SRDP-PR33

UK SAFEGUARDS SUPPORT PROGRAMME

Report on Activities and Progress during the period 1 April 2012 to 31 March 2013

J W A Tushingham

August 2013

UK Safeguards Support for the IAEA

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This work was funded by the UK Department of Energy and Climate Change through the UK Support Programme to IAEA Safeguards.

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.

National Nuclear Laboratory
Building 168, Harwell Science Campus
Didcot
Oxfordshire OX11 0QT
United Kingdom
Tel: +44 7595 088 263

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EXECUTIVE SUMMARY

The UK Support Programme to IAEA Safeguards (UKSP) was established in 1981, to provide technical support to the Department of Safeguards of the International Atomic Energy Agency (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 2012 to 31 March 2013, the UK Support Programme contributed to 29 out of 31 active UK tasks within the Department of Safeguards' Development and Implementation Support Programme for Nuclear Verification, completing work on 3 of these, whilst a further 3 tasks were 'on standby'. 9 task proposals were considered during the year, of which 4 were accepted and 5 remained pending at the year-end. Activities undertaken included:

- continuing support to environmental sampling, with issue of a report on air-particulate sampling, analysis of five batches of inspection samples, completion of libraries of isotopic data for research reactors and commencement of work on additional reactors of current importance to IAEA inspection activities;
- Provision of open source information, with eight State Profiles updated and two ad-hoc reports issued;
- further support to the new IAEA nuclear material laboratory, through an extrabudgetary contribution of €500k to the project 'Enhancing Capabilities of the Safeguards Analytical Services' (ECAS);

- delivery of seven training courses to IAEA inspectors and analysts, including the first UK-run course to provide training in analytical skills, with additional contributions to a further three courses in collaboration with other Member State Support Programmes (MSSPs);
- development of software tools to assist safeguards implementation and interpretation;
- following successful development of an advanced neutron measurement technology under a previous task, completion of the development of the electronics for a plant-scale integrated system for IAEA application; and
- provision of expertise in satellite imagery, through both training of the Agency's own imagery analysts and continuation of a five-year cost-free expert position within the IAEA Satellite Imagery Analysis Unit.

This report provides a summary of the progress on those tasks active during 2012/2013 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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National Nuclear Laboratory, Harwell, UK

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 funded by the UK Department of Energy and Climate Change (DECC) and is administered on its behalf 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.

Assistance is provided to the IAEA Department of Safeguards in six areas of technical support:

- 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.

This report provides a summary of the progress against specific tasks in each of these six areas during the period 1 April 2012 to 31 March 2013.

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. 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 within the Department of Safeguards in the planning and conduct of safeguards inspections and to evaluate the correctness and completeness of State Declarations.

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 ultra-sensitive measurement techniques, 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.

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

IAEA SP-1 No:	96/XXX-010	**UK Sub-contractor:**	AWE Aldermaston
IAEA SPRICS No:	UK X01045	**UK Task Manager:**	A J Pidduck
IAEA Task Officer:	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. Environmental swipes are taken by inspectors using 10x10cm cotton or round cellulose wipes of around 2.5cm diameter, the latter designed for use with remote manipulators and used within hot cells. In either case, the inspector wipes surfaces that may have been exposed to nuclear material, removing a portion of any surface contamination on the wipe for subsequent analysis. Samples may also be taken by special particulate sampling using installed sample filters (Koshelev filters). 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, with the aim to ensure sufficient analytical capacity to service the diversity of samples and analytical requirements. The NWAL also fulfils an important role by enabling routine inter-laboratory comparisons and cross checks on analytical results.

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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, whilst TIMS can provide high accuracy in the measurement of both major and minor isotopes. This combination 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 relatively fast 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 are 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 UKSP particle analysis capabilities at AWE.

Summary Report on Activities in 2012/2013

AWE Aldermaston continued to provide an FT-TIMS capability during 2012/2013, completing the analysis of 10 samples with a further 5 near completion at the year-end. Using fission track analysis, particles containing fissile material were detected and selected for measurement by TIMS. The procedure involved removal of the 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 placed upon 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 Scanning Electron Microscopy (SEM).

In parallel with FT-TIMS work, AWE completed the installation and commissioning of a Cameca 4f-RAE SIMS instrument from QinetiQ. The analysis of a series of uranium particle standards and a previously-analysed field sample was undertaken in both RAE-PSearch and ion-microprobe modes of operation, in order to re-qualify the instrument for IAEA NWAL environmental sample analysis. Results obtained were comparable with those from measurements at QinetiQ before equipment transfer, and a report detailing the revalidation exercise was accepted by the Agency.

Measurements were subsequently completed on 4 inspection samples by RAE-SIMS during the remainder of the year, with a further 4 samples undergoing analysis at the year-end. Analysis involved the recovery of particles from swipes using an impactor particle extraction technique, transfer of the particles to SIMS planchets and measurement. The measurement included an

initial scan of all uranium-containing particles by RAE, often providing thousands of results, followed by a more detailed and accurate measurement of the uranium isotopic composition of individual particles of interest by ion microprobe. A uranium swipe standard and sample blanks were analysed as part of the quality control procedure applied to each batch.

A further three high-priority samples were analysed by SEM alone, providing data on the elemental composition of uranium particles and the presence of materials used within the nuclear fuel cycle.

The IAEA will continue to require the analysis of environmental swipe samples by both FT-TIMS and SIMS in 2013/2014, and is looking to AWE Aldermaston to provide a full particle analysis service.

Task A5(h) – Review and Assessment of Air-Particulate Sampling Field Trials

IAEA SP-1 No:	09/IDS-001	**UK Sub-Contractor:**	Nicholson Environmental
IAEA SPRICS No:	UK A01822	**UK Task Manager:**	K Nicholson
IAEA Task Officer:	M Penkin		

Background to Task

From 1997 to 1999, the UK Support Programme was involved in a detailed theoretical study, performed by experts from six Member States and coordinated by the Department of Safeguards, to determine the potential feasibility, practicability, and costs of wide-area environmental sampling (WAES) techniques to detect undeclared reprocessing and/or enrichment activities on a countrywide or large-area basis. The study identified atmospheric sampling as one of the most promising measurement techniques.

Three field trials of air particulate sampling were subsequently undertaken, from 2001 to 2005, to enable the Agency to make an initial evaluation of the potential of the technique as a means to detect undeclared nuclear activities. The first trial was undertaken around a large-scale reprocessing plant (Sellafield, UK), with subsequent trials around a large-scale enrichment plant (Capenhurst, UK) and a small-scale reprocessing operation (Gatchina, Russia). As the three trials were conducted independently and reported over a period of several years, the Agency considered there to be benefit in undertaking a review to integrate and summarise all the findings, the recommendations and the lessons learnt.

The UK Support Programme commenced preparation of the required report in 2009. The report was intended to identify the steps that remained to be taken before WAES might be deployed as an effective safeguards verification measure, including an assessment of the status of techniques.

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Summary Report on Activities in 2012/2013

The final report under this task was issued to a limited Agency distribution list in April 2012. The Agency confirmed that the report fulfilled intended objectives including capturing the knowledge and experience gained during the three field trials. It provided a consolidated summary of the three field trials conducted to evaluate the application and logistics issues associated with air particulate sampling for the WAES.

The report is useful in providing a summary of past experience and an overview of the pertinent issues that need to be addressed should the IAEA wish to implement WAES in the future. This sampling method is not currently employed for safeguards, but is an option mentioned in the Additional Protocol. The document therefore serves an important role in preserving knowledge gained through the field trials for future assessment.

Task A5(i) – WIMSD Reactor Calculations

IAEA SP-1 No:	09/IDS-002	**UK Sub-Contractor:**	Serco Assurance
IAEA SPRICS No:	UK A01853	**UK Task Manager:**	N Davies/B Matthews
IAEA Task Officer:	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 neutronics code. Data on the isotopic composition of both reactor fuel and cladding and construction materials was to be provided in stages, during a task that was originally anticipated to be of one year's duration.

Practical work on the task commenced in September 2010, using a combination of WIMS9A and the FISPIN fuel inventory code. Series of calculations, covering isotopic compositions of fuel and cladding/structural materials for a range of fuel enrichments within five types of power reactor and eight plutonium production or research reactors were 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.

Following the success of the original task, in September 2011 the Agency requested a second phase of work, to model additional reactor and fuel combinations. Descriptions and modelling of a further five power reactors, under various fuelling and irradiation scenarios, were subsequently completed by end-2011/2012.

