



# ITWG NUCLEAR FORENSICS UPDATE

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## CHAIRPERSONS' ADDRESS

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Welcome to the Nuclear Forensics International Technical Working Group (ITWG) newsletter. This year, the ITWG marks its 25th anniversary and hence a quarter century of contributions to nuclear security, e.g. by identifying, developing, and making available best practices in the field of nuclear forensics. Reflecting on this milestone, we are proud to highlight the close cooperation between the ITWG and the International Atomic Energy Agency (IAEA). The fruits of this long-standing collaboration—which extends beyond training, guidance, and identifying areas of needed research—are detailed in an article included in an upcoming special issue of the IAEA Bulletin published for the IAEA International Conference on Nuclear Security (ICONS 2020). The ICONS 2020 conference program incorporates the work of ITWG experts and task groups as well as an ITWG side-event. The event highlights how our exercises and related activities have advanced the state of nuclear forensics practice around the world. It also displays how our unique status as an informal association of nuclear forensics practitioners has allowed us to contribute to nuclear security in ways that may be difficult for more formal organizations. This issue of the 'ITWG Update' highlights these qualities with articles on the upcoming ICONS 2020 meeting (page 3), on the ITWG's most recent collaborative material exercise and lessons learned from the exercise series (page 1), and on nuclear forensics training offered by the IAEA to Russian-speaking experts (page 4). The ITWG congratulates the IAEA in anticipation of a productive ICONS 2020 and wishes participants success as we all work to advance our shared goal of strengthening nuclear security.

With best regards,  
Klaus Mayer and Michael Curry

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## TWENTY YEARS OF COLLABORATIVE MATERIALS EXERCISES BY THE NUCLEAR FORENSICS INTERNATIONAL TECHNICAL WORKING GROUP

**JON SCHWANTES AND OLIVIA MARSDEN**

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The Collaborative Materials Exercise (CMX) series are a critical mechanism used to advance the ITWG's mission of identifying, developing and promoting the best practices of nuclear forensics. These exercises are not designed to test laboratory performance, but as learning experiences that provide opportunities for participants to test and demonstrate state-of-the-practice to the global scientific and law enforcement communities. They are run as mock nuclear forensic investigations under realistic scenarios, with timelines and conditions designed to mimic actual operations. These situations provide the relatively unique opportunity for the appropriate governmental agencies to exercise their collective response to a nuclear security incident. Utilizing well-characterized materials of a known history and origin that are taken from specific process locations within the nuclear fuel cycle, these 'real world' materials are used to fully

consider the potential significance of process-derived heterogeneities and characteristics that might be used by investigators to derive useful information such as intended use, point of loss of control, process history or origin. While individual laboratory results are kept confidential, a summary of the major outcomes of each exercise is published in the open literature. The ITWG has carried out six CMXs since 1999. The sixth (CMX-6) and largest (21 participants) was completed in June 2019. Each CMX has contributed demonstrably to advancements in the state of practice and the emergence of novel techniques in nuclear forensic science.

### CMX-I

Five states and one multinational organization participated in the first exercise (CMX-1). The exercise was conducted between 1999 and 2000, and utilized

*Continued page 2*

**Twenty Years of CMX... continued from page 1**

reactor grade PuO<sub>2</sub> derived from the European nuclear fuel cycle. A major outcome of the exercise was its demonstration of the power of a National Nuclear Forensic Library (NNFL), as one of the participants correctly identified the origin of the material by comparing the results of analyses of the material with historical records.

**CMX-2**

CMX-2 took place between 2001 and 2002, and utilized Highly Enriched Uranium (HEU) oxide. A total of 10 laboratories representing nine countries and one multinational organization participated. CMX-2 was the first in the CMX series of exercises to include traditional forensics evidence in the exercise materials. The traditional evidence included a fingerprint, a plant seed and a handwritten note on the back of a coaster stained with beer. Many of the laboratories hypothesized different sources of the material, an outcome that was further complicated by the fact that the pedigree of the nuclear materials used was not well known to the exercise facilitators. In addition, none of the traditional forensics evidence was considered by the participating laboratories, with the sole exception of one laboratory which attempted to establish an ad hoc fingerprint station within its radiological laboratory to develop the latent print included in the evidence. As a result, future CMXs avoided considering traditional evidence until CMX-6. The lessons learned during CMX-2 led to the establishment of design features and objectives that have become integral components of the CMX series.

