ITWG Nuclear Forensics
International Technical Working Group

ITWG NUCLEAR FORENSICS UPDATE

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CHAIRPERSONS' ADDRESS

Welcome to the 37th edition of the Nuclear Forensics International Technical Working Group (ITWG) newsletter. As we celebrate an important milestone—30 years—we are reminded of the immense dedication that fuels the ITWG. While the annual meetings rightly highlight the group's dynamic energy and collaboration, it is the tireless, all-volunteer efforts of our members in the 51 weeks in between that truly sustain our mission of advancing nuclear forensics.

One such effort was the recent webinar hosted by the Australian Nuclear Science and Technology Organisation (ANSTO) and the Australian Border Force (ABF) on Operation Drafthall. This session stood out as a compelling example of nuclear forensics in action, offering invaluable insights into real-world operations. We extend our sincere gratitude to ANSTO and the ABF for their exceptional work in sharing this experience with the community. If you missed the webinar, it is available on our website—don't hesitate to explore it for a deeper understanding of collaborative efforts in the field.

This edition showcases three intriguing articles. First, reflecting on the ITWG's journey, we are thrilled to share a retrospective that traces our evolution from a visionary idea to a global network of over 200 members. With the assistance of Paul Thompson (the only remaining member active since ITWG-0) and David Smith (an early ITWG co-chair), we recount how foundational collaboration and innovation have shaped our identity today. Second, our US colleagues present an in-depth analysis of the Epic Shadow exercise series that demonstrates operational readiness in nuclear forensics. Finally, an article from the International Atomic Energy Agency (IAEA) described the recent Coordinated Research Project aimed at translating nuclear forensics science into practical, deployable capabilities—such as the rapid retrieval of investigative information from radiological crime scenes.

As 2025 draws to a close, we are proud of the progress made this year and excited about what's next. While details of the 2026 annual meeting are still being finalized, we anticipate hosting the event in the summer of 2026. Together, we continue to strengthen the field of nuclear forensics through shared knowledge and unwavering commitment.

Wishing you a joyful end to 2025 and a promising start to 2026!

With best regards,

James Blankenship and Maria Wallenius

30 YEARS OF THE NUCLEAR FORENSICS INTERNATIONAL TECHNICAL WORKING GROUP: A GLIMPSE INTO THE EARLY DAYS

MARIA WALLENIUS, JAMES BLANKENSHIP, DAVID KENNETH SMITH AND PAUL THOMPSON

How it all began

The origins of the Nuclear Smuggling International Technical Working Group, as the ITWG was originally named, can be traced back to the International Conference on Nuclear Smuggling Forensic Analysis held at Lawrence Livermore National Laboratory (LLNL) on 7–9 November 1995. Fourteen countries and international organizations convened to establish a forum for international cooperation on nuclear forensics. This initiative gained momentum at the G7+1 Summit in Ottawa in December 1995, where leaders issued a declaration emphasizing the urgent need to prevent nuclear material from falling into terrorist hands. The G7+1 summit in Moscow in April 1996 reinforced this

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30 Years of the Nuclear Forensics... *continued from page 1*

commitment by declaring illicit nuclear trafficking a critical public safety and non-proliferation concern. The summit resolved to enhance cooperation among governments on prevention, detection, information sharing, investigation and prosecution involving cases of nuclear smuggling.

The first official ITWG annual meeting (ITWG-1) was held in Karlsruhe, Germany, in January 1996 (see figure 1, for the photo from the most recent ITWG meeting see figure 2). A second meeting (ITWG-2) in Obninsk, Russia, followed later that year. Initially planned as biennial events, meetings soon transitioned to an annual schedule. Participation has grown significantly, from 20–30 attendees in the early years to 80–90 participants today (see figures 1 and 2). The ITWG's co-founders and first co-chairs were Lothar Koch (European Commission Joint Research Centre, Institute of Transuranium Elements) and Sid Niemeyer (LLNL). The group has been jointly led by the European Commission and the USA ever since.

