ITWG Nuclear Forensics International Technical Working Group

ITWG NUCLEAR FORENSICS UPDATE

No. 12 September 2019

CHAIRPERSONS' ADDRESS

Welcome to the Nuclear Forensics International Technical Working Group (ITWG) newsletter. As the nuclear forensics community holds a review meeting in September about traditional evidence included in the sixth collaborative material exercise (CMX-6) and kicks-off the fourth iteration of the Galaxy Serpent exercise series, this edition of the newsletter includes several additional items of interest. Our Romanian colleagues have provided an article summarizing a nuclear forensics case study they presented at ITWG-24 (page 2), and JRC-Karlsruhe penned an article summarizing their decades long work in the field (page 3). In addition, this edition of the newsletter includes an article summarizing this year's annual ITWG meeting (page 1). Finally, in looking forward to the IAEA International Conference on Nuclear Security (ICONS 2020) next February, we congratulate the forensics community on submitting more than 40 abstracts for consideration by the programme committee and look forward to the discussions at the meeting next year in Vienna.

With best regards,
Klaus Mayer and Michael Curry

ANNUAL MEETING OF THE NUCLEAR FORENSICS INTERNATIONAL TECHNICAL WORKING GROUP

KLAUS MAYER AND MICHAEL CURRY

The Nuclear Forensics International Technical Working Group (ITWG) held its annual meeting in Bucharest on 25–27 June 2019. Over 90 nuclear forensics experts and law enforcement personnel attended from 28 countries and international organizations. The ITWG's mission is to help to identify, socialize and promote best practices in the field of nuclear forensics. As in previous years, the annual meeting was structured to provide updates from key stakeholders, discuss plans for upcoming exercises and develop guidelines.

Scientific talks and professional development seminars

In the session on Nuclear Forensics Laboratories (INFL), representatives from Romania presented a recent case in which nuclear forensics techniques were applied and the International Atomic Energy Agency (IAEA) presented a briefing on new trends in the Incident and Trafficking Database (ITDB). The professional development seminars on the Graded Decision Framework and Chain-of-Custody Best Practices highlighted the collaboration between scientists and law enforcement.

ITWG-24 plenary session and task groups

In addition to the updates on IAEA nuclear forensics efforts, during the plenary session participants learned about bioforensic applications in the investigative process and the Chemical Forensics International Technical Working Group (CFITWG). The plenary also reviewed the Nuclear Forensics ITWG's recent achievements, discussed the outcomes of CMX-6 and reviewed the recent national nuclear forensics library (NNFL) exercise, Galaxy Serpent, and the preparation of new guidelines on nuclear forensics techniques. Finally, the plenary provided opportunities to share information on the multitude of national activities that various laboratories are pursuing.

The IWTG's five task groups (Evidence and Testimony, Exercise, Guidelines, Libraries and Outreach and Training) made significant progress in their work and fostered insightful discussions. New thinking was highlighted and each task group discussed its strategic five-year plan. The Evidence and Testimony Task Group discussed the development of new products for describing analytical techniques for non-scientist personnel and proposed working

Continued page 6

CONTAMINATED PLAYING CARDS: AN ILLUSTRATION OF THE PROSECUTOR'S ROLE IN INVESTIGATIONS CONCERNING NUCLEAR AND RADIOACTIVE MATERIALS

ELENA DINU*

In July 2018, two individuals, two weeks apart, were stopped at Bucharest Otopeni Airport following the triggering of a radiation alarm as they passed through the airport radiation portals. On checking their luggage, five and four decks of contaminated playing cards, respectively, were found in their possession. The mobile radionuclide identification device had already given a first indication of the presence of the radioactive isotope: iodine-125 (I-125). Both individuals were travelling from Viet Nam. When asked by the Border Police, they stated they had no knowledge of the radioactive materials. One of the people stopped is a Romanian citizen who works for a company that recruits Vietnamese workers to work in Romania. The other is a Vietnamese citizen who had travelled to Romania for work. Both individuals claimed that they had been asked by Vietnamese colleagues to deliver the packages to co-workers who they had not met before. The Prosecutor's Office was not informed of the incidents as the Police decided that there were no legal grounds for launching a criminal investigation and the illicit acts were treated as misdemeanours. However, information about the events was brought to our attention during a meeting at the headquarters of the regulatory body for nuclear activities. All the cards found were branded 'Double K' and had the same appearance (see figures 1 and 2). In a similar 2019 incident, cards branded 'Best' had also been retrieved.

