



Department for  
Business, Energy  
& Industrial Strategy

# UK SAFEGUARDS SUPPORT PROGRAMME

Report on Activities and Progress during the  
period 1 April 2015 to 31 March 2016

February 2017

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# UK SAFEGUARDS SUPPORT PROGRAMME

REPORT ON ACTIVITIES AND PROGRESS DURING THE PERIOD  
1 APRIL 2015 TO 31 MARCH 2016

C J Holmes and J W A Tushingham

February 2017

This work was funded by the UK Department of Energy and Climate Change through the UK Support Programme. The responsibilities of DECC were merged into the newly established Department for Business, Energy and Industrial Strategy in July 2016.

The results of this work may be used in the formulation of UK Government policy, but the views expressed in this report do not necessarily represent UK Government policy.

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# Executive Summary

Nuclear safeguards are technical measures used to verify that States comply with their international Treaty obligations not to misuse nuclear materials for the manufacture of nuclear explosives. They are an essential part of the nuclear non-proliferation regime. The International Atomic Energy Agency (IAEA) is charged with establishing and administering an international safeguards system to provide assurances that civil nuclear material is used for peaceful purposes.

The UK Support Programme to IAEA Safeguards (UKSP) was established in 1981, to provide technical support to the Department of Safeguards of the IAEA in verifying the peaceful use of nuclear technology. The UK Support Programme contributes:

- expertise and advice for the further development of safeguards strategies in new and existing activities and plant in the nuclear fuel cycle;
- services to support the IAEA in analysing nuclear material arising from samples taken in the course of safeguards inspections;
- access to facilities and experts for the training of Agency personnel in advanced techniques applied in safeguards inspections and on fuel cycle plants;
- development of techniques, methods and procedures for safeguarding facilities in the nuclear fuel cycle;
- development and assessment of equipment, instruments and methods for application in safeguarding the nuclear fuel cycle; and
- assistance through the provision of expert staff to complete specialised programmes of work that cannot be resourced through a permanent position with the IAEA.

During the period 1 April 2015 to 31 March 2016, the UK Support Programme contributed to 27 of its 34 active tasks within the IAEA Department of Safeguards Development and Implementation Support Programme, whilst a further 3 tasks were 'on standby'. Activities undertaken included:

- analysis of inspection samples, including the analysis of 22 environmental swipe samples and reactor modelling to support the evaluation of analytical data;
- promotion of UK technology solutions to meet current and future safeguards challenges identified in the Department of Safeguards' Instrumentation Technology Foresight project;
- provision of open source information: with seven State Profiles updated and three ad-hoc reports issued; and the completion of eight manufacturing base reports on the global manufacturing base of specific proliferation-relevant technologies;
- provision of expertise to enhance the effectiveness and efficiency of the Agency's implementation of safeguards through expert guidance to the development and use of scenarios for strategic planning purposes;
- delivery of 14 training events to IAEA inspectors, analysts and senior staff, including an expansion of support in the areas of analytical and negotiation skills, leadership and performance training, whilst retaining a portfolio of courses utilising UK expertise and facilities of the nuclear fuel cycle; and

- 
- provision of expertise and software relevant to the assessment of data available to the Department of Safeguards, including the provision of funding for an expert position within the Department of Safeguards.

This report provides a summary of the progress on those tasks active during 2015/2016 within the framework of the UK Support Programme. It excludes tasks that were maintained 'on standby' throughout the year at the request of the Agency.

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# Introduction

Nuclear safeguards are technical measures used to verify that States comply with their international Treaty obligations not to misuse nuclear materials for the manufacture of nuclear explosives. They are an essential part of the nuclear non-proliferation regime. The International Atomic Energy Agency (IAEA) is charged with establishing and administering an international safeguards system to provide assurances that civil nuclear material is used for peaceful purposes.

The United Kingdom Support Programme to IAEA Safeguards (UKSP) is part of the UK contribution to the maintenance of the international safeguards regime, with the aim to assist the IAEA in ensuring the continued and improved effectiveness of its safeguards system.

The UK Support Programme is now funded by the UK Department for Business, Energy and Industrial Strategy (BEIS), which was established in July 2016 and took responsibility for the Programme from the former Department of Energy and Climate Change. The Programme is administered on behalf of BEIS by the National Nuclear Laboratory (NNL). A range of contractors undertake work on behalf of the UK Support Programme, which was initiated by the UK Government in 1981 with the following formal objectives:

- to assist the IAEA in the provision of efficient and effective solutions to identified safeguards needs as set out in the Department of Safeguards Development and Implementation Support Programme for Nuclear Verification;
- to provide the IAEA with essential services and training which are not commercially available or cannot be provided from the Agency's own resources;
- to develop techniques and methods for safeguarding facilities in the fuel cycle, particularly reprocessing plants and enrichment plants;
- to develop techniques and methods for the application of safeguards in general situations; and
- to provide the IAEA with cost-free consultancy, particularly on systems analysis.

In January 2013, the IAEA Department of Safeguards issued a Long-Term R&D Plan, covering the twelve-year period 2012-2023, setting out the capabilities that the Department of Safeguards needs in order to achieve its strategic objectives; and key milestones towards achieving those capabilities for which Member State support is needed. The Long-Term R&D Plan covers a wide variety of areas such as safeguards concepts and approaches; detection of undeclared nuclear material and activities; safeguards equipment and communications; information technology, collection, analysis and security; analytical services; new mandates; and training.

The specification of long-term capabilities provides a framework to assist Member State Support Programmes (MSSPs), including the UK Support Programme, in deciding where their resources can best be used, and also helps the Department of Safeguards formulate the projects that make up a biennial programme and monitor progress towards the strategic objectives.

The IAEA's biennial Development and Implementation Support (D&IS) Programme for Nuclear Verification 2014-2015 was composed of 22 projects. These projects are themselves composed of over 300 'tasks'. Each project contains objectives, targets and activities that are



defined for the relevant two-year period. Both internal tasks, carried out by IAEA staff and consultants, and external tasks, carried out under MSSPs, are included in the projects; some of which are aimed at meeting shorter-term needs and others that are part of longer-term R&D efforts.

The UK Support Programme is one of 20 MSSPs (plus the European Commission) that provide support to the Department of Safeguards, the full list being: Argentina; Australia; Belgium; Brazil; Canada; People's Republic of China; Czech Republic; European Commission; Finland; France; Germany; Hungary; Japan; Netherlands; Republic of Korea; Republic of South Africa; Russian Federation; Spain; Sweden; United Kingdom; and United States of America. The MSSPs work singly and in collaboration to fulfil the priority needs of the Department of Safeguards, taking into account their individual expertise, resources, national and international priorities.

Support is provided in response to specific 'Task Proposals', known as SP-1s, issued through the Support Programmes Coordination Team of the Department of Safeguards. Within the UK, each SP-1 is assessed against capabilities and priorities before the UK Support Programme's decision to accept or decline the Task Proposal is communicated to the Department of Safeguards. Appropriate arrangements are then made for a programme of work to be undertaken to meet the Department of Safeguards' need.

The UK currently provides support to the IAEA Department of Safeguards in six technical areas:

- Area A, Safeguards Strategies;
- Area B, Support for IAEA Analytical Services;
- Area C, Training Courses;
- Area D, Safeguards Procedures;
- Area E, Instrument Development and Assessment; and
- Area F, Consultants and Cost-Free Experts.

Each task undertaken within the UK Support Programme is assigned to one these six Task Areas, cross-referenced to the Department of Safeguards' Long-Term Capability and D&IS Project to which each task relates.

This report provides a summary of the progress against specific tasks in each of these six areas during the period 1 April 2015 to 31 March 2016.

## Area A – Safeguards Strategies

Many of the requests for support to the IAEA are concerned with novel methods and techniques aimed at strengthening safeguards activities at all stages of the nuclear fuel cycle. As part of a strengthened safeguards system, the IAEA requires increased amounts and types of information on States' nuclear and nuclear-related activities. This information includes that provided directly by States (e.g. INFCIRC/540 Article 2 declarations), that collected by the IAEA (e.g. environmental sampling data) and other information available to the IAEA (e.g. open source literature and satellite imagery). The information is used to identify any inconsistency between a State's declaration and information available from other sources concerning a State's nuclear activities, and to optimise the strategy for safeguards implementation within the State.

### Task Area A5 - Environmental Sampling

Environmental sampling was introduced in 1996 as an IAEA measure to contribute to safeguards conclusions on the absence of undeclared activities at facilities. Collection of environmental samples at nuclear sites by inspectors, combined with techniques for ultra-sensitive measurement and interpretation of results, can reveal signatures of past and present activities at locations where nuclear material is handled. These signatures can be used to corroborate the status of declared activities, or to detect undeclared activities. As such, the programme directly meets the strengthened safeguards objective of increasing the assurance of the absence of undeclared nuclear material and activities. Results and conclusions from environmental sampling contribute to the State evaluation process and have an impact upon revisions to the facility attachments and safeguards approaches.

#### Task A5(b) - Special Analyses of Environmental Samples Supplied by IAEA

<b>IAEA SP-1 No:</b>	96/XXX-010	<b>UK Sub-contractor:</b>	AWE Aldermaston
<b>IAEA SPRICS No:</b>	UK X01045	<b>UK Task Manager:</b>	A J Pidduck
<b>IAEA Task Officer:</b>	C Hoffmann		

#### ***Background to Task***

Current implementation of environmental sampling for safeguards focuses primarily on the collection of swipe samples inside enrichment plants and hot cell facilities. Samples are analysed by either bulk or particle analysis techniques, depending on the sampling objectives and the activity levels of the swipes. A Network of Analytical Laboratories (NWAL) for environmental samples has been set up by the IAEA, consisting of Member States' laboratories with particular expertise in techniques suited to environmental sampling. These laboratories complement the Agency's own in-house capabilities, and ensure sufficient analytical capacity to service the diversity of samples and analytical requirements received from inspectors. The NWAL also fulfils an important role by enabling routine inter-laboratory comparisons and cross checks on analytical results. This is of particular importance given the sensitivity of analytical techniques deployed and the need to eliminate the potential for false results due to cross contamination.

Until 2010, the UK Support Programme provided the services of two laboratories within the IAEA NWAL for environmental samples. AWE Aldermaston undertook Fission Track Thermal

Ionisation Mass Spectrometry (FT-TIMS) analysis of particles, whilst QinetiQ provided a particle analysis service using Resistive Anode Encoder - Secondary Ion Mass Spectrometry (RAE-SIMS). Fission-track analysis detects fissile material, making the technique more sensitive towards particles with a higher fissile content. TIMS can provide high accuracy in the measurement of both major and minor isotopes. The combination of fission track analysis and TIMS is desirable to the IAEA, because it enables the highest uranium enrichment on a swipe to be identified through measurement by TIMS of only a small number of particles. Whilst FT-TIMS is capable of providing greater accuracy in analytical results, and a capability to measure minor isotopes of particular importance for data evaluation, RAE-SIMS has the potential for more rapid turnaround in sample analysis. RAE-SIMS involves an initial scan, during which particles of uranium are identified and recorded with their size, relative locations and individual uranium isotope ratios using specialist software (PSearch) and RAE hardware. More accurate measurement of individual particles is then undertaken using a tightly-focussed primary ion beam (microprobe operating mode) and an electron multiplier for the detector. The two techniques of FT-TIMS and RAE-SIMS are complementary, and both were routinely requested by the IAEA.

In November 2010, for commercial reasons, QinetiQ announced that it was closing its analytical facilities and relinquishing its role as a Network Laboratory. The UK Support Programme subsequently worked with AWE Aldermaston to transfer the existing SIMS capability to its laboratory, consolidating UK particle analysis capabilities at AWE from where support to the Department of Safeguards through the application of both FT-TIMS and RAE-SIMS continued.

