPS	Optical Fibre Radiation Probe System
PNNL	Pacific Northwest National Laboratory (USA)
SUDA	Single Use Destructive Assay
UNCL	Uranium Neutron Coincidence Collar

Context Highlights

The Role of Non-Destructive Assay (NDA) Techniques in Safeguards

NDA techniques are vital tools in nuclear safeguards, providing a non-invasive means to verify and monitor nuclear materials without compromising their integrity. This is paramount for ensuring compliance with international agreements and treaties, as NDA methods facilitate the timely verification of nuclear material, thereby enhancing the overall efficiency of Safeguards operations.

The non-intrusive nature of these techniques is particularly advantageous, allowing for frequent monitoring while mitigating radiation exposure risks. Furthermore, the standardization of NDA methods fosters international collaboration by establishing a common framework for verification processes. Concurrently, NDA techniques contribute to the continuous evolution of technological innovation within the field of nuclear safeguards.

Achievements

In 2022–2023, the most significant accomplishment was the authorization of the Multichannel Analyser - Touch (MCAT)-based Cadmium Zinc Telluride (CZT) Module (MCCM) for Safeguards verifications. The MCCM, a portable gamma radiation detection system, includes an MCAT and a H3D M400 CdZnTe detector module. Operating in an attended mode, this portable device is authorized for use in various facilities, aiming to replace current medium- and low-resolution detectors employed for verification. At present, the MCCM detector has been authorized for use alongside the MCAT software and a laptop PC in table-top version. Ongoing efforts are focused on developing a handheld hardware and software platform that will enable the MCCM to be used in a handheld mode as well.

The Department has made the decision to standardize the software approach, implementing the use of MCAT on both the desktop and handheld versions of these instruments. This standard approach ensures consistent results across various platforms and streamlines the training requirements for IAEA Safeguards inspectors.

Figure 40: The MCCM attached to a cylinder is to be the "workhorse" of NDA tools for the foreseeable future.

Shifting NDA Priorities

In 2024–2025, this D&IS Plan is set to embrace new development and innovation. Building upon the accomplishments of the previous biennia, the focus remains on completing outstanding work while shifting to tackling other verification challenges that have not yet been explored due to the absence of appropriate verification technologies.

A priority is completing the Hand Held Monitor Version 6 (HM-6) project. The HM-6 is a handheld multifunctional instrument for various measuremens. Its default detector is the MCCM, which utilizes large cadmium-zinc-telluride crystals for enhanced performance. The HM-6 is designed for attended operation and operates as a stand-alone handheld device capable of continuous use throughout a full working day without requiring recharging. Its versatile applications include qualitative and quantitative assessment of Uranium enrichment under infinite thickness conditions and measurements of Uranium content of items such as pellets, rods, Materials Test Reactor (MTR) plates, or various samples.

Furthermore, the Department aims to explore advanced techniques to enhance verification capabilities at enrichment plants. Instruments, such as the In-Field Alpha Spectrometry (IFAD) system and the Fieldable Atomic Beam Isotopic Analyzer (FABIA), in conjunction with Single Use Destructive Assay (SUDA) sampling technique, are already showing potential, and, once established with comprehensive procedures, analysis protocols, and validated SUDA sampling methodologies, could be deployed to further improve timeliness and accuracy in nuclear material verification.

Most Needed External Support in 2024–2025

☐ Financial Support	☐ Consultants	☐ Equipment	☐ Training
☐ Financial Support for IT Development	☒ CFEs	☒ Reference Materials	☒ Studies
☐ Financial Support for Travel	☒ JPOs	☒ R&D	
☐ Expert meeting participation		☒ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

M.2.C1*	Ability to strategically plan, maintain and improve safeguards IT tools, information assets, and associated infrastructure
S.1.C1	Ability to deploy data visualization and other methods and techniques to present safeguards findings and performance-related data in a clear and compelling manner
T.1.C1*	Ability to more efficiently verify and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle, including through remote means
T.1.C10	Ability to rely upon an integrated system of instrumentation data (e.g. spectra) processing and review, with high level of automation and with unified user interface
T.1.C2	Ability to reliably and quickly deliver sample analysis results for special and high priority demands
T.1.C6	Ability to verify nuclear material in containers with heterogenous matrices
T.1.C7	Ability to unintrusively monitor the flow rate of UF6 in cascades and at conversion plants
W.3.C1	Ability to train inspectors on spent fuel measurement techniques inside facilities

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: Improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.

Outputs	1. A new data processing algorithm. 2. Performance evaluation and authorization of the Compact Tomographic Gamma Scanner (CTGS).

Supporting Resource Mobilization Priorities

T.1.C6	T.1.C10	S.1.C1

Support Needed

The Department will continue promoting CTGS activities for evaluating and authorizing the assessment of nuclear waste. Acquired in 2016–2017, the CTGS addresses a verification challenge related to heterogeneous waste and scrap containing nuclear material. Neutron measurements may not be accurate enough to meet the specification for partial defect tests since the matrix of the material (particularly with regard to hydrogen and neutron-absorbing compounds) is unknown and difficult to assay. An alternative solution is transmission-emission high-resolution gamma spectrometry performed at the level of individual voxels in the inspected object.

Under MSSP Task USA A 2369 (Implementation Support of CTGS for Verification of Containers), the Department shipped the CTGS to the Pacific Northwest National Laboratory (PNNL), and PNNL experts will make the necessary improvements. Once the CTGS is ready, PNNL will ship it back to the Department for testing and authorization.

Continued outcome

★ **Outcome #2:** Software standardization throughout different data acquisition platforms to enhance performance and usability of gamma spectroscopy for nuclear material verification and streamlined IAEA Safeguards inspector training.

Outputs	1. Development of a multi-platform version of Multichannel Analyser - Touch (MCAT) deployable on Windows and Linux operating systems. 2. Amendment of the MCAT software to include Multi-Group Analysis/Multi-Group Analysis code for Uranium (MGA/MGAU) modules. 3. Amendment of the MCAT software to include criticality check, reactivity determination, and neutron pulse train analysis modules. 4. Amendment of the MCAT software to include nuclide identification and active length measurement capabilities.

Supporting Resource Mobilization Priorities

T.1.C1*	T.1.C2	W.3.C1	S.1.C1	M.2.C1*	W.3.C1

Support Needed

The Department continues efforts under MSSP Task GER A 2278 (Upgrading of the MCA-Touch Software) to develop a new MCAT version for both Windows and Linux operating systems. Furthermore, the Department is working on enhancing the features and capabilities of MCAT. The MSSP Task GER A 2278 will include the implementation of modules for criticality checks, reactivity determination, and neutron pulse train analysis. Additionally, the MGA/MGAU modules will be incorporated as part of MSSP Task USA A 931 (NDA Implementation Support - Instruments and Techniques).

Moreover, functions previously supported by HM-5, such as nuclide identification and active length measurement, will be transferred to MCAT to fully extend the range of capabilities of the Hand Held Monitor Version 6 (HM-6).

This consolidation effort aims to bring nearly all gamma-spectrometric applications for fresh fuel verification under the MCAT framework, which will serve as the core for both tabletop HM-6.

Continued outcome

★ Outcome #3: Faster verification of fresh fuel assemblies (FFAs) using Non-Destructive Assay (NDA) systems.

Output	1. A Deuterium-Deuterium (DD) neutron generator with the Fast Neutron Coincidence Collar (FNCL) that shortens FFA verification time from minutes to seconds.

Supporting Resource Mobilization Priorities

n/a

Support Needed

The Department developed and authorized the FNCL as a technical solution to the limitations of the conventional Uranium Neutron Coincidence Collar (UNCL) to independently verify FFAs containing burnable poisons. FNCL supports partial defect tests with an active neutron coincidence counting technique without a-priori information about the burnable poison content. The main features of the FNCL are:

- Interrogation of FFAs with epithermal neutrons from a moderated Americium-lithium (Am(Li)) neutron source.
- Detection of fast neutrons (En>0.5 MeV) from induced fission predominantly from U-235.
- Negligible intensity of accidental enabled by a very short coincidence gate (120 ns).

The first and second features significantly reduce the influence of burnable poison content in the material being verified; the third feature increases the interrogation source emission rate (and hence, linearly reduces the verification time) by at least two orders of magnitude with no impact to the precision since the contribution of the accidentals remain negligibly small.

Am(Li) sources, emitting the desired neutron flux (around 1 million neutron/s), are not available and no new Am(Li) sources are manufactured. Isotopic sources of that strength already in existence would also be very difficult to transport internationally. Hence, an alternative solution was identified with integration of a DD neutron generator within the FNCL system. The neutron generator nGen-350 from Starfire Industries was procured in 2019 by the Department and delivered in Q2 2021 (see figure below).

Figure 41: nGen-350 DD neutron generator for use as a neutron interrogation source with FNCL.

The goal is to improve the efficiency of FFA verifications by FNCL with no reduction of its effectiveness by using a DD neutron generator for interrogation of fissile material as an alternative to the conventional Am(Li) isotopic neutron source. In the longer term, use of solid-state neutron detectors in conjunction with FNCL and the neutron generator will be considered.

The Department has limited knowledge and experience in applying neutron generators for NDA. Cooperation with external partners where similar work has been already done would be vital.

The Department seeks support in the development of a FNCL setup, incorporating a transportable DD neutron generator as a source. Assistance is required for the effective coupling of the DD generator with the FNCL, addressing considerations for maintenance and the life cycle management of the DD generator.

New outcome

★ **Outcome #4:** Improved monitoring capabilities for in-process materials at enrichment facilities and enhanced capacity for conducting onsite Destructive Assay (DA) of UF_6 samples.

Outputs	1. Development of a non-intrusive, non-contact technique and instrument for UF_6 gas pressure measurement in cascade header pipes. 2. Development of a non-intrusive, non-contact technique and instrument for UF_6 gas flow measurement in cascade header pipes. 3. Development of the Fieldable Atomic Beam Isotopic Analyzer (FABIA).

Supporting Resource Mobilization Priority

T.1.C7

Support Needed

The Department is seeking assistance in advancing techniques and tools that can improve the monitoring capabilities for materials in the process at Uranium enrichment facilities. Additionally, they aim to enhance the capacity for conducting onsite destructive analysis of UF_6 samples. Enabling non-intrusive UF_6 pressure and flow measurement in cascade header pipes would facilitate the development of a UF_6 monitoring instrument. Such an instrument would have the ability to simultaneously account for both the quality and quantity of the produced material.

Los Alamos National Laboratory (LANL) developed laboratory setups for non-intrusive pressure and flow meters that showed promising results. The Department would like to evaluate the performances of the techniques used in those laboratory setups and, if satisfactory, receive prototype instruments for evaluation.

The Department has expressed interest for the FABIA system developed by LANL. A thorough performance evaluation and subsequent extensive measurement campaign at the Seibersdorf laboratories involving Single Use Destructive Assay (SUDA) samples will be needed before FABIA can be deployed in the field. The Department will need support from Member States to organize testing of the FABIA system in support of its authorization for inspection use.

New outcome

Outcome #5: Support for authorizing the latest version of Optical Fibre Radiation Probe System (OFPS) as a Joint Use Equipment (JUE).

Outputs	1. Documentation for the updated version of OFPS. 2. In-field testing for the latest OFPS version. 3. Assessment of the feasibility of authorizing OFPS as JUE.

Supporting Resource Mobilization Priority

T.1.C10

Support Needed

The Department is seeking assistance in conducting an evaluation to facilitate the authorization of the latest iteration of the OFPS as a JUE.

Originally, the OFPS was developed and used for spent fuel verification in the Republic of Korea (ROK) and received initial authorization for use by the Department in 2007. Over time, the Korea Institute of Nuclear Nonproliferation and Control (KINAC) has made significant enhancements to both the hardware and software components of the OFPS, necessitating a re-evaluation.

Collaborative discussions between the Department and ROK SP have revolved around the potential authorization of the updated OFPS under the JUE framework. To proceed with this authorization, the Department will review documentation, conduct in-field testing of the instrument, and perform assessments, which is crucial to ensure that the joint use of OFPS does not compromise the IAEA Safeguards implementation, security standards, nor its ability to make independent measurements in line with relevant safeguards agreements.

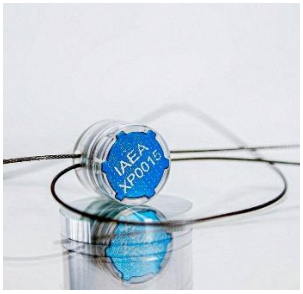
The Department is enthusiastic about advancing the authorization procedure for the OFPS, and the ROK-specific contribution and support are pivotal in propelling this effort forward. Support from ROK SP is essential to facilitate the authorization of OFPS as a JUE. This involves the provision of comprehensive assistance to gather all necessary information, grant access to relevant facilities for testing, and allocate funds to cover travel expenses of IAEA technical staff.

SGTS-002: Techniques and Instruments for Sealing and Containment Verification

Established

2001

Manager	SGTS Director
Martin MOESLINGER	Alexey ANICHENKO



Objective

Improving containment verification systems, identifying vulnerabilities in safeguards equipment, and increasing the data security of all safeguards equipment.

Agency Programme and Budget Links

4.1.6.001 Provision of Safeguards Instrumentation and Services

4.1.6.002 Development of Safeguards Instrumentation

Plan Abbreviations

AUAS	Active Universal Asymmetric Seal
CAPS	Cap seal
EOSS	Electronic Optical Sealing System
FBOS	Fibre-optic General Purpose Seal (also known as COBRA seal)
FVPS	Field Verifiable Passive Seal
INL	Idaho National Laboratory
IRAP	Integrated Review and Analysis Platform
LCCT	Laser Curtain for Containment
mmWR	millimetre-Wave Radar
RMSA	Remotely Monitored Seals Array

Context Highlights

Advancing Safeguard Techniques and Instrument Security

Sealing and Containment Verification are essential technical components in the application of Safeguards measures. IAEA Safeguards inspectors expend significant effort applying seals and verifying containment, often in adverse and potentially dangerous environments such as at elevated heights at the top of spent fuel casks or in high-radiation areas.

To make inspections safer and more efficient, the work performed under this plan aims at reducing sealing efforts, removing the need to access dangerous locations, and minimizing radiation exposure to Departmental staff members in the field.

This D&IS Plan also supports research and work done in an effort to sustain and improve the overall security of any instruments used for Safeguards. That includes the security of data generated by these instruments as well as any active or passive tamper indication technology applicable to maintain such data security and the coordination of related vulnerability assessments.

As outlined in the figure below ("Timeline of when Safeguards seals were authorized."), two major new sealing technologies were recently authorized for routine use by Safeguards: The Field Verifiable Passive Seal (FVPS) and the electronic Active Universal Asymmetric Seal (AUAS). Both new technologies have been designed to enhance efficiency and effectiveness in the application of sealing systems by IAEA Safeguards inspectors while addressing obsolescence of the old Cap seals (CAPS) and Electronic Optical Sealing System (EOSS) seals. The successful development of the FVPS and the AUAS was relying on crucial support by MSSPs.

The provision of FVPSs to IAEA Safeguards inspectors will be ramped up throughout 2024, fully replacing the provision of the old CAPS metal seal by 2025. The ability to perform forensic verification

of the old seals will, however, have to be sustained for as long as there are old CAPS seals remaining in the field, which is expected to take several years.

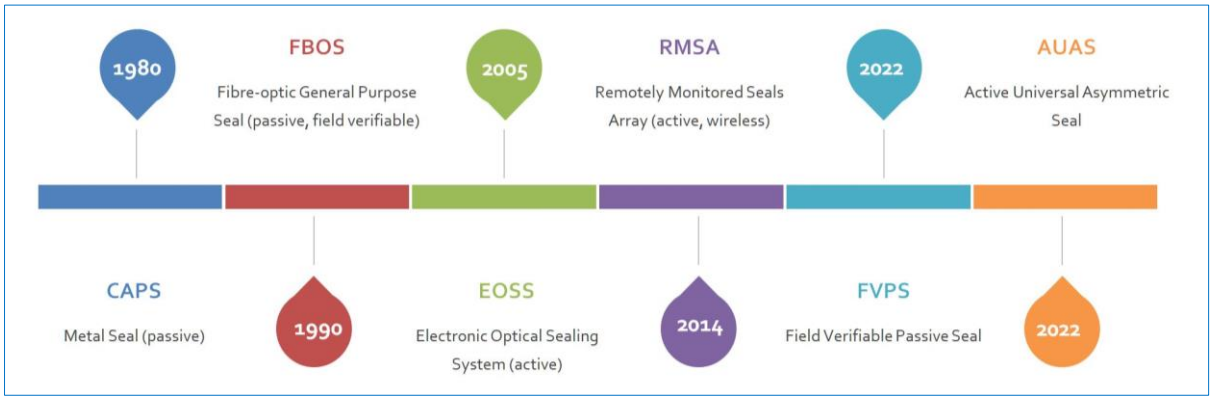


Figure 42: Timeline of when Safeguards seals were authorized.

Exploring Innovative Technologies to Address Growing Nuclear Material Inventory

With the amount of nuclear material under safeguards steadily increasing (i.e., spent nuclear fuel) traditional, passive containment measures become increasingly inconvenient due to the increasing human verification effort required. Active technologies that would alleviate the need for attaching individual seals are promising increased efficiency and will need to be investigated for their applicability in Safeguards applications. Such active technologies emerging on the commercial market include millimetre-Wave Radar (mmWR), advanced fibre-optics, and laser systems.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☒ Equipment	☐ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☐ Financial Support for Travel	☒ JPOs	☒ R&D	
☒ Expert meeting participation		☒ Facility Access	

Plan Resource Mobilization Priority Link

* Indicates a prioritized capability

T.1.C5* Ability to develop, deploy and maintain new sealing system technologies with improved security and efficiency

T.1.C12* Ability to expand the use of robotic technology for verification activities

New Plan for 2024–2025

★ Indicates top priority

New outcome

Outcome #1: ★ Enhanced efficiency and effectiveness of safeguarding nuclear material, leading to improved IAEA Safeguards inspector safety and higher security of installed Safeguards equipment.

Outputs	
	1. Evaluation of the Idaho National Laboratory's (INL, USA) millimetre-Wave Radar (mmWR) technology assessment report.
	2. Development of a mmWR appliance that can be used for current and future instrument enclosures and cabinets.
	3. A benchmarked and tested mmWR appliance in an effort to validate the device for routine use in unattended Safeguards instruments.

Supporting Resource Mobilization Priority

T.1.C5*

Support Needed

Firstly, it is imperative that the ongoing work undertaken by INL as part of a United States of America domestic R&D programme is successfully concluded, and the resulting reports made accessible for evaluation by the Department.

Secondly, the Department is planning to transmit a new MSSP Task Proposal (SP-1) in Q3 2024. This proposal will seek support for the development of the mmWR appliance designed for instrument enclosures and cabinets. Access to technology experts and assistance in coordinating the requisite meetings will be crucial.

Lastly, the Department aims to establish a fully operational and scalable mmWR appliance. This technology is strategically designed to safeguard small- to medium-sized instrument enclosures and would eliminate the need for additional (i.e., passive) sealing methods. An active tamper indicating technology like mmWR would also reduce potential exposure to radiation of IAEA Safeguards inspectors, who otherwise need to spend time verifying passive seals in the field. Subsequently, the appliance will undergo meticulous validation by the Department to ascertain its suitability for Safeguards applications.

In conclusion, this initiative is a significant step towards enhancing the safeguarding of nuclear materials while simultaneously streamlining inspection procedures. Invaluable Member State support in these endeavours is pivotal in realizing these transformative objectives.

New outcome

Outcome #2: ★ Improved efficiency of safeguarding spent nuclear fuel in dry storages by implementing and sustaining state-of-the-art laser-based containment verification systems, ensuring enduring effectiveness and reducing exposure of IAEA Safeguards inspectors to nuclear radiation.

Outputs	1. Advancement in the sustainability and life cycle management of the Laser Curtain for Containment (LCCT) system to ensure long-term effectiveness. 2. Development and authorization of LCCT data review capabilities integrated into the Integrated Review and Analysis Platform (IRAP). 3. Re-engineering of the LCCT-server application software, aligning it with Department requirements for software vulnerability assessments and enhancing overall acceptability.

Supporting Resource Mobilization Priority

T.1.C5*

Support Needed

To bolster the sustainability and life cycle management of the LCCT system, collaboration with LCCT technology developers through MSSP Task EC E 2008 (Identification, Development, Testing and Vulnerability Assessment of Sealing Technologies for International Safeguards) is indispensable. The ever-increasing demand from IAEA Safeguards inspectors for LCCT system implementation necessitates additional human resources, particularly from Cost Free Experts (CFEs). The influx of requests highlights the growing recognition of the system's significance in enhancing the efficiency in applying safeguards at nuclear spent fuel dry storages. Life cycle and sensor technology management of a sustainable version of the LCCT will be accomplished through D&IS Plan SGTS-003 (Surveillance Techniques).

Furthermore, the completion of the development and authorization of LCCT data review capabilities within the IRAP is a pivotal undertaking. Expert advice and financial support are sought to bring this initiative to fruition, aligning it with the overall objectives outlined in D&IS Plan SGTS-014 (Remote Data Transmission and Processing Systems). This collaborative effort will be instrumental in integrating this component into the Safeguards framework, thereby advancing inspection and verification processes.

Lastly, re-engineering the LCCT-server application software to meet Department requirements for software vulnerability assessments is of paramount importance. This effort not only enhances the system's sustainability but also ensures its acceptability and effectiveness in safeguarding nuclear materials. The successful re-engineering requires coordinated support from LCCT technology developers via MSSP Task EC E 2008 (Identification, Development, Testing and Vulnerability Assessment of Sealing Technologies for International Safeguards) and will contribute significantly to the system's long-term security and viability.

New outcome

Outcome #3: ★ Improved application of Safeguards measures through the integration of advanced active sealing methods.

Outputs	1. Implementation and life cycle management of the new Active Universal Asymmetric Seal (AUAS). 2. Development, testing, and authorization of an active seal equipped with wireless communication capabilities, leveraging AUAS technology. 3. Development of a unified seal reader device capable of verifying and interrogating all active and passive Safeguards seals, including Field Verifiable Passive Seal (FVPS), CAPS, Fibre-optic General Purpose Seal (FBOS), Electronic Optical Sealing System (EOSS), and AUAS.

Supporting Resource Mobilization Priority

T.1.C5*

Support Needed

Expertise for Seamless Implementation: The presence of the CFE under MSSP Task USA A 2533 (CFE - Containment and Security Engineer (Seals Team)) is pivotal to the successful implementation of the AUAS. The CFE's expertise and assistance are integral to the intricate process of implementing and managing the AUAS, ensuring its integration into Safeguards.

Financial Backing for Technological Advancements: As the Department incorporates advanced AUAS electronic seals into Safeguards procedures, it is actively seeking financial support. Financial contributions will play a critical role in expediting the procurement or manufacturing of these seals.

Authorization and Field Testing for Innovation: To realize the full potential of the "wireless" AUAS, the Department needs support to secure authorization for its use in safeguarded facilities and initiate comprehensive field tests. This innovative seal, set to replace the aging Remotely Monitored Seals Array (RMSA) seal, will help modernize and strengthen Safeguards.

Enhancing Security Through Technological Transition: The transition from outdated RMSA seals to "wireless" AUAS is a critical to safeguarding nuclear material. Support in facilitating this transition efficiently and effectively is paramount in achieving this outcome.

Facilitating Comprehensive Seal Verification: Building upon the ongoing efforts in universal seal reader development under MSSP Task EC E 2008 (Identification, Development, Testing and Vulnerability Assessment of Sealing Technologies for International Safeguards), the Department is preparing a new MSSP Task Proposal focusing on such seal reader development. Being a single portable device, the unified seal reader will support in-field verification of several active and passive Safeguards seals such as EOSS, AUAS, FBOS (Cobra), and FVPS. The success of this work would hinge on support and is pivotal in the comprehensive verification of Safeguards seals. This not only enhances overall efficiency but also elevates the security measures in place. MSSP support in this endeavour will contribute significantly to achieving Safeguards objectives.

Figure 43: The wireless AUAS prototype.

Figure 44: Prototype of a unified seal reader under MSSP Task EC E 2008 (Identification, Development, Testing and Vulnerability Assessment of Sealing Technologies for International SG).

New outcome

Outcome #4: ★ Improve the application of Safeguards measures through the integration of advanced passive sealing methods.

Outputs	1. Implementation and life cycle management of the new Field Verifiable Passive Seal (FVPS). 2. Technology that enables the objective verification of the FVPS seal wire. 3. Development and implementation of advanced infrastructure that enhances the efficiency of FVPS implementation.

Supporting Resource Mobilization Priority	
T.1.C5*	T.1.C12*

Support Needed

Expertise for Technological Advancements: Support from technology experts is essential for developing reliable FVPS seal wire verification technology.

Infrastructure Enhancement for Efficiency: Financial and technical support is needed to optimize infrastructure, streamline procedures, and integrate FVPS into Safeguards. Given the constraints in human resources, the process of preparing some 10 000 FVPS per year needs to be highly automated by, e.g., utilizing robotized machine vision technology capable of reading the seal IDs, acquiring and archiving FVPS baseline images, and preparing FVPSs for distribution and transportation.

Collaboration with Stakeholders: Member States financial contributions and resources are vital for research, technology transfer, and infrastructure enhancement.

Continuous Evaluation and Improvement: Ongoing assessments and data analysis, with input from experts and inspectors, are necessary to refine and enhance the FVPS technology and implementation. Member States support is crucial for elevating Safeguards measures.

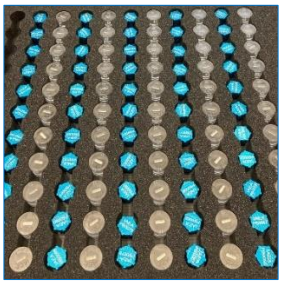


Figure 45: New FVPSs ready for packaging and distribution to IAEA Safeguards inspectors.

Figure 46: IAEA Safeguards Inspectors using the new FVPS.

SGTS-003: Surveillance Techniques

Established

2001

Manager	SGTS Director
Melvin JOHN	Alexey ANICHENKO

Objective

Developing and implementing comprehensive surveillance techniques and replacing legacy surveillance equipment and related instruments used for routine Safeguards inspection activities.

Agency Programme and Budget Links

4.1.6.001 Provision of Safeguards Instrumentation and Services

4.1.6.002 Development of Safeguards Instrumentation

Plan Abbreviations

DCM-A1	next generation analogue camera recording module
DIV	Design Information Verification
DL	deep learning
GARS	General Advanced Review Software
IRAP	Integrated Review and Analysis Platform
LCCT	Laser Curtain for Containment
NGSR	Next Generation Surveillance Review
NGSS	Next Generation Surveillance System
UWB	Ultra-Wideband

Context Highlights

Evolving Surveillance Strategies

2022–2023 saw remarkable strides in the development and authorization of the Next Generation Surveillance Review (NGSR) software, advancements in data analysis algorithms, and the identification of new technologies to bolster the Department's surveillance capabilities. The rollout of NGSR has improved the data review and application sustainability, effectively retiring the legacy review application named General Advanced Review Software (GARS).

However, the Covid-19 pandemic's far-reaching effects significantly impacted operations, underscoring the continued need for adaptability and resilience. In this new phase, the Surveillance Team remains dedicated to enhancing international safeguards. The Department's focus now extends to the development, implementation, and maintenance of comprehensive surveillance solutions and a surveillance replacement project to identify the Next Generation Surveillance System (NGSS) successor technology, supported by sustainable and secure software tools. Because of the substantial number of installed surveillance cameras, such technology replacement is expected to require a large level of effort in terms of capital investment, human resources, and time needed to complete the replacement.

The Department also continues to address ongoing challenges while looking forward to a dynamic future where emerging technologies and robust user requirements drive endeavours.

Comprehensive Surveillance Solutions and Sustainable Software Tools

As mandated by programmatic requirements, this D&IS Plan's overall objective is to develop, implement, and maintain comprehensive surveillance solutions and replace legacy surveillance equipment and instruments used for routine Safeguards inspection activities. Important parts of any surveillance solution include highly reliable hardware components, sustainable maintenance framework, and secure software tools, which enable IAEA Safeguards inspectors to perform surveillance data reviews in an efficient manner to assist in drawing Safeguards conclusions.

Foreseen challenges

The primary anticipated challenges that this D&IS Plan could face in the near future include:

- Increasing volume of surveillance data that require advanced data review and analysis capabilities to facilitate a comprehensive and efficient review process.
- Radiation effects on surveillance equipment potentially causing equipment malfunction.
- Infrastructure problems experienced in remote or off-the-grid implementations, which could be mitigated with alternative surveillance power and data transmission capabilities.
- Scarce availability of highly-reliable batteries that perform in extreme environments for extended periods of time between maintenance windows.
- Continued scarcity of human resources.
- Supply chain shortages.

Top project priorities in 2024–2025

- Continue to develop advanced surveillance data analysis algorithms, using machine learning and deep learning (DL) techniques, to provide rapid video review capabilities for large datasets and additional data generated by cameras and other sensors.
- Identify and evaluate safeguards-relevant applications of new and/or emerging technologies, to broaden the capabilities of surveillance by incorporating alternate technologies (for example mmWave radar, ultrasonic, acoustics, sonar, and hyperspectral imaging).
- Continue to develop user requirements of an NGSS successor needed by the end of the decade.
- Re-engineer the Laser Curtain for Containment (LCCT) and LCCT software to improve sustainability and life cycle management of this important tool for supporting Safeguards at spent fuel dry storages.

Most Needed External Support in 2024–2025

☒ Financial Support	☐ Consultants	☒ Equipment	☐ Training
☐ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☒ Financial Support for Travel	☒ JPOs	☒ R&D	
☒ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

M.3.C4	Ability to deploy project management approaches to ensure effective execution of strategic priorities and projects
T.1.C1*	Ability to more efficiently verify and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle, including through remote means
T.1.C5*	Ability to develop, deploy and maintain new sealing system technologies with improved security and efficiency
T.6.C1*	Ability to leverage emerging technologies, such as artificial intelligence and machine-learning, to develop and deploy improvements to instrumentation data analysis
T.6.C2	Ability to deploy next generation capabilities to the cameras used in future surveillance systems (e.g. non-optical surveillance, climate insensitivity)
V.1.C6	Ability to apply optical character recognition/text extraction as a robust service to enable information integration into digital systems

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: ★Enhanced ability to deploy equipment at facilities, to meet safeguards requirements through development of highly effective and cost-efficient optical surveillance measures with improved security features.

Outputs	1. Deep learning (DL) models for additional applications and facilities to expand the implementation of enhanced surveillance review techniques. 2. A stakeholder workshop to refine user requirements and evaluate existing technologies for the development of a Next Generation Surveillance System (NGSS) successor. 3. A finalized Ultra-Wideband (UWB) data link device for IAEA Safeguards inspectors' field use.