In its early years, the ITWG aimed to address a broad range of issues, from physical protection breaches to postal shipments of nuclear material and border detection technologies. Over time, other initiatives, such as the Border Monitoring Working Group, assumed responsibility for various areas, narrowing the ITWG's focus to in-field response, scene-of-crime operations and laboratory analysis to forensic standards. These pillars later formed the foundation of the ITWG Task Groups.

Model action plan

The ITWG has developed a credible, widely accepted approach to nuclear forensics investigations to guide national authorities in conducting nuclear forensics examinations. This guidance became the ITWG Model Action Plan (MAP), which was first discussed during ITWG-3 in Como, Italy, in 1997. Initially conceptual, the MAP covers key elements, such as securing the site where material was discovered, conducting in-field categorization to assess nuclear or radiological hazards, collecting and transporting evidence to a specialized nuclear forensics laboratory, developing an analytical plan approved by the lead investigator, performing laboratory characterization of nuclear, radiological and conventional forensic signatures and interpreting results to support investigative conclusions (see figure 3).

The ITWG has refined the MAP over the years. At ITWG-8 in Budapest in 2003, the International Atomic Energy Agency (IAEA) asked the ITWG to fully document the MAP for use by its member states. Experts from the US Department of Energy's LLNL and Pacific Northwest National Laboratory delivered a technical report to the IAEA in 2004. After several IAEA consultancy meetings—including one immediately after ITWG-9 (see figure 4) in Cadarache, France—the MAP was published in 2006 as IAEA Nuclear Security Series No. 2 with the title *Nuclear Forensics Support*. A revised version, *Nuclear Forensics in Support of Investigations* (IAEA Nuclear Security Series No. 2-G) was published in 2015.

Analytical round robins and the ITWG Nuclear Forensic Laboratories (INFL)

Collaborative Material Exercises (CMX) have been central to the ITWG's mission from the outset. The first such exercise, initially called a Round Robin (RR-1), began in early 1999. Six laboratories (Austria, France, the European Commission, Poland, Lithuania and the USA) analysed a plutonium powder sample.

Figure 1. The first official ITWG annual meeting (ITWG-1) was held in Karlsruhe, Germany, in January 1996.

Figure 2. The most recent ITWG annual meeting (ITWG-28) was held in Bologna, Italy, in July 2025.

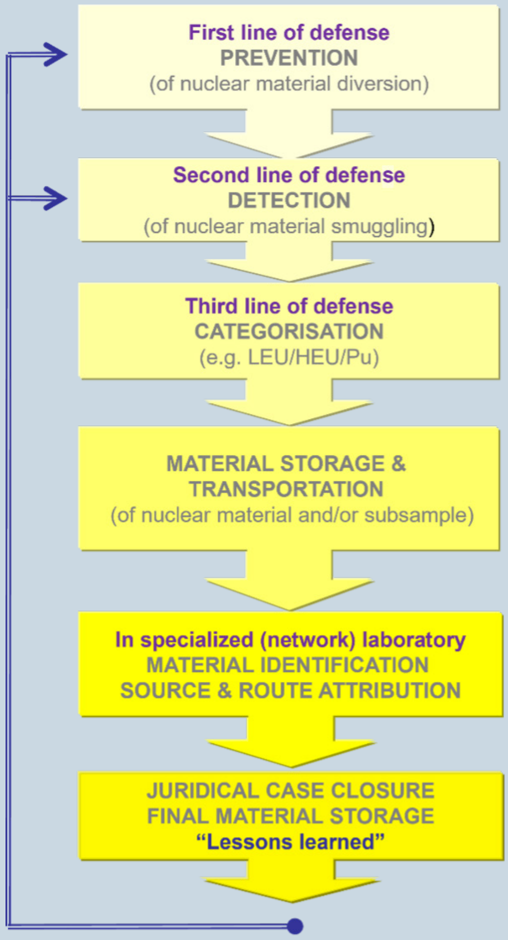

Figure 3. Schematic of the Model Action Plan (MAP).

