ITWG Nuclear Forensics International Technical Working Group

ITWG NUCLEAR FORENSICS UPDATE

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COMMENT FROM THE CO-CHAIRS

Welcome to the 6th edition of the Nuclear Forensics International Technical Working Group (ITWG) newsletter. This edition contains articles on the recently completed Galaxy Serpent exercise, the outcomes from a Joint US-Nordic workshop in Norway, recent IAEA nuclear forensics training and outreach activities around the world, and the EUSECTRA training programme. In addition, the ITWG leadership continues to develop plans for the annual meeting this summer. ITWG members are encouraged to read the first announcement on the private ITWG website and contact the co-chairs about their plans to participate and possibly to share updates on recent nuclear forensics developments in their country. Enjoy the newsletter, and we hope to see you at the annual meeting.

With best regards,
Klaus Mayer and Michael Curry

EUSECTRA: HALF A DECADE OF OPERATION IN STRENGTHENING NUCLEAR SECURITY THROUGH CONTINUOUS PROFESSIONAL DEVELOPMENT AND TRAINING

JEAN GALY

The widespread use of radioactive materials for medical and industrial applications is associated with the risk of theft of such materials and potential use in criminal and terrorist acts. Such increasing threat concerns are acknowledged by the international community in numerous international commitments and resolutions. In our globalized world, faced with steadily expanding trade, directed efforts—in particular to assist countries to develop, enhance and upgrade their prevention, detection and response capabilities—increase nuclear security without hampering international trade.

A successful fight against the illicit trafficking of nuclear and other radioactive materials requires the mobilization of and interactions among various competent authorities, such as the police, customs authorities, border guards, regulators, radiation protection experts and scientists. Each of these authorities would have a role to play and specific responsibilities during a nuclear security incident. Such incidents require close interagency cooperation, interdisciplinary skills and an understanding of the technicalities involved in the detection, handling and analysis of nuclear or other radioactive materials. Thus, non-experts in the radiological field, such as frontline officers, need to be familiarized with radiation detection, radiation hazards, and measuring and relaying the technical information obtained from instruments for subsequent analysis by scientific experts. The complexity and the need for optimal use of radiation measurement equipment obviously call for thorough training of frontline officers and the other competent authorities on their roles in a state's national nuclear security plan.

A dedicated European centre for nuclear security training

The European Nuclear Security Training Centre (EUSECTRA) was specifically established to address these concerns. The Joint Research Centre was tasked by the European Commission (DG HOME) to set up a dedicated training centre, based on the recommendations in the EU CBRN Action Plan adopted by the European Council in December 2009. EUSECTRA—with multiple bases at the European Commission in Brussels, the Joint Research Centre in Karlsruhe, Germany and Ispra—aims to improve member states' capabilities to address the threats associated with incidents involving illicit nuclear or other radioactive materials by providing hands-on training for frontline officers using real nuclear materials, as well as for their managers, trainers and other experts in the field. Based on a unique combination of scientific expertise, specific technical infrastructure and the availability of a wide range of nuclear materials, EUSECTRA complements national

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UPCOMING TRAININGS AND MEETINGS

- GICNT Nuclear Forensics Working Group Exercise, Bangkok, 6–8 March 2018
- IAEA Consultancy Meeting: Steering Group for 2019 IAEA 'Technical Meeting on Nuclear Forensics', Vienna, 20–22 March 2018
- Methods and Applications for Radioanalytical Chemistry (MARC) Conference, Kona, HI, USA, 8–13 April 2018
- GICNT Radiological Security Workshop, Budapest, 10–12 April 2018
- IAEA International Nuclear Forensics Methodologies Training Course, Richland, WA, USA, 23 April–4 May 2018
- US–EU Counter Nuclear Smuggling Workshop, Karlsruhe, Germany, 15–17 May 2018
- ITWG Annual Meeting (ITWG-23), Bern, 5–7 June 2018
- GICNT Implementation and Assessment Group Meeting, Helsinki, 11–13 June 2018
- IAEA General Conference, Vienna, 17–21 September 2018
- International Conference on the Security of Radioactive Material: The Way Forward for Prevention and Detection, IAEA, Vienna, 3–7 December 2018

Dates and locations of IAEA training and meetings will be officially confirmed with host member states; participation in IAEA training and meetings is by nomination and in accordance with established IAEA procedures.