A relatively new development in SIMS – Large Geometry (LG) SIMS – offers the sample throughput of SIMS but with an accuracy for minor isotopes approaching that of TIMS. Following successful validation of a new LG-SIMS instrument at AWE, analysis of a first batch of environmental swipe samples using the AWE LG-SIMS instrument was completed end-March 2015. LG-SIMS has now replaced RAE-SIMS as the instrument of choice for higher-throughput environmental sample analysis, whilst FT-TIMS continues to fulfil the important role of providing the highest accuracy in minor isotope measurement and capacity to measure plutonium isotopes.

### ***Summary Report on Activities in 2015/2016***

AWE Aldermaston continued to support the Department of Safeguards' environmental sampling programme, through the provision of both FT-TIMS and LG-SIMS capabilities and the application of other microanalysis techniques.

A total of twelve samples were submitted to elemental analysis of individual particles using Scanning Electron Microscopy (SEM) combined with energy-dispersive X-ray microanalysis. Reports listing particles detected containing specific elements were provided to the Agency, along with appendices giving more detailed morphological and compositional information from selected particles.

Two routine batches of five samples were also received, for analysis by FT-TIMS and LG-SIMS techniques, respectively.

For the first sample batch, fission track analysis was used to detect and select particles containing fissile material for measurement by TIMS. The procedure involved removal of particles from the swipe material, transfer onto a polycarbonate or lexan frame and irradiation with neutrons in a reactor. Particles containing fissile material were identified from the fission tracks that they produced. Particles selected on the basis of their fissile content were

subsequently transferred to TIMS filaments and the isotopic composition of uranium and/or plutonium within the particles was determined by mass spectrometry. Up to 20 particles were measured per sample, with additional information on particle morphology derived from measurements using SEM.

The second sample batch was submitted to analysis by LG-SIMS. Particles were recovered from the swipes using an impactor particle extraction technique and transferred to SIMS planchets. Measurements on individual particles were then carried out using a Cameca 1280HR SIMS instrument.

The IAEA will continue to require the analysis of environmental swipe samples by both FT-TIMS and LG-SIMS in 2016/2017, and is looking to AWE Aldermaston to maintain a full particle analysis service.

### Task A5(i) – WIMS Reactor Calculations

<b>IAEA SP-1 No:</b>	09/IDS-002	<b>UK Sub-contractor:</b>	Amec
<b>IAEA SPRICS No:</b>	UK A01853	<b>UK Task Manager:</b>	B Matthews
<b>IAEA Task Officer:</b>	A Kochetkov		

#### ***Background to Task***

Neutronics codes are used by the Department of Safeguards in the evaluation of results from inspection samples. Sample analysis results are compared with results from calculations, to judge whether they are consistent with declared or expected irradiation scenarios. In 2010, the UK Support Programme agreed to the provision of libraries of isotopic data for different reactor and fuel types, based upon calculations to be performed using the state-of-the-art WIMS9A (Winfrith Improved Multigroup Scheme) code in combination with the FISPIN fuel inventory code. Series of calculations were required to cover isotopic compositions of fuel and cladding/structural materials for a range of fuel enrichments under various irradiation scenarios. Calculations for ten different power reactors and eleven plutonium production or research reactors were subsequently completed. In each case, completed files were transmitted to the Agency together with details of the modelling parameters including: core and fuel geometry; fuel and moderator temperature and density; specific power; and the application of burnable poisons. Additional calculations were completed to estimate uncertainties (due to geometry factors) for uranium and plutonium isotopes generated/depleted in power reactor fuel for the examples of Pressurised Water Reactor (PWR) and CANDU reactors.

Further work commenced in December 2012, targeted at a range of fast reactors and more complex research reactors. In comparison to the reactor physics calculations that are required for thermal reactor fuels, those required for fast spectrum systems are more complex, with reactor fuel and breeder elements often irradiated in regions where both the magnitude and the energy spectrum of the neutron flux can change rapidly. Therefore, it was important to provide an accurate representation of both resonance shielding and burn-up effects.

To enable the geometry and material properties of each reactor core to be defined, and to propose a calculation method for each reactor, a modelling specification for each of the ten reactors under consideration was developed.

Following on from this study, work commenced to determine the optimum modelling route for calculating isotopic compositions and one group actinide (Th – Cm) cross sections using WIMS-PANTHER-FISPIN, for some burn-up steps for a model of a reactor as a finite core

model with critical rod positions. This study was completed during December 2013, with the conclusion that the WIMS-PANTHER-FISPIN combination provides a feasible route for whole core fuel burn-up modelling of the reactor. Further modelling was then undertaken during 2014/2015. In the absence of detailed information regarding control rod insertions, the Agency advised on assumptions to be made; whilst accurate reflector data and a detailed energy group scheme were modelled. The WIMS-PANTHER model of the reactor at start of life was then verified against an alternative methodology, the MONK Monte Carlo code, to confirm its accuracy. Once a definitive and verified WIMS-PANTHER-FISPIN model of the reactor core had been produced, inventory data was calculated for various fuel types and core locations. Provision of the inventory data requested by the Agency was completed in September 2014.

Upon completion of the above study, further work commenced on the modelling of a reactor to be used for plutonium disposition.

### ***Summary Report on Activities in 2015/2016***

Modelling of the reactor considered for plutonium disposition was successfully completed. This involved:

- Preparation of cross sections for all core materials using WIMS ECCO, using a fine energy group scheme appropriate for fast spectrum systems;
- Preparation of a whole core model using WIMS SNAP to provide a three-dimensional diffusion theory flux solution;
- Definition of a batch refuelling scheme to derive an equilibrium core to achieve the desired burn-up whilst maintaining criticality;
- Preparation of a whole core model using WIMS CACTUS to provide a three dimensional transport theory flux solution, and thereby apply where appropriate a transport connection to the SNAP diffusion theory flux solution; and
- Burn-up calculations and provision of material averaged inventory data for core fuel and breeder materials.

Results were reported to the Agency in April 2015.

The Agency's next priority within this task was for further development of an existing reactor model, to accommodate different fuel types and core locations. This activity remained on hold during the year, awaiting the availability of detailed modelling specifications. The UK Support Programme remains available to complete revised calculations for this reactor. Meanwhile, detailed modelling of another reactor will commence in 2016/2017.

## Task A5(j) – Analysis Results and Metadata for the Springfields UOC Sample Collection

<b>IAEA SP-1 No:</b>	12/IFC-002	<b>UK Sub-contractor:</b>	AWE
<b>IAEA SPRICS No:</b>	UK D01968	<b>UK Task Manager:</b>	P Turner/P Thompson
<b>IAEA Task Officer:</b>	M Penkin		

### ***Background to Task***

Under a UK-US initiative, 2006 saw the transfer of archive samples of uranium ore concentrate (UOC) from Springfields to US Department of Energy (USDoE), Institute for Transuranium Elements (ITU) and AWE Aldermaston laboratories for use in studies to develop capabilities to fingerprint nuclear materials and verify their declared origin. A substantial body of work was subsequently undertaken, outside the UK Support Programme, to characterise the samples through a range of analytical measurements and also to assemble relevant information (metadata) on their origins, associated geology and the processes involved in their production. Data was reviewed during a meeting in Karlsruhe, in October 2011, which was also attended by Agency staff with responsibilities for the analysis of data from environmental sampling and destructive analysis for safeguards purposes.

Following the Karlsruhe meeting, the Agency sought an agreement whereby the data obtained could be used by the Department of Safeguards. Task Proposal 12/IFC-002 was subsequently accepted by the EC, US and UK Support Programmes, as a collaborative effort to support the Department of Safeguards in populating its own database with trace element and isotopic signatures of UOC of various origins. The datasets of UOC signatures and associated metadata would then be used by safeguards data analysts, for reference in safeguards evaluations involving assessment of provenance of UOC samples collected by IAEA inspectors.

AWE liaised with the other laboratories involved, compiling a comprehensive version of the metadata, incorporating the conclusions of research from Lawrence Livermore National Laboratory (LLNL) and deductions from the analytical records provided by Springfields. This document was distributed to participants for final comment, with the intention to issue formally by end-2014. In parallel, AWE provided its analytical data, to the agreed format, to allow Los Alamos National Laboratory (LANL) to complete its compilation and evaluation of the analytical data.

A teleconference was held in January 2015, to discuss delivery to the Agency of the required data. The participants' goal was to provide data that adhered as closely as possible to that requested by the Agency, within the constraints inherent to the combined LANL-AWE-ITU dataset. Data consistency was proposed to be evaluated using the results from twelve samples that were analysed by all three laboratories.

### ***Summary Report on Activities in 2015/2016***

The US laboratories agreed to take the lead role in data evaluation, and AWE subsequently forwarded all of its data to LANL. LANL finalised a report summarising the data, for review by AWE, ITU, and Lawrence Livermore National Laboratory (LLNL) prior to final delivery to the IAEA. During June 2015, AWE completed its review of the draft report, effectively concluding AWE's involvement in the task.



## Task Area A6 – The Use of Commercial Satellite Imagery in Support of Safeguards

The UK Support Programme has provided assistance in the development of techniques employing satellite imagery for safeguards purposes - particularly for the identification of undeclared facilities and the identification of change in activities within facilities. This work, in addition to that carried out by the US, Germany and Canada, has proven a range of techniques and has confirmed the availability of suitable images on the commercial market for safeguards use. Studies have shown that it is possible to develop sophisticated methods for detection of undeclared facilities or activities and to detect a change in activities in a declared facility.

### Task A6(d) – Support for SGIM Analysis

**IAEA SP-1 No:**

**UK Sub-contractor:**

**IAEA SPRICS No:**

**UK Task Manager:**

**IAEA Task Officer:**

#### ***Background to Task***

On the basis of studies by the MSSPs, the IAEA decided to develop an in-house technical capability for satellite imagery analysis. The Satellite Imagery Analysis Unit (SIAU) commenced operation during 2001, using commercially available satellite images to gain information in support of safeguards.

The UK supported the work of the SIAU initially through the provision of an analyst experienced in the interpretation of satellite images pertaining to nuclear facilities. From 2003, the UK Support Programme assisted in the procurement of commercially available satellite images and equipment, whilst further support from imagery analysts was provided under Task Area F.

#### ***Summary Report on Activities in 2015/2016***

In October 2015, the UK Support Programme offered a voluntary contribution to the Department of Safeguards: for the procurement of satellite images and equipment; or to support open source information collection through tasks placed with King's College London (KCL). The Agency responded by requesting that the funds be utilised to retain support from King's College London. The extrabudgetary voluntary contribution was subsequently utilised for this purpose, to support open source information collection in 2016.

The UK Support Programme anticipates that a further contribution to open source information collection/satellite imagery will be offered in 2016/2017.

## Task Area A7 - Strengthening/Integration of Safeguards

Strengthening safeguards has aimed at providing credible assurance of the absence of undeclared activities in States. Once an assurance has been gained, all of the measures available to the IAEA through traditional and strengthened safeguards systems can be reviewed and combined to produce an integrated safeguards regime. Integrated Safeguards is defined as the optimum combination of all safeguards measures available to the IAEA under a comprehensive safeguards agreement, including those from Additional Protocols, that

achieves the maximum effectiveness and efficiency within available resources in fulfilling the Agency's safeguards obligations.

IAEA safeguards implementation is now evolving to an approach that makes greater use of the IAEA's ability to consider the State as a whole. It involves a comprehensive evaluation of all safeguards-relevant information regarding a State, and the use of objective State-specific factors to draw up a State-level approach (SLA) for each State. The implementation of SLAs will enable the IAEA to make best use of its resources and focus effort on areas of greater safeguards significance. The use of generic objectives common to all states with the same type of safeguards agreement (and, where applicable, Additional Protocol) enables differentiation without discrimination.