Supporting Resource Mobilization Priorities

T.6.C2	T.6.C1*	M.3.C4	T.1.C1*	V.1.C6

Support Needed

For the development of DL models, the Department requires MSSP assistance in developing models for additional applications and facilities. These models are essential to expand the implementation of enhanced surveillance review techniques (including advanced character recognition methods) and are a vital component for more effective analysis of surveillance data. The Department seeks expertise, financial support for specialized computing resources, and the contributions of one CFE and one JPO to advance this initiative.

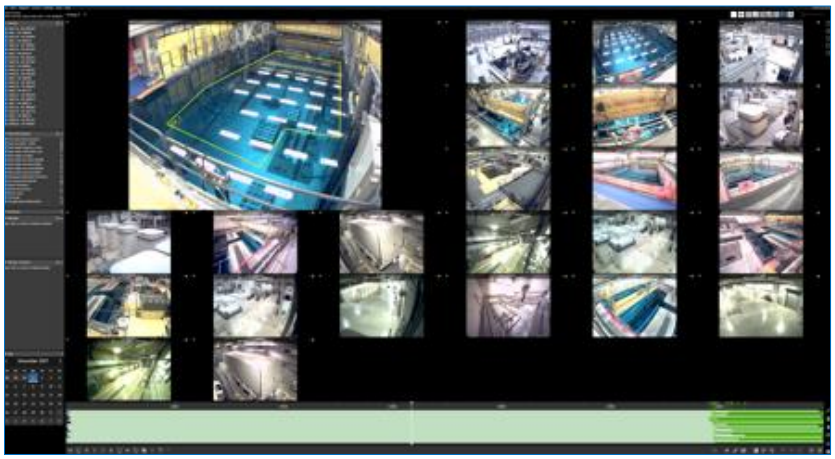


Figure 47: Enhanced surveillance review within the Next Generation Surveillance Review (NGSR) with DL algorithms.

Given the NGSS design and its performance characteristics experienced since 2012, it is expected that the NGSS technology can be sustained until at least the end of the decade (2029). Thereafter new Safeguards surveillance technology, capable of replacing the NGSS, must be authorized and ready for deployment. Such technology therefore needs to be defined and selected in time and any unavoidable, additional development needs to be completed well before.

To advance the Department's goals, the organization of a stakeholder workshop is essential. This workshop will serve as a pivotal platform for refining user requirements and evaluating existing technologies relevant to the NGSS successor. The Department requests financial support and the involvement of a senior technology expert.

The finalization of the UWB data link device for use by IAEA Safeguards inspectors is expected to be completed within the framework of MSSP Task USA E 2484 (Ultra-Wideband (UWB) Data Link). The primary objective is to enhance the capacity for equipment deployment at facilities, ensuring alignment with Safeguards requirements. This enhancement includes the development of highly effective and cost-efficient optical surveillance measures integrated with advanced security features.

In addition to the aforementioned support, the Department also requires assistance in the form of a CFE who would coordinate and compile the findings, recommendations, and assessment reports into an action plan for decision-makers and stakeholders.

Figure 48: NGSS cameras deployed in a nuclear facility.

Continued outcome

Outcome #2: Improved ability to detect undeclared activities at nuclear facilities with tools and techniques.

Output	1. Surveys and assessments of emerging 3D camera and laser (i.e., LiDAR) technologies to support and sustain Design Information Verification (DIV) applications at geological repositories and elsewhere.

Supporting Resource Mobilization Priority

T.6.C2

Support Needed

The Department aims to conduct comprehensive surveys and assessments of emerging 3D camera and LiDAR technologies. These assessments are intended to support and sustain DIV applications at geological repositories and other relevant sites. To successfully carry out these surveys and assessments, the Department kindly requests the following support from MSSPs:

- **Technical Expertise:** Access to SMEs who specialize in 3D camera and LiDAR technologies. Their specialized knowledge is essential in conducting thorough assessments and providing valuable recommendations.
- **Equipment and Tools:** The provision of advanced 3D cameras, LiDAR equipment, and tools is vital for hands-on assessments and surveys. Access to cutting-edge technology will ensure the accuracy and effectiveness of evaluations.

The collective support from MSSPs in these areas will significantly contribute to the successful completion of the surveys and assessments, ultimately enhancing the effectiveness and sustainability of DIV applications at geological repositories and related facilities.

Continued outcome

Outcome #3: ★Improved response to new threats resulting from technology advancements, through advanced intrusiveness and vulnerability analysis on current and future use of unattended systems.

Outputs	1. Extended Next Generation Surveillance Review (NGSR) analysis and reporting capabilities to include the spread-spectrum time domain reflectometry data generated by the Next Generation Surveillance System (NGSS) next generation analogue camera recording module (DCM-A1) module to improve tamper detection capabilities. 2. Contributions to the standardization of Safeguards instruments data security technologies, including the potential NGSS successor. 3. Contributions to the development, selection, and testing of new active tamper indicating technologies required for future Safeguards instruments, including the potential NGSS successor.

Supporting Resource Mobilization Priority

T.1.C11

Support Needed

To enhance the Department's ability to respond effectively to new threats arising from technological advancements, specifically through advanced intrusiveness and vulnerability analysis related to the current and future use of unattended systems, it has identified specific outputs that require support. MSSP collaboration in these endeavours is crucial.

To be most effective during the data review process, it is vital that the Department extends the NGSR analysis and reporting capabilities to include the spread-spectrum time domain reflectometry data generated by the NGSS DCM-A1 module. This enhancement will contribute to a more robust tamper detection feature within the surveillance review platform.

Figure 49: A radiation-hardened camera connected to NGSS DCM-A1 modules.

The Department aims to contribute to the standardization of data security technologies for Safeguards instruments, as outlined in D&IS Plan SGTS-14 (Remote Data Transmission and Processing Systems) and MSSP Task E 2384 (Remote Monitoring VPN Hardware Support). This standardization will include technologies such as Rainstorm and RAINBOX, and will apply to future Safeguards instruments, including the potential NGSS successor.

For active tamper-indicating technologies, the Department seeks support for the development, selection, and testing of new active tamper indicating technologies required for future Safeguards instruments, including the potential NGSS successor.

To obtain these outputs, the Department requires assistance from CFEs and JPOs to support the Surveillance Team in their development efforts. Additionally, expertise from national laboratories is needed to conduct vulnerability reviews as required.

The Department is committed to ensuring effective mitigation and detection measures are in place within its implementation toolkit to address evolving threats. MSSP support in terms of human resources and expertise is invaluable in achieving these goals.

Modified outcome

Outcome #4: Improved real-time monitoring capabilities of nuclear material at nuclear facilities (for example, static inventory monitoring of spent fuel casks) by developing tools and techniques.

Outputs

1. A re-engineered Laser Curtain for Containment (LCCT) and associated software to improve sustainability and life cycle management for supporting Safeguards at spent fuel dry storages.
2. Integration of LCCT data within the Integrated Review and Analysis Platform (IRAP) framework.

Supporting Resource Mobilization Priorities

T.1.C1*	T.1.C5*

Support Needed

Aligned with D&IS Plan SGTS-002 (Techniques and Instruments for Sealing and Containment Verification), the Department aims to re-engineer the LCCT and its associated software to improve sustainability and life cycle management. These tools play a vital role in supporting safeguards at spent fuel dry storages. To achieve this, the Department needs support from LCCT technology developers under MSSP Task EC E 2008 (Identification, Development, Testing and Vulnerability Assessment of Sealing Technologies for International Safeguards) to enhance their sustainability.

Moreover, the Department requires a CFE to address the growing number of requests from IAEA Safeguards inspectors seeking to implement LCCT systems.

Additionally, the Department is working towards integrating LCCT data into the IRAP framework in collaboration with D&IS Plan SGTS-014 (Remote Data Transmission and Processing Systems). To successfully complete this integration and gain authorization for LCCT-data review within IRAP, the Department requests expert advice (consultancy) and financial support.

Lastly, to improve the overall sustainability and life cycle management of the LCCT system, the Department seeks assistance from the LCCT technology developers under MSSP Task EC E 2008 (Identification, Development, Testing and Vulnerability Assessment of Sealing Technologies for International Safeguards) to re-engineer the LCCT server software.

Figure 50: LCCT units deployed in a nuclear facility.

SGTS-008: Instrumentation Technology Foresight

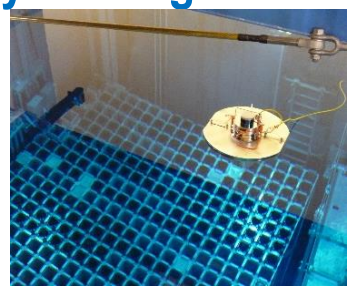
Established

2004

Manager	SGTS Director
Dimitri FINKER	Alexey ANICHENKO

Objective

Achieving effective and efficient Safeguards verifications through the use of radical technology innovations.



Agency Programme and Budget Link

4.1.6.002 Development of Safeguards Instrumentation

Plan Abbreviations

ANPS	Autonomous Navigation and Positioning Sensors
CASCADE	Centralized Automated System for Correlated Analysis and Data Evaluation
CVD	Cerenkov Viewing Device
DCVD	Digital Cerenkov Viewing Device
ICVD	Initial Cerenkov Viewing Device
IRIS	Inertial Positioning Sensors
MMXRF	Micro-focusing X-ray Fluorescent spectroscopy
RCVD	Robotic Cerenkov Viewing Device
TRL	Technology Readiness Level
XCVD	Next Generation Cerenkov Viewing Device

Context Highlights

Charting a Course for Technological Advancement and Innovation

With a strong foundation of successful initiatives, the focus for 2024–2025 is on bringing technological innovation to the field and IAEA Safeguards inspectors. The Department will continue to cultivate strategic collaborations with MSSPs and non-traditional partners in diverse scientific domains, positioning itself to unlock major technological advancements. The mission is clear: to optimize and deploy cutting-edge solutions that not only bolster the efficiency and sustainability of IAEA verification activities but also significantly reduce costs.

Overall Objectives

The overall objectives of this D&IS Plan are to identify, evaluate, test, develop, authorize, and deploy emerging technical advances from other scientific fields and optimize them for use in Safeguards. While many field verification activities use highly specialized instruments developed by the nuclear scientific community, the Department has recognized and articulated the need to take full advantage of relevant 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 Department placed renewed emphasis on developing a robust in-house technology foresight capability. As a result, major technological breakthroughs could be achieved by partnering with non-traditional stakeholders not previously engaged in developments for nuclear safeguards in fields as diverse as astronomy, robotics, or optical design.

The Technology Foresight Pipeline

The Technology Foresight innovative pipeline consists of the following stages:

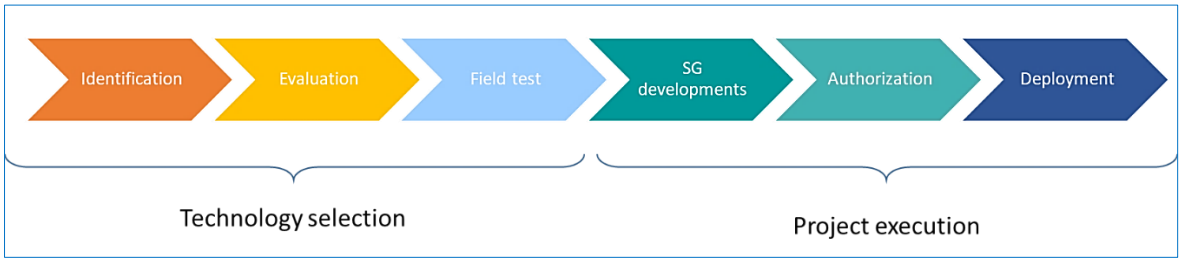


Figure 51: The Technology Foresight innovation pipeline.

Technologies are evaluated and prioritized at each stage using the following 5 criteria:

Relevance	Does it solve a Safeguards problem?
Maturity	Does it work?
Applicability	Can be it adapted for Safeguards verification?
Operational convenience	Will it be used? Are there any competing, less cumbersome alternatives?
IAEA readiness	What are the current obstacles preventing its deployment?

A thorough selection is made throughout the innovation pipeline. During the early stages (technology selection), many of the initial technologies are discarded or placed on standby, when the level of effort to adapt them is not proportionate to the value brought to Safeguard verification. This de-selection ensures that Department staff members work on only the most promising projects that could lead to successfully authorized instruments.

Technology Challenges

One effective mechanism to significantly accelerate a selection through the pipeline has been to organize Technology Challenges, a crowdsourcing approach to expand outreach. Technology Challenges offer multiple opportunities for MSSPs to contribute to the development effort providing immediate and measurable results that are widely communicated through the Office of Public Information and Communication.

Next Generation Cerenkov Viewing Device (XCVD) Production

Initiated over the course of a crowdsourced Technology Challenge (2016), the XCVD has now matured into a routinely used Safeguards instrument, authorized both for gross defect and partial defect verification of spent fuels. The largest Spent Fuel verification campaign in the history of the IAEA (over 3 000 fuels) was completed in 2023 with an XCVD, saving over 60 calendar days in the field in comparison with a verification using a Digital Cerenkov Viewing Device (DCVD).

The most recent batch of instruments is based on a radically new and compact form-factor, which will progressively replace the previous generation of Cerenkov instruments, the Initial Cerenkov Viewing Device (ICVD) and DCVD.

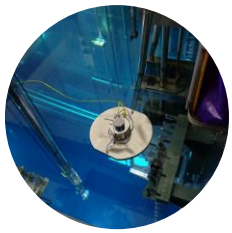
Development of the Robotic Cerenkov Viewing Device (RCVD)

Following the tracks of the XCVD, the 2018 Technology Challenge on robotics lead to the development of the RCVD, an autonomous system capable of hosting the XCVD as payload. Several prototypes were manufactured and tested in various nuclear facility environments in coordination with the ARG, FIN, CZ, and CHE SPs. Moreover, the RCVD received authorization for facility-specific verifications and is the only viable solution for high-radiation or difficult-to-access environments. Its utilization substantially diminishes the risk of personnel exposure in these areas. Similar to the XCVD, the RCVD is now equipped for both gross defect and partial defect verification.

ICVD
Initial Cerenkov Viewing Device

DCVD
Digital Cerenkov Viewing Device

XCVD
Next Generation Cerenkov Viewing Device



RCVD
Robotic Cerenkov Viewing Device

Figure 52: Evolving Safeguards Instrumentation: From ICVD to RCVD – Four Generations of Cerenkov Viewing Devices.

Muography Feasibility Study

In 2023, a specialized working group was established with support of MSSPs to investigate the feasibility of employing muography in nuclear safeguards. A kick-off meeting was held in May 2023 to gather essential data required to start simulations. This group is actively engaged in conducting computer simulations to evaluate the viability of utilizing muography in the safeguarding of geological repositories.

Most Needed External Support in 2024–2025

☒ Financial Support	☐ Consultants	☐ Equipment	☐ Training
☐ Financial Support for IT Development	☐ CFEs	☐ Reference Materials	☒ Studies
☐ Financial Support for Travel	☒ JPOs	☒ R&D	
☐ Expert meeting participation		☒ Facility Access	

Requested Support Summary (detailed in plan below):

- Financial assistance for organizing Crowdsourced Technology Challenges.
- JPO and consultants for targeted project development.
- Scientific research for enhancing data analysis of the new CVD generation.
- Equipment procurement for replacing ICVD/DCVD, along with establishing IT infrastructure for XCVD data processing.
- Expert support to facilitate muography technology evaluation for geological repository safeguarding.
- Facility access to validate the outcome of new developments.

Resource Mobilization Priority Links

* Indicates a prioritized capability

T.1.C1*	Ability to more efficiently verify and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle, including through remote means
T.1.C4	Ability to perform partial defect verification of spent fuel with the digital Cerenkov viewing device (XCVD)
T.1.C5*	Ability to develop, deploy and maintain new sealing system technologies with improved security and efficiency
T.1.C10	Ability to rely upon an integrated system of instrumentation data (for example, spectra) processing and review, with high level of automation and with unified user interface
T.1.C12*	Ability to expand the use of robotic technology for verification activities
T.2.C1	Ability to reliably and quickly deliver sample analysis results for special and high priority demands
V.6.C1	Ability to implement effective and efficient safeguards for geological repositories

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: Improved and more efficient safeguards verification activities in the field through the use of innovative technologies.

Outputs

1. ★A developed Robotic Cerenkov Viewing Device (RCVD) that integrates an advanced computer vision module that assists the autonomous verification of spent fuel.
2. Production of 40–50 Next Generation Cerenkov Viewing Device (XCVD) units that progressively replaces Initial Cerenkov Viewing Device (ICVD) and Digital Cerenkov Viewing Device (DCVD) used for both gross and partial defect verification.
3. A study of novel methods for analysing Cerenkov light data and identifying outliers in a population of fuel assemblies.
4. ★Implementation of a data workflow and an IT infrastructure for supporting the post-processing and storing of CVD measurements data.
5. Validation of the field performance of the portable Micro-focusing X-ray Fluorescent spectroscopy (MMXRF), in close collaboration with SGAS.
6. Conclusion of the applicability of muography for safeguarding geological repositories.

Supporting Resource Mobilization Priorities

T.1.C1*	T.1.C4	T.2.C1	V.6.C1	T.1.C12*

Support Needed

Cerenkov Viewing Devices (CVDs)

The primary focus in 2024–2025 is deploying the latest generation of Cerenkov Viewing Devices (CVDs) to more IAEA Safeguards inspectors. The XCVD v3 has been redesigned and is now a compact, highly manufacturable, and easily-maintainable instrument. This transformation has enabled efficient small-batch production, typically ranging from 10 to 20 units annually, depending upon the available budget.

The RCVD is already regularly used for conducting spent fuel verifications in demanding environmental conditions, like high radiation areas and hard-to-reach covered spaces. In these settings, it significantly reduces radiation exposure for those involved in the verification process (operators and IAEA Safeguards inspectors). Nevertheless, the system still requires substantial enhancements to achieve resilience and autonomy. The AUL SP will continue to provide active support for the ongoing development efforts, particularly concerning advanced computer vision models to ensure precise alignment of the RCVD over each fuel assembly.

Both the XCVD and RCVD now capture significantly richer data than their predecessors (ICVD and DCVD), yet the methods for data analysis have remained unchanged. A new MSSP Task is set to investigate novel methods for analysing Cerenkov light data, applicable to both gross and partial defect verification, in order to identify outliers in a population of fuel assemblies and inconsistencies with the operator's declarations.

As the CVD fleet expands and their utilization intensifies in verification activities, this will affect data management within the Department. The Department is establishing a new data workflow supported by a dedicated IT infrastructure, encompassing processing software and local servers. The existing Centralized Automated System for Correlated Analysis and Data Evaluation (CASCADE) platform is slated to manage access to XCVD data for IAEA Safeguards inspectors and scientific support staff.

Given this expanded scope, continued support through the active Support for Instrumentation Technology Foresight MSSP Tasks with 17 MSSPs (ARG, AUL, BEL, BRZ, CAN, CHE, EC, FIN, FRA, GER, HUN, JPN, NET, ROK, RSA, UK, and USA) is invaluable. This support will continue to bolster the following initiatives:

- Financial support for the production of XCVD components.

- Financial support and/or JPO assistance for RCVD (both software and hardware) development, along with increasing its Technology Readiness Level (TRL) for IAEA Safeguards inspector operation.
- Financial support and/or JPO assistance to expand the XCVD data workflow within CASCADE.
- Expert support to investigate novel methods for analysing Cerenkov light data.

Micro-focusing X-ray fluorescent system (MMXRF)

Significant progress has been made in the development of the portable MMXRF within the framework of MSSP Task ROK A 2512 (Portable MMXRF for Field Use). Encouraging results have been observed in terms of both sensitivity and spectral resolution. The Department expects to fully validate its field performance to turn it into a valuable tool for swipes analysis.

Muography

To further explore the potential of muography for safeguarding geological repositories, the Department seeks continued support through active Reporting on the Feasibility of Large-Scale Muography for Geological Repositories MSSP Tasks with AUL, CAN, CHE, EC, ESP, FIN, GER, and USA. The ongoing investigation aims to deliver:

- Comprehensive muography simulation results for diverse safeguards scenarios.
- A comprehensive written report that concludes on the applicability and limitations of muography in the context of safeguarding geological repositories.

Continued outcome

Outcome #2: Ability to develop, design, and enhance safeguards solutions faster and with fewer resources by using external technologies from relevant R&D fields.

Outputs	1. Conduct two Crowdsourcing Technology Challenges through an external crowdsourcing challenge platform. 2. Extend the utilization of the Technology Foresight database to various stakeholders, including support for SGTS scientific panels and the generation of external technology reports for MSSPs.

Supporting Resource Mobilization Priorities		
T.1.C4	T.1.C5*	T.1.C10

Support Needed

Crowdsourcing Technology Challenges have proven to be a highly visible and successful method for the Department to efficiently integrate new technologies into Safeguards instruments and solve complex data analysis problems. By the close of 2023, these challenges have resulted in the development of 11 new instruments, including the Next Generation Cerenkov Viewing Device (XCVD).

The generous in-kind contribution through MSSP Task USA A 1616 (Support for Instrumentation Technology Foresight) enables the Department to use an external, dedicated crowdsourcing challenge platform for the upcoming two technology challenges: one centred on data science to improve the processing of the Autonomous Navigation and Positioning Sensors (ANPS) inside Inertial Positioning Sensors (IRIS), and one focused on innovation related to containment systems. Using a dedicated platform is expected to help the Department engage with external participants more effectively, expand outreach to different areas of expertise, and optimize the allocation of Department staff members to areas of value.

MSSPs have played a pivotal role in the organization of these Technology Challenges. Through the active Support for Instrumentation Technology Foresight MSSP Tasks with 17 MSSPs (ARG, AUL, BEL, BRZ, CAN, CHE, EC, FIN, FRA, GER, HUN, JPN, NET, ROK, RSA, UK, and the USA), MSSPs can extend their support in the following key areas:

- Advertising and promoting the Technology Challenges.
- Financing a dedicated crowdsourcing platform.
- Identifying potential suppliers.
- Directly supporting its organization(s) by funding candidates, hosting challenges, and/or providing technical observers.

The Technology Foresight Database serves as a repository for knowledge gathered during technological outreach activities, employing a structured taxonomic categorization to summarize technology evaluations. The database's usability was improved in 2023 and its usage expanded within the Verification Technologies Section. It will continue to be populated with data and further extended to accommodate the needs of the Department (e.g., Scientific and Technical panels) and external stakeholders such as MSSPs.

SGTS-011: Unattended Measurements Techniques

Established

2006

Manager	SGTS Director
Mikhail MAYOROV	Alexey ANICHENKO

Objective

Optimizing unattended measurement techniques for monitoring and detecting declared and undeclared nuclear material and activities.

Agency Programme and Budget Links

4.1.6.001 Provision of Safeguards Instrumentation and Services

4.1.6.002 Development of Safeguards Instrumentation

Plan Abbreviations

ADAM	Autonomous Data Acquisition Module
AMGB	Advanced Material Accountancy Glove Box
CFM	Coriolis flow meter
COTS	Commercial Off-The-Shelf
EMDS	Enrichment Measurement Device System (also known as OLEM)
EPGR	Encapsulation Plant and Geological Repository
FRSS	Fuel Rod Scanning System
GCEP	gas centrifuge enrichment plant
JMOX	Japan Nuclear Fuel Ltd. MOX Fuel Fabrication Plant
LANL	Los Alamos National Laboratory (USA)
LWR	light-water reactor
NGAM	Next Generation of ADAM module
OLEM	On-Line Enrichment Monitor
ORNL	Oak Ridge National Laboratory (USA)
PGET	Passive Gamma Emission Tomography
PNNL	Pacific Northwest National Laboratory (USA)
RRP	Rokkasho Reprocessing Plant
TDR	Time Domain Reflectometer
UCVS	Unattended Cylinder Verification System
UDCM	Unattended Dual Current Monitor
UDCP	Unattended Direct Current Power Supply
UGET	Unattended Gamma Emission Tomography
UMCA	Unattended Multichannel Analyser
UMS	Unattended Monitoring System
VIFM	VXI Integrated Fuel Monitor

Context Highlights

The Crucial Role of Unattended Measurement Techniques in Nuclear Safeguards

Unattended measurement techniques are crucial for nuclear safeguards for several reasons. They allow continuous, real-time monitoring of nuclear facilities without the need for onsite inspections, promoting increased cooperation and trust. These methods provide improved sensitivity, detecting even small changes in nuclear material quantities and characteristics, enabling timely identification of anomalies. Their redundancy and resilience ensure the reliability of data collection, even in the event of technical failures or external disruptions. Additionally, unattended systems are cost-effective in the

long term, reducing expenses related to onsite inspections and travel. Their versatility makes them suitable for various nuclear facilities, playing a vital role in supporting international agreements and safeguarding nuclear material.

Unprecedented Challenges Associated with the Japan Nuclear Fuel Ltd. MOX Fuel Fabrication Plant (JMOX) and Encapsulation Plant and Geological Repository (EPGR) Projects

Several nuclear facilities with large-scale Unattended Measurement Systems (UMS) footprints in safeguards monitoring and verification, such as JMOX, Rokkasho Reprocessing Plant (RRP), and EPGR, will become operational or resume operations in 2024–2025. This will pose unprecedented challenges to the UMS Team in terms of ensuring the availability of both conventional and new systems for continuous material flow monitoring. These challenges will also place limitations on the allocation of resources for the development of new systems and techniques.

Focus Areas in 2024–2025

The strategy centers on three key areas:

- **Completing Development Work**: The Department is committed to finishing development related to:
  - Unattended Cylinder Verification System (UCVS),
  - Enrichment Measurement Device System (EMDS) (also known as On-Line Enrichment Monitor (OLEM)),
  - Unattended Gamma Emission Tomography (UGET),
  - Time Domain Reflectometer (TDR),
  - Next Generation of Autonomous Data Acquisition Module (ADAM) module (NGAM), and
  - Unattended Dual Current Monitor (UDCM).
- **Supporting Large-Scale Projects:** The Department will provide essential support for the development and authorization of systems and components required for the aforementioned large-scale projects, which include:
  - Unattended Gamma Emission Tomography (UGET),
  - Advanced Material Accountancy Glove Box (AMGB),
  - Fuel Rod Scanning System (FRSS),
  - Unattended Multichannel Analyser (UMCA), and
  - Unattended Direct Current Power Supply (UDCP).
- **Authorization and Implementation of New UMS Technique:** The Department aims to authorize and implement a new UMS technique for power monitoring in research reactors. This technique is based on the activation of coolant through fast neutrons interacting with $^{16}\mathrm{O}(n,p)^{16}\mathrm{N}$.

Extrabudgetary Support

The D&IS Plan SGTS-011 (Unattended Measurements Techniques) for 2024–2025 relies significantly on extrabudgetary support. This support encompasses specific knowledge and expertise, financial contributions, including in-kind assistance, human resources (JPO and CFE), and access to test facilities. The Department greatly values the generous support.

Most Needed External Support in 2024–2025

☒ Financial Support	☐ Consultants	☒ Equipment	☐ Training
☐ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☐ Studies
☒ Financial Support for Travel	☒ JPOs	☒ R&D	
☐ Expert meeting participation		☒ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

T.1.C1* Ability to more efficiently verify and maintain knowledge of spent fuel in shielding/storage/transport containers at all points in their life cycle, including through remote means

T.1.C3 Ability to more effectively and efficiently verify spent fuel from on-load reactors

T.1.C8 Ability to detect HEU production in real time at declared LEU enrichment facilities

T.1.C10 Ability to rely upon an integrated system of instrumentation data (for example spectra) processing and review, with high level of automation and with unified user interface

T.1.C11 Ability to rapidly detect, characterize and address breaches to unattended systems, and evaluate their vulnerabilities more broadly, particularly from threats arising from technology advancements (for example conduit integrity verification)

New Plan for 2024–2025

★ Indicates top priority

Modified outcome

Outcome #1: Improved effectiveness of the Uranium enrichment monitoring activities with regard to the data processing and analysis.

Outputs	1. Develop and validate a methodology to determine, correct, and account for continuously changing thickness of the UF_6 and $UO_2F_2 \cdot H_2O$ wall deposits. 2. Enhance the functionality of the data processing software AnalyzeN42 to ensure no data loss under 'abnormal' measurement conditions, such as rapidly changing pressure, and to improve the AnalyzeN42 code (or develop an alternative) to accurately determine a peak area under 186 keV.

Supporting Resource Mobilization Priority

T.1.C8

Support Needed

The Department requires support in the form of SME assistance to review and refine the methodology. Additionally, access to the AnalyzeN42 software or an alternative solution under MSSP Task USA A 1913 (On-Line Enrichment Monitor (OLEM)) is vital for achieving this outcome.

New outcome

Outcome #2: Effective and efficient verification of material balance and process attribute monitoring at Gas Centrifuge Enrichment Plants.

Outputs	1. Successful demonstration of an Unattended Cylinder Verification System (UCVS) performance at a safeguarded gas centrifuge enrichment plant (GCEP). 2. Authorization of UCVS for quantitative analysis of feed, product, and tails cylinders.

Supporting Resource Mobilization Priority

T.1.C8

Support Needed

The Department has outlined the following critical work to accomplish the defined outputs:

1. Collaborate with Department experts and SMEs from US National Laboratories under the framework of MSSP Task JNT A 1979 USA (Viability of a UCVS for Enrichment Plant Safeguards) to review the methodology and expected performances, focusing on the quantities of the assayed Uranium.
2. Implement the UCVS at the selected gas centrifuge enrichment plant and analyse data from feed, product, and tails cylinders.
3. If required, further improve algorithms and methodologies to reduce assay uncertainties.
4. Apply Unattended Monitoring System (UMS)-specific hardware and software security measures to ensure data and hardware integrity and alignment with IAEA standards.
5. Authorize the UCVS for verification of Uranium content in the product, feed, and tail cylinders.

To successfully carry out this work and reach the desired outcomes, strong and continuous support from Subject Matter Experts (SMEs) from Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest National Laboratory (PNNL) (all USA) is indispensable throughout the performance evaluation and authorization phases.

The value of the UCVS system has been demonstrated, and the Department will refurbish the system to meet UMS technical, standardization, and security requirements.

The ongoing plans between the Department, the UK SP and USSP regarding the pilot deployment of UCVS at Capenhurst Gas Centrifuge Enrichment Plant further exemplify the collaborative efforts in achieving these objectives.

New outcome

Outcome #3: Capability to detect diversion of nuclear material from light-water reactor (LWR) spent fuel regardless of the defect size in unattended mode.

Output	1. Development and authorization of the Unattended Passive Gamma Emission Tomography System.

Supporting Resource Mobilization Priority

T.1.C1*

Support Needed

To achieve this outcome, the Department will focus on the specific output of developing and authorizing the Unattended Passive Gamma Emission Tomography System (PGET).

