ITWG Nuclear Forensics International Technical Working Group

ITWG NUCLEAR FORENSICS UPDATE

No. 26 March 2023

CHAIRPERSONS' ADDRESS

Welcome to the 26th edition of the ITWG Update. Firstly, in this newsletter, the Federal Bureau of Investigations (FBI) shows how conventional forensics examinations are done on bulk nuclear material and associated contaminated evidence. The interface between nuclear and conventional forensics is still an issue that many countries are looking into, thus this article may provide some useful tips. Secondly, National Nuclear Forensics Library (NNFL) is a concept that ITWG has been advocating for many years. In this edition, Romania presents their efforts in developing and implementing an NNFL. Thirdly, the International Atomic Energy Agency (IAEA) has launched a new Coordinated Research Project (CRP) on nuclear forensics. CRP is a great platform to bring research institutes together; even if working on individual topics, collective problem solving and knowledge sharing has been a very much desired outcome of the two previous CRPs. More information about the scope and topics can be found in the article itself. Last, but not least, and just in time, we are happy to announce that the 26th annual meeting, ITWG-26, will be held on 20-22 June 2023 in Tbilisi, Georgia. Stay tuned, a second announcement with more details will be posted in April. We hope to see you all in Tbilisi!

With best regards,

Michael Curry and Maria Wallenius

TRADITIONAL FORENSIC SCIENCE EXAMINATIONS OF BULK SPECIAL NUCLEAR MATERIAL

KEVIN SWEARINGEN AND JAMES BLANKENSHIP*

The Federal Bureau of Investigation (FBI) Laboratory at Quantico, Virginia, is responsible for forensics examinations of radiological evidence and evidence contaminated with radioactive materials. The unique features of these hazards and the need for specialized safety protocols have led the FBI to develop a network of Partner Laboratories (PLs) across the United States to support conventional forensic science examinations of such evidence. The FBI Laboratory has also established the Hazardous Evidence Analysis Team (HEAT), a group of qualified forensics examiners, scientists, technicians and photographers, members of which can deploy to laboratories outside the FBI to perform conventional forensics on evidence containing or contaminated with hazardous materials.

One of the FBI's PLs, the U.S. Department of Energy's Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico, has specialist facilities, personnel and procedures for securing, safe handling, and processing significant quantities of special nuclear material (SNM). While LANL's procedures for working with SNM are well established, working with SNM under evidentiary controls is not. Close cooperation between LANL and FBI HEAT is required due to FBI policies on evidence handling, as well as the challenges associated with the use and preservation of conventional forensics (fingerprints, trace evidence and photography) on SNM evidence.

Hazardous evidence analysis team capability at LANL

For FBI HEAT members to be deployed to LANL, they must meet all the requirements of the HEAT programme, as well as site-specific requirements. For LANL, site-specific requirements include radiological worker training (16 hours of in-person

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*The work described above could not have been completed without the help of the HEAT members, all of whom volunteer for the extra duties. Additional thanks are due to the HEAT members who offered their insights when reviewing this article. This is publication 22.27 of the FBI Laboratory Division. The names of commercial manufacturers are provided for identification purposes only; inclusion does not imply endorsement of the manufacturer or its products or services by the FBI. The views expressed are those of the authors and do not necessarily reflect the official policy or position of the FBI or the US government.

Traditional forensic science examinations... *continued from page 1*

training), respirator training (one hour of in-person training), medical clearance to use the respirator, and completion of other health and safety training courses (approximately five hours of online training). Safety and security concerns mean that even after completion of all the site-specific training, FBI personnel must rely on experts at LANL for physical manipulation of SNM. Throughout the planning and execution of a HEAT deployment to LANL, the FBI receives guidance and assistance from LANL's team of experts, such as radiation safety specialists, environmental health and safety specialists and SNM handlers. During a HEAT deployment to LANL, SNM handlers work side-by-side with FBI HEAT personnel, and additional oversight and guidance are provided by environmental health and safety, and radiation safety experts. The training and guidance provided by LANL allows FBI HEAT personnel to conduct conventional forensics examinations on SNM to the standards required in the FBI Laboratory at Quantico without any unnecessary safety risks.

