ITWG Nuclear Forensics International Technical Working Group

ITWG NUCLEAR FORENSICS UPDATE

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CHAIRPERSONS' ADDRESS

Welcome to the Nuclear Forensics International Technical Working Group (ITWG) quarterly newsletter. As we transition from 2018 to 2019, ITWG efforts continue. Following a productive annual meeting in June, ITWG is finalizing academic publications from Galaxy Serpent version 3 (GSv3) and has initiated its sixth Collaborative Material Exercise (CMX-6). These rich opportunities for learning and discussion help to advance nuclear forensic science and more members than ever are participating. In June 2019, ITWG anticipates holding a Data Review Meeting for teams to review CMX-6 outcomes and experiences, and in June ITWG will hold its annual meeting to discuss these and other forensic science activities. In this newsletter you will find an article describing nuclear forensics work at the Australian Nuclear Science and Technology Organisation, a report on the Australian and New Zealand Forensics Science Society symposium and an update from the ITWG Guidelines Task Group. We hope these articles enrich your understanding of nuclear forensic science and strengthen your participation in international forensics activities.

With best regards,
Klaus Mayer and Michael Curry

THE HISTORY AND ACHIEVEMENTS OF THE ITWG GUIDELINES TASK GROUP

MICHAEL KRISTO AND ZSOLT VARGA*

Since its founding in 1995, the Nuclear Forensics International Technical Working Group (ITWG) has focused on improving the scientific and technical methods used to support a nuclear forensics examination in response to incidents involving nuclear and other radioactive material out of regulatory control. As an informal international association of nuclear forensic science practitioners that includes laboratory scientists, law enforcement officials, first responders and members of affiliated international organizations, the ITWG promotes the implementation of, and advances in, nuclear forensics. The work of the ITWG is carried on through its annual meetings, by task groups and by organizing collaborative exercises. Underpinning all these activities is the concept of advancing the state of practice in nuclear forensics, while reflecting consensus international approaches, techniques and methods of analysis, interpretation and reporting. The ITWG is informal and its guidance is not proficiency based. In this context, the ITWG has worked since its inception to provide scientific and technical recommendations, adopted voluntarily, that can be used to assist the working group and its members to develop and sustain a nuclear forensics capability.

The ITWG Guidelines Task Group was established to provide practitioners with documented tools to fulfil the requirements of the nuclear forensics 'model action plan' as the generalized approach to an examination response to a nuclear security event, involving the collection of evidence, categorization to inform the subsequent characterization in the nuclear forensics laboratory and interpretation bearing on the risk, origin and history of materials for use in legal proceedings or a nuclear security investigation. The guidelines are complementary to the analytical 'round robins'—now collaborative material exercises—in which a common sample is shared among participating self-declared nuclear forensics laboratories, with coding to allow for anonymous analysis, which have been central to the work of the ITWG since its inception. The sharing of results from the round robin exercises allows the exchange of information on the analyses pursued by the different laboratories. This information exchange has fostered the need for consensus guidelines to be drafted that reflect best practices. In addition, the guidelines

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NUCLEAR FORENSICS AT THE AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION (ANSTO)

KAITLYN TOOLE, TEGAN BULL, ELIZABETH KEEGAN, PETRA BAJO, NED BLAGOJEVIC, JACK GORALEWSKI, SAMANTHA LEE, ELAINE LOI, RILEY VAN DE VOORDE AND EMMA YOUNG

In 2009, law enforcement in two separate Australian jurisdictions conducted raids on clandestine drug laboratories. The two operations were not related in any way, but police found a jar labelled 'uranium oxide' at one scene and a jar labelled 'gamma source' at the other. Nuclear forensics examination of these materials later revealed no links between them. Nor were there any indications of an intention to use these materials maliciously. However, the discovery of such materials at 'routine' crime scenes at the time underscored the importance of Australia's ongoing efforts to develop indigenous nuclear forensics capabilities, already under way in response to the increased threat of use of these materials by terrorists.