ON THE ROAD AGAIN: IAEA NUCLEAR FORENSICS TEAM FOCUSES ON PARTNERSHIPS IN THE FOURTH QUARTER

JERRY DAVYDOV, DAVID SMITH, TIMOFEY TSVETKOV AND NICOLA VORHOFER

With the completion of eight human resource events and coordination meetings, one expert mission and two outreach activities within 90 days, the IAEA Nuclear Forensics Team continued to apply nuclear forensic science to prepare states to confront the risks posed by nuclear and other radioactive material found outside of regulatory control.

By consistent implementation of nuclear forensic science, the IAEA demonstrates its commitment to prevent and respond to nuclear security events by reinforcing and enhancing existing partnerships, and continued investment in the key element of nuclear forensic science—the people. The IAEA's success in the fourth quarter is a direct reflection of the remarkably talented counterparts and colleagues working to address the threat posed by nuclear and other radioactive material found outside of regulatory control. This fourth quarter review outlines the IAEA Nuclear Forensics Team's key accomplishments in the final three months of 2017 across its core nuclear security mission to assists states to develop, sustain and advance indigenous nuclear forensics capacities.

Human resource development

Key to the IAEA's work is the use of its human resource development (HRD) to promote a consistent nuclear forensics state of practice globally. Through the implementation of training, residential assignments and technical visits, the IAEA's HRD programme on nuclear forensics continued to champion the work of states to prevent and respond to nuclear security events.

The IAEA convened its classroom-based 'Introduction to Nuclear Forensics' training course twice during the fourth quarter. The first offering—held at the regional level at Necsa Headquarters in Pretoria, South Africa, on 6–9 November—was the first IAEA nuclear forensics training to be held in southern Africa and served to boost relationships regionally. The second offering—held at the national level at Dubai Police Headquarters, United Arab Emirates (UAE), on 20–23 November—was an important step forward in deepening the relationship between the UAE and the IAEA in nuclear forensics.

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Figure 1. Fully equipped trainee in duty in a radiological crime management proficient development exercise at EUSECTRA

Figure 2. EUSECTRA working to offer realistic training scenarios simulating border crossing point or interior detection event

EUSECTRA *continued*

training efforts by providing realistic scenarios involving specialist nuclear material. The training programme offers unique opportunities for trainees to see and experience actual materials and commodities, as EUSECTRA is one of the few places in the world where a wide range of samples of plutonium and uranium with different isotopic compositions can be used for training in detection, categorization and characterization.

EUSECTRA represents a substantive, enduring and sustained new core activity for the JRC and positions nuclear security training at the centre of its extensive nuclear counterterrorism and nuclear non-proliferation portfolio. This initiative integrates the different modules into a coherent and comprehensive set of training courses covering both detection and response strands. The EUSECTRA training topics are border detection, mobile detection, covert search, training-the-trainers, mobile response (MEST), reach-back, the creation of national response plans, nuclear forensics, radiological crime scene management, nuclear security awareness and the sustainability of a national nuclear security posture. In the specific area of nuclear forensics, headline training includes, but is not limited to, an awareness workshop, the application of existing capabilities to a nuclear forensics investigation, advanced gamma spectroscopy, and dedicated technical and hands-on instrumentation training, for example on ICPMS and SEM.

Training for international partners

EUSECTRA benefits from the experience of and cooperative working with the Border Monitoring Working Group and experts from the Nuclear Forensics ITWG in elaborating comprehensive practical and tabletop training schemes for frontline officers, first responders, measurement expert support teams and nuclear forensics experts. These reference and standardized training materials were developed in close collaboration with international experts (e.g. from the IAEA and the US Department of Energy (DOE), the US Federal Bureau of Investigation (FBI), the Netherlands Forensic Institute (NFI), and the French Alternative Energies and Atomic Energy Commission (CEA)) to integrate different available modules into a coherent and comprehensive set of training courses. The concept of EUSECTRA is continually optimized with the help of partners and states in a complementary and effective combination of national and regional capabilities. Trainers originate from the competent Commission services, member states' authorities or international organizations, as well as from third countries. EUSECTRA can therefore provide assistance to states with indigenizing training activities by integrating elements into established law enforcement curricula.