To accomplish this, the Department is actively progressing under an internal IAEA task dedicated to developing the unattended mode of operation for PGET. With valuable support from MSSP Tasks JNT A 2414 FIN and JNT A 2431 USA (both titled Support for testing of PGET new functionalities in attended, remote and unattended modes) the joint MSSP/SGTS-001/SGTS-011 project team is dedicated to developing and implementing the PGET in unattended mode, also known as the Unattended Gamma Emission Tomography (UGET). The Department plans to ensure a long-term, minimum 12-month, failure-free unattended operation of the system in the spent fuel pond to validate UGET's performance.

To successfully accomplish this mission, the Department seeks the following support:

1. The assistance of Subject Matter Experts (SMEs) is required to finalize the development of UGET software under MSSP Task JNT A 2431 USA (Support for testing of PGET new functionalities in attended, remote, and unattended modes).
2. Support is required for the pilot installation of UGET at Olkiluoto NPP interim spent fuel storage and the remote transmission of data to the IAEA under MSSP Tasks JNT A 2414 FIN and JNT A 2428 EC (both titled Support for testing of PGET new functionalities in attended, remote and unattended modes).

Support in these crucial areas will greatly contribute to the mission and the enhancement of nuclear material monitoring for improved Safeguards.

New outcome

Outcome #4: Improved Unattended Monitoring System (UMS) reliability, modularity, and security.

Outputs	1. Successful demonstration and authorization of a time-domain reflectometry (TDR) system for use along UMS components cabling pathways. 2. Authorization of a Coriolis flow meter (CFM)-based UMS for mass and density determination of liquid flowing through a pipe (internal task). 3. Assistance in the final testing phase and deployment at a nuclear facility to showcase its performance. 4. Validation of the Unattended Dual Current Monitor (UDCM). 5. Improved reliability of Next Generation of Autonomous Data Acquisition Module (ADAM) module (NGAM) through modification of the NGAM firmware/Data Collect software.

Supporting Resource Mobilization Priorities	
T.1.C11	T.1.C3

Support Needed

TDR System Details and Support Needed

The Department's goal is to make a more compact and versatile TDR system for UMS cabling pathways. The modified system will be only 1U in height and will be able to handle up to eight multiplexed input channels. The Department will also update the mechanical design to make it 2U or ideally 1U in height. Testing will begin at Pacific Northwest National Laboratory (PNNL) with standard UMS components, including NGAM, UDL1, and RDL3 acquisition modules, detectors, splitters, and junction boxes. Once the Department has tested it successfully, the next step is validation and authorization by the IAEA.

To achieve this, the Department requires guidance through the TDR system modification, collaboration and testing support, especially from PNNL, and the IAEA's validation and authorization support. Ongoing partnership under MSSP Task USA E 2641 (Development of TDR devices for Use Along UMS Detector Cabling Pathways) is crucial.

CFM-based UMS Details and Support Needed

The Department aims to finalize the design and testing of a UMS utilizing Commercial Off-The-Shelf (COTS) CFM for mass and density measurements of liquid. Following this, the Department will deploy the system at a nuclear facility to demonstrate its effectiveness. The Department anticipates conducting the final testing phase and deploying the system at a nuclear facility to showcase its performance using in-house resources without the need for MSSP support at this time.

Unattended Multichannel Analyser (UMCA) Testing Details and Support Needed

The Department’s objective is to complete the procurement and collaborate with Euratom for the testing and validation of UMCA in various unattended applications. The Department needs collaboration and testing support from Euratom and other relevant partners.

UDCM Validation Details and Support Needed

The Department plans to modify the UDCM design to meet the requirements for unattended operation. After that, the Department will test and validate the component. The Department will also collaborate with Euratom to refurbish the mini-UFDM and integrate the UDCM into the design. The Department requires technical assistance to make these design modifications and validate the component. Collaboration and coordination with Euratom for refurbishing and integrating are crucial.

Improved NGAM Details and Support Needed

The Department is focused on troubleshooting and resolving technical issues with NGAM to prevent potential data loss. The Department needs technical assistance to identify and resolve these technical issues through MSSP Task CAN E 1530 (VXI Integrated Fuel Monitor (VIFM) Implementation Support).

New outcome

Outcome #5: Improved effectiveness of safeguards at research reactors.

Output	1. Authorization and implementation of new Unattended Monitoring System (UMS) technique for power monitoring of research reactors based on activation of coolant by fast neutrons through $^{16}O(n,p)^{16}N$.

Supporting Resource Mobilization Priority

T.1.C5*

Support Needed

To enhance the effectiveness of Safeguards at research reactors, the goal is to authorize and implement a new UMS technique for power monitoring and confirm the presence of at least one critical mass of fissile material in a core. The underlying principle for the method is based on the detection of gamma radiation following a beta-decay of nitrogen-16. The latter isotope is built in through an $^{16}O(n,p)^{16}N$ reaction. The concentration of nitrogen-16 present in a primary coolant is directly proportional to the fission rate in the reactor core, i.e., to the reactor power. With a half-life of 7.13 seconds, neutron-reach nitrogen-16 beta-decays into oxigen-16 and emits a cascade of gamma rays. The most prominent energy lines are at 6128.6 KeV (67%) and at 7115.2 keV (4.9%). Detection of those gamma rays allows for determination of the nitrogen-16 concentration, which, as mentioned above, is proportional to the prompt flux of fission neutron, i.e., the reactor power.

To activate detectable amount of nitrogen-16 in a primary coolant circuit the neutron flux shall be of some 10^{11}-10^{13} $s^{-1}cm^{-2}$. The reaction is endothermic (Q-value is -9.64 MeV) and hence only fast fission neutrons[4] can breed nitrogen-16. To generate such a neutron flux, a minimum critical amount of fissile material shall be present in the core.

The Department plans to pilot this system, known as the Cooling Water Activation Monitor, at a research reactor. It's important to note that this system is non-invasive and does not require specific site preparation. The Department is seeking an opportunity to deploy this system for a trial run at a research reactor that utilizes water as a coolant. Support in facilitating this deployment would be greatly appreciated.

[4] 14 MeV neutrons from accelerator-based high-power deuterium-tritium neutron generators could also be a viable option to breed nitrogen-16. Such systems, however, are unique and hence the scenario is not conceivable.

SGTS-014: Remote Data Transmission and Processing Systems

Established

2001

Manager	SGTS Director
Angelo ALESSANDRELLO	Alexey ANICHENKO

Objective

Collecting, transmitting, and reviewing data from Safeguards equipment installed in facilities around the world.

Agency Programme and Budget Link

4.1.6.002 Development of Safeguards Instrumentation

Plan Abbreviations

AI	Artificial Intelligence
CASCADE	Correlated Analysis and Data Evaluation
CSFSF	Central Spent Fuel Storage Facility
EDM	Equipment Data Management
EPGR	encapsulation plant and geological repository
Euratom	the European Atomic Energy Community
INCC	IAEA neutron coincidence counting
IRAP	Integrated Review and Analysis Package
ISE	Integrated Safeguards Environment
JMOX	Japan Nuclear Fuel Ltd. MOX Fuel Fabrication Plant
JRC	IAEA Facility ID of the Rokkasho Reprocessing Plant
LANL	Los Alamos National Laboratory (USA)
LCCT	Laser Curtain for Containment
NGSR	Next Generation Surveillance Review
NRTS	Near Real Time System
RAINBOX	Real-time And INtegrated STream-Oriented Remote Monitoring (RAINSTORM) interface BOX
RDT	Remote Data Transmission
ROOGLE	Name of application where users can view the status of remotely connected systems
RRP	Rokkasho Reprocessing Plant
SAFIRE	Safeguards Inspection Reporting and Evaluation
SCALE	A modeling and simulation suite for nuclear safety analysis and design
VPN	virtual private network

Context Highlights

The Significance of Remote Data Tansmission in Safeguards

Remote Data Transmission (RDT) and remote data review of Safeguards equipment data play a crucial role in enhancing the efficiency of Safeguards verification activities. They achieve this by reducing the necessity for IAEA Safeguards inspectors to collect data in person. This time-saving benefit can then be allocated to other work, providing IAEA Safeguards inspectors with the assurance that all RDT-enabled safeguards equipment systems are functioning as expected.

Additionally, RDT offers insights into equipment performance, specifically providing state-of-health data. This allows for remote system diagnostics and troubleshooting. It also supports predictive maintenance activities, potentially reducing the need for inspectors to travel for maintenance-related duties, including certain inspection work associated with unattended systems.

RDT serves as the foundation for the hardware, software, and networking infrastructure required for remote data collection, review, and evaluation from various locations around the world. This capability enables the timely detection and resolution of issues, ultimately reducing the workload for IAEA Safeguards inspectors in the field. With these features in place, RDT substantially enhances both the efficiency and effectiveness of IAEA Safeguards implementation. It achieves this by facilitating earlier data review and evaluation, thus aiding in meeting the timeliness aspect of inspection goals.

Furthermore, the use of RDT decreases radiation exposure for IAEA Safeguards inspectors and facility personnel, which is of paramount importance in ensuring inspector safety and health, as prolonged or excessive exposure to radiation can lead to adverse health effects.

RDT and its Role During the Conflict in Ukraine

RDT not only proved valuable for achieving Safeguards objectives during the Covid-19 pandemic but also emerged as a vital data gathering tool for the IAEA during the conflict in Ukraine. Particularly in Q1/Q2 2022, as the conflict unfolded, SGTS encountered multiple network disconnections at various Ukrainian power plants. As it was impossible to perform regular Safeguards inspection visits for a few months, RDT was the only means available to the Department to maintain the continuity of knowledge (CoK) on the status of nuclear material in Ukraine. As such, it was important for the Department to provide Safeguards data in a timely manner through RDT. Even a few days' worth of disconnection, which was common in the initial period of the conflict, could hinder the Department's ability to maintain the nuclear material CoK in Ukraine.

To address this challenge and enable SGTS management to provide reliable information on the nuclear material status to the IAEA's Director-General and Deputy Director-General for Safeguards, ROOGLE features were developed. These features promptly detect disconnections, start downloading data as soon as connections were re-established, and check and report the status of SGTS equipment immediately. The two most important features were derived by developing an app to download and analyse the logs of the remote virtual private networks (VPNs) in Ukraine. This allowed detection specifically of any possible intrusion in the VPNs to physically penetrate IAEA cabinets and any possible downtime longer than 10 minutes. In this latter case, by clustering the VPNs in the same location, the Department was able to filter out the unmeaningful disconnections of single VPNs for short periods of time (up to 10 minutes) and identify the meaningful disconnections of a single VPN (local problems that can be fixed by the Ukrainian facility operators) and the disconnection of the whole cluster, which indicated a general network problem normally out of the Department's control. It should be noted that this app is now extended to other important connected locations to improve the RDT service as whole.

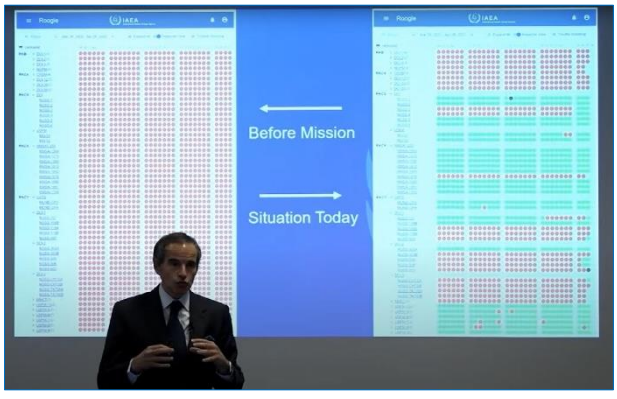


Figure 53: In an April 2022 press conference, IAEA Director General Mr Grossi emphasizes the importance of RDT network tools and illustrates the IAEA mission's effectiveness in restoring RDT communication at the Chornobyl NPP.

Through these measures, RDT ensured that the relevant SGTS teams remained well-informed, allowing SGTS management to develop mitigation and remediation plans for submission to the IAEA's Director-General and Deputy Director-General for Safeguards. This not only underscores the critical role of RDT during challenging times but also its contribution to maintaining the integrity of Safeguards efforts.

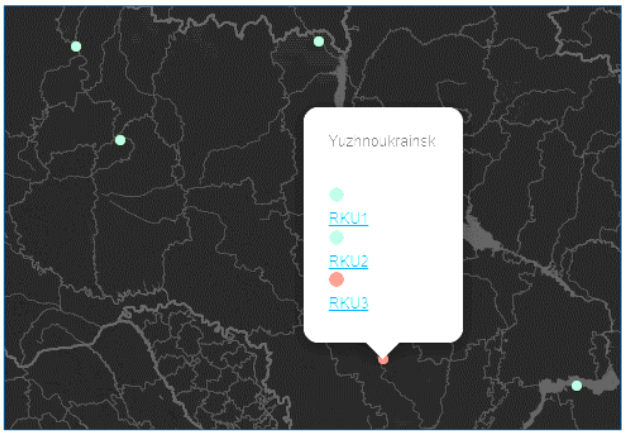


Figure 54: This screenshot displays the real-time status of Ukrainian facilities' connections on a random day in Q2 2022, with updates reliably provided on an hourly basis.

Figure 55: Enhancing the RDT Network: A Starlink satellite antenna was installed in Chornobyl in response to network disruptions caused by Ukrainian mobile network damage in the conflict's early stages (Q1 2022). The depicted Department staff member is setting up the antenna using a mobile app.

The Equipment Data Management (EDM) Team achieved a critical milestone by installing a satellite Starlink system in Chornobyl, Ukraine in April 2022 (see figure above "Enhancing the RDT Network: The installation of a Starlink satellite antenna…"). This accomplishment was of paramount importance as it enabled the team to swiftly study, procure, and install this new network component under difficult conditions. The satellite Starlink system provides essential connectivity during a time of increased network disruptions in Chornobyl due to the conflict in Ukraine, ensuring the continuity of vital data transmission and Safeguard operations.

Challenges and the Need for Continued Development

The increased utilization of the RDT network has brought with it heightened demands in terms of maintenance efforts and networking costs. Notably, the volume of data received at IAEA headquarters has doubled over the last three years, surpassing one terabyte per month in 2023. The primary challenge does not lie in the operation of the RDT network itself but rather in the development of proficient data processing applications capable of effectively managing the current data volume, which consists of diverse datasets including varying file formats from instruments, data streams, and documents. This challenge becomes particularly crucial as IAEA Safeguards inspectors often need to quickly analyse this heterogeneous data in very short time windows, sometimes even within a few hours.

To do this, there is an ongoing requirement for continuous development of the software tools introduced through this D&IS Plan in previous biennia. These essential tools encompass the:

- Integrated Review and Analysis Package (IRAP),
- Centralized Automated System for Correlated Analysis and Data Evaluation (CASCADE),
- Near Real Time System (NRTS), now equipped to integrate surveillance review with deep learning analysis, and
- ROOGLE3, the application designed for monitoring the status of remotely connected systems.

This continuous development is vital in enhancing the effectiveness and efficiency of Safeguards.

Most Needed External Support in 2024–2025

☒ Financial Support	☐ Consultants	☒ Equipment	☒ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☐ Studies
☐ Financial Support for Travel	☒ JPOs	☒ R&D	
☐ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

S.2.C1*	Ability to strengthen the capacity of SSACs/SRAs and monitor and measure progress
S.3.C1	Ability to identify and address the needs of designers and operators of modified or new facilities in the early preparation for efficient implementation of safeguards
T.1.C10	Ability to rely upon an integrated system of instrumentation data (e.g., spectra) processing and review, with high level of automation and a unified user interface
T.1.C11	Ability to rapidly detect, characterize, and address breaches to unattended systems, and to evaluate system vulnerabilities more broadly, particularly from threats arising from technology advancements (e.g., conduit integrity verification)
T.3.C2	Ability to provision SRAs with an IT tool to assist with the creation and submission of accountancy reports and additional protocol declarations
T.6.C1*	Ability to leverage emerging technologies, such as artificial intelligence and machine-learning, to develop and deploy improvements to instrumentation data analysis
V.1.C1	Ability to synthesize and evaluate disparate sets of verification data from the field through data analysis methods and tools
V.1.C2*	Ability to receive/collect, process, analyze and evaluate all safeguards-relevant information efficiently and effectively through innovation, integration, and governance
V.4.C1	Ability to leverage statistical methodologies to evaluate verification data, assess verification performance (detection probability, timeliness, and deterrence), and gauge the associated level of confidence, at the facility and State levels
V.6.C1	Ability to implement effective and efficient safeguards for geological repositories
V.6.C3	Ability to implement effective and efficient safeguards at JMOX
V.6.C4	Ability to perform process monitoring and associated data analysis for safeguarding facilities, particularly advanced reactors with liquid or pebble fuel

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: More efficient data review and evaluation tools for IAEA Safeguards inspectors and SGTS technicians.

Outputs

1. ★ Integration of Correlated Analysis and Data Evaluation (CASCADE) in the Integrated Safeguards Environment (ISE) with Safeguards Inspection Reporting and Evaluation (SAFIRE) and the Dataflow app.
2. ★ Integration of the ROOGLE3 application with CASCADE, SAFIRE, and the Dataflow app.
3. ★ Integration of hand-carried data (e.g., USB) with remotely transmitted data and transfer of their respective stores into ISE.
4. ★ Complete Integrated Review and Analysis Package (IRAP)/Next Generation Surveillance Review (NGSR) deployment and configuration for facilities with Remote Data Transmission (RDT).

Supporting Resource Mobilization Priorities

V.1.C1	V.1.C2*	V.4.C1	T.1.C10	T.3.C2	T.6.C1*	S.2.C1*

Support Needed

To accomplish this outcome, it is imperative for the effective and efficient handling of the data required for nuclear activity verification during in-field inspections. To achieve the expected outputs, the integration of ROOGLE3 (the application where users can view the status of remotely connected systems) and CASCADE applications with other major Department equipment-related applications, such as SAFIRE, is necessary.

This integration is essential as the measurement systems configured in CASCADE/ROOGLE3 align with the authorized systems reported by IAEA Safeguards inspectors in SAFIRE. This integration is key to enhancing the effectiveness and efficiency of the verification process, ensuring the correctness of inventory reports and generating more comprehensive equipment performance reports.

Accurate and reliable data integration necessitates proper tagging, which is facilitated by a new SGIS application known as the Dataflow app, serving as another integration point for CASCADE, IRAP, and NGSR. While this integration is an ongoing effort, the infrastructure it creates will

support future advancements in collecting and aggregating any data generated during inspections, such as portable instrument measurements.

The importance of upgrading ROOGLE 3 became evident during the initial stages of the conflict in Ukraine. Furthermore, the Department must consider the continuous evolution of equipment technologies, which the review applications need to analyse, as well as the integration of Artificial Intelligence (AI)-related analyses into current applications. For example, in 2024–2025, the introduction of the Laser Curtain for Containment (LCCT) will significantly impact IRAP and its configuration and scripts, just as the introduction of deep learning algorithms for surveillance review will impact NGSR.

It should be noted that this Outcome has dependencies with the SGIS D&IS Plans SGIS-002 (Information Security and Infrastructure) for information security tools to be applied to the SGTS developed applications and SGIS-003 (Safeguards Information Systems and System Usability) that aims to integrate and harmonize all Department-developed applications.

Given the importance of Outcome #1, this plan would greatly benefit from the following support:

- Approximately €100 000 in financial support to purchase equipment (servers, fast network devices, disk storage).
- In-kind donations of equipment valued at approximately €100 000 (servers, fast network devices, disk storages).
- Approximately €120 000 per year in financial support for IT.
- Acceptance of MSSP Task Proposal 22/TME-002 (CFE - Equipment Data Manager Engineer).
- MSSP Task USA D 2386 (JPO - Associate Remote Monitoring Engineer), with a contract expiring in Q1 2024, for whom the Department would like to replace.
- Training for specific software packages like IAEA neutron coincidence counting (INCC).

Under this plan, SGTS currently benefits from four active MSSP Tasks, including:

- MSSP Task USA E 2582 (Expert - Remote Monitoring), who is providing software development and network engineering expertise.
- MSSP Task USA D 2386 (Junior Professional Officer - Associate Remote Monitoring Engineer), who is heavily involved in developing ROOGLE3 features, especially those related to virtual private network (VPN) boxes.
- MSSP Task USA B 2555 (SCALE training at the IAEA), enabling the proper use of SCALE (a modelling and simulation suite for nuclear safety analysis and design) in IRAP.
- MSSP Task USA D 2677 (Expert Support for IRAP, INCC5/6, COMBIT and LANL Rad Review Suite), primarily related to IRAP and INCC integration.

The Department is grateful for the support, as it would face considerable challenges without.

Continued outcome

Outcome #2: Continuous improvement of the Remote Data Transmission (RDT) network.

Outputs	1. Implementation of the Real-time And INtegrated STream-Oriented Remote Monitoring (RAINSTORM) interface BOX (RAINBOX) device. 2. Assessment(s) of the RDT network. 3. Continuous upgrading of RDT network capabilities (new networks/new technologies).

Supporting Resource Mobilization Priorities	
T.1.C10	S.2.C1*

Support Needed

At the end of 2022, there were 159 nuclear facilities in 33 Member States connected to the IAEA Safeguards RDT network. Although more facilities join each year, with an approximate 5% annual growth rate, the greatest impact on the Department RDT network is the surge in data volume originating from advanced Safeguards instruments in various facilities. Cameras and other devices are transmitting higher resolution and larger data files, particularly with the introduction of the

new Laser Curtain for Containment (LCCT) lasers. The Department's top priority is to maintain and ideally enhance the network's security and speed.

To achieve Outcome #2, the plan for 2024–2025 includes the implementation of three outputs through the following activities:

- Development of a RAINBOX device, designed to function as a virtual private network (VPN) device using open-source VPN software (pfSense). It will also serve as a reliable and robust device for locally signing equipment data using a cryptographic algorithm, eliminating the need for a local collection computer in systems containing modern Safeguards data acquisition devices like the UDL1. Support for this initiative is already in place through MSSP Task USA E 2384 (Remote Monitoring VPN Hardware Support). The first RAINBOX prototype is expected early in 2024, with the subsequent focus on testing, authorization for safeguards use, and field deployment. Depending on the needs of the testing and fielding phase, the Department may request an extension of the current MSSP Task or initiate a new MSSP Task Proposal.
- Regular security assessments of the RDT network are essential to maintain its integrity and security. The network underwent vulnerability checks in 2019 and 2020 and a full penetration test in 2022. To ensure ongoing security, these assessments need to be repeated at least once every two years, resulting in one more assessment in 2024–2025. The CFEs/JPOs already requested under Outcome #1 will also contribute to this activity.

The Equipment Data Management (EDM) Team, responsible for the Safeguards RDT network, is dedicated to continuously evaluating the market for VPN and other network technologies as potential replacements for current systems. This evaluation includes specific installations requiring additional features and the search for alternative technologies to address obsolescence concerns. Notably, in 2019, the Stormshield VPN was approved for use in EC Member States by the European Atomic Energy Community (Euratom) authorities and has been installed in those regions. MSSP Task GER E 1859 (Testing and Implementation of Data Remote Transmission Security) supports the installation of Stormshield VPNs in Germany as part of this effort.

Continued outcome

Outcome #3: Enable rapid verification of activities in complex facilities.

Outputs	1. Develop a Near Real Time System (NRTS) instance for the Central Spent Fuel Storage Facility (CSFSF) (RKB- facility) in Chornobyl, Ukraine. 2. Develop an NRTS instance for the Rokkasho Reprocessing Plant (RRP) (JRC- facility) in Rokkasho, Japan. 3. Develop an NRTS instance for the Japan Nuclear Fuel Ltd. MOX Fuel Fabrication Plant (JMOX) in Rokkasho, Japan. 4. Develop an NRTS instance for the encapsulation plant and geological repository (EPGR) (W0LE/W0LF facilities) in Olkiluoto, Finland.

Supporting Resource Mobilization Priorities

V.1.C1	V.6.C1	V.6.C3	V.6.C4	T.1.C10	T.1.C11	S.3.C1

Support Needed

In 2020, the Equipment Data Management (EDM) team successfully built the initial instance of an NRTS to operate at the ISF-2 facility (RKCY/RKCX) in Chornobyl. The NRTS is an advanced verification system that effectively utilizes data from both Safeguards equipment and facility operator declarations to facilitate rapid verifications when needed. Through NRTS, facility operators get near real-time "proceed" or "hold" notifications for processes where the physical presence of an onsite IAEA Safeguards inspector is impractical, such as during the welding of casks after loading nuclear material.

Looking ahead, four more facilities are expected to require customized NRTS implementations in 2024–2025:

- CSFSF (RKB-, Chornobyl, Ukraine) by Q2 2024;
- RRP/JMOX (JRC-, Rokkasho, Japan) by Q1 2025;
- JMOX (Rokkasho, Japan) by Q4 2026; and
- EPGR (W0LE/W0LF, Olkiluoto, Finland) by Q3 2024.

The work involved in customizing an NRTS are intricate and encompass the following:

- Analysing a facility's key measurement points (KMPs) as identified during the Safeguards by Design process;
- Analysing the flow of nuclear material within a facility in relation to the measurement obtained by the KMPs and the corresponding data provided in facility operator declarations;
- Developing a comprehensive swim-lane analysis chart to define interactions between facility operators, the NRTS system, and the IAEA Safeguards inspectorate; and
- Implementing the requisite algorithms to facilitate and expedite the interactions between facility operators and IAEA Safeguards inspectors for efficient verification processes.

Due to the complexity of Outcome #3, this D&IS Plan is seeking MSSP support in the form of financial contributions for IT development totalling approximately €500 000 per year. This support is particularly crucial for the development of the more complex NRTS implementations for the EPGR and the JMOX facility. Additionally, the Department anticipates extrabudgetary contributions from the EC SP (for EPGR) and the USSP (for JMOX) to further support the ongoing projects. The continued assistance is greatly appreciated.

SGTS-016: Occupational Health and Radiation Safety

Established

2022

Manager	SGTS Director
Virginia KOUKOULIOU	Alexey ANICHENKO

Objective

Managing safety matters related to Department staff members, ensuring compliance with applicable international and local regulations, enforcing radiation safety measures, restricting the spread of contamination, and strengthening radiation safety of safeguards activities worldwide.

Agency Programme and Budget Link

4.1.6.001 Provision of Safeguards Instrumentation and Services

Plan Abbreviations

ERML	Equipment Radiation Monitoring Laboratory
HQM	Equipment Handling, Storage and Quality Management Team
kBq	kilobecquerel
NSRW	Radiation Safety and Monitoring Section
OEW	Occupationally Exposed Worker
PPE	Personal Protective Equipment
RPO	Radiation Protection Officer

Context Highlights

Evolution and Future Focus: A Two-Year Retrospective of the D&IS Plan

This D&IS Plan has now been in existence for two years, marking a period of growth and evolution. In the inaugural Plan conceived two years ago, the context highlights were dedicated to detailed and intricate aspects of occupational health and radiation safety. For an in-depth exploration of these topics, please refer to the 2022–2023 Plan. A concise overview is presented below, reflecting the plan's evolution from its initial inception, while acknowledging the potential for its ongoing adaptation. In 2022–2023, the primary focus was improving detection capabilities in the Equipment Radiation Monitoring Laboratory (ERML). This outcome is related to radiation safety. For 2024–2025, outcomes #2 and #3 focus on occupational safety. The development of the Department Safety Policy, as well as improvement of the facility hazards database, include both radiation and industrial safety elements. In collaboration with D&IS Plan SGCP-102 (Training), this Safety Policy will align with the Deputy Director's General for Safeguards prioritization of industrial safety.

Occupational Health and Radiation Safety Brief Overview

Risks and Stringent Standards: Department staff members face diverse risks, including radiation exposure and contamination. Safety standards, driven by Member States and public expectations, continually tighten. Global regulations on contaminated material release are becoming ever-stricter. Lower surface contamination release limits and proper identification and quantification of radionuclides are becoming an increasing need. Detection efficiency and accuracy need to be optimized in order to fulfil current and future regulatory limits and facility requirements.

Figure 56: An ERML staff member performs measurements.

The ERML's Vital Role: The ERML is pivotal. It identifies and eliminates radioactive contamination on various items used in the field. ERML ensures the safe return of equipment, including personal items, after

contamination removal. Its role is crucial not only for the safety of Department staff members and the public, but also for the Department's reputation, to ensure that no contaminated items are released within or from the Vienna International Centre.

Data-Driven Activity: The ERML conducts around 30 000 contamination measurements yearly on seals, inventoried and non-inventoried items, ensuring transparency through statistical reporting.

Industry-wide Significance: Occupational health and radiation safety is vital across the nuclear industry, from mining to verification. Strict contamination control prevents cross-facility contamination. Ensuring the safety of travelling Department staff members enhances the ability to focus on work.

Addressing Challenges: Challenges include adapting to evolving standards, aging equipment, and fostering and preserving the credibility of a Department safety culture.

Decontamination Services: The ERML performs decontamination activities before contaminated equipment can be returned to the pool of safeguards items for field use. The metrics of decontamination activities are shown in below.

Regulatory Compliance: Divisional Radiation Protection Officers (RPOs) and the Equipment Handling, Storage and Quality Management Team (HQM) Team Leader oversee compliance with radiation safety regulations. Each Division establishes a Radiation Protection Programme, which is authorized by the IAEA Radiation Safety and Nuclear Security Regulator.

Methodology: The ERML employs diverse methods for measuring surface area contamination, including direct, indirect, and nuclide identification techniques. To provide Member States as well as Department staff members with assurance as to the quality of these measurements, the ERML maintains its accreditation as an ISO 17025-accredited testing laboratory.

Mandatory Training: Radiation safety training is mandatory for occupationally exposed workers (OEWs), reinforcing the Department's commitment to assuring Department staff member safety. According to the IAEA Radiation Safety and Nuclear Security Regulations, which comply with Radiation Protection and Safety of Radiation Sources International Basic Safety Standards General Safety Requirements Part 3 (STI/PUB/1578), as well as applicable national regulations and facility requirements, radiation safety training is mandatory and certificates for training completion are often required to obtain entrance to facilities.