Annual exercises are conducted at LANL to allow FBI HEAT personnel the opportunity to work with LANL experts for training purposes and practice, and on methodological development and process improvement. In the most recent exercise, the evidence being examined was a training aid that did not contain SNM and the work was conducted in a radioactive material-free practice area. However, the exercise was conducted under the SNM LANL safety and surety protocols for working with SNM. The objectives were to exercise bringing FBI- owned equipment and chemicals into LANL space and to conduct conventional forensic science examinations. Cameras require a review and approval process due to the controlled nature of LANL space, latent print processing chemicals require approval by LANL's chemical safety experts and other electronics—alternate light sources (ALS), laser pointers and the necessary batteries—require approval by LANL safety experts.

The FBI worked with LANL to design a tent (see figure 1) to house the HEAT forensics examinations. This provides a working environment that is free from any existing contamination from previous work and prevents the evidence from contaminating LANL's workspace. The tent is specifically designed for conventional forensics examinations of SNM; it has an air handling system for proper ventilation, pass-throughs to provide power for necessary equipment and windows with coverings to control the lighting in the tent for ALS examinations. Following each exercise, the FBI and LANL participate in discussions to determine whether any changes should be made to the design of future tents.

To further mitigate the hazards of SNM and decrease the likelihood of contamination spread, disposable glove bags are used to contain the evidence within the tent. The glove bags are fabricated by LANL to FBI specifications and the standards required by LANL for use inside a Category II nuclear facility. The glove bag allows for SNM evidence to be manipulated without risking contamination of LANL SNM handlers or FBI examiners. According to FBI design specifications, quartz windows on the glove bag allow photography without any distortion being introduced by the glove bag material. The disposable nature of the glove bag and tent ensures that there is never any risk of a current exam being contaminated by previous work. In cases where higher hazards are present, the work practices used with the glove bags can be mirrored while using LANL's glove boxes. There is no additional training burden on FBI staff if the decision is made to use the glove boxes, since LANL SNM handlers perform the manipulations.

Recent HEAT Exercise at LANL

As part of the FBI Laboratory's agreement with LANL, and for methodological development, process improvement and training, HEAT conducts regular onsite exercises. In 2020, the FBI Laboratory deployed a team of latent prints, trace evidence and photography subject matter experts to LANL for an exercise. The focus of this exercise was to conduct traditional forensics examinations on a large object composed of simulated uranium. The specifics meant that while the injected dose/dose rate was not a hazard, there were considerations regarding risk of contamination, and the security and surety of the simulated uranium object.

The tent and glove bag were assembled at LANL, and the uranium object was transferred into the glove bag with the help of LANL's radiological safety and SNM handlers. Once the item was in the glove bag, LANL SNM handlers physically manipulated the object during the examinations, following the directions of the FBI forensics examiners. After initial visual examinations and photography, the lighting inside the tent was temporarily adjusted to allow the use of ALS by latent print examiners (see

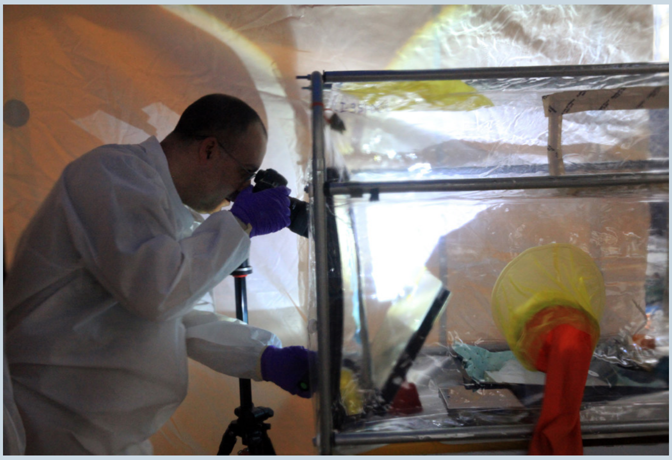

Figure 1. FBI HEAT photographer using the quartz window to photograph evidence inside the glove bag

