ITWG
Nuclear Forensics
International Technical Working Group

ITWG NUCLEAR FORENSICS UPDATE

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CHAIRPERSONS' ADDRESS

Welcome to the 22nd edition of the Nuclear Forensics International Technical Working Group (ITWG) newsletter, the ITWG Update. The ITWG was formed in 1995 to counter the smuggling of nuclear and other radioactive materials and since then has focused on identifying, developing and socializing best practices in the field of nuclear forensic science. ITWG activities like the collaborative materials and Galaxy Serpent exercises provide important learning opportunities for nuclear forensics practitioners around the world, and they complement other international efforts like those organized by the International Atomic Energy Agency (IAEA) and the Global Initiative to Combat Nuclear Terrorism (GICNT). As ITWG co-chairs, we applaud the work of the IAEA and in particular the Technical Meeting on Nuclear Forensics being held in Vienna, Austria, 11–14 April 2022. The meeting will showcase many advances in the field, including work by ITWG members, and we commend the meeting and its findings to our readers. This edition of the newsletter includes an article introducing the technical meeting (page 4), as well as a case study involving examination of highly contaminated radioactive evidence (page 1) and an article on nuclear security training during the pandemic (page 5). The newsletter also includes a calendar of upcoming nuclear forensics activities (page 7) and a list of academic publications over the past three months (page 6). Again, we congratulate the IAEA on the technical meeting and hope readers find the newsletter to be a useful resource.

With best regards,

Klaus Mayer and Michael Curry

FORENSIC EXAMINATION OF HIGHLY CONTAMINATED EVIDENCE FROM THE BREACH OF A 3000 CI RADIOACTIVE SEALED SOURCE IN DOWNTOWN SEATTLE

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Source breached

A sealed radioactive source containing 2805 Ci of the radioactive isotope cesium-137 (137Cs) was breached on 2 May 2019 at the University of Washington Harborview Research and Training (HRT) building in downtown Seattle while attempting to recover the source for the United States National Nuclear Security Administration's (NNSA's) Off-site Source Recovery Program (OSRP). As a result of the breach, the radioactivity that was released contaminated 13 personnel and seven floors of the HRT building as well as the local environment, which led to a two-year remediation effort. Nuclear forensic examinations of the contaminated items recovered from the scene, including the breached source capsule, provided key information that informed recovery operations and supported the US Department of Energy (DOE) Joint Investigation Team's investigation into the root cause and contributing factors. This article outlines the processes used in the investigation.

Objectives of the forensic examinations

The Joint Investigation Team, leaders from the DOE, the State of Washington regulatory body and the University of Washington coordinated closely to develop the objectives and scope of the forensic examinations. These objectives included (*a*) inventorying and documenting evidence collected at the scene; (*b*) characterizing the physical condition of those items,

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Forensic Examination... *continued from page 1*

Figure 1. Nuclear forensic examination stations established to support the investigation into the sealed source breach at the Harborview Medical Facility

including the irradiator components (dimensions, masses etc.); (*c*) transferring electronic media from contaminated digital video records; (*d*) comparing as-built conditions of key components of the irradiator system with design information; and (*e*) characterizing, to the extent possible under the constraints of the examination, the form and amount of the source term released. A graded approach was developed to examine radioactively contaminated and co-mingled evidence. This approach balances the needs of the investigation with the requirements to protect staff and facilities from contamination and dose risks, with the overall goal of achieving each of these forensic objectives.

Examination stations

In several instances, traditional forensic methods had to be modified to support the examinations of highly contaminated items that may have posed high contamination and dose risks. These examinations were carried out in one of five built-for-purpose examination areas (see figure 1) located on the Richland campus of Pacific Northwest National Laboratory (PNNL). They were designed according to the level of contamination and dose risk represented by each examination. Examinations included digital photography, basic physical measurements (dimensions and masses), cut mark analysis, 3D optical scanning and X-ray computed tomography (XCT), X-ray fluorescence, high resolution gamma spectrometry, and optical and electron (scanning and transmission) microscopies.

Most of the examination stations (four of five) were located within PNNL's Category II Nuclear Facility, the Radiochemical Processing Laboratory (RPL), including the Remotely Operated Shielded Examination Station (ROSES), the Contained Hazard Intermediate Examination Facility (CHIEF) and a radiological greenhouse designed and constructed for the examination of the ~6-tonne contaminated irradiator body. The ROSES was established within three hot cells located in RPLs High Level Radiation Facility (HLRF) to examine evidence representing the highest dose and contamination risks to personnel, equipment and facilities. This station was outfitted with cutting, photography, ultrasound and weighing capabilities as well as a unique, heavily columnated gamma spectroscopy scanning instrument (installed in the back hatch of one of the hot cells) capable of scanning the emitted gamma radiation across the length of the inner source capsule. Also located within ROSES was a station for decontaminating heavily contaminated items prior to their transfer to other examination stations outside of the hot cell.

