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How to respond a crime scene contaminated with radioactive material?[1]

Abstract

Radioactive materials have become an explicit target for criminal and terrorist organizations in recent years, as they can be effective tools for panic and serious economic damage generation when used in a variety of weapons (e.g. explosive devices capable of dispersing radioactive material). In addition, radioactive material has been used in several cases to commit crimes such as poisoning or radiation exposure to potential target persons. The most famous is the so-called 'Litvinenko case', in which a Russian intelligence officer was poisoned with polonium in 2006. In addition to the international cases, however, radioactive material is also found in Hungary time-to-time during home searches. Even the detection of these materials can be challenging in the absence of appropriate detection equipment. Their exact identification, collection and specific examination requires specialized expertise. If the crime scene personnel does not detect the presence of radioactivity at the scene in a timely manner (e.g, because it cannot be detected without measuring equipment), the persons working there may subsequently suffer serious damage to health, as well as large areas and objects can be contaminated by dispersed radioactive material. It can also cause serious economic damage. This article describes an operating procedure for the professional respond of crime scenes contaminated with radioactive material, developed by experts of the Hungarian National Police, National Bureau of Investigation, Criminal Forensics Department and radiologists at the Centre for Energy Research in the frame of a project supported by the Home Affairs Security Fund.

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Keywords: radioactive, radiological crime scene, radiation hazard, radiological evidence, radiologically contaminated traditional evidence

Introduction

Radioactive materials have become an explicit target for criminal and terrorist organizations in recent years, as they can be used in various type of weapons (such as radiological dispersal devices) resulting effective panic and serious economic damage. In addition, they can be also used in other criminal cases, such as poisoning and radiation exposure of potential target persons or groups. One of the most famous criminal events is the so-called 'Litvinenko case' (Owen, 2016, 1-328.), in which a Russian intelligence officer was poisoned with polonium in 2006. Illicit trafficking and smuggling of nuclear and other radioactive materials is a real existing problem worldwide. The International Atomic Energy Agency (IAEA) collects in a database (Incident and Trafficking Database, ITDB) unusual events and incidents related to radiological materials (such as theft, loss, misuse of radioactive material, etc.) from around the world (URL1). Nearly 3.600 cases have occurred in the last 30 years following ITDB data only from officially reported events (Fig. 1.).

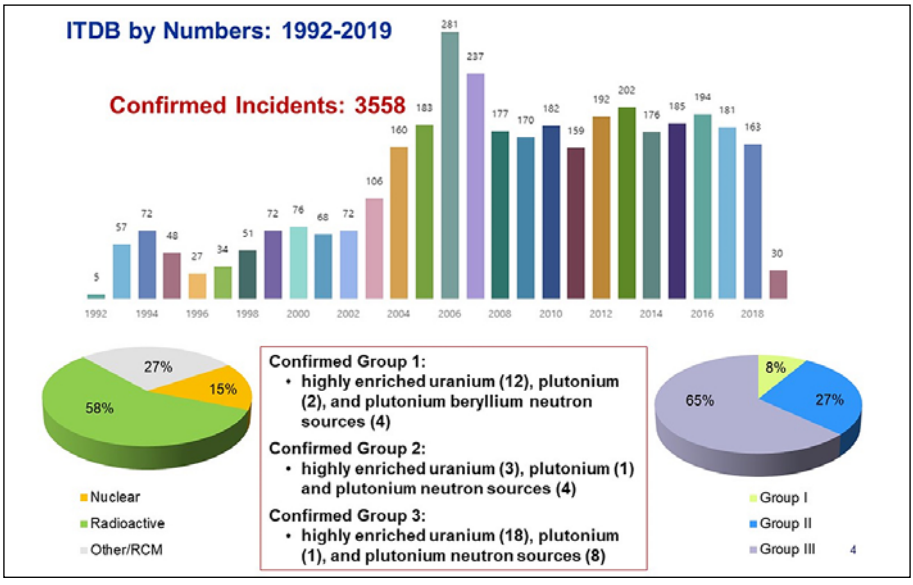

Fig. 1: Incident number connected to radioactive materials at the ITDB database of the IAEA (URL1)