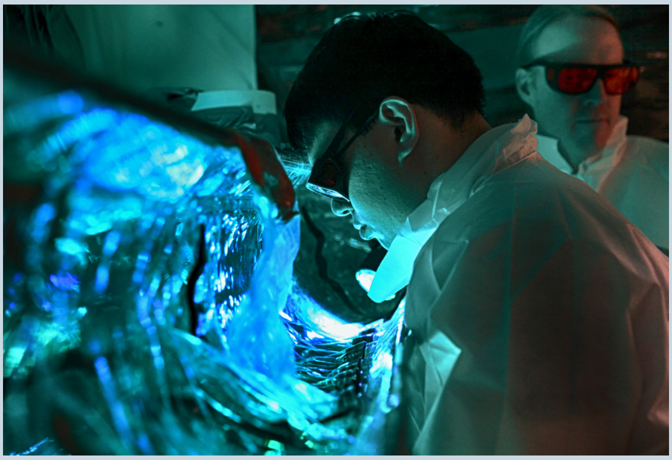

Figure 2. Alternate light sources being used for latent print examinations of evidence in the glove bag

figure 2). Next, trace evidence examiners collected and preserved any hairs and fibres found on the items. Finally, latent print examiners used chemical processing to obtain any additional prints on the pieces of evidence. Throughout the entire process, LANL SNM handlers manipulated the object to facilitate the best possible orientation for examinations and photography.

Ultimately, the exercise showed how FBI HEAT, working inside LANL facilities and with the support of the experts at LANL, was capable of handling and conducting conventional forensics examinations on bulky nuclear material. The trace evidence and latent prints on the object and associated items were collected and preserved, with photographic support throughout the examinations. FBI latent print examiners were able to develop prints that had the necessary quality to enable a search of fingerprint databases. Furthermore, all the examinations were done in a manner consistent with the practices and procedures of the FBI and would be defensible in a court of law.•

ROMANIA'S NUCLEAR AND OTHER RADIOACTIVE MATERIALS INFORMATION SYSTEM

ANDREI APOSTOL AND CLAUDIA OLARU*

International Atomic Energy Agency (IAEA) Nuclear Security Series document no. 15 recommends that each member state establish a National Nuclear Forensics Library (NNFL) for its inventory of nuclear or other radioactive material. The aim of such a library is to assist the investigative authorities with criminal cases involving nuclear or other radioactive material out of regulatory control (MORC). At the same time, the safeguards agreements with the IAEA envisaged in the 1968 Treaty on the Non-Proliferation of Nuclear Weapons (Non-Proliferation Treaty, NPT) require that states parties account for and keep records of their physical inventories of nuclear material and report on any associated changes. Good practice for an efficient nuclear security and safeguards regime within a state would involve development of a digital system for nuclear and other radioactive material accountancy and control that includes all safeguards-related information as well as information associated with other radioactive material in a state's domestic holdings.

Despite the fact that the IAEA sees nuclear safeguards and nuclear security as two separate domains, for small domestic holdings such as Romania's, a unified nuclear and other radioactive material information system is a natural choice that can serve both purposes in a cost-effective manner. The successful development, implementation, and maintenance of such a system serves multiple purposes. It can: (*a*) facilitate nuclear forensics support for the investigation of incidents involving MORC, thereby contributing to responses to and detection and prevention of further thefts or other illicit activities involving such material; (*b*) strengthen implementation of a state-of-the-art IAEA/European Atomic Energy Committee (EURATOM) safeguards system; (*c*) organize information related to a state's

*This work was implemented under the IAEA Coordinated Research Project J02013 "Applying Nuclear Forensic Science to Respond to a Nuclear Security Event", Contract Number 23206.

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Romania's nuclear and other radioactive materials... continued from page 3

domestic holdings and on material in previous criminal cases involving MORC; (*d*) improve understanding of the legacy material available within a state; and (*e*) contribute to the preservation of knowledge for a future generation of experts.

The Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH) in Bucharest has developed a prototype for a unified nuclear and other radioactive material information system and had it approved at the highest national level. Efforts are ongoing to upgrade this prototype and provide it with relevant data from research, studies, and analyses performed on nuclear material under safeguards or other available radioactive sources. Information on interdicted nuclear or other radioactive material has also been included.

Past perspectives

Any functioning nuclear institution requires that its nuclear security and safeguards implementation procedures undergo constant readjustment as research activities and plans change over time. The decommissioning of the Soviet-era water-moderated, water-cooled VVR-S research reactor, the establishment of Extreme Light Infrastructure-Nuclear Physics (ELI-NP), and development of the first Romanian Nuclear Forensics Laboratory (NFL-RO) led to changes in Key Measuring Points (KMPs) associated with storage and analysis of nuclear material as well as a reconfiguring of the radioactive material holding facilities within IFIN-HH. A constant need to revise procedures and inventory lists emerged as a result.