The CHIEF work area was a large glovebag (roughly 2.5 m x 1 m) with double hepa filter placed within a benchtop contamination area in one of RPLs radiological laboratories. This station was established for the examination of contaminated evidence that represented relatively low dose and medium contamination risks. Capabilities within CHIEF included digital imaging, macro photography (with ~50 µm resolution), 3D optical scanning and dimensional analysis by photography, Vernier digital callipers and ultrasound. The digital camera, optical scanner and body of the ultrasound unit were all located outside of the glovebag to avoid contaminating expensive equipment and to allow for their easy operation and maintenance. An additional examination station composed of a disposable glovebag placed within a radiological hood was designed and constructed for processing contaminated evidence that posed a higher contamination risk than what could be processed within CHIEF, but due to the successful implementation of the decontamination station within ROSES, this station was never utilized.

A fourth station within RPL, known as the 'quiet microscopy suite', was used to analyse particles collected from evidence within ROSES, CHIEF, and the radiological greenhouse by scanning and transmission electron microscopies. A fifth examination station located across campus from RPL was also used for 3D X-ray computed tomography imaging. This station was located within the Environmental and Molecular Sciences Laboratory (EMSL), a non-radiological laboratory and national user facility that typically supports a variety of basic research for the DOE. Special permission was received from the DOE leadership to transfer several sealed evidence pieces that were too contaminated for hands-on examinations to EMSL for remote, autonomous, non-destructive interrogations using an X-Tek/Metris XTH high resolution microfocus 3D Computed Tomography instrument. With a spatial resolution of approximately ~100–200 µm (depending on the size of the item being examined) and the ability to image a volume of ~1400 cm^3 or a cylinder with a height and diameter equal to 30 cm, this instrument

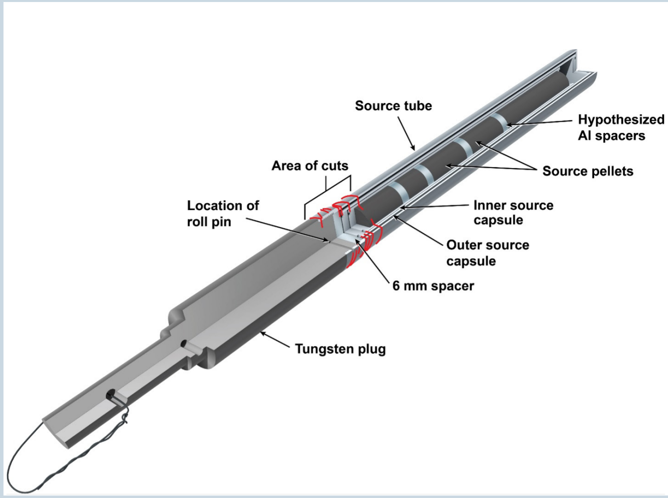

Figure 2. Artist's rendition documenting the damage to the breached source assembly recovered from the Harborview Medical Facility

was critical to the investigation. Prior to their transfer to EMSL, pieces of evidence were triple encapsulated within low density materials (plastic bags, 3D printed plastic and PVC containers) to ensure they did not represent a contamination risk to the facility and personnel.

Forensic objectives achieved

Examinations carried out within each of the five work areas provided important information to the investigation, allowing examiners to achieve all five forensic objectives. All damage to the components of the source assembly were documented in detail, including damage to a single source pellet residing within the inner source capsule (ISC) (see figure 2). All the cuts were consistent with damage expected from a dry grinding process generated from a rotating cutting tool of similar dimensions to that of the grinding wheel recovered at the scene. The absence of any significant dispersible material spilling from the ISC during physical examinations within ROSES suggested that the remainder of the source material within the ISC was intact and non-dispersible. A single source pellet that was visible through the cuts in the ISC appeared to be in good condition and pelletized except where the pellet was directly impacted by the grinding wheel. The total amount of radioactivity released from the ISC as a result of the breach was estimated to be a maximum of ~1.25 Ci (~0.14 g) as a result of the careful geometric analysis of cut marks on the damaged source pellet and the assumption that only a portion of the pellet was available for release. This amount of activity represented less than 0.04 per cent of the total activity originally contained within the sealed source prior to the accident. •