Summary Report on Activities in 2012/2013

The second phase of work under this task was completed in July 2012, with the issue of data derived from the modelling of a further three research reactors under different fuelling scenarios. In addition, 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 PWR and CANDU reactors.

A third phase of work subsequently commenced in December 2012, targeted primarily at a range of fast reactors and more complex research reactors. Fast reactor modelling is somewhat more complicated than the modelling required during the earlier phases of the task, and information required for modelling is not as abundant as that for thermal reactors. In comparison to the reactor physics calculations that are required to derive flux, cross section and inventory data 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 is important to provide an accurate representation of both resonance shielding and burn-up effects, which may be significant.

To enable the geometry and material properties of each reactor core to be defined, and to propose a calculation method for each reactor, work was to commence with the development of a modelling specification for each of ten reactor designs. Modelling specifications for the first four reactors were completed during 2012/2013, following which the sub-contractor issued a proposal with options for modelling these reactors. This proposal was under consideration at the year-end.

Task Area A6 - 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.

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Task A6(d) - Commercial Satellite Imagery Analysis and Photo Interpretation Support

IAEA SP-1 No:	00/IIS-002	**UK Sub-Contractor:**	-
IAEA SPRICS No:	UK D01329	**UK Task Manager:**	J Tushingham, NNL
IAEA Task Officer:	S Robb		

Background to Task

On the basis of studies by the Member State Support Programmes, 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 2012/2013

In February 2013, the UK Support Programme offered a voluntary contribution to the Department of Safeguards for the procurement of satellite images and equipment, or to support other open source information collection. The Agency responded by requesting that the funds be made available for the procurement of satellite imagery from commercial sources not covered by Agency arrangements under the Regular Budget. Funds were duly utilised for this purpose from the 2012/2013 budget. The UK Support Programme anticipates that a further contribution to open source information collection/satellite imagery may be offered in 2013/2014.

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.

Task A7(e) – Conceptual Development Support for Integrated Safeguards

IAEA SP-1 No:	99/PSS-006	**UK Sub-contractor:**	Wind River Consulting Inc
IAEA SPRICS No:	UK C01265		
IAEA Task Officer:	J Cooley	**UK Task Manager:**	R Hooper

Background to Task

Strengthened and integrated safeguards has changed the nature of safeguards and the knowledge required of those responsible for its implementation. An appreciation is required of safeguards concepts and how these concepts have become manifest in the legal framework and Agency practice. In 2004, a need was identified to provide a paragraph-by-paragraph commentary on INFCIRC/153, and an article-by-article commentary on INFCIRC/540. The commentaries were intended to draw from negotiating histories, but would also include Secretariat assertions to the Board on how the measures included in agreements should be interpreted after 30 years of practice. Late in 2004, the Task Manager commenced work to compile the extensive reference material needed for the development of the commentaries.

It had been intended that the first draft would be completed by the end of 2005. However, difficulties encountered in reaching agreement on the scope and level of detail of the commentary, together with priority being given to assisting the Secretariat with preparations for a new Committee of the Board of Governors, delayed progress, and work was halted in 2007. In 2009, the Agency renewed its interest in receiving a commentary and the task resumed as a joint undertaking with the IAEA, principally the Section Head for Non-Proliferation and Policy Making within the Office of Legal Affairs (OLA).

The INFCIRC/153 and /540 commentary is intended to be a highly accessible description of the evolution of safeguards concepts, legal instruments and Agency practice: an internal working document to assist safeguards implementers. Work on the commentary progressed with completion of introductory and background material addressing the IAEA safeguards system and its evolution, the nature of safeguards conclusions and the negotiation of the comprehensive safeguards requirement contained in the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Sections dealing with the implementation of comprehensive safeguards agreements and the process of strengthening safeguards were also completed, and work commenced on a number of overarching implementation issues. In October 2011, Mr Hooper travelled to Vienna, to continue the task in collaboration with OLA. A copy of a partial draft of the Commentary was provided to OLA upon Mr Hooper's departure from Vienna, in November 2011. Since then, he has continued to provide OLA with a proposed treatment of overarching issues, sending the information in instalments to make it more manageable.

Summary Report on Activities in 2012/2013

Significant progress on the INFCIRC/153 and /540 commentary was made during a second month-long period of work at IAEA Headquarters, from September-October 2012, during which Mr Hooper was supported by staff of OLA. Work on the overarching issues was completed and an outline of the steps involved in implementing a comprehensive safeguards agreement and an additional protocol was prepared. This outline provided the organisational

basis for identifying the implementation issues/problems that have accompanied the implementation process.

In the following months, the Task Manager continued to progress the implementation part of the Commentary, including a substantial body of work requiring input from OLA. With continued support from OLA, it is hoped that a draft Commentary may be completed during 2013/2014.

Task A7(h) - Support for Novel Technologies (Umbrella Task)

IAEA SP-1 No:	06/TDO-07	**UK Sub-Contractor:**	-
IAEA SPRICS No:	UK A01599	**UK Task Manager:**	J Tushingham, NNL
IAEA Task Officer:	J Whichello/J Kocjan		

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.

In 2006, the UK Support Programme agreed to contribute to the project through an umbrella task, initially to provide a contact point for the identification of appropriate expertise and resources. Since then, the UK Support Programme has participated in Technical and Advisory Meetings on laser spectrometry techniques and antineutrino detection and has funded a visit by the IAEA Task Officer to the UK, in addition to assisting in the identification of appropriate expertise within the UK.

Summary Report on Activities in 2012/2013

There was no development activity within the UK Support Programme under this task during the year, whilst the Agency continued to consider the application of portable gas mass spectrometry - including an instrument available through a UK company, Kore Technologies. A feasibility study and assessment of applications was conducted by the Agency, and the UK Support Programme remains willing to consider supporting the work of Kore Technologies, if requested by the Agency.

The Agency continues to encourage Member State Support Programmes (MSSPs) to provide scientific and technical information concerning techniques and instruments of potential application to the effective and efficient implementation of nuclear safeguards. Equally, the Agency requests that the provision of diverse advanced technologies undergo a preliminary evaluation for potential safeguards use by the MSSPs as a prerequisite for sharing technologies

with the IAEA. The UK Support Programme will continue to provide a point of contact with the Agency, to liaise with the Task Officer to identify appropriate UK expertise and to consider specific requests for support within the framework of this task.

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:	08/CCA-002	**UK Sub-Contractor:**	-
IAEA SPRICS No:	UK C01755	**UK Task Manager:**	J Tushingham, NNL
IAEA Task Officer:	J Sprinkle		

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 enabled the participation of UK delegates in a technical workshop on the subject convened by the Agency in October 2008. Discussions at the workshop focussed on facility design and plant operation features that facilitate the implementation of effective and cost efficient IAEA safeguards. The workshop was viewed by the Agency as an important resource and input for drafting an overview report describing the basic principles of IAEA safeguards and fundamental design features and measures that facilitate the implementation of international safeguards. The document "International Safeguards in Nuclear Facility Design and Construction" was subsequently submitted for review to the IAEA Department of Nuclear Energy in February 2012, and will be published as an IAEA Nuclear Energy series document during 2013.

Summary Report on Activities in 2012/2013

The second part of the task, to provide facility-specific guidance, is required to elucidate the facility design features and measures that facilitate the implementation of international safeguards at nuclear fuel cycle facilities. The aim is to provide guidance to designers, operators and owners unfamiliar with the details of international safeguards with information including:

- terminology and definitions;
- the legal basis of safeguards;
- international safeguards objectives;

- elements of the facility and facility design features of particular relevance to safeguards;
- potential technical measures to achieve safeguards goals;
- best practices;
- lessons learnt; and
- opportunities for improving effectiveness and efficiency,

without limiting the designer, operator or State to past approaches, or constraining the negotiation of innovative approaches.

A workshop was held in September 2012, to discuss facility-specific documents with the focus on nuclear reactors, and a draft document on safeguards by design for nuclear reactor facilities, "International Safeguards in the Design of Nuclear Reactors", was prepared by the Agency. Safeguards experts from two UK Government Departments reviewed the document and provided feedback, before it was finalised within the Agency for issue in 2013.