Another important consideration is changes in staff and their responsibilities, which is not always a smooth process. When it comes to the responsibilities of personnel involved in nuclear security and/or safeguards within a nuclear institution, information and instructions related to nuclear or other radioactive material should always be preserved in an efficient manner according to procedures and in relevant documents. Accountancy information on the nuclear and other radioactive material inventory should be centralized, digitalized, and fully secured.

Current efforts

IFIN-HH has developed a secure information system that centralizes and fully digitalizes accountancy information on the nuclear and other radioactive material available at the institute. The system is known as the Nuclear and Other Radioactive Material Information System (NRMIS). Input options allow the user to include information that can be used to identify the material and its storage location, check the date of entry under safeguards, and provide data on its origin. In addition to safeguards-related details, the user can add physical, chemical, elemental, and isotopic characteristics, as well as analytical reports, which extends the purpose of the database from a safeguards accountancy system to supporting the National Nuclear Forensics Library. All the data in the NRMIS is stored offline and is protected by a username and password.

Implementation of the NRMIS web interface employs a number of modern and robust technologies, some of which are outlined further below. At the core of the project is Next.js (v12), a framework which sustains both the backend and the frontend of the application. The application programming interface (API) is written mostly in TypeScript, due to its safe and rigid structure, while the frontend uses JSX for rapid user interface (UI) prototyping. MySQL was used to create the database itself, due to its proven reliability, large community, and support for fixed-point numeric types, which allows storage of numeric values with associated uncertainties, as well as easy search of ranges.

At the heart of the project are two different databases. The first is the Nuclear Material Database (NMD), designed to keep records of the nuclear materials under safeguards in the WRMA Material Balance Area (MBA). The second is the Radioactive Source Database (RSD), used to store information on radioactive sources or objects contaminated with radionuclides but not subject to safeguards.

Nuclear and Radioactive Material Databases

The NMD has three components: a General Ledger, a Physical Inventory Listing (PIL) regular view, and a PIL detailed view.

The General Ledger is designed as a tool for tracking changes to the MBA inventory within a Material Balance Period (MBP). At the end of the MBP (or the end of Physical Inventory Taking), the General Ledger is saved and a new one is created.

Figure 3 shows that the records are displayed in element categories, while the book inventory column always indicates the book ending inventory.

The regular PIL view is an instrument for verifying the total inventory of the MBA and checking the

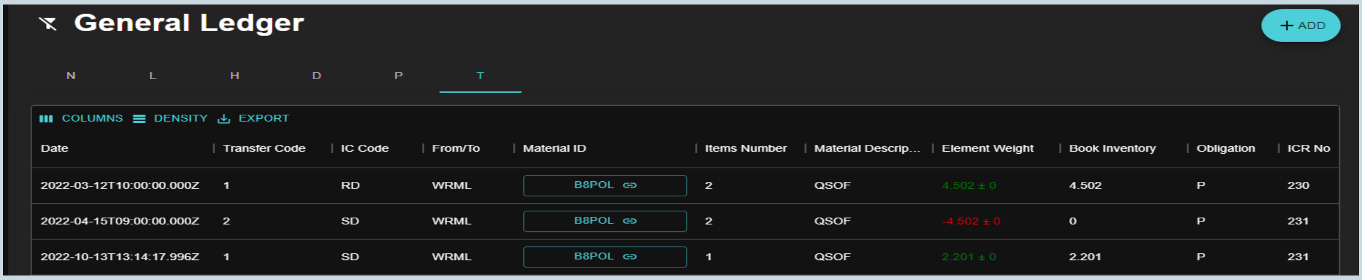

Figure 3. Screenshot of the General Ledger implemented within the NRMIS

annual PIL and MBP reports that are sent to the IAEA. The regular view also displays a summary of the inventory for each element category.

The detailed PIL view is a centralized and itemized list of inventory items, sorted by KMP and element category. It is also a valuable tool for identifying materials in their storage location. By accessing the link connected to each material ID, the user can open a window that contains detailed information about the item. The user also has access to safeguards-related information about the item, its physical and chemical characteristics, isotopic composition, and so on.