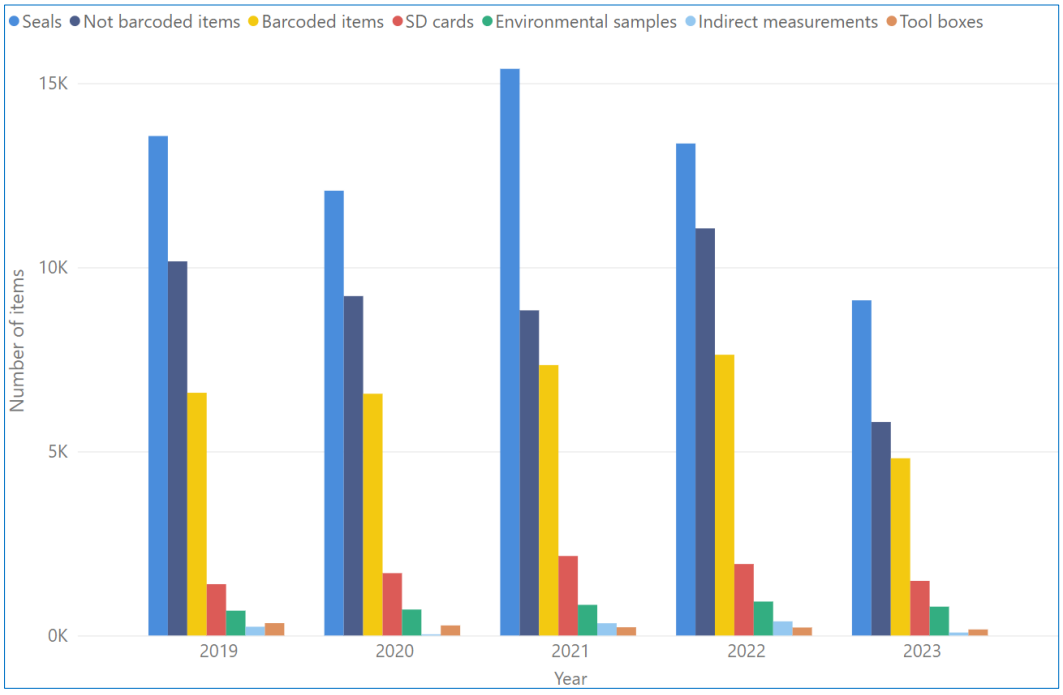


Figure 57: ERML Contamination Monitoring Activities.

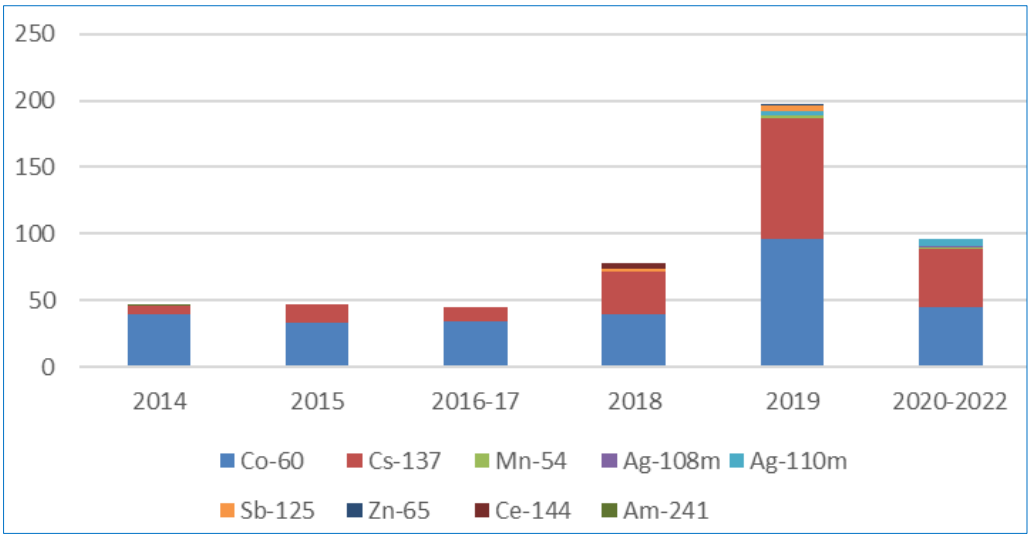


Figure 58: ERML Contamination Monitoring Activities: Total activity removed per year in kilobecquerel (kBq).

Progress and Achievements from MSSP from 2022–2023

- Ordering of new Alpha, Beta, and Gamma measurement equipment has been made possible due to Member State support and will be delivered in Q1 2024. Existing equipment is more than 15 years old and facing several operational issues. The new equipment will improve the capabilities and detection efficiency of ERML methods.
- A new JPO is expected to join the ERML team in Q1 2024 to perform acceptance testing and to update the methodology for using the new equipment, as well as to assist in the inclusion of new equipment under the existing ISO 17025 accreditation.
- With the support of a trainee via the Traineeship Programme, items stored in the Safeguards Warehouse were remeasured and quantified; many of these items are no longer contaminated due to short half-lives and/or the application of new decontamination techniques, and have therefore been released back to the general pool of equipment.

New Challenges

- In 2023, the number of facilities with lower contamination acceptance limits has increased, demanding an expansion of non-destructive decontamination techniques
- Low-level non-destructive decontamination techniques are not well-studied in the wider scientific community, due to unique nature of the Department's requirements.

Success Story

- The ERML has examined using over-the-counter cleaning products such as foaming kitchen cleaner and compressed air for decontamination purposes; these products have been successful at cleaning, for example, fork detectors and some other equipment. Using such techniques, equipment can often be successfully decontaminated and safely used without incurring additional shipping costs and without facility restrictions.
- Improving the scope of the Department Radiation Protection training by providing practical training courses during specifically-designed exercises, which make use of equipment commonly used in the field and real contaminated items.
- Detection of low-level contamination in personal items triggered by personal dosimeters has often revealed actual low-level internal contamination not previously detected by facility monitoring.
- Significant increases in the Personal Protective Equipment (PPE) provided to SG staff enables the Department to cover the safety needs arising during the Covid-19 pandemic and, for example, critical missions to Ukraine. In 2019, 8 000 PPE items were distributed while in 2022, this number increased to 65 000.

Occupational Health and Radiation Safety Plan Objectives

- Strengthen the Department occupational health and radiation safety culture.
- Develop the ability to assess independently dose rates received by Department staff members as a result of incidents, accidents, and emergencies (for example, intake of radionuclides), and adequately assess follow-up actions.
- Establish a Department Safety Policy.
- Develop an advanced "train the trainer" training course for Department RPO relating to industrial and radiation safety training.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☐ Equipment	☒ Training
☒ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☐ Studies
☒ Financial Support for Travel	☒ JPOs	☐ R&D	
☐ Expert meeting participation		☒ Facility Access	

Resource Mobilization Priority Links

T.1.C9 Ability to detect and quantify contamination in equipment returned from the field with heterogenous matrices and shapes

W.3.C3 Ability to improve safety culture by enhancing staff skills and expertise related to radiological and industrial safety

W.3.C4 Ability to effectively utilize knowledge and expertise already existing with the Department

New Plan for 2024–2025

★ Indicates top priority

♻ Continued outcome

Outcome #1: Improved ability to verify dose assessments as per regulations and mandates and to respond to exposure emergencies quickly and effectively.

Outputs

1. ★ Acquisition of a COTS dose assessment software.
2. Available software training for Radiation Protection Officers (RPOs).
3. Draft procedures for dose assessment activities in case of accidents/incidents.

Supporting Resource Mobilization Priorities

T.1.C9	W.3.C3

Support Needed

Safeguards RPOs currently rely on the Radiation Safety and Monitoring Section (NSRW) in the Department of Nuclear Safety and Security to perform dose assessments and amendments. RPOs must have both the ability and proper tools to perform dose assessments in the event of an incident. At present, the Department is entirely dependent on the service provider, which is not aligned with the regulations and may create delays (as experienced when serious incidents occurred previously). In the case of dose reassessments, the Department must currently interface with both the Department staff member being reassessed and with NSRW to perform the reassessment. In the event of an emergency (contamination incident), accurate and timely assessment of the dose is crucial, due to treatment options and the medical response being highly dependent on the initial dose estimation. Any delays must be avoided. Therefore, RPOs (or at least some RPOs) need to have the capacity to perform initial dose estimation without delay and the ability to verify the dose assessment performed by the dosimetry service provider.

In light of these challenges and bolster our capabilities, the following support is essential:

- **Equipment**: A specialized software for the assessment of internal contamination with multiple licenses valued at approximately €40 000.

- **Consultant**: The services of a consultant proficient in dose assessment for one year to create the procedures and train Department staff members on both procedures and software, for one year valued at approximately €110 000.

The Department will continue its efforts to have clear and direct communication with the service provider and will participate in appropriate training courses whenever possible, as well as keep track of and follow up on international standards and publications related to dose assessment.

Continued outcome

Outcome #2: More efficient and effective ability to meet the IAEA's mandate from a procedural and preventative standpoint.

Outputs	1. ★ A Safety Policy for the Department. 2. The necessary approvals to distribute and implement the Safety Policy. 3. Implementation of the Safety Policy. 4. ★ Organization of a "Train the Trainers" Radiation Protection Officer (RPO) Training Course on radiation risks in industrial environments.

Supporting Resource Mobilization Priorities	
W.3.C3	W.3.C4

Support Needed

A Safety Policy plays a crucial role in establishing a culture of safety within an organization. It defines how safety is managed, who is responsible for it, and the methods used to assess safety performance. This policy would receive endorsement from Department managers, which in turn makes them accountable for the ongoing success of the safety system. It is imperative that this Safety Policy aligns with both international standards, IAEA policies, and national legislations. Furthermore, the Safety Policy should address specifically the activities of each Department and the associated risks these activities entail.

In addition, the Department needs to establish an RPO Training Course led by nuclear industry/facility experts. This training course aims to ensure that RPOs are well-equipped to provide accurate advice and instructions on occupational safety (addressing radiation and industrial hazards) to all occupationally exposed workers (OEWs) travelling to a range of different facilities and facility types.

To strengthen our safety culture and equip Department staff members with the necessary expertise, the Department seeks the following support:

- **Consultant:** The Department is seeking approximately €110 000 for the engagement of a consultant proficient in Occupational Health and Radiation Safety policies. This consultant will play a pivotal role in creating a Safety Policy and assisting in its implementation over the course of one year.
- **Training Courses:** The Department requests MSSP assistance to organize and host two "train the experts" training courses in a suitable facility. Each training course is expected to accommodate a maximum of 30 RPOs, covering expenses such as travel, training materials, and fees for expert lecturers. The Department estimates the total cost to be approximately €200 000.

Continued outcome

Outcome #3: Department staff member awareness of safety risks at facilities.

Outputs	1. ★ An upgraded Facility Hazard Database from the existing MS® Access database to an SG IT system. 2. Classification of facilities according to risk, based on experience and work performed at each facility. 3. Basic instructions according to each class of facility, for example, spent fuel repositories. 4. Updated facility instructions based on IAEA Safeguards inspectors' field observations in the Facility Hazard Database.

Supporting Resource Mobilization Priorities	
W.3.C3	W.3.C4

Support Needed

One of the key responsibilities of Radiation Protection Officers (RPOs) is to provide Department staff members who are preparing for duty travel with the necessary instructions concerning potential safety risks at facilities. Part of each RPO's duties is collecting occupationally exposed worker (OEW) feedback and relevant information concerning safety in facilities visited. The Safeguards Health and Safety Sub-Committee has consolidated this information into a unique database, which contains comprehensive information and insights into the safety risks associated with each facility visited. This database represents a unique archive and very detailed tool in assessing potential facility-specific risks. Currently, this information is maintained in MS® Access database, but it would be more efficient if this tool could be upgraded and consolidated in an existing SG IT platform.

To bolster our safety protocols and improve information management, the Department is set to undertake the following:

- **Enhancement of Database:** Integrating this information into an established Safeguards IT system, which will enable RPOs to maintain and extract information in a more efficient manner and provide staff members with precise and up-to-date information on the actual status of facilities.
- **On-Site Assessments:** Additionally, the Department is planning duty travels to randomly selected facilities by some Department Health and Safety experts. The purpose will be to assess actual onsite risks, thereby ensuring that the database remains consistently updated. This effort will also contribute to the development of an "observation form," which can be distributed and completed for each future duty travel.

To achieve these goals, the Department seeks support in:

- **IT Infrastructure Support:** Approximately €100 000 to either create a more robust database or to integrate this information into an existing Department IT system in collaboration with SGIS.
- **Facility Access:** To facilitate this process, the Department requires the presence of one Safeguards RPO with expertise in radiation safety to accompany and observe selected duty travels.

Modified outcome

Outcome #4: Improve the Equipment Radiation Monitoring Laboratory's (ERML) Decontamination Capabilities.

Outputs	1. ★ Advanced decontamination training for ERML staff members. 2. Implementation of advanced decontamination processes in the ERML's decontamination laboratory. 3. Procured specific equipment for the characterisation of contaminated items and waste. 4. Updated contamination reporting system.

Supporting Resource Mobilization Priorities	
W.3.C3	W.3.C4

Support Needed

The ERML offers a crucial service involving the decontamination of items that are returned to IAEA headquarters and found to be contaminated. Decontamination is a mission-critical activity, as it allows these items to be re-integrated into the Department's equipment pool and safely dispatched to facilities worldwide.

Furthermore, these initiatives play a pivotal role in cost-saving efforts, reducing the need for item replacement and disposal. With international regulations regarding contamination acceptance limits becoming more stringent, it is imperative that the ERML continually upgrades its decontamination techniques to meet evolving regulatory requirements.

To do this, the Department has outlined the following activities:

- **Advanced Training:** The Department plans to provide advanced training to ERML staff members with the aim of further enhancing expertise in decontamination techniques.
- **Equipment Procurement:** The Department aims to acquire specific equipment for characterising contaminants and measuring dose rates.

To facilitate these activities, the Department seeks support in the following areas:

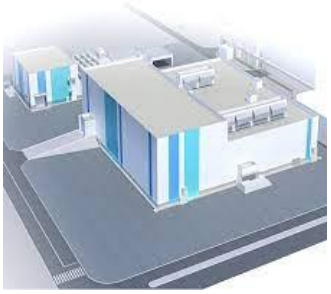
- **Financial Support:** Approximately €50 000 to cover estimated costs associated with acquiring characterisation and dose monitoring equipment.
- **IT Infrastructure Support:** Approximately €100 000 to establish a more robust reporting system for contaminated equipment, which will significantly improve the Department's monitoring and reporting capabilities.
- **Training course:** Organization of a training course, accommodating a maximum of 10 Department technicians, which would include expenses for travel, accommodation, training materials, and expert lecturers. The estimated cost of this course is approximately €50 000.

SGOA-002: Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX)

Established

2006

Manager	SGOA Director
Christophe CREUSOT	Mohamed LAMARI



Objective

Developing and implementing joint-use equipment, data collection systems, and evaluation software at the Japan Nuclear Fuel Ltd. (JNFL) mixed oxide (MOX) Fuel Fabrication Plant (J-MOX).

Agency Programme and Budget Link

4.1.8.001 Develop and implement a safeguards approach for J-MOX

Plan Abbreviations

C/S	Containment and Surveillance
CASCADE	Centralized Automated System for Correlated Analysis and Data Evaluation
DA	Destructive Analysis
DIE	Design Information Examination
DIV	Design Information Verification
J-MOX	Japan Nuclear Fuel Ltd. MOX Fuel Fabrication Plant
JNFL	Japan Nuclear Fuel Ltd.
JTC	Joint Technical Committee
MOX	Mixed Oxide
NDA	Non-Destructive Assay
NRTA	Near Real Time Accountancy
NRTS	Near Real Time System
OSL	On-Site Laboratory
Pu	Plutonium
RDT	Remote Data Transmission
RRP	Rokkasho Reprocessing Plant
SLA	State Level Approach
U	Uranium

Context Highlights

J-MOX at the Japan Nuclear Fuel Ltd. 1 Site

The Japan Nuclear Fuel Ltd. (JNFL) mixed oxide (MOX) Fuel Fabrication Plant (J-MOX) is a MOX fuel fabrication plant located at the JNFL 1 site, located in north Japan which currently also includes the large scale Rokkasho Reprocessing Plant (RRP). J-MOX will operate in line with RRP with a maximum annual capacity of 130 tons of Heavy Metal, equivalent to a yearly throughput of 8 tons of Plutonium (Pu). Upon commencement of operations, it will rank among the largest facilities subject to IAEA Safeguards, alongside RRP.

Plan Objective

The overall objective of this D&IS Plan is to develop and implement the J-MOX safeguards systems, which includes the development of joint-use equipment and data collection systems and evaluation software. The J-MOX Joint Technical Committee (JTC) (which includes Japanese State Authorities and the facility operator) monitor the development of the equipment, systems, and software. An overview

of the J-MOX safeguards systems is shown in the figure below ("An overview of the J-MOX safeguards systems."). More than 20 unattended Non-Destructive Assay (NDA) systems and 50 cameras will be installed under Remote Data Transmission (RDT) to verify/monitor the inventories and flows of nuclear material through the process.

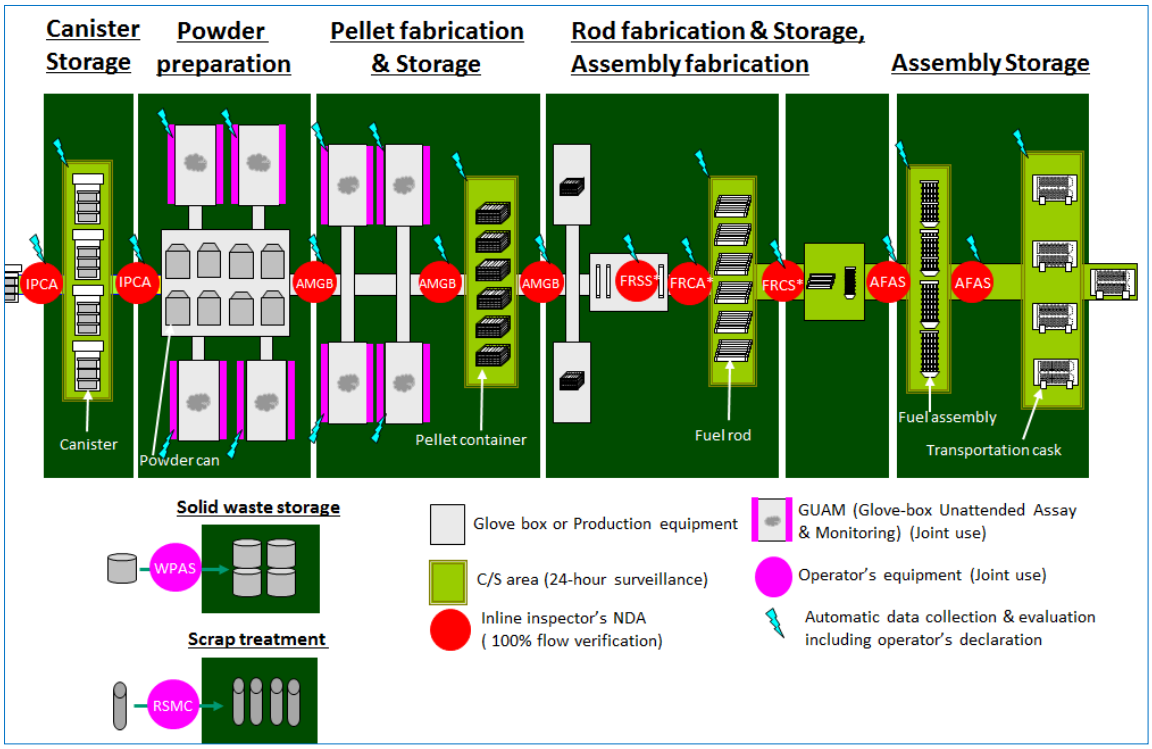


Figure 59: An overview of the J-MOX safeguards systems.

J-MOX Timeline

June 2005	The preliminary design information for J-MOX was submitted.
October 2010	Plant construction commenced.
March 2011	Plant construction was suspended following the major earthquake and tsunami that struck Japan.
April 2012 to September 2022	Construction restarted mainly on the foundations of the main process building. Main process building construction is awaiting further authorization by the safety authorities based upon updated safety regulations introduced following the accident at Fukushima Dai-ichi. The utilities building construction is completed.
September 2022	The construction of the main process building restarted following approval by the Japanese safety authorities,
September 2024	Estimated/target completion date of the main process building construction.
2026 or 2027	Estimated/target start of commercial operation after Uranium (U) and MOX commissioning.

Resuming Development Activities and Safety Reviews for J-MOX Construction

Development activities resumed in late 2022 alongside the restart of J-MOX construction. The primary goal is to have most Safeguards equipment installed by September 2024 to align with the operator's current schedule. However, the Japanese safety authorities are currently conducting safety reviews concerning J-MOX glove-boxes and equipment. These reviews are still in progress and may potentially result in delays in the construction, commencement of commissioning, and the start of operations, which could impact the Department's planned timeline.

Figure 60: MOX Fuel Plant Construction June 2023 at JNFL 1 site (credit Japan Nuclear Fuel Limited).

Resource Forecast

With the re-start of construction activities, the Department has transitioned from a period of uncertainty to one of more concrete progress. Following the construction re-start, the spending and resource plans have been reassessed to align with the operator's schedule for the project's lifespan.

While the majority of funding for J-MOX safeguards verification systems is expected from the Department's regular budget, the stringent timeline may necessitate extrabudgetary support. This extrabudgetary support will be requested to focus on specific areas, including support to develop and test equipment and software dedicated to the J-MOX facility.

Most Needed External Support in 2024–2025

☒ Financial Support	☒ Consultants	☒ Equipment	☐ Training
☐ Financial Support for IT Development	☒ CFEs	☐ Reference Materials	☒ Studies
☒ Financial Support for Travel	☒ JPOs	☐ R&D	
☐ Expert meeting participation		☒ Facility Access	

Plan Resource Mobilization Priority Link

V.6.C3 Ability to implement effective and efficient safeguards at J-MOX

New Plan for 2024–2025

★ Indicates top priority

♻ Continued outcome

Outcome #1: Effective and efficient Safeguards Approaches and procedures for the Japan Nuclear Fuel Ltd. (JNFL) mixed oxide (MOX) Fuel Fabrication Plant (J-MOX).

Outputs	1. The finalization of the Safeguards Approach and related procedures for J-MOX. 2. The establishment of Design Information Examination (DIE) and Design Information Verification (DIV) procedures, ensuring the facility's construction and operation align with declared specifications and maintain a robust safeguards approach.

Supporting Resource Mobilization Priority

V.6.C3

Support Needed

Approved J-MOX Safeguards Approach

The Department needs an approved J-MOX Safeguards Approach in line with the Japan State Level Approach (SLA). The Department will prepare tailored implementation procedures for J-MOX and engage in negotiations with State Authorities and the facility operator.

A Near Real Time Accountancy (NRTA) Tool

A pivotal element of this approach is the development of an NRTA tool customized for J-MOX. Past efforts, such as MSSP Task UK D 1878 (Development of a Software Tool to Simulate the Nuclear Material Accountancy System for MOX Facilities), have provided a simulation tool for typical MOX facilities, aiding in the review of the facility operator's accountancy system and assisting in the design phase of the J-MOX NRTA tool. Methodological NRTA software development is covered by

D&IS Plan SGIM-008 (Statistical Analysis). However, the Department may seek support for the specific coding of the NRTA software tailored to J-MOX.

Design Information Examination (DIE) and Design Information Verification (DIV) Procedures

To ensure the facility's construction aligns with declared specifications and that the Department's Safeguards Approach remains robust, DIE and DIV procedures are essential. These activities will be conducted from the construction phase to MOX commissioning and continue during commercial operation. Planning and equipment installation for these activities will receive strong support by way of MSSP Task JPN X 2725 (CFE - MOX Fuel Fabrication Expert), which will directly coordinate with Japanese stakeholders.

Destructive Analysis (DA) Sample Procedures

Additional extrabudgetary support may be requested for the development of destructive analysis (DA) sample treatment, analysis, and transportation procedures to the Rokkasho On-Site Laboratory (OSL) in close cooperation with D&IS Plan SGAS-001 (Destructive Analysis of Nuclear Materials).

Continued outcome

Outcome #2: Ability to meet safeguards requirements with high-quality, independent, and reliable results from safeguards equipment.

Outputs	1. Completed design, tests, and installations of safeguards equipment, including Non-Destructive Assay (NDA) and Containment and Surveillance (C/S) systems, with equipment interfacing the operator's systems. 2. Designed, tested, and implemented integrated data collection and evaluation tool to be ready before the facility's targeted completion date, ensuring the readiness of this crucial tool before the facility's start-up.

Supporting Resource Mobilization Priority

V.6.C3

Support Needed

Under this plan, the Department will continue to collaborate with several MSSPs who play pivotal roles in shaping the design and testing of safeguards verification systems for J-MOX. These contributions are facilitated through various umbrella MSSP Tasks including MSSP Tasks:

- JPN A 1721 (Support for Development of J-MOX SG Systems),
- USA A 1801 (Support for the Safeguards Systems at the JNFL MOX Fuel Fabrication Plant (J-MOX)),
- FRA A 1944 (Support for the Safeguards Systems at the JNFL MOX Fuel Fabrication Plant (J-MOX)), and
- EC A 1778 (Support for the Safeguards Systems at the JNFL MOX Fuel Fabrication Plant (J-MOX)),

with the objective of providing support that includes:

- **Expert Review:** Expert review of hardware and software designs.
- **Development and Testing:** Assistance with developing and testing new systems, covering NDA, C/S components, and identification readers.

Figure 61: Testing of the fuel rod scanning system prototype.

- **Integrated Data Systems:** Support in configuring an integrated data acquisition and evaluation system.
- **Evaluation Software Modules:** Assistance with the developing, testing, and configuring evaluation software modules.
- **Prototype Testing:** Testing of prototype or new-generation detectors at MOX facilities in France and/or Japan.

The role of a CFE provided by MSSP Task USA E 2612 (CFE - Senior Project Engineer) is essential in 2024–2025. Additionally, the cooperation of another CFE, MSSP Task JPN X 2725 (CFE - MOX Fuel Fabrication Expert), will also be crucial for liaising between Japanese stakeholders and the Department to that the equipment's development aligns with operator constraints and complies with detailed construction and commissioning schedules.

The development of NDA and C/S systems will be performed in close collaboration with D&IS Plans SGTS-003 (Surveillance Techniques), SGTS-002 (Techniques and Instruments for Sealing and Containment Verification), and SGTS-011 (Unattended Measurement Techniques).

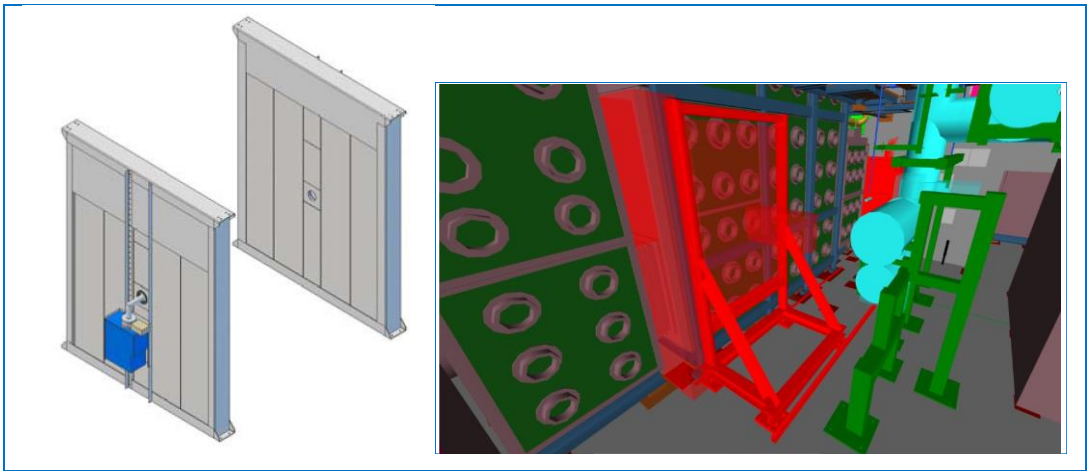


Figure 62: Advanced Material Accountancy Glove Box NDA system.

Regarding the evaluation software, development is set to restart in 2024. The Department plans to revise the high-level user requirements, initially gathered in 2010–2011, in accordance with the updated approach. The Department intends to develop a Near Real Time System (NRTS) based on a Centralized Automated System for Correlated Analysis and Data Evaluation (CASCADE). This work will be closely coordinated with D&IS Plans SGTS-014 (Remote Data Transmission and Processing Systems) and SGIS-003 (Safeguards Information Systems and System Usability).

Depending on the progress of J-MOX construction and commissioning in 2024–2025, there may be additional needs for support, including potential financial assistance for equipment or software development, financial support for Department technicians' travel for equipment installation, and the potential additional JPO/CFE/consultants. Continued MSSP support and collaboration are invaluable in ensuring the success of this project.

SGOA-003: Fukushima Dai-ichi Safeguards

Established

2016

Manager	SGOA Director
Glen HORTON	Mohamed LAMARI

Objective

Maintaining safeguards on nuclear material and facilities at the Fukushima Dai-ichi site.

Agency Programme and Budget Link

4.1.2.002 Verification and monitoring of Iran's nuclear related commitments

Plan Abbreviations

IRAP	Integrated Review and Analysis Platform
NDA	Non-Destructive Assay
OASM	Open Air Spent Fuel Monitor
SF	spent fuel
TEPCO	Tokyo Electric Power Company Holdings, Incorporated

Context Highlights

Background

At the time of the earthquake and tsunami that struck Japan in March 2011, there were six large nuclear power reactors on the Fukushima Dai-ichi site and two spent fuel (SF) 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.

Figure 63: TEPCO recovery of Spent Fuel from Unit 3 (Credit: TEPCO).

The tsunami caused considerable damage to facilities and safeguards equipment. IAEA Safeguards inspectors were first able to enter the damaged site seven months later, in October 2011, to re-establish safeguards to the extent possible. Safeguards surveillance was re-established in accessible locations, and nuclear material was re-verified, in stages, as infrastructure was restored and as nuclear material was gradually removed from high-radiation areas.

By April 2021, the nuclear material inventories of Reactor Units 4, 5, and 6, as well as the inventories of both SF storage facilities, and the inventory of SF from the pond of Reactor 3 had been fully re-verified. The inventories of Reactor Units 1, 2, and the remainder at Reactor 3 remained inaccessible.

As of early 2024, the situation in terms of material left to be reverified remains the same. Tokyo Electric Power Company Holdings, Incorporated (TEPCO) is in the process of developing the design for the first facility to be built onsite to receive core debris retrieved from Unit 2. The Department will design its Safeguards Approach and select the necessary technologies once sufficient details are made available. Accordingly, specific requests for extrabudgetary support may emerge in the future.

Foreseen Challenges

The Department faces two main, ongoing challenges, which inform this D&IS Plan:

Challenge 1: Ongoing challenge of providing assurances that there has been no unreported removal of nuclear material as the conditions on the site evolve.

The IAEA monitors the site with site-wide monitoring equipment, which includes a second-generation Open Air Spent Fuel Monitor (OASM) surveillance tool installed in 2022. The Department would benefit from improved monitoring review software and would welcome support in scanning for novel technologies to enhance the its ability to perform site-wide monitoring. To further enhance the

monitoring effectiveness, the Department is eager to explore advanced monitoring review software and innovative technologies. The primary focus remains on SF monitoring, with special attention to scenarios where SF becomes intermingled with core debris, particularly as the Department embarks on large-scale core debris recovery efforts.

Challenge 2: Development of safeguards approaches for newly-constructed facilities that will handle recovered core debris material.

There remains extremely limited access to the damaged cores and little knowledge, if any, of the precise location and form of nuclear material within them. This makes it difficult to begin the design of safeguards equipment in the near future.In addition, remediation progress is slow. A new facility is being designed to receive the first retrievals, likely in 2025. Large scale retrieval operations will not begin for some years. In the interim, measures are required to enable monitoring of any removal of nuclear material from a changing and challenging environment and the verification of material transferred to the new facility. The Department would benefit greatly from new non-destructive assay techniques for heterogeneous, uncharacterised core debris material.