**CMX-3**

Stemming from experience gained during CMX-2, CMX-3—which took place in 2009–2010—was the first in the series to distribute more than one set of materials in order to facilitate comparative analyses by laboratories. This approach is referred to as a paired comparison exercise and became a common design feature of all subsequent CMXs. Nine laboratories were provided with two sets of HEU metal ingots to compare during the mock CMX-3 forensic investigation. The outcome of their efforts included the first demonstrated use of morphological features (angular inclusions within the metal pieces) as a means of determining relational connections between the two sample sets. The radiochronometry results that stemmed from the exercise were one of the early

applications of U/Th parent daughter pairs to establish the casting date of U metal.

**CMX-4**

CMX-4 took place in 2014–15. Three separate samples of Low Enriched Uranium (LEU) oxide were distributed to laboratories representing 15 countries and the European Commission, continuing the paired comparison exercise approach. During the exercise, several laboratories employed Secondary Ion Mass Spectrometry (SIMS) to exploit heterogeneities in the U isotopic distributions observed within the samples, thereby establishing one of the most powerful analytical techniques in nuclear forensic science today.

**CMX-5**

In 2016–17, CMX-5 continued the trend for growth in participation with representation from 19 countries and the Commission. Two LEU oxide pellets and one virtual sample were distributed to participants for comparison purposes. The samples were specifically produced for CMX-5 to test the limits of the use of morphology and isotopic distributions as a means of material comparison. Exercise samples were generated from the same feedstock, but sintered and pressed differently to generate vastly different morphological features and spatial U isotopic distributions. Evaluations were confounded by group inclusion/exclusion decision-making processes that highlighted the need for expert judgment to weigh the significance of individual components within a multicomponent decision matrix in order to translate analytical results into investigative conclusions. Directly resulting from this exercise, the ITWG issued an update to its guidance on group inclusion/exclusion evaluations, known as the Graded Decision Framework, to include multicomponent decision making during nuclear forensic investigations. One laboratory demonstrated the use of Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) as a cost-effective technique for probing U isotopic heterogeneities within solid materials, similar to SIMS but at a fraction of the cost.

**CMX-6**

The most recent and largest ITWG materials exercise (CMX-6) was completed in 2019 with 20 states and one multinational organization participating. For the first time since CMX-2, traditional evidence, including

latent and patent fingerprints and a variety of tool marks on metal pipes, the radioactive metal ingots, and heat sealed plastic bags, was also incorporated into the exercise. As a result, 14 law enforcement agencies assisted nuclear forensics laboratories with the examination of traditional forensic science evidence. One depleted U metal ingot and one stable Ce metal ingot, each contaminated with a trace amount of weapons grade Pu fluoride, were used for the basis of the mock investigation. Participants exploited five separate sets of radiochronometers to estimate the process age of the Pu and the casting age of the depleted U. Nearly half of the participating laboratories were able to process fingerprints on the evidence contaminated with radioactivity. The morphology and the chemical composition of the Pu trace contamination were useful in establishing links between sample sets.

### The future of the CMX series

Over the past 20 years, the ITWG has increased the network of ITWG Nuclear Forensics Laboratories (INFLs) that participate in CMXs by over 300 per cent and strengthened needed cooperation between scientists and law enforcement investigators. Each of the six CMXs has contributed meaningfully to the state of practice and the emergence of new technologies for nuclear forensics analysis. Future CMXs will continue to encourage partnering with investigative authorities and to seek opportunities to incorporate exercise play that includes radiological crime scene management and national nuclear forensics library queries. The seventh CMX by the ITWG is planned toward the end of 2021. Countries interested in participating in the next ITWG exercise are encouraged to contact either of the authors for further information. •



**Figure 1.** Participants at the ITWG CMX-6 Data Review Meeting, Warsaw, Poland, 3–5 June 2019

## NUCLEAR FORENSICS AT THE INTERNATIONAL CONFERENCE ON NUCLEAR SECURITY: SUSTAINING AND STRENGTHENING EFFORTS (ICONS 2020)

**KIMBERLY MONTGOMERY AND DAVID KENNETH SMITH**

The third International Conference on Nuclear Security: Sustaining and Strengthening Efforts (ICONS 2020) will be convened by the International Atomic Energy Agency (IAEA) on 10–14 February 2020.

ICONS 2020 will be a venue for ministers, policymakers and nuclear security professionals to reflect on achievements and to discuss current strategies and future priorities for nuclear security. This five-day conference will highlight international cooperation efforts in nuclear security, provide an opportunity for states to share practice and information on nuclear security and promote IAEA nuclear security guidance and efforts.

