ITWG Nuclear Forensics International Technical Working Group

ITWG NUCLEAR FORENSICS UPDATE

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CHAIRPERSONS' ADDRESS

Welcome to the 27th edition of the International Technical Working Group (ITWG) Update. We hope you are reading this newsletter as a printed copy, as this will mean that you have joined us for the 26th annual meeting of the Nuclear Forensics International Technical Working Group (ITWG-26). We want to sincerely thank the Ministry of Internal Affairs of Georgia for hosting this year's meeting and are very excited to share with you the latest developments in work of the ITWG. As usual, a lot of time will be dedicated to the work of the task groups, to which everyone can contribute not only at the annual meeting, but throughout the year.

You can find a full preview of the annual meeting in the newsletter. This edition also contains a preview of a 'Prosecutor's Guide to Radiological and Nuclear Crimes.' The United Nations Interregional Crime and Justice Research Institute (UNICRI) is in the process of creating the guide as the second in a series that also features a guide to chemical and biological crimes, published in 2022. The guide is directed at prosecutors, investigators and judges and is the first of its kind in nuclear forensics. The guide will be published in 2024 and we are eagerly waiting to see the final product.

Another highly interesting article in this newsletter discusses South Africa's efforts to establish a nuclear forensics laboratory. It took a decade of hard work, and the article describes in detail how the Nuclear Energy Corporation of South Africa accomplished it in partnership with the U.S. Department of Energy's National Laboratories. A great example to everyone!

With best regards,

Michael Curry and Maria Wallenius

PREVIEW OF THE ITWG ANNUAL MEETING

MICHAEL CURRY AND MARIA WALLENIUS

The 26th annual meeting of the Nuclear Forensics International Technical Working Group in Tbilisi on 20–23 June 2023 falls roughly mid-way between the International Atomic Energy Agency (IAEA) 2022 Technical Meeting on nuclear forensics and the IAEA 2024 International Conference on Nuclear Security (ICONS 2024). This timing is useful as many ITWG activities, such as its exercises and guidelines, will be the subject of Technical Meeting presentations and could be topics for ICONS 2024. For this reason, the upcoming annual meeting will be a useful opportunity to take stock of recent ITWG work and to help shape future activities.

Active participation in annual meeting activities by members is vital to advancing ITWG efforts to identify, develop and socialize best practices in nuclear forensics. In keeping with the working group nature of the ITWG, appropriate time has been allocated to the task groups (TGs), to the ITWG Nuclear Forensics Laboratories (INFL) group and for a professional development seminar.

The Exercise TG will complete its review of the seventh collaborative material exercise (CMX-7) and continue planning for CMX-8 in 2024. Alongside the laboratory component of past exercises, CMX-7 included a new crime scene in a box (CSIAB) element, which provided an opportunity for participants to understand the crime scene-laboratory interface more fully. In addition to working with the Evidence and Testimony TG on inclusion of the CSIAB in future CMXs, the Exercise TG will continue its discussions with the Libraries TG on including a National Nuclear Forensics Library (NNFL) component in CMX-8.

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Annual Meeting... *continued from page 1*

The Libraries TG, in addition to planning a CMX-8 NNFL element, will review initial outcomes from the fifth iteration of Galaxy Serpent exercise (GSv5), in which increased emphasis was placed on data interpretation.

The Evidence and Testimony TG, in addition to the CSIAB element, plans to review various documents, such as the guidelines on the chain of custody and on documenting casework. This TG will also discuss the possibility of creating a new table-top activity that will focus on how to interpret and present nuclear forensics results in a way that is tailored to law enforcement, public messaging and decision makers.

The Guidelines TG is developing consensus guidelines on a range of nuclear forensics topics that will enable comparison of results among nuclear forensics practitioners. These will provide additional credibility when presenting information to investigative authorities or in a court of law. At ITWG-26, the TG will review a number of these guidelines, which are currently in development, and solicit the production of new guidelines.

The Outreach and Training TG will focus on opportunities for enhanced outreach through a digital presence, technical meetings and international conferences, and the content of future editions of the ITWG Update. It will also share effective approaches to training in nuclear forensics.