Participants submitted reports at 24-hour, one-week and one-month intervals, and a data review meeting was held during ITWG-5 in Helsinki in June 1999 (see figure 5).

A second exercise (RR-2) was launched in 2000. It involved nine laboratories (Austria, the Czech Republic, France, the European Commission, Germany, Hungary, Turkey, the United Kingdom and the USA) analysing highly enriched uranium (HEU) powder. This was the first exercise to incorporate traditional forensic evidence, such as fingerprints and pollen, and featured the first extensive After-Action Report (PNNL-14698). After an almost decade-long hiatus, RR-3 was held in 2009, leading to the establishment of regular Collaborative Material Exercises. Around 30 laboratories are currently working on CMX-8.

The exercises played a pivotal role in the founding of ITWG Nuclear Forensics Laboratories (INFL) in the early 2000s. INFL membership was initially limited to scientists from laboratories that had participated in ITWG Round Robins or other laboratories, by invitation, that had demonstrated basic nuclear forensics competency. The INFL's early activities were developing guidelines and accreditation processes, coordinating international exercises, publishing reports and facilitating cross-laboratory collaboration. While many responsibilities were later delegated to the Task Groups, the INFL remains a cornerstone of the ITWG by coordinating research and development efforts in nuclear forensics.

Conclusions

Over the past three decades, the ITWG has played a pivotal role in strengthening nuclear security globally. What began as a small circle of experts in 1995 has evolved into an informal but widely recognized international working group that has established a common framework for nuclear forensics, developed the Model Action Plan for effective response to nuclear smuggling and illicit trafficking incidents, and organized collaborative analytical exercises that improve confidence in support of investigations. Looking ahead, the ITWG will continue its unwavering commitment to promote shared nuclear forensics expertise, develop technical best practices and foster scientific innovation, and to communicate these through comprehensive outreach. •

Figure 4. ITWG-9 in Cadarache, France, in June 2004.

Figure 5. ITWG-5 in Helsinki, Finland, in June 1999.

EPIC SHADOW: HOW THE UNITED STATES DEMONSTRATES OPERATIONAL READINESS IN ITS NUCLEAR FORENSICS PRE-DETONATION MATERIALS PROGRAMME

JAMESON TOCKSTEIN, AUSTIN MILLER AND MICHAEL KRISTO

Operational material analysis for nuclear forensics in the United States

Nuclear forensics is a key component of the USA's strategic nuclear deterrence capability. The US nuclear forensics capability provides the scientific foundation for the US government's commitment to identify and hold fully accountable any state, terrorist group or other non-state actor that supports or enables terrorist efforts to obtain or employ radiological or nuclear devices or materials. The Office of Nuclear Forensics, within the Department of Energy's National Nuclear Security Administration (DOE/NNSA) Office of Counterterrorism and Counterproliferation, manages the Material Analysis Program (MAP). The MAP maintains and advances US operational capability in pre-detonation nuclear forensics for material found outside of regulatory control (MORC). The MAP's operational capability on pre-detonation nuclear forensics is used in connection with law enforcement investigations, national security events and international requests. Its biannual Epic Shadow exercise series demonstrates the operational capability of the US pre-detonation nuclear forensics programme. In a recent exercise, four US national laboratories demonstrated the ability to receive, analyse and deliver required analytical results within specified timelines. The exercise culminated in an interlaboratory comparison of quantitative data to demonstrate the precision and accuracy of nuclear forensics results.