The conference will comprise a ministerial segment and a technical programme. The ministerial segment

will feature high-level national statements from member states and the adoption of a Ministerial Declaration. The technical sessions will focus on specialized scientific and technical, legal and regulatory issues related to nuclear security. Nuclear forensics is identified as a priority within the technical programme for the conference.

### ICONS 2020 themes

Among the conference themes are: (a) the legally and non-legally binding international nuclear security instruments, such as universalization of the Amendment to the Convention on the Physical Protection of Nuclear Material which entered into force in 2016; (b) the role of the IAEA in nuclear security; (c) national nuclear security regimes;



## IAEA REGIONAL SEMINARS ON AN INTRODUCTION TO NUCLEAR FORENSICS

ALINA NITREAN, ANDREI APOSTOL AND VLADIMIR STEBELKOV

The third introduction to nuclear forensics seminar for Commonwealth of Independent States and Eastern European countries was held in December 2019. The main objective of these regional seminars is to develop the skills of the specialists involved in creating and improving their states' systems for identifying seized nuclear or other radioactive material (NRM). Since none of the countries in the region is experiencing an epidemic of crimes involving NRM, there is no need to train a large number of nuclear forensics experts in those countries. However, an analysis of the crimes committed in the past has revealed a considerable diversity in such crimes and the need for in-depth and multifaceted training of the experts required for their investigation. Thus, the aim of these regional seminars is to train a small number of experts in the full range of issues dealt with by nuclear forensics, covering each issue to the maximum extent possible, and to inform them of the nuclear forensics capabilities available in other countries in their region and help them to utilize those capabilities effectively if required.

**Concepts and approaches**

The IAEA conducted the first seminar in Moscow in September 2017 in cooperation with the Laboratory for Microparticle Analysis. The seminar participants discussed the concept of 'nuclear forensics', its objectives and its role in a criminal investigation, and compared the terminology used in 'traditional forensic science' and nuclear forensics. They discussed approaches to creating a national system for identifying NRM seized during illicit trafficking, its basic elements and measures to ensure its continuing functionality.

The participants exchanged views on the issues that are regularly discussed at ITWG meetings and other international events:

- the role of international cooperation in reinforcing efforts to combat NRM trafficking;
- interagency activity on the detection, identification, seizure, transportation and storage of NRM out of regulatory control;
- the role of experts and NRM databases in forensics investigations;
- laboratory investigations, their objectives and techniques;



**Figure 1.** Working meeting in progress (first seminar)



**Figure 2.** A 'crime scene investigation team' prepares to enter the incident site (second seminar)

- the methods for analysing nuclear and radioactive materials used in the states participating in the seminar;
- the prospects for regional cooperation, such as international and regional Round Robins; and
- promoting interactions between nuclear forensics experts analysing seized NRM and forensics experts.

**Perspectives from investigators**

The seminar participants representing investigative bodies and forensic science organizations shared their experiences of investigating NRM trafficking cases, discussed the legal and organizational aspects of judicial authorities' activities in the field of combating NRM trafficking and heard a report on biomedical investigations involving radioactive material.

It was agreed that finding NRM out of regulatory control was a prerequisite for launching an investigation into an incident involving NRM trafficking. Participants were shown the operation of an automated control system for vehicles transporting NRM, the interception and seizure of vehicles and the collection of evidence at an incident scene.

**Nuclear Forensics at ICONS 2020... continued from page 3**

(d) emerging technologies; and (e) international cooperation to enhance nuclear security. ICONS 2020 will have two technical sessions on nuclear forensics, interactive content presentations, and a side-event on the accomplishments of the Nuclear Forensics International Technical Working Group (ITWG).

**Nuclear forensics technical sessions**

The ICONS 2020 nuclear forensics technical sessions will focus on creating and sustaining national nuclear forensics programmes and nuclear forensics collaborative efforts. The technical sessions will feature presenters from states and organizations that are using or contemplating the use of nuclear forensics science as a preventive or a response to a nuclear security event.

