ITWG Nuclear Forensics International Technical Working Group

ITWG NUCLEAR FORENSICS UPDATE

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CHAIRPERSONS' ADDRESS

Welcome to the 34th edition of the Nuclear Forensics International Technical Working Group (ITWG) Update. Spring is always the busiest time for the ITWG leadership. It is the time when preparations for the annual meeting are underway. At the same time, we are now finalizing the new website. While you eagerly await the outcomes of these activities, we offer you interesting reading.

In this edition of the newsletter, we have three articles focusing on leadership, training and exercises. There have been few leaders in the world of nuclear forensics community who have made a bigger impact than our own Klaus Mayer. You might say Klaus was always a 'person of interest' or 'prime suspect' when it came to nuclear forensics and fostering its worldwide appeal. In an invited article by fellow nuclear forensic legends Michael Curry, Sidney Niemeyer and David Smith, they provide a peek 'behind the scenes' of Klaus Mayer—one of the cornerstones of the ITWG.

Eva Szeles and Peter Volgyesi give a fascinating in-depth look into the approach that the HUN-REN Centre for Energy Research has taken in implementing training activities involving, for example, radiological crime scene management, emphasizing available international cooperation opportunities. Finally, James Borgardt, leading the way with Galaxy Serpent, has succinctly summarized the impact that this virtual exercise has had on the nuclear forensics community since its humble beginnings over a decade ago.

We hope to meet you at the ITWG-28 meeting in July 2025 in Bologna, Italy. *Ci vediamo lì!*

With best regards,

James Blankenship and Maria Wallenius

KLAUS MAYER'S LEGACY AND LEADERSHIP OF NUCLEAR FORENSICS AND THE INTERNATIONAL TECHNICAL WORKING GROUP

MICHAEL CURRY, SIDNEY NIEMEYER AND DAVID K. SMITH

The Nuclear Forensics International Technical Working Group (ITWG), in an evidential sense, has Dr Klaus Mayer's fingerprints all over it. His contributions to the working group and the broader international nuclear forensics community have been profound. As Klaus retires from the European Commission's Joint Research Centre in Karlsruhe, Germany (JRC Karlsruhe), it is only fitting to reflect on his dedication to and lasting impact on nuclear forensics—guiding its evolution from the early days to its establishment as a vital tool for competent authorities in preventing and responding to the serious threat of nuclear and other radioactive materials out of regulatory control.

Klaus's connection to the ITWG traces back to his mentor, Dr Lothar Koch of the Institute for Transuranium Elements (the predecessor of JRC Karlsruhe). Lothar, together with Dr Sid Niemeyer of Lawrence Livermore National Laboratory (LLNL), United States, helped establish the ITWG in 1995 with the encouragement of the Group of Seven (G-7) Non-Proliferation Experts Group (NPEG). At the time, the G-7 was exploring ways to combat the smuggling of weapons-usable materials from the former Soviet Union into Europe, such as the creation of an information-sharing mechanism that later evolved into the International Atomic Energy Agency's (IAEA) Incident and Trafficking Database (ITDB).

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Klaus Mayer's Legacy and Leadership... *continued from page 1*

Lothar and Sid co-led the ITWG for 7 years, and several years after Lothar retired, Sid invited Klaus to serve as the new co-chair. In 2006, they briefed the NPEG together, which encouraged them to explore avenues for expanding the ITWG's reach.

In the post-9/11 era, as the international community intensified efforts to prevent nuclear terrorism, Klaus played a key role in raising awareness of nuclear forensic science and his vision was instrumental in cementing it as a critical component of nuclear security. He contributed extensively to the Global Initiative to Combat Nuclear Terrorism's workshops and its Nuclear Forensics for Policymakers guidance, as well as to communiqués and work plans derivative from the four head-of-state Nuclear Security Summits convened between 2010 and 2016. From the outset, Klaus recognized the importance of linking nuclear forensic science with law enforcement to support criminal prosecutions related to the unauthorized use, possession or storage of nuclear and radioactive materials.