Figures 1 and 2. The Double K branded playing cards

Under Romanian law, it is the prosecutor who leads criminal investigations and the prosecution of serious offences, such as terrorism, organized crime and non-compliance with the legal regime on nuclear and radioactive materials when such acts are committed by criminal groups. Following the principles specific to civil law systems, the Romanian prosecutor has certain judicial powers. Among these are authorizing, for up to 48 hours in case of urgency, special investigative measures such as: (*a*) the interception of communications; (*b*) gaining access to information systems and financial information; (*c*) surveillance; (*d*) authorizing undercover investigations; (*e*) authorizing the detention of suspects for 24 hours and other measures that restrict freedom or liberties; (*f*) retrieving evidence and confiscating goods; (*g*) issuing requests for international legal assistance; (*h*) signing agreements on setting up joint investigation teams and engaging in direct cooperation with foreign judicial authorities; and (*i*) requesting technical or scientific reports. In exercising these judicial powers, the prosecutor decides which officers are assigned to a criminal investigation and the specific activities they are authorized to take. In addition, the prosecutor can decide to initiate an investigation ex officio if there are indications that a crime has been committed.

Based on the information available about the two incidents, and taking into consideration pre-existing knowledge acquired during participation in nuclear forensics meetings of cases where contaminated playing cards have been discovered in Germany, the decision was made to start a criminal investigation. The decision was based on a number of considerations, such as the repeated occurrence of the illicit activity, public safety and the seeming existence of illicit,

Continued page 4

* Elena Dinu is the Head Prosecutor at the Service for Combating Terrorism and National Security Crimes, Directorate for Investigating Organized Crime and Terrorism, Prosecutor's Office of Romania.

JRC KARLSRUHE: ALMOST 30 YEARS OF NUCLEAR FORENSICS

KLAUS MAYER, MARIA WALLENIUS, ZSOLT VARGA, MICHAEL KRACHLER AND NADYA RAUFF-NISTHAR

In 1991, seizures of smuggled radioactive material were reported in Switzerland and Italy. In the next three years numerous similar incidents involving nuclear materials occurred in Germany, Czechia, Hungary and other Central European states. The German authorities called on the Institute for Transuranium Elements, which later became the Joint Research Centre Karlsruhe (JRC Karlsruhe), to analyse the intercepted illicitly trafficked nuclear materials to provide details of their origins and intended use. To this end, JRC Karlsruhe was able to make use of its long-standing experience in nuclear materials analysis for IAEA safeguards and for research purposes, as well as a broad range of measurement techniques and instruments and its unique infrastructure for handling such materials.

The first nuclear forensics analysis was performed at JRC Karlsruhe in 1992. In the following three years, 21 investigations were performed of materials seized in Germany. The majority of these cases concerned uranium fuels that were intended for use in early generation graphite-moderated or pressurized-water nuclear power reactors. The most serious incidents involved kilograms of highly enriched uranium, several hundred grams of plutonium mixed oxide and weapon-grade plutonium. Improved physical protection in the late 1990s and the deployment of radiation detection systems at borders led to a decrease in smuggling. Nuclear forensics analysis, however, continued to investigate samples arising from other types of incident, such as contaminated scrap metal or the illegal disposal of radioactive material (see figure 1).

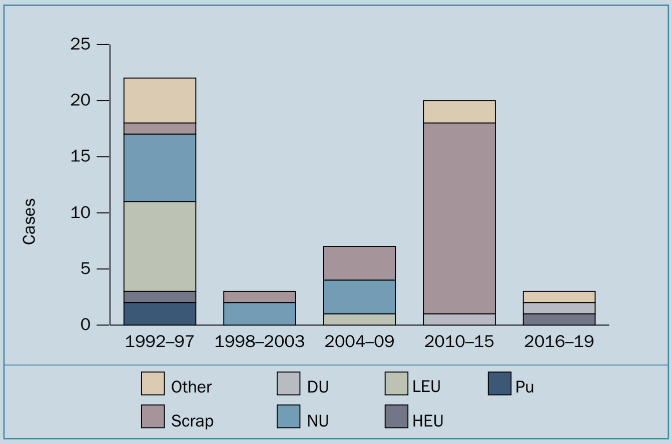

Figure 1. Chronological evolution of nuclear forensics investigations at JRC Karlsruhe per material type

