ITWG Nuclear Forensics International Technical Working Group

ITWG NUCLEAR FORENSICS UPDATE

No. 36 October 2025

CHAIRPERSONS' ADDRESS

Welcome to the 36th edition of the Nuclear Forensics International Technical Working Group (ITWG) newsletter! Following the successful conclusion of the 28th annual meeting of the ITWG in Bologna, Italy, we extend our heartfelt gratitude to ENEA, the Italian National Agency for New Technologies, Energy, and Sustainable Economic Development, for their exceptional organization and hospitality. We are especially deeply grateful to Giuseppe Ottaviano for his tireless efforts in preparing for and pulling together the meeting. All this was instrumental in making ITWG-28 a resounding success. Our appreciation also extends to the US Department of Energy's Nuclear Smuggling Detection and Deterrence program and the European Commission for their sponsorship, which made the participation in such high numbers possible. Lastly, we thank all participants for their active engagement. The lively Q&A sessions, dynamic panel discussions, and collaborative task group meetings were vital to the meeting's impact. For a full summary of the meeting and additional details, please refer to the article below. More stories in this edition include Australian participation in the CMX-7 Crime-Scene-in-a-Box (CSIAB) exercise, and the retrospective on the Galaxy Serpent exercises.

The Australian Nuclear Science and Technology Organisation (ANSTO), in collaboration with the Australian Federal Police, developed a refined approach to conduct the CSIAB component of the CMX-7 exercise amid the operational challenges posed by restrictions during the COVID-19 pandemic. These innovative solutions, while tailored for a crisis environment, demonstrate clear applicability in 'normal' operational contexts as well. An insightful article highlighting the added value of traditional forensic analysis in nuclear forensic investigations can be found on page 3.

The Galaxy Serpent (GS) exercises, the ITWG's virtual, web-based tabletop exercises, have been conducted in five iterations to date. Coordinated by the Libraries and Assessment Task Group, the GSs aim to advance the application and use of National Nuclear Forensic Libraries. An in-depth review of the evolution of the GS exercises since 2013, including lessons learned and future expectations, is presented on page 4.

As co-chairs, we are already looking ahead to the future and have begun planning for the next ITWG annual meeting. While the details are not yet finalized, we hope to reunite in the summer of 2026 to continue our collective efforts in advancing nuclear forensics. We look forward to sharing more details in the next ITWG Update. Thank you for your continued engagement and support!

With best regards,

James Blankenship and Maria Wallenius

REVIEW OF THE 28TH ITWG ANNUAL MEETING

JAMES BLANKENSHIP AND MARIA WALLENIUS

The 28th Annual Meeting of the Nuclear Forensics International Technical Working Group (ITWG-28), held in Bologna, Italy, from 1–3 July 2025, brought together approximately 80 nuclear forensics experts from over 30 countries and international organizations. The event also commemorated a significant milestone: 30 years since the establishment of the ITWG. This marked Italy's second time hosting the annual meeting, following its first in Como (ITWG-3) in 1997, which had been among the earliest in the group's history. Welcoming remarks were delivered by Alessandro Dodaro of the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), and Davide Cutrino, representing the Carabinieri and the Ministry of Foreign Affairs.

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Review of the 28th ITWG annual meeting... *continued from page 1*

The first plenary session featured updates on ongoing nuclear forensics activities at the International Atomic Energy Agency (IAEA), including training programs, workshops, and conferences. A key highlight of the upcoming year will be the IAEA's Technical Meeting on Nuclear Forensics, scheduled for 5–9 October 2026 in Vienna. The session also included an introduction to the Global Forum to Prevent Radiological and Nuclear Terrorism (Global FTPRNT), launched in autumn 2024 to succeed the Global Initiative to Combat Nuclear Terrorism (GICNT). The Global FTPRNT unites like-minded partners to address urgent needs for international cooperation and coordination in preventing, detecting, and responding to radiological/nuclear terrorism threats. Updates were also provided on the newly launched ITWG restricted website, developed by the Outreach and Training Task Group with funding from the French Commissariat à l'Énergie Atomique (CEA). The second plenary session highlighted national capability updates and other key developments.