Beyond his scientific contributions, Klaus has been an exceptional mentor and educator, generously sharing his expertise with interns, graduate students, postdocs and senior scientists alike. His dedication to professional development ensures that his influence will endure for decades to come.

Together with Sid, Klaus remained steadfast in preserving the ITWG's scientific focus and integrity. This commitment distinguishes the ITWG from other policy-driven groups in the nuclear security field and has been crucial to its sustained success for over 25 years. He also advocated for the ITWG to remain an independent and informal association of practitioners. Sid remembers Klaus telling him at the 2014 IAEA International Conference on Advances in Nuclear Forensics that he had diligently sought to preserve the informal and scientific nature of the ITWG. His persistence in this regard continues to be particularly relevant given today's global landscape.

Klaus's leadership also extends beyond the science: he was a strategic collaborator who prioritized partnerships within the ITWG. Cooperation is embedded in the ITWG's nuclear forensics 'model action plan' and its Nuclear Forensics Laboratories (INFL). David Smith (LLNL) recalls that during his tenure at the IAEA, with Klaus' endorsement, he positioned the ITWG as the agency's go-to scientific resource for nuclear forensics. Today, much of the IAEA's leading guidance—including 'Nuclear Forensics in Support of Investigations', Nuclear Security Series No. 2-G (Rev. 1), 2015—incorporate the ITWG's best practice guidelines, effectively linking nuclear science with law enforcement to support

Figure 1. Klaus Mayer, Head of Nuclear Forensics at the Institute for Transuranium Elements (ITU), examines a sample of nuclear material in Karlsruhe, Germany, 9 Feb. 2011. Photo: Uli Deck/Alamy.

nuclear security investigations. This collaboration would not have been possible without the scientific credibility Klaus brought from the ITWG to the IAEA.

Dr Maria Wallenius (JRC Karlsruhe) notes that while the 'hype' around nuclear smuggling has waned, the ITWG remains as vibrant as ever. 'Annual meetings still feel like big family gatherings', she says. 'For this, I credit Klaus and his co-chairs.'

On behalf of the ITWG's membership and as former co-chairs, we extend our deepest gratitude to Klaus for his extraordinary leadership over the past two decades. He has been a guiding force in the advancement of nuclear forensic science, shaping its role in global nuclear security with vision, wisdom and a personal touch that has strengthened partnerships worldwide. We wish Klaus all the best in his next chapter.

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TRAINING ACTIVITIES ON RADIOLOGICAL CRIME SCENE MANAGEMENT AND NUCLEAR FORENSICS IN HUNGARY

EVA SZELES AND PETER VOLGYESI

In the last 10–15 years, there has been an increasing international trend to connect radiological crime scenes to the nuclear forensics laboratory—to draw attention to the fact that nuclear or other radioactive material can also have evidential value, should be treated as evidence, and a criminal investigation and prosecution should be initiated connected to the case, if appropriate. Nuclear forensic examination starts at the crime scene, for example with material categorization and initial characterization to inform the receiving laboratory and plan safe and secure transport. Likewise, communication between law enforcement and scientists is essential in order to focus on questions that support the criminal investigation and to help the prosecutors understand the nuclear forensic findings.

The IAEA and ITWG are leading the way in this area and running several relevant programmes, for example two of the IAEA's Coordinated Research Projects, 'J02013: Applying Nuclear Forensic Science to Respond to a Nuclear Security Event' and 'J02020: Nuclear Forensics Science to Bridge the Radiological Crime Scene to the Nuclear Forensics Laboratory'. A further example is the Integrated Workshop on Radiological Crime Scene Management and Nuclear Forensics, developed by the IAEA in 2023. The ITWG's Collaborative Material Exercises (CMX) also focus on supporting the connection between

Figure 2. Hands-on training in radiological crime scene management for law enforcement

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Training Activities on Radiological Crime Scene Management... *continued from page 3*

Figure 3. National awareness training on RCSM and nuclear forensics for Hungarian crime scene investigators

radiological crime scenes and the nuclear forensics laboratory and have tried to strengthen cooperation and communication between law enforcement and scientists for a long time using specific exercises and scenarios (e.g. Crime Scene in a Box).