The Munich case

The most prominent and still today the most significant case occurred in 1994. A Colombian physician arriving on a Lufthansa flight from Moscow was stopped at Munich airport and found to be carrying a suitcase containing 560g of mixed plutonium and uranium oxide powder (containing more than 340 g of plutonium) and 210 g of enriched lithium metal. The analyses at JRC Karlsruhe revealed that the isotopic composition of the plutonium was close to weapon-grade quality and that the piece of lithium metal was highly enriched in the isotope required for the deuteron-triton nuclear fusion processes in a thermonuclear weapon. However, the isotopic composition of the uranium was not of weapon-grade quality. A particularity of the isotopic composition of plutonium—an unusual abundance of isotopes ^{238}Pu and ^{242}Pu—was determined using secondary ion mass spectrometry (SIMS). This suggested a graphite-moderated nuclear reactor as the possible origin of the plutonium. Measurement of the ^{241}Pu/^{241}Am isotope ratio using gamma-spectroscopy suggested that the plutonium had been produced at the end of 1979.

The Nuclear Smuggling ITWG, known today as the Nuclear Forensics ITWG, was formed in 1995 to foster international cooperation, advance the scientific discipline of nuclear forensics and promote inter-agency cooperation. JRC Karlsruhe immediately became an active member of the ITWG and has co-chaired the group from the beginning.

Nuclear forensic science at JRC Karlsruhe

A specific nuclear forensic science programme began at JRC Karlsruhe in 1997. For uranium materials the initial interest focused on measurements of the $^{18}O/^{16}O$ isotopic ratio in uranium oxides, to gather information on the geographic location of production sites, and on surface roughness characterization of fuel pellets in connection with grinding processes. For plutonium materials, the isotopic signature reveals information about the production process. In addition, nuclear material age determination (age dating) using multiple parent/daughter isotope ratios could be demonstrated

Continued page 6

Contaminated Playing Cards… *continued from page 2*

organized and apparently lucrative activity that is profitable enough to outweigh the risk of being caught. The objectives of the investigation were to discover the intended recipients of the illicit materials, the provenance of the contaminated cards, their purpose and the potential financial gains, while at the same time identifying any other similar materials already in the possession of the perpetrators and ending the criminal activity.

Together with the contaminated cards, a small blue device was identified in the second incident. Because its purpose was not obvious to the police at the time, it had not been confiscated. We began by gathering information about the device online. This led to its association with Xóc Đĩa, a Vietnamese gambling game where a bowl is used to 'shake' and mix four discs that have been cut out from playing cards. The cut-outs come in two colours—red and black—and bets are made on the various combinations of colours and the number of tokens that will land face-up.

Xóc Đĩa is a traditional game but it seems to have had an entire industry built around it. There are numerous websites for playing Xóc Đĩa online, as well as phone apps. A simple search online reveals a large number of Vietnamese websites that offer various methods and technologies for cheating at cards, including at Xóc Đĩa. These range widely from micro-cameras inserted in the bottom of the shaking bowls, to the use of radioactive materials. The latter are sold either in small receptacles as 'ionic water', which must be applied to the cards by the purchaser, or as ready-made packs of cards, together with the blue device which proved to be a Geiger-Müller counter apparently custom made for the detection of I-125 isotopes. (It should be noted that the device and possibly also the ionic water with which it is sold do not seem to have been produced in Viet Nam, as they come in packaging that does not use the Vietnamese alphabet.) It appears that the contaminated playing cards are being industrially produced by individuals or companies that probably have access to a medical source of I-125, as this isotope is mainly used in brachytherapy.