While identifying presentations for this year's technical part of the agenda, the INFL is also organizing a professional development session on gamma spectrometry.

The annual meeting will also feature updates from key international nuclear forensics leaders. The IAEA will provide an update on its nuclear forensics activities and a briefing with case studies on the IAEA Incident and Trafficking Database (ITDB) programme. National representatives who lead the Global Initiative to Combat Nuclear Terrorism (GICNT) Nuclear Forensics Working Group will also report on their activities. The ITWG co-chairs will report on the activities of the past year and on upcoming events and announce changes to the leadership team. Finally, in addition to an official dinner, our Georgian hosts from the Ministry of Internal Affairs are offering an optional demonstration of their interdiction capabilities on 23 June. •

A PROSECUTOR'S GUIDE TO RADIOLOGICAL AND NUCLEAR CRIMES

TALGAT TOLEUBAYEV*

The prosecution of and adjudication on Chemical, Biological, Radiological and Nuclear (CBRN) crimes is the area least explored and least adequately addressed by relevant international organizations and national stakeholders. There are a plethora of guidance manuals and training activities dedicated to the detection and identification of CBRN agents, CBRN crime scene management, sampling and evidence collection, but very little when it comes to the related administration of justice. Although existing guidance documents can make a significant contribution to the investigation and prosecution of such crimes, in an emergency it is not possible to find all this guidance in one place.

Depending on the legal system of a particular country, prosecutors play different roles in cases of the deliberate criminal use of CBRN materials. In civil law countries, they directly oversee the entire investigation and even lead or conduct elements of it. In common law countries, by contrast, the investigation is led by dedicated law enforcement investigators, and where applicable results in the formation of a joint state and federal investigative and prosecutorial team. In any system, prosecutors must provide a very strong case in court to convince a judge and jury of the premeditated nature of such crimes and the case must be supported by impeccable evidence. However, it can take many years for a criminal case to progress from crime scene to adjudication in a courtroom, which can affect the integrity of the evidence.

Arguably, the greatest challenge in CBRN investigation and prosecution occurs when the crime scene is contaminated with CBRN materials. Unfortunately, the vast majority of training institutions and academies for prosecutors, investigators and judges do not teach this subject as part of the curriculum. As a result, different

*The opinions, findings, conclusions and recommendations expressed here do not necessarily reflect the views and positions of the United Nations and UNICRI, or any other national, regional or international entity involved.

Figure 1. A crime scene at which radioactive material may be present, requires special care.
Credit: Dean Calma / IAEA.

response methods and additional mechanisms are required to protect investigators, first responders and other actors involved at the crime scene, and to preserve the evidence. Fortunately, some of these procedures are already well referenced and covered in various manuals published by international partner organizations.

The International Atomic Energy Agency (IAEA) plays a pivotal coordination role in the field of nuclear forensics and radiological crime scene management. Its Nuclear Security Series (NSS 2G) *Implementing Guide on Nuclear Forensics in Support of Investigations* is an important substantive manual that outlines the role of nuclear forensics in supporting investigations of a nuclear security event and provides a context for nuclear forensics within a national nuclear security infrastructure. Another important IAEA publication is *The Radiological Crime Scene Management Implementing Guide* (NSS 22G), which was jointly sponsored by the IAEA, the UN Interregional Crime and Justice Research Institute (UNICRI) and INTERPOL when it was published in 2014. The guide is currently being updated by the IAEA with input from UNICRI.

This joint IAEA-UNICRI initiative has led to the production of a second complementary publication, *The Prosecutor's Guide to Radiological and Nuclear Crimes*, which UNICRI is developing in close coordination with the IAEA, the United Nations Office on Drugs and Crime (UNODC), the Nuclear Forensics Centre of the European Commission Joint Research Centre (JRC) in Karlsruhe and the International Association of Prosecutors (IAP). Twenty-five experienced subject matter experts with pertinent backgrounds in Radiological and Nuclear (RN) prosecution and investigation, traditional and nuclear forensics, law enforcement and the legal profession are participating in the development of this guide. The objective is to complete the development and review process by the end of 2023 and publish the guide early in 2024.