Top Plan Priorities

- Maintain a reliable safeguards system at the Fukushima Dai-ichi site that is capable of providing credible assurance that nuclear material cannot be removed from the damaged facilities without the IAEA's knowledge.
- Improve and adjust the monitoring system to accommodate changes in the remediation status of the damaged onsite facilities.
- Develop measures to re-verify the inaccessible nuclear material as soon as material is made available for verification.

Most Needed External Support in 2024–2025

The Department has only needed in-house technology and expertise thus far for this D&IS plan. While the immediate focus is to determine if in-house technology will be suitable for verification activities related to the new facility being designed to handle the first core debris quantities, the Department may later request support in developing techniques to verify the debris.

Resource Mobilization Priority Links

* Indicates a prioritized capability

T.1.C5*	Ability to develop, deploy and maintain new sealing system technologies with improved security and efficiency
T.1.C11	Ability to rapidly detect, characterize and address breaches to unattended systems, and evaluate their vulnerabilities more broadly, particularly from threats arising from technology advancements (e.g. conduit integrity verification)
S.3.C1	Ability to identify and address the needs of designers and operators of modified or new facilities in the early preparation for efficient implementation of safeguards

New Plan for 2024–2025

Continued outcome

Outcome #1: Maintain ability to provide credible and reliable assurances that nuclear material is not being removed without the Agency's knowledge as the site evolves.

Outputs	1. Updated onsite monitoring configuration as new removal routes open. 2. Enabled Open Air Spent Fuel Monitor (OASM) Non-Destructive Assay (NDA) review through use of Integrated Review and Analysis Platform (IRAP).

Supporting Resource Mobilization Priorities		
T.1.C5*	T.1.C11	S.3.C1

Support Needed

The Department continuously monitors changes and assesses new removal routes at the site. Monitoring equipment upgrades would improve reliability and efficiency, and software updates would increase efficiency in reviewing monitoring data. Identification of new technologies for site-wide monitoring could further enhance capabilities at the site, and the Department would be interested in learning more from external partners.

Continued outcome

Outcome #2: Implementation of effective and efficient safeguards approaches for the Fukushima Dai-ichi site that include measures applicable to removed fuel-containing debris.

Outputs	1. An approved Safeguards Approach with specific procedures applicable to the new facilities and activities related to the recovery of core debris. 2. A survey of new technologies for possible Non-Destructive Assay (NDA) verification of fuel-containing debris materials.

Supporting Resource Mobilization Priorities	
T.1.C11	S.3.C1

Support Needed

The Department is actively developing a new Safeguards Approach in response to the evolving design of new facilities, such as the core debris storage facility. As of early 2024, the site has effectively addressed all NDA challenges utilizing in-house technologies. However, the dynamic nature of core debris material requires continuous learning and a potential shift in strategies.

As the Department's understanding of core debris material advances, it recognizes the need to explore cutting-edge technologies. Surveys aimed at identifying novel technologies capable of supporting NDA verification on a smaller scale may be applicable. These technologies may prove applicable to future, larger-scale retrieval activities. Consequently, the Department may potentially request support in developing techniques to verifying the debris.

SGOC-001: Chornobyl

Established

2001

Manager	SGOC Director
Faisal AJJEH	Mosatiwa RASWESWE

Objective

Developing and implementing effective and efficient safeguards systems at the Interim Spent Fuel Storage Facility 2 and associated Conditioning Facility (collectively referred to as ISF-2) and the New Safe Confinement (NSC) placed over the existing shelter that covers the Chornobyl Nuclear Power Plant (ChNPP) Unit 4.

Agency Programme and Budget Link

4.1.4.001 Safeguards Implementation for States under the Responsibility of Division SGOC, Verification for States with a CSA and an AP in force

Plan Abbreviations

CSFSF	Centralized Spent Fuel Storage Facility
ISF-2	Interim Spent Fuel Storage Facility 2 and associated Conditioning Facility
NSC	New Safe Confinement
TRC	Technical Review Committee

Context Highlights

Introduction: Development and Implementation Support Plan for Chornobyl

In the sphere of Chornobyl, where nuclear activities intersect with various challenges, it becomes crucial to outline the path over the past two years and convey the plan for 2024–2025. The Department extends its appreciation to the dedicated partners and Member States who have supported throughout this journey.

Progress Amidst Conflict

Ukraine has encountered a period of conflict. Throughout this time, the Department's commitment to the uninterrupted continuation of nuclear fuel cycle activities has remained firm. Ukraine has continued all nuclear operations, including those initially considered potentially susceptible to disruption.

Notable Achievements

Over the past two years, the Department has achieved significant milestones. The centralized spent fuel facility initiated spent fuel reception in May 2023. Concurrently, spent fuel transfers started at the Interim Spent Fuel Storage Facility 2 and associated Conditioning Facility (collectively known as ISF-2) facilities, surpassing initial expectations. The ability to facilitate such transfers signifies substantial progress in Chornobyl initiatives.

Unit 4, a focal point of attention, is ready for further examination. Decisions regarding additional measures fall under the purview of the Department’s Technical Review Committee (TRC), a dedicated body responsible for advising the Deputy Director General - Safeguards (DDG-SG) on technical matters.

A notable accomplishment is the commissioning of equipment for the Centralized Spent Fuel Storage Facility (CSFSF). Testing, supported by the USSP, culminated in the official commencement of operations in May 2023. The CSFSF now operates under routine safeguards.

The Path Forward

The ISF-2 and CSFSF facilities have been operational since September 2020 and May 2023 respectively, and the current focus is providing training for the operator. Comprehensive training has equipped the State and operators to perform sealing procedures independently. In the 2024 timeframe, the Department anticipates conducting a technical trip to enhance capabilities.

In 2024–2025, the acquisition of a new safe confinement structure takes priority. In line with TRC recommendations, the Department will initiate the bidding process.

The backdrop of conflict necessitates additional funding to address these evolving dynamics. Prior to the conflict, a trip to Chornobyl could be arranged within half to a full business day. However, due to the current circumstances, the process has become more intricate. Obtaining the necessary clearances, coordinating logistics, securing an armoured vehicle, and arranging for a specialized driver now requires an extended timeframe, typically ranging from two to three weeks, and sometimes even longer. The Department's initial infrastructure and equipment installation budget allocation of €300 000 has been adjusted to €500 000 to reflect increased costs due to extensive paperwork, extended fieldwork, and heightened security requirements.

A Call for Collaboration

The plan ahead requires technical trips to ensure that the Department's partners, including contractors and subcontractors, align on safeguards requirements. Each trip will include a minimum of one technician. Furthermore, contract reviews and an examination of safeguards standards will remain integral to the Department's strategy.

A differentiating form of support in the last two years has been the technical trip to the New Safe Confinement (NSC) led by MSSP Task USA E 2560 (CFE - Senior Project Engineer). This trip greatly contributed to clarifying technical issues and facilitating alignment with IAEA standards and requirements.

Most Needed External Support in 2024–2025

☒ Financial Support	☐ Consultants	☐ Equipment	☒ Training
☐ Financial Support for IT Development	☐ CFEs	☐ Reference Materials	☐ Studies
☒ Financial Support for Travel	☐ JPOs	☐ R&D	
☐ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

M.2.C1*	Ability to strategically plan, maintain and improve safeguards IT tools, information assets, and associated infrastructure
M.4.C2*	Ability to carry out mission-critical functions – needed for continued delivery of safeguards conclusions – in case of disasters (e.g. disruptive, massive cyber-attack or physical loss of critical infrastructure)
S.1.C1	Ability to deploy data visualization and other methods and techniques to present safeguards findings and performance-related data in a clear and compelling manner
S.3.C1	Ability to identify and address the needs of designers and operators of modified or new facilities in the early preparation for efficient implementation of safeguards

New Plan for 2024–2025

★ Indicates top priority

Modified outcome

Outcome #1: Implementation of efficient and effective safeguards at Chornobyl facilities.

Outputs	1. IAEA Safeguards inspectors and State inspectors and operators have successfully participated in sealing activity training courses. 2. ★ Approval of the Safeguards Approach for the New Safe Confinement (NSC). 3. Approval of verification procedures for the NSC.

Supporting Resource Mobilization Priorities	
S.3.C1	S.1.C1

Support Needed

This plan ensures the uninterrupted application of Safeguards to enable the verification of nuclear material at Chornobyl facilities.

For Output 1, the Department is are seeking assistance from MSSPs to provide training mainly to the State inspectors and operators that covers sealing activities. This support will enable the Department to equip IAEA Safeguards inspectors, State inspectors, and operators with the

necessary skills and knowledge to efficiently conduct sealing activities in compliance with IAEA standards.

For Output 2, the approval of the Safeguards Approaches by the Technical Review Committee (TRC) will expedite the decision-making process for crucial project milestones. After TRC approval, the final decisions regarding the number and cost of safeguards equipment and the commencement of the bidding process will be confirmed. Consequently, the Department would request MSSPs to expedite the necessary funding associated with the project.

For Output 3, obtaining internal approvals will facilitate the efficient implementation of safeguards activities.

The support from MSSPs is pivotal in achieving the goal of efficient and effective safeguards implementation. The Department welcomes MSSP collaboration to ensure the successful realization of these critical outcomes and outputs.

Continued outcome

Outcome #2: Enhanced ability to carry out verification activities using equipment that is installed, adjusted, and authorized for verification use.

Outputs	1. Finalization of a contract for the equipment at the New Safe Confinement (NSC). 2. Completed installation of equipment at the NSC. 3. Tested, adjusted, and approved equipment at the NSC.

Supporting Resource Mobilization Priorities

M.2.C1*	M.4.C2*

Support Needed

For Output 1, the Department requires financial and logistical support to expedite the procurement and execution of a contract for the installation of equipment at the NSC. It will involve coordinating with contractors, guaranteeing adherence to quality standards, and streamlining the contract negotiation process. In addition to these essential steps, the Department must also arrange a technical visit to the NSC site. This visit will serve a dual purpose, enabling the Department to discuss and clarify any technical issues with the operators and contractors. Furthermore, the visit will play a pivotal role in the commissioning process, where the infrastructure and equipment installation will be assessed and validated for operational readiness. Therefore, in order to achieve the desired outcome, the Department needs a collaborative effort that includes financial support, logistical coordination, technical consultations, and a thorough site visit to oversee the project's progress and ensure its successful execution.

For Output 2, assistance is sought to ensure the timely and efficient installation of equipment at the NSC. This support would encompass financing and logistical coordination to overcome any potential delays and ensure that equipment is installed in accordance with safety and operational requirements.

For Output 3, the Department requires financial and technical support for the testing, adjustment, and approval processes of the equipment at the NSC. This includes funding for testing procedures, technical assessments, and quality assurance measures to ensure equipment functionality and compliance with international standards.

The implementation of verification activities at the NSC is critical for upholding nuclear safeguards. The timely procurement, installation, and verification of equipment are paramount in achieving this objective. MSSP support is instrumental in facilitating efficient equipment installation, adherence to quality standards, and the overall enhancement of verification capabilities. The financial support will help in overcoming potential delays and ensuring the successful completion of this crucial work.

Furthermore, support for the procurement of equipment, such as portal monitors and surveillance devices, is essential for equipping the NSC with state-of-the-art technology to bolster the Department's verification efforts. This investment contributes to strengthening global nuclear security and maintaining the integrity of safeguards measures at the NSC.

SGVI-001: JCPOA Verification

Established

2016

Manager	SGVI Director
Andrew CATTON	Frédéric CLAUDE

Objective

Verifying and monitoring the Joint Comprehensive Plan of Action (JCPOA).

Agency Programme and Budget Link

4.2.1.002 Verification monitoring of Iran's JCPOA nuclear related commitments

Plan Abbreviations

AP	Additional Protocol
CSA	Comprehensive Safeguards Agreement
JCPOA	Joint Comprehensive Plan of Action

Context Highlights

Background Information

As part of the transparency measures under the verifying and monitoring the Joint Comprehensive Plan of Action (JCPOA), IAEA Safeguards inspectors have enhanced access to Uranium mines and mills and continuous surveillance of centrifuge manufacturing and storage locations. These measures go beyond the scope of Iran's Comprehensive Safeguards Agreement (CSA) and Additional Protocol (AP) and require IAEA Safeguards inspectors and analysts to be specially equipped and trained. As of 7 November 2023, extrabudgetary funding had been pledged sufficient to meet the cost of JCPOA-related activities for the remainder of 2023 and until early July 2024.

JCPOA Update

On 29 January 2021, Iran informed the Agency that, according to a new law passed by Iran's Parliament, Iran would take certain measures related to the JCPOA, including stopping Agency inspections beyond the Safeguards Agreement.

On 15 February 2021, Iran informed the Agency that Iran "will stop the implementation of voluntary transparency measures as envisaged in the JCPOA, as of 23 February 2021."

As of the beginning 2024, the IAEA stands ready to implement any resulting agreement, as appropriate. Given the changing nature of the Iranian nuclear related political landscape, inspector training may be required in the future, hence it is advisable to maintain this D&IS Plan.

Most Needed External Support in 2024–2025

☐ Financial Support	☐ Consultants	☐ Equipment	☒ Training
☐ Financial Support for IT Development	☐ CFEs	☐ Reference Materials	☐ Studies
☐ Financial Support for Travel	☐ JPOs	☐ R&D	
☐ Expert meeting participation		☐ Facility Access	

Resource Mobilization Priority Links

* Indicates a prioritized capability

V.1.C1 Ability to synthesize and evaluate disparate sets of verification data from the field through data analysis methods and tools

V.1.C2* Ability to receive/collect, process, analyze and evaluate all safeguards-relevant information efficiently and effectively through innovation, integration, and governance

V.1.C3 Ability to efficiently process and interpret multi-lingual safeguards-relevant information, including within the Agency's secure air-gapped network

W.3.C2 Ability to further develop the expertise of the Safeguards Department's workforce and train the next generation of safeguards experts

New Plan for 2024–2025

★ Indicates top priority

Continued outcome

Outcome #1: SGVI inspectors and analysts who continue to have the knowledge and skills to conduct safeguards verification activities in Iran.

Outputs	1. An implemented Carbon Fibre Mechanical Testing training for SGVI inspectors. 2. Identified need for any new, emerging, and/or unexpected training.

Supporting Resource Mobilization Priorities			
V.1.C1	V.1.C2*	V.1.C3	W.3.C2

Support Needed

Annex I, section I, paragraph 54 of the Joint Comprehensive Plan of Action (JCPOA) States that the Agency is required to verify certain aspects relating to the definitions agreed on implementation day. To do this, specialized training is required and supplied through MSSP Task FRA B 2405 (Carbon Fibre Mechanical Testing Training Course for Inspectors).

The technical content of the training, required to fulfil the needs of the IAEA Safeguards inspectors and technical experts involved in verification activities of the JCPOA in Iran, was discussed between SGVI and the French Support Programme in 2018. The training was assessed as fully consistent with the technical needs of the participants. SGVI had two Carbon Fibre Mechanical Testing Training Courses in 2018–2019, and a third in 2021. Further training may be requested to accommodate developing needs, depending on JCPOA developments.

Progress from the 2022–2023 Biennium

DDGO-001: Overall Safeguards Management and Coordination (Malik DERROUGH)

Outcome #1: Enhanced foresight and decision support on funding needs and budgeting decisions for replacement of safeguards assets.	
Outputs	**Status/Comment**
Updated Asset Management Strategy and Plans.	**Completed:** The asset management documentation is updated as appropriate to reflect changes driven by lessons learned from implementation over the past few years.
ISO 55000 Alignment Assessment.	**Completed:** The Department hired an outside contractor to perform an assessment of the asset management system and concluded there are no significant gaps. The Department is now implementing the prioritized recommendations for improvement from the review.

Outcome #2: Increased capability for information sharing and greater collaboration.	
Outputs	**Status/Comment**
Implementation of the Internal Communications Strategy to enhance senior leadership and departmental staff member communication capabilities.	**Completed and work continues:** This is an ongoing effort, which will continue to be implemented, addressing challenges and opportunities as the environment and culture changes over time.
Reviewed and updated use of the Safeguards Portal (intranet) and new or improved communication channels for feedback, sharing, and relationship building, in close collaboration with SGIS-003: Safeguards Information Systems and System Usability.	**On hold:** Following an initial project start, this output was put on hold, pending the identification of an appropriate IT solution.
Coordinated development of published communication to ensure consistency of messages conveyed to departmental staff members and to Member States.	**Completed and work continues:** This is core communication work, and the Department will continue it for the long-term.

Outcome #3: Increased departmental staff member engagement and satisfaction.	
Outputs	**Status/Comment**
Results of spot/pulse surveys and communication surveys.	**Completed and work continues:** Pulse surveys were deployed via a number of mechanisms. The 2023 Communication Survey was conducted in Q4 2023.
Facilitation of departmental staff member focus groups regarding communication.	**On hold:** This will take place in 2024–2025.

SGAS-001: Destructive Analysis of Nuclear Materials (Mika SUMI)

Outcome #1: Improved analytical techniques, methods, and resources to ensure analytical capabilities at the On-Site Laboratory (OSL) in Japan.	
Outputs	**Status/Comment**
★ Implementation of new evaluation software for Hybrid K-Edge Densitometry (HKED).	**Work in progress:** Implemented Multi Elemental K-Edge (MEKED) and Multi Elemental X-ray Fluorescence (MEXRF) software were tested, evaluated, and discussed at the third HKED workshop in September 2022. Further improvement of the HKED codes will continue in 2024–2025 including a fourth workshop in 2024.
Design new handling tools for glove box and hot cell operations.	**Completed and work continues:** Several new handling tools were provided by MSSPs. This requirement is essential and ongoing.
Evaluation of new instrumentation with regard to business continuity plan.	**Work in progress:** The business continuity plan has been discussed and instrumentation requirements have been identified with Members States. This requirement is essential and ongoing.

Outcome #2: Improved techniques and methods for independent verification of Pu amount in DA samples and reference materials.	
Outputs	**Status/Comment**
A technical meeting for reference materials.	**Completed and work continues:** The Department organized a workshop for reference materials in May 2023. All participants from Member States agreed to hold annual online reviews and technical meetings combined with other related topical meetings and training opportunities.
Implementation and validation of a modernized software for controlled potential coulometry (CPC) system in the Nuclear Material Laboratory (NML) for Pu assay.	**Completed and work continues:** Upgraded software was provided and demonstrated under MSSP Task USA A 1049 (Controlled Potential Coulometry of 3-5 mg Pu with SRL Coulometer). Support will be needed annually to maintain instrument and software robustness and troubleshooting.

Outcome #3: Improved techniques, methods, and instrumentation to enhance the timely delivery of reliable analytical results.	
Outputs	**Status/Comment**
★ Development and deployment of a microcalorimetry system(s) at the Nuclear Material Laboratory (NML).	**Work in progress:** Development of microcalorimetry systems is ongoing, and a demonstration was provided in 2022 under MSSP USA A 2535 (Microcalorimetry analysis technique for NML). Implementation continues with the system(s) expected to be delivered and installed in NML in 2024–2025.
★ Implementation of the ABACC-Cristallini UF_6 sampling method for collecting safeguards samples from commercial Uranium enrichment plants for analysis at the NML.	**Work in progress:** Field testing of the ABACC-Cristallini UF_6 sampling method is ongoing and will continue in 2024.
Support for reference materials and verification of in-house working standards used for the destructive analysis (DA) in the NML.	**Completed and work continues:** Member States have provided crucial support in verification of Large-Size Dried (LSD) spikes produced by NML. The Department seeks continued support for new, in-house working standards in 2024–2025.

SGAS-002: Environmental Sample Analysis Techniques (Matthew KILBURN)

Outcome #1: Improved reliability of analytical results through the provision of reference materials for internal and external Quality Assurance/Quality Control (QA/QC) programmes.	
Outputs	**Status/Comment**
★ Additional new reference materials (one per year) to be made available for internal and external QA/QC programmes.	**Achieved and ongoing:** Several new QC materials were provided by MSSPs in 2022–2023. This requirement is essential and ongoing.

Outcome #2: Improved techniques, methods, and equipment to detect signatures of undeclared nuclear activities in environmental samples.	
Outputs	**Status/Comment**
★ Implementation of a procedure for the age determination of particles using Large-geometry secondary ion mass spectrometry (LG-SIMS).	**Work in progress:** This work is still under development and remains a top priority.
Implementation of a procedure for the analysis of Pu and mixed U/Pu particles in environmental samples using laser-ablation inductively-coupled-plasma mass-spectrometry (LA-ICP-MS).	**Work in progress:** Further development of this approach highlighted some technical limitations with the LA-ICP-MS technique for particle analysis. Further R&D support by a MSSP(s) to enhance the accuracy of the measurement results would be appreciated.
Development and implementation of a methodology to detect nuclear fuel cycle (NFC) materials and determine nuclear activities based on the elemental and morphological analysis of particles in environmental samples, in particular using scanning electron microscopy (SEM) techniques to determine anthropogenic origin of particles.	**Work in progress:** Further development and implementation of the SEM capabilities will continue in 2024–2025.
★ Development of a rapid particle screening method for Pre-Inspection Check (PIC) sample analysis.	**Work in progress:** Development of modified LG-SIMS Automated Particle Measurement (APM) screening is underway. Other approaches are being developed by MSSPs.
Outcome #3: Maintained ability to reliably perform analysis of nuclear material and environmental samples at SG Analytical Laboratories.	
Outputs	**Status/Comment**
Replace analytical and ancillary equipment in line with the Integrated Life Cycle Management of Safeguards Assets Project in DDGO-001: Overall Safeguards Management and Coordination.	**Completed and work continues:** The new LG-SIMS was installed and commissioned in the Environmental Sample Laboratory (ESL) in 2022–2023. Procurement of a new multi-collector Inductively-coupled-plasma mass spectrometry (ICP-MS) for bulk ES analysis has been initiated using extrabudgetary funding.

SGAS-003: Analysis Support and NWAL Coordination (Veena TIKARE)

Outcome #1: Modernized distribution of safeguards samples to the NWAL.	
Outputs	**Status/Comment**
Delivery of a re-engineered Network of Analytical Laboratories (NWAL) coordination application to track sample assignment, shipping, analysis, and reporting, and full integration of this application into the SGAS Laboratory Information Management System (LIMS) architecture.	**Work in progress:** In January 2023, the Department welcomed an Associate Laboratory IT Systems Analyst (extrabudgetary position supported by the USSP), tasked with developing the NWAL Hub, the re-engineered sample coordination and tracking tool. The Department anticipates its completion and validation by the end of 2024.

Outcome #2: Improved reliability of analytical results through the provision of reference materials for internal and external quality assurance/quality control (QA/QC) programmes.	
Outputs	**Status/Comment**
Qualification of one—possibly two—additional NWAL members for the provision of particle reference materials.	**Completed and work continues:** In March 2023, the Pacific Northwest National Laboratory (PNNL) and Savannah River National Laboratory (SRNL) (USA) qualified for reference particle production. The Department's collaboration with CEA (France) is ongoing.
Continued support from NWAL and other laboratories of high-quality reference materials.	**Completed and work continues:** PNNL, SRNL, and Forschungszentrum Jülich have successfully produced new reference particles, already used in Inter-Laboratory Comparison (ILC) exercises. In addition to these particles with specified isotopic composition, there is a demand for highly specialized materials essential for quality control in various analyses, such as reference materials for trace elements or minor isotopes in Uranium, material age-dating techniques, and scanning electron microscopy (SEM) analyses.

Outcome #3: Strengthened quality assurance of the NWAL analytical services.	
Outputs	**Status/Comment**
Conduct an Inter-Laboratory Comparison (ILC) exercise on bulk analysis of environmental samples in 2022.	**Completed:** The 2020–2022, the US DOE-sponsored ILC on bulk analysis of environmental samples was successfully completed and results were discussed at the Technical Meeting on bulk analysis of environmental samples, held in December 2022.
Conduct an ILC exercise on particle analysis of environmental samples in 2023.	**Completed:** The 2021 and 2023 IAEA blind ILC exercises on particle analysis of environmental samples were successfully completed and results were discussed at the technical meeting, held in December 2023.
Conduct a nuclear material (NM) analysis round-robin exercise (NMRoRo) during the 2022–2023 biennium.	**Completed:** The NMRoRo was successfully completed with 29 participating laboratories including facility operators. Results were discussed at the Technical Meeting held in May 2023.
Conduct an ILC exercise for controlled potential coulometry in 2023.	**Completed:** This ILC was successfully completed in 2023 and provided an overview of the analytical performances achievable among the controlled potential coulometry users.

Outcome #4: Expanded NWAL capabilities and capacity to analyse field samples quickly and to high-quality standards.	
Outputs	**Status/Comment**
Qualify up to three new laboratories to join the NWAL for analysing environmental samples.	**Work in progress:** In January 2023, the Centrum Výzkumu Řež (CVŘ), in the Czech Republic, officially qualified for the irradiation of environmental samples for particle analysis. In addition, SGAS has responded to growing analysis demands by initiating a formal outreach campaign to identify and enlist new qualified laboratories for environmental sample analysis. This endeavour is expected to span several years.

SGCP-003: Safeguards Approaches (Traci NEWTON)

Outcome #1: Improved ability to fully implement the State Level Concept through the development of internal guidance documents and additional tools for the development of State Level Approaches.	
Outputs	**Status/Comment**
Acquisition path analysis reports on nuclear fuel cycle technologies.	**Delayed and nearing completion:** Subtask consultancy meetings are now complete for the seven nuclear fuel cycle technologies and the work documented in draft reports. The remaining work is to internally review each of the drafts for final approval, which is expected in 2024.

Outcome #2: Increased ability to detect undeclared nuclear material and activities through an updated and improved of the *Physical Model*.	
Outputs	**Status/Comment**
A completed version of the Physical Model, which would contain Volumes 1–3 and 5–11.	**Delayed and work in progress:** Subtask consultancy meetings are now complete for the 11 volumes covering the nuclear fuel cycle, with no further need for technical meetings with external experts foreseen. The remaining work requires technical editing from a knowledgeable technical editor.

Outcome #3: Enhanced ability to safeguard new types of facilities through development of safeguards concepts and approaches for pyroprocessing plants and small modular and/or Gen IV reactors.	
Outputs	**Status/Comment**
Model SG approach for a pyroprocessing plant proposed by the ROK SP.	**Delayed and nearing completion:** All consultancy meetings are completed, and the remaining work includes final technical editing with final approval expected early 2024.
Model SG approach for a transportable (floating) nuclear power plant (RITM 200M) proposed by RUS SP.	**In progress:** As per mutual decision of the Department and the RUS SP, the KLT 40S subtask has been closed and a new subtask for the RITM-200M floating reactor has been opened.
Model SG approach for a pebble–bed modular reactor (HTR-PM) proposed by the CPR SP.	**In progress:** No comment available.

Model SG approach for a passive small modular pressurized light water reactor (SMART: System-integrated modular advanced reactor) proposed by the ROK SP.	**In progress:** No comment available.
Model SG approaches for NUWARD proposed by FRESPAS.	**In progress:** No comment available.
Model SG approaches for Moltex Stable Salt Reactor Wastebunner 300 (SSR-W300 of Moltex) proposed by the CAN SP.	**In progress:** No comment available.
Model safeguards approaches for Integral Molten Salt Reactor (IMSR of TEI) proposed by the CAN SP.	**In progress:** No comment available.
Model safeguards approaches for two micro modular reactors for district heating proposed by the FIN SP.	**In progress:** No comment available.
Model safeguards approaches for SMRs (types to be decided) to be proposed by the USSP.	**In progress:** With consideration of the USSP decision not to nominate SMR vendors at this time, the Department is currently engaged with two vendors independently on reactor designs while maintaining mission alignment.
Model safeguards approaches for emerging nuclear fuel cycle technologies and SMRs that are proposed by other Member States.	**In progress:** A new MSSP Task has been initiated by United Kingdom, pending the nomination of a vendor.

Outcome #4: Improved ability to verify facilities under the decommissioning phase through the development of safeguards implementation guidelines and concepts.

Outputs	Status/Comment
Workshops on safeguards implementation at facilities under decommissioning.	**Completed:** No comment available.
Finalized safeguards guidelines for post-accident facilities.	**In progress:** The third remaining subtask (developing a safeguards approach for post-accident nuclear facilities) still in progress. A final product is expected early 2024.

SGCP-004: Strategic Analyses and Partnerships (Jenni RISSANEN)

Outcome #1: Enhanced dialogue among global safeguards stakeholders with increased understanding of common challenges and opportunities and ideas for solutions.	
Outputs	**Status/Comment**
★ The 2022 Safeguards Symposium.	**Completed:** The 14th Symposium—under the theme 'Reflecting on the Past and Anticipating the Future'—featured 70 sessions and over 150 presentations. Some 700 registered participants from 124 States and 15 organizations attended the event with an additional 280 virtual observers, increasing geographic diversity to the highest level to date. Of the registered participants, 36% were women, representing the highest share of female participation to date. The *Report: Symposium on International Safeguards* and other related resources are available on the Symposium on International Safeguards 2022 webpage.

Outcome #2: Improved organizational ability to monitor, identify, and adjust to changes in the operating environment in a timely manner.	
Outputs	**Status/Comment**
★ The 2023 Emerging Technologies Workshop.	**On hold:** The organization of the Emerging Technologies Workshop that had been planned for 2023 is dependent on additional human resources within the Strategic Planning Team, in particular the acceptance and recruitment of MSSP Task Proposal 22/CPC-002 (CFE - Emerging Technologies Expert) that is yet to be accepted by any MSSP.
External operating environment analyses.	**Completed and work continues:** In 2023, the Department presented to senior management two 'deep dive' analyses: on trends and developments in the non-proliferation policy area and on the changing nuclear landscape, including nuclear facility projections up to 2035. A third analysis, on workload and resource trends, is underway.

Outcome #3: More efficient coordination and more effective resource mobilization support to the needs of the Department.	
Outputs	**Status/Comment**
Implementation of improvements to MSSP Annual Review meetings based on surveys and focus groups with internal and external participants.	**Work in progress:** The interactive discussion among 18 MSSP representatives in May 2022 informed the SPCT of areas for improvement, such as organizing a 1-day event to showcase mid-biennium D&IS progress and status. User-requested upgrades to meeting content and meeting packages have been identified; implementation of improvements awaits SPRICS IT development resources.
Organization of biennial MSSP Coordinators' meeting in 2022.	**Completed:** The meeting was held virtually due to the Covid-19 pandemic.
Implementation and refinement of weekly tracking on CFE and JPO recruitment activities for relevant SG divisions and MSSPs.	**Completed and work continues:** Improved case tracking infrastructure was developed to help identify bottlenecks. Weekly tracking emails to internal stakeholders was recently relaunched.