The ITWG's Nuclear Forensics Laboratories (INFL) session featured cutting-edge scientific presentations, including advancements in technologies such as MC-ICP-MS/MS, SEM-EDS, and ion beam analysis. Presenters also compared common software tools used in gamma spectroscopy, while perennial favourites like age determination remained a focal point. Given the global interest in Small Modular Reactors (SMRs) and advanced reactor fuels, the community welcomed a session on 'Signatures of Advanced Fuels,' offering valuable insights into this evolving field. The Emerging Topics in Nuclear Forensics (ETNF) session, a new format replacing the previous Professional Development Seminars (PDS), explored SMRs and artificial intelligence, two high-priority areas. Two 1.5-hour sessions provided the community with comprehensive, up-to-date information on these emerging topics.

The ITWG's five task groups—Evidence and Testimony Task Group (ETTG), Exercise Task Group (ETG), Guidelines Task Group (GTG), Libraries and Assessment Task Group (LATG) and Outreach and Training Task Group (OTTG)—reviewed their progress since the last annual meeting. Enhanced collaboration between annual meetings is expected through the new restricted website, which now hosts dedicated sections for each task group to conduct activities such as document reviews. Summaries of task group sessions will be posted on the platform following future annual meetings.

During the ETTG session, an early draft of the casework documentation guide was reviewed by attendees. Discussions centred on its alignment with existing IAEA documents (e.g., NSS 2-G and NSS 22-G), as well as its intended audience. Participants emphasized that countries should develop their own casework documentation frameworks tailored to national needs. As a result, the guide will focus on providing a standardized list of tasks commonly addressed in such frameworks, such as 'Sections of a case package' or 'Storage of evidence.' Notes from the session will be compiled into a revised draft, which will be circulated to attendees for further feedback.

During the ETG session, an overview of the Collaborative Materials Exercises (CMX) was provided, along with updates on the ongoing CMX-8 exercise. This was followed by two technical presentations by graduate students from the University of Florida, USA, and the University of Bristol, UK. The session concluded with roundtable discussions on proposed content for the closed ITWG website, as well as general feedback on the format, structure, and content of the Exercise Review Meetings.

The GTG shared exciting updates regarding new guidelines developments. The final revisions to the guideline on 'Characterization of Particle Morphology via Microscopy' have been completed and the document is now ready for final acceptance. Additionally, over the past year, GTG members revised two fundamental guideline documents related to alpha spectrometry and gamma spectrometry, and their application in nuclear forensics. These updates were reviewed during the meeting and the revised guidelines will soon be published on the ITWG website. Finally, the 'Graded Decision Framework' guideline is currently in the final stage of the acceptance process, while the 'National Nuclear Forensics Libraries' guideline is now available for revision by GTG members.

During the LATG session, the Galaxy Serpent version 5 (GSv5) exercise was reviewed, sparking a lively discussion among participants about the investigative questions posed and the diverse strategies employed to address them. The session also featured a review of the LATG strategy paper, proposals on integrating AI technology into data assessment, and a call for attendees to submit ideas for the next Galaxy Serpent exercise.

During its breakout session, OTTG reviewed feedback on the new restricted website, discussed work needed to address the content updates in the open website, and explored how the two ITWG websites can work together to meet the needs of the nuclear forensics expert community. Finally, the OTTG reviewed a list of global nuclear forensics trainings to inform its next strategic initiative: mapping the development of global nuclear forensics expertise.