A meeting was convened by the Agency in March 2013, to draft three new guidance documents addressing inclusion of safeguards in the design process for conversion, fuel fabrication and spent fuel management facilities. Review of these documents will take place during 2013. The Agency envisages the preparation of additional draft documents, covering enrichment and reprocessing plants, during a meeting tentatively scheduled for September 2013, with the UK Support Programme continuing to participate in the technical review process.

Task A7(k)- Acquisition Path Analysis Methodology and Software Package

IAEA SP-1 No:	10/CCA-004	**UK Sub-Contractor:**	Tessella plc
IAEA SPRICS No:	JNT C01871	**UK Task Manager:**	D Dungate
IAEA Task Officer:	S Munoz		

Background to Task

The IAEA is continuing to enhance the effectiveness and efficiency of safeguards by further developing and applying a holistic approach that focuses on the nuclear programme of the State as a whole, rather than the sum of its declared nuclear facilities: the so-called State-level concept. Development of the State-level concept is possible due to the availability of increased quantities and quality of safeguards-relevant information. Acquisition Path Analysis is an essential element of the State-level concept, to determine whether a proposed set of safeguards measures would provide sufficient detection capability with respect to a specific acquisition path or acquisition strategy. To implement the State-level concept, it is necessary to perform an ongoing analysis of all safeguards-relevant information concerning a State and its relevance to the acquisition path for that State. Such analysis must be based on accepted safeguards methodology, to ensure the objectiveness and consistency of State evaluations, and should factor in expert judgements and State-specific factors for the evaluation.

The Agency proposed a task to provide a coordinated framework for Member State Support Programmes to work together within a dedicated IAEA work group to produce an accepted

methodology, enhanced safeguards knowledge and customised software tools. The UK Support Programme accepted the task, initially to enable Tessella, a technology and consultancy company, to provide input to a proposed workshop on acquisition path analysis methodology. In June 2011, Tessella participated in a workshop comprising a series of presentations from the Agency and Member States followed by three working group sessions. An outcome from the meeting was a proposal that the UK prepare a report describing objective techniques for combining different sources of information into measures of likelihood or confidence in data that can be used in acquisition path analysis. It was agreed that Tessella would undertake work to:

1. Consolidate its understanding of the types of data and uncertainties that are applicable to the acquisition path problem, and what outputs are required;
2. Identify and review candidate techniques from literature and Tessella's previous experience that have the potential to be used in this context;
3. Identify a set of evaluation criteria for the methods and use these to analyse the benefits and drawbacks of each candidate approach; and
4. Select a shortlist of the best candidate techniques for further investigation or prototyping.

In March 2012, the Agency advised that it had almost finished defining the methodology for acquisition path analysis, having moved away from a mathematical approach to one that was less numeric. There was to be increased emphasis on 'estimator language', for example, 'low to medium confidence' in propositions. Tessella's experience in qualitative techniques, such as avoiding cognitive biases, was therefore of greater relevance. It was agreed that the final report would include some demonstration of how these techniques work on example data.

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Tessella was provided with example data on a fictitious State by the Agency, prior to a meeting between Tessella technical staff and Agency personnel in October 2012. During the meeting, Tessella presented its work to date, focusing on cognitive biases that affect people's ability to combine information, and candidate techniques that may help with these problems. These techniques were discussed with the Agency, and usability tests were carried out to see how comprehensible and useful the candidate techniques were. This gave some clear feedback:

- The more mathematical techniques can be difficult for Agency staff to use: not simply because they are unfamiliar but because their understanding of the situation can be difficult to express in these forms. When asked for a numerical value, it may not be possible to define exactly what is required: the probability of X; of X given Y; the likelihood of Y given X, etc.
- There was interest in using mathematical techniques for a few specific cases, but more general interest in using visualisation techniques to add structure to the reasoning process.
- There was considerable interest in the area of cognitive biases, and how working through a formal technique might help to identify and overcome some common biases even without using an equation.

Following this feedback, priorities were agreed for the remaining part of the study. In addition to documenting the results of usability testing, Tessella would focus on describing visual techniques that help to illustrate a reasoning process.

Tessella's draft report, on objective techniques for combining different sources of safeguards-relevant information into measures of likelihood or confidence in data that can be used in acquisition path analysis, was forwarded to the Agency for review in January 2013. A meeting was held with the Agency the following month, during which the Task Manager gave a presentation on the contents of the draft report and conducted a workshop to illustrate the recommended techniques, using some example scenarios provided by the IAEA. Feedback from the Agency was incorporated into a revised report, which is expected to be available for final review by the Task Officer early-April 2013.

Further support may be provided during 2013/2014, for example to assist the Agency in training and roll-out of techniques.

Task A7(l) – Member State Contributions to IAEA Topical Guidance on Safeguards Implementation

IAEA SP-1 No:	12/CPC-001	**UK Sub-Contractor:**	Sellafield Site Ltd
IAEA SPRICS No:	JNT C01959	**UK Task Manager:**	J Tushingham, NNL
IAEA Task Officer:	C Mathews		

Background to Task

Task Proposal 12/CPC-001 sought the participation of experts from Member States and their input into 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 have resulted from experience and evolution over years of implementation. These detailed topical guidance documents would build upon the Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols. They are 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.

The IAEA intends to organise two expert meetings focused on each specific topic and document. The outcome of the first meeting on each topic will be a plan for preparing and submitting input to the guidance document and an annotated skeleton of the document with the input for each section summarised. Participants would then prepare input as agreed in the plan, prior to a second meeting, to review and improve the draft document before it is finalised by the IAEA. Each document is expected to be published approximately 18 months after the first meeting.

Summary Report on Activities in 2012/2013

Meetings were scheduled to cover the first two topics proposed by the Agency, as follows:

- 16-19 April 2013 - Input to guidance on facilitating IAEA in-field activities;
- 23-26 April 2013 – Input to guidance on establishing and maintaining an SSAC and associated infrastructure;
- 5-8 November 2013 – Review of guidance on facilitating IAEA in-field activities; and
- 12-15 November 2013 – Review of guidance on establishing and maintaining an SSAC and associated infrastructure.

The UK Support Programme accepted the task in March 2013, initially to provide input to the guidance document for IAEA safeguards activities associated with facilities, sites and other locations. A member of the Safeguards Office of Sellafield Site Ltd is expected to participate in the meetings, and to provide additional support from within the UK. Further support may be provided in 2014, to cover additional topics.

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:	08/ICA-003	**UK Sub-contractor:**	King's College London
IAEA SPRICS No:	UK D01730	**UK Task Manager:**	J Kidd
IAEA Task Officer:	C Eldridge		

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 2012/2013

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 2012/2013.

Four State Profiles were updated. In addition, an ad-hoc report on the subject of research on heavy water, nuclear power reactors and nuclear research reactors was prepared. Updates on political issues were also researched and sent to the Agency during the year.

Activity will continue through 2013/2014, 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:	08/ICA-002	**UK Sub-contractor:**	King's College London
IAEA SPRICS No:	UK D01728	**UK Task Manager:**	J Kidd
IAEA Task Officer:	C Eldridge		

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 2012/2013

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 2012/2013.

Two State Profiles were updated, with a further three developed in specific technical areas. 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 2013/2014, 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:	09/ICA-012	**UK Sub-contractor:**	King's College London
IAEA SPRICS No:	UK D01916	**UK Task Manager:**	I Stewart
IAEA Task Officer:	P Schot		

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 proliferation activities. Task Proposal 09/ICA-012 sought to improve understanding of the availability and feasibility of predictive analytical approaches, develop capabilities to improve the recognition of non-declared activities through the assessment of non-technical indicators and consider methods to improve the acquisition of information. This was expected to include consultancies on trade analysis and export control.

The UK Government has an existing project on proliferation procurement. By December 2011, activities under the project had included:

- Engagement with hundreds of companies and tens of trade associations involved in dual-use industries;
- Gathering and analysing input on compliance and non-proliferation from 75 – 100 British companies; and
- Highlighting to national authorities the role the private sector should play in countering proliferation, together with recommendations on how this role can be realised.

The UK project on proliferation procurement provides new insights into proliferation risks and how to enhance proliferation risk analysis and awareness. Task Proposal 09/ICA-012 was accepted by the UK Support Programme in December 2011, to enable the Agency to benefit from the research carried out under the UK project. During the remainder of the financial year, work included the preparation of proliferation briefs, detailing proliferation concerns and compliance requirements across themes including metals; machinery; and control systems, production of a WMD awareness training module in collaboration with Cranfield University and the launch of a proliferation awareness website.