The RSD is an important part of the NRMIS. Its aim is to support the Romanian NNFL by storing information about radioactive sources that are not subject to safeguards. The main page displays a list of all the radioactive sources in the database and their specific parameters, such as serial number, radionuclide, half-life, activity, container, production date, producer and distributor, and live activity (activity correlated to the clock of the computer). Like the NMD, the radioactive sources information stored in the RSD can be edited or deleted through its user-friendly interface. The name of each source has a link that opens a window containing a complete description, pictures, and a generated QR-code.

Like the NMD, two important options will be available in the RSD: to add and to search data. The search engine, which will be available for both databases, is an important sub-tool of the NNFL. The databases are optimized for searches of a large amount of information, using an advanced real-time calculus system to find the radioactive sources and nuclear material that correspond to a user's queries, taking account of the uncertainties. The search results will return the most relevant data within the associated uncertainty.

Conclusions

The NRMIS will have a significant long-term impact on implementation of nuclear safeguards and nuclear security commitments under the NPT, as well as the Convention on the Physical Protection of Nuclear Material and it's Amendment (CPPNM/A) and the International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANTI, to which Romania is a State Party. The NRMIS is transferrable (without country-specific data) to other countries should they choose to use it. It is an essential element in ensuring the sustainability of a nuclear safeguards and security regime within a state. •

NOTABLE PUBLICATIONS ABOUT THE WORK OF THE ITWG, NUCLEAR FORENSICS AND RELATED DISCIPLINES

- Choi, S.-U., 'In situ detection of neodymium isotopes using tunable diode laser absorption spectroscopy for nuclear forensic analysis', *Journal of Analytical Atomic Spectrometry*, vol. 38, no. 1, pp. 166-173.
- Zhang, L., et. al., 'Evaluation of Graphene Oxide as a Thermal Ionization Enhancer for Plutonium in TIMS Measurement', *Analytical Chemistry*, vol. 95, no. 2, 17 Jan. 2023, pp. 1106-1114.
- Devlin McLoughlin, V.E., et.al., 'Determining provenance of uranium ore concentrates using 143Nd/144Nd', *Talanta*, vol. 253, 1 Feb. 2023, 124088.
- Kumar, S., et.al., 'In View of "On-Site" Nuclear Forensics and Assay of Fissile Materials in Sealed Packages by High-Resolution γ-Ray Spectrometry', *Analytical Chemistry*, 1 Feb. 2023.
- Martinson, S.P., et.al., 'Nondestructive and destructive assay for forensics characterization of weapons-grade plutonium produced in LEU irradiated in a thermal neutron spectrum', *Annals of Nuclear Energy*, vol. 183, April 2023, 109645.

NUCLEAR FORENSIC SCIENCE TO BRIDGE THE RADIOLOGICAL CRIME SCENE AND THE NUCLEAR FORENSICS LABORATORY: A NEW IAEA COORDINATED RESEARCH PROJECT

GARY EPPICH

The International Atomic Energy Agency (IAEA) takes a multifaceted approach to assisting states with the development of a nuclear forensics' capacity, through publications, training courses, workshops, expert missions, webinars, and support for research and development on nuclear forensics. Through its Coordinated Research Activities programme, the IAEA supports countries with research on and applications for peaceful uses of nuclear science and technology globally. The programme brings research institutions together to collaborate on coordinated research projects (CRPs).

The IAEA has recently initiated a new CRP in the areas of nuclear forensics and radiological crime scene management. In the past, the IAEA has supported two CRPs in the area of nuclear forensics, and it is currently supporting a third, which will conclude in June 2023. Building on prior research supported by the IAEA, the new CRP (Project Code J02020) aims to narrow the gap and strengthen the practical relationship between a radiological crime scene and a state's nuclear forensics laboratory through research projects on methods for analysing and interpreting the physical, elemental, chemical, and isotopic properties of nuclear or other radioactive material.

Intentional unauthorized acts involving nuclear or other radioactive material out of regulatory control present a serious threat to both national and international security. Effective detection and prosecution of criminal acts involving such materials serve to deter future illicit trafficking. Research projects supported by this CRP could range from the development of new forensics signatures to the use of robotics in crime scenes and beyond.