Since its official launch, EUSECTRA has hosted trainees from more than 75 countries. In 2016 alone, for instance, more than 300 participants were trained at facilities. EUSECTRA training is repeatedly recognized as beneficial in terms of enhancing preparedness, as well as detection of and responses to nuclear security events. EUSECTRA's unparalleled training opportunities have led to a steadily increasing demand for training sessions. Within just a few years of operation, EUSECTRA has become a cornerstone of the EU and international training network that aims to ensure the transfer and dissemination of the knowledge required to spread a rigorous nuclear security culture worldwide, in the most appropriate way. •

On the Road Again *continued*

At the conclusion of the training, the UAE and the IAEA proposed a roadmap for future collaboration. Through a combination of lectures, case studies, tabletop exercises and laboratory tours, the courses provided the stakeholders involved in the response to a nuclear security event with enhanced awareness and understanding of the scope and application of nuclear forensics.

The two offerings of the IAEA's laboratory-based 'Practical Introduction to Nuclear Forensics' constituted an important step in reinforcing its collaborative relationship with the Hungarian Academy of Sciences Centre for Energy Research (MTA-EK) and offered an opportunity to expand its partnership with the Australian Nuclear Science and Technology Organisation (ANSTO). MTA-EK, the host of the first two offerings of the course in 2014 and 2016, again hosted participants from across southern Europe on 2–6 October at its campus in Budapest, which has been officially designated as an IAEA Collaborating Centre in Nuclear Forensics since 2016. The ANSTO-hosted course, which was held on 16–20 October in Lucas Heights, Australia, for participants from across South East Asia, gave the IAEA an opportunity to further internationalize its training. Through applied instruction on analytical measurements relevant to nuclear forensic examinations, instructors were able to introduce current scientific methods of nuclear forensic analysis and highlight both technical and organizational needs during a nuclear forensic examination.

The IAEA was fortunate to be able to offer its most advanced human resource development opportunity, the Residential Assignment Programme, twice during the autumn of 2017 at the European Commission's Joint Research Centre in Karlsruhe and the Centre for Energy Research. Under the guidance of leading nuclear forensics experts, nuclear scientists from Croatia, the Czech Republic, Kenya and Romania spent three months at leading nuclear forensic institutes. The research programme was tailored to the interests of the participants involved, and included non-destructive analysis, mass spectrometry and microscopy methods. One of the most important outcomes was that participants were able to take the lessons learned during their assignment back to their home countries to enhance indigenous capacities.

As part of recent efforts to develop an indigenous and sustainable nuclear forensics capability in Morocco, the IAEA convened a nuclear forensics technical visit for Moroccan nuclear forensics stakeholders to the Lawrence Livermore National Laboratory, USA on 8–10 November 2017. As a part of the technical visit, Moroccan nuclear forensics stakeholders held discussions with US DoE nuclear forensics experts and participated in a series of technical tours. These tours, originally designed for the 2016 Nuclear Security Summit Apex Gold Exercise, simulated the conduct of a nuclear forensics examination. As a result of the technical visit, a number of actions were identified as being of joint interest to Morocco, the USA and the IAEA for potential future implementation.

Outreach

On 24 October the IAEA travelled to Bucharest to sign a Practical Arrangement cooperative mechanism with the 'Horia Hulubei' National Institute for Nuclear Research and Engineering (IFIN-HH). Through partnerships with internationally recognized institutes such as IFIN-HH, the IAEA is seeking to promote regional networks to address the various threats posed by nuclear and other radioactive material outside of regulatory control. As an output of the meeting, the IAEA and IFIN-HH mapped out a collaborative technical programme encompassing the scientific strengths of the Romanian institute.

To close out the year, on 29–30 November the IAEA travelled to Beijing to meet with the China Institute of Atomic Energy (CIAE) and the State Nuclear Security Technology Centre (SNSTC) to promote nuclear forensics coordination and cooperation. The IAEA was also supported by an expert from the US National Nuclear Security Administration on this mission. The visit, which was a follow-on from an inaugural mission in May 2017, sought to deepen cooperation between China and the IAEA on nuclear forensics. As a result of the visit, China and the IAEA began to formulate a work plan on joint cooperation that includes the potential to host IAEA nuclear forensics training at the SNSTC, with instruction by the IAEA, the CIAE and external experts.