The severity of the problem is also shown by the fact that major international organizations such as the IAEA, the Nuclear Forensics International Technical Working Group (ITWG) or the Global Initiative to Combat Nuclear Terrorism (GICNT) place great emphasis on this area in major international forums such as Nuclear Security Summits (URL2). They seek to raise awareness of the threat and consequences of nuclear terrorism because increasing terrorism results in growing chance to have different nuclear security events like a radiological terror attack or other possibilities for different type of radiological crime scenes. Discovery of these materials at a scene can be challenging. Radioactivity is hardly detectable in the absence of appropriate measuring instruments. Although certain signs may indicate the presence of radioactive material, such as radiation symbol (i.e. trefoil), lead containers, manipulators, radiation measuring equipment, dosimeters, glove bags, etc. if they can be found. Besides, the precise identification, collection, professional transport, handling and examination of these materials, especially nuclear materials, requires special expertise and procedures. Particular attention needs to be paid to the fact, that radioactive material may not be presented at a scene in a well-separated, closed or packaged form, like in a plastic bag or container, but may also be as a contamination on various surfaces such as floor, tables or clothing. It also means that the radioactive material can contaminate the crime scene personnel and the conventional evidence like fingerprints, DNA or material residues. Therefore, investigation of such a crime scene requires very special preparedness, rules, and procedures. An important issue is the personal safety (radiation protection) of crime scene personnel and the special security and safety rules for collection, transport and subsequent investigation of radiological materials and radioactively contaminated conventional forensic evidences. In most countries, two methods are generally used to process radiological crime scenes (i.e. Radiological Crime Scene Management, RCSM). More common is that the localization and collection of radioactive materials are carried out by police officers (crime scene investigators), because a civilian - even a radiation expert – must not enter the scene. The onsite work is assisted by a radiation protection expert, but he/she can give advice to the team only from outside of the hazard control area. The currently available general guideline written together by the IAEA and Interpol (IAEA, 2014, 1-93.) is also based on this approach and proposes appropriate action accordingly. The other possibility is that the radioactive material is considered to be merely a potential source of hazard, therefore a radiation expert or team of experts will first remove it from the scene and then begins to investigate the crime scene traditionally. The first case is questionable, because crime scene personnel is not always trained to measure and collect

radioactive materials properly. They often have no experience and practice in doing it. Besides, in some cases the situation can be so complicated that only an experienced scientific expert can evaluate the information correctly onsite. Lack of expertise can become a source of danger and failures.

The second case is absolutely justified from the safety and health point of view but can cause problems in the prosecution process. Following this second method, the scene is basically changed before it is recorded, and the radiation expert can erase evidences that could otherwise have been preserved. Furthermore, radioactive materials can also be evidences or potentially even the main evidence in a criminal case, therefore it is necessary to ensure chain-of-custody and handling them as evidence for forensics examination. Possibilities depend on the type of situation. In some cases, if e.g. the level of radiation significantly exceeds the background level, then the primary aim is the protection of human life. However, if the situation allows and does not pose an increased health risk, the protection of the crime scene personnel and the professional collection of radioactive materials can be carried out simultaneously. Nowadays, nuclear and other radioactive materials are being detected at more and more places in Hungary during home searches and in other different criminal cases. Therefore, Hungary has placed more emphasis on developing procedures for radiological crime scene management. In the last 2 years, in a project supported by the Home Affairs Security Fund conventional and nuclear forensic experts have developed a procedure to handle a crime scene which contains or is contaminated with nuclear or other radioactive material. The main goal was to develop a harmonized procedure with the cooperation of crime scene investigators of the Hungarian Police and radiation experts of the Centre for Energy Research. The work was focusing on some key points like how to work together at a radiological crime scene, how to establish the safety of the crime scene personnel and in between how to preserve the scene and the evidence during collecting radiological materials and ensure nuclear forensics (IAEA, 2015, 1-62.) already at the scene. The aim of the project was to develop a procedure where each actor performs his or her own task in which he or she has practice and experience, in such a way that serves best the purposes of safety and the criminal investigation. The procedure based on the fact that the Hungarian laws allow special experts to be involved in onsite work if necessary. In addition, our activity is based on Government Decree 490/2015 (XII.30.) On '*notifications and measures related to lost, found and seized nuclear and other radioactive materials, as well as measures following other notifications related to nuclear and other radioactive materials*', which also requires an on-site inspection with the participation of the Centre for Energy Research for found and seized nuclear material (URL3).

The integration of the procedure developed into the national strategy will be due in connection with the forthcoming National Nuclear Security Response Plan when it enters into force. The Response Plan is under construction by leading of the Hungarian Atomic Energy Authority in cooperation with all the relevant stakeholders connected to response nuclear security events in Hungary. Until the final version of the Response Plan, the procedure is based on the regulation allowing the involvement of experts in special cases during crime scene investigation (100/2018. (VI. 8.) Government Decree, URL4).