THE 2022 IAEA TECHNICAL MEETING ON NUCLEAR FORENSICS: FROM NATIONAL FOUNDATIONS TO GLOBAL IMPACT

GARY R. EPPICH AND EVA SZÉLES

Goals and objectives of the technical meeting

The IAEA is hosting a 'Technical Meeting on Nuclear Forensics: From National Foundations to Global Impact' in Vienna from 11 to 14 April 2022. To be held three years after the last IAEA Technical Meeting on Nuclear Forensics, this meeting aims to focus on the application of nuclear forensics in support of investigations of incidents involving nuclear and other radioactive material out of regulatory control. In addition, it aims to demonstrate links to radiological crime scene management (RCSM) as well as support potential judicial proceedings. Another important objective is to highlight states' experiences in utilizing nuclear forensics for the prevention of and response to nuclear security events. The technical meeting is currently being planned as a hybrid event to ensure full accessibility to its programme for more than 150 participants. Those unable to attend in person will be able to deliver virtual remarks or send pre-recorded presentations.

Programme of the technical meeting

The technical meeting programme was developed with the support of a steering committee of subject matter experts. The programme consists of eight technical sessions covering topics including technical advances in nuclear forensic science and the development of nuclear forensics at the radiological crime scene as well as the legal and regulatory framework that underpins nuclear forensics at the national level.

Oral sessions will also highlight member state achievements in nuclear forensics capacity building and successful international cooperation and exercises as well as nuclear forensics during the Covid-19 pandemic. In addition, discussions will cover a multitude of topics, such as the support that nuclear forensics can provide to legal proceedings, experiences with the nuclear forensics 'self-assessment tool' developed by the Global Initiative to Combat Nuclear Terrorism, and future directions in nuclear forensic science as envisioned by leaders in the international community. Panel discussions will provide participants with the opportunity to learn from experienced nuclear forensics practitioners and law enforcement representatives, ask probing questions, and gain insight from the various views and opinions offered by panel members from all over the world.

The interactive activities during this meeting will be available to all participants. In the first activity, an exercise, the participants will be presented with a scenario that takes place in the fictitious country of Rudas Cove, involving nuclear forensics after the discovery of illicitly obtained radioactive material. Using a series of video injects to convey the scenario fact pattern, the participants will learn how several techniques in nuclear forensics can be used to analyse and assess the recovered radioactive material. Participants can engage with the exercise by responding to the questions and requests for feedback posted by the facilitator by using their personal smartphones.

Additionally, an activity entitled 'Nuclear Forensics Drama Theatre' will take the form of a mock trial, demonstrating good (and not so good) practices when answering questions in court as an expert witness. The participants will take the role of members of an impartial jury, voting on a case presented by real prosecutors with experience in legal proceedings involving nuclear and other radioactive material out of regulatory control. In addition, a scenario-based, interactive mini-exercise led by the ITWG will focus on establishing and operating a national nuclear forensic library.

Radiological crime scene management

Another notable aspect of this meeting is that it will highlight the close connection between RCSM and nuclear forensics as well as the critical role of RCSM in national strategies to respond to the smuggling and trafficking of nuclear and other radioactive material. In addition to dedicated panels and oral sessions on the topic, a Hungarian team of law enforcement and nuclear forensic experts will demonstrate good practices in responding to and managing radiological crime scenes using a video-projected live-play demonstration.

Many states recognize the importance of RCSM and have requested assistance from the IAEA in this essential activity that supports a better and wider understanding on how to establish and further enhance RCSM by implementing good practices, maintaining the integrity of evidence, and ensuring the chain of custody as well as conducting conventional and nuclear forensics—all of which are essential in supporting any subsequent prosecution. Furthermore, the science utilized in the analysis of evidence can be used not only in the laboratory but also at the crime scene.

Reporting and additional information

The IAEA-hosted technical meeting aims to meet the needs of the international community in strengthening nuclear security by providing opportunities for all participating states to present their achievements in nuclear forensics and RCSM, to gain insight from other participants about how to enhance their national capabilities, and to chart a pathway forward in the development of nuclear forensic science together with the scientific support, RCSM.

Following the meeting, the IAEA plans to produce a technical document containing key findings and developments.