The nuclear forensics examination requested by the prosecutor revealed that small handwritten labels glued on to the card decks indicated a card inside the deck wrapped in aluminium foil, which had the

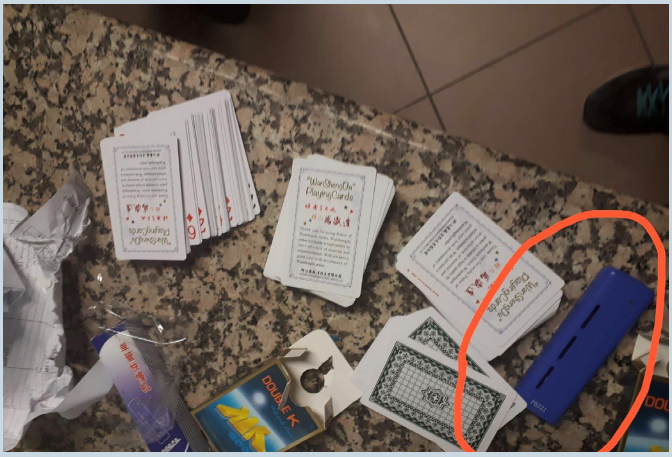

Figure 3. The blue device (ringed) together with the contaminated cards

Figure 4. A photograph taken from a Vietnamese website demonstrating the use of contaminated playing cards together with the detection device

highest level of activity. All the samples examined (decks of cards) contained I-125 isotopes. The activity per sample ranged from 9.15 MBq to 19.2 MBq. Lead was detected in the first batch and silver was identified in the second batch. These metals were deposited to shield the I-125 on one side, allowing the players to use the Geiger-Müller counter to detect on which side the cut outs had flipped when shaken. For the purposes of producing the nuclear forensics reports and clarifying various scientific issues relevant to the criminal investigation, constant communication between the prosecutor and the forensics experts proved essential. Based on the knowledge gained from the scientific examination, the investigation set out to prove that the individuals who brought the playing cards treated with I-125 had intentionally acquired these illicit materials in order to obtain money unlawfully by using detection devices systematically and in a coordinated manner with other individuals.

The most difficult aspects of the investigation were finding proof of the existence of an organized criminal group (its structure, roles, duration and scope), and determining the intent of the couriers and whether they should be held criminally responsible. In addition to these legal challenges, there were also investigative hurdles to overcome—logistical, technical but also cultural—as the investigation concerned members of a closed community. During the investigation, it was proved that two individuals jointly owned various card cheating devices. They had paid money to a co-national for the contaminated playing cards and the detection device to be delivered to them from Viet Nam. The two were fully aware of the nature of the materials used in the playing cards and following confiscation of the two packages, they had made plans to bring another set of radioactive playing cards into Romania. A further three people knew about the device and were being coordinated and instructed by the two leaders on use of the detection device to assist them with organized gambling. The two leaders were lending money to interested players at interest rates of 50 per cent and keeping debtors' bank cards and mobile phones as guarantees. While investigating the financial situation of the perpetrators, we established that illicit gains ranging from a few thousand to tens of thousands of euros had been made, depending on the position and role of the respective group members. The two couriers were exonerated as it was established that they had no knowledge of the illegal nature of the playing cards. It should be noted therefore that an investigation into only the obvious suspects would have been fruitless.

Given the powers and competences pertaining to its judicial function, the prosecutor can play a leading role in criminal investigations concerning nuclear or radioactive materials. In order to play this role, it is paramount that the prosecutor becomes informed about the means and opportunities offered by nuclear forensics for obtaining evidence and providing investigative leads. At the same time, he or she must remain aware of new developments in the field through exchanges of information with colleagues. •

UPCOMING TRAININGS AND MEETINGS

- ITWG Review Meeting on Traditional Evidence included in CMX-6, Budapest, 2–3 September
- JRC/DOE: Nuclear Forensics Summer School for Georgia, Ukraine, Azerbaijan and Moldova (GUAM), Kiev, 9–13 September
- IAEA Training, Practical Introduction to Nuclear Forensics, Budapest, 9–13 September
- IAEA General Conference, Vienna, 16–20 September
- EC/JRC/IAEA: Nuclear Forensics Training Course for Balkan Countries, Novi Sad, Serbia, September 24–26
- IAEA Regional Introduction to Nuclear Forensics, Ghana, 1–4 October
- IAEA International Training Course on Nuclear Forensics Methodologies, Karlsruhe, Germany, 14–25 October
- STCU Table-top Exercise on Response to and Investigation of Illicit Trafficking Incidents, Tbilisi, 19–21 October
- IAEA International Conference on Nuclear Security: Sustaining and Strengthening Efforts (ICONS2020), Vienna, 10–14 February 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.