Special characteristics of radiological crime scenes

The presence of radioactivity at a crime scene changes completely most conventional crime scene investigation procedures, because it justifies/requires the introduction of special rules (e.g. use of special personal protective equipment (PPE) and the involvement of a radiological assessor or radiation protection expert. This can basically affect commonly used crime scene investigation procedures. Three basic parameters need to be considered, which are related to radiation protection rules and clearly change the course of the site: '*time, distance and shielding*' (IAEA, 2014, 1-93.). It means, crime scene personnel should minimize the time spent onsite and near to radioactive objects. During the investigation, the crime scene personnel should stay away from contaminated objects as far as possible. These actions may require the use of tools, like manipulators, spacers, or even robots. At higher radiation levels, onsite workers must protect themselves from radiation using so-called shielding, like lead vest or lead walls. Furthermore, there are more differences at a radiological scene:

- Any work in radiation field and contaminated areas needs the use of special personal protective equipment (PPE) like chemical resistant, closed coverall, double or triple layer of gloves, respirator, electronic personal dosimeter, etc. Moving and manipulating in PPE is uncomfortable, making movement, vision, hearing, and communication very difficult.
- Hazard control area should be established and marked out considering doses and weather conditions, like wind direction (IAEA, 2014, 1-93.).
- Scene control should follow even stricter rules, like log the personal doses absorbed by crime scene personnel during the onsite work.

In general, during the initial site survey radiological hotspots should be identified and marked. Removing the radioactive objects from the site has absolute

priority in order to reduce the risk (IAEA, 2014, 1-93.). Removing hotspots changes the original scene, therefore, the importance of pre-recording of the scene (photographing, filming) is even more emphasized. In addition, the radiation level measured onsite determines the time crime scene personnel can spend inside and can modify the structured search strategies. It is important to be aware that radioactive material may be present at any scene, e.g. in an old device, removed from a disassembled improperly destroyed device. As already mentioned, radioactive radiation cannot be detected by normal sensory organs, only by using special devices, radiation detectors. Therefore, it is important to know what kind of signs can be expected at a radiological scene that can reveal the presence of radiation if a measuring device is not available. Really dangerous radiation sources with high radioactivity are in most cases of very small size (1-2 cm), but the protection built around them (radiation shielding) is mostly extensive. This is why radiation shielding devices (enclosures, special protection) are easier to detect. These are mostly special containers made of very heavy metals (e.g. lead). Discovery of such objects at a scene warns of the presence of possible radioactivity.

Some possible signs can show the presence of radiation at a crime scene (Fig. 2):

- radiation symbol (trefoil)
- manipulators, spacers, tweezers
- many rubber gloves, glove bags, coveralls, lab coats, masks
- scattered white crystalline material, including chemical devices, metal cans, rubber gloves
- presence of radiation measuring devices
- typical instruments and equipment containing radioactive materials: e.g. irradiation equipment, smoke detectors, containers
- typical documents: quality certificates, delivery note, official certificate, codes describing nuclear material, transport document, markings on the packaging of the boxes
- Unexplained, spotted burns to persons, animals connected to the scene.

Fig. 2: Some objects at a crime scene which can indicate the presence of radioactivity (1. glove box; 2. tweezers; 3. gloves, masks; 4. radiation detectors; 5. manipulators; 6. radiation symbol and special shipping containers)

Method developed

The Hungarian RCSM procedure is based mainly on the international guideline (IAEA, 2014, 1-93.) but it differs slightly due to adapting it to national specialities. There are some unique characteristics in the Hungarian procedure which are based on what the Hungarian legal system allows. In our procedure, in a unique way, police officers and radiation experts work together at the crime scene. Helping each other, all actors can perform his or her own tasks in which he or she has practice and experience. For this purpose, crime scene investigator team members are in our case:

Onsite team (inside the hazard control area, Fig. 3.):

- Searcher (primary evidence collector): a person who detects radiation, localizes and collects radioactive materials (radiation expert, i.e. an expert who is able to recognize, detect and professionally handle radiological materials)

- Documenter (assistant evidence collector): a person responsible for onsite documentation and assisting in the collection of materials and packaging (police officer)
- Photographer (police officer)
- Onsite team leader: a scientific expert (radiation expert) whose primary task is to coordinate the onsite work of the team from the point of view of radiation (warns of emergencies, monitors instrumental detection and collection, warns of places that have not been inspected, maintains continuous communication with radiation protection experts and crime scene manager, helps to determine the order of collection of material and preserve evidence)

Offsite team (in the secured area):

- Scene entry person (radiation protection expert): a person in a 'clean station' at the entrance of the hazard control area, assists the team's work by providing clean equipment, changing gloves, measuring the contamination on the PPE of personnel leaving the area, receiving the collected evidence, continuously communicating with the evidence custodians and decontamination unit
- Evidence Custodians: take evidences, place them into official evidence collection bag with labelling, measure and record doses, ensure chain-of-custody (police officer), as well as perform gamma spectrometric analysis to categorize the material onsite for nuclear forensics purposes (gamma spectrometry expert)
- Crime Scene Manager: continuously communicates on-line (through head cameras and radio communication) with the onsite crime scene team.
- Backup team: to change crime scene personnel after working time have elapsed, calculated by the radiation protection expert.