This trend to develop and implement cross-type training programmes and exercises started at the HUN-REN Centre for Energy Research (HUN-REN EK-CER) in Budapest, Hungary, in 2014–15. In addition to the international nuclear forensics programme run by the centre since 2013, specific programmes started to be developed for radiological crime scene management (RCSM), first as RCSM demonstrations integrated into the nuclear forensics programme. Later, in 2019, in the framework of a national project supported by the Hungarian Ministry of Interior, a large-scale training programme was organized for the Hungarian Police. The programme saw 400 investigators trained in the basics of radiation protection, RCSM and awareness of nuclear forensics.

Following strengthened multi-agency cooperation in Hungary, the national training programme has been programmatically extended over the last 10 years. In 2020, a specific training facility was established at HUN-REN EK-CER for the training of first responders in source location and recovery, and of crime scene investigators in RCSM (including PPE protocols with simulated contamination, radiation survey, search and collection of contaminated evidence, and working together with nuclear forensics experts at the crime scene). Different scenarios at both basic and advanced level are used for trainees from the Hungarian Police, the National Directorate General for Disaster Management and the Counter Terrorism Centre. A unique capability of HUN-REN EK-CER is the large scale of nuclear and other radioactive materials (including medical, industrial isotopes and special nuclear materials) available for training purposes.

Another important programme at the centre is the training of traditional forensic experts to work in a glove box to examine contaminated evidence, following the instructions of radiological experts in the nuclear forensics laboratory. The Hungarian Police

Figure 4. Training of traditional forensic experts to work in the glove box

Figure 5. Training using the Virtual Source Simulation System

often uses the glove box exercise for the examination of traditional forensic evidence from real cases. The newest development at HUN-REN EK-CER is a Virtual Source Simulation System (VRSSS), which is also used for training purposes for the simulation of an elevated dose rate at the scene (for the collection of high-activity sources). The VRSSS simulates a large area of surface contamination and the effects of distance and shielding in this special working environment. Detectors in virtual mode can be used as a dose rate metre, surface contamination monitor and radioisotope identifier. Participants have the possibility of hands-on practice in specific radiation search and survey mechanisms, in an environment with a simulated elevated dose rate. They can also try procedures to collect a simulated highly radioactive source using manipulators and shielding.

As well as running the national training programme, HUN-REN EK-CER's training facility is open to the international community. For example, the International Law Enforcement Training Centre located in Budapest, hosting among others the International Law Enforcement Academy (ILEA) and the European Union Agency for Law Enforcement Training (CEPOL), often uses the training facility and capabilities provided. •

GALAXY SERPENT V: ENHANCING NUCLEAR FORENSICS CAPABILITIES THROUGH INTERNATIONAL VIRTUAL EXERCISES

JAMES BORGARDT

The ITWG Libraries and Assessment Task Group has been facilitating virtual, web-based exercises designed to mature the concept of national nuclear forensics libraries (NNFLs) and demonstrate their efficacy as a valuable tool in support of an investigation involving nuclear and other radioactive material (R/N) found out of regulatory control since 2013. Named 'Galaxy Serpent', these exercises are designed to raise awareness of the technical aspects of developing and applying NNFLs.

The fifth version of Galaxy Serpent (GS5), the latest in this ongoing series, was designed to evaluate the ability of international laboratories to analyse uranium samples and swipes, assess consistency and identify potential relationships between them. This exercise, like its predecessors, provided participants with challenging problem sets aimed at advancing NNFL technical capabilities and demonstrating the value of a NNFL in answering questions in support of an ongoing nuclear forensics investigation.

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Galaxy Serpent V... *continued from page 5*

In addition, the current exercise increased the focus on responding to a mock investigative team using the Graded Decision Framework (GDF) to assign confidence to material consistency findings, and demonstrated how findings might shift in light of new information.

Exercise overview

The GS5 exercise consisted of seven phases, each presenting different technical challenges. Teams were provided with a model material holdings database. Each phase of the exercise introduces a new element to the storyline and new data with questions from the mock investigative team.