Summary Report on Activities in 2012/2013

A paper and presentation on illicit trade were prepared and shared with the Agency during a conference in October 2012, prior to publication of the paper in an academic journal. The paper provided a net assessment of a State's nuclear-related procurement requirements based upon open source and illicit trade data. The presentation highlighted the value of monitoring illicit trade to support the IAEA's mission. Prerequisites to effective use of illicit trade data were included in a related paper, to be shared with national authorities. Work was also undertaken on the proliferation risks associated with proliferation-sensitive composite materials. Data drawn from the UK Government project's work on illicit trade was combined with knowledge

drawn from experts in the manufacture of certain technologies and materials, and the information was shared with the IAEA.

The Agency has a need for trade and manufacturing data on certain proliferation-sensitive technologies. In particular, the Agency has an interest in knowing which firms manufacture the specific grades of materials that are sought by proliferators. The UK research project has already engaged leading experts in one area, to produce a report on companies with the capability to produce grades of proliferation concern, and their report has been shared with the Agency. There may be additional technologies of specific interest to the Agency, and these will be explored during 2013/2014.

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 Nuclear Material Laboratory (NML), 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. More recently, support has focussed primarily on the Agency project Enhancing Capabilities of the Safeguards Analytical Services (ECAS), and also continued support to the development of 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 SGAS

IAEA SP-1 No:	08/TTS-004	**UK Sub-Contractor:**	NNL
IAEA SPRICS No:	UK C01742	**UK Task Manager:**	J Tushingham
IAEA Task Officer:	C Mansoux		

Background to Task

In 2006, the Task Manager 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. One of the main recommendations of that workshop was that the Agency should explore the possibility of expanding the existing NWAL for nuclear materials analysis.

Under the current task, the UK Support Programme subsequently explored the possibilities and practicalities of expanding the NWAL, and the degree of expansion required under different scenarios to provide the Department of Safeguards with sufficient analytical support to satisfy the timeliness and performance criteria for safeguards. The Task Manager chaired

a Panel of Consultants, convened by the Agency to provide recommendations on the current and future requirements for analytical services, and provided further input to the Agency in respect of advice on the draft plans for a new NML and the constraints on its mission that could be envisaged following the development of appropriate support from the NWAL. He completed a report on options for the utilisation of an NWAL for nuclear materials analysis, with emphasis on how to maintain a sustainable resource to supplement the Agency's in-house capabilities and mitigate against a single point of failure. In addition, he chaired two further Experts' Meetings, in June 2010 and May 2011, convened by the Agency to review the conceptual design of the proposed new NML and 30% design, respectively, and participated in a workshop on progress and developments in the ECAS project that drew significantly on the earlier UK Support Programme contributions.

Additional advice and support was provided on request during the remainder of the year from within the UK. In January 2012, an extrabudgetary voluntary contribution of €500,000 was provided through the UK Support Programme, for application by the Agency in support of the ECAS/NML project.

Summary Report on Activities in 2012/2013

The scope of this task was broadened during 2012, to enable the provision of ad-hoc implementation support to the Safeguards Office of Analytical Services (SGAS) and to facilitate technical exchanges between UK experts and SGAS analytical laboratories.

On 22 February 2013, the DDG Safeguards was advised of a further extrabudgetary voluntary contribution of €500,000 from the United Kingdom towards the successful accomplishment and completion of the ECAS project. The funds were subsequently transferred to the Agency's bank account on 6 March 2013.

Support will continue to be required by the Department of Safeguards, as it progresses transition arrangements to the new NML, and the UK Support Programme anticipates providing further assistance to the ECAS Programme during 2013/2014.

Task B1(v) – Evaluation of Ultra-High Sensitivity Secondary Ion Mass Spectrometry for Environmental Samples

IAEA SP-1 No:	08/IDS-002	**UK Sub-Contractor:**	AWE
IAEA SPRICS No:	UK A01776	**UK Task Manager:**	A J Pidduck
IAEA Task Officer:	L Sangely		

Background to Task

SIMS is employed by several laboratories within the IAEA NWAL for environmental samples, and the IAEA operates its own instrument in the Clean Laboratory. SIMS offers relatively rapid measurement of samples at moderate mass resolution and sensitivity, but the quality of data for minor isotopes is affected by high molecular ion interferences and low signal strength, leading to high uncertainty in results. The alternative technique of FT-TIMS offers improved performance in the measurement of minor isotopes, which can provide important information in support of safeguards conclusions or detection of undeclared

activities. However, FT-TIMS is available to very few laboratories and it is not considered feasible for the Agency to develop its own in-house FT-TIMS capability.

The Agency requires an independent capability to measure minor isotopes in environmental samples. In the absence of FT-TIMS, a more sophisticated type of SIMS instrument, Large-Geometry (LG) SIMS, was considered. 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. QinetiQ had access to an existing LG-SIMS instrument at Edinburgh University, in addition to its own conventional SIMS instruments. During 2008/2009, the UK Support Programme undertook comparative trials of conventional and LG-SIMS instruments, presenting the initial results at an IAEA Particle Analysis Consultants' Group Meeting in October 2009. Trials continued in 2010/2011, and work subsequently commenced on the preparation of a full report on the UK SIMS comparison trials. This was subsequently revised, to provide updated information on LG-SIMS and the status of the NWAL. Meanwhile, the Agency procured its own LG-SIMS instrument, with installation completed during 2011.

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 Aldermaston, the Agency sought expert support from QinetiQ's former staff in commissioning and operation of its LG-SIMS instrument. The UK Support Programme provided funding to secure the services of a SIMS expert under a Special Service Agreement, running from December 2011 to February 2012 inclusive. During this period, the UK SIMS expert assisted in developing the Agency's in-house capability whilst obtaining valuable experience to bring back to the UK. AWE intends to procure its own LG-SIMS instrument and it is hoped that this can be utilised, in part, in support of Agency environmental sample analysis.

Summary Report on Activities in 2012/2013

A report on the comparative trials of SIMS and LG-SIMS in the UK was issued in April 2012.

Two SIMS experts from AWE participated in an informal meeting of NWAL members on the subject of LG-SIMS uranium particle analysis in October 2012. Representatives from five laboratories with experience of operating Cameca 1270 or 1280 LG-SIMS instruments for isotopic analysis of uranium particles were present, and the forum facilitated in-depth discussion of the latest experiences with instrument installation and operation, of advances in sample preparation and data analysis, as well as of IAEA sample analysis requirements and priorities. Later that month, AWE hosted a visit by two staff members from SGAS. This enabled presentation of the results from AWE's SIMS re-validation exercise and provided the opportunity to discuss AWE's capabilities and visit laboratories utilised in support of low-level analyses.

The Agency wishes to continue to utilise the expertise of AWE staff, as it continues the development of an in-house LG-SIMS capability.

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 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) - DIV Exercise at Bulk Handling Facilities

IAEA SP-1 No:	06/TTR-003	**UK Sub-Contractor:**	NNL
IAEA SPRICS No:	UK B01618	**UK Task Manager:**	S M Francis
IAEA Task Officer:	D Lacey/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, over 350 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 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.

Summary Report on Activities in 2012/2013

The course on safeguards and design verification at bulk handling facilities was successfully delivered to twelve IAEA inspectors, accompanied by two Agency tutors, from 7-17 May 2012. The itinerary included two days of classroom-based lectures and practical exercises, including a general description of the main processes relating to reprocessing, conversion and fuel fabrication operations; DIE and DIV concepts and procedures; and exercises involving checking the accuracy and completeness of design information and identifying possible routes for the diversion of nuclear material. These were followed by six days of site visits, taking in

facilities at Springfields and Sellafield, with a final day for reporting back and making presentations.

At Springfields, the course commenced with a tour of the Oxide Fuels Complex and preparatory time for exercises. This was followed by a site-wide exercise, to identify the buildings and locations relevant to the facility's declared operations and to assess whether the site could support undeclared nuclear operations. A full day in the B633 Residue Recovery plant proceeded with DIE/V exercises involving the pulsed column and harp tank/dissolution areas, with the third day including operational status (i.e. Essential Equipment) exercises within the B336 natural uranium conversion area and time for the preparation of results. The course participants were supported throughout by plant guides and UK experts in conversion and fuel fabrication.