## Task A7(h) - Support to Instrumentation Technology Foresight (Umbrella Task)

**IAEA SP-1 No:**

**UK Sub-contractor:**

**IAEA SPRICS No:**

**UK Task Manager:**

**IAEA Task Officer:**

### ***Background to Task***

Following the 2004 IAEA General Conference, Project SGTS-08, "Novel Techniques and Instruments for Detection of Undeclared Nuclear Facilities, Materials and Activities", was established within the Department of Safeguards to:

- monitor and address observed deficiencies or vulnerabilities in safeguards approaches, equipment and technology;
- acquire new, or improved, equipment or technology where appropriate; and
- develop and/or use new concepts, approaches, techniques and technology for information analysis and verification activities, in particular with regard to enhanced capabilities to detect undeclared nuclear material and activities.

The UK Support Programme accepted this task end-March 2006, initially to provide a contact point within the UK for the identification of appropriate expertise and resources, with the acceptance of individual sub-tasks to be considered on a case-by-case basis. The UK is currently one of 15 Support Programmes to have accepted this umbrella task. Since 2006, the task has enabled UK expert participation in a number of technical meetings associated with novel technologies, together with preliminary evaluation of such technologies.

Over the last two years, the direction of both the Project, now re-named Instrumentation Technology Foresight, and the specific task have changed somewhat, with increased emphasis on the Member State Support Programmes identifying and undertaking a preliminary evaluation of novel technologies prior to bringing these to the Agency's attention. Under this task, the UK Support Programme may fund specific development work but, equally important, may facilitate access to nuclear sites for the development and testing of instrumentation developed under other programmes. An example of the latter was the testing of a prototype robust plastic-based antineutrino detector, developed by University of Liverpool, in the vicinity of a UK gas-cooled reactor. For this particular work, the UK's Office for Nuclear Regulation (ONR) liaised with the site operator, instrument developer and UK Support Programme to ensure successful installation and testing of the instrument.



### **Summary Report on Activities in 2015/2016**

During 2015/2016, testing of the Liverpool University prototype antineutrino detector was completed, with results reported to the safeguards community during the 2015 European Safeguards Research and Development Association (ESARDA) Safeguards Symposium. The possibility of further testing, at a second reactor facility, was explored with ONR and the reactor operator.

The “Autonomous Navigation and Positioning System” (ANPS) is currently under development within the Agency, with the aim to allow IAEA inspectors to deploy the technology during field activities and progressively automate the collection, fusion and analysis of geo-localised data. Further to their participation in a Technology Evaluation Workshop, Cambridge Consultants liaised with the Agency over aspects of indoor positioning. Under the UK Support Programme, they evaluated the capability of four alternative indoor positioning approaches for the Agency’s application in terms of location accuracy and implementation. A report on the evaluation was issued to the Agency in October 2015 and further work, including integration of a floor detection algorithm into the ANPS software, was identified.

The UK Support Programme facilitated the inclusion of two UK-based companies in a Technology Demonstration Workshop, convened by the Department of Safeguards in October 2015, on Gamma Imaging. The task will continue to be used to satisfy ad-hoc requests from the Agency for participation in technical meetings and technology evaluation workshops on specific topics, and may be used for the initial stages of development work of instrumentation identified as of potential value to safeguards implementation.

### **Task A7(j) – Guidance for Designers and Operators on Design Features and Measures to Facilitate the Implementation of Safeguards at Future Nuclear Fuel Cycle Facilities**

**IAEA SP-1 No:**

**UK Sub-contractor:**

**IAEA SPRICS No:**

**UK Task Manager:**

**IAEA Task Officer:**

### **Background to Task**

In June 2007, the Standing Advisory Group on Safeguards Implementation (SAGSI) advised the Department of Safeguards that it should develop documentation that can serve as guidance for the inclusion of safeguards considerations at an early stage of nuclear technology designs. This, and needs arising from the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO); the Generation IV International Forum (GIF) Proliferation Resistance and Physical Protection (PR&PP) Expert Group; and the International Framework for Nuclear Energy Cooperation (IFNEC), led the Agency to propose a task to provide concise guidance for Member States.

This task was accepted by the UK Support Programme in June 2008, initially to support the development of basic guidance to encourage States to consider safeguards during the conceptual planning for nuclear facilities. The UK Support Programme subsequently facilitated expert input to a number of workshops convened by the Agency: first to address generic design and operation features that facilitate the implementation of effective and cost efficient IAEA safeguards; and then to support preparation of facility-specific documents.

Documents were subsequently prepared by the Agency, with contributions from a number of Member State Support Programmes, and published in the IAEA Nuclear Energy series. Those to which the UK Support Programme contributed included:

- International Safeguards in Nuclear Facility Design and Construction;
- International Safeguards in the Design of Nuclear Reactors; and
- International Safeguards in the Design of Reprocessing Plants.

### ***Summary Report on Activities in 2015/2016***

In September 2015, the final draft document in the series of basic guidance to encourage States to consider safeguards early in the conceptual planning for nuclear facilities was received by the UK Support Programme. The Enrichment Facilities document was distributed for review, and feedback to the Agency was provided the following month. This completed the UK Support Programme's involvement in this particular task.

## **Task A7(n) – Member State Support to IAEA Outreach Events on the SIP Guides**

**IAEA SP-1 No:**

**UK Sub-contractor:**

**IAEA SPRICS No:**

**UK Task Manager:**

**IAEA Task Officer:**

### ***Background to Task***

Under a previous task, the Agency sought assistance from Member State Support Programmes in the development of IAEA guidance documents on various topics relevant to safeguards implementation. Guidance was required in order to assist States in better understanding safeguards obligations and to share good practices that resulted from experience and evolution over years of implementation. The detailed topical guidance documents would build upon the Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols, and were intended for use by regulatory authorities; facility operators and licensed users of nuclear material; nuclear facility designers; safeguards students and practitioners; and professionals of the IAEA. Preparation of three of the four Safeguards Implementation Practice (SIP) guidance documents on the implementation of safeguards was subsequently supported by experts from the UK.

### ***Summary Report on Activities in 2015/2016***

The Agency requested further support from some of the experts who contributed to the published SIP Guides, to attend events that are planned to familiarise representatives from States with the content, purpose and use of the SIP Guides. Support was also sought to fund travel for participants from developing countries to attend the workshops.

The external experts would assist the IAEA team in designing an agenda for the workshops, in creating scenarios and exercises for small group use, and in delivering the workshops on the SIP Guides. The experts were requested to participate in the workshops as lecturers/facilitators and assist the participants with the contents of the SIP Guides and their use for problem solving and planning.

The task was accepted by the UK Support Programme in October 2015, in anticipation of a specific request for support at a later date.

## Task Area A8 - Information Evaluation in Support of a Strengthened Safeguards System

In support of the strengthened safeguards system, the IAEA Department of Safeguards requires broad access to geographically and linguistically diverse sources of relevant open source information. Information is required, in particular, on nuclear dual use technologies relating to industrial infrastructure and nuclear research and development, as well as information on security, economics, weapons of mass destruction and the politics surrounding such weapons. Detailed surveys are required of States' industrial and nuclear research infrastructure and issues that may induce a State to proliferate. The collection and analysis of such information, on scientific, technical, economic, political and nuclear-related developments, is now an integral component of the State evaluation process.

### Task A8(e) – Regional Information Collection Centre – 1

**IAEA SP-1 No:**

**UK Sub-contractor:**

**IAEA SPRICS No:**

**UK Task Manager:**

**IAEA Task Officer:**

#### ***Background to Task***

In November 2001, the UK Support Programme initiated the development of a Regional Information Collection Centre (RICC) within the International Policy Institute, King's College London (KCL). The RICC subsequently established methodologies for the collection of information to support the production of detailed surveys of States' industrial and nuclear research infrastructures. The KCL RICC, established under Task UK D01569, extended the Agency's ability to identify relevant information, without which the Agency's confidence in safeguards conclusions would be reduced.

Upon completion of Task UK D01569, the Agency prepared a new Task Proposal for the provision of open source information, to include monthly provision of scientific and technical original language abstracts, updated country profiles, ad-hoc reports and regular political updates on the security situation and associated issues. Work commenced under the new task in April 2008.

#### ***Summary Report on Activities in 2015/2016***

Collections of abstracts of open source information on nuclear-related issues in the region, gathered from both English and regional language sources, were sent monthly to the IAEA during 2015/2016.

Four State Profiles were updated, covering specific subjects requested by the Agency. In addition, an ad-hoc report was prepared to a specification agreed with the Agency. Updates on political issues in the region were researched and sent to the Agency on six occasions during the year.

Activity will continue through 2016/2017, including expansion of existing information collection capabilities; the update of a further four State Profiles; the continued provision of abstracts and political updates; and an ad-hoc report on a subject to be specified by the Agency.

## Task A8(f) – Regional Information Collection Centre – 2

**IAEA SP-1 No:** **UK Sub-contractor:**  
**IAEA SPRICS No:** **UK Task Manager:**  
**IAEA Task Officer:**

### ***Background to Task***

From 2003 to 2008, a second RICC collected open source information on a second region. As a successor to this task, the Agency proposed a RICC to focus primarily on emerging nuclear programmes within an expanded region, whilst also updating existing reports for some States. In addition, the RICC would continue the regular monitoring of open sources, providing abstracts of new information on a monthly basis. The task of providing this expanded RICC was accepted by the UK Support Programme, and work commenced in April 2008.

### ***Summary Report on Activities in 2015/2016***

Collections of abstracts of open source information on nuclear-related issues, gathered from both English and regional language sources, were sent monthly to the IAEA during 2015/2016.

Four updates of State Profiles were prepared, together with an ad-hoc report on specific aspects of nuclear infrastructure and activities. Reviews on political issues were researched and sent to the Agency during the year. This particular activity was undertaken with a financial contribution provided under separate contract between KCL and the Agency.

The work will continue through 2016/2017, to include the updating of four State Profiles and preparation of an ad-hoc report; in addition to the regular research and issue of scientific abstracts and political updates.

## Task A8(h) – Improving the Analysis of Trade Data for Safeguards-Relevant Proliferation Activities

**IAEA SP-1 No:** **UK Sub-contractor:**  
**IAEA SPRICS No:** **UK Task Manager:**  
**IAEA Task Officer:**

### ***Background to Task***

To assist the process of information collection and analysis within the Department of Safeguards, support is required from Member States to develop methods and skills to find indications of non-declared safeguards-relevant procurement activities. The UK Government had an existing open-source project on proliferation procurement, established within King's College London, providing new insights into proliferation risks and how to enhance proliferation risk analysis and awareness. The project included engagement with companies and trade associations involved in dual-use industries, gathering and analysing input on compliance and non-proliferation and highlighting the role of the private sector in countering proliferation. Task Proposal 09/ICA-012 was accepted by the UK Support Programme in December 2011, initially to enable the Agency to benefit from the research already carried out under the UK project.

Subsequently, the UK Support Programme was requested to consider the provision of resources to enable the preparation of a number of "Manufacturing Base Reports" (MBRs),

each addressing a specific proliferation-relevant technology. These were intended to provide an assessment, from open sources, of suppliers/manufacturers and/or producers of manufacturing equipment; uses and control status; and aspirants and prospects for future expansion of the supply base.

In 2014/2015, 14 MBRs were completed. In addition, four illicit procurement case studies and a report on Trade Data and State Evaluation were provided. A further two MBRs and a compendium on selected technologies were near-completion at the year-end.