When a new potential crime scene is revealed, teams are initially given field data from handheld instruments, followed in the subsequent phase by more refined data from an analytical laboratory.

In this way, player responses to the mock investigative tea m regarding materials and their consistency may change during the course of the exercise as higher confidence data becomes available, mirroring the progression of a nuclear forensics investigation.

Key findings and trends

In material identification, participants demonstrated a strong ability to correctly categorize the materials in question:

- Depleted uranium (DU) in phases 1a and 1b.
- Swipe 1 as DU and swipe 2 as high-assay low-enriched uranium (HALEU) in phases 2a and 2b.
- Sample 3 as DU.
- Sample 4 as high-enriched uranium (HEU) in phases 3a and 3b.

The GDF was consistently used by teams to determine consistency between samples and swipes. Using analytical techniques in conjunction with the GDF, teams evaluated material consistency, generally making similar findings:

- Phase 1a: using the provided surrogate field data, most teams assessed the two samples from the van as consistent.
- Phase 1b: given mass spectrometry data from a mock laboratory, most teams correctly determined

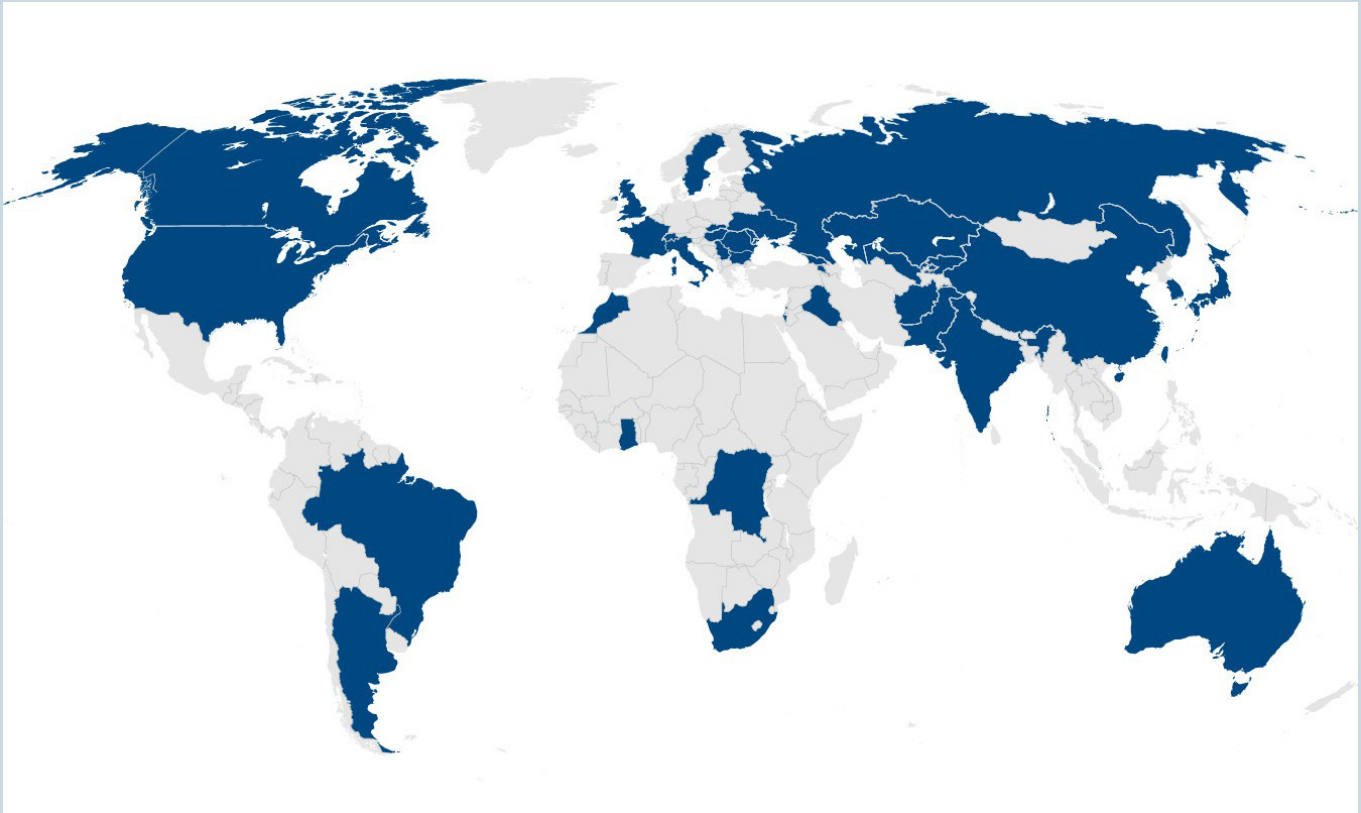

Figure 6. Over 600 distinct participants from over 30 countries and international organizations have taken part in the Galaxy Serpent exercises. Participants have been associated with laboratories, universities and other organizations

the samples were inconsistent with high confidence based on isotopic composition, trace elements and uranium content.

- Phase 2: nearly all participants concluded that the materials on swipe 1 and swipe 2 were inconsistent with high confidence.
- Phase 3: most participants concluded that samples 3 and 4 were not the same and found sample 3 to be consistent with swipe 1 and sample 1 from the van.
- Phase 4: using mass spectrometry data, most teams found swipe 2 to be inconsistent with sample 5, the missing HALEU. The predominant explanation for the material on swipe 2 was that it was a mixture of samples 3 and 4, by considering the uranium isotopic data and calculating the mixing ratios required to produce the isotopic composition of swipe 2.

Results and lessons learned

The release of data in each phase of GS5, starting with field data and followed by more precise laboratory data, allowed for refined assessments and a general increase in confidence levels.

Teams generally used a common document, the GDF, to provide a consistent framework for ascribing confidence levels. This highlights the value of community-accepted documents to help provide consistent interpretive findings across laboratories.