Outcome #4: ★ Enhanced strategic project management capabilities to manage the Department's priority projects and actions.	
Outputs	**Status/Comment**
Enhanced strategic project management processes and competencies for Departmental priority projects and actions.	**Work in progress:** In 2022, the Department issued a process description linking the front end (strategic foresight & planning) with backend (strategy execution) of strategy; it is the first-ever process description to detail strategy execution through practical projects and actions. The Department continued to utilize the Strategy Execution Application to monitor progress and record results achieved. MSSP Task USA F 2614 (CFE - Strategy Project Specialist) supported the SLA Improvement Project and other priority projects and coordinated the update of the Safeguards Glossary.

SGCP-101: Quality Management (Gary DYCK)

Outcome #1: Improved process management and an enhanced process framework to support consistent implementation of departmental processes.	
Outputs	**Status/Comment**
★ Standards and templates for business process mapping.	**Completed:** BPMN 2.0.2 standards have been selected and process maps completed based on MS Visio® Process Mapping extensions.
Standards and guidelines for managing shared processes.	**Completed:** SGCP has assumed the role of coordinator for shared processes, while process owners retain decision-making responsibilities.
Options for improving process management and governance through updated processes and procedures.	**Work in progress:** Documentation and updates of processes and procedures have continued.

Outcome #2: An enhanced web-based domain for processes and process applications linking associated documentation and relevant IT applications.	
Outputs	**Status/Comment**
★ Business case and proposal(s) for process mapping software and application.	**Completed:** The Department has continued to use MS Visio® Process Mapping extensions. After evaluating commercial tools, they were not suitable for the Department's collaborative process mapping model with multiple owners and Quality Management Section (CQM) support.

Outcome #3: Improved process performance monitoring enabling more efficient operations and improved process management.	
Outputs	**Status/Comment**
Identification of process outputs and products.	**Completed:** As part of operational process documentation and mapping activities, the Department has successfully identified process outputs and products. The Department considers this completed, but will continue.
★ Identification of specific performance attributes for process outputs and products.	**Work in progress:** Both the 2022 and 2023 Internal Quality Audit (IQA) and Assessment programmes identified and evaluated numerous process outputs and products. Process and performance monitoring will be expanded in 2024–2025.

SGCP-102: Training (Susan PICKETT)

Outcome #1: Competent and confident SSAC staff members with the knowledge and skills to effectively implement safeguards and fulfil safeguards obligations.

Outputs	Status/Comment
SSAC Support: Virtual national engagements and webinars for 60 States as identified by Operations Divisions.	**Completed and work continues:** In 2022–2023, the Section for Safeguards Training (CTR) successfully conducted a series of nine webinars, consistently attracting participation from over 120 attendees at a time spanning across 90 countries. This achievement has broadened the Department's outreach, thereby ensuring that essential knowledge regarding safeguards is readily accessible to those who seek it. Furthermore, ad-hoc, virtual engagements took place with 35 States on specific topics such as the Additional Protocol (AP), Nuclear Material Accountancy (NMA), and general safeguards implementation outreach in support of Operations Divisions.
COMPASS: Implemented workplans for the seven COMPASS pilot States that have a balance of virtual and in-person training, fellowships, and other engagements.	**Completed:** The Comprehensive Capacity-Building Initiative for SSACs and SRAs (COMPASS), encompassing seven States, culminated in a successful completion on 31 March 2023. The project entailed a comprehensive range of achievements, including 15 in-person training sessions, five scientific visits, the orchestration of 14 outreach and webinar events, the formulation of five national training plans, as well as the enactment of progressive legislation in three States. Moreover, the project saw the drafting of 23 procedures and guidelines, underscoring its significant impact and comprehensive scope.  *Figure 64: Identifinders provided to Member States through COMPASS.*
IAEA SSAC Advisory Service (ISSAS): ISSAS Missions in response to Member States' requests.	**Completed and work continues:** ISSAS missions were conducted in response to requests from all interested States, notably the People's Republic of Bangladesh the Republic of Türkiye. A request from the Plurinational State of Bolivia was also received in 2023.
E-learning: More e-learning and a structured package on the Open Learning Management System (CLP4NET) (elearning.iaea.org).	**Completed and work continues:** The Open Learning Management System (CLP4NET) platform, with 4000+ users, offers online learning opportunities, information pages and (restricted) virtual classrooms for IAEA training courses. Participants access instructional materials, including safeguards-related guidance, while 23 new public course pages cover topics such as nuclear accounting, design information, Protocol Reporter 3, and many more. These courses, available to registered NUCLEUS users (NUCLEUS is IAEA's information resource portal providing access to over 100 scientific, technical, and regulatory resources), include options in French, Spanish, and Russian via Member State Support. Funding for the Instructional Designer role relies MSSP support, crucial for further content development, improvement of existing content, and maintenance for the Department's part of the portal.

Outcome #2: Knowledgeable and skilled departmental staff members who can plan, conduct, and evaluate safeguards implementation issues.	
Outputs	**Status/Comment**
Secured access to a facility(ies) for 10 high-priority training courses per year for the next 5 years.	**Completed and work continues:** Providing an optimal learning environment remains an ongoing challenge due to limited facility access. Annual access to facilities persists for bulk handling facilities, power and research reactors, and spaces suitable for complementary access training. While availability of access has improved after the pandemic, access to nuclear facility is an essential pillar of the training programme and the Department seeks to diversify facilities which can provide access.
A comprehensive Safeguards Training Programme for Staff.	**Completed and work continues:** A comprehensive training programme was implemented for Department staff members, encompassing more than 50 courses and over 90 offerings annually. Notably, this initiative also facilitated the successful completion of two Introductory Courses for Agency Safeguards (ICAS) courses, paving the way for 29 newly trained safeguards inspectors. The Department also initiated a webinar series with over 100 Department staff members participating per webinar.
A comprehensive State evaluation curriculum that clearly defines and maps State evaluation processes and guides.	**Nearing completion:** The comprehensive State evaluation curriculum, which outlines and navigates State evaluation procedures and directives, is approaching its final stages. The endeavour is being driven by internal resources. Notably, the State Evaluation Strategy Seminar underwent a thorough reevaluation and enhancement to align with the Department's evolving requirements. Efforts remain dedicated to this endeavour, as CTR collaborates with the State Evaluation project team. Work is still required to develop training to suit 'evolving' planning and evaluation processes in the Department (including the Acquisition Path Analysis (APA), State Level Agreements (SLAs), and State Evaluation (SE).
An industrial safety curriculum.	**Work in progress:** Subsequent to a comprehensive Training Needs Analysis (TNA) conducted as part of MSSP Task USA B 2549 (Industrial Safety Training), the Department is seeking interested Member States to design and develop an Industrial Safety Basic Training curriculum tailored for Department staff needs. The intended execution of this output envisions the engagement of an accomplished industrial safety subject matter expert and a skilled instructional designer. Given the singular operational and regulatory framework of inspection activities, the search for the suitable expertise has presented challenges. In 2024, the Department's priority is to develop an Industrial Safety Curriculum. For details, see Outcome 2: Output 3 in the 2024–2025 D&IS Plan.

Outcome #3: Increased accessibility of training and learning.	
Outputs	**Status/Comment**
Tailoring of the new internal IAEA Learning Management System (LMS) to the Department.	**Work in progress:** The Department is currently advancing the integration of the new internal LMS. The focus is on testing the connection between participant course evaluations and LMS course offerings for automated evaluation procedures. Additionally, the Department established standardized processes for course and offering creation in the LMS, with ongoing staff training to enhance standardization and data accuracy. Pending work includes the implementation of LMS reporting features to unlock its full potential. The automation and streamlining of participant selection processes are pivotal for efficiency gains and reduced administrative workload. Plans are underway to appoint an LMS consultant, a crucial step towards realizing the LMS' full potential for effective training management processes.

Outcome #4: Improved knowledge sharing management and communication culture.	
Outputs	**Status/Comment**
★ 100% managerial participation at a 1-day knowledge management (KM) workshop (there will be several opportunities throughout the biennium).	**Completed & Cancelled:** In collaboration with the Department of Nuclear Energy's Knowledge Management Section, a series of four knowledge management workshops were conducted. These workshops yielded individualized action plans from participants, and the feedback was relayed to the Department. This feedback is currently under consideration, shaping the forthcoming Departmental Knowledge Management Action plan.
For every section in the Department, a 1-page document that declares its key KM activities.	**Cancelled:** The responsibility for this has shifted from CTR to a more encompassing role within the Department. It has been integrated into the larger framework of the Department-wide knowledge management plan, which falls within the scope of the Director of the SGCP.

Outcome #5: Increased knowledge of safeguards and aspects of the nuclear fuel cycle in Member States with limited or no nuclear fuel cycle technologies.	
Outputs	**Status/Comment**
Yearly implementation of the Safeguards Traineeship Programme.	**Completed and work continues:** The Safeguards Traineeship Programme achieved successful completion in 2022 and is currently underway for both 2023 and 2024. The Director's General focus on this initiative endures, ensuring its continuity as an annual fixture, catering to a cohort of nine participants each year. The sustained success of the programme hinges upon securing critical funding.
Launch of the IAEA Safeguards Mid-Career Leadership Programme.	**Completed and work continues:** In 2022, a pilot session of the Mid-Career Leadership Programme was conducted for five participating States. This initiative culminated in the crafting of State-specific safeguards action plans by participants. The continuation of this programme depends on the support of Member States. MSSPs remain crucial to its ongoing success.

SGIM-002: Acquisition and Analysis of Satellite Imagery and Geospatial Data (Marc LAFITTE)

Outcome #1: Enhanced satellite imagery analytical capabilities (sensors, data services, software tools, analytical/processing techniques, technologies, methodologies, etc).	
Outputs	**Status/Comment**
Broaden, diversify, and ease access to relevant commercial satellite imagery (spatial, spectral, and temporal) and ensure the integrity and authenticity of satellite imagery as an independent source of information for the Agency.	**Completed for biennium; ongoing:** The Department accomplished its goal of improving access to commercial satellite imagery in 2022–2023. This effort will continue in 2024–2025 (outcome #1).
★ Enable effective spectral analysis by incorporating more in-depth spectral analytics derived from SWIR, TIR, SAR, multi spectral (MS), and HSI satellite imagery analysis products.	**Completed for biennium; ongoing:** The Department enriched spectral analysis in 2022–2023, and this support will persist in 2024–2025 (outcome #2).
Sustain/perpetuate the ability to process all types of satellite imagery and enhance accuracy and pixel consistency of large datasets for better comprehensive and additional applications.	**Completed for biennium; ongoing:** This support should continue in 2024–2025 to keep progressing (outcome #1).
⋆ Optimize the selection of the most relevant imagery by using new technologies.	**Completed for biennium; ongoing:** This support should continue in 2024–2025 to keep progressing (outcome #1).
Enhance satellite imagery analysis skills, geospatial analysis skills, and data science capabilities that are required to conduct effective and in-depth analysis of nuclear-related infrastructure.	**Completed for biennium; ongoing:** In light of rapidly evolving technologies, personnel turnover, retirements, and administrative factors, this remains an ongoing and persistent requirement that must be sustained in 2024–2025 and beyond.

Outcome #2: Maintain and enhance staff skills in processing and analysing satellite imagery and geospatial data.	
Outputs	**Status/Comment**
Ensure awareness of satellite imagery and geospatial analysis capabilities (users), new techniques and applications (analysts).	**Completed for biennium; ongoing:** This support should continue in 2024–2025 to keep progressing (outcome #2).
★ Ensure understanding and more effective use of: (i) geospatial analysis capabilities and associated techniques, (ii) new technologies in analytical products.	**Completed for biennium; ongoing:** Use of geospatial information has become crucial for the Department. Efforts on use and dissemination of geospatial data should be pursued. The need to incorporate new types of information (imagery) remains.

★ Investigate and use artificial intelligence technology to: • Sustain the exploitation and analysis of very large volumes of data, and optimize the prioritization of the analytical workload (tasking) and imagery orders. • Support and ease satellite imagery analysis processes with new technologies: automatic detection of specific features, and detection of anomalies via automatic change detection algorithms, etc.	**Completed for biennium; ongoing:** New technologies are essential to maintaining the ability to cope with the ever-increasing workload. Efforts should be maintained and enhanced, particularly with regard to the use of automatic change detection algorithms.
Enhance (and automate) the verification (compliance/discrepancies) of Additional Protocol (AP) declarations versus Imagery or Geospatial Foundation Data[5].	**Delayed and work in progress:** The Department has experienced delays due to resource constraints. It is imperative that support is maintained in 2024–2025 to achieve the desired outcome (outcome #1).
Sustain and enhance the understanding of nuclear fuel cycle imagery signatures (all types of satellite imagery).	**Completed for biennium; ongoing:** Sustaining and training IAEA Safeguards image analysts in understanding nuclear fuel cycle imagery signatures is crucial for the accuracy and credibility of the satellite imagery analytical assessment. This remains an ongoing requirement due to the IAEA's rotation policy and must be continued in 2024–2025.

Outcome #3: Enhanced collaborative analysis and synergy of safeguards-relevant information.	
Outputs	**Status/Comment**
Enhance the capture of safeguards-relevant geospatial information.	**Completed for biennium; ongoing:** The Department is increasingly reliant on the use of geospatial information, resulting in a requirement to properly capture and store this information. This important need has to be sustained in 2024–2025 in order to ensure geospatial information is properly and effectively used within the Department.
★ Enhance Imagery Analysis knowledge management.	**Work in progress:** Correctly and effectively capturing imagery analysis knowledge is critical in maintaining an accurate and comprehensive knowledge management database. The large volume of imagery analysed in conjunction with the IAEA's rotation policy hinders the capture and proper knowledge management gained through imagery analysis. Due to a lack of resources, this has not progressed.
★ Boost the synergy and dissemination of geospatial data, including satellite imagery and geospatial analysis.	**Completed for biennium; ongoing:** Dissemination of geospatial analysis has become crucial for the Department. The necessity for decision makers to maintain a high-level of awareness, and the need to enhance synergy of information available to the inspectors has significantly boosted the acceptance of geospatial information. Efforts to support this have to be maintained and sustained.

[5] *Geospatial Foundation are the minimum primary sets of data that cannot be derived from other datasets, and that are required to spatially represent phenomena, objects, or themes, providing common, standardized and quality-controlled reference to all users.*

Enforce the data quality (data accuracy and reliability) and improve procedures for data capture and quality control processes.	**On hold:** Currently on hold pending resource availability.
Enhance IT infrastructure to cope with the growing volume of data.	**On hold:** Currently on hold pending resource availability.
Strengthen international geospatial network cooperation or partnerships regarding methodologies, techniques, or R&D.	**Completed for biennium; ongoing:** This is essential to maintain awareness of new techniques and applications and to enhance existing capabilities through cooperation and partnerships. Support needs to be sustained in 2024–2025 with the primary emphasis on enhancing the cooperation with national laboratories and/or universities.

SGIM-003: Open Source Information Collection and Analysis (Woan Jin KIM)

Outcome #1: Enhanced identification and collection of open source information through the development of optimized tools and methods.	
Outputs	**Status/Comment**
Improved capability to provide an increasingly automated identification and collection of safeguards-relevant information from internet-based sources.	**Work in progress:** The Department has been improving its existing open source collection system, which is currently in the implementation phase, and working on the development of a new system for the collection of technical publications.
Enhancement to the processing and management of safeguards-relevant open source information, including mechanisms for adding structure to unstructured data.	**Completed and work continues:** The Department is continuously enhancing its open source collection systems in response to the evolving data environment. These improvements are focused on processing and managing safeguards-relevant open source information and include mechanisms for adding structure to unstructured data.
Structured data library for the storage of historic safeguards-relevant information and for the recording of newly-collected information.	**Cancelled:** Requirements have been reformulated and integrated into other work.

Outcome #2: Improved integration of all "other safeguards-relevant information."	
Outputs	**Status/Comment**
Implemented strategy for the selection and implementation of a data analytics platform for the assemblage, integration, and analysis of information from multiple data sources.	**Cancelled:** Requirements have been reformulated and integrated into other work.
Increased and consistent integration of collected open source information with State Files and other applications in the Integrated Safeguards Environment (ISE).	**Work in progress:** The Department is using updated and new open source collection systems to improve data integration.

Use of a commercial reference manager software to facilitate the efficient capture and structuring of science and technology publications.	**Completed:** The Department has purchased and implemented the Citavi reference management software, a vital tool for efficiently capturing and structuring science and technology publications.

Outcome #3: Extending the collection of available safeguards-relevant, open source information.	
Outputs	**Status/Comment**
Identification and acquisition of new streams of safeguards-relevant information.	**Completed and work continues:** The Department has acquired new streams of safeguards-relevant information through the purchase of subscription-based sources funded by MSSPs. The Department is open to further support from MSSPs to continue enhancing capabilities in this area.
Increased ability to collect safeguards-relevant data from sources not published in English.	**Completed and work continues:** The Department is currently benefiting from ongoing support by MSSPs in collecting and translating open source information from a variety of languages, enhancing the ability to collect safeguards-relevant data not published in English. More support is always needed in this crucial effort to strengthen the Department's capabilities, especially in less commonly used languages.

Outcome #4: Improved collection and analysis of large volumes of science and technology and nuclear trade data.	
Outputs	**Status/Comment**
Implementation of a workplan to develop and implement the use of Natural Language Processing techniques to optimise the use of automated textual searches and the classification of science and technology-related open source information.	**Completed and work continues:** The Department has incorporated machine learning techniques into both existing and new open source collection systems, aligning with ongoing efforts to develop and implement Natural Language Processing techniques.
Better utilisation of advanced analytical techniques and data visualization tools for disparate sources of open source information, including global trade data and science and technology publications.	**Cancelled:** Requirements have been reformulated and integrated into other work.
Successful deployment of The Big Table (TBT) software tool developed in conjunction with JRC, Ispra on the IAEA Safeguards network.	**Completed:** The implementation of The Big Table on the IAEA Safeguards Network is in the final stages, nearing completion.

Outcome #5: Enhanced analysis of open source information, science and technology publications, and nuclear trade data.	
Outputs	**Status/Comment**
Identification and implementation of technical consultancies to support identified analytical needs.	**Work in progress:** The Department is currently in the process of specifying new consultancies to meet identified analytical needs. MSSP Task Proposals for these consultancies will be transmitted to MSSPs in 2024–2025.

Evaluation of nuclear fuel cycle modelling software for use in the State evaluation process.	**Work in progress:** The Department is currently awaiting the provision of fuel cycle modelling code from a MSSP to enable the evaluation process to proceed. An implementation plan is in place.
Attendance at technical conferences and trade fairs and technical visits to safeguards-relevant industrial and manufacturing locations.	**Completed and work continues:** The Department organized and completed several technical visits to industrial and manufacturing locations, in addition to attending technical conferences, and participating in trade fairs. This initiative is ongoing, building upon the work that has been completed.

Outcome #6: Structured training and development plans to support staff in the collection, analysis, and reporting of open source information and nuclear trade data.	
Outputs	**Status/Comment**
Development of "learning paths" for SGIM-ISF staff.	**Work in progress:** Work to develop "learning paths" for the State Factor Analysis Section (SGIM-ISF) staff is ongoing in collaboration with D&IS Plan SGCP-102 (Training).
Portfolio of training resources to support open source, technical, and trade analysis.	**Work in progress:** Efforts to create a portfolio of training resources to support open source, technical, and trade analysis are ongoing, in collaboration with D&IS Plan SGCP-102 (Training).
New training products developed to specifically support open source, technical, and trade analysis.	**Completed and work continues:** The Department is in the process of organizing new technical visits to nuclear fuel cycle and related facilities. Initial discussions and pre-visits have taken place.

SGIM-007: Evaluation of Data from ES and Material Characterisation (Mika NIKKINEN)

★ **Outcome #1:** Enhanced environmental sampling evaluation environment.	
Outputs	**Status/Comment**
★ Transition of the current environmental sampling database (ESDB) to the Environmental Sampling Environment Enhancement (ESEE), the new technical environment.	**Work in progress:** The Department has had data management and data loading in ESEE under production since October 2023. Efforts are focussed on the evaluation, reporting, and integration of nuclear modelling tools. The Department anticipates a project end date in 2027. Approximately 40% of the work has been completed as of the end of 2023.
Enhanced ES evaluation process to provide more efficient workflow and faster turnaround of evaluations.	**Work in progress:** The improved workflow, which incorporates integrated peer review and the capability to generate graphical representations for the reports, has significantly streamlined work. This development is imperative due to the steady rise in the volume of environmental samples that require evaluation.
Easier management of the interaction between modelling tools and the ESDB.	**Work in progress:** During the final phase of the ESEE project, essential modelling tools are integrated into the core system, simplifying the process of transferring data and results.

Outcome #2: Improved nuclear fuel cycle (NFC) modelling tools and pre-calculated models.	
Outputs under this outcome continue in the 2024–2025 plan under Outcome 2: Updated nuclear fuel cycle analysis tools and results.	
Outputs	**Status/Comment**
Functional and maintained tools for Uranium enrichment modelling and reactor burn-up calculations.	**On hold:** This initiative is currently on hold as the Department seeks additional support, potentially through a MSSP, potentially in the form of reactor calculation tools updates and reactor models that are made for newer fuel types.
New, calculated reactor models, with one being a comprehensive mixed oxide (MOX) scenario.	**On hold:** The Department is actively seeking the assistance of a MSSP to provide the necessary support. The Department would be happy to receive various MOX fuel models or readily calculated burn-up data.
An enhanced impurity library with new samples collected from additional Uranium processing locations.	**Completed and work continues:** The Department has recently received samples from mines, which are now in the impurity library. The aim is to continue enhancing the library by adding data from new Uranium processing locations. The Department will accept new samples if they become available.
Improved automatic analysis, analytics, and evaluation methodology.	**Completed and work continues:** In 2023, the Department successfully completed the Spotlight project on statistical methodologies. Currently, the focus is on exploring new unsupervised data matching methods. Additionally, the Department recently updated the impurity analysis software tool, R-Dave, to further enhance automatic analysis, analytics, and evaluation methodology. The Department also developed the Visual Scanning Electron Microscope (SEM) tool, which uses machine learning for particle analysis. It compares elemental compositions of samples globally with the Department's database, enabling insights into particle origins and associated nuclear activities. This analytical environment is especially valuable for IAEA Safeguards nuclear forensics evaluators comparing detected materials with declared nuclear materials and activities. More work for automatic morphology analysis within image processing will be done in coordination with D&IS Plan SGIM-010 (Artificial Intelligence/Machine Learning for Information Analysis).

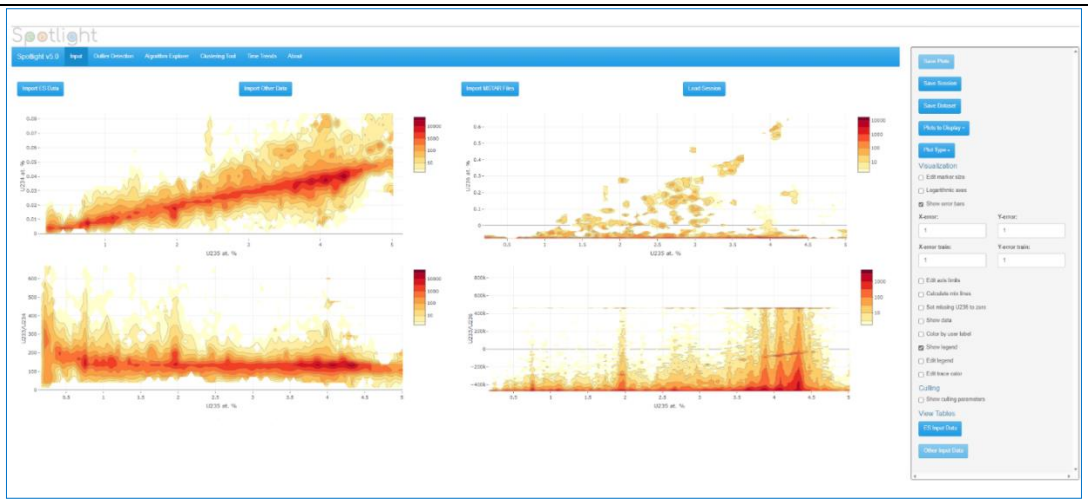


Figure 65: Interface of supervised matching tool, Spotlight.

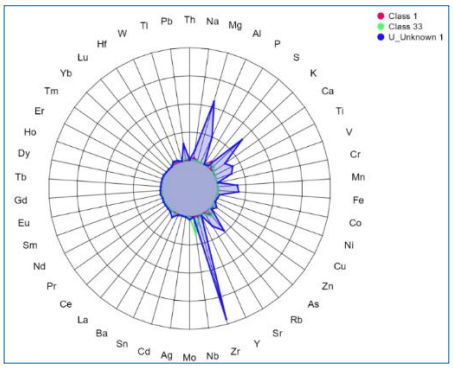


Figure 66: Radar plot of impurity matching tool R-Dave.

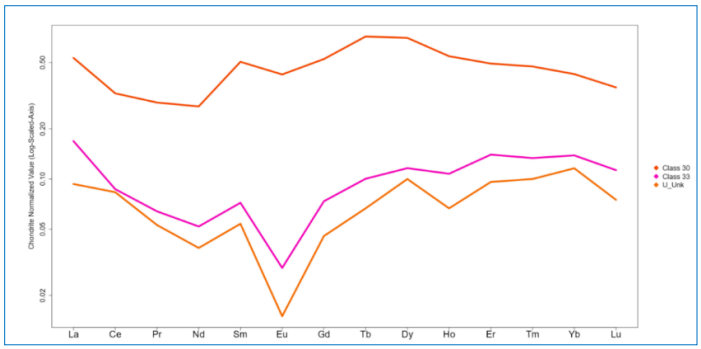


Figure 67: Result of the Uranium impurity matching tool R-Dave; Rare-Earth-Elements pattern show good matching with one other sample.

Outcome #3: Continuity of knowledge and best practices in data evaluation.	
Outputs	**Status/Comment**
Update ES data reporting formats (for the transfer of data from the Network of Analytical Laboratories (NWAL)) that support new analytical methods such as Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) and simultaneous reporting of isotopic and elemental data for particles.	**Completed and work continues:** The Department updated ES data reporting formats for greater flexibility, supporting advanced methods like LA-ICP-MS and enabling simultaneous reporting of isotopic and elemental data. This enhances the capacity for advanced analytical technologies, including rapid PIC analysis, in collaboration with D&IS Plan SGAS-002 (Environmental Sample Analysis Techniques).
Internally-published Best Practices Documentation for ES evaluations.	**On hold:** This is currently on hold, pending the completion of the ESEE project.
Maintain ongoing communication and participation in meetings to highlight key issues on ES evaluations to NWAL members.	**Completed and work continues:** The ES team is actively participating and contributing to the annual NWAL technical meetings. Additionally, the Department has conducted R&D-related meetings and workshops with significant contributors, fostering collaboration and addressing key issues in ES evaluations.

SGIM-008: Statistical Analysis (Robert BINNER)

Outcome #1: Standardized methodologies in support of State Level Approaches for calculating detection probabilities achieved through verification activities at facility and State levels.	
Outputs	**Status/Comment**
Development of simulation-based methodologies to estimate achieved detection probabilities against all diversion scenarios.	**Work in progress:** The development of detection probability simulation tools is ongoing and led by the University of Massachusetts, Lowell (UML) through the USSP. The continuation of this work is contingent upon securing MSSP funding.
Development of optimized sampling plans achieving a maximum detection probability using the same inspection effort.	**Work in progress:** Optimization of sampling plans for maximum detection probability will align with the development of detection probability simulation tools. Continuation of this work depends on securing MSSP funding.

Integration of non-Gaussian Uncertainty Models and mixed random/systematic models.	**Work in progress:** The Department is currently integrating non-Gaussian uncertainty models into the detection probability simulation tools under development by UML.

Outcome #2: ★ Improved and harmonized random verification schemes, including sampling plans and random inspection schemes, and methodologies to evaluate their effectiveness.

Outputs	Status/Comment
A peer-reviewed, revised version of *STR-381: Statistical Methods for Verification Sampling Plans*.	**Completed and work continues:** *STR-381: Statistical Methods for Verification Sampling Plans* has undergone peer review and is currently in the publication clearing process. Future revisions will incorporate refinements to the sampling methodologies as they are developed and peer reviewed.
Prototype software implementing sampling plan procedures described in *STR-381: Statistical Methods for Verification Sampling Plans* and documentation of practical sampling plan implementation procedures for inclusion in the Inspector Handbook.	**Work in progress:** Initial sampling plan software (SAMPLAN) was released in October 2023 for initial field testing. This software is expected to replace the legacy sampling plan calculator and will see future enhancements, including the addition of functionalities like two-stage and follow-up sampling plans in the years ahead.  *Figure 68: This is a detection probability graph produced by SAMPLAN, which shows the range of how much the detection probability would change with the addition or removal of one measurement -this shows the sensitivity of detection probability to small changes in the sample size.*
Development and documentation of a set of standard random inspection schemes (including standard evaluation methodologies and tools) as a basis for a more harmonized approach to implementing and evaluating such schemes in State-level approaches (SLA).	**Work in progress:** In line with the new State-Level Approach methodology (SLAIP) and its associated performance targets, work is in progress to standardize selection methodologies for random inspections and develop standardized evaluation criteria for implementing random inspection schemes.

Outcome #3: Improved ability to determine measurement uncertainties from operator-inspector paired-data, 3-laboratory data, and calibration data.	
Outputs	**Status/Comment**
Peer-reviewed STR on the uncertainty quantification (UQ) methodologies used as a basis for UQ methods applied to safeguards verifications.	**Nearing completion:** The STR, supported by MSSP reviews, is currently in the process of incorporating peer-reviewed comments to finalize the document for publication.
Technical guidance document based on the continuation of the methodological work begun on approximate Bayesian computation (ABC) for UQ.	**Work in progress:** The Department has initiated discussions with the UK SP, and a collaborative work plan with the Nuclear Fuel Cycle Analysis Section is in development for this technical guidance document.
Publication of the paper titled *Statistical model-based and GUM-based analysis of measurement uncertainties in nuclear safeguards – a reconciliation*.	**Completed:** The paper was successfully published in the ESARDA bulletin in June 2022.

Outcome #4: Reviewed, updated, and consolidated methodologies, including Bayesian methodologies, applied to the evaluation of material unaccounted for (MUF), D Statistic (D), Inspector's MUF (IMUF), and Shipper-Receiver Difference (SRD) in the context of material balance evaluation (MBE).	
Outputs	**Status/Comment**
A technical document, most likely an STR, on MBE methodologies and their implementation in relevant analytical software.	**On hold:** Production of this technical document is pending the availability of resources, which will be determined after the completion of the UQ STR (STR-366).
★ Comprehensive Near Real Time Accountancy (NRTA) methodology documentation in the form of an STR and requirements documentation for a harmonized NRTA software system for use as a standardized platform for NRTA evaluation systems at the Rokkasho Reprocessing Plan and at the JMOX plant.	**Completed and work continues:** The NRTA STR (STR-403) is completed and awaiting final clearance for publication. Concurrently, work on requirements documentation for the NRTA software is in progress.
Documented concepts, methodologies, and processes supporting MBE at the State level including prototype deliverables.	**Work in progress:** The Department is currently developing a standardized template for SER input for MBE at the State level, taking account of the newly-developed State-Level Approach procedures (SLAIP) and performance targets.
Implementation of methodologies supporting the tracking of UF_6 cylinders in support of MBE, for example, SRD evaluation at enrichment and conversion facilities (related to SGIM-009: State Declared Information Management's Outcome #7 from 2022–2023).	**Work in progress:** This work, previously on hold, restarted in October 2023.