Presentations and other related material of the annual meeting are available to the ITWG members on the restricted website. •

ANSTO'S PARTICIPATION IN CMX-7 CRIME SCENE IN A BOX: OPERATION HEBANON

NIKKI KEIGHRAN, JACK GORALEWSKI, ADAM BORTZ, MELANIE FRASER

In 2022, Australia faced significant challenges due to the COVID-19 pandemic, including a surge in cases and deaths. This led to widespread disruptions and the implementation of various public health measures, such as lockdowns and physical mandates like masks and social distancing. Despite serious consideration by Australian Nuclear Science and Technology Organisation's (ANSTO) Nuclear Forensic Team to cancel participation in the ITWG CMX 7, the leadership team devised a modified participation plan. This plan allowed the team to exercise their capabilities under restricted conditions, in line with New South Wales Health and ANSTO COVID guidelines.

Key modifications included:

- Taking measures to reduce onsite movement.
- Requesting flexibility from CMX organisers and planning for delays in deadlines in the analytical plan due to reduced capacity and onsite analytical capability.
- Simplifying the Crime Scene in a Box (CSIAB) scenario.

The CSIAB response was streamlined from a full-scale mock crime scene, which included the full operational capabilities of the Australian Federal Police Level 3 Laboratory Exploitation Team, to a more focused version. In this refined approach, a forensic examination was conducted on selected evidence from the CSIAB. Local crime scene examiners carried out the examination, while a specialist was engaged remotely to conduct fingerprint and physical fit comparisons and provide reporting.

For the exercise, a small selection of items were retrieved from the CSIAB, guided by its accompanying documentation and an understanding of the limitations of traditional forensic capabilities in our modified analytical plan.

Figure 1. ANSTO's Nuclear Forensics team undertaking deconstruction of the seized samples

This approach showcased the team's ability to leverage local forensic resources rather than relying solely on interstate experts. It also demonstrated their capability to conduct radiological hazard assessments and progressively downgrade examinations from a glovebox to a fume cabinet and a benchtop fingerprint tank. Additionally, the team effectively collaborated with forensic experts remotely, transferring digital images for comparison when in-person attendance was not feasible.

As per the Australian model for Nuclear Forensic examinations, all the traditional forensic examinations were performed by the AFP crime scene investigators at the ANSTO nuclear materials laboratory (Figure 1). Any required equipment such as photography kit, fingerprint chemicals and portable cyanoacrylate tanks, were relocated to an appropriate workspace to comply with COVID restrictions.

The initial forensic examinations involved viewing the seized sample containers with different lighting techniques to identify any potential latent prints, followed by cyanoacrylate fuming and chemical staining to develop latent prints. Any visualised

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ANSTO's participation in CMX-7 crime scene in a box... *continued from page 3*

Figure 2. Photographing with an orange lens to capture the fluorescent emission, ensuring the ridge details stand out

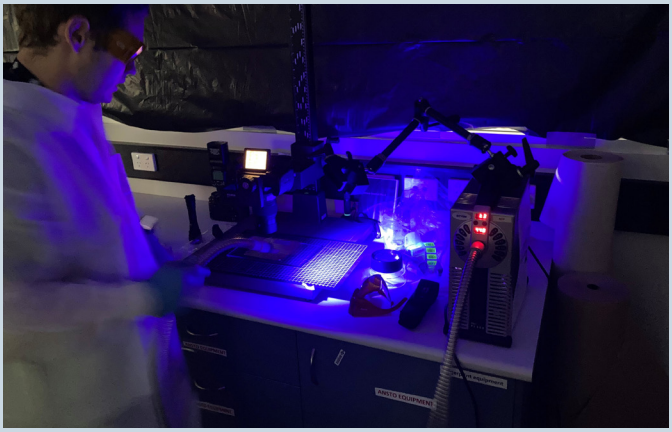

Figure 3. Fluorescing ridge detail against a dark background using the Polilight at 505 nm following chemical staining

Figure 4. Areas of ridge detail enhanced with chemical staining and cyanoacrylate fuming located on 'Item 5/ ES-1'.