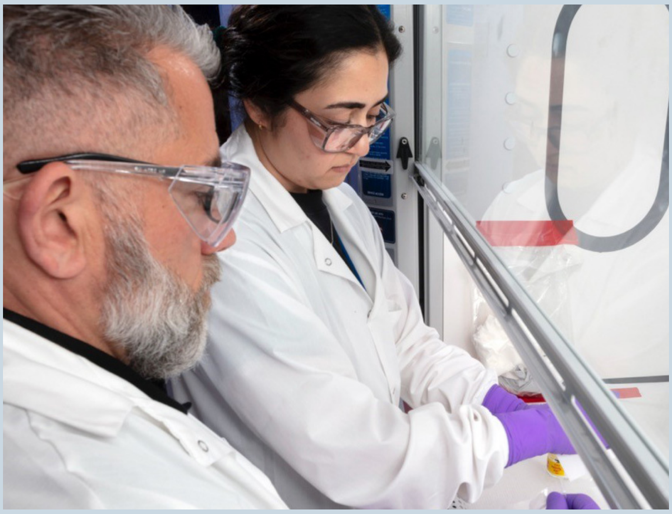

Figure 6. Forensic Microscopists at LLNL prepare an Epic Shadow exercise sample for initial non-destructive analysis.

The MAP delivers requirements-based, state-of-the-art nuclear forensics results on prescribed timelines. It integrates with mission partners, receives and characterizes samples to provide the material characteristics necessary to assess the provenance of bulk samples. The MAP implements nuclear forensics operational readiness by properly and continually preparing to fulfil its mission. It remains ready to perform the nuclear forensics analyses required to characterize nuclear materials to a designated timeline and report nuclear material(s) characteristics and technical conclusions to meet sponsors' needs.

The MAP also manages the US National Nuclear Materials Archive (NNMA), a repository of nuclear materials designed to preserve, document and understand nuclear forensics signatures in order to derive US-origin material provenance. The ability of MAP laboratories to provide high-confidence analytical results and technical conclusions in a timely manner is supported by the NNMA programme's identification, collection, preservation and analysis of forensically valuable nuclear material specimens. Analyses of materials accepted into the NNMA provide ongoing nuclear forensics analysis work for the laboratories and are an increasingly valuable tool for signature discovery.

DOE/NNSA laboratories supporting the Material Analysis Program

The MAP laboratories are accredited as ISO/IEC 17025 Testing and Calibration Laboratories capable of determining nuclear material characteristics at the highest level of quality.[1] The current MAP laboratories are Lawrence Livermore National Laboratory (LLNL) and Los Alamos National Laboratory (LANL). The analyses provided by the MAP laboratories are supplemented by Baseline Characterization analyses of a more limited scope performed at the NNMA laboratories, Oak Ridge National Laboratory (ORNL) and Pacific Northwest National Laboratory (PNNL). The MAP and NNMA laboratories are responsible

[1] ISO/IEC 17025 is the International Organization for Standardization (ISO)/International Electrotechnical Commission's (IEC) international standard for testing and calibration laboratories. It sets out requirements for the competence, impartiality and consistent operation of laboratories, ensuring the accuracy and reliability of their testing and calibration results.

for performing nuclear forensics analyses for law enforcement or national security purposes in support of attribution in cases of an attempted or actual nuclear event.

Epic Shadow: Exercises to demonstrate operational readiness

The Epic Shadow (ES) exercise programme comprises biannual sample analyses and/or tabletop exercises using various nuclear material samples, scenarios and designated analysis objectives and timelines in order to demonstrate operational readiness. The ES is a tool for gauging MAP capacity, capability and performance as part of the plan-do-check-act cycle of programme management. The primary purpose of the ES is to demonstrate and evaluate MAP operational readiness; that is, MAP's ability to receive, sample and analyse unknown nuclear materials and then report findings within specified timelines. The ES also fulfils three other vital functions. First, it keeps the MAP laboratories in operational practice, even in the absence of actual casework. Second, it establishes and fosters relationships with the other offices and agencies needed to effectively execute specific missions. Third, the ES is used to identify gaps in MAP operations, to evaluate new capabilities for their readiness under operational conditions and to implement and assess corrective actions from previous exercises.