More information about the meeting is available here: https://conferences.iaea.org/event/266/ •

RETHINKING THE PRACTICE OF REMOTE TRAINING THROUGH AN EVOLUTION OF THE VIRTUALIZATION: THE HYBRID APPROACH OF EUSECTRA REMOTE INTERACTIVE ETRAINING (ERIET)

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The European Nuclear Security Training Centre (EUSECTRA) was inaugurated approximately 10 years ago and is operated by the European Commission's Joint Research Centre (JRC), located at the Karlsruhe (Germany) and Ispra (Italy) sites. It includes a large variety of capacity-building and professional development activities, which range from hands-on training for nuclear security and safeguard actors (e.g. respectively, border guards or customs and nuclear inspectors) to educational efforts in both nuclear security and safeguards. EUSECTRA aims to improve the capabilities of European Union (EU) member states and beyond to address the threats associated with illicit incidents involving nuclear or other radioactive materials by providing front-line officers, their management, trainers and other experts in the field with hands-on training using real nuclear materials. Based on the unique combination of scientific expertise, specific technical infrastructure and the availability of a wide range of nuclear materials, EUSECTRA complements national training efforts by providing realistic scenarios with real, special nuclear material. The training programme offers a unique opportunity 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 of different isotopic compositions can be used for training in detection, categorization and characterization.

Figure 4. Interactive remote secondary inspection during a FLO ERIeT. Credit: European Commission, Joint Research Centre, Directorate for Nuclear Safety and Security

Figure 3. Virtual classroom at EUSECTRA during the pandemic. Credit: European Commission, Joint Research Centre, Directorate for Nuclear Safety and Security

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Rethinking the Practice of Remote Training… *continued from page 5*

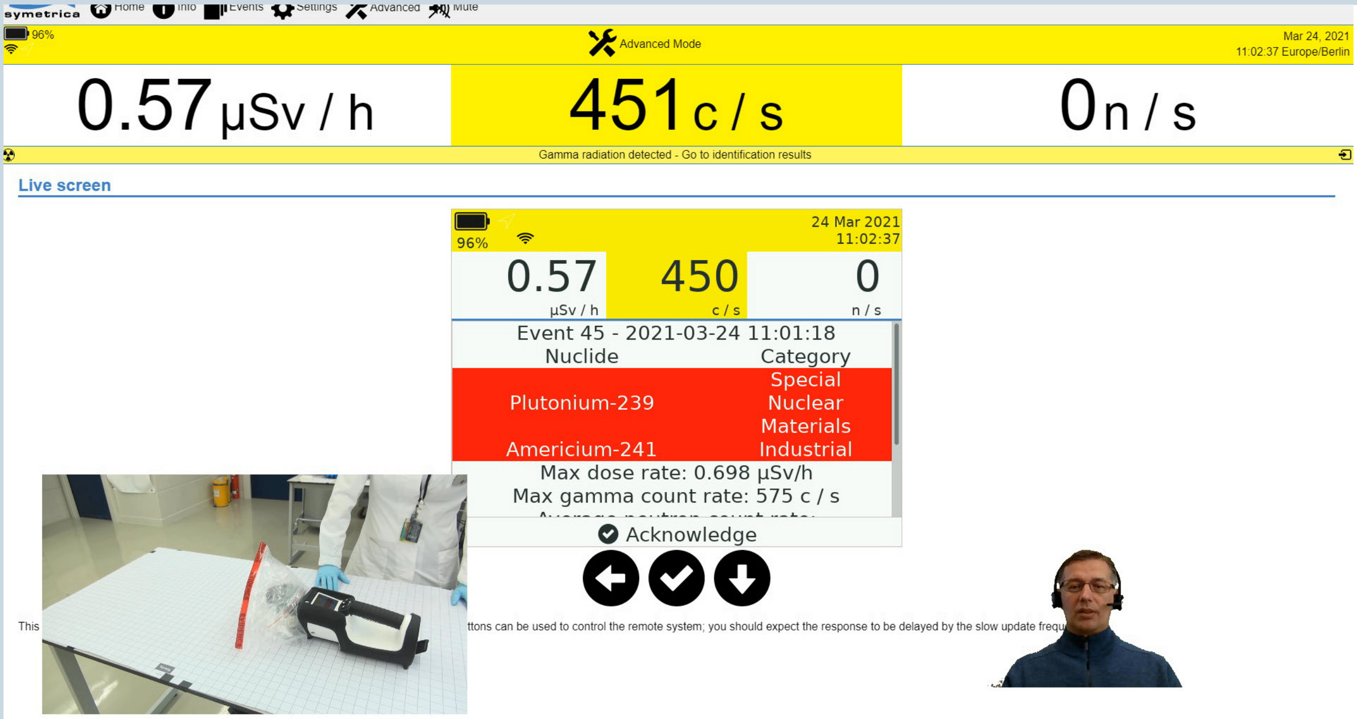

Figure 5. Remote access to instrument measuring nuclear material during a Reachback ERIeT. Credit: European Commission, Joint Research Centre, Directorate for Nuclear Safety and Security