Exercises at Sellafield proceeded over a three-day period, encompassing THORP and the NNL Central Laboratory. Within THORP, each group of three participants completed exercises in selected elements of DIE/V, supported by experts from THORP operations. The Central Laboratory was utilised to complete a Design Information Questionnaire (DIQ) exercise, providing the opportunity for an exercise that covered a range of both large and small facilities.

The course was completed off-site, with participants presenting the conclusions of their practical work. Based upon their presentations, the participants in all four groups completed the exercises successfully and demonstrated an understanding of the facilities.

The Agency confirmed its desire for the course to be repeated in May 2013, and arrangements for the 2013 course were subsequently progressed. Some changes were envisaged for the 2013 course, including additional training in the understanding and use of engineering drawings and consolidation of some exercises, and these were reviewed late in 2012/2013.

Task C1(f) - Training on the Nuclear Fuel Cycle and Proliferation Pathways

IAEA SP-1 No:	07/CTR-004	**UK Sub-contractor:**	NNL
IAEA SPRICS No:	UK B01698	**UK Task Manager:**	S M Francis
IAEA Task Officer:	S Pickett		

Background to Task

A principal objective of the IAEA strengthened safeguards system is to provide assurance of the absence of undeclared nuclear activities in Member States. Under the 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 with the aim to provide:

- A high level of knowledge of process technologies associated with many fuel cycle facilities; and
- An understanding of the most typical technical indicators of possible undeclared activities that would be observable (either visually or analytically) during the implementation of safeguards at such fuel cycle facilities.

Over the next seventeen years, the course was run on 29 occasions by the UK Support Programme.

Summary Report on Activities in 2012/2013

Two Nuclear Fuel Cycle and Proliferation Pathways Courses were run in 2012, in June and November. These concentrated on the safeguards-relevant elements of the nuclear fuel cycle and on the nuclear proliferation pathways associated with its more 'sensitive' activities, such as enrichment, fuel reprocessing, MOX fuel fabrication and power generation from reactors capable of unreported plutonium production.

The 30th Proliferation Pathways Course was delivered to 16 participants from Operations and Support Divisions, with introductory lectures at IAEA Headquarters followed by a week-long residential course at Puchberg. The introductory lectures covered an introduction to proliferation indicators and the nuclear fuel cycle, and integrated safeguards and information review. The course that followed provided for one day of presentations and exercises per fuel cycle stage, with the UK Support Programme providing five experts who gave lectures on subjects including conversion, enrichment, reprocessing and reactors. For the June course, modified conversion, enrichment, reactor and reprocessing exercises were used with the aim of providing a consistent scenario through the fuel cycle.

A further 16 participants attended the 31st Proliferation Pathways Course in November 2012. The course followed the same format as the previous one, with the UK Support Programme again providing five experts. For this course the reprocessing and reactor modules were expanded, introducing new material from facilities around the world.

Demand from the Department of Safeguards for the course remains high, with the course now considered mandatory for all staff that sit on State Evaluation committees, and a further two Proliferation Pathways Courses were requested by the Agency for 2013/2014. These are expected to be held in June and November, and planning for the courses commenced during the year. Further revision of course modules is expected, to reflect developments in safeguards and non-proliferation, and the training manuals and presentations will be updated.

Task C1(t) – Revision to Nuclear Fuel Cycle Training Manuals

IAEA SP-1 No:	07/CTR-010	**UK Sub-Contractor:**	NNL
IAEA SPRICS No:	UK B01727	**UK Task Manager:**	S M Francis
IAEA Task Officer:	S Pickett		

Background to Task

The Department of Safeguards requires up to date information on all parts of the fuel cycle, to train inspectors and to provide information and training to Member States. In 1985, a series of training manuals was prepared that described the technical aspects of fuel fabrication, research reactors, critical assemblies, nuclear power plants and reprocessing plants. In 2007, the Agency requested support in preparing updated manuals, to reflect developments in the fuel cycle, plus expansion of the range to include the front end of the fuel cycle, waste and, most importantly, enrichment.

Individual Member State Support Programmes were expected to take responsibility for preparation of the different manuals, with the UK Support Programme agreeing to provide the revised Fuel Fabrication and Power Reactor volumes. Work was subsequently undertaken on both manuals, with the Fuel Fabrication manual completed during 2010 and published the following year. However, the Power Reactor manual required further work, to broaden the scope to a worldwide focus, and this was subsequently undertaken together with the revision of sections that dealt with gas-cooled and boiling water reactors. Input from the Agency's Department of Nuclear Energy provided additional detail but also possibly biased the manual towards reactor design, engineering and safety systems. Further work was therefore required in order to provide a safeguards focus. Meanwhile, the UK Support Programme was requested to commence preparation of a Reprocessing manual. A first draft was completed during a week-long session in Vienna, in December 2011, and an additional section on pyroprocessing prepared by the Agency was incorporated into the manual.

Summary Report on Activities in 2012/2013

The Agency requested additional support in a number of areas, in order to progress the various technical manuals in preparation under this task.

The UK Support Programme was requested to revise the core physics section of the Research Reactors manual, to review and potentially re-characterise the 'types of research reactor' section and to edit the TRIGA reactor section. This work was completed and passed to the Agency during 2012. Files associated with the Power Reactor manual were subsequently provided with a request for limited input and review by June 2013.

A more extensive review was required of the Reprocessing manual, and this was undertaken by an expert from Sellafield Ltd. Following review with the Task Officer in November 2012, revisions were completed, and the final version was provided to the Agency in March 2013.

The Task Manager was requested to review and provide comments on the Mining, Milling and Conversion manual, initially with emphasis on the conversion section but later expanded

to consideration of the whole manual. This activity was completed in March 2013, and is expected to lead to requests for further support during 2013/2014.

Task C1(u) – Limited Frequency Unannounced Access (LFUA) Training

IAEA SP-1 No:	08/CTR-004	**UK Sub-Contractor:**	Urenco Capenhurst
IAEA SPRICS No:	UK B01797	**UK Task Manager:**	D Williams
IAEA Task Officer:	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. The first full LFUA course was subsequently run under the Netherlands Support Programme, at Urenco (NL) Almelo, in September 2010. A second course was run at Capenhurst, in January 2011, and a third at Gronau, under the auspices of the German Support Programme, in October 2011. The 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. The UK Support Programme enabled the continued participation of Urenco UK staff, as part of a team from the three Urenco sites used to facilitate the courses.

Summary Report on Activities in 2012/2013

A course took place from 2-4 October 2012 at Almelo, Netherlands, under the auspices of the Netherlands Support Programme. Urenco (Capenhurst) provided support to the course, the content of which was changed to include greater emphasis on routine inspection and DIV activities. Very positive formal feedback was received from both course participants and instructors, confirming that the revised course met the participants' professional needs for implementing safeguards at enrichment plants.

The UK Support Programme anticipates continuing to facilitate support from Urenco (Capenhurst) staff to future courses, with the next course at a Urenco site expected to be held in 2014.

SRDP-PR33

Task C1(v) – Negotiation Skills Training Course

IAEA SP-1 No:	10/CTR-006	**UK Sub-Contractor:**	ADRg Ambassadors
IAEA SPRICS No:	UK B01874	**UK Task Manager:**	P Jenkins
IAEA Task Officer:	R Barnes		

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. These include direct/positive speaking, careful listening, open questions, impartiality, confidentiality, emotions, self-esteem and face-saving strategies, handling values, differing ethnic/cultural value systems and dealing with 'spoilers' and 'bad leaders'.

Late in 2010, the UK Support Programme was requested 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.

Summary Report on Activities in 2012/2013

A second diplomatic negotiation skills training course was held in Vienna from 24-27 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 course was extremely positive, and the Agency proposed that the course be held on an annual basis. The next course was subsequently scheduled for October 2013.

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

IAEA SP-1 No:	11/CTR-004	**UK Sub-contractor:**	NNL
IAEA SPRICS No:	UK B01903	**UK Task Manager:**	S M Francis
IAEA Task Officer:	S Pickett		

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 in the process 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, with a second course run to the revised format in March 2012.

Summary Report on Activities in 2012/2013

The third course 'Advanced Training on NFC Facilities to Assist State Evaluation' was held during October 2012, for the benefit of nine course participants. This included an introduction in Vienna, involving presentations on the sites to be visited, imagery analysis techniques and open source analysis, followed by more detailed study of site imagery and schematics plus examination of a package of open source information related to the two sites. There followed a week of detailed technical visits to sites, plant and equipment at Sellafield and Springfields.