Annual Meeting of the Nuclear Forensics ITWG... *continued from page 1*

with the Exercise Task Group on the creation of an optional crime scene element for future collaborative material exercises. The Exercise Task Group reviewed high-level outcomes of CMX-6, and finalized an after-action report and the drafting of two articles for publication in scientific journals. The Guidelines Task Group discussed the positive feedback on the Graded Decision Framework used in CMX-6 and discussed new guidelines that are still under development. The Libraries Task Group discussed the outcomes of the third iteration of the Galaxy Serpent (GSv3) virtual exercise series and discussed the upcoming fourth instalment, which is due to begin in September 2019. The Outreach and Training Task Group reviewed use of the ITWG website, and reviewed and populated a nuclear forensics training matrix.

Gracious hosts

Our thanks to the Romanian authorities at the IFIN-HH Laboratory, and especially Nicolae Marginean, Andrei Apostol, Larisa Ganea and Doina Stancui, who hosted ITWG-24 and organized everything perfectly. •

JRC Karlsruhe: Almost 30 Years of Nuclear Forensics... *continued from page 3*

using mass spectrometry for bulk samples and for particles.

Today, research and development (R&D) work on nuclear forensics at JRC Karlsruhe focuses on the front-end of the fuel cycle. In recent years several novel methods have been developed and validated using a large set of uranium samples. Research topics have included: (*a*) the measurement of high-precision ^{236}U isotope ratios in natural U materials; (*b*) age dating of impure U materials (yellow cake); (*c*) compound determination and classification of uranium ore concentrates (UOC) using Fourier-transform infrared spectroscopy and Raman spectroscopy; (*d*) morphological studies; and (*e*) measurement of stable isotope ratios in impurities such as lead, strontium, neodymium and sulphur.

Improving the accuracy of age dating methods plays a significant role in these R&D activities. Several methods have been developed for this purpose, such as U production date determination by $^{230}Th/^{234}U$ or $^{231}Pa/^{235}U$ chronometers. A dedicated U age dating reference material has been developed and produced at JRC Karlsruhe. This was certified in collaboration with JRC Geel and is now commercially available as IRMM-1000.

More recently, the focus has been on solid sampling and micro-analytical techniques such as Laser Ablation ICP-MS (LA-ICP-MS) in order to investigate UOC powders and uranium oxide (UO_2) nuclear fuel pellets. The application of a focused laser beam during LA-ICP-MS analysis enables JRC Karlsruhe to obtain spatially resolved sample information at the micrometre scale. This approach not only helps to identify the inhomogeneity of a particular

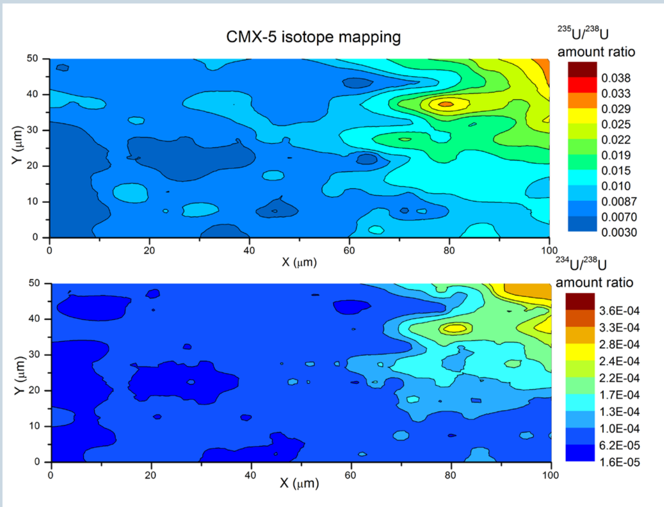

Figure 2. Uranium isotope mapping of an inhomogeneous UO_2 material

parameter—for example U isotopic composition, within an investigated specimen—but also allows the correlation of a measured parameter with a specific location on the sample surface. Moving the laser beam over a larger sample area, the U isotopic composition of a UO_2 pellet, for example, can be visualized in a two-dimensional map, and the isotopic homogeneity can be imaged (see figure 2).

Evidence contaminated with radionuclides

The examination of traditional forensic evidence contaminated with radionuclides has been the subject of development work for almost two decades. In ITWG exercise “Round Robin 2”, JRC Karlsruhe developed fingerprints on a brass vial containing PuO_2 powder. The methodology was refined and validated in cooperation with the German police (see figure 3).