The guide will be a complementary document for prosecutors, investigators and judges and contain summaries of prosecuted RN criminal cases that can serve as precedents and provide useful tips, lessons learned and best practices. An integral part of the manual will be step-by-step recommendations on the successful conduct of an RN-related investigation and building an RN criminal case for prosecution. Chapters on international legal frameworks—which touch on legislation and criminalization aspects, explain national capabilities in investigation and prosecution, including investigative intelligence, and outline prosecutorial challenges, success stories and appeal procedures—will assist all end-users with this process.

Progress from crime scene to courtroom requires different agencies to understand complex scientific regulations and procedures, and to acquire the necessary expertise on the CBRN materials used

A Prosecutor's Guide... *continued from page 3*

by perpetrators. The successful investigation, prosecution and adjudication of such crimes requires that the authorities have knowledge of the various CBRN materials, the methods used by perpetrators to plan and execute such crimes, available forensics capabilities, and intelligence and information sharing methods, as well as of many other disciplines. The involvement, coordination and cooperation of national CBRN teams, prosecution and judicial authorities, investigators and law enforcement officials, as well as forensics laboratories, research facilities and intelligence agencies, all help to safely address the various aspects of the crime. Moreover, while such crimes are the responsibility of national authorities, international and regional cooperation is not just extremely useful, but essential.

States spend huge amounts of their taxpayers' financial resources on building robust national security architectures. A small component of this architecture entails the procurement of expensive CBRN detection and forensic equipment, which comes with an ongoing financial burden for proper maintenance. Beyond the equipment component, states should invest in strengthening their prosecution and adjudication capabilities by promoting internationally endorsed guidelines and conducting proper training. Ultimately, it is the job of prosecutors and judges to bring wrongdoers to justice under existing laws and regulations. If criminals, non-state actors or terrorist organizations are able to escape responsibility and punishment for committing CBRN crimes, then all the significant sums spent by a given state on the security and safety of its population will have been wasted. This could easily happen if law enforcement, prosecution and judicial authorities do not have the necessary knowledge and training to deal with CBRN-related criminal cases.

Thus, UNICRI's 'From Crime Scene to Courtroom' series of action-oriented guides was launched in 2020 in close cooperation with relevant international partner organizations and subject matter experts. UNICRI has developed and continues to develop its manuals dedicated to prosecutors, investigators, the judiciary and law enforcement authorities. This initiative has been endorsed by partner countries within the framework of the European Union CBRN Risk Mitigation Centres of Excellence Initiative (EU CBRN CoE) and is fully funded by the European Commission's Service for Foreign Policy Instruments. The initiative's first result, the recent publication of *A Prosecutor's Guide to Chemical and Biological Crimes*, has become central to the development of capacity-building activities aimed at enhancing knowledge and skills across the entire process of investigating and prosecuting a criminal case. The goal is to publish a similarly successful supplementary volume, *The Prosecutor's Guide to Radiological and Nuclear Crimes*. •

ESTABLISHING A NUCLEAR FORENSICS LABORATORY AT NECSA IN SOUTH AFRICA

AUBREY NELWAMONDO, JEANETH KABINI, BANYANA KOKWANE AND RACHEL LINDVALL

South Africa has a long track record of working with the international community to strengthen its nuclear security regime. South Africa first announced its commitment to establishing a national nuclear forensics capability at the 2010 Nuclear Security Summit in Washington, DC. The Nuclear Energy Corporation of South Africa (Necsa) is South Africa's premier nuclear research institution. It has a broad spectrum of expertise in the handling and analysis of nuclear and other radioactive materials, including spent nuclear fuel and waste. In 2011, Necsa was chosen by the South African government as the location for its Nuclear Forensics Laboratory. Necsa then commenced its development of technical nuclear forensics capabilities in support of global non-proliferation and counterterrorism efforts to strengthen the national nuclear security regime and prevent criminal activity within the borders of the South Africa, and to promote access by Southern African states to technical expertise and nuclear analytical capabilities in South Africa.

*This article is the first in a two-article series on the development of South Africa's nuclear forensics capabilities. The second article, focused on international cooperation and sustainability issues, will be published in the September 2023 issue of the ITWG Nuclear Forensics Update.