At Sellafield, detailed tours included Calder Hall; the Fuel Handling Plant; MAGNOX and THORP Reprocessing Facilities; the vitrification plant; laboratory areas; and a satellite imagery and open source analysis exercise based at the low-level waste facility at Drigg. At Springfields, a similarly detailed level of visits encompassed main line chemical plants; the Oxide Fuels Complex; Enriched Uranium Residues Recovery Plant; and fuel fabrication areas.

A fourth course was held to the same format during February/March 2013, again for nine course participants. Feedback from both courses was very positive, and will be used to fine-tune further courses anticipated for October 2013 and March 2014.

Task C1(x) – Developing Analytical Skills for Safeguards

IAEA SP-1 No:	12/CTR-001	**UK Sub-contractor:**	-
IAEA SPRICS No:	UK B01940	**UK Task Manager:**	S Saintclair-Abbott
IAEA Task Officer:	J M Crété		

Background to Task

With the Agency's efforts to implement the State-level concept, involving safeguards that are objectives-based and utilise all safeguards-relevant information, together with developments in nuclear fuel cycle related technologies, the tasks of safeguards staff are evolving. As a result, the training needs for analysis have increased. 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.

The Department of Safeguards wished to strengthen the level of professional analytical capability within its work. The US Support Programme already runs a two-day workshop, providing familiarisation with a range of techniques, whilst a three-day course through the Australian Support Programme considers 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.

To explore the potential for UK Support, experts visited the IAEA during November 2011, participating in meetings with the Training Section of the Department of Safeguards. Following the visit, the UK experts agreed to provide support, for at least a pilot course, and started work to adapt existing material for use by the IAEA.

Summary Report on Activities in 2012/2013

A detailed draft of the course content was reviewed with the Agency and the structure and scenario material for a 5-day training course in a range of analytical techniques was finalised in July 2012. A 'dry run' was held in the UK in October 2012, with each topic on the course consisting of a lecture followed by an exercise, enabling adjustment and refinement of the course prior to delivery to the Agency.

The pilot of the course took place at IAEA Headquarters from 12-16 November 2012, delivered by three UK experts to 13 inspectors and analysts from the Department of Safeguards. The pilot 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, subject to the availability of the UK experts, the UK Support Programme was requested to facilitate a further two training courses in 2013.

Before the first of these courses, scheduled for May and November, its content was reviewed during a meeting with the Agency in February 2013. The course was subsequently revised, to provide more time for the final exercise, and a more proscriptive view will be taken as to the outputs that are expected from the exercise. In terms of delivery, the Agency may present one or two modules of the May course, before taking on a more substantial training role in

November. The intention is that the Agency will ultimately provide the training in-house, with the UK providing a continuing consultancy.

Task C1(y) – Specialised Training and Visit to Nuclear Facilities

IAEA SP-1 No:	12/CTR-006	**UK Sub-contractor:**	-
IAEA SPRICS No:	UK B01936	**UK Task Manager:**	J Tushingham, NNL
IAEA Task Officer:	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 IAEA's internal committee, which overseas 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.

Summary Report on Activities in 2012/2013

This task was accepted in June 2012, and was first used to enable a UK contribution to the training of a group of inspectors in Vienna, scheduled for December 2012. The possibility was also explored to utilise the task to enable a training visit for analysts from the Agency's Satellite Imagery Analysis Unit, to UK facilities. However, it proved impossible to schedule this event, which is now expected to take place later in 2013.

Use of this task for ad-hoc training through the Safeguards Training Section is intended to 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

IAEA SP-1 No:	10/OA2-001	**UK Sub-Contractor:**	University of Glasgow
IAEA SPRICS No:	UK D01878	**UK Task Manager:**	J Howell
IAEA Task Officer:	K Zhao		

Background

A software tool to simulate the nuclear material accountancy system for MOX facilities was required by the Agency, to support review of the operator's accountancy system design and the refinement of safeguards approaches for the J-MOX facility. The 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 statistics in nuclear material accounting under different diversion scenarios, identify major contributors to 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 completed between April and December 2011, and a draft report and sample studies were produced. A meeting was held at IAEA Headquarters in December 2011 to review progress, at which the end-users requested further refinement, to provide a more flexible tool, before commencing in-house studies.

Summary Report on Activities in 2012/2013

All of the software developments agreed in December 2011 were implemented, and delivered to the Agency during meetings in June 2012. These included:

- output of the build-up of glovebox holdups;
- provision of repeatable random number sequences;
- consideration of the program software control;
- addition of columns for systematic errors; and
- improvements to the recycling component of the simulation, with dosing to be recalculated based upon destructive analysis.

The new, flexible, MOX software was installed and demonstrated, with further modifications made during the visit. In particular, the program was modified to allow for the introduction of additives at each stage.

A third phase of enhancements was implemented by the end of 2012. A close collaboration between the Task Manager, Task Officer and an Agency cost-free expert (CFE) led to the development of a software tool that is considerably different to that originally offered. The revised tool has a number of features that reflect the likely realistic operation of a MOX plant, as opposed to its nominal design operation. The simulation package is now a great deal more flexible, so that the IAEA can enter proprietary information and perform studies. A draft report was prepared to support this goal, and sent to the Task Officer for review.

The Task Manager followed up submission of the draft report with two further visits to IAEA Headquarters. In January 2013, he worked with the Agency to review the simulation tool and report in detail. Improved equations were agreed, to remove certain assumptions when performing detailed can calculations that were unlikely to be valid at J-MOX. Re-programming commenced, to investigate the implications of incorporating these revisions, with work continuing from the UK. The report was revised to reflect these changes, and reviewed against the computer program installed on Agency laptops. A number of issues were identified, and it was agreed that these would be addressed prior to a second visit. A second visit, in March 2013, then enabled progress to be reviewed and work to be undertaken on test cases.

Requests for further enhancements are considered unlikely to come before end-users have engaged with the software tool. Meanwhile, extensive testing by the CFE is expected to require support from the Task Manager in 2013, prior to involving the end-users themselves.

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 E10 – Instrument Vulnerability Assessments

Technical assessments of vulnerabilities are required during equipment development; to optimise design; prior to implementation; and periodically during the lifetime of the equipment, to account for advances in technology. It is important that the IAEA gains assurance through verification by organisations neither connected with the manufacturer nor operating facilities where the equipment may be employed by the IAEA. However, during development, it is more appropriate to employ a vulnerability assessor from the same State as the equipment manufacturer, and to foster collaboration between developer and assessor in order to optimise resistance to tamper. The assessment techniques applied may be defined by the IAEA, who will highlight specific features or applications for analysis. Equally, the assessor may be left to utilise a broad range of technologies in an attempt to exploit potential vulnerabilities. The results from assessments are provided in confidence to the IAEA.

Task E10(j) - Laser Surface Authentication Prototype Test and Evaluation

IAEA SP-1 No:	08/TSR-003	**UK Sub-contractor:**	Ingenia Technology
IAEA SPRICS No:	UK E01762	**UK Task Manager:**	J Tushingham, NNL
IAEA Task Officer:	B Wishard		

Background to Task

Laser Surface Authentication (LSA) is a technique developed in the UK, to identify materials using an intrinsic fingerprint extracted by a laser scanning device. Such a method, if successfully proven for safeguards application, could lead to automation of seals identification within the Agency's Seals Laboratory, and could also enable authentication of seals on site or in-situ, in addition to increasing confidence in the integrity of the metal seal.

The Department of Safeguards requested that the UK Support Programme provide financial assistance towards the procurement of two prototype LSA instruments plus one field scanner. These were to be utilised in a vulnerability assessment and parallel development work within the IAEA's seals laboratory. In March 2009, the UK Support Programme completed a voluntary financial contribution towards the procurement of LSA equipment from Ingenia Technology. Ingenia Technology worked directly with the Agency during the following

year, supplying two laboratory LSA instruments and a portable scanner for evaluation at the Seals Laboratory. The performance of the instruments was generally satisfactory, although difficulties were encountered in reading the serial numbers engraved on the seals when using the in-built character recognition software, particularly in the case of mechanically deformed or corroded seals. The use of a 2D barcode on the seals was successfully implemented as a solution to the difficulties encountered in reading serial numbers. Meanwhile, the Agency proceeded to a full third-party vulnerability assessment, which was completed in January 2012. Application of LSA, and further assistance from the UK Support Programme, would depend upon the conclusions from this assessment.