2018 Outlook

The IAEA nuclear forensics team expanded its outreach and training efforts with existing and new partners in the final quarter of 2017. In the coming year, the IAEA will focus on applying best practices in nuclear forensic science to serve the needs of states investigating nuclear security events. •

THE JOINT US/NORDIC WORKSHOP ON NUCLEAR SECURITY AND FORENSICS, 17–19 JANUARY 2018

PER STRAND, MICHAEL CURRY AND MARK DOWDALL

The Norwegian Radiation Protection Authority (NRPA), the Swedish Radiation Safety Authority (SSM) and the Radiation and Nuclear Safety Authority in Finland (STUK) in association with the US Department of State organized a Joint US/Nordic Workshop on Nuclear Security and Forensics in Oslo on 17–19 January 2018. The workshop was part of ongoing collaboration between the Nordic authorities and the USA in the area of nuclear security. This collaboration has focused on improvements in nuclear safety and security in a number of European countries, and in particular on efforts to protect at-risk nuclear and radiological materials and counter illicit trafficking of such materials.

More than 90 nuclear security and forensic science specialists from the USA, the Nordic countries and the rest of Europe participated in the workshop, including experts from international organizations such as the IAEA, INTERPOL and the European Commission. This multinational participation served to broaden the usefulness of the workshop for the Nordic countries by providing a forum in which the expertise and experiences of non-Nordic actors could be shared.

Aim

The workshop was conceived and developed in order to provide for comprehensive information and knowledge exchange on the subjects of nuclear security and nuclear forensics, as well as relevant information on case studies involving nuclear forensic examinations for the purpose of investigating the smuggling of nuclear and other radioactive materials. The workshop was also intended to raise awareness of the subject matter among non-expert actors with a role to play in nuclear security and forensics, and to promote cross-sectoral cooperation and collaboration in the Nordic region.

Programme and subject matter

The workshop covered a broad range of topics of interest to nuclear security experts, law enforcement entities, regulators/authorities and forensics experts. The workshop opened with a series of presentations highlighting the importance of nuclear security and forensics. The current status of international efforts on nuclear forensics was described and the role of international actors such as INTERPOL was presented in detail. The interplay between science and law enforcement in the area of nuclear security and forensics was discussed, and the position of security and forensics in a regional context was elaborated. The deterrent role of nuclear security and forensics was described and an active discussion followed on all the above aspects.

The second session of the workshop focused on the practical aspects of nuclear security and forensics. Presentations were held on nuclear forensics and extant law enforcement and operational systems, and the interplay between the two. Ukrainian experts described their efforts in relation to nuclear smuggling incident protocols and the work of the Swedish, Moldovan and Georgian collaboration on nuclear security was presented. The Galaxy Serpent virtual exercises were also presented and discussed. The technical challenges of nuclear forensics were described from a Swedish perspective. The presentations formed the basis for an active and interesting discussion among the participants.

The subject of capacities in a Nordic context was discussed in the third session. A thorough elaboration of Swedish capabilities related to the handling of lost nuclear and radiological material opened the session, followed by a presentation on the role of stakeholder networks in improving CBRN responses. An overview of reach-back capacities in the Nordic/Baltic region was provided along with the results of a number of projects aimed at appraising reach-back performance in situations involving special nuclear materials and the malicious use of radioactive materials. The relationship between nuclear forensics, non-proliferation and international security frameworks outside of the nuclear security sphere was discussed and there was a detailed presentation on Swedish/US work on Certified Reference Materials for nuclear forensic purposes.

The fourth and penultimate session of the workshop was oriented towards concrete case studies in the area of nuclear security and forensics and the lessons that can be learned from such studies. An interesting presentation of the Litvinenko case effectively highlighted the role of radiological analysis in an active criminal investigation. This was followed by an in-depth elaboration of a number of European cases involving smuggled highly enriched uranium. Two

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The Joint US/Nordic Workshop *continued*

Figure 1. Group photo of participants at the Joint US/Nordic Workshop on Nuclear Security and Forensics

Figure 2. Per Strand, Deputy Director General of the Norwegian Radiation Protection Authority addressing the workshop participants

Slovakian case studies were then presented—one involving the illicit cross-border sale of uranium and the other on the use of radioactive material in a terrorist act in Slovakia. A detailed description of the Finnish nuclear security detection architecture and the role of reach-back in that architecture closed the session.