JRC Karlsruhe staff members are involved in national exercises and follow-on training at traditional forensic science laboratories to support know-how transfer.

Training, capacity building and international cooperation

Training has become a priority area for JRC Karlsruhe. A wide portfolio of training areas can be covered at the European Nuclear Security Training Centre (EUSECTRA), ranging from detection to response—including nuclear forensics. Nuclear forensics training can be conceptual (national response plans), introductory, audience-specific (e.g. mobile expert support teams), technique-specific (e.g. ICP-MS) or in-depth (e.g. internships, visiting scientists, IAEA residential assignments and postdoc training).

Nuclear forensics research at JRC Karlsruhe greatly benefits from the variety of activities and the broad range of analytical equipment and expertise available within the institute. Beyond that, a number of international collaborations with partner organizations in the United States, France, Japan and Israel or under the IAEA's Coordinated Research Projects enable the conduct of bilateral and multilateral research activities.

Capacity building projects have been a key element of the JRC Karlsruhe nuclear forensics programme. These projects are typically funded by the European Commission within the framework of its nuclear security policies. Cooperative work with states in Eastern and South Eastern Europe has focused on establishing and improving nuclear forensics capabilities in partner countries. Similarly, nuclear forensics projects in South East Asia have been implemented, where possible, in coordination and in partnership with the NNSA.

Overall, JRC Karlsruhe has been involved in nuclear forensics through case work, research activities and training for almost three decades. Nuclear security and nuclear forensics in particular remain high on the agenda of the centre's work programme. •

Figure 3. Cyanoacrylate fuming inside a glovebox of a piece of evidence collected from a radiological crime scene during an exercise with the German police

CONTENTS

NUCLEAR FORENSICS

Nuclear forensics is an essential component of national and international nuclear security response plans to events involving radioactive materials diverted outside of regulatory control. The ability to collect and preserve radiological and associated evidence as material is interdicted and to conduct nuclear forensics analysis provides insights to the history and origin of nuclear material, the point of diversion, and the identity of the perpetrators.

THE NUCLEAR FORENSICS INTERNATIONAL TECHNICAL WORKING GROUP

Since its inception in 1995, the Nuclear Forensics International Technical Working Group (ITWG) has been focused on nuclear forensic best practice through the development of techniques and methods for forensic analysis of nuclear, other radioactive, and radiologically contaminated materials. The objective of the ITWG is to advance the scientific discipline of nuclear forensics and to provide a common approach and effective technical solutions to competent national or international authorities that request assistance.

ITWG PRIORITIES AND ACTIVITIES

As a technical working group, the priorities for the ITWG include identifying requirements for nuclear forensic applications, evaluating present nuclear forensic capabilities, and recommending cooperative measures that ensure all states can respond to acts involving illicit trafficking and unauthorized possession of nuclear or other radioactive materials. An objective of the working group is to encourage technical peer-review of the nuclear forensic discipline. These goals are met through annual meetings, exercises, and informal and formal publications.

Outreach is a primary goal of the ITWG. The working group disseminates recent progress in nuclear forensic analysis and interpretation with the broader community of technical and security professionals who can benefit from these advancements. Affiliated international partner organizations include the International Atomic Energy Agency (IAEA), the European Commission, the European Police Office (EUROPOL), the International Criminal Police Organization (INTERPOL), the Global Initiative to Combat Nuclear Terrorism (GICNT) and the United Nations Interregional Crime and Justice Research Institute (UNICRI).

ITWG MEMBERSHIP

Nuclear forensics is both a technical capability as well as an investigatory process. For this reason the ITWG is a working group of experts including scientists, law enforcement officers, first responders, and nuclear regulators assigned by competent national authorities, affiliated contractors, and international organizations. The ITWG is open to all states interested in nuclear forensics.

ITWG participating states and organizations recognize that radiological crimes deserve thorough investigation and, when warranted, criminal prosecution. The ITWG encourages all states to possess the basic capability to categorize nuclear or other radioactive materials to assess their threat. As an international group, the ITWG shares its expertise through its membership to advance the science of nuclear forensics as well as its application to nuclear security objectives.

http://www.nf-itwg.org/

sipri

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. The content and the views expressed here belong to the authors.