**Nuclear forensics: Create and sustain**

The first technical session will comprise presentations on national nuclear forensics programmes and be an opportunity for states to share their experiences of developing and preserving nuclear forensics capabilities to meet national nuclear security responsibilities. The session presentations will focus on collaboration between relevant national organizations, ranging from scientific organizations, to develop and sustain national nuclear forensics capabilities. Activities such as establishing effective information exchange between organizations, conducting joint activities and developing future cooperation to ensure that national nuclear forensics programmes are able to respond to a nuclear security event will be discussed. The session will also include presentations on the necessary elements for developing a national nuclear forensics capability, highlighting how existing national resources and infrastructure may be able to be repurposed and utilized for nuclear forensics activities. Finally, the session will feature presentations on the development and utilization of a national nuclear forensics library as a system for the identification of nuclear and radioactive material encountered out of regulatory control, as well as an example of the implementation of such a library system.

**Nuclear forensics collaborative efforts**

The second technical session will involve presentations on nuclear forensics cooperative

activities and be a forum for discussion of past and future nuclear forensics collaborative efforts, focused on strengthening global nuclear forensics capabilities. Session presentations will highlight the IAEA's April 2019 'Technical Meeting on Nuclear Forensics: Beyond the Science' and its key themes and outcomes. A presentation on the Global Initiative to Combat Nuclear Terrorism (GICNT) Self-Assessment Tool will provide an overview of the tool and discuss strategies for facilitating its use. There will also be a presentation on bilateral collaborative activities between two states, focused on advancing technical nuclear forensics and supporting global nuclear forensics capacity building. In addition, presentations on nuclear forensics training programmes will showcase how states have developed regional training courses based on identified gaps, how states have worked with national and international partners to provide training programmes, and the different models used by institutions that have participated in the IAEA Residential Assignment for Human Capacity Building in Nuclear Forensics Analytical Measurements.

**Nuclear forensics ITWG side-event**

Along with the two technical sessions focused on nuclear forensics, an ICONS 2020 side-event will focus on the accomplishments of the ITWG and its activities to advance nuclear forensic science capabilities to meet national nuclear security obligations. The side-event will feature an interactive session on the handling of evidence at a radiological crime scene and queries to a National Nuclear Forensics Library. Notably, the important and lasting technical partnership between the ITWG and the IAEA in promoting nuclear forensics state of the art practice will be featured in an upcoming edition of the flagship *IAEA Bulletin* scheduled for publication at the time of ICONS 2020.

ICONS 2020 is the premier international conference on nuclear security and will have sessions and activities highlighting the full range of the nuclear security spectrum, including the important role that nuclear forensics plays in nuclear security. Both the ministerial declaration and the outcomes from the technical sessions will influence efforts to strengthen nuclear security across the globe and inform the IAEA's Nuclear Security Plan, 2022–25. •

**IAEA Regional Seminars... continued from page 4**

The seminar was conducted in Russian. This and the fact that, for historical reasons, the law-enforcement systems in the region are based on common approaches, helped to foster frank and productive discussions.

**Articulating commonalities and differences**

As a follow-up to the first seminar, and again in cooperation with the Laboratory for Microparticle Analysis, the IAEA held a second Regional Seminar in Moscow in May 2019. That seminar discussed a number of issues related to nuclear forensics with the aim of either developing a common position and approaches, or clearly articulating the differences in the positions of the participating states' expert communities. The issues were:

- engagement with international organizations with the aim of developing national nuclear forensics capabilities;
- crime scene management and the subsequent investigation of incidents involving NRM;
- the main types of devices used in acts of nuclear and radiological terrorism, and the composition and content of samples for nuclear forensics depending on the type of device;
- certification of expert departments' laboratories to confirm their expertise and procedural independence;
- expert forensic examination of NRM and NRM traces as an important stage in NRM trafficking investigations based on practical research experience and participation in international collaborative materials exercises;
- training investigators in the specifics of crimes involving NRM.

**NRM experts and traditional forensics**

The issue of the interaction between NRM experts and traditional forensic science experts was discussed at the first seminar, generated heated discussion at the second and was at the core of an exercise conducted as part of the third. The exercise tested the opinions of seminar participants on the interaction between an investigation's three main actors—an investigator, a traditional forensics expert and an NRM expert—both at the incident scene and when answering the investigator's questions.