The CRP will seek to develop and apply practical approaches that enable countries to implement nuclear forensics examinations in support of investigations that involve analysis of nuclear or other radioactive material, as well as traditional evidence contaminated with radionuclides collected at a radiological crime scene, enabling states to better investigate, and prosecute as required, events involving nuclear or other radioactive material encountered out of regulatory control.

As part of this CRP, the IAEA would welcome submission of proposals on the following topics:

- Development of approaches to enable laboratory processes at a radiological crime scene, including methods for performing fast in-field analysis of collected nuclear or other radioactive materials, and of traditional forensics evidence contaminated with radionuclides;
- Development of secure online data transfer and communication systems for direct data sending from the crime scene to the nuclear forensics laboratory;
- Development of requirements for use of robots at a radiological crime scene;
- Development of methods to maximize the quality of analytical data collected using in-field instrumentation (e.g. gamma spectrometry, X-ray fluorescence and other field-deployable techniques) for categorization and initial characterization of nuclear or other radioactive material at a radiological crime scene;
- Development of approaches to improve the collection and interpretation of physical characterization (morphology) data from nuclear or other radioactive material, and evidence contaminated with radionuclides, using macro- and micro-scale analytical techniques, especially for powder, particulate and microparticle samples;
- Development of approaches to measure inhomogeneously distributed nuclear forensics signatures in nuclear or other radioactive material;
- Development of methods to exploit the physical, elemental, chemical, and isotopic properties of non-nuclear evidence associated with nuclear or other radioactive material out of regulatory control (e.g. packaging and shielding material; paper and other associated documents; the effect of radiation on evidence);
- Development of new nuclear forensics signatures in nuclear and other radioactive material;
- Development of analytical approaches to measure key nuclear forensics signatures (e.g. isotope ratios) using sustainable, cost-effective instrumentation;
- Development of nuclear forensics analytical

approaches specifically designed for the collection of data from sealed radioactive sources and other radioactive materials commonly used in industrial and medical applications;

- Development of improved statistical and data analysis tools for mathematical inclusion or exclusion when comparing nuclear forensics signature data to data compiled in a national nuclear forensics laboratory;
- Development and adaptation of advanced nuclear technologies applied to nuclear forensics.

The new CRP will comprise up to 20 participating research groups from different states. Each team will pursue independent research on nuclear forensics and radiological crime scene management with a specific focus on collaboration between the two fields. Countries interested in participating in the CRP are encouraged to submit project proposals to the IAEA through the Coordinated Research Activities portal, which can be found on the IAEA website. Proposals for Research Contracts or Research Agreements should be submitted to the IAEA's Research Contracts Administration Section no later than 30 June 2023. •

Figure 4. Nuclear forensic scientists performing an examination of the physical properties of nuclear or other radioactive material (pictured here in a glove bag) collected at a radiological crime scene

UPCOMING TRAINING COURSES AND MEETINGS*

- ITWG Webinar: CMX-7 Virtual Data Review Meeting, Virtual, 21 February 2023
- IAEA International Training Course on Nuclear Forensics Methodologies, Pacific Northwest National Laboratory, United States of America, 27-10 February-March 2023
- IAEA Regional Training Course on Introduction to Nuclear Forensics, Mauritius, 13-17 March 2023
- IAEA Regional Workshop on Radiological Crime Scene Management, Victoria, Seychelles, 27-31 March 2023
- ITWG Webinar: How to get involved as a new ITWG member, Virtual, 28 March 2023
- IAEA Regional Training Course on Introduction to Nuclear Forensics, Cairo, Egypt, 7 – 11 May 2023
- IAEA Third Regional Exercise on Forensic Examination of Evidence and Trace Amounts of Nuclear Material from Radiological Crime Scenes, Moscow, Russian Federation, 29-7 May - June 2023
- ITWG Annual Meeting, Tbilisi, Georgia, 20-22 June 2023
- IAEA National Train the Trainer Course on Radiological Crime Scene Management: Session 2, Bangkok, Thailand, 24 – 28 July 2023

*Please check directly with the event organizer on the status and dates for implementation of the individual events listed above.

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

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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/

The 'ITWG Nuclear Forensics Update' is produced by the Stockholm International Peace Research Institute (SIPRI) on behalf of the Nuclear Forensics International Technical Working Group and with the financial support provided by the United States Department of Energy, National Nuclear Security Administration. The content and the views expressed here belong to the authors.