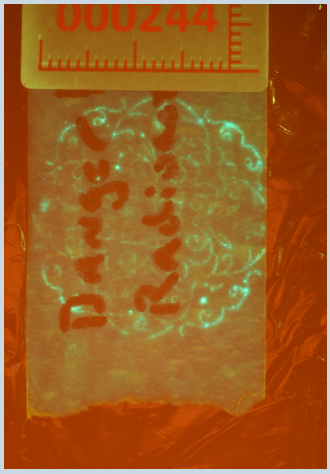

Figure 5. Ridge detail enhanced with chemical staining on the non-sticky side of the tape removed from 'Item 7/ES-2'

prints were photographed, and digital images were transmitted remotely to AFP fingerprint experts for comparison against the CSIAB fingerprint cards. Integrating AFP Crime Scene Investigators into the development of the analytical plan and Nuclear Forensic physical examination enabled close consultation with the NF team, ensuring the sequence of examinations preserved potential fingerprint marks. This approach successfully developed several partial fingerprint marks for comparison.

Physical fit examinations were conducted on five sections of blue masking tape recovered from Neil's laboratory (Item 10), Lise's office, and Otto's office and compared to the tape removed from the seized sample containers (ES-1 and ES-2). The process involved transferring the tape to transparency film, photographing the sections, and sending digital images to experts for comparison using specialised software (Figures 2–3). The examination assessed various physical properties, including width, type and construction, texture, subjective colour, and the torn edges of each tape section.

Fingerprints were identified on four samples taken from the tape removed from the sample containers and the external surface of these containers (ES-1 and ES-2), all matching the fingerprint set belonging to Niels (Figures 4–5). Additionally, unique physical fits were observed between the blue tape removed from ES-1 and the tape recovered from Niels' laboratory (Item 10), as well as between the blue tape removed from ES-1 and ES-2 containers. These findings established a clear evidentiary link between the person of interest, Niels, and the samples recovered from multiple locations.

Integrating the CSIAB evidence with the nuclear forensic characterisation of materials highlighted the significant added value of traditional forensic analysis in a nuclear forensic investigation. This approach effectively contributed to reconstructing the scenario and strengthening the evidentiary framework. Incorporating these elements into CMX-7, even in its modified version, facilitated collaboration with law enforcement by enhancing the triaging sequence of events and reinforcing the evidentiary value of subsequent CMX-7 reports. Additionally, this effort demonstrated ANSTO's capability to achieve meaningful outcomes despite operational restrictions, such as those imposed by COVID-related challenges.

As is often the case, our most valuable takeaway from participating in this exercise was the critical importance of collaboration with our law enforcement partners. Such partnerships are essential for building strong evidential linkages that integrate both traditional and nuclear forensic methodologies, ultimately leading to more effective outcomes.

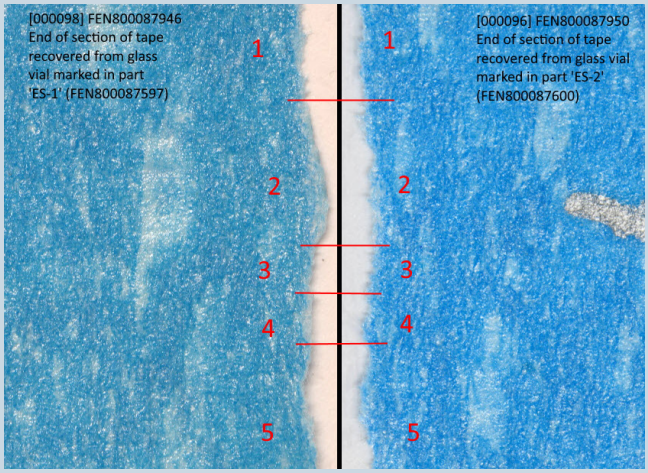

Figure 6. Image demonstrating the physical fit of the tape removed from 'Item 5/ES-1' to the tape removed from 'Item 7/ ES-2.