Covid-19 led to online and remote training

While the core activities of the trainings are based on field and hands-on exercises, the ongoing pandemic has constrained training in person, and the value of online and remote training has come to light in such a tough situation. A high number of requests from partners (individual EU member states, European Commission Directorate General such as DG HOME, TAXUD or ENER, international partners) to continue EUSECTRA training even during the crisis has led to the development of the EUSECTRA Remote Interactive eTraining (ERIeT). The ERIeT was thus designed at the time of the Covid-19 crisis to be used as a temporary substitute for training in person for as long as it is suspended. In the medium and long term, ERIeT is foreseen to complement physical training or be used as refresher and introductory material.

Hybrid approach to avoid online fatigue

During the pandemic, many organizations have switched to online events (mostly in the form of webinars). However, experience shows that individuals rapidly reach a level of saturation from digital events. This might result in the participants

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

- Varga, Z. et.al., 'Trends and perspectives in nuclear forensic science', *Trends in Analytical Chemistry*, vol. 146 (Jan. 2022).
- Kitcher, E. D., Osborn, J. M. and Chirayath, S. S., 'Characterization of plutonium for nuclear forensics using machine learning techniques', *Annals of Nuclear Energy*, vol. 170 (2022).
- Burkhardt, A. W., Bickley, A. A. and Bevins, J. E., 'Spatially-variant isotope production burnup modeling in a CANDU-6 reactor for nuclear treaty monitoring', *Annals of Nuclear Energy*, vol. 168 (2022).
- O'Neal, P. J., Chirayath, S. S. and Cheng, Q., 'A machine learning method for the forensics attribution of separated plutonium', *Nuclear Science and Engineering*, Feb. 2022.

feeling exhausted and disinterested. Taking this into consideration, essential requirements were brought to the design phase which involved an integrated SAT (Systematic Approach to Training) methodology, namely (*a*) to remain as interactive as possible using all modern technical available tools; (*b*) to offer and focus on streamed live interactive field/practical exercises with the use of extended instrument and facility portfolios of EUSECTRA and with the real live use of nuclear and radioactive material; and (*c*) to use new virtual methodology in the best way to avoid online event fatigue.

The ERIeT resulted in a hybrid approach, with the virtualization of the physical training, merging the best of two worlds: the interactivity of an e-classroom (through serious game, flipped classroom etc.) and the unique approach of interactive live-streaming field exercises. In the latter, the participants have access to multiple live video feeds and instrument displays and can interact in real time with the talents in the field (mimicked by JRC staff) to teach them how to operate instruments and apply their related national standard operating procedures during the nuclear security event provided in the scenario-based exercise.

By the first quarter of 2022, ERIeT courses will have been provided in the areas of MEST/Reachback and Radiation Detection FLO (see figures 3–6).

Figure 6. The EUSECTRA team adding cinema performances to the use of RIDs in time of Covid-19. Credit: European Commission, Joint Research Centre, Directorate for Nuclear Safety and Security

Participants appreciated this hybrid approach for its highly interactive character and preferred it to pure eLearning or simple webinars. JRC will continue to expand ERIeT to other areas and include these sessions as complementary elements in the training portfolio. •

UPCOMING TRAINING COURSES AND MEETINGS*

- 12th International Conference on Methods and Applications of Radioanalytical Chemistry (MARC XII), Kailua-Kona, Hawaii, 3–8 April 2022
- IAEA Technical Meeting on RCSM and Nuclear Forensics, Vienna, Austria, 11–14 April 2022
- IAEA Triennial Technical Meeting of States' Points of Contact for the Incident and Trafficking Database, Virtual, 26–28 April 2022
- French Alternative Energies and Atomic Energy Commission (CEA) CBRNE R&I Conference, Lille, France, 2–5 May 2022
- IAEA International Training Course on Essential Elements of Nuclear Security for Nuclear and Other Radioactive Material out of Regulatory Control, Argonne, IL, United States, 25 April–6 May 2022
- ITWG Annual Meeting, San Francisco, California, USA, 20–24 June 2022
- JAEA 7th Asia-Pacific Symposium on Radiochemistry 2022 (APSORC22), Fukushima, Japan, 11–16 September 2022

*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/

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