### ***Summary Report on Activities in 2015/2016***

8 MBRs were completed during the year, providing open source information including: suppliers/manufacturers and/or producers of manufacturing equipment; uses and control status; and aspirants and prospects for future expansion of the supply base. In addition, a compendium on selected technologies and a report on Trade Data and State Evaluation were also prepared and issued to the Agency. A further two MBRs were near-completion at the year-end.

Work is expected to continue in 2016/2017, including the completion of additional MBRs on priority subjects and a report on trends in illicit procurement.

## **Task Area A11 – Management Support**

The UK Support Programme may provide expertise to enhance the implementation of safeguards through advice on planning, implementing and performance monitoring procedures and best practice.

### **Task A11(b) – Performance Indicators Workshop**

**IAEA SP-1 No:**

**UK Sub-contractor:**

**IAEA SPRICS No:**

**UK Task Manager:**

**IAEA Task Officer:**

### ***Background to Task***

The Performance Indicators Initiative (PII) seeks to improve the Department of Safeguards' reporting to its stakeholders regarding the conclusions drawn from the implementation of safeguards, and to measure internal performance in achieving its strategic objectives.

In 2014, the Agency sought expert guidance and support in developing relevant performance indicators through which to monitor the efficiency and effectiveness of safeguards verification and supporting processes. Specifically, an expert was sought to develop and present a workshop on the subject. The UK Support Programme accepted the task in July 2014, engaging Mr B Marr of the Advanced Performance Institute.

Mr Marr designed a workshop to address the need for foundational knowledge and understanding, whilst also facilitating interactive work on a draft strategy map. The workshop was subsequently delivered to members of the Performance Indicator Working Group (PIWG), representing all of the Divisions and Offices of the Department of Safeguards, during September 2014.

A coaching session that summarised general performance management methodology and the output of the workshop was subsequently delivered to the Safeguards Management Committee and a further session, on visualisation of performance indicators, was delivered to the Chair of the PIWG.

### ***Summary Report on Activities in 2015/2016***

The UK Support Programme engaged Mr Marr to review the latest version of the PIWG's "strategy on a page" and the resulting Key Performance Questions (KPQ) and Key Performance Indicators (KPI).

Following this review, Mr Marr facilitated a two-day workshop to:

- Provide feedback to the Performance Indicators Working Group (PIWG) on the strategy map, the resulting KPQs and KPIs;
- Conduct a coaching session on KPIs and their use;
- Advise on a pilot study of the KPIs; and
- Demonstrate and discuss the visualisation of results.

In September 2015, the UK Support Programme facilitated the participation of Mr C Schiller of the Chartered Institute of Personnel Development in an Advanced Facilitation Skills workshop. The two day workshop was delivered to twelve participants from the Department of Safeguards, providing them with a range of facilitation strategies and decision making tools and techniques to manage and facilitate structured group discussions.

Subject to the availability of resources, the UK Support Programme intends to continue to offer support within the framework of this task in response to requests from the Agency.

### **Task A11(c) – Consultants – Making Use of Scenarios for Strategic Planning**

**IAEA SP-1 No:**

**UK Sub-contractor:**

**IAEA SPRICS No:**

**UK Task Manager:**

**IAEA Task Officer:**

### ***Background to Task***

The Department of Safeguards issued its first long-term strategic plan in August 2010, to assist in directing the Department in more efficient and effective safeguards that anticipate future requirements and challenges. The Department's strategic planning methodology provides for its regular review and updating and, in its October 2015 session, a SAGSI Working Group suggested that the Department consider the use of scenarios in its planning work. Scenario planning is a technique that assists organisations to cope with the increasing complexity, uncertainty and turbulence in their external operating environment.

### ***Summary Report on Activities in 2015/2016***

A Task Proposal was submitted to the UK Support Programme in December 2015, through which the Department sought high-level expert guidance with the development and use of scenarios for strategic planning purposes. Assistance was requested for the latter part of the planning process, when strategic choices are made and Department priorities set, which is the most challenging part of the process.



The first phase of the UK task involved the provision of expertise, to provide training in scenario planning methodology and the preparation of draft scenarios for 2030 within a workshop for staff from the Department of Safeguards' strategic planning team. NormannPartners was engaged to support the workshop, which was delivered in January 2016 to 13 staff members.

A second phase of the task was subsequently proposed, requesting that the same experts assist Department of Safeguards staff in completing and reviewing the draft scenarios, and presenting them to the Department's senior management. This activity was in progress at the financial year-end, with work expected to be completed during April 2016.

## Area B - Support For IAEA Analytical Services

Destructive Analysis (DA) provides the most accurate means to assay nuclear materials, and the methods play an essential role to verify the declarations of facility operators at bulk handling plants. For this purpose, safeguards inspectors take samples of process material for analysis of elemental and/or isotopic composition. The samples are sent for analysis to the IAEA's own laboratory, or to an accredited member of the IAEA NWAL in a Member State.

Since its inception, the UK Support Programme has assisted with all aspects of destructive analysis, from on-site sampling trials through the development of analytical techniques and provision of equipment and standards to the assessment of processes for the treatment of analysis waste residues. In more recent years, support focussed primarily on the Agency project "Enhancing Capabilities of the Safeguards Analytical Services" (ECAS), and has now turned to assisting both the new Nuclear Material Laboratory and continuing environmental sampling capabilities.

### Task Area B1 - Analytical Services

As bulk handling plants become larger, and material throughput increases, so there is a need for greater accuracy of analysis in order that diversion of material cannot be hidden within the uncertainty of measurement. The destructive analysis methods employed, and the standards used in their calibration and quality control, must therefore keep pace with developments in the fuel cycle. Safeguards inspectors are also interested in taking advantage of any advances in analytical techniques, so that independent verification of the operator's declaration can be carried out more effectively. In particular, the implementation of strengthened safeguards and environmental sampling requires the development and implementation of new and improved methodologies for sample collection, preparation and analysis.

#### Task B1(t) – Implementation Support to Nuclear Material Laboratory

<b>IAEA SP-1 No:</b>	08/TTS-004	<b>UK Sub-contractor:</b>	A.>NNL B. NPL C. -
<b>IAEA SPRICS No:</b>	UK C01742	<b>UK Task Manager:</b>	A. J Alcock B. S Jerome C. UKSP Coordinator
<b>IAEA Task Officer:</b>	C Mansoux		

#### ***Background to Task***

In 2006, the UKSP Coordinator chaired a workshop, convened by the Agency's Department of Nuclear Science and Applications, to consider the future requirements for analytical support to the Department of Safeguards and the need for renovation, replacement or substitution of the Agency's existing Safeguards Analytical Laboratory for nuclear materials.

Under the current task, the UK Support Programme subsequently provided input to the Department of Safeguards' strategy and development of analytical capabilities through the



ECAS Project, including both a rejuvenation of the NWAL for nuclear materials analysis and the construction of a new Nuclear Material Laboratory (NML). The latter was supported through both the provision of a Chair to several meetings associated with the design and realisation of the new laboratory, and also through extrabudgetary voluntary contributions totalling €1.4M.

With inauguration of the new NML in 2013, the Agency's needs turned to support for the implementation of analytical services. In December 2013, the Agency requested that the UK Support Programme enable the production of a range of certified reference materials by the UK's National Physical Laboratory (NPL).

In parallel with NPL's engagement for the provision of reference materials, a requirement emerged for the characterisation of samples using a range of physical and chemical analysis techniques. Following a review of the analytical capabilities of NNL's Preston laboratory at Springfields, agreement was reached for the characterisation of samples supplied by the IAEA. This work commenced in February 2014, with sample batches subsequently progressed in response to analysis requests from the Department of Safeguards.

### **Summary Report on Activities in 2015/2016**

In 2015/2016, NPL successfully completed the shipment of the following range of certified reference materials (CRMs) to the NML:

- A highly-enriched  $^{233}\text{U}$  spike, for determination of uranium amounts in swipe samples;
- A  $^{243}\text{Am}$  spike, for use in age determination of plutonium;
- A  $^{237}\text{Np}$  spike, for use in determination of neptunium amount in spent nuclear fuel samples for flow sheet verification on reprocessing plants; and
- A set of five mixed Np/Pu isotopic reference materials.

NNL's Preston Laboratory continued to provide support through specialised analysis of samples against the relevant standards. Comprehensive reports were completed and issued on the analysis of four batches of samples.

Measurement of a fifth batch of samples was in progress at the end of the financial year, with further requests for analytical support expected to be received during 2016/2017.

### **Task B1(v) – Implementation Support to Environmental Sample Laboratory**

<b>IAEA SP-1 No:</b>	08/IDS-002	<b>UK Sub-contractor:</b>	AWE Aldermaston
<b>IAEA SPRICS No:</b>	UK A01776	<b>UK Task Manager:</b>	A J Pidduck
<b>IAEA Task Officer:</b>	L Sangely		

### **Background to Task**

The Agency required an independent capability to measure minor isotopes in environmental samples. In the absence of FT-TIMS, as described under Task A5(b), a more sophisticated large-geometry SIMS instrument, LG-SIMS, was considered. Compared with conventional SIMS, this new instrument offers improvements in ion transmission, mass resolution and simultaneous multiple ion counting, resulting in data of higher quality, optimal for drawing safeguards conclusions. From 2008 to 2010, the UK Support Programme facilitated comparative trials of conventional and LG-SIMS instruments, utilising instruments at QinetiQ and Edinburgh University, respectively. Meanwhile, the Agency put in place arrangements to

procure and install its own LG-SIMS instrument. This instrument was delivered to the Agency's new clean laboratory at Seibersdorf in May 2011, and commissioning was progressed during the course of the year.

With the cessation of support to environmental sampling from QinetiQ in 2010/2011, and pending the transfer of instrumentation and recruitment of some of QinetiQ's former staff by AWE, expert support from QinetiQ's former staff was provided to commissioning and operation of the Agency's LG-SIMS instrument. This included a three-month Special Service Agreement, under which a UK expert assisted in developing the Agency's in-house capability. The Agency's LG-SIMS instrument is now in routine operation, and AWE procured its own LG-SIMS instrument in 2013.

Installation of the Cameca 1280HR high-mass-resolution SIMS instrument at AWE was completed in April 2014. After a period of training, work was undertaken to collect data to demonstrate application of the instrument for IAEA environmental swipe analysis. A report on the newly-installed LG-SIMS instrument's validation was completed, and issued to the Agency in December 2014. The report was accepted by the Agency, enabling AWE to commence the analysis of environmental swipe samples using its LG-SIMS under Task A5(b).

### ***Summary Report on Activities in 2015/2016***

In July 2015, a report was provided to the Department of Safeguards on a project at AWE to investigate methods for the removal of poorly-adhered particles from SIMS planchets, with the aim of mitigating the possibility of cross-contamination arising between samples within the LG-SIMS instrument caused by sample loading and particle charging.

AWE participated in a Technical Meeting on Particle Analysis, held at IAEA Headquarters in November 2015. Following the meeting, the Agency hosted a visit by AWE's LG-SIMS experts to Seibersdorf, for further discussions on LG-SIMS particle analysis. The UK Support Programme anticipates further interactions with AWE staff, as the Agency and UK laboratory continue to develop their in-house and NWAL capabilities, respectively.

## Area C - Training Courses

The IAEA has a long-term requirement for a wide range of safeguards-related training courses. New safeguards inspectors require training and practical experience on fuel cycle plants and the techniques and procedures to be applied during inspections. More advanced courses are required for senior inspectors, whilst specialised courses are desirable for other key personnel. To undertake this training, the IAEA needs access to appropriate expertise and nuclear facilities, which can only be made available by Member States.

### Task Area C1 - Inspectors' Training Courses

The UK Support Programme has provided training courses on a cost-free basis since its inception in 1981. These courses are constantly evolving to meet the changing needs of the Agency and are tailored to meet their specific requirements.