SGIM-009: State Declared Information Management (Snezana KONECNI)

Outcome #1: More effective and efficient State Declarations Handling System with improved workflows.	
Outputs	**Status/Comment**
Implement full workflow (including QC checks) for Exemption, Termination, and Re-application requests of nuclear material to be integrated with the nuclear material accounting system to allow for matching State NMA reports to requests for exemptions and terminations of nuclear material.	**Work in progress:** SGIM and SGIS are working closely to provide a solution for the Department to effectively and efficiently track nuclear material exemption, termination, and de-exemption requests requested by Member States.
Apply optical character recognition (OCR)/text extraction as a robust service to reduce manual input of declarations received as hard copies while still allowing for robust verification procedures to eliminate data entry errors in the NMA database.	**On hold:** The Department has encountered challenges in identifying a viable solution. Frequently, the reports have suboptimal quality, rendering the application of OCR extraction to reduce manual entry a complex endeavour.

Outcome #2: Improved effectiveness and efficiency of analysis of all State Declared Information (e.g., NMA, Additional Protocol (AP), SGMD, etc.).	
Outputs	**Status/Comment**
★ Development of a new analysis platform/environment (software tool) to integrate information from various sources.	**Work in progress:** SGIS is currently in the process of developing the CUBE tool, designed to facilitate IAEA Safeguards analysts in parsing information from the SSDH-C database.
★ Ability to automatically generate relevant data outputs in multiple formats (flat tables, graphical, etc.) for routine NMA work, for example, State Evaluation Report (SER) contributions.	**Work in progress:** SGIS is developing the CUBE tool, aimed at aiding IAEA Safeguards analysts in dissecting information and generating tables and graphs that are crucial for diverse report preparations.
★ Development of a new graphic user interface (GUI) that allows IAEA analysts to work with NMA data intuitively.	**Work in progress:** The Department anticipates that the CUBE tool will effectively address these requirements.
Easier comparison of SG-relevant data and State declarations and consistency analysis.	**On hold:** The understanding of the need for an integration platform remains too limited to formulate requirements.
Ability to tag all locations declared in NMA and AP declarations with geospatial data.	**On hold:** This was not a priority in 2022–2023.

Outcome #3: Improved NMA testing & training capabilities.	
Outputs	**Status/Comment**
Creation of an NMA training and testing environment.	**On hold:** Lack of resources in 2022–2023 prevented progress. NMA testing/training database is also needed for D&IS Plan SGIM-008 (Statistical Analysis).

Creation of a comprehensive set of simulated NMA training data.	**On hold:** Lack of resources in 2022–2023 prevented progress. A set of simulated NMA data is needed for Material Balance Evaluation.

Outcome #4: More efficient information exchange by optimizing SDP processes.	
Outputs	**Status/Comment**
Ability for Member States to validate NMA Reports so that corrective action can be taken. Validation would include QC checks against historical data. Validation results would be returned to the Member States as reports with easily-to-interpret QC error messages.	**Completed and work continues:** Member States can validate Code10 in all formats (fixed, labelled, and XML). Quality Control (QC) validation includes validating against historical data. Approximately half of the 600 validation checks are implemented, providing Member States with robust validation report on a submission. Work will continue to further extend the validation.
Ability to give near-real-time NMA feedback to Member States with on-demand requests for current NMA Book balances. An automated, on-demand service interface integrated with the SDP State-specific portal as "Self Service."	**On hold:** Lack of resources in 2022–2023 prevented progress.
An implemented Customer Resource Management (CRM) system.	**Work in progress:** A CRM system is needed for internal use to efficiently oversee everchanging external contacts.
Integration with the new IAEA record-keeping system, the Agency Correspondence Management System (ARMS).	**Nearing completion:** IAEA's support of the ARMS ERMS system ceased in 2023. There is a suggestion for SDP to replace some of the ERMS functions.

Outcome #5: Enable creation, validation, and submission of declarations and other State-declared information for SRAs.		
Outputs	**Status/Comment**	
An established single client platform/application.	**On hold**	In 2022–2023, this outcome and all associated outputs were put on hold due to resource constraints.
★ An established open-source repository for application code and documentation.	**On hold**	
★ Defined governance for collaboration.	**On hold**	
★ Integration with the SDP for the transmission of files and messages.	**On hold**	
★ Capability to encrypt and digitally sign all files destined for the IAEA.	**On hold**	
★ Capability to decrypt and verify digital signatures of files received from the IAEA.	**On hold**	
Feature to conduct real-time QC verification of Code 10 files in fixed, labelled, and xml formats.	**Completed and work continues**	

Feature to conduct real-time QC verification of AP declarations.	**On hold**
Capability to allow the management of NMA data sufficient to allow creation of Code 10 reports.	**On hold**

Outcome #6: Competent and confident State Authorities who have the knowledge and skills to effectively submit declarations to the IAEA.	
Outputs	**Status/Comment**
An interactive e-learning portal to demonstrate the optimal method for States to submit declarations to the IAEA.	**Completed and work continues:** The *Basic Concepts: Nuclear Material Accounting in Facilities* e-learning course is currently accessible via CLP4NET (IAEA's open LMS) and includes 15 concept modules that provide foundational knowledge and 12 interactive, multi-part exercises in which learners gain hands-on experience in completing NMA reports. In addition, the course serves as a vehicle for delivering NMA-related job aids and tools, recordings of training webinars, and two formal assessments to gauge learning. Additional features include the awarding of a completion certificate and a two-tiered micro-credentialing system (badges) to help motivate learner persistence, and online forums to promote peer-to-peer and peer-to-expert communication. After the deployment of an ad hoc learner survey, a report on both usage analytics and learner feedback was compiled and provided to MSSP POCs in mid-2023. The Department's plan in 2024–2025 is to continue developing this course with a number of advanced reporting modules, developing innovative new learning tools including micro-learning and AI-enabled tools, and exploring ways to better integrate online offerings with face-to-face instruction of Member States in SSAC training.
Translation of the e-learning modules into Arabic, French, Spanish, Chinese, and Russian.	**Completed and work continues:** The *Basic Concepts: Nuclear Material Accounting in Facilities* e-learning course encompasses a series of conceptual modules, with nine of them having already been translated into Spanish by the ARG SP and presently accessible through CLP4NET (IAEA's open LMS). Translations of three more modules by ARG SP are in progress, and the Department is in preliminary discussions with ESP SP to translate the interactive exercises and assessments into Spanish. Collaborative efforts with the RUS SP are underway to translate the modules into Russian, with one module translated thus far. Translation into the remaining United Nations languages (Arabic, Chinese, and French) is scheduled in 2024–2025.
A nuclear material accounting e-learning portal that will provide support for in-person courses and a self-paced e-learning portal for State declarations, small quantities protocol, AP, and corrections to declarations.	**Completed and work continues:** Both a *Corrections to Reports* module and a *Corrections for a Shipment Foreign* interactive reporting exercise have been developed and deployed as part of the *Basic Concepts* course described above. A *Termination and Exemption under SQP* module has also been deployed as part of the course. New content development on additional protocol declarations and PR3 have eluded the Department in 2022 –2023 due to a nine-month vacancy in the Safeguards Reporting e-Learning Expert position during the latter half of 2022 and first quarter of 2023, but will commence in early 2024.
10 more NMA and AP e-learning modules.	**Work in progress:** The e-Learning Expert coverage gap cause a pause in new development. Although work has resumed, only two new modules were developed in 2022–2023. The remaining modules are deferred to 2024–2025.

Outcome #7: Enhanced UF_6 cylinder tracking via unique identifier.	
Outputs	**Status/Comment**
Ability to track individual UF_6 cylinder unique identifier (UF_6ID) (ID to be voluntarily provided by Member States). Increased value for Environmental Sampling reports from plants using UF_6 cylinders. Increased ability to analyse operators' measurement systems and data.	**On hold:** Due to insufficient internal support, this outcome and its associated outputs are on hold. This long-lasting issue is currently revived in the IAEA with meetings with ORNL. There was a meeting at ORNL in October 2023 to discuss collaboration on this topic. The Department remains interested and plans to pursue this in 2024–2025.

Outcome #8: Further improvement of the Additional Protocol System (APS) and Protocol Reporter 3 (PR3).	
This outcome and associated outputs will reside under the new D&IS Plan SGIS-003 (Safeguards Information Systems and System Usability) for 2024–2025.	
Outputs	**Status/Comment**
Renewed translation tool in order to improve the quality of translations.	**Completed:** SGIS recently enhanced the translation engines, moving to the latest neural versions specifically for the offline translation tool, PROMT. This enhancement has resulted in notable improvements in the accuracy and quality of automatically translated AP declarations, particularly in French, Russian, and Spanish. Furthermore, aside from its integration into the APS, PROMT can also function as a stand-alone translation tool within ISE, facilitating translations even when internet access is unavailable.
Introduction of dashboards with different views.	**Work in progress:** The Department is focusing on the development and implementation phases. This work aligns with the maintenance phase scheduled in 2024–2025 in PR3.
Redeployment of the latest PR3 version to Euratom States.	**Work in progress:** More Euratom States have implemented the latest PR3 version. This version incorporates improved workflows and facilitates information sharing between SRAs and facilities, mirroring successful practices in various Euratom States. Through training, the IAEA aims to deploy the updated PR3 version to all Euratom States by the end of 2024, as outlined in Outcome #5, Output #3 of the new plan.
Ability for the Declared Information Analysis Section (ISD) to ~~**correct**~~ **reformat** declarations in the PR3 format.	**On hold:** Work has not yet started.

Outcome #9: Improved functionality in and maintenance of the Safeguards Master Data (SGMD) application.	
This outcome and associated outputs will reside under the new D&IS Plan SGIS-003 (Safeguards Information Systems and System Usability) for 2024–2025.	
Outputs	**Status/Comment**
A centralized location for SRA addresses for easier maintenance and access for other Integrated Safeguards Environment (ISE) applications.	**Cancelled:** Work has not yet started. It will be incorporated into the CRM system as a component of the SDP project.
Conversion of SGMD into a web-based application.	**On hold:** It would be proposed to move this output to SGIS. To date, no progress has been made.
Enhanced interface.	**Completed and work continues:** SGMD was aligned with the latest version of *SG-GD-13728 SGMD Guidelines per Completion* document. SGMD is based on older technology and an update is needed.
Improved reports in line with internal guidelines.	**Completed:** SGMD reports have been enhanced to align with revisions made to SGMD in the preceding year, which were necessitated by the approved *SG-GD-13728-Safeguards Master Data - Guidelines for Completion* guide. This ensures continued compliance with the updated fields and descriptions in SGMD.

Outcome #10: Improved import communications with Member States.	
Outputs	**Status/Comment**
Organization of an import communications consultancy meeting.	**Completed:** A Consultancy Meeting was held 16–18 May 2023 in Vienna.
Set of new import communications recommendations.	**Completed:** The consultants wrote draft recommendations.
Instructions and information regarding proper import tracking practices to send to Member States.	**Completed:** The IAEA will convey the recommendations to Member States in Q1 2024.

SGIS-002: Information Security and Infrastructure (Michael Scott PARTEE)

Outcome #1: Information security risk mitigation through an effective information security management system and security operations.	
Outputs	**Status/Comment**
A measured and coordinated information security management and operations programme that is focused on the Department's most critical information security risks.	**Completed and work continues:** The Department's Information Security Management System (ISMS) remains the basis for risk management activities. The evolving risk landscape necessitates perpetual updates to the system.
Effective security operations, systems access management, training, and security control implementations that are tuned to the Department's threats and enable the Department's business processes, measured with appropriate maturity models.	**Work in progress:** The Department continues to focus on the essential security controls for mitigating the risk of targeted cyber intrusion into its information technology environments. Specific and very important areas of improvement, such as extended endpoint protection and response, have been identified as necessary to improve the Department's defences.
A programme of risk, threat, and technical security controls assessment that includes at least three targeted or comprehensive security assessments per year.	**Completed and work continues:** The Department allocates both regular budget and extrabudgetary resources on the critical activity of identifying security flaws in its applications, systems, and processes. Any resulting vulnerabilities are identified and managed until remediation in accordance with the relevant policies and procedures with target key performance indicators.
A continuous social engineering awareness training and testing programme with both general and targeted campaigns for email phishing and other social engineering attacks.	**Completed and work continues:** The Department's aim to build a world-class security culture centers on general information security awareness, covering topics such as phishing attacks. Effectiveness is measured through testing an metrics. In 2022–2023, the Department expanded topics to include: physical security; risk and threat briefings; secure communications concepts; and many more topics.

Outcome #2: Increased trust in the Department's information and systems through improved security engineering and enhanced solutions for secure communications, data protection mechanisms, and data exchange.	
Outputs	**Status/Comment**
Improvements to the Department's secure software development life cycle, including the cryptographic validation of all departmental software products.	**Completed and work continues:** All software in the Department's code repositories undergoes automatic checks for dependencies, outdated components, framework vulnerabilities, and software security issues. Deployment packages are digitally signed automatically to ensure integrity. Software teams attend regular security reviews.
Expanded and improved cryptographic support for additional and enhanced capabilities, including an assessment of the Agency-standard data protection mechanism for potential use in the Department to protect information outside of the secure Integrated Safeguards Environment (ISE) and bringing more resilience and uses to the Agency's Public Key Infrastructure (PKI).	**Nearing completion:** The PKI system's hardware and software, managed by the Department, were completely renewed in 2022–2023 and will be made more resilient in 2024–2025. Using cryptography and other methods of security information outside of ISE continues to be used, but several areas of investigation needed to streamline, improve, or innovate such capabilities remain viable areas of activity, especially in light of modern information system platforms and concepts such as artificial intelligence and cloud computing.

Provide staff in the field and the Department's regional offices with communications solutions that meet the Department's security requirements.	**Completed and work continues:** The Department deploys specialized communication solutions for Department staff members that require mobile phone-based secured email. Additional, highly-secured methods of communication, such as voice, chat, and messaging remain an area of interest.

Outcome #3: Increased trust in the Department through enhanced physical security and environmental security solutions.	
Outputs	**Status/Comment**
A feasibility study based on a technical proof of concept that will serve as the foundation for deciding the future of the Department's physical security management system.	**Completed:** A comprehensive activity involving Agency-wide stakeholders concluded with the result that the most cost-effective and viable solution for improving the physical security management system is to refresh the existing system. The stakeholders devised a two-part plan to immediately begin refreshing the critical areas and tackle the longer-term upgrades in phases.
Depending on the outcome of the technical proof of concept, a project to either improve the existing system or migrate to a new system.	**Work in progress:** The Department initiated work to complete the core and most essential back-end items (such as software and IT components) in 2022–2023. The Department plans to upgrade the long-term items, consisting of physical security controller cards and mechanisms in 2024–2025, and will seek extrabudgetary support to achieve this output.

Outcome #4: Securely enabling the Business Continuity of the Department through the provision of reliable, resilient, and highly available IT infrastructure even during a disruptive event.	
Outputs	**Status/Comment**
Enhanced IT DR capabilities for the information technology systems that enable the critical Safeguards business processes.	**Work in progress:** The Department made significant progress in its DR capabilities for IAEA headquarters by building capacity for IT recovery in Seibersdorf. The Department successfully restored the Integrated Safeguards Environment (ISE) in Seibersdorf as a test of this capability and will continue to develop DR capabilities in Seibersdorf in 2024–2025.
Identification and capability to utilize alternative facilities for DR scenarios.	**Completed and work continues:** The Department identified and arranged for an alternate site for the Tokyo Regional Office and continues to develop the required IT systems and processes. The Department plans to develop further scenarios of other facilities.
Well-maintained and demonstrably executable BC and DR programme for the Department.	**Completed and work continues:** The Department engaged in significant business continuity activities—both planned and unplanned—and will continue to develop additional business continuity capabilities for more scenarios.

SGIS-003: Safeguards Information Systems and System Usability (Remzi KIRKGOEZE)

Outcome #1: Increased efficiency of Safeguards processes through consolidation and integration of current IT systems.	
Outputs	**Status/Comment**
★ Improved integration of IT systems that close gaps in the IT support of SG processes saving departmental staff member time to enter or re-enter data.	**Completed and work continues:** For IAEA Safeguards inspectors dealing with verifications in bulk-handling facilities, a time-saving advantage has been achieved. They can now efficiently transfer data from Operator General Ledgers to the relevant reporting modules within SAFIRE. Additionally, the consistency between the Acquisition Path Analysis (APA) and the State Level Approach (SLA) has been enhanced through the implementation of automatic derivation rules.
Increased performance of existing systems across all environments saving departmental staff member time.	**Completed and work continues:** Numerous applications have been successfully upgraded to enhance their performance, resulting in decreased wait times for users while utilizing the software.
★ Reduced time for users to learn and use IT systems through a uniform user experience across all systems.	**Completed and work continues:** The Department introduced an integrated reporting and evaluation user interface for verifications that feature a unified visual design that's easier to learn. This new interface not only simplifies the data entry and review process for verification activities but also incorporates user feedback to enhance overall efficiency.
Full availability of all IT systems during business hours at IAEA headquarters and regional offices.	**Completed and work continues:** The Department maintained continuous monitoring of all software and underlying systems to ensure their availability during business hours, thereby sustaining operational efficiency at both the IAEA headquarters and regional offices.

Outcome #2: Extended support of Safeguards processes through new IT capabilities.	
Outputs	**Status/Comment**
Consistent implementation of the State Level Concept across Member States.	**Nearing completion:** The Department is nearing completion in its support of SEGs to achieve consistent implementation of the State Level Concept across Member States. This includes assisting SEGs in conducting Acquisition Path Analysis (APA) consistently with an intuitive graphical tool, automating the creation of State Level Approach (SLA) draft documents using the latest template, validating alignment between SLA and Annual Implementation Plans (AIPs) through Quality Control (QC) rules, and ensuring the coherence between APA and SLA through derivation rules.
★ Increased efficiency of verification activities through the integration of data received via remote monitoring and surveillance into the verification activity reporting.	**Work in progress:** The Department is currently making significant progress towards enhancing the efficiency of its verification activities by integrating data received from remote monitoring and surveillance into the verification activity reporting. The Next Generation Surveillance System (NGSR) has obtained authorization for in-field usage, and the Department has finalized IRAP configuration for facilities in the Tokai Region in Japan, enabling the analysis of data acquired from unattended monitoring systems. Additionally, the ERML Kiosk has streamlined the process of equipment return for radiation assessment, replacing traditional paper forms and significantly improving operational efficiency.

More secure solutions replacing outdated IT technologies for environmental sampling.	**Nearing completion:** The environmental sampling system, designed to track, analyse, evaluate, and report on samples collected by IAEA Safeguards inspectors, has made substantial progress. Phases one and two, which also included successful user acceptance testing, have been successfully completed, bringing the Department closer to the replacement of the outdated existing system.
Integrated work planning and reporting for equipment-related activities in the field.	**Completed and work continues:** The SEQUOIA Team successfully implemented a new stock management system, enhancing the Department's ability to track, plan, and budget for spare parts and other essential supplies. The introduction of a battery checklist has improved the efficiency of equipment shipments. Additionally, the All-in-One Duty Trip initiative is consolidating SGTS processes within ISP, which streamlines the planning and reporting of technical in-field work.

Outcome #3: Enabled digital transformation.	
Outputs	**Status/Comment**
A SG Enterprise Architecture that includes governance processes.	**Work in progress:** The Department established an IT architectural group dedicated to standardizing the technology environment, fostering efficiency, innovation, security, and alignment with business goals.
A future-proof software platform for all new, custom-built Safeguards applications.	**Completed and work continues:** The Department achieved an open architectural software platform for new Safeguards applications, reduced hardware through virtualization, and enhanced DevOps for quicker deployments. Additionally, the Department established a dedicated platform and process for AI/ML solutions.
★ Harmonized IT environment with lower maintenance costs.	**Completed and work continues:** The Department upgraded to the latest Hyper-Converged Server infrastructure, which simplifies storage, networking, and processing hardware management. The Department consolidated servers, added automation for routine work, and implemented proactive monitoring and maintenance practices.
Lower software development costs through enforcing standards and fostering reuse of software services and platforms.	**Completed and work continues:** The Department enhanced its knowledge base for applications to promote knowledge sharing across teams. The newly-established IT Architecture group encourages platform utilization and service reuse through reviews and design decisions.
Improved integration and interoperability of IT solutions.	**Completed and work continues:** The Department is currently standardizing APIs for data exchange, consolidating data storage systems, and promoting cross-functional collaboration among development teams.

SGTS-001: NDA Techniques (Davide PARISE)

Outcome #1: ★ Faster verification of fresh fuel assemblies using NDA systems.	
Outputs	**Status/Comment**
A Deuterium-Deuterium (DD) neutron generator with the Fast Neutron Coincidence Collar (FNCL) that shortens fresh fuel assembly verification time from minutes to seconds.	**Work in progress:** Design requirements are finalized, and a preliminary numerical modelling study has produced a concept. Equipment malfunctioning has delayed the experimental measurements. The activities will continue as soon as equipment functionalities are re-established.

Outcome #2: Improved instruments and techniques to address verification of waste and scrap nuclear material with impure composition or heterogeneous isotopic composition.	
Outputs	**Status/Comment**
A new data processing algorithm.	**Work in progress:** The Department is actively working on the development of a new data processing algorithm. During this process, there was an issue with the CTGS, which was damaged during transportation. Consequently, the algorithm development relied mainly on existing experimental data. However, the CTGS has been successfully repaired, and the development of the processing algorithm using newly acquired experimental data is proceeding.
Performance evaluation and authorization of the Compact Tomographic Gamma Scanner (CTGS).	**Work in progress:** The ongoing process pertains to the performance evaluation and authorization of the Compact Tomographic Gamma Scanner (CTGS). Unfortunately, the CTGS sustained damage during transportation, necessitating its return to the manufacturer for repair. The fully repaired instrument was received by PNNL in August 2023, and the performance evaluation process has been initiated.

Outcome #3: ★ An improved fresh nuclear material verification method with consolidated gamma-spectrometric techniques.	
Outputs	**Status/Comment**
Development of the successor to HM-5, a Hand-Held Monitor Version 6 (Spectrometric Gamma Hand-Held Monitors), with a new hardware platform and software environment.	**Work in progress:** The hardware design for Hand-Held Monitor Version 6 has been successfully completed. Subsequently, the IAEA has initiated the procurement process to select a company capable of producing and maintaining this hardware. A decision was taken to develop a multi-platform version of the MCAT, compatible with the operating system of Hand-Held Monitor Version 6. This software will serve as the primary application for the new instrument, and development is in progress.

Outcome #4: ★ Enhanced performance and better usability of high- and medium-resolution gamma spectrometry for nuclear material verification.	
Outputs	**Status/Comment**
Amendment of the MCAT software to include Multi-Group Analysis/Multi-Group Analysis code for Uranium (MGA/MGAU) modules.	**Work in progress:** Progress is contingent upon the release of MCAT-compatible libraries for MGA/MGAU.

Amendment of the MCAT software to include criticality check, reactivity determination, and neutron pulse train analysis modules (GER A 2278).	**On hold:** The amendment of the MCAT software, supported under MSSP Task GER A 2278 (Upgrading of the MCA-Touch Software) to include criticality check, reactivity determination, and neutron pulse train analysis modules is on hold. This decision is based on the assessment that it would be more efficient to integrate these functionalities directly into the multi-platform version of the MCAT.
Integration of MCAT with H3D CDZT modules M400 via an established Application Programming Interface (API).	**Completed:** MCAT, in conjunction with MMCM, is now authorized for safeguards verification.

SGTS-002: Techniques and Instruments for Sealing and Containment Verification (Martin MOESLINGER)

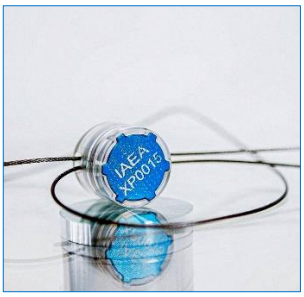
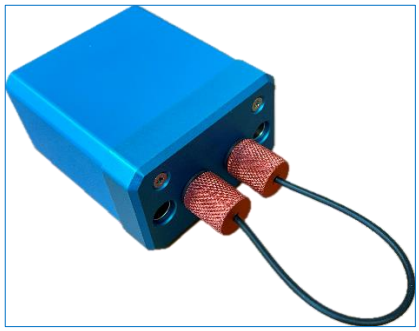
Outcome #1: ★ Proven or disproven efficacy of millimetre-Wave Radar (mmWR) technology for applicability in relatively confined location such as small rooms or inside cabinets.

Outputs	Status/Comment
Constructed a mock-up system of mmWR.	**Completed and work continues:** Based on a feasibility study provided by Brookhaven National Laboratory (BNL, USA), Idaho National Laboratory (INL, USA) has successfully constructed a mock-up system to evaluate the feasibility of utilizing mmWR technology for tamper detection within limited, compact spaces, such as instrument enclosures.
Assessment report of mmWR.	**Completed and work continues:** In October 2023, the Department received the first assessment report for the mock-up system using standard Safeguards cabinets, as prepared by INL. Pending favourable results from ongoing assessments, the Department plans to transmit a new MSSP Task Proposal for the development of an mmWR solution, tailored for use in Safeguards instruments.

Outcome #2: Ability to confidently maintain continuity of knowledge under critical emergence conditions at relatively low costs.

Outputs	Status/Comment
An assessment of advance fibre-optic techniques/the fibre-optical system based on interferometry proposed by Los Alamos National Laboratory.	**On hold:** While the IAEA has noticed advancements in this technology, a thorough evaluation of the proposed advanced fibre-optic system, based on interferometry from Los Alamos National Laboratory, is on hold. This delay is due to a shortage of human resources within the Department and the need to establish related priorities.
A methodology that defines the active and passive seal perimeters of spent fuel cask boundaries.	**On hold:** This work is currently on hold due to a shortage of human resources within the Department and the necessity to establish related priorities.

Outcome #3: Ability to confirm the movements of casks in multiple planes without the need of surveillance images and with improved security.	
Outputs	**Status/Comment**
Assessment of new Light Detection and Ranging (LIDAR) technologies that could improve the security and capabilities of the LCCT.	**Completed and work continues:** In 2023, the Laser Curtain for Containment (LCCT), a C/S system utilizing LIDAR technology, was authorized for Safeguards use. The Department is currently validating new multi-line LIDAR heads as part of the ongoing LCCT life cycle management process.

Outcome #4: ★Ability to seal containments through active and passive sealing methods	
Outputs	**Status/Comment**
Development, implementation and life cycle management of a new, field-verifiable passive seal (FVPS).	**Completed and work continues:** Following the authorization of the new Field Verifiable Passive Seal (FVPS), the FVPS open bid procurement has been organized, and design has been released for large-scale commercial production. Field implementation is currently in progress, with approximately 10 000 FVPS units received in mid-2023. Additionally, the FVPS in-field verifier (reader), utilizing a customized Apple iPhone hardware and software platform, is now under routine life cycle management.  *Figure 69: The new Field Verifiable Passive Seal (FVPS).*
Development, implementation and life cycle management of a new active seal.	**Completed and work continues:** With the authorization of the new Active Universal Asymmetric Seal (AUAS), the Department has manufactured several hundred seals to initiate the replacement of the outdated Electronic Optical Sealing System (EOSS). This transition is currently in progress with further developments underway.  *Figure 70: The new Active Universal Asymmetric Seal (AUAS).*

SGTS-003: Surveillance Techniques (Melvin JOHN)

Outcome #1: Enhanced ability to deploy equipment at facilities to meet safeguards requirements through development of highly effective and cost-efficient optical surveillance measures with improved security features.

Outputs	Status/Comment
★ Authorize the Next Generation Surveillance Review (NGSR) software for application by IAEA Safeguards inspectors in the field.	**Completed:** NGSR was fully authorized for routine use in June 2022. Ongoing core NGSR developments are within the scope of software life cycle and maintenance management.
★ Integrate Artificial Intelligence (AI) image processing into NGSR and release for testing (see conditions and details below).	**Work in progress:** Initial Deep Learning (DL) technology was developed and implemented for approximately 20 data streams from CANDU reactor and ID-camera surveillance since 2022. Authorization for this initial phase is scheduled for Q1 2024, and work is in progress to create DL models for additional applications and facilities.  *Figure 71: Test of integration of deep learning algorithms within NGSR to enhance surveillance review capability.*
★ Conduct a workshop with stakeholders to refine user requirements and assess available technologies for an NGSS successor.	**Work in progress:** In 2023, the Department reviewed and extended the timeline for the NGSS successor technology to the end of 2029. Initial draft requirements will be shared with stakeholders in Q4 2023, and the Department anticipates conducting a kick-off workshop in 2024, contingent upon acquiring necessary additional staff resources.

Outcome #2: Improved ability to detect undeclared activities at nuclear facilities with tools and techniques.	
Outputs	**Status/Comment**
Surveys and assessments of emerging 3D camera and laser (LiDAR) technologies to provide life cycle support to existing systems (3DLR) to provide valuable input for the eventual NGSS technology replacement.	**Work in progress:** The IAEA is actively receiving input and assessments from multiple MSSPs, which contribute to the ongoing work supporting Outcome #1, above.  *Figure 72: A Department staff member conducting 3D mapping of a facility using LiDAR sensors as part of a Design Information Verification (DIV) activity.*
★Test results from the upgraded LiDAR-based Laser Curtain for Containment (LCCT) system that was installed for field testing.	**Completed and work continues:** LCCT, initially developed under D&IS Plan SGTS-002 (Techniques and Instruments for Sealing and Containment Verification) and authorized for routine Safeguards use in July 2023, utilized test results from the first installation. D&IS Plan SGTS-003 (Surveillance Techniques) will now oversee its mainstream implementation, refinement, and life cycle management as outlined in the 2024–2025 D&IS Plan.

Outcome #3: Improved response to new threats resulting from technology advancements, through advanced intrusiveness and vulnerability analysis on current and future use of unattended systems.	
Outputs	**Status/Comment**
★ Evaluation and integration of data review capabilities in NGSR as reported in the vulnerability assessment.	**Completed and work continues:** The NGSS DCM-A1 analogue camera module vulnerability assessment, conducted as part of MSSP Task USA E 2354 (Vulnerability Assessment of the DCM-A1 SSTDR Diagnostics Feature (LiveWire)), concluded at the end of 2021. Work continues on extending NGSR analysis and reporting capabilities to include spread-spectrum time domain reflectometry data from the DCM-A1 module.