Summary Report on Activities in 2012/2013

Ingenia Technology continued to work directly with the Agency, so that this task was effectively on standby from a UK Support Programme perspective. A physical security team from the Department of Safeguards conducted experiments with the LSA instruments to verify the conclusions of the third-party vulnerability assessment. These experiments confirmed the assessor's view that the LSA technique could not replace the existing technology, due to the effect of corrosion on the metal seals, and it was agreed that the task should be considered complete.

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 assistance to the Department of Safeguards through the preparation of technical manuals and procedures for NDA instrumentation used by safeguards inspectors. This work has been undertaken by staff from Canberra-UK Ltd since 1996.

Task E11 - Technical Manuals and Procedures for Safeguards Instrumentation

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

Background to Task

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 and ICx Raider.

Summary Report on Activities in 2012/2013

During 2012, two additional categories of equipment were identified by the Agency that required documentation updates:

- EHP LD5, LD10 and LD20 Crane Weighers; and
- 3 Tonne 30B U Cylinder Reference Weight.

The information and existing documentation/templates required to carry out this work were received from the Agency, prior to work commencing in October 2012. Drafts of the reference manual and checklist procedure for the Crane Weighers were completed, and issued to the Task Officer for review during December 2012. The draft reference manual for the 30B Reference Weight was completed and sent to the Task Officer in February 2013. The Agency's review of the documents was in progress at the year-end, so no further work was undertaken on them within the UK Support Programme.

The UK Support Programme anticipates contributing to the preparation of further documents, in response to requests from the IAEA, during 2013/2014.

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.

Task E12(d) – On-Line Enrichment Monitor (OLEM)

IAEA SP-1 No:	10/TAU-004	**UK Sub-contractor:**	-
IAEA SPRICS No:	UK A01868	**UK Task Manager:**	J Tushingham, NNL
IAEA Task Officer:	E Smith		

Background to Task

The concept of an On-Line Enrichment Monitor (OLEM), enabling a relative enrichment measurement on a header pipe, is seen by the Agency as a powerful and direct way to support the goal of ^{235}U material balance in large-scale enrichment plants. The intention would be to install OLEM at Gas Centrifuge Enrichment Plants, to monitor permanently and accurately the uranium enrichment of uranium hexafluoride in unit header pipes through application of passive gamma spectrometric measurements.

Task Proposal 10/TAU-004 was issued by the Agency in March 2010, with the scope to develop the measurement technology and system architecture required to measure and record accurate enrichment of the uranium hexafluoride circulated in the three high pressure unit

header pipes (Feed, Product and Tails) of each enrichment unit. A phased approach was foreseen, commencing with system design and cost evaluation against IAEA user requirements. This was to be followed, subject to positive evaluation, by manufacture and subsequent demonstration on an appropriate test bed facility.

Following extensive discussions between Urenco, the US Department of Energy (USDoE), Los Alamos National Laboratory and the IAEA, Urenco agreed to allow a field test of an OLEM of US origin at its Capenhurst enrichment plant. Contractual arrangements were agreed late in 2010. USDoE and Agency parties subsequently met at Urenco Capenhurst in January 2011, to enable the US side to gather preliminary analysis data at a product header pipe location and to discuss the preliminary results with meeting participants.

Summary Report on Activities in 2012/2013

An on-site field trial progressed through 2012/2013 without call on the resources of the UK Support Programme. Urenco (Capenhurst) worked directly with the IAEA and US parties to facilitate testing.

Task E12(e) – Support for the Safeguards Systems at the JNFL MOX Fuel Fabrication Plant (J-MOX)

IAEA SP-1 No:	08/OA2-001	**UK Sub-contractor:**	Hybrid Instruments
IAEA SPRICS No:	UK A01887	**UK Task Manager:**	M Joyce
IAEA Task Officer:	A Lavietes		

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}He is widely used in neutron detectors due to its outstanding γ-ray rejection properties. Recently, a world-shortage of ^{3}He has led to renewed interest in systems based upon ^{10}B and even ^{6}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.

The Mixed Field Analyser (MFA) produced by Hybrid Instruments, a UK start-up company, is a small, portable instrument that performs real-time neutron/gamma discrimination of scintillator pulses for direct input into a data acquisition and analysis system. The instrument was evaluated by the IAEA, at its Headquarters in Vienna and then at Rokkasho in Japan, and found to offer superior performance to any other development in neutron detection. The UK Support Programme was requested to enable its further development, to produce an advanced MFA with the following performance specification enhancements:

- Three parallel data processing channels;
- One million counts per second throughput per channel;
- Signal processing timing jitter of less than 5ns;
- Channel to channel timing jitter of less than 5ns; and
- An industrial operating temperature range of -40°C to +85°C.

This work was completed and additional developments undertaken including:

- A means to incorporate a nonlinear threshold for optimisation of neutron/gamma discrimination;
- Improvements to the graphic user interface; and
- Upgrading of the dynamic range of the preamplifier input circuitry, for compatibility with the IAEA Special Liquid Cell.

One unit was subjected to a period of testing at the UK's National Physical Laboratory, confirming performance and functionality. Further arrangements for user evaluation were subsequently pursued by the Agency. The outcome of the task was successful testing of the only multichannel digital processing system for fast scintillators which interfaces directly to the IAEA shift register system for multiplicity assay.

Summary Report on Activities in 2012/2013

A report on the development of a mixed field analyser for fast scintillator neutron measurements was prepared, and issued in December 2012. Further work on the development of a specific prototype instrument was undertaken within a new task, UK A01951/E12(f), below.

This task was subsequently placed on standby, pending a further request from the Agency for development of the safeguards system for J-MOX.

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

IAEA SP-1 No:	12/TSI-001	**UK Sub-contractor:**	Hybrid Instruments
IAEA SPRICS No:	UK A01951	**UK Task Manager:**	M Joyce
IAEA Task Officer:	A Lavietes		

Background to Task

Following on from the successful development of single and multichannel prototype pulse shape discriminator (PSD) instruments under Task E12(e), the capability requires demonstration in a plant-scale, integrated system that includes an array of liquid scintillator detectors and PSD channels. This task was accepted on 13 August 2012, to provide UK-based support to the development of such a system. Under respective tasks of the UK and Netherlands Support Programmes, Hybrid Instruments and Scionix intend to integrate an array of 16 PSD modules and detectors into a single detector system to the IAEA's specification.

Summary Report on Activities in 2012/2013

A kick-off meeting was held in Lancaster, UK, with the Task Officer in October 2012. The project was originally divided into three phases comprising: (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. However, during the meeting, it was agreed that the majority of design and build activity would be brought forwards into the first phase. Following this, the individual construction and testing of each instrument would proceed as per the original proposal.

Development and manufacture of both the 4- and 16-channel PSD modules was completed by end-March 2013. Upon receipt of the detectors, and subsequent assembly of the array, prototype system testing is expected to commence in the first quarter of 2013/2014.

The 16-channel Pulse Shape Discriminator Module

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(d) – Consultant: Training on Satellite Imagery Analysis for Safeguards Applications

IAEA SP-1 No:	05/IIS-005	**UK Sub-contractor:**	J E C Cartwright
IAEA SPRICS No:	UK B01655	**UK Task Manager:**	J E C Cartwright
IAEA Task Officer:	S Robb		

Background to Task

Since 2002, the IAEA Department of Safeguards has made use of satellite imagery as an operational tool for safeguards inspections and State evaluation purposes, and the demand for detailed analytical reports derived from imagery has increased dramatically. The Department wished to develop, in-house, the analytical skills of the present staff of the SIAU and those to be recruited.

Mr Cartwright had fulfilled the role of an imagery analyst, initially as an external consultant and then as a full-time CFE in imagery analysis. During the latter period, he developed a specialised handbook for the imagery analyst, based on the nuclear fuel cycle and all associated facilities and activities. In addition, briefings and presentations to IAEA inspectors and operations staff were undertaken on satellite imagery capabilities and applications to safeguards. For the specific training of imagery analysts, training tutorials, exercises and assessed examination material were compiled. Following the completion of this period of full-time consultancy, and the recruitment of additional imagery analysts by the Agency, there was a continuing requirement for periodic support to develop fully the potential capabilities of newly recruited imagery analysts and operations staff. From April

2006, Mr Cartwright supported the work of the Agency in the periodic training of both imagery analysts and safeguards inspectors.