In the almost 10 years since these finds, Australia's nuclear forensics capabilities have evolved and matured, drawing on the nuclear science and technology expertise found within the Australian Nuclear Science and Technology Organisation (ANSTO). The portfolio of activities of ANSTO's Nuclear Forensics capability area under the leadership of Tegan Bull now incorporates operational support, innovation, and international outreach and engagement. The responsibility to deliver on these activities rests with a core team of nine staff with expertise in radiochemistry, geochemistry, environmental science and traditional forensic science. Radiochemist, Liz Keegan notes that, 'we are a relatively small group, but we have access to the expertise of people across the site and an exceptional range of instrumentation'.

Nuclear Forensics is located at the Lucas Heights campus outside Sydney and forms part of ANSTO's broader nuclear stewardship activities, which also include radionuclide metrology, ionizing radiation detection and measurement, environmental monitoring and radioanalytical chemistry.

Operational support

ANSTO maintains Australia's national capability for the forensic analysis of nuclear and other radioactive materials on behalf of law enforcement, which can be called on in cases such as those described above. This has entailed the development of legally defensible processes such as chain of custody, should the nuclear forensic analysis ultimately be tested in court, as well as the refining of analytical capabilities and developing a broad understanding of the signatures of a range of nuclear and other radioactive materials.

Figure 1. ANSTO's nuclear forensics team

Figure 2. Examination of traditional forensic evidence under way in the glove box

Raising awareness among domestic law enforcement of the safety and security risks of nuclear and other radioactive materials and the important role that nuclear forensics can play in the investigation of material outside of regulatory control has become a crucial function. According to Laboratory Manager Jack Goralewski, 'Establishing relationships between first responders and subject matter experts through participation in training and exercises is critical to enhancing interoperability'.

In addition to the capability to analyse nuclear and other radioactive materials, ANSTO houses the national capability for the forensic examination of evidence contaminated with radionuclides, with

Figure 3. Training regional partners on the physical examination of nuclear materials as part of the IAEA's Practical Introduction to Nuclear Forensics

support from the forensic science expertise of the Australian Federal Police (AFP).

Nuclear forensic scientist Kaitlyn Toole explains that, 'forensic experts in fingerprints, DNA and electronic evidence from the AFP have been trained to apply their skills in the custom facilities developed in ANSTO's laboratories. Law enforcement has been a key partner in the development and maintenance of this capability'.

In addition to case work, ANSTO maintains and enhances its operational capability through participation in exercises such as the ITWG collaborative material exercises (CMXs). Nuclear forensic scientist Emma Young feels that:

> the ITWG CMXs are some of the most challenging yet rewarding experiences for our team. Each exercise helps us to deepen our technical knowledge and strengthen the working relationships that are essential to the success of a nuclear forensic examination, both within our team and across ANSTO. Participation in the exercises has also been a great way for us to engage with the international nuclear forensics community, share our experiences and learn from others.

Innovation

Innovation in nuclear forensics at ANSTO is stakeholder-driven, reflecting the operational needs of clients. The focus of our innovation and capability extension work is the front end of the nuclear fuel cycle, reflecting the materials most commonly found in Australia.

Recent projects have included the investigation of radiochronometers such as $^{231}Pa/^{235}U$ and $^{230}Th/^{234}U$, and the development of analytical methodologies for uranium ore concentrates (UOC). According to Liz Keegan, 'our research on the chemical and microstructural characterization of UOCs underpinned our ability to determine the likely provenance of the material found at one of the crime scenes'.

ANSTO has also investigated the effects of radiation and decontamination on forensic evidence. Studies evaluating the efficacy of commercial DNA extraction kits for the decontamination of biological samples contaminated with radionuclides guided the selection of a methodology to apply to operational capabilities for analysis of contaminated DNA samples.

Where possible, ANSTO seeks partnerships with Australian universities and international nuclear forensics laboratories to develop and deliver projects. International Atomic Energy Agency (IAEA) Coordinated Research Projects (CRPs) have also provided a valuable vehicle for ANSTO to share developments in nuclear forensics.