Establishing a nuclear forensics laboratory programme at Necsa

The US Department of Energy (DOE) National Laboratories (Lawrence Livermore National

Figure 2. Analytical techniques available for nuclear forensic analysis at Necsa.
Notes: (*a*) Inductively-Coupled Plasma Mass Spectrometry (ICP-MS); (*b*) High Resolution Gamma Spectrometry. Photos (*c*) and (*d*) show the new dedicated clean rooms complex at Necsa for nuclear forensics analysis.

Laboratory, LLNL; and Los Alamos National Laboratory, LANL) and the National Nuclear Security Administration (NNSA) assisted Necsa with its assessment of existing and required nuclear forensics capabilities. That assessment identified specific areas for improvement in terms of facilities, equipment, instruments and expertise. Once Necsa had been tasked by the South African government with strengthening national nuclear forensics capabilities, it began to develop its nuclear forensics laboratory in four priority areas: (*a*) building infrastructure and developing human capital; (*b*) the development of prioritized analytical techniques and methods of forensics analysis for seized nuclear and other radioactive materials; (*c*) improving technical capabilities for the categorization of nuclear material at a crime scene and laboratory nuclear forensics analysis; and (*d*) building international cooperation on nuclear forensics, including participation in inter-laboratory exercises.

In the decade since the Necsa nuclear forensics laboratory was launched, scientific staff have received specialist training in nuclear forensics, and key technical instruments and equipment, as well as spare parts and certified reference material, have been acquired for development and validation of nuclear forensics analysis methods useful for response to nuclear security threats. Detailed consultations are being held with law enforcement agencies and conventional police forensics laboratories to define roles and responsibilities and integrate nuclear forensics into national security response planning. A plan has also been put in place to strengthen nuclear forensics laboratory capabilities through participation in inter-laboratory exercises.

Necsa has created a roadmap for nuclear forensics capabilities development in South Africa, focused on strengthening the expertise of a national nuclear forensics laboratory. The collaboration with the U.S. DOE National Laboratories provided Necsa with initial impetus for this work. Necsa, LLNL and LANL jointly developed a work programme for building South African nuclear forensics capabilities, which comprised five components: (*a*) establishment of general nuclear forensics infrastructure; (*b*) building a nuclear forensics clean room complex; (*c*) establishment of nuclear forensics analysis laboratories (key instrumentation/facilities); (*d*)

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Establishing a Nuclear Forensics Laboratory... *continued from page 5*

human resources development; and (*e*) establishment of a plan to develop a National Nuclear Forensics Library (NNFL) at Necsa.

Building a nuclear forensics laboratory

Collaboration agreements between Necsa and the U.S. National Laboratories made possible construction of Necsa's clean room complex, selection and procurement of key equipment and instruments, operational support, benchmarking of the development of critical nuclear forensics analysis methods, training on maintaining the infrastructure, and nuclear forensics training for Necsa scientists at the LLNL.

The first visit by Necsa scientists to LLNL took place in the spring of 2012. It included training on analytical techniques such as optical microscopy, X-ray diffraction, X-ray fluorescence, gamma spectrometry and the Inductively-Coupled Plasma Mass Spectrometer (ICP-MS). In subsequent years, Necsa's nuclear forensics personnel benefited greatly from multiple scientific exchanges with LLNL and LANL. This cooperation helped Necsa commission and build a clean laboratory complex, and to procure for it a High Resolution Gamma Spectrometer (HRGS) and a new ICP-MS (see figure 2).

An ICP-MS is crucial for the identification of nuclear forensics signatures in uranium ore concentrate (UOC), which can help to pinpoint its origin and whether such material is outside of regulatory control. An HRGS is needed for categorization and characterization of nuclear and other radioactive material. Both instruments are essential to the process of nuclear forensics analysis. Several other new pieces of analytical equipment have been installed in the nuclear forensics laboratory, such as a hot block for ore dissolution, high precision laboratory balances, laminar flow cabinets and water deionization machines. These have allowed Necsa to improve its capabilities for identifying nuclear forensics signatures using, for instance, uranium isotope ratios or impurity profiles.