Equally important is the continued development of these working relationships. Establishing and maintaining strong connections ensures that, when operational coordination is required, the process is seamless and efficient. Strong communication practices are essential to ensuring successful operational outcomes

Acknowledgements

CMX 7 ANSTO Nuclear Forensics Team

Elizabeth Keegan, Kaitlyn Toole, Anny Toch, Katherine Adena, Emma Young, Ned Blagojevic, Elaine Loi, Masturina Kracica, Tegan Bull

Australian Federal Police Level 3 Laboratory Exploitation Team

Melanie Fraser, Adam Bortz, Karina Nelson, Rebecca Thurling, Kaymann Cho, Gregory Robertson, Timothy Shaw, Jennifer Stone, Andrew Goodman-Jones, Stephan Renwick, Daniel Scott, Alan Wong. •

RETROSPECTIVE ON FIVE ITERATIONS OF THE GALAXY SERPENT EXERCISE

JAMES BORGARDT

Since 2013, the Nuclear Forensics International Technical Working Group (ITWG) has conducted the Galaxy Serpent (GS) series of virtual, web-based tabletop exercises. These exercises are designed to advance the application of National Nuclear Forensics Libraries (NNFLs) in investigations involving nuclear and other radioactive material found out of regulatory control (MORC). Over five iterations, GS has brought together dozens of teams comprised of hundreds of practitioners worldwide (Figure 1), fostering technical expertise, standardizing methodologies, and building international cooperation.

Origins and objectives

The impetus for GS arose from the security threat posed by illicit trafficking of nuclear and radioactive materials, as documented in the International Atomic Energy Agency's Incident and Trafficking Database (ITDB). An NNFL is a structured national database or knowledge system, developed and interpreted by subject matter experts (SMEs), that compiles detailed information on a country's nuclear and other radioactive materials produced, used, or stored under regulatory control. NNFLs are a powerful tool to assess whether seized material is consistent with national holdings, guiding investigative leads. GS provides a secure, cost-effective platform for participants to practice developing and applying NNFLs without the need to transport or handle actual radioactive material.

Evolution of the Exercises

Each GS iteration has centered on different material types, progressively increasing complexity and investigative focus. Table 1 provides a summary retrospective of the essential attributes of the five versions of the exercise conducted to date.

The GS exercises have increasingly incorporated use of the Graded Nuclear Forensics Decision Framework (GDF), which provides laboratories with a standardized approach for interpreting analytical results on interdicted nuclear materials. Applying this guideline, participating laboratories have been able to more consistently categorize, characterize, and evaluate the exercise samples, and more clearly articulate graded conclusions to the scenario questions.

Another development has been the growing practice of laboratories fielding multiple teams. This has allowed the exercises to serve not only as technical challenges but also as training opportunities, facilitating cross-comparison of findings and techniques and fostering broader discussion among participants.

University team involvement, first introduced in GSv2, has also proven to be an unexpected yet

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Retrospective on five iterations of the Galaxy Serpent exercise... *continued from page 5*

Table 1. Comparison of Galaxy Serpent Exercises

Version	Timeframe	Material Focus	Notable Features	Key Learning Objectives
GSv1	2013–14	Spent fuel (SFCOMPO public data)	First use of NNFL concept in exercise; 2-phase design (build library, test against seizure data); all data public domain	Demonstrated NNFL value; importance of uncertainty assignments; involvement of reactor engineers and fuel experts
GSv2	2015–16	Synthetic sealed radioactive sources	3-phase structure including intercepted source & RDD scenarios; diverse data streams (catalogs, manifests, lab reports) with intentional errors	Handling incomplete/mixed-quality data; progressive refinement from field to lab data; benefits of manufacturer specifications
GSv3	2017–18	Uranium ore concentrate (UOC)	Focused on trace element chemistry; statistical discrimination of ore classes; managed missing data by design	Variety of statistical methods; need for multiple methodologies to validate consistency; identified importance of alternative hypotheses
GSv4	2019–20	Uranium fuel pellets	Increased complexity of investigative questions; emphasis on multiple lines of evidence	GDF approach; integration of physical and chemical signatures; cross-validation of results
GSv5	2022–23	Enriched and depleted uranium compounds	7-phase structure alternating field/lab data; direct interaction with mock investigative team; emphasis on evolving conclusions	Continued use of GDF. Showed that conclusions change with new data; identification of mixtures; value of investigative questioning; subject matter expertise essential