The final session concerned cyber and other threats in the context of nuclear security. The presentations engendered a lively and interesting discussion. A general and comprehensive overview of the threat posed to nuclear facilities by cyberattacks opened the session and was followed by a presentation on the experience of Ukraine in this regard. The activities of the Nuclear Threat Initiative further reinforced the message in relation to cyberattacks and the serious threat they pose. The Norwegian system of using unmanned aerial vehicles as a nuclear spectrometry platform was presented, and this was followed by a presentation on cybersecurity in a nuclear context.

Outcomes

The regional workshop provided an invaluable opportunity for the range of actors involved in nuclear security and forensics in the Nordic region to come together to hear from international experts on a number of matters of direct relevance to their work. It was apparent from the audience feedback that the workshop achieved its aim with respect to promoting an understanding of the multifaceted and cross-sectoral nature of the challenges faced by actors with a role to play in nuclear security and forensic incidents. Of significance, the workshop demonstrated the importance of the speakers' ability to deliver technical information in a manner that was amenable to non-technical experts. The presentations in the workshop and the discussions of the matters raised served to further highlight and provide a better appreciation of the problems faced in establishing and maintaining effective regional capacity in nuclear forensics and security, and the benefits to be obtained from active international and regional cooperation. •

DESIGNING AND VALIDATING THE GALAXY SERPENT 3 DATASET

NAOMI MARKS

Introduction

The value of the National Nuclear Forensics Library (NNFL) in supporting nuclear forensics investigations can be demonstrated through tabletop exercises that clarify roles and responsibilities, and develop data organization and analysis skills, as well as practice query and response communications. The Galaxy Serpent exercises are virtual, web-based nuclear forensics library tabletop exercises conducted under the auspices of the NNFL Task Group of the ITWG. The exercises are designed to raise awareness of the technical aspects of developing and applying NNFLs, and have focused on different types of nuclear and radioactive materials in order to exercise a diversity of participant skills and expertise.

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Designing and Validating the Galaxy Serpent 3 Dataset *continued*

The use of a realistic dataset is critical to producing a virtual tabletop exercise that will be both meaningful and beneficial to participants. Designing a Galaxy Serpent exercise poses several challenges, such as the need to develop a realistic dataset that is interesting, neither sensitive nor proprietary, and can be easily shared with any team that wishes to participate in the exercise. In addition, the exercise should ideally be engaging and non-trivial for a diverse set of exercise teams with a wide range of experience in the development and use of NNFLs, nuclear and radioactive material signatures, and algorithm development. For this third Galaxy Serpent exercise (GS V3) we developed a surrogate forensic signature dataset for uranium ore concentrate (yellowcake, UOC) that is based on real trace element data for similar geologic materials.

Design principles

Basalt is an extremely common, fine-grained volcanic rock that occurs in many places on the earth's surface, and covers almost all of the ocean floors. Like UOC, there are several important sub-classes of basalt that can be distinguished based on their trace element compositions. To create the surrogate GS V3 dataset, basalt data was transformed into 'UOC data' using a few simple relabelling and mathematical operations. Basalt is approximately 45 per cent silicon dioxide (SiO_2) by weight (wt%), while UOC is approximately 75 wt% uranium (U), so we simply added 30 per cent to the SiO_2 values and relabelled the data as 'U wt%'. Basalt also has other major elemental constituents, such as aluminium, calcium and magnesium, while UOC does not, so the concentrations for these elements were changed from their 'wt%' concentrations reported for basalt into 'parts per million' concentrations for the surrogate data. Finally, we relabelled the U concentration in the basalt data (initially in the parts per billion range) to 'Si', which is approximately correct for UOC. By making these simple changes, the basalt data was transformed into a dataset that resembled UOC data.

We determined that four classes ('affinities') of UOC would be the correct number for the Galaxy Serpent exercise, as this is a tractable number of sources that would be challenging but not overwhelming to sort out. The data was sourced from many laboratories and we determined that the within-class variation was much greater than the analytical uncertainty, so no measurement uncertainties were provided. In order to create a realistic dataset, we also included a number of 'missing' values, making the dataset deliberately sparse. This feature allowed teams to wrestle with how to address the missing values and added a challenging element to the exercise.