Summary Report of Activities in 2012/2013

In May 2012, the Task Manager participated in an IAEA Safeguards Satellite Imagery workshop, held in Tsukuba, Japan. The event, the second to be held in four years, was hosted jointly by the Japanese Atomic Energy Authority and the Japanese Space Exploration Agency. Mr Cartwright provided the opening presentation, 'Fifty Years of Imagery Analysis'.

Mr Cartwright conducted specialist satellite imagery training at IAEA Headquarters in November 2012. Two, back-to-back, Satellite Awareness Courses were run for the benefit of up to 24 safeguards inspectors and other operations staff. Instructors from the UK and Swedish Support Programmes delivered the core subjects of the course, with additional support provided by four Agency staff from the SIAU.

Discussions were held between staff of the SIAU, Mr Cartwright and the UKSP Coordinator on the subject of additional activities that might be undertaken. The preparation of three tutorials was identified as a priority. The focus of each project would be on signatures and indicators, where and if they can be identified. Mr Cartwright began to research the three projects during the remainder of the year.

Subject to Mr Cartwright's continued availability, completion of the tutorials and support to further courses is foreseen during 2013.

Task F1(e) – Expert: Satellite Imagery/Geospatial Analyst

IAEA SP-1 No:	08/ICA-010	**UK Sub-contractor:**	M Flory
IAEA SPRICS No:	UK D01794	**UK Task Manager:**	J Tushingham, NNL
IAEA Task Officer:	K Steinmaus		

Background to Task

In order to respond effectively to increasing demands for imagery-driven products and services, the SIAU needs to maintain and grow its current analytical capabilities. CFEs are required in the areas of satellite imagery and geospatial analysis: to supplement in-house expertise; to analyse commercial satellite imagery and related geospatial information; and to contribute to the enhancement and automation of analytical processes within the Unit.

During 2008, the Agency approached a number of Member State Support Programmes, seeking the nomination of imagery experts for initial two-year posts within the SIAU. The Agency accepted the UK Support Programme's nomination of a candidate for the position of satellite imagery cost-free expert in January 2009, and an extrabudgetary voluntary contribution, equivalent to the costs associated with the first year of employment of the expert by the Agency, was made the following month. The nominated CFE commenced work with the Agency in September 2009, in a position that was subsequently extended to September 2014.

Summary Report of Activities in 2012/2013

The UKSP-sponsored imagery analyst completed his third year with the Agency, and commenced a fourth year working within the SIAU. During this period, he continued the production of imagery analysis reports in support of safeguards monitoring and verification activities, participated in a number of workshops and continued to develop training materials. In particular, he developed relationships with country and facility officers to better understand operational requirements for analytical products, and authored and presented a historical imagery study as part of a training course for inspectors.

He worked with GIS staff in the creation of site plans for nuclear facilities, for uploading to the new Geospatial Exploitation System, and continued to test the system for operational deployment. In addition, he supported training activities including the May 2012 Satellite Imagery workshop in Japan, to discuss and prioritise areas of imaging technology that may be relevant within the next ten years, and attended a week-long site visit programme in Canada. This was designed to allow imagery analysts to see signatures of the CANDU fuel cycle. He acted as facilitator to a number of UK Support Programme training events, and also liaised with other MSSPs to support and promote specific tasks.

Mr Flory will continue to work in support of the SIAU during 2013/2014, undertaking a range of duties.

Task F1(f) – Nuclear Fuel Cycle Specialist Assistance

IAEA SP-1 No:	09/ICA-004	**UK Sub-contractor:**	Various
IAEA SPRICS No:	UK D01819	**UK Task Manager:**	J Tushingham, NNL
IAEA Task Officer:	S Robb		

Background to Task

The SIAU requires 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, it became apparent that there was a wider requirement, within the Department of Safeguards as a whole, for 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.

SRDP-PR33

Summary Report of Activities in 2012/2013

During the year, the UK Support Programme provided expert assistance in a number of areas in response to requests under this task, including:

- Preparing for and participating in a 5-day bespoke fuel cycle training event in May 2012;
- Support to a nuclear fuel cycle technical study that will continue in 2013/2014;
- Continued support from an expert in process monitoring. Four visits to IAEA Headquarters were made for this purpose during the year. This work also remained ongoing at the end of the year; and
- Software development 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.

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 2012/2013, support was limited to those specific tasks described within this report.

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.

SRDP AND OTHER REPORTS PUBLISHED OR IN PREPARATION DURING 2012/2013

A5(b) **SRDP-R312** "Revalidation of Cameca 4f SIMS Instrument for the Isotopic Analysis of Uranium Particles Extracted from Environmental Swipe Samples", A J Simons, A J Pidduck, N J Montgomery and J W Cairns. (Issued October 2012)

A5(h) **SRDP-R305** "Review of Air Particulate Sampling for Potential Application in Safeguards", K W Nicholson. (Issued April 2012)

A7(k) **SRDP-R311** "Review of Objective Techniques for Combining Different Sources of Information", T Pattenden and C Mistry. (Draft)

B1(v) **SRDP-R308** "A Comparison of Standard SIMS, Large-Geometry SIMS and SEM-EDX Analysis of Selected Environmental Swipe Samples", A J Pidduck, M R Houlton, G M Williams and P O Jackson. (Issued April 2012)

D2(h) **SRDP-R310** "SimMOX: A Computer Simulation to Examine Implications of Applying NRTA to a MOX Facility", J Howell and G T Cowell. (Awaiting publication)

E12(e) **SRDP-R309** "Development of a Mixed Field Analyser for Fast Scintillator Neutron Measurements", M J Joyce, M D Aspinall and F D Cave. (Issued December 2012)

SRDP-PR32 "Report on the Activities and Progress during the Period 1 April 2011 to 31 March 2012", J W A Tushingham. (Issued September 2012)

ABBREVIATIONS

Abbreviation	Term
ARM	Annual Review Meeting
AWE	Atomic Weapons Establishment
BNFL	British Nuclear Fuels Ltd
CANDU	Canadian Deuterium Uranium Reactor
CFE	Cost Free Expert
DA	Destructive Analysis
DDG	Deputy Director General
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
DIE/V	Design Information Evaluation/Verification
DIQ	Design Information Questionnaire
DIV	Design Information Verification
ECAS	Enhancing Capabilities of the Safeguards Analytical Services
FISPIN	A Fuel Inventory Code
FT-TIMS	Fission Track-Thermal Ionisation Mass Spectrometry
GIS	Geographic Information System
IAEA	International Atomic Energy Agency
INFCIRC	IAEA Information Circular
J-MOX	Japanese Mixed Oxide facility
KCL	King's College, London
LFUA	Limited Frequency Unannounced Access
LG-SIMS	Large Geometry-Secondary Ion Mass Spectrometer
LSA	Laser Surface Authentication
MAGNOX	A graphite-moderated, gas-cooled reactor (originally with MAGnesium Non-OXidising fuel cladding)
MFA	Mixed Field Analyser
MOX	Mixed Oxide
MSSP	Member State Support Programme
MUF	Material Unaccounted For
NDA	Non-Destructive Analysis
NFC	Nuclear Fuel Cycle
NML	Nuclear Material Laboratory
NNL	National Nuclear Laboratory
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NRTA	Near Real Time Accountancy
NWAL	Network of Analytical Laboratories
OLA	IAEA Office of Legal Affairs
OLEM	On-Line Enrichment Monitor
PIV	Physical Inventory Verification
PSD	Pulse Shape Discriminator
PWR	Pressurised Water Reactor
RAE	Resistive Anode Encoder

RICC	Regional Information Collection Centre
SAGSI	Standing Advisory Group on Safeguards Implementation
SEM	Scanning Electron Microscopy
SGAS	IAEA Safeguards Office of Analytical Services
SGTS	IAEA Safeguards Division of Technical Services
SIAU	IAEA Satellite Imagery Analysis Unit
SIMS	Secondary Ion Mass Spectrometry
SSAC	State System of Accounting for and Control of nuclear material
THORP	Thermal Oxide Reprocessing Plant, Sellafield
TIMS	Thermal Ionisation Mass Spectrometry
TRIGA	A pool-type reactor
UK	United Kingdom
UKSP	United Kingdom Support Programme to IAEA Safeguards
US	United States of America
USDoE	US Department of Energy
WAES	Wide Area Environmental Sampling
WIMS	Winfrith Improved Multigroup Scheme, a neutronics code
WMD	Weapons of Mass Destruction

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