#### Task C1(c) – Design Information Verification at Bulk Handling Facilities Training Course

<b>IAEA SP-1 No:</b>	13/CTR-003	<b>UK Sub-contractor:</b>	Sellafield Ltd
<b>IAEA SPRICS No:</b>	UK B01990	<b>UK Task Manager:</b>	A Homer
<b>IAEA Task Officer:</b>	G Berthelot		

#### ***Background to Task***

Courses on safeguards at bulk-handling facilities have been run for the benefit of IAEA inspectors by the UK Support Programme since 1992. During this period, approximately 390 inspectors (usually recent recruits) have received general training and familiarisation aimed at providing an enhanced understanding of operations at a variety of bulk handling facilities.

Prior to 2001, the course included a simulated Physical Inventory Verification (PIV) exercise, using Non-Destructive Analysis (NDA) instrumentation at Springfields. In 2001, the course was reviewed and, at the request of the IAEA, the focus changed to performing a Design Information Verification (DIV) exercise. The course was of three weeks' duration, the first week being conducted by the IAEA in-house; the second and third weeks being hosted by British Nuclear Fuels Ltd (BNFL), at Springfields and Sellafield in the UK, and including one day at Capenhurst hosted by Urenco (Capenhurst) Ltd. Consolidation over subsequent years led to the visit to the Urenco enrichment plant being removed and the overall duration of the course being reduced to two weeks.

In January 2014, the Agency submitted a new Task Proposal seeking the continued provision of a DIV training course, building upon the predecessor training course under Task UK B01618. In addition to the training of safeguards inspectors, the new course would target members of State Evaluation Groups (SEGs) whose performance within such groups requires them to understand and make full use of DIV at bulk handling facilities (BHF) when performing State evaluation and preparing safeguards implementation plans. The Task Proposal was accepted in February 2014, with the course to be held on an annual basis.

### **Summary Report on Activities in 2015/2016**

The 2015 course on safeguards and design verification at bulk handling facilities was successfully delivered from 13-24 April 2015.

The introductory days at both Springfields and Sellafield included lectures on conversion/fuel fabrication/reprocessing technologies and practical exercises, but were dominated by preparation time for the plant exercises. Mr M Brody (Consultant), Mr Francis (NNL) and Mr S Johnson (Springfields Fuels Ltd) provided support to the Springfields component of the course, with a day-long exercise in the Oxide Fuels Complex targeting an initial DIV visit to a newly declared facility; whilst the Enriched Uranium Residues Recovery Plant (EURRP) provided for the verification of detailed process flow diagrams across a diverse and complex facility.

The agenda for the Sellafield part of the course included exercises based in the Thermal Oxide Reprocessing Plant (THORP), carried out over a single day with the course participants instructed to lead the direction of the tours, whilst a Design Information Questionnaire (DIQ) exercise was successfully held in the Phase 2 and Phase 3 areas of the NNL Central Laboratory.

Based upon the participants' presentations that followed the exercises, each group demonstrated an understanding of the facilities and successfully completed each exercise. Feedback from the participants and IAEA Task Officer was very positive.

The IAEA has requested that a course on Safeguards at Bulk Handling Facilities be conducted in 2016, and a further course is now anticipated for 2017.

### **Task C1(f) - Training on the Nuclear Fuel Cycle, Indicators and Proliferation Pathways**

<b>IAEA SP-1 No:</b>	13/CTR-004	<b>UK Sub-contractor:</b>	NNL
<b>IAEA SPRICS No:</b>	UK B01991	<b>UK Task Manager:</b>	M Thomas
<b>IAEA Task Officer:</b>	J M Crété		

#### **Background to Task**

The main objective of the IAEA strengthened safeguards system is to provide assurance of the absence of undeclared nuclear activities in Member States. Under an Additional Protocol, the Agency has wider access to information and facilities, intended to enhance its capability to detect such clandestine activities. In preparing for this extended role, the Agency developed a 'Physical Model' of the nuclear fuel cycle, drawing out a comprehensive set of indicators of nuclear fuel cycle activities.

In 1995, a training need was identified for more experienced inspectors, subsequently addressed by this task, to increase their awareness of the fuel cycle indicators and show them the items concerned, either in photographs or as models. This would assist them in identifying signs of any illicit activity during inspections. A course was subsequently developed, and run on 33 occasions over the next nineteen years.

In January 2014, the Agency submitted a new Task Proposal incorporating experience and lessons learned from the courses carried out under the predecessor task, UK B01698. The new proposal aimed to address training needs more efficiently by increasing interactivity in the course, engaging trainees more and allowing a more effective evaluation of trainees'

performance. It would continue to consist of lectures; individual and group exercises, to enhance inspector and analyst knowledge of the safeguards-relevant elements of the nuclear fuel cycle and the observable nuclear fuel cycle and proliferation indicators. The course would address topics including:

- General principles and process technologies associated with conversion, fuel fabrication, enrichment, nuclear power generation and fuel reprocessing;
- Basic technologies indicative of nuclear explosive device manufacturing processes involving nuclear material and the associated facilities, equipment and activities; and
- Practices useful for identifying indicators throughout the nuclear fuel cycle activities.

The Task Proposal was accepted in February 2014 and the first course under the new task took place from 16 – 20 June 2014 at Puchberg, Austria, preceded by an introductory session at IAEA Headquarters on 13 June.

### ***Summary Report on Activities in 2015/2016***

Two Nuclear Fuel Cycle, Indicators and Proliferation Pathways courses were successfully delivered, on 12-19 June and 13-20 November 2015, for the benefit of 16 and 18 participants, respectively.

Each course involved presentations to the Agency participants by a team of UK experts and specialists in the nuclear fuel cycle and proliferation indicators. The course commenced with the Task Manager providing an introduction and concluding with the “Inquisitive Inspector”. Agency presentations included aspects of the State-level Approach and a practical exercise on related issues. There followed a week-long residential course at Puchberg, with each day dedicated to one of five modules on the fuel cycle. Course exercises followed each module, maintaining a consistent scenario through the course.

A further two courses have been requested by the Agency for 2016.

### **Task C1(u) – Implementation of Safeguards at Enrichment Facilities**

<b>IAEA SP-1 No:</b>	08/CTR-004	<b>UK Sub-contractor:</b>	Urenco Capenhurst
<b>IAEA SPRICS No:</b>	UK B01797	<b>UK Task Manager:</b>	M Peers
<b>IAEA Task Officer:</b>	D Lacey		

### ***Background to Task***

Enrichment plants are some of the most proliferation-sensitive nuclear facilities, and it is important for inspectors to be able to implement Limited Frequency Unannounced Access (LFUA) activities in an efficient and effective manner.

In 2008, the Agency requested access to the UK's gas centrifuge enrichment plants at Capenhurst, including their cascade halls, to enable in-situ training. Representatives from Urenco participated in a two-day workshop on the feasibility and practicalities of Enrichment LFUA training, convened by the Agency. Approval was subsequently given by the Quadripartite Committee Safeguards Working Group, for IAEA and DG-TrEn Inspectors to have access to cascade areas during an LFUA inspection course, subject to certain restrictions. A pilot LFUA course was held at Capenhurst in December 2009, providing the necessary information and experience to establish and finalise the course content for a regular

LFUA course. Subsequent courses followed a similar schedule of lectures; exercises, including visual observation and swipe sampling along the agreed LFUA routes; and demonstrations of sampling and mailbox interrogation procedures. Courses were run at Almelo (September 2010), Capenhurst (January 2011) and Gronau (October 2011) under the respective Support Programmes of the Netherlands, the UK and Germany, with the UK Support Programme facilitating additional support from Urenco Capenhurst to the Almelo and Gronau courses.

A fourth course, at Almelo in October 2012, was redesigned with the intention that the course continue on an annual basis, with a focus on practical safeguards at an enrichment plant. Urenco subsequently fulfilled its commitment to sharing the responsibility to host a course between the European gas centrifuge enrichment facilities.

### **Summary Report on Activities in 2015/2016**

In September 2015, the latest course on practical safeguards at enrichment plants was successfully delivered at Urenco's Capenhurst plant to ten IAEA and two Euratom participants. The course included a pilot running of new presentations and interactive exercises, in addition to the site visits that provided the trainees with a unique opportunity to discuss possible scenarios and appropriate safeguards measures.

A 2016 course on safeguards at enrichment facilities will be held at Almelo, under the Netherlands Support Programme. It is anticipated that Urenco Capenhurst will continue to support the Almelo and Gronau courses, if required, in addition to hosting a Capenhurst-based course every four years.

### **Task C1(v) – Training in Negotiation Skills**

<b>IAEA SP-1 No:</b>	10/CTR-006	<b>UK Sub-contractor:</b>	The Ambassador Partnership LLP
<b>IAEA SPRICS No:</b>	UK B01874	<b>UK Task Manager:</b>	P Jenkins
<b>IAEA Task Officer:</b>	G Berthelot		

### **Background to Task**

To deal confidently with awkward situations arising from disagreements with local, regional and State authorities and facility personnel in planning, conducting and reporting safeguards inspections and other activities based on Safeguards Agreements, inspectors need to develop specific listening and negotiation skills. Late in 2010, the UK Support Programme agreed to provide training to senior inspectors in diplomatic negotiation skills, utilising a team of former diplomats with high-level experience in negotiation and professional mediation.

During May 2011, the former Permanent Representative of the United Kingdom to the IAEA conducted a detailed needs assessment based on interviews and consultation with Agency staff. A course was developed with the purpose to help experienced negotiators fine-tune their skills, with an emphasis on providing insights and guidance applicable in all structured negotiating situations, and specific tips for dealing with inflexible interlocutors and for handling issues arising from cultural differences and difficult personality traits. Four consecutive half-day training sessions were subsequently provided in June 2011 by two former UK Ambassadors to twelve senior inspectors and section heads, including role-plays based on real-life professional challenges typically encountered by the participants. A second "Diplomatic negotiation skills" training course was held in Vienna in April 2012, following a period of further research and fine-tuning of the course content. Two former UK diplomats provided training in core negotiation



skills; asking and listening; and advanced negotiation to an audience of inspectors, and led role-plays targeting IAEA scenarios. Feedback from the Agency enabled the course to be further developed prior to its delivery in October 2013 and September 2014.

Meanwhile, an additional course was requested for inspectors, with the emphasis on managed access. A specific programme was subsequently developed prior to delivery of the course “Negotiation Skills and the Concept and Practice of Managed Access” from 23 – 25 April 2014, and its repeat to a second group of inspectors from 2 - 4 June 2014.

The portfolio of courses offered by the Ambassador Partnership was completed through additional support to the Department of Safeguards’ existing Communications Skills course and the introduction of a course for managers of the Department of Safeguards. The objective of the latter was to complement the development programme offered by the Agency to Section Heads and Directors in the areas of managerial skills and leadership, in order to meet the specific needs of the Department of Safeguards. Following acceptance of the request by the UK Support Programme, The Ambassador Partnership worked with the Department of Safeguards to develop a training event to cover the core competencies of communications, decision making and change orientation. A course on “Leadership Skills” was subsequently delivered over a three-day period from 7-9 October 2014 at IAEA Headquarters.

### ***Summary Report on Activities in 2015/2016***

Six training courses were delivered under the UK Support Programme by the Ambassador Partnership in 2015/2016, for the benefit of a total of 27 staff from the Department of Safeguards.

From 7 – 8 May 2015, additional support was provided to the Department of Safeguards’ existing Communications Skills course, including a presentation and role play on the theme of negotiation skills.