Epic Shadow analysis of HEU samples

The MAP laboratories conducted the Epic Shadow 23-01 exercise (ES-23-01) early in fiscal year 2023. It was designed to exercise their capabilities to provide comprehensive analyses, and the capabilities of the NNMA laboratories to provide baseline characterization analyses, of two samples of highly enriched uranium (HEU) metal. Each laboratory analysed these samples, which comprised one or more metal drill turnings, in the context of a fictional foreign country requesting MAP/NNMA assistance with a comparison analysis of two samples as a part of a MORC case. In addition to fulfilling the functions described above, this ES exercise was designed to determine the similarities between the two samples, demonstrate the precision and accuracy of nuclear forensics results through an inter-laboratory comparison, build confidence in the NNMA labs and verify the MAP sample handling process.

The laboratories continuously ensure that all of their facilities, methods and procedures are operational, accredited and documented. ES-23-01 provided an opportunity to test some of the capacity and capability enhancements funded by the NNSA in recent years. The laboratories also ensured that sufficient trained personnel were available to conduct analyses. Seventy-one people participated in ES-23-01 across the four laboratories.

Samples were shipped to each laboratory from the Y-12 National Security Complex without any issues. The laboratories documented and triaged their samples and then subdivided them as necessary for their analyses. While the geometry of metal drill turnings can present challenges for microanalytical techniques, each laboratory was able to adapt its sample preparation methods and instrumental approach to this unique geometry (see figure 6).

The MAP laboratories provided physical measurements, microscopic imaging and microanalyses, which were compared in a qualitative way. For example, the LANL and the LLNL used different but complementary approaches to applying secondary ion mass spectrometry (SIMS) and other imaging and microanalytical techniques to nuclear forensics. In addition, each laboratory delivered dozens of quantitative bulk parameters for each sample (see figure 7).

The quantitative bulk parameters from all four laboratories were statistically compared with one another. Since the materials for ES-23-01 did not have certified values for any of the parameters measured during the exercise, the results were evaluated through an interlaboratory comparison in accordance with MAP standards. This interlaboratory comparison included comparisons of direct measurements of U assay, U isotopics, Pu isotopics, trace actinide (Np, Am, Pu) content and

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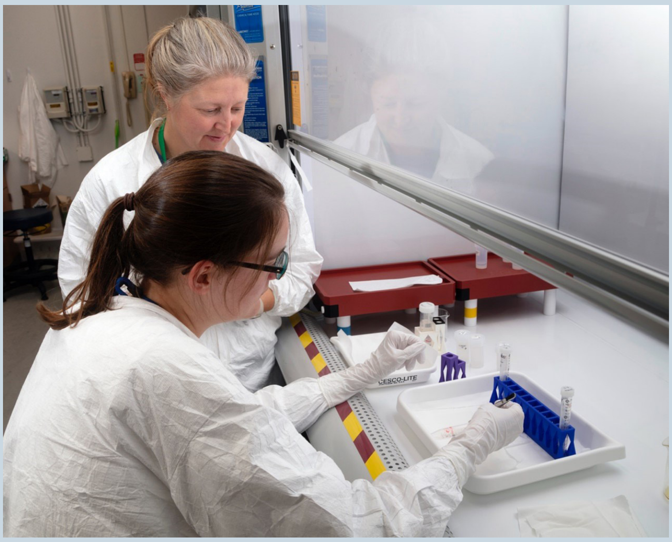

Figure 7. LLNL scientists dissolving an Epic Shadow sample for subsequent chemical purifications and measurements by mass spectrometry.

Epic Shadow... *continued from page 5*

trace elemental composition. The interlaboratory comparison also included comparisons of model ages for the 230Th/234U, 231Pa/235U and 241Am/241Pu radiochronometric systems. There was excellent agreement between the MAP labs for U assay, U and Pu isotopics and age dating. The NNMA laboratories were also consistent with the MAP labs for U assay and U isotopics. There was, in general, good agreement between the MAP labs on the elements measured in common in their trace element analyses. The results from the trace element analyses of the NNMA laboratories were also consistent with the results from the MAP labs.

Conclusions

The DOE/NNSA Office of Nuclear Forensics MAP and ES exercise series continues to demonstrate the operational capability of the US pre-detonation nuclear forensics programme. In ES-23-01, the LLNL, the LANL, the ORNL and the PNNL demonstrated their ability to receive, analyse and deliver the required results within specified timelines for two samples of HEU metal. ES-23-01 culminated in an interlaboratory comparison of high-precision quantitative elemental and isotopic composition data to demonstrate the precision and accuracy of nuclear forensics results. The MAP's capability to analyse MORC for nuclear forensics signatures is a critical part of the US commitment to identify and hold fully accountable anyone who supports or enables terrorist efforts to traffic or use radiological or nuclear devices or materials. •

HOW IAEA'S CRP J02020 CONNECTS PEOPLE, LABORATORIES, AND COUNTRIES

ANDREI APOSTOL, JOVANA NIKOLOV, BILAL AMRO, TEBOGO KUPI, RAIMONDS MURNIEKS, TASHIEMA ULRICH AND GARY EPPICH

The International Atomic Energy Agency (IAEA) Coordinated Research Project (CRP), 'Nuclear Forensics Science to Bridge the Radiological Crime Scene to the Nuclear Forensics Laboratory (J02020)', is advancing the area of nuclear forensics by connecting scientific innovation with operational needs. Launched in 2023, the CRP brings together the European Commission and 19 IAEA member states from across the world to develop methods and tools that strengthen the interface between the radiological crime scene and the nuclear forensics laboratory.

At its core, the project seeks to translate nuclear forensics science into practical, deployable capabilities aimed at rapid retrieval of relevant investigative information. Research teams are investigating new analytical signatures, portable and robotic detection systems, and secure data-transfer mechanisms that allow laboratory-grade information to be obtained at or near the scene of a criminal or other intentional unauthorized act, or suspected act involving seized nuclear or other radioactive material out of regulatory control. From developing AI-assisted gamma spectrometry and robotics to building nuclear forensic libraries, the CRP is shaping the next generation of tools to support criminal investigations in which radiation is involved.

Beyond scientific progress, the CRP embodies the spirit of collaboration and trust that underpins the global nuclear forensics community. Several examples illustrate how this cooperative framework is strengthening both technical capabilities and international partnerships.

In Europe, a dynamic collaboration has developed between the Nuclear Physics Group (NPG) at the University of Novi Sad in Serbia and the Latvian Environment, Geology and Meteorology Centre (LEGMC). Supported by the IAEA Coordinated Research Project J02020, their joint work focuses on analysing gamma spectra from nuclear material measurements. This includes testing various software codes and developing techniques for the examination of swipe samples relevant to crime scenes involving nuclear or other radioactive materials.

In parallel, the NPG has established an official partnership with North-West University (NWU) in Mafikeng, South Africa. This cooperation involves both in-person and virtual training in gamma spectrometry for NWU staff and students, as well as joint research and educational activities applicable to nuclear forensics. Their collaborative studies on uranium ore are contributing to the development of South Africa's national nuclear forensic library while strengthening related expertise across Europe and Africa.

What began as a technical partnership has now evolved into a sustainable international network of

Figure 8. Photos of the Serbian team visiting and performing measurements at North-West University in South Africa, as part of the IAEA Coordinated Research Project J02020.

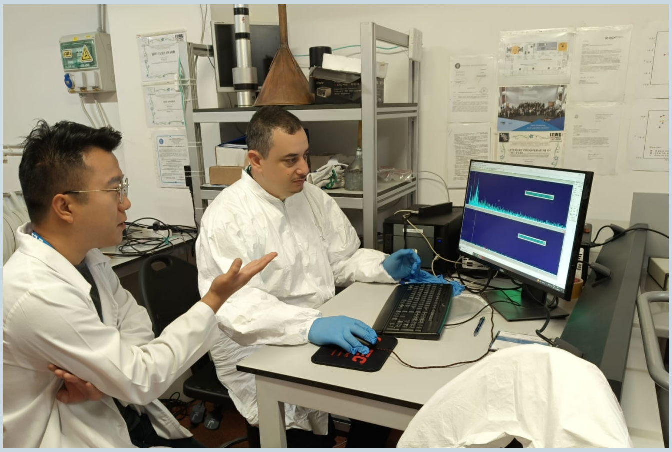

Figure 9. Jordan Atomic Energy Commission (JAEC) team visiting and performing measurements at the Horia Hulubei National Institute for Physics and Nuclear Engineering (IFIN-HH) in Bucharest, Romania.

researchers dedicated to advancing nuclear security through nuclear forensics science.

Similarly, the collaboration between the Jordanian Atomic Energy Commission (JAEC) and the Horia Hulubei National Institute for Physics and Nuclear Engineering (IFIN-HH) in Romania demonstrates how the CRP fosters meaningful scientific exchange. During a recent visit to Bucharest, the Jordanian team carried out its initial measurements of nuclear material samples, using advanced detectors such as planar and coaxial high-purity germanium systems, LaBr3(Ce), and CdZnTe spectrometers. Hands-on experience with these instruments alongside specialized software, some of which are not available in Jordan, expanded the team's technical competence and confidence in performing complex uranium isotopic composition analyses. The visit also paved the way for a long-term cooperation agreement, which will include training opportunities for Jordanian researchers in ICP-MS and nuclear sample preparations for nuclear forensics purposes.

These partnerships illustrate how the CRP J02020 promotes collaboration among scientists and institutions from different countries. By linking laboratories across continents, it reinforces the international foundation of nuclear forensics and enhances global readiness to respond to incidents involving nuclear and other radioactive material out of regulatory control.

As the CRP enters its next phase, participating institutions are preparing for the Second Research Coordination Meeting, to be held at IAEA Headquarters in Vienna in February 2026. The meeting will showcase scientific results, discuss validation and standardization, and continue building collaboration among all involved. •

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

- Guo, S., Wang W., Li, Z. et al., 'State-of-the-art MC-ICP-MS methodology for precise plutonium isotope ratios', *Spectrochimica Acta Part B: Atomic Spectroscopy*, vol. 235 (Jan. 2026).
- Johnson, J., McDonald, L. and Tasdizen, T., 'An exploration of data fusion techniques applied to nuclear forensics tasks', *Journal of Radioanalytical & Nuclear Chemistry*, Nov. 2025, pp. 1–9.
- Macsik, Z., LaMont, S. P., Wende, A. M. et al., '230Th/234U radiochronometry for uranium materials by alpha spectrometry for nuclear forensics analysis', *Journal of Radioanalytical & Nuclear Chemistry*, Oct. 2025, pp. 1–10.
- Shollenberger, Q. R., Render, J., Chalifoux, A. et al., 'Recovery of stable isotope taggants along a wet production pathway of uranium dioxide', *Journal of Radioanalytical & Nuclear Chemistry*, Oct. 2025, pp. 1–8.
- Varga, Z. and Wallenius, M., 'Measurement of uranium samples for nuclear forensics by laser ablation multi-collector inductively coupled plasma mass spectrometry using a pre-cell mass filter for collision/reaction cell (MC-ICP-MS/MS)', *Spectrochimica Acta Part B: Atomic Spectroscopy*, vol. 233 (Nov. 2025).

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/

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