Outcome #4: Improved real-time monitoring and flow measurement capabilities of nuclear material at nuclear facilities (for example, UF_6 cylinders and spent fuel casks) by developing tools and techniques.	
Outputs	**Status/Comment**
A developed ultra-high frequency (UHF) Passive Tag monitoring and tracking system with advanced capabilities for persistent, real-time, non-optical surveillance of items of interest.	**Work in progress:** The development of an ultra-wideband (UWB) data link device continues under D&IS Plan SGTS-003 (Surveillance Techniques) and MSSP Task USA E 2484 (Ultra Wideband (UWB) Data Link). Work related to UWB and UHF Passive Tag technology is managed by D&IS Plan SGTS-008 (Instrumentation Technology Foresight) and continues under MSSP Task USA E 2483 (Passive Tag Technology).

SGTS-008: Instrumentation Technology Foresight (Dimitri FINKER)

Outcome #1: Improved and more efficient safeguards verification activities in the field through the use of innovative technologies.	
Outputs	**Status/Comment**
★ 30 Next Generation Cerenkov Viewing Device (XCVD) unit to replace the improved Cerenkov viewing device (ICVD) and Digital Cherenkov Viewing Device (DCVD) used for gross defect verification.	**Work in progress:** 15 XCVD units are available for both gross and partial defect verification; the five most recent units are based on a new and compact form-factor, which will be used for the bulk production starting in 2024.
Conclusions on XCVD applicability for partial defect verification of spent fuel.	**Completed:** The XCVD was authorized for partial defect verification in February 2023.
Setup of the IT infrastructure for post process and storage of XCVD data.	**Work in progress:** Preliminary work was undertaken to integrate XCVD post-processing software and data storage into the existing Centralized Automated System for Correlated Analysis and Data Evaluation (CASCADE).
★ Deployment of Robotized Cerenkov Viewing Device (RCVD) in at least one significant spent fuel verification campaign, including difficult-to-access and/or large quantities of items.	**Completed:** The RCVD was authorized for facility-specific verifications and used for spent fuel verifications in challenging environmental conditions, such as high radiation areas or difficult-to-access covered areas.
Finalization of the development of a portable MMXRF (micro-focusing X-ray fluorescent spectroscopy) in close collaboration with SGAS.	**Nearing completion:** The latest prototype of the portable MMXRF improves the performance of the initial benchtop model. Further testing is planned to validate the behaviour of the instrument in real-life transportation scenarios.
Expand use of Instrument Record Integrator for Safeguards (IRIS) in the Integrated Safeguards Environment (ISE), currently restricted to a few test users, through further integration with SG IT Tools.	**On hold:** Routine maintenance and minor updates were carried out. Discussions about integrating IRIS with Dataflow and ESEE have taken place, and it's included in the development backlog of SGIS. However, due to resource constraints, this integration has not been implemented yet.

Outcome #2: Ability to develop, design, and enhance safeguards solutions faster and with fewer resources by using external technologies from relevant R&D fields.	
Outputs	**Status/Comment**
Identification of at least 4 new, external, non-traditional technology suppliers that have demonstrated an ability to develop specific solutions applicable to the domains of non-destructive assay, containment, surveillance, and destructive analysis (in close collaboration with SGCP-004: Strategic Analyses and Partnerships).	**Completed and work continues:** New technology suppliers were identified to solve specific instrumentation challenges (e.g., radiological and visual survey in high-dose environment, liquid level measurement) and improve existing systems (design and produce custom non-lithium battery packs for NDA instruments; re-engineering of AUAS enclosure).
At least one Technology Challenge for improving SG instrument data analysis. Prospective topics include machine learning applied to improvement of spectral analysis, improvement of inertial positioning capabilities, and Cerenkov image analysis.	**Work in progress:** The Department is planning a technology challenge to enhance the data analysis process for the Autonomous Navigation and Positioning Sensor (ANPS) by utilizing an external crowdsourcing challenge platform. The preparations for this challenge will begin in early 2024.
Expanded usage of the Technology Foresight database for stakeholders external to Technology Foresight: support to SGTS scientific panels and generation of external technology reports for MSSPs.	**Work in progress:** The database is in frequent use by the Technology Foresight Team and has seen increased adoption within the Verification Technologies Section. Ongoing efforts are directed towards enhancing the database's functionality and user-friendliness, with the goal of reach more users in the Department in the future.

SGTS-011: Unattended Measurements Techniques (Mikhail MAYOROV)

Outcome #1: Faster (and potentially real-time) detection of highly enriched Uranium production in low enriched Uranium enrichment facilities through improved tools and techniques.	
Outputs	**Status/Comment**
★ On-Line Enrichment Monitor software suite, including final versions of On-Line Enrichment Monitor Data Acquisition module (OLEMDAQ), AnalyseN42, and On-Line Enrichment Monitor Review (OLEMR) software tools.	**Nearing completion:** Testing of the received software beta versions has not yet been finished.
★ Identification of new facilities for OLEM installation in collaboration with Operations Divisions.	**Completed and work continues:** The Department has installed two OLEM nodes (also known as EMD – Enrichment Monitoring Device) at two facilities under challenging measurement conditions, and commissioning efforts are underway.
Electrically cooled high purity germanium (HPGe) detector to achieve continuous enrichment (including 234U) assay, including a cooling circuit to trap UF_6 into a sample bottle.	**Cancelled:** Currently, there are no technical reasons for modifying the current NaI(Tl)-based design.

Outcome #2: Implementation of the Unattended Cylinder Verification Station at an operating enrichment plant.	
Outputs	**Status/Comment**
★ Successful installation of an Unattended Cylinder Verification System (UCVS) at a safeguarded gas centrifuge enrichment plant (GCEP).	**Work in progress:** Installation of the Unattended Cylinder Verification System (UCVS) at a safeguarded Gas Centrifuge Enrichment Plant (GCEP) faced challenges in 2022–2023 due to several reasons: • The UCVS was damaged during transportation from PNNL to the IAEA and had to be repaired. The USSP has successfully coordinated a repair. • System operation and expected performance discussions between SMEs from US national labs and the IAEA (SGOC and UMS) are scheduled for Q1 2024. • Currently, operations cannot identify a GCEP in non-nuclear-weapon State interested in participating in the pilot operation of UCVS. The IAEA and the UK SP plan to install UCVS at Capenhurst in 2024.
Measurement and analysis of feed, product, and tails cylinders.	**On hold:** Since April 2022, the UCVS has been at the IAEA headquarters, and as a result, the Department is unable to conduct any field measurements at this time.

Outcome #3: Established and maintained knowledge of spent fuel in shielding/storing/transporting containers, at all points in their life cycle, by developing safeguards equipment.	
Outputs	**Status/Comment**
★ Advancing Unattended Fork Detector Monitor data analysis for improved partial defect verification.	**Nearing completion:** Data analysis has been successfully completed and documented in a report. The Department is currently in the process of authorizing FDET measurements for partial defect verification. The initial phase of this authorization will encompass VVER-440/1000 and PWR assemblies.
★ Development of unattended Passive Gamma Emission Tomography (PGET).	**Nearing completion:** In collaboration with the Finnish, United States, and Swiss Support Programmes, as well as teams from D&IS Plans SGTS-001 (NDA Techniques) and SGTS-011 (Unattended Measurements Techniques), the Department has made significant progress towards enabling the operation of PGET in unattended mode. Key accomplishments include: (All MSSP Task titles below are "Support for testing of PGET new functionalities in attended, remote and unattended modes.") • Development of UGET Concept of Operations (ConOps) and algorithms under MSSP Task JNT A 2431 USA. • Development and testing of the UGET code functionality under MSSP Task JNT A 2431 USA. • Two field tests at Olkiluoto Nuclear Power Plant (NPP) and one test at Loviisa NPP under MSSP Tasks JNT A 2414 FIN and JNT A 2431 USA (see figure below "Testing of UGET at the interim Spent Fuel Storage at the Olkiluoto Nuclear Power Plant (Finland)"). Additionally, under MSSP Tasks JNT A 2708 CHE and JNT A 2414 FIN, the Department successfully completed a field test to evaluate PGET performance in an air environment (hot cell setting at Zwilag, see figure below, "The PGET system's performance evaluation on the Boiling Water Reactor (BWR) spent fuel in a hot cell at Zwilag (Switzerland)".

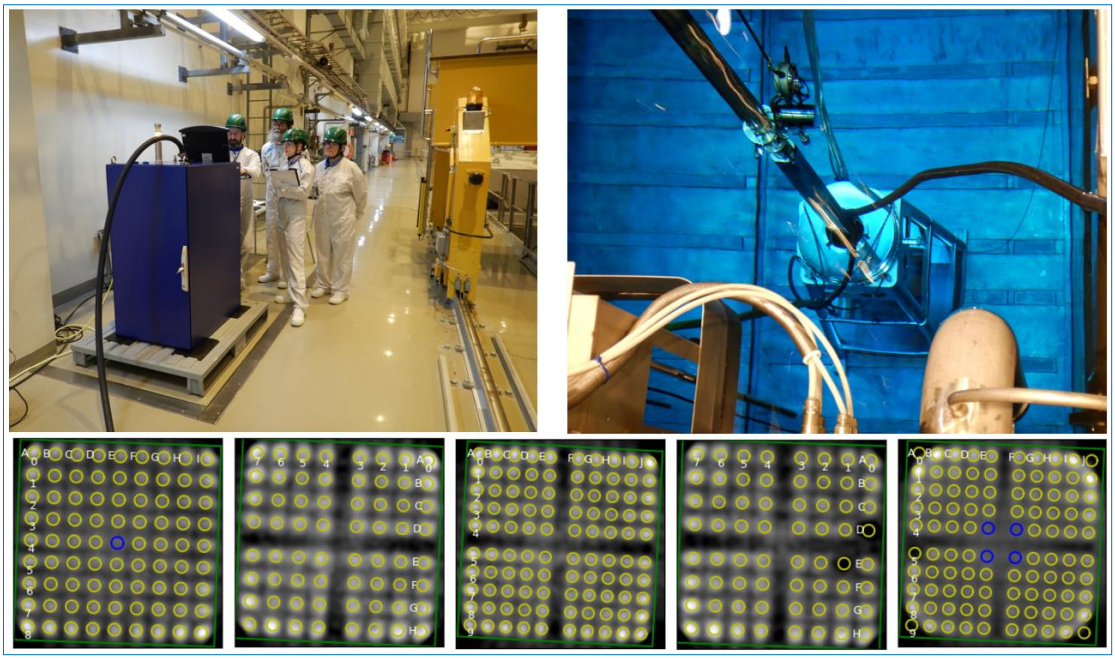


Figure 73: Testing of the Unattended Gamma Emission Tomography (UGET) at the interim Spent Fuel Storage at the Olkiluoto Nuclear Power Plant (Finland).

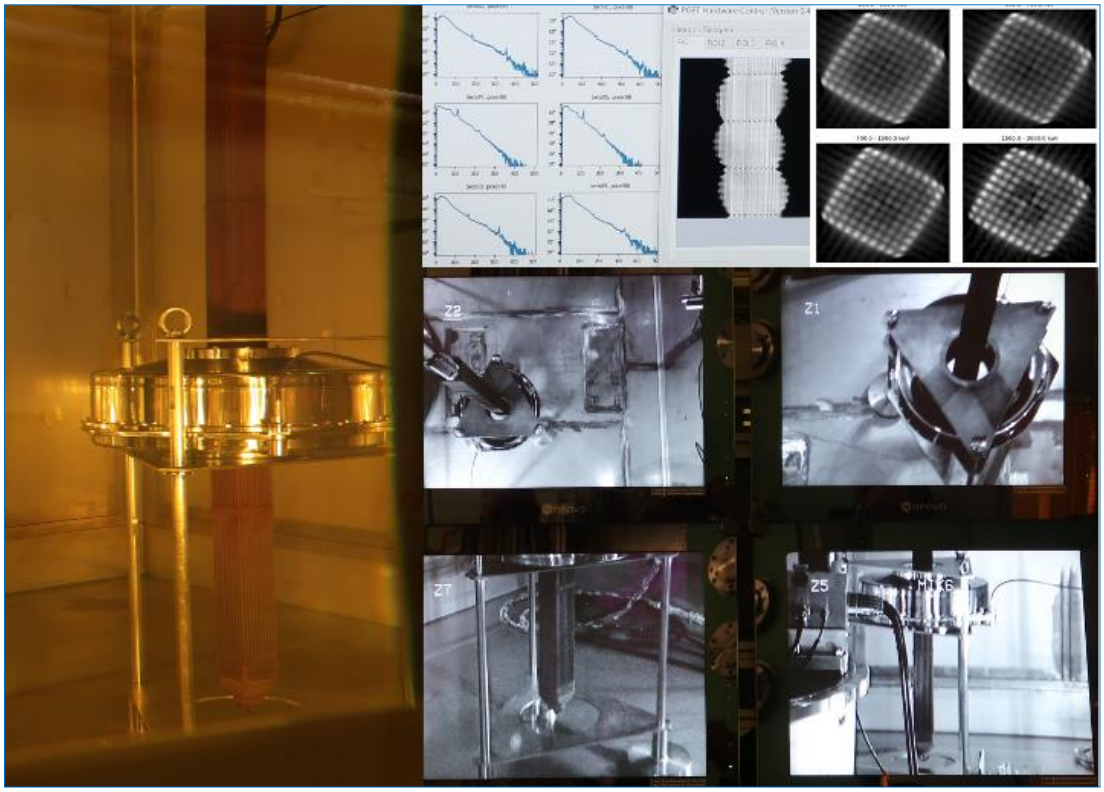


Figure 74: The Passive Gamma Emission Tomography (PGET) system's performance evaluation on the Boiling Water Reactor (BWR) spent fuel in a hot cell at Zwilag (Switzerland).

Outcome #4: Development of UMS based on new measurement technologies and increasing proportion of deployed unattended systems that are sustainable, standardized and modular, with increased use of COTS products.	
Outputs	**Status/Comment**
★ A time-domain reflectometry (TDR) device based on UMS requirements is expected to be installed for field testing, following the acceptance of MSSP Task Proposal 21/TUS-001 (Development of Time Domain Reflectometer (TDR) Devices for Use Along Unattended Monitoring Systems (UMS) Detector Cabling Pathways).	**Work in progress:** The development of the TDR device is currently in progress. Several online meetings have been held to provide updates on its status.
★ Proposed sensors to confirm operational or non-operational status of facility	**On hold:** Unfortunately, the Department has not yet made any progress. The research topic is however still valid and relevant.
★ Coriolis flow meter (CFM)-based unattended measurement system for mass and density determination of liquid flowing through a pipe.	**Work in progress:** The Department has established a test system at IAEA headquarters, featuring three Coriolis flow meters (CFMs) to assess and test various aspects of the system (see figure below "Coriolis flow meter-based system…"). The goal is to potentially install this system at a facility next year.  *Figure 75: Coriolis flow meter-based system undergoing a functional and technical performance evaluation at the UMS laboratory.*
★ Feasibility of COTS Raman spectroscopy technique for unattended measurement of Uranium concentration in liquids.	**On hold:** Unfortunately, the Department has not yet made any progress. The research topic is however still valid and relevant.
★ COTS non-nuclear measurement methods for characterisation of spent fuel.	**On hold:** Unfortunately, the Department has not yet made any progress. The research topic is however still valid and relevant.

★ Survey on existing COTS techniques to address timely detection of tampering of UMS cabinets.	**Work in progress:** The Department's ongoing research focuses on an industrial sensor capable of measuring a range of audible and ultrasonic frequencies, durations, and sound pressure levels. A prototype of the built activity security system consists of a network of eight sensors: door contacts, seismic, motion, and retroreflective sensors (see figure below "A prototype of an active security system…"). All are connected to a control unit AKCP SPX+. The advantages of this solution are low power consumption (3W), simplicity, modularity, and ability to install the sensors up to 300 meters away from the cabinet, hence securing the other sensitive components of the UMS, such as junction boxes or detector enclosures.  *Figure 76: A prototype of an active security system installed in the medium-size cabinet.*

Outcome #5: Identification of new (fast) neutron and gamma ray spectroscopic sensors and associated nuclear instrumentation electronic for use in unattended systems.	
Outputs	**Status/Comment**
★ Low-power gamma ray spectroscopic detectors with better resolution than sodium iodide.	**Completed:** The Department identified CdZnTe detectors as a valid solution for some applications and plans their use in a new system to monitor the power of research reactors.
★ Low power fast neutron sensors (semiconductor- or scintillator-based) with very good pulse-shape discrimination.	**Completed:** The Department identified and tested a diamond fast-neutron detector. The results indicate that this type of detector is not suitable for IAEA Safeguard purposes.
★ Development and maintainability support (hardware and software) of UMS standard electronic modules.	**Work in progress:** The Department has been facilitating the development of several UMS components, and key accomplishments include: • The authorization of UDL1 as a replacement for the miniGrand and JSR-12 shift register. • Development and testing of a UDCM prototype, with further work needed in this regard.
Multi-Channel Multiplicity Counter Shift Register software to run on COTS hardware for unattended shift register applications requiring many separate inputs.	**Cancelled:** The need has been fully addressed by the 8-channel UDL1.

SGTS-014: Remote Data Transmission and Processing Systems (Angelo ALESSANDRELLO)

Outcome #1: ★More efficient data review and evaluation tools for IAEA Safeguards inspectors and SGTS technicians	
Outputs	**Status/Comment**
★ Integration of CASCADE in the Integrated Safeguards Environment (ISE) with the State Declaration Portal (SDP) and SAFIRE-CIOSP.	**Work in progress:** CASCADE now serves as the secure data storage for operator declarations and offers a user-friendly interface for IAEA Safeguards inspectors' review. Furthermore, it is integrated with the State Declarations Portal (SDP) within ISE since Q1 2023, managing operator declarations transmitted through SDP.
★ Integration of ROOGLE3 data with CASCADE, SMT, SEQUOIA, and SAFIRE.	**Nearing completion:** ROOGLE3 integration with SEQUOIA and SMT started in Q1 2023, with some remaining configuration work for UMS equipment. It enables ROOGLE3 to keep SEQUOIA updated on remotely connected equipment, aiding in error identification, although it involves manual oversight. Additionally, ROOGLE3 facilitates equipment issue data collection, which supports users in creating equipment-related tickets in SMT.
★ Integration of hand-carried data with remotely transmitted data and transfer of their respective data stores into ISE.	**Work in progress:** The Department built a ROOGLE prototype to import hand-carried data in an RDT-like structure, updating the ROOGLE state-of-health database. Successful testing with NGSS camera and EOSS seals data is complete. However, extending this to all SGTS equipment requires further work. The ongoing transfer of SGTS equipment data into ISE by SGIS is scheduled to finish in late 2024.
★ IRAP and Next Generation Surveillance Review (NGSR) deployment in ISE and on IAEA Safeguards inspector laptops for in-field use.	**Completed:** In Q1/Q2 2022, NGSR and IRAP met the requirements for installation in ISE and on IAEA Safeguards inspector laptops. However, to use them fully in ISE, the Department must also transfer SGTS equipment data into ISE (see previous output).
★ Complete IRAP/NGSR deployment and configuration for facilities in RDT.	**Completed and work continues:** NGSR was authorized in Q2 2022, and so far, IRAP can analyse data from around 70% of SGTS equipment in the remote data transmission regime. Since new facilities and technologies are always being added, this work will keep going. Nevertheless, the Department aims to reach 90% completion for current and planned configurations by 2025.

Outcome #2: Continuous improvement of the RDT network	
Outputs	**Status/Comment**
Implementation of RAINBOX device.	**Nearing completion:** The RAINBOX was developed according the latest SGTS requirements, and the delivery of a prototype is scheduled for Q1 2024.

A risk assessment of the RDT network.	**Completed and work continues:** In Q2 2022, a thorough penetration test was conducted on the RDT network, revealing medium-level risks that were promptly addressed.
Enhanced RDT network capabilities.	**Completed and work continues:** The Department is enhancing the RDT network with ongoing updates, including transitioning from the Asymmetric Digital Subscriber Line (ADSL) to fibre optics in Japan and Korea. Additionally, the Department expanded the network, connecting more nuclear facilities, increasing from 148 in 2021 to 159 as of December 2022.

Outcome #3: Enable rapid verification of activities in complex facilities	
Outputs	**Status/Comment**
Develop an NRTS instance for the Central Spent Fuel Storage Facility (CSFSF) (RKB facility) in Chornobyl, Ukraine.	**Work in progress:** This was on hold for almost 2 years due to the conflict in Ukraine but was restarted in Q3 2023.
Develop an NRTS instance for the Rokkasho Reprocessing Plant (RRP) (JRC facility) in Rokkasho, Japan.	**Work in progress:** This is advancing alongside the hardware update and should be mostly completed by the end of 2024.
Develop an NRTS instance for the encapsulation plant and geological repository (EPGR) (W0LE/W0LF facilities) in Olkiluoto, Finland.	**Work in progress:** The requirements gathering phase ended in Q2 2023 and development started in Q3 2023.

SGTS-016: Occupational Health and Radiation Safety (Virginia KOUKOULIOU)

Outcome #1: Improved ability to identify and quantify radioactive contamination.	
Outputs	**Status/Comment**
★ A modern replacement of the ERML's aging high-purity germanium gamma monitor.	**Work in progress:** The detector has been ordered and is planned to be delivered in Q1 2024.
A report on the current condition of the portable surface contamination monitoring system, which includes a listing of existing systems that should be replaced.	**Work in progress:** Several instruments have been evaluated and specifications of new instruments submitted and new detectors will be delivered in Q1 2024
An automated system replacing the low-level alpha-beta counter contamination monitor.	**Work in progress:** The detector has been ordered and is planned for delivery in Q1 2024.

Outcome #2: Improved ability to verify dose assessments pursuant to applicable regulations and mandates and to respond quickly and effectively to occupational exposure emergencies.	
Outputs	**Status/Comment**
Acquisition of commercial off-the-shelf dose assessment software.	**Work in progress:** The Department is exploring existing software systems. At the IAEA, the Department of Nuclear Safety and Security (NS) is using software such as Taurus and IMBA® Internal Dosimetry Software (UK), IDEA Plus, etc.
Available software training for radiation protection officers.	**On hold:** Training cannot commence until the software is ordered.
Draft procedures for dose assessment activities in case of accident/incident.	**On hold:** Procedures cannot commence until the software is ordered.

Outcome #3: More efficient and effective ability to meet IAEA's mandate from a procedural and preventative level.	
Outputs	**Status/Comment**
★ A Safety Policy for the Department of Safeguards.	**Work in progress:** Department RPOs have engaged in discussions to define the scope of the safety policy. Additionally, the Department is in the process of creating a MSSP Task Proposal for a CFE.
The necessary approvals to distribute and implement the Safety Policy.	**On hold:** The plan cannot be approved until it is drafted and finalized.
Implementation of the Safety Policy in the Department.	**On hold:** The plan cannot be implemented until it is approved for implementation.

Outcome #4: Awareness of safety risks at facilities.	
Outputs	**Status/Comment**
★ An upgrade of the existing Facility Hazard Database from the existing access database to an IT system.	**Work in progress:** Department RPOs have recently defined the scope of the database and identified specific requirements. Discussions are underway with SGIS related to potential use of an existing SG IT system.
Classify facilities according to risk based on experience of work performed at each facility.	**Work in progress:** Department RPOs' duties, according to the authorized divisional radiation protection programmes, include this data.
Basic instructions according to the class of facility, for example, spent fuel repositories.	**Work in progress:** Discussions will need to take place with facilities, and support in facilitating these discussions would be welcome.
Updated facility instructions based on IAEA inspector field observations in the Facility Hazard Database.	**Work in progress:** The Department plans to transmit a new MSSP Task Proposal to first visit facilities of highest interest from the RP standpoint.

SGOA-002: Safeguards System for JNFL MOX Fuel Fabrication Plant (J-MOX) (Christophe CREUSOT)

Outcome #1: Effective and efficient safeguards approaches and procedures for J-MOX.	
Outputs	**Status/Comment**
Safeguards approach for J-MOX based on the basic elements agreed upon with Japan.	**Work in progress:** The Department is revising the J-MOX Safeguards approach to align it with Japan's State Level Approach (SLA). During 2023, the Department successfully prepared the initial draft of this revised approach. Subsequently, the Department engaged in discussions with both the State and the operator, specifically focusing on the modifications compared to the original basic elements previously agreed upon with the State.
Design Information Examination (DIE)/Design Information Verification (DIV) procedures that assure that the facility is constructed and will operate as declared, while ensuring that the safeguards approach remains adequate and robust.	**Work in progress:** In 2023, the Department conducted initial DIE/DIV procedures on select floors of the main building under construction at J-MOX to verify the layout. Detailed plans for DIV activities until the end of the construction and commissioning have been initiated and are pending a more detailed schedule and information from the operator.

Outcome #2: Ability to meet safeguards requirements with high-quality, independent, and reliable results from safeguards equipment.	
Outputs	**Status/Comment**
Designed, tested, and installed safeguards equipment (non-destructive assay (NDA) and containment and surveillance (C/S)).	**Work in progress:** The Department has re-assessed the list of equipment in alignment with the updated J-MOX safeguards approach, exploring new technology and cost-reduction possibilities. In 2023, the Department initiated the procurement process for the essential systems, with installation anticipated for the latter half of 2024.
Designed, tested, and implemented integrated data collection and evaluation software for J-MOX using synergies with the RRP Information System.	**Work in progress:** The Department collaborated closely with the State and State operator to define the data collection network. In early 2024, the Department plans to re-start work on the data evaluation software, focusing on a high-level reassessment of the requirements for data analysis.

SGOA-003: Fukushima Dai-ichi Safeguards (Glen HORTON)

Outcome #1: Maintain ability to provide credible and reliable assurances that nuclear material is not being removed without the Agency's knowledge as the site evolves. Seek new efficiencies, enhanced reliability for installed systems, and adopt novel technologies that offer advances.	
Outputs	**Status/Comment**
Install upgraded site monitoring equipment.	**Completed:** Second generation OASM system was installed in 2022.
Update configuration as new removal routes are opened up.	**Completed and work continues:** New camera was installed as a result of changes to Unit 1.
Enable OASM NDA review through use of IRAP.	**Work in progress:** Ongoing in-house development of IRAP is in progress.

Outcome #2: ★ Implementation of effective and efficient safeguards approaches for the Fukushima Dai-ichi site that include measures applicable to removed fuel-containing debris.	
Outputs	**Status/Comment**
An approved Safeguards Approach with specific procedures applicable to the new facilities and activities related to the recovery of core debris.	**Work in progress:** Development is ongoing as details of new facilities become available. This output is in the 2024–2025 plan.
A survey of new technologies for possible NDA verification of fuel-containing debris materials.	**On hold:** The Department is currently evaluating its standard in-house technology in light of a more comprehensive understanding of verification requirements. This output is in the 2024–2025 plan.

SGOC-001: Chornobyl (Faisal AJJEH)

Outcome #1: Safeguards are applied efficiently and effectively through finalized procedures for safeguards implementation at facilities.	
Outputs	**Status/Comment**
★ Carry out regular safeguards inspections at the Central Spent Fuel Storage Facility (CSFSF) and ISF-2 after approval of the safeguards approaches and procedures.	**Completed:** An important milestone was achieved as the facility was commissioned in May 2023, marking the reception of the first batch of spent fuel. Training of IAEA Safeguards inspectors, State inspectors, and operators on sealing activities has been completed.
★ Approval of safeguards approach for NSC.	**Work in progress:** The Safeguards Approach for the facility is being prepared and discussed internally.
Approval of verification procedures for NSC.	**Work in progress:** After internal approval, the Department will prepare the procedure.

Outcome #2: Enhanced ability to carry out verification activities using equipment that is installed, adjusted, and approbated for verification use.	
Outputs	**Status/Comment**
Making a contract for the equipment installation at NSC.	**Work in progress:** The initiation of the bidding process is contingent upon the approval of the key components of the safeguards approach.
Installation of equipment at NSC is complete.	**Work in progress:** This is awaiting internal approval process.
Equipment at NSC is tested, adjusted, and approved.	**Work in progress:** Anticipating the placement of infrastructure to support 11 cameras and four gate monitors, the IAEA will wait for approval from Ukrainian counterparts to proceed with the installation of the 11 cameras and four gate monitors. This process is estimated to span approximately 5–8 years.

SGVI-001: JCPOA Verification (Andrew CATTON)

Outcome #1: SGVI inspectors and analysts who continue to have the knowledge and skills to conduct safeguards verification activities in Iran.	
Outputs	**Status/Comment**
An implemented Carbon Fibre Mechanical Testing training for SGVI inspectors.	**On hold:** In 2022–2023, Iran did not implement the JCPOA measures pertaining to the verification of carbon fibres used in the production of rotor parts for gas centrifuges. Consequently, there was no immediate requirement for additional training of inspectors during this period.
Identified need for any new, emerging, and/or unexpected training.	**Completed for biennium and work continues:** No comment available.

Appendix: Abbreviations

Member State Support Programmes

SPRICS Abbreviation	Support Programme Abbreviation	Member State Name
ARG	ARG SP	Argentina (Argentine Republic)
AUL	AUL SP	Australia
BEL	BEL SP	Belgium, Kingdom of
BRZ	BRZ SP	Brazil, Federative Republic of
CAN	CAN SP	Canada
CHE	CHE SP	Switzerland (Swiss Confederation)
CPR	CPR SP	China, People's Republic of
CZ	CZ SP	Czech Republic
EC	EC SP	European Commission
ESP	ESP SP	Spain, Kingdom of
FIN	FIN SP	Finland, Republic of
FRA	FRESPAS	France (France Republic)
GER	GER SP	Germany, Federal Republic of
HUN	HUN SP	Hungary
JPN	JASPAS	Japan
NET	NET SP	Netherlands, Kingdom of the
NOR	NOR SP	Norway, Kingdom of
ROK	ROK SP	Korea, Republic of
RSA	RSA SP	South Africa, Republic of
RUS	RUS SP	Russian Federation
SWE	SWE SP	Sweden, Kingdom of
UAE	UAE SP	United Arab Emirates
UK	UK SP	United Kingdom of Great Britain and Northern Ireland
USA	USSP	United States of America

Department of Safeguards Divisions and Offices

DDGO	Deputy Director General for Safeguards
SGAS	Office of Safeguards Analytical Services
SGCP	Division of Concepts and Planning
SGIM	Division of Information Management
SGIS	Office of Information and Communication Systems
SGOA	Division of Operations A
SGOB	Division of Operations B
SGOC	Division of Operations B
SGTS	Division of Technical and Scientific Services
SGVI	Office for Verification in Iran

General

API	Application Programming Interface
CFE	Cost Free Expert
COTS	Commercial off-the-shelf
D&IS	Development and Implementation Support
IT	Information Technology
JPO	Junior Professional Officer
MSSP	Member State Support Programme
POC	Point of Contact
R&D	Research and Development
SME	Subject Matter Expert
SP-1	MSSP Task Proposal
VPN	Virtual private network