From 18 – 20 May 2015 and 12 -14 October 2015, two courses on “Leadership Skills” were delivered including:

- Presentations on managing change, and facilitated discussions on IAEA Change Programmes and Safeguards in 2020;
- Communicating, public speaking, chairing meetings and dealing with conflict, with role-play on mediating between competing claims; and
- Making decisions, including presentations, exercises and role-play.

From 26 – 29 May 2015, and 31 August - 3 September 2015, two courses on “Negotiation Skills” were delivered including presentations and role play on the theme of negotiation skills.

From 16 – 18 June 2015, the course “Managed Access” was delivered to provide training and experience of negotiation techniques relevant to duties in the context of managed access.

The UK Support Programme anticipates a request from the Agency to facilitate the delivery of two Leadership Skills courses, together with one iteration of each of the negotiation skills course; the managed access negotiating course; and the negotiation skills module of the Agency’s own inspector communication skills course in 2016. These will continue to be delivered by the Ambassador Partnership.

## Task C1(w) – Advanced Training on NFC Facilities to Assist State Evaluation

<b>IAEA SP-1 No:</b>	11/CTR-004	<b>UK Sub-contractor:</b>	NNL
<b>IAEA SPRICS No:</b>	UK B01903	<b>UK Task Manager:</b>	C Shearer
<b>IAEA Task Officer:</b>	C Olivieri		

### ***Background to Task***

Arising from the Agency's strengthened and integrated safeguards approach, advanced training was required: to provide increased knowledge of the process technologies associated with fuel cycle facilities; and an improved understanding and recognition of the equipment and processes, particularly proliferation indicators and dual use equipment and activities. Because a proliferator may choose to adopt old technology, the scope of any training course was required to cover both new and old equipment. Physical access to reactors, conversion, enrichment and reprocessing facilities on three scales: laboratory, pilot plant and commercial, were specific requirements. From 2000 to 2011, the UK Support Programme provided training on the technologies associated with fuel cycle facilities and the equipment employed.

Following the March 2011 course, agreement was reached to replace the existing course with one that would provide the opportunity for safeguards staff, in particular inspectors and analysts with significant responsibilities in State Evaluation, to apply knowledge gained and competencies acquired during the Proliferation Pathways course. Physical access to conversion and fuel fabrication plants, reactors and reprocessing plants would still be required, but the new course would not require access to an enrichment plant. Following development of a detailed course schedule, a pilot course was delivered to nine participants in October 2011. Feedback from the course was generally positive, although some improvements were identified. Revisions were then made before the first full course, which was delivered to a group of twelve inspectors and analysts in March 2012. A further two courses were held in September/October and March of financial years 2012/2013 to 2014/2015, to a similar schedule, but with nine participants on each course.

### ***Summary Report on Activities in 2015/2016***

A further two courses were held on 'Advanced Training on NFC Facilities to Assist State Evaluation'. The first was delivered from 1 - 2 October in Vienna and 5 - 9 October 2015 in the UK, with nine participants, whilst the second, from 10-11 March 2016 in Vienna and 13-18 March 2016 in the UK, benefitted ten participants.

Both courses followed the same format, with an introduction in Vienna providing summary presentations on the Sellafield and Springfields sites, imagery analysis techniques and open source analysis. This was followed by detailed preparatory sessions looking at site imagery and schematics, plus an examination of a package of open source information relating to the UK sites.

The UK component of the course commenced with a site visit to Sellafield, including Calder Hall, AGR and Magnox Fuel Handling Plant and the Sellafield Ion Exchange Effluent Plant (SIXEP) facility. The following day, a visit to Magnox Reprocessing was coupled with an extensive walk that included external areas of the old separation plants, Windscale Piles and ponds. Visits to THORP Receipt and Storage, Head End and Chemical Separation areas provided a contrast between old and new facilities. The final day at Sellafield included visits to the Low Level Waste Repository (LLWR), Drigg, and NNL Central Laboratory facilities, before travel to Springfields.



At Springfields, an initial site tour included viewing a range of plant associated with conversion, fuel fabrication and storage. More detailed visits included the Main Line Chemical (B336) and denitration plant (B337); the Oxide Fuels Complex; and Enriched Uranium Residue Recovery Plant (EURRP). The week-long course concluded with Group work and a course critique.

Feedback from both courses was very positive, and will be used to fine-tune further courses to be delivered in 2016/2017.

## Task C1(x) – Developing Analytical Skills for Safeguards

<b>IAEA SP-1 No:</b>	12/CTR-001	<b>UK Sub-contractor:</b>	-
<b>IAEA SPRICS No:</b>	UK B01940	<b>UK Task Manager:</b>	J Moore
<b>IAEA Task Officer:</b>	J M Crété		

### ***Background to Task***

Within the State-level Approach to integrated safeguards, consistency analysis of declared nuclear capabilities of States, using available sources of information; nuclear material acquisition path analysis; and preparation of relevant information collection and processing plans, requires strong individual as well as collaborative analytical skills.

In 2011, the Department of Safeguards sought to strengthen the level of professional analytical capability within its work. The US Support Programme already ran a two-day workshop, providing familiarisation with a range of techniques, whilst a three-day course through the Australian Support Programme considered their application. A five-day course was requested from the UK, to provide greater depth and rigour than could be achieved in the brief coverage within the US workshop, whilst complementing the Australian course.

Following a series of meetings in Vienna, UK experts prepared a detailed draft of the proposed course content, which was subsequently finalised in consultation with the Agency. A 'dry run' of the course was held in the UK in October 2012, followed by a pilot course at IAEA Headquarters the following month. Delivered by three UK experts to 13 inspectors and analysts from the Department of Safeguards, the pilot course was largely based upon material taught in the UK, with some adjustments to provide new exercise material focussed on a nuclear issue. Feedback from the Agency was very positive, and the UK Support Programme was requested to facilitate a further two training courses in 2013. These were to be presented in the context of a phased transition towards presentation of the training in-house by the Agency, the intention being to embed specialised analytical skills and appreciation within the Department of Safeguards.

The two courses were successfully held in May and October/November 2013, and were repeated in 2014 with the Department of Safeguards taking increased responsibility for course delivery. This was assisted by the UK Support Programme facilitating the participation of two SEG members in a "Train the Trainers" course in the UK. During the Vienna-based courses, the participants were engaged in highly interactive exercises, to enhance individual and collaborative skills for analysis of State information, learning and practicing a range of relevant techniques.

Meanwhile, in September 2014, the Task Officer began to explore with the UKSP Coordinator the possibility and practicalities of the UK providing additional training for IAEA staff planning to take over delivery of the course in 2015.

### **Summary Report on Activities in 2015/2016**

As a prelude to the Agency delivering its first totally in-house analytical skills training course, two UK experts provided a three-day “Train the Trainer” course for Department of Safeguards staff at IAEA Headquarters in June 2015.

The following month, the Agency completed its first totally in-house analytical skills training event. Following the course, additional assistance was provided to expand the core experience of the Agency trainers by permitting two Agency staff to accompany the UK experts during the second week of a course delivered in the UK.

A further Agency-run Advanced Analytical Skills course was held in Vienna from 2 - 6 November 2015. Two UK trainers attended the course as observers/evaluators, completing the currently-agreed support under this task. The task has therefore been placed on stand-by, pending any requirement for UK-based consultancy.

### **Task C1(y) – Specialised Training and Visits to Nuclear Facilities**

<b>IAEA SP-1 No:</b>	12/CTR-006	<b>UK Sub-contractor:</b>	-
<b>IAEA SPRICS No:</b>	UK B01936	<b>UK Task Manager:</b>	UKSP Coordinator
<b>IAEA Task Officer:</b>	K Dinov		

### **Background to Task**

Agency staff require specialised skills and competences to implement effectively international safeguards. The Training Section of the Department of Safeguards provides systematic training for staff performing safeguards functions, and the identified training needs are addressed within the annual Safeguards Departmental Training Programme. However, urgent training needs may emerge that are not covered by planned training courses. These needs go first through the Department’s internal committee, which oversees the overall training programme, to ensure consistency with the programme. A new course may then be designed at short notice, possibly requiring support from experts or access to nuclear facilities, laboratories or sites from Member States.

This task, functioning as an umbrella task, aims to give the required flexibility, reactivity and capacity for the Training Section to organise such courses under a formal arrangement with the UK Support Programme but with the minimum delay. It is intended to provide flexibility for the Safeguards Training Section to request support from UK experts or access to UK nuclear facilities, laboratories or sites in order to provide training on a short timescale, to meet operational needs and deadlines. It was first used to enable a UK contribution to the training of a specific group of inspectors in Vienna, in December 2012, and has been used on four subsequent occasions prior to April 2015, providing three periods of Vienna-based training plus a technical visit to specific UK nuclear facilities.

### **Summary Report on Activities in 2015/2016**

A request was received mid-December 2015 to provide training associated with specific UK nuclear facilities to imagery and other analysts. The purpose was to provide the group with a detailed knowledge of such facilities and their associated infrastructure and equipment. This request was progressed, with an itinerary developed to deliver introductory lectures and include visits to UK sites from 4-5 May 2016.

The UK Support Programme expects to continue to receive requests for training-related support outside the Safeguards Departmental Training Programme. Use of this task for ad-hoc training will ensure the involvement of the Safeguards Training Section and should promote training that meets operational needs and deadlines in a timely, effective and efficient manner.

## Area D - Safeguards Procedures

A number of large-scale reprocessing plants were scheduled to come on-stream from the 1990s in Member States and, in view of the fact that such plants are capable of producing high quality separated plutonium, the way in which they would be safeguarded was the subject of much discussion. The IAEA continues to need assistance in areas such as design information verification, authentication and solution monitoring, if fully effective safeguards are to be applied at such plants. Although aimed primarily at reprocessing plants, many of the methods apply equally to other types of facility in the fuel cycle.

### Task Area D2 - Near Real Time Accountancy

Near Real Time Accountancy (NRTA) is a tool for safeguarding large-scale reprocessing plants. Due to the highly complex nature of such plants, it can be difficult to determine an accurate estimate of the account. Anomalies can lead to investigations that would impose substantial burdens on inspectors and plant operators. Solution monitoring, which tracks the transfer of solutions through the plant, complements NRTA and can not only enhance the estimation process, but can also be viewed as a contributor to containment and surveillance. The methodology of solution monitoring can be adapted to other stages of the fuel cycle, such as enrichment or fuel fabrication, where material flows require monitoring.

#### Task D2(h) – Development of a Software Tool to Simulate the Nuclear Material Accountancy System for MOX Facilities

<b>IAEA SP-1 No:</b>	10/OA2-001	<b>UK Sub-contractor:</b>	Morson International
<b>IAEA SPRICS No:</b>	UK D01878	<b>UK Task Manager:</b>	J Howell
<b>IAEA Task Officer:</b>	C Portaix		

#### **Background**

A software tool to simulate the nuclear material accountancy system for mixed oxide (MOX) facilities was required by the Agency, to support the review of the operator's accountancy system design and refinement of approaches for the Japan Nuclear Fuels Ltd (JNFL) MOX Fuel Fabrication Plant (J-MOX). The software tool would make it possible to simulate the movement of nuclear materials associated with plant operation parameters and generate simulated accountancy records based upon the design specifications of the operator's and inspector's accountancy measurement systems. With such simulated information, the Agency would be able to assess further the properties of different statistics in nuclear material accounting for J-MOX under different diversion scenarios, identify major contributors to material unaccounted for (MUF) sources specific to the facility and compare the effectiveness of different safeguards approaches.

Glasgow University had previously worked on the development of a simulation tool for MOX facilities, and the Agency sought development of a prototype software written in Python, set up with model MOX plant parameters for demonstration purposes. The UK Support Programme agreed to fund enhancement of the existing discrete simulation of the movement of material through a MOX facility. Most movements are in cans, so the simulation would focus on their filling, emptying, measurement and storage. The aim was to simulate the data an operator would have available on a day by day basis, together with the true values behind this data.