Benchmarking development of analytical methods

To ensure confidence in the results of analytical measurements made using the ICP-MS and HRGS instruments mentioned above, Necsa and the U.S. National Laboratories developed a joint sample analysis programme in which uranium-rich materials, mainly certified reference materials (CRM), were analysed independently by each laboratory for inter-laboratory comparison studies. CRMs were used to evaluate the quality of analytical techniques used for measurement of radioactive materials (mainly uranium and thorium isotopes) at the laboratories involved. This work was followed-up in regular in-person meetings of nuclear forensics experts from Necsa and the US laboratories to review the results, identify lessons learned and review the status of activities in both countries.

These meetings also provided opportunities to update key stakeholders, discuss upcoming

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

- Chen, S. et al., 'Linear regression and machine learning for nuclear forensics of spent fuel from six types of nuclear reactors', *Physical Review Applied*, vol. 19, no. 3 (Mar. 2023).
- Church, J. A. et al, 'Fission neutron activations of stainless steel and its corresponding elemental components', *Journal of Radioanalytical and Nuclear Chemistry*, 8 Apr. 2023.
- Egozi, C. et al., 'Use of Compton suppression gamma ray spectrometry to determine 239Pu', *Applied Radiation and Isotopes*, vol. 194 (Apr. 2023).
- Holland, E. et al., 'An introduction to nuclear industrial archaeology', *Sustainability*, vol. 15, no. 7 (Apr. 2023).
- Lusk, R. et al., 'Retention of radionuclides in sol–gel surrogate nuclear explosive debris', *Journal of Radioanalytical and Nuclear Chemistry*, vol. 332, no. 3 (Mar. 2023), pp. 683–89.

exercises, listen to scientific talks on cutting-edge research and exchange information on technical progress and nuclear forensics case studies. Covid-19 travel restrictions meant that the 2021 meeting was conducted online.

The analytical capabilities developed as part of this work have been evaluated through participation in the collaborative material exercises (CMX) and Galaxy Serpent (GS) table-top exercises organized by the Nuclear Forensics International Technical Working Group.

Development of a prototype NNFL

A National Nuclear Forensics Library is a national system of reference information and subject matter expertise on the nuclear and other radioactive materials produced, used or stored in a state that could be used to identify materials out of regulatory control. The development of an NNFL in South Africa is at an advanced stage. For its development, South Africa is following relevant guidelines published by the IAEA and the ITWG. The NNFL concept protects proprietary and sensitive nuclear material characteristics and inventories. South Africa has appointed a National Nuclear Forensics Library-Point of Contact (NNFL-POC) that can respond to or initiate regional or international queries, facilitate international cooperation during an investigation and protect proprietary and sensitive information on nuclear materials inventories.

Necsa has developed a prototype database that will cover both nuclear materials and radioactive sources. The structure of the prototype database was designed to accommodate nuclear materials and other radioactive materials possessed by Necsa. The nuclear forensics laboratory aims to include all such material available in South Africa in the NNFL, and to develop computational tools for comparison of material characteristics and material discrimination analysis using the database.

Conclusion

In the past decade, Necsa has established a significant nuclear forensics capability in South Africa. With the assistance of the United States, Necsa has established an advanced nuclear forensics laboratory, developed and implemented analytical methods for the forensic fingerprinting of uranium ore concentrates and other radioactive materials, and set up a prototype NNFL. •

UPCOMING TRAINING COURSES AND MEETINGS*

- Forensics and Framework Exercise ‘Snow Leopard’, Dushanbe, 30 May–1 June 2023
- ITWG 26th Annual Meeting, Tbilisi, 20–22 June 2023
- IAEA International Training Course on Introduction to Nuclear Forensics, Bangkok, 4–8 September 2023
- NSDD GUAM Regional Workshop on Signatures, Azerbaijan, 11–12 September 2023
- IAEA Practical Introduction to Nuclear Forensics Course, Budapest, 2–6 October 2023
- IAEA International Training Course on Introduction to Nuclear Forensics, Nairobi, 16–20 October 2023
- International Conference on Nuclear Security (ICONS), Vienna, May 2024

*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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