**Figure 3.** Discussion of laboratory analysis results (second seminar)

The exercise scenario was based on a crime involving NRM. In the scenario, an investigation team had to collect material samples and evidence at the incident scene, after which the samples were sent to a laboratory for analysis. The analysis results were then interpreted and the investigator's questions answered. The scenario was that a vehicle transporting a 'dirty bomb' containing HEU and Cs-137 had been detonated, and HEU and Cs-137 powder dispersed at the incident site. Several objects remaining at the site of the explosion were contaminated with the radioactive powder. An investigation team was sent to the site of the explosion. The 'role' of radioactive materials in this exercise was performed by imitators: tungsten powder with a non-natural isotopic composition imitating HEU, and non-radioactive caesium imitating Cs-137. The participants collected samples in accordance with their understanding of the rules and the legal requirements of this procedure. The analysis results given to the participants so they could answer the investigator's questions contained the results of the analysis of the samples collected by the members of the 'investigation team' working at the incident scene.

Both the successful actions of and the mistakes made by the exercise participants were discussed and analysed. At the conclusion of this discussion, it was decided that it would be necessary to conduct another exercise, in which the details of the interactions between the main actors in the investigation—the investigator, the forensics expert and the NRM expert—could be discussed in advance and the experience of forensics experts in crime scene investigation would be taken into account. In addition, it was suggested that a regional Round Robin exercise should be conducted involving an analysis of non-radioactive samples (or samples containing only small amounts of NRM). This approach to Round Robin exercises will simplify the transportation of



samples and make it possible to send them for analysis to laboratories that do not work with NRM.

### Almaty IAEA seminar

The third IAEA seminar was held in Almaty in December 2019 in cooperation with Kazakhstan's Institute of Nuclear Physics. The frank discussions on nuclear forensics that began at the previous seminars continued in Almaty.

There was a discussion of the IAEA Incident and Trafficking Database (ITDB), that contains over 3000 incidents. The seminar participants expressed an interest in finding new opportunities for using the ITDB information for nuclear forensics purposes. The results of the analysis of publications about crimes involving NRM were reported and discussed. It was noted that little information about specific crimes is reported at international forums, while deeper analysis of information about real incidents is needed in order to examine the responses to such incidents and to develop a wider range of exercise scenarios based on real cases. The seminar participants presented a series of real case studies of illicit trafficking of radioactive material. The presentations described lessons learned from both investigative (e.g. the use of undercover operations and intelligence



**Figure 4.** A scene from the exercise involving the investigation of a radioactive source (third seminar)

information, or the benefits of cross-border cooperation) and scientific practice (e.g. prevention of cross-contamination, or identification and analysis of material mixtures). An exercise was conducted as part of the seminar, which aimed to practice the interaction between the investigators, traditional forensics experts and nuclear forensics experts involved in investigating NRM crimes.

The effectiveness and the practical relevance of the three seminars indicate the need for further such events. The possibility of conducting a fourth and the fifth seminar was discussed. The exercises demonstrated the importance of participants' preparation. The next such exercise is scheduled to be held in Moscow in May 2020. •

### UPCOMING TRAININGS AND MEETINGS

- ITWG fourth Galaxy Serpent exercise (GSv4), December 2019–March 2020
- Nuclear Forensics Workshop for ASEAN Member States, Seoul, Republic of Korea, 8–9 January, 2020
- IAEA Research Coordination Meeting for CRP JO2013, Vienna, Austria, 28–31 January, 2020
- 10th International Conference on Isotopes (IOICI), Kuala Lumpur, Malaysia, 3–7 February, 2020
- IAEA International Conference on Nuclear Security: Sustaining and Strengthening Efforts (ICONS2020), Vienna, Austria, 10–14 February 2020
- GICNT Rogue Tango RMWG–NFWG Exercise, Buenos Aires, Argentina, 3–6 March, 2020
- Radiological Crime Scene Management Workshop for GUAM countries organized by the Science and Technology Center in Ukraine (STCU), Baku, Azerbaijan, 12–14 May, 2020
- Nuclear Forensics Training for South East Asia organized by the Japan Atomic Energy Agency, Bangkok, Thailand, 25–29 May, 2020
- 22nd Triennial Meeting of the International Association of Forensic Science, Sydney, Australia, 21–25 September, 2020
- Nuclear Forensics Conference (NuFor 2020) organized by the Atomic Weapons Establishment (AWE), London, United Kingdom, 14–15 October, 2020

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

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## CONTENTS

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|  |   |
|--|---|
| Chairpersons' Address  | 1 |
| Twenty Years of Collaborative Materials Exercises                                | 1 |
| Nuclear Forensics at the International Conference on Nuclear Security ICONS 2020 | 3 |
| IAEA Regional Seminars on an Introduction to Nuclear Forensics                   | 4 |
| Upcoming Trainings and Meetings  | 7 |

### 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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