International outreach and engagement

While the responsibility for nuclear forensics rests with each state, ANSTO recognizes the importance of international collaboration in the development of best practices and the role it can play, particularly in South East Asia, in supporting other states as they develop nuclear forensic capabilities. ANSTO actively participates in the ITWG, the Global Initiative to Combat Nuclear Terrorism (GICNT) and IAEA activities. It is also taking on an increasingly significant role in the provision of training. In October 2017 ANSTO ran the IAEA's Practical Introduction to Nuclear Forensics training course in Lucas Heights, New South Wales, Australia—the first time the IAEA conducted practical nuclear forensics training in South East Asia. This course will be run by ANSTO again in February 2019.

ANSTO has also conducted customized training on a bilateral basis for partner agencies in Indonesia and Singapore. Kaitlyn Toole, who led the coordination of these activities, believes that, 'providing nuclear forensics training presents an opportunity to enhance nuclear security in our own region by sharing the expertise we have developed in over a decade of operational experience'.

Looking back, looking forward

In the nine years since the discovery of nuclear material at clandestine laboratories in Australia, the global security situation has arguably changed

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ITWG SCIENTISTS WIN AWARDS IN PERTH

KAITLYN TOOLE, SAMANTHA LEE, MATTHIJS ZUIDBERG AND DAVID SMITH

The Australian and New Zealand Forensic Science Society convened its 24th symposium in Perth, Australia on 9–13 September 2018 (ANZFSS 2018). There were several contributions from scientists affiliated with the Nuclear Forensics International Technical Working Group (ITWG). The theme of the symposium was 'Forensic Science Without Borders' and the event was attended by approximately 700 forensic examiners, law enforcement officials and first responders, as well as academic experts and industrial representatives drawn largely from Australia and New Zealand but also from throughout the international forensics community. ITWG scientists actively participated in a technical session on 'CBRN and Counterterrorism', during which several papers featured the work of the ITWG and its international partners.

Making connections

The ANZFSS 2018 symposium was invaluable in further connecting the ITWG to the broader discipline of forensic science, and in particular for building synergies between nuclear and traditional forensic science, for example in the examination of fingerprints, DNA, digital evidence, hair, fibres, explosive residues, toolmarks, soil and dust, and so on. The symposium featured in-depth morning keynote presentations on topics ranging from international forensics cooperation to challenges in toxicology, the science and technology of chemical weapons and the challenges associated with digital forensics. Technical streams encompassed a variety of forensic topics such as judicial context, illicit narcotics, fingerprint examination, crime scene investigation, pathology, quality assurance, document examination, education, firearms, digital evidence and chemical-biological-radiological-nuclear (CBRN) forensics. CBRN forensics as a technical stream was reintroduced to the symposium after almost a decade's absence. It featured presentations from the International Atomic Energy Agency (IAEA), the Australian Nuclear Science and Technology Organization (ANSTO) and the Netherlands Forensic Institute (NFI).

Kaitlyn Toole of ANSTO made two presentations. Her keynote, 'Nuclear Forensic Science in Australia: Current Status and Future Plans', discussed the regional and national threats posed by nuclear and radioactive material out of regulatory control and the Australian model for responding to incidents that involve radiological crime scene management, analyses of nuclear and other radioactive material, and the examination of evidence contaminated with radionuclides. She emphasized the importance of partnerships between subject matter expertise and laboratory infrastructure, and in particular the collaboration between ANSTO and the Australian Federal Police. Involvement in ITWG collaborative material exercises (CMX 5 and 6) and virtual interpretative exercises (Galaxy Serpent 3) has strengthened national capabilities. ANSTO also provides diverse training for the national police, counterterrorism units and forensics personnel.