Accountancy results would then derive from this data, combined with hold-up measurements made in the facility.

A number of enhancements to the existing package were subsequently completed, with further refinements implemented within a new, flexible, MOX software. A close collaboration between the Task Manager, Task Officer and an Agency cost-free expert (CFE) enabled the development of a software tool with a number of features that reflected the likely realistic operation of a MOX plant, as opposed to its nominal design operation. The simulation package - SimMOX - enabled the IAEA to enter proprietary information and perform studies.

A report on the SimMOX software tool was completed, and the Task Manager contributed to a paper and presentation for inclusion in the 2014 IAEA Safeguards Symposium.

At the request of the Task Officer, additional features were incorporated into a further revision of the software, including a more detailed recycle simulation and modifications to the outputs to enable a more appropriate interface to be made to IAEA evaluation packages. These changes were incorporated within a new version, SimMOX5.0, and delivered to the Agency late-January 2015.

The software version provided to the Task Officer was considered sufficient for the Agency to work on the NRTA interface and to produce a detailed specification. However, the Task Manager would need to perform extensive testing, before the implications of how various scenes might affect safeguards systems performance could be examined by the Agency with a view to recommending changes to the safeguards system design.

### ***Summary Report on Activities in 2015/2016***

The Task Manager completed extensive testing of SimMOX5.0 in the UK, prior to a week-long period of work at IAEA Headquarters in May 2015. Whilst in Vienna, he installed the latest version of the software and tested it with a set of complete configuration files.

During a second visit, in August 2015, he collaborated with the Task Officer and US CFE on further development and optimisation of the software, including implementation and testing of two new scenes. Post-processors were developed to enable a skeletal version of the software to generate NRTA balances with an estimate of their associated covariance matrix.

During 2016/2017, The Task Manager will update the skeletal version of the post-processor that generates the covariance matrix, prior to visiting the IAEA to test their recipe and explore implications of covariance matrix auto generation.

# Area E - Instrument Development and Assessment

New types of nuclear plant, and facilities that handle increased throughput of nuclear material, require the development of new instrumentation and equipment in order to apply safeguards in an effective and efficient manner. The application of strengthened and integrated safeguards requires not only new equipment but improved computer systems in order to collate and assess data from a range of sources. Nuclear materials and the instruments used in their verification must be secure and not vulnerable to tampering. Manuals and procedures for the operation of safeguards instrumentation require updating on a regular basis.

## Task Area E11 - Technical Documentation

The Agency requires documentation to a standard format for safeguards instrumentation, including a Reference Manual for Instrumentation and a Checklist Procedure. The UK Support Programme provides regular assistance to the Department of Safeguards through the preparation of technical manuals and procedures for NDA instrumentation used by safeguards inspectors, and considers additional support on request.

### Task E11 - Technical Manuals and Procedures for Safeguards Instrumentation

<b>IAEA SP-1 No:</b>	08/TAU-001	<b>UK Sub-contractor:</b>	Canberra UK Ltd
<b>IAEA SPRICS No:</b>	UK A01729	<b>UK Task Manager:</b>	C Wilkins
<b>IAEA Task Officer:</b>	H Klein		

#### ***Background to Task***

Canberra UK has undertaken the preparation of reference manuals and checklist procedures for safeguards instrumentation since 1996. Previous tasks, UK A01031 and UK A01408, involved the provision of simplified documentation for instrumentation including the CANDU Spent Fuel Bundle Verification Basket (CBVB); the Inventory Sample Counter (INVS); the Passive Neutron Coincidence Collar Detector (PNCL); the Fork Detector Irradiated Fuel Measurement System (FDET); and the Fresh MOX Attribute Tester (FMAT). A new Task Proposal, for the preparation of further Reference Manuals and Checklist Procedures, was accepted by the UK Support Programme in March 2008. Work subsequently proceeded with completion of documentation for the Active Well Coincidence Counter (AWCC); High-Level Coincidence Counter (HLCC); Triangular Load Cell; ATOMTEX Backpack Radiation Monitor; ICx Raider; crane weighers and cylinder reference weight; and the mini multichannel analyser, the mMCA-527.

In a separate initiative on the part of the Department of Safeguards, to achieve quality improvements for safeguards forms and working papers (F/WPs), the Agency provided a letter request in October 2013 seeking an appropriate expert to review all such documents, to revise selected forms and papers, and to draft a guide on their preparation. The rationalisation of safeguards forms and working papers was progressed to a successful conclusion during 2014. In total, 50 F/WPs were processed, reviewed and improved and a guide on "Design and preparation of working papers and forms" was prepared to assist the Department of Safeguards in the preparation of further forms.



### **Summary Report on Activities in 2015/2016**

Work commenced on the production of new documentation for the handheld Raman spectrometry-based material identifier 'FirstDefender RM', to be employed in complementary access missions. Following receipt of an example of the Raman instrument from the Agency, along with the existing manufacturer's documentation for the equipment, a new Reference Manual and Checklist Procedure were produced to schedule and sent to the Task Officer. Feedback from the Agency was incorporated and the final documents were issued end-September 2015, prior to return of the Raman instrument to IAEA Headquarters.

The UK Support Programme anticipates contributing to the preparation of further documents, in response to requests from the IAEA.

## **Task Area E12 – Development of Remote Monitoring Techniques and Equipment**

The UK Support Programme provides support to equipment development tasks in areas where its particular expertise or experience in facility application is essential, or in cases where the UK has advanced technologies available that cannot be provided from elsewhere.

### **Task E12(f) – Fast Neutron Detector Pulse Shape Discriminator System**

<b>IAEA SP-1 No:</b>	12/TSI-001	<b>UK Sub-contractor:</b>	Hybrid Instruments (HI)
<b>IAEA SPRICS No:</b>	UK A01951	<b>UK Task Manager:</b>	M Joyce
<b>IAEA Task Officer:</b>	Taehun Lee		

#### **Background to Task**

Neutron detectors play an essential role in NDA systems for plutonium measurement, such as those that will be required to be installed at J-MOX.  $^3\text{He}$  is widely used in neutron detectors due to its outstanding  $\gamma$ -ray rejection properties. However, a world-shortage of  $^3\text{He}$  has led to renewed interest in systems based upon  $^{10}\text{B}$  and even  $^6\text{Li}$ . However, what all these systems lack is an ability to detect fast neutrons: the neutrons emitted by plutonium must be slowed down to energies in thermal equilibrium with their surroundings.

During 2010, the UK Support Programme was approached by the Department of Safeguards to facilitate continued development of an innovative alternative to  $^3\text{He}$ -based detectors based upon liquid scintillation detectors and a pulse shape discriminator (PSD) developed by Hybrid Instruments. Under Task UK A01887, "Support for the Safeguards Systems at J-MOX", work on the upgrade of existing prototype instrumentation at J-MOX was completed during 2010/2011, followed by the design and manufacture of an improved device in 2011/2012. The successful completion of this work led to a request to develop a plant-scale integrated measurement system under a new task, E12(f)/UK A01951.

Under respective tasks of the UK and Netherlands Support Programmes, Hybrid Instruments and Scionix worked to integrate an array of 16 PSD modules and detectors into a single detector system to the IAEA's specification. The project comprised: (1) the supply and integration of a 4-channel PSD instrument; (2) the development and manufacture of a 16-channel PSD module; and (3) integration of the 16-channel module, with each phase originally envisaged to have a duration of three months. Development and manufacture of both the 4- and 16-channel PSD modules was completed by end-March 2013.

The following year saw completion of commissioning tests at the University of Birmingham, the National Physical Laboratory and the IAEA Seibersdorf Laboratories. Initial testing at Seibersdorf was supported by an engineer from Hybrid Instruments, with identified issues resolved through design modifications. The final instrument provided excellent pulse-shape discrimination and returned significant improvements in multiplicity order sensitivity: effectively moving the capability on from doubles event assay to demonstrable efficiency for quads. This led to the identification of further near-term potential opportunities that included:

- Plutonium assay;
- Curium assay and discrete isotopics;
- Isotopic signatures of nuclear material; and
- Measurement of low-enriched uranium (LEU) in gadolinium-doped VVER fuel assemblies.

Further testing at ITU Karlsruhe, utilising a variety of sample materials, raised some additional issues, associated with user interfaces and data presentation. Hybrid Instruments reviewed the required enhancements and developed a strategy for their implementation. These issues were addressed during the first half of 2014, prior to commissioning and acceptance testing of the system.

Following completion of commissioning and acceptance testing of the 16-channel mixed-field analyser (MFA) instrument at IAEA Headquarters during September 2014, Hybrid Instruments staff accompanied the Task Officer to JRC Ispra for benchmarking during October 2014. The system proved to work extremely well, demonstrating its superior performance over a  $^3\text{He}$  system for new fuel measurement; as well as its potential for other applications. All of the analytical requirements were demonstrated, and some minor adjustments incorporated. The system was retained at Ispra for some further measurements by the JRC team prior to its return to Vienna. The Agency subsequently declared proof of concept with the existing instrument to have been successful.

### ***Summary Report on Activities in 2015/2016***

In 2015/2016, a number of developments of the mixed field analyser MFAx4.3 firmware and software were completed in order to optimise its performance.

Following the proof of concept of the fast neutron collar (FNCL) as a technical solution for fresh fuel verification (partial defect test), the Department of Safeguards decided to authorise a liquid scintillator-based collar for inspection use. However, considering the complexity of the data evaluation process and advances in data transmission capabilities, the Agency decided that it was desirable to record the signals from the detectors: to be able to repeat any signal analysis in the field or to bring the data back to HQ for expert evaluation. This capability had been designed out of the Hybrid Instruments system, meaning that it was unable to meet the specific requirement for data transfer.

Whilst not continuing with the UK design, the Agency emphasised its high appreciation of the UK Support Programme for extensive support to the feasibility study phase that resulted in building and successful testing of the FNCL prototype. The Agency proposed that the task be considered as successfully completed, noting that Hybrid Instruments had contributed the essential first stage of development without which in-field deployment of the technology would not be possible.



## Task Area E15 – Computer Systems

The Department of Safeguards relies upon computer systems for the storage, collation and retrieval of safeguards data for use in safeguards evaluations. Adoption of strengthened safeguards measures, the Additional Protocol and Integrated Safeguards has resulted in a dramatic increase in the amount of data and information received and analysed. Developments to existing systems and the introduction of new systems are therefore required in order that the Agency maintains its capability for effective assessment of safeguards-relevant information.

### Task E15(c) – Developing Business Capabilities for the Modernisation of Safeguards Information Technology (MOSAIC)

<b>IAEA SP-1 No:</b>	14/PS-001	<b>UK Sub-contractor:</b>	-
<b>IAEA SPRICS No:</b>	UK D02171	<b>UK Task Manager:</b>	UKSP Coordinator
<b>IAEA Task Officer:</b>	G Whitaker		

#### ***Background to Task***

In July 2013, the Director General of the IAEA requested that a clear vision and prioritised objectives be established for the Department of Safeguards' Information Technology. A concept paper, Modernisation of Safeguards Information Technology (MOSAIC) was prepared with the aim of fully integrating the Department's IT system with safeguards implementation processes.

The resulting MOSAIC programme is developing applications and software to improve the structure and integration of all safeguards information within a modernised IT system, to allow better planning, conducting, reporting and quality assessment of safeguards activities within the Department of Safeguards. Assistance was sought from Member States for the enhancement of existing capabilities and the development of new capabilities, including: the provision of funds to support software development; consultants for the software development and project management teams; and development of specific components that are compatible and integrated with the new information systems.