Prior to deploying the exercise data, it was necessary to conduct extensive vetting and validation to ensure that the problems set out in the exercise would be sufficiently challenging, but not impossible. This task was made more difficult because it was important to keep key staff members who might be asked to participate in the exercise in the dark about the nature of the data and its challenges. We knew that many different analytical approaches would be taken for this exercise, and as a result the dataset would need to be especially robust. First, we extensively characterized the data, making sure that the samples were chemically consistent, well behaved and separable by key index elements. Outliers were discarded from the dataset. We then ensured that it would be possible to achieve class separation in PCA space, first without pre-processing and later with. We also employed several other multivariate statistical techniques to make sure the data was sufficiently separable. Finally, we tested how long it would take for someone with a background in data assessment, but unfamiliar with the dataset, to do a rudimentary analysis and complete the exercise.

For the purpose of the exercise, three unknown samples were to be queried against the Galaxy Serpent UOC database. These unknowns were chosen to be: (*a*) clearly sourced from one of the known classes; (*b*) an outlier to one of the known classes; and (*c*) not represented in the dataset. Additional testing was required to ensure that these unknowns were solvable.

Summary

The most recent implementation of the Galaxy Serpent enjoyed a high level of participation from teams with a wide variety of skills and experience. There were nearly as many different approaches to the exercise as there were teams, and it has been extremely rewarding working with participants and hearing about all of the new approaches and ideas that were developed as a part of this exercise. Overall, GS V3 successfully validated that we can develop applicable, robust synthetic datasets for NNFL exercises, and will provide an important source of datasets for future Galaxy Serpent exercises. •

CONTENTS

NUCLEAR FORENSICS

Nuclear forensics is an essential component of national and international nuclear security response plans to events involving radioactive materials diverted outside of regulatory control. The ability to collect and preserve radiological and associated evidence as material is interdicted and to conduct nuclear forensics analysis provides insights to the history and origin of nuclear material, the point of diversion, and the identity of the perpetrators.

THE NUCLEAR FORENSICS INTERNATIONAL TECHNICAL WORKING GROUP

Since its inception in 1995, the Nuclear Forensics International Technical Working Group (ITWG) has been focused on nuclear forensic best practice through the development of techniques and methods for forensic analysis of nuclear, other radioactive, and radiologically contaminated materials. The objective of the ITWG is to advance the scientific discipline of nuclear forensics and to provide a common approach and effective technical solutions to competent national or international authorities that request assistance.

ITWG PRIORITIES AND ACTIVITIES

As a technical working group, the priorities for the ITWG include identifying requirements for nuclear forensic applications, evaluating present nuclear forensic capabilities, and recommending cooperative measures that ensure all states can respond to acts involving illicit trafficking and unauthorized possession of nuclear or other radioactive materials. An objective of the working group is to encourage technical peer-review of the nuclear forensic discipline. These goals are met through annual meetings, exercises, and informal and formal publications.

Outreach is a primary goal of the ITWG. The working group disseminates recent progress in nuclear forensic analysis and interpretation with the broader community of technical and security professionals who can benefit from these advancements. Affiliated international partner organizations include the International Atomic Energy Agency (IAEA), the European Commission, the European Police Office (EUROPOL), the International Criminal Police Organization (INTERPOL), the Global Initiative to Combat Nuclear Terrorism (GICNT) and the United Nations Interregional Crime and Justice Research Institute (UNICRI).

ITWG MEMBERSHIP

Nuclear forensics is both a technical capability as well as an investigatory process. For this reason the ITWG is a working group of experts including scientists, law enforcement officers, first responders, and nuclear regulators assigned by competent national authorities, affiliated contractors, and international organizations. The ITWG is open to all states interested in nuclear forensics.

ITWG participating states and organizations recognize that radiological crimes deserve thorough investigation and, when warranted, criminal prosecution. The ITWG encourages all states to possess the basic capability to categorize nuclear or other radioactive materials to assess their threat. As an international group, the ITWG shares its expertise through its membership to advance the science of nuclear forensics as well as its application to nuclear security objectives.

http://www.nf-itwg.org/