Toole's second presentation, 'Training in Nuclear Forensic Science: the Australian Experience, Supporting the Development of Regional Capabilities', focused on ANSTO's bilateral nuclear forensic engagement throughout South East Asia and with the IAEA. She emphasized nuclear security capacity building with the National Nuclear Energy Agency of Indonesia (BATAN) and the Ministry of Home Affairs of Singapore as well as ANSTO's experience of running the IAEA regional practical introduction to nuclear forensics training. Toole noted that engaging with all relevant stakeholders, incorporating training

Figure 1. ITWG scientists at the ANZFSS 2018 Symposium in Perth, September 2018. Samantha Lee and Matthijs Zuidberg win awards from the organizers for the papers they presented

requirements into course curricula and adequate preparation, including interactive activities, are the keys to successful nuclear forensics training.

Posters and toolboxes

A poster presentation from Samantha Lee of ANSTO, 'Exploring the Potential Implementation of a National Nuclear Forensics Library through Participation in Galaxy Serpent Version 3 Virtual Tabletop Exercise' outlined ANSTO's thorough approach to and the results from interpretations from a national nuclear forensics library (NNFL) exercise organized by the Nuclear Forensics ITWG. Using early career researchers and readily available software, the ANSTO team was able to analyse the data provided and identify various benefits and challenges from implementing an NNFL for uranium ore concentrate (UOC). The co-authors of the poster were Riley van de Voorde, Liz Keegan and Elaine Loi, all of ANSTO.

Matthijs Zuidberg of the NFI spoke about the Generic Integrated Forensic Toolbox (GIFT), which is a European initiative to develop a response to CBRN incidents. One of the main research aims is to develop decontamination and containment methods capable of handling and analysing contaminated exhibits. The results on decontamination and containment are technically promising. Zuidberg emphasized that the results on decontamination efficiency should facilitate further discussions on the acceptable levels for work in a forensic science laboratory.

A paper by David Kenneth Smith of the IAEA and his IAEA colleagues, 'Current Status of the International Atomic Energy Agency Nuclear Forensic Science Coordinated Research Projects and Future Needs for Research and Development', highlighted the IAEA's goal of using research to develop scientifically validated methods that support examination of nuclear and other radioactive material out of regulatory control. Nuclear forensic science improves the confidence of practitioners through innovation and sharing of experiences, best practices and lessons learned—including examination of traditional evidence contaminated by radionuclides.

Awards and future plans

The organizers presented ANZFSS 2018 Symposium awards for the best oral presentation in the CBRN and Counterterrorism stream to Matthhijs Zuidberg of NFI and the best poster presentation in the stream to Samantha Lee of ANSTO.

The ANZFSS 2018 Symposium provided a bridge for the ITWG to the broader discipline of forensic science, raising awareness and understanding of the latest developments in traditional forensic science that link people, places, materials and events important to a comprehensive investigation of a nuclear security event.

The next ANZFSS Symposium, in 2020, will be held in collaboration with the 22nd Triennial Meeting of the International Association of Forensic Sciences in Sydney, Australia and is expected to attract in excess of 1500 delegates. For more information and to register for updates see http://iafs2020.com.au/. The organizers anticipate that many ITWG-affiliated scientists will participate in the next symposium. •

Nuclear Forensics at the ANSTO *continued*

Figure 4. A forensic light source in use in ANSTO's glove box for a fingerprint examination

Figure 5. ANSTO staff providing training to regional partners as part of the Proliferation Security Initiative's Exercise Pacific Protector

profoundly. These changes have perhaps made nuclear forensics capabilities in support of states' nuclear security architecture more important than ever before. In recent times ANSTO has seen an expansion in staff numbers and infrastructure upgrades in the Nuclear Forensics capability area to ensure ongoing quality in the delivery of operational support and international outreach and engagement. Riley Van De Voorde, a laboratory technician who has entered nuclear forensics in the earliest stages of her career, recognizes that, 'it is a privilege to launch my career in such a dynamic field of science, where I am driven by the importance and real-world implications of the work my team and I do'. •

UPCOMING TRAININGS AND MEETINGS

- GICNT Resolute Sentry Exercise, Montreal, Canada, 29 January–1 February 2019
- GICNT Reachback Support Workshop 'Cunning Karl', Karlsruhe, Germany, 12–14 February 2019
- IAEA Regional Training Course on Practical Introduction to Nuclear Forensics, Lucas Heights (Sydney), Australia, 25 February–1 March 2019
- IAEA Technical Meeting on Nuclear Forensics, Vienna, Austria, 1–4 April 2019
- ITWG CMX-6 Data Review Meeting, location TBD, mid/late May 2019 (tentative)
- IAEA Regional Seminar on Introduction to Nuclear Forensics (Russian speaking), Moscow, Russia, Q2 2019 (TBC)
- ITWG Annual Meeting (ITWG-24), Bucharest, Romania, 25–27 June 2019

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.