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

- Bailey, T. L. et al., 'Producing 236U reference standards for Accelerator Mass Spectrometry at the University of Notre Dame', *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, vol. 567, no. 65825 (Oct. 2025).
- Joyce, M. J. et al., 'Using 244Pu/239Pu to pinpoint 240Pu/239Pu signatures of locally derived reactor material in the terrestrial environment', *International Journal of Modern Physics E*, vol. 34, no. 9 (Sep. 2025).
- Higginson, M. A. et al., 'Radiochronometric discordance in cast uranium metal: A multi-laboratory intercomparison exercise', *Journal of Radioanalytical and Nuclear Chemistry*, (Aug. 2025).
- Kelly, J. T. et al., 'Real-Time Screening for Uranium Enrichment by Paper Spray Ionization Mass Spectrometry for Field Applications', *Journal of the American Society for Mass Spectrometry*, vol. 36, no. 8 (June 2025).
- Shollenberger, Q. R. et al., 'Understanding neutron capture processes in uranium deposits using combined U-Sm-Nd isotopic compositions', *Applied Geochemistry*, vol. 191, no. 106514 (Oct. 2025).
- Krachler, M. et al., 'Assessing uranium enrichment levels using digital autoradiography', *Analytica Chimica Acta*, no. 1361 (Aug. 2025).
- Varga, Z., and Wallenius, M. 'Measurement of uranium samples for nuclear forensics by laser ablation multi-collector inductively coupled plasma mass spectrometry using a pre-cell mass filter for collision/reaction cell (MC-ICP-MS/MS)', *Spectrochimica Acta Part B: Atomic Spectroscopy*, vol. 233, (Nov. 2025).