#### ***Summary Report on Activities in 2015/2016***

In April 2015, the UK Support Programme advised the Agency that it intended to make an initial allocation of funds to support the MOSAIC programme. A second extrabudgetary contribution was made in March 2016, with further contributions to be considered.

## Area F - Consultants and Cost-Free Experts

The IAEA cannot retain sufficient resources within its permanent staff to meet all requirements for highly specialised development and evaluation work. In addition to obtaining assistance from Member State Support Programmes to undertake specific tasks, the IAEA looks to States and Institutions to provide expert staff to fulfil a temporary position at the IAEA's premises in support of such activities. This may involve a full-time role as a Cost-Free Expert (CFE), or part-time as a Consultant.

### Task Area F1 - Provision of Consultants and Cost-Free Experts

CFEs are persons provided by States at no cost to the IAEA to perform specific tasks for which no resources are available within the Secretariat. CFEs are employed as officials of the IAEA, but the cost of that employment, plus overheads, is provided to the IAEA by the donor State or Institution. In situations where the CFE mechanism is inappropriate, for example in cases where the expert does not attend the IAEA on a full-time basis, it may be more appropriate to offer a Consultant to the Agency. In contrast to CFEs, Consultants are normally funded via the current employer of the staff involved, and not through transfer of funds to the Agency. Both mechanisms provide the means for the IAEA to attract expert staff for the limited period required to complete a specialised work programme.

#### Task F1(f) - Nuclear Fuel Cycle Specialist Assistance

<b>IAEA SP-1 No:</b>	09/ICA-004	<b>UK Sub-contractor:</b>	Various
<b>IAEA SPRICS No:</b>	UK D01819	<b>UK Task Manager:</b>	UKSP Coordinator
<b>IAEA Task Officer:</b>	D Peranteau		

#### ***Background to Task***

The Satellite Imagery Analysis Unit required technical support from specialists in the nuclear fuel cycle, to assist on priority imagery analysis tasks to complement or supplement in-house expertise. This task was accepted in order that the UK might provide such support on an ad-hoc basis, in response to specific requests.

Following acceptance of the task in 2010/2011, it became apparent that there could be a wider benefit, within the Department of Safeguards as a whole, from technical support to the review and assessment of information from a variety of sources including, but not limited to, satellite imagery. The scope of the task was subsequently expanded in order to accommodate this requirement.

#### ***Summary Report of Activities in 2015/2016***

During the year, the UK Support Programme provided expert assistance through nuclear fuel cycle technical studies and modelling developments in support of safeguards.

Subject to the availability of resources, the UK Support Programme intends to continue to offer technical support within the framework of this task in response to urgent and ad-hoc requests from the Agency.

## Task F1(g) – Expert – NFC Technology Expert

<b>IAEA SP-1 No:</b>	14/ISF-001	<b>UK Sub-contractor:</b>	(S Francis)
<b>IAEA SPRICS No:</b>	UK D02013	<b>UK Task Manager:</b>	UKSP Coordinator
<b>IAEA Task Officer:</b>	M Fowler		

### ***Background to Task***

The evaluation of nuclear activities within a State and the process required to draw safeguards conclusions require the analysis of information from wide and diverse sources. These activities require technical expertise with a broad and deep knowledge of NFC-related equipment, infrastructure and processes.

In July 2014, the Department of Safeguards issued a Task Proposal seeking an NFC technology expert, to be located within the Safeguards Division of Information Management (SGIM), to provide technical analysis in support of nuclear sites and activities. The research and assessments conducted by the expert would be used as input to the State Evaluation Process, contributing to the Department's annual conclusions on Safeguards Implementation in States.

The UK Support Programme consulted widely within the UK nuclear industry and identified an appropriate candidate, who was nominated late-2014.

### ***Summary Report of Activities in 2015/2016***

Following his selection by the Department of Safeguards, Mr Francis commenced an initial two-year term as a cost-free expert within the IAEA Department of Safeguards on 22 June 2015.

He is now assisting the technical review and analysis of open source information collected by the Department, and provides additional technical assistance as required.

## Additional Meetings and Activities

The UK Support Programme receives each year a small number of requests for members of the UK nuclear industry or associated experts and advisors to attend safeguards-related meetings convened by or contributing to the Department of Safeguards. During 2015/2016, the UK Support Programme facilitated expert participation in a Technology Evaluation Workshop on Gamma Imaging, 19 – 23 October 2015; a Technical Meeting on Particle Analysis of Environmental Samples for Safeguards Purposes, 10-13 November 2015; and in a Technical Meeting on the Analysis of Elemental Impurities in Uranium, 23 – 25 February 2016.

The UK Support Programme continued to provide funds to enable staff from the Department of Safeguards to undertake approved visits in connection with activities associated with the UKSP, including participation in training events.

# SRDP and Other Reports Published or in Preparation during 2015/2016

Reports Published or In Preparation under the auspices of the UK Support Programme during 2015/2016 included:

- A7(h)** **SRDP-R319** "Evaluation of Foot-Mounted Tracking", P Baxter, C Morgan, B Windsor and T Wood (Issued October 2015)
- SRDP-R314** "Trade Data and Nuclear Non-Proliferation", I J Stewart (Issued September 2015)
- SRDP-R316/5** "Bellows-Sealed Valves Manufacturing Base Report" (Issued April 2015)
- SRDP-R316/6** "Centrifuge Rotor Materials Manufacturing Base Report" (Issued July 2015)
- SRDP-R316/7** "Frequency Converters Manufacturing Base Report" (Issued July 2015)
- SRDP-R317** "Compendium of Nuclear Technologies", I J Stewart (Issued June 2015)
- SRDP-R318/1** "Vacuum Pumps Manufacturing Base Report" (Issued October 2015)
- SRDP-R318/2** "Isostatic Presses Manufacturing Base Report" (Issued November 2015)
- SRDP-R318/3** "Flash X-Rays Manufacturing Base Report" (Issued November 2015)
- SRDP-R318/4** "Flow-Forming Equipment Manufacturing Base Report" (Issued December 2015)
- SRDP-R318/5** "Neutron Detectors Manufacturing Base Report" (Under review)
- SRDP-R318/6** "High-Energy Capacitors Manufacturing Base Report" (Under review)
- B1(v)** **SRDP-R315** "Sample Preparation for IAEA Safeguards Cameca SIMS 1280 Analysis", T Nicholls, J Collins and S Crooks. (Issued July 2015)
- D2(h)** **SRDP-R310** Addendum 4 "Key Features of SimMOX version 2.2.6." (Issued June 2015)
- SRDP-R310** Addendum 5 "NRTA Provision in SimMOX version 2.2.6." (Issued September 2015)
- SRDP-R310** Addendum 6 "NRTA Covariance Matrix Formulation for SimMOX." (Issued December 2015; updated February 2016)
- SRDP-PR35** "UK Safeguards Support Programme: Report on Activities and Progress during the period 1 April 2014 to 31 March 2015", J Tushingam (Issued November 2015).

# Abbreviations

<b>Abbreviation</b>	<b>Term</b>
AGR	Advanced Gas-cooled Reactor
Am	Americium
ANPS	Autonomous Navigation and Positioning System
APA	Acquisition Pathway Analysis
AWCC	Active Well Coincidence Counter
AWE	Atomic Weapons Establishment
B	Boron
BEIS	Department for Business, Energy and Industrial Strategy
BHF	Bulk Handling Facility
BNFL	British Nuclear Fuels Ltd
CANDU	Canadian Deuterium Uranium Reactor
CBVB	CANDU Spent Fuel Bundle Verification Basket
CFE	Cost-Free Expert
Cm	Curium
CRM	Certified Reference Material
DA	Destructive Analysis
D&IS	Development and Implementation Support
DECC	Department of Energy and Climate Change
DG-Ener	Directorate General for Energy of the European Commission (split off from DG-TrEn in February 2010)
DG-TrEn	Directorate General for Transport and Energy of the European Commission
DIQ	Design Information Questionnaire
DIV	Design Information Verification
EC	European Commission
ECAS	Enhancing Capabilities of the Safeguards Analytical Services
ESARDA	European Safeguards Research and Development Association
EURRP	Enriched Uranium Residues Recovery Plant
FDET	Fork Detector Irradiated Fuel Measurement System
FISPIN	A Fuel Inventory Code
FMAT	Fresh MOX Attribute Tester
FNCL	Fast Neutron Collar



<b>Abbreviation</b>	<b>Term</b>
FT-TIMS	Fission Track-Thermal Ionisation Mass Spectrometry
F/WPs	Forms and Working Papers
GIF	Generation IV International Forum
He	Helium
HLCC	High-Level Coincidence Counter
IAEA	International Atomic Energy Agency
IFNEC	International Framework for Nuclear Energy Cooperation
INFCIRC	IAEA Information Circular
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
INVS	Inventory Sample Counter
ITU	Institute for Transuranium Elements, EC Joint Research Centre
J-MOX	JNFL MOX Fuel Fabrication Plant
JNFL	Japan Nuclear Fuels Ltd
JRC	European Commission Joint Research Centre
KCL	King's College, London
KPI	Key Performance Indicators
KPQ	Key Performance Questions
LANL	Los Alamos National Laboratory
LEU	Low-Enriched Uranium
LFUA	Limited Frequency Unannounced Access
LG-SIMS	Large Geometry-Secondary Ion Mass Spectrometer
Li	Lithium
LLNL	Lawrence Livermore National Laboratory
LLWR	Low Level Waste Repository
MAGNOX	A graphite-moderated, gas-cooled reactor (originally with MAGnesium Non-OXidising fuel cladding)
MBR	Manufacturing Base Report
MFA	Mixed Field Analyser
Mo	Molybdenum
MONK	A Monte Carlo neutronics code
MOX	Mixed Oxide
MOSAIC	Modernisation of Safeguards Information Technology
MSSP	Member State Support Programme

<b>Abbreviation</b>	<b>Term</b>
MUF	Material Unaccounted For
NDA	Non-Destructive Analysis
NFC	Nuclear Fuel Cycle
NML	IAEA Nuclear Material Laboratory
NNL	National Nuclear Laboratory
Np	Neptunium
NPL	National Physical Laboratory
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NRTA	Near Real Time Accountancy
NWAL	Network of Analytical Laboratories
ONR	Office for Nuclear Regulation
PANTHER	A neutron diffusion and thermal hydraulics code
PII	Performance Indicators Initiative
PIV	Physical Inventory Verification
PIWG	Performance Indicators Working Group
PNCL	Passive Neutron Coincidence Collar Detector
PR&PP	Proliferation Resistance and Physical Protection
PSD	Pulse Shape Discriminator
Pu	Plutonium
PWR	Pressurised Water Reactor
R&D	Research and Development
RAE	Resistive Anode Encoder
RICC	Regional Information Collection Centre
SAGSI	Standing Advisory Group on Safeguards Implementation
SEG	State Evaluation Group
SEM	Scanning Electron Microscopy
SGIM	IAEA Safeguards Division of Information Management
SIAU	IAEA Satellite Imagery Analysis Unit
SIMS	Secondary Ion Mass Spectrometry
SIP	Safeguards Implementation Practices
SPRICS	Support Programme Information and Communication System
SRDP	Safeguards R&D Project
Th	Thorium

<b>Abbreviation</b>	<b>Term</b>
THORP	Thermal Oxide Reprocessing Plant, Sellafield
TIMS	Thermal Ionisation Mass Spectrometry
U	Uranium
UK	United Kingdom
UKSP	United Kingdom Support Programme to the IAEA
UOC	Uranium Ore Concentrate
US	United States of America
USDoE	US Department of Energy
VVER	A Pressurised Water Reactor, of Russian design
WIMS	Winfrith Improved Multigroup Scheme, a neutronics code

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