The History and Achievements of the ITWG Guidelines Task Group *continued*

now encompass evidence collection, non-destructive analysis for categorization of the material at a nuclear security event as well as determinations of confidence in findings. Each nuclear forensics examination is different and the guidelines are not prescriptive. They are not requirements but are rather meant to inform.

At the first ITWG Meeting convened at the former Institute for Transuranium Elements (ITU) in Karlsruhe, Germany, in January 1996 the terms of reference advanced included the aim to 'Identify and prioritize techniques and methods for forensic analyses of nuclear materials in order to answer questions regarding source attribution and the intended use of seized nuclear materials'. The idea of nuclear forensics guidelines can be traced back to 2004, when the ITWG Executive recognized the need to create 'general guidelines', as opposed to standards, that would strengthen confidence in the findings derived from international nuclear forensics laboratories engaged in ITWG round robin exercises, as well as actual casework.

In 2006, following the 11th annual meeting of the ITWG in Speyer, Germany, the ITWG Guidelines Task Group was created to 'develop consensus guidelines, consistent with the IAEA/ITWG Model Action Plan, to be utilized by all laboratories that participate in the ITWG's Collaborative Material Exercises (CMXs). The use of such guidelines will enable intercomparison of results among all of the participating laboratories, as well as provide additional credibility for our analytical results to legal authorities'. Initial work focused on the type and structure of the guidelines, their corresponding level of detail, prioritization of guideline development and review and approval processes within the ITWG.

Important to the work of the task group is the definition of consensus guidelines. The task group has determined that:

> Consensus guidelines provide general descriptions and/or recommended approaches for specific activities or procedures in nuclear forensics. Consensus guidelines are consistent with the ITWG Model Action Plan, but provide additional detail. Consensus guidelines are less detailed than laboratory procedures, but provide sufficient detail to be useful. The term 'consensus' means that all members can support the guideline; it does not mean that all members believe that it is the best guideline possible for the specific activity or procedure.

ITWG guidelines are developed and regularly reviewed by the ITWG Guidelines Task Group and approved by the ITWG Executive Committee. Consistent with international practice, written procedures are essential to obtaining high confidence findings associated with a nuclear forensics examination. ITWG guidelines do not by themselves constitute a nuclear forensics quality assurance programme, but they can provide the basis for such a control as required.

Guideline preparation has evolved. As an association of ITWG nuclear forensics practitioners, many of whom are nuclear scientists, analytical chemists or radiochemists, the initial direction of the guidelines tended to reflect analytical methods commonly encountered as part of a nuclear forensics examination, and in particular those used in the examination of several high-profile cases of seized highly enriched uranium in the late 1990s. Thermal ionization mass spectrometry and alpha spectrometry were among the first guidelines to be approved by the ITWG. The currently approved ITWG guidelines cover alpha spectrometry, evidence collection in a radiological or nuclear contaminated crime scene, in-field and laboratory applications of high resolution gamma spectrometry for analysis of special nuclear material, powder X-ray diffraction (XRD), secondary ion mass spectrometry, thermal ionization mass spectrometry, age dating, characteristic parameters of UO_2 fuel pellets, U and Pu elemental assay, and the importance of uncertainty in nuclear forensics measurements. •

*Dr Michael Kristo of the Lawrence Livermore National Laboratory, USA; and Dr Zsolt Varga of the European Commission's Joint Research Centre in Karlsruhe, Germany, currently lead the ITWG Guidelines Task Group as co-chairs and oversee the work of the task group as well as its strategy.

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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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