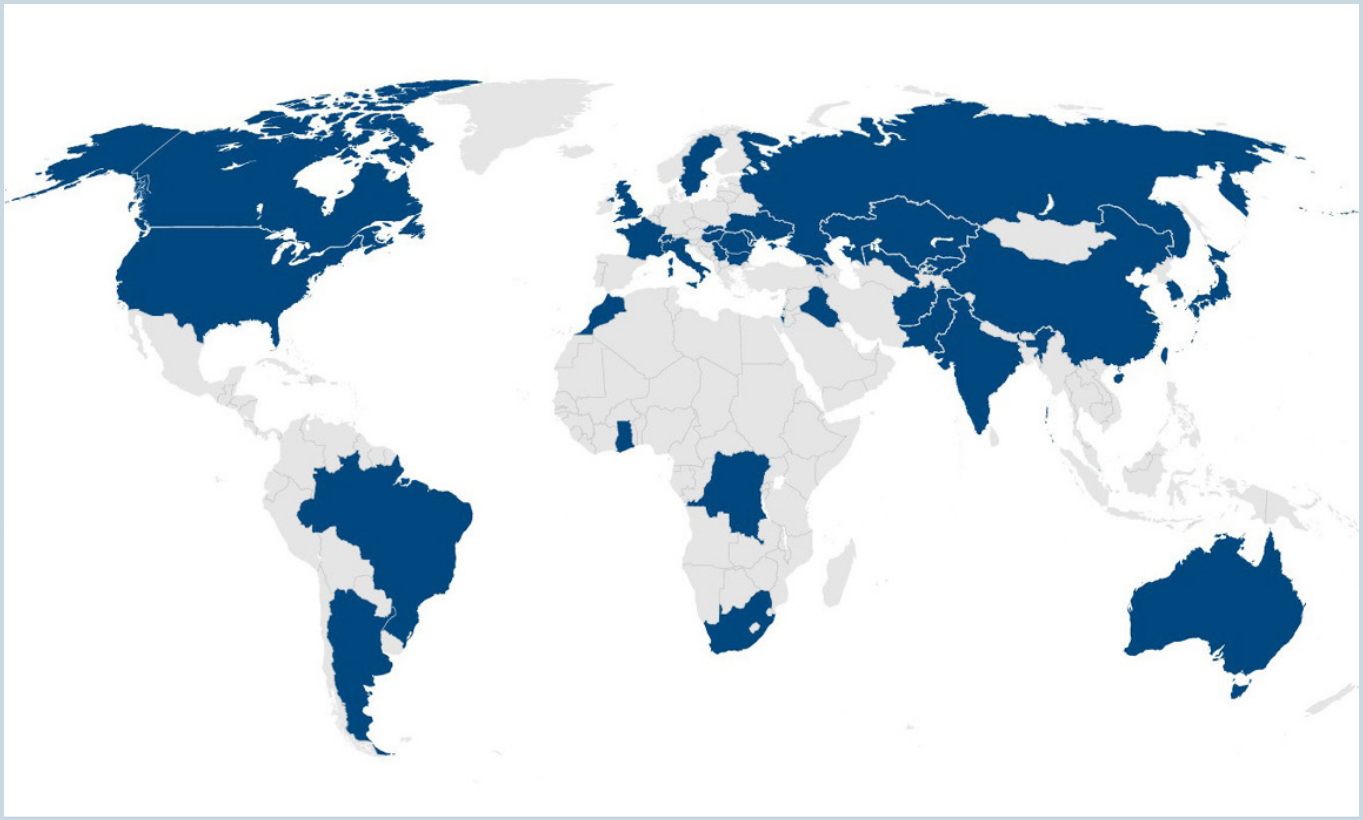

Figure 1. Over 600 distinct participants from over 30 countries and international organizations have taken part in the Galaxy Serpent exercises. Participants have been associated with laboratories, universities and other organizations

highly valued benefit of the exercises. Engagement peaked in GSv4, with eight academic teams from four countries. Participation declined in GSv5, largely due to scheduling misalignment with most academic calendars. This challenge will be addressed for GSv6, now in development.

Benefits to the Nuclear Forensics Community

Across its iterations, GS has matured the technical capability of participants to develop and apply NNFLs, in some cases prompting teams to initiate indigenous efforts to assess their internal NNFL framework and processes. Through their participation in GS, participants have expanded the nuclear forensics community, integrating expertise from analytical chemistry, nuclear engineering, geology, statistics and law enforcement. They have helped socialize NNFLs as a practical and probative investigative tool, capable of suggesting potential origins of MORC materials. By promoting use of the GDF to standardize reporting, GS has enhanced both understanding and expression of forensic confidence in the community.

Evolving Emphasis and Lessons Learned

The exercises have evolved from relatively static dataset analysis toward dynamic, multi-phase investigations. GSv5, in particular, demonstrated that forensic conclusions can shift over time as initial field measurements may be refined by more precise laboratory analysis. The incorporation of the GDF has provided a common interpretive framework, ensuring transparent reasoning and graded confidence statements. At the same time, the exercises have reinforced that NNFLs require subject matter expertise and investigative context for accurate interpretation.

Conclusions

Over five iterations, Galaxy Serpent has engaged more than 600 practitioners from over 30 laboratories, universities, and agencies worldwide. It has strengthened international capacity to identify and assess nuclear and radioactive materials out of regulatory control, standardized the reporting of forensic conclusions using the GDF, and provided a proving ground for investigative collaboration. Future GS exercises will build on past iterations, expanding simulated engagement with investigative authorities, utilizing the GDF, and renewing participation from academic teams, ensuring the series remains a valuable platform for strengthening the nuclear forensics community. •

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) 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/

The 'ITWG Nuclear Forensics Update' is produced by the Stockholm International Peace Research Institute (SIPRI) on behalf of the Nuclear Forensics International Technical Working Group and with the financial support provided by the United States Department of Energy, National Nuclear Security Administration. The content and the views expressed here belong to the authors.