Most teams determined that swipe 2 (HALEU) was consistent with a mixture of approximately 83.2 per cent sample 3 (DU) and 17.8 per cent sample 4 (HEU). While some teams did not explicitly identify this specific mixture, many recognized the possibility of a mixing scenario or highlighted inconsistencies that could be explained by a combination of depleted and high-enriched uranium.

Impact and future directions

GS5 provided valuable insights into the capabilities and challenges faced by international laboratories in nuclear forensics analysis.

The exercise underscored the importance of accurate material identification, robust consistency in assessment methods (e.g. using the GDF), comprehensive reference libraries and standardized procedures. The feedback received from participants will be used to refine future exercises and improve international capabilities in nuclear forensics.

The Libraries and Assessment Task Group extends its gratitude to all participating teams for their dedication and contributions to the success of GS5. The ongoing commitment of the international nuclear forensics community is essential for enhancing global nuclear security efforts.

Galaxy Serpent has been successful in raising global awareness of NNFLs, with about 600 distinct participants from over 30 countries and international organizations. We thank the ITWG community for their investment of time and effort in the success of the exercise and look forward to additional interactions through Galaxy Serpent over the coming years. •

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

- Giglio, D. et al., 'Field deployable trace radioisotope analysis through combined electrochemical and alpha spectroscopy methods', *Journal of Radioanalytical and Nuclear Chemistry*, vol. 334 (2025).
- Verma, N., Jacob, J. and Arora, J., 'Radioactive contaminants: A forensic perspective', N. Kumar (ed.), *Radioactive Pollutant: Sources, Issues and Remediation, Environmental Science and Engineering* (Springer: Cham, 2025).
- Edwards, M. A. et.al., 'Model ages of three uranium metal CRMs and implications for radiochronometry data interpretation', *Journal of Radioanalytical and Nuclear Chemistry*, 1 Feb. 2025.
- Snow, M. et.al., 'Optimizing sol–gel surrogate nuclear explosive debris for laboratory analysis applications', *Journal of Radioanalytical and Nuclear Chemistry*, 12 Feb. 2025.
- Li, Z. et al., 'Application of element and isotopic fingerprint features in nuclear forensics: A review', *Forensic Chemistry*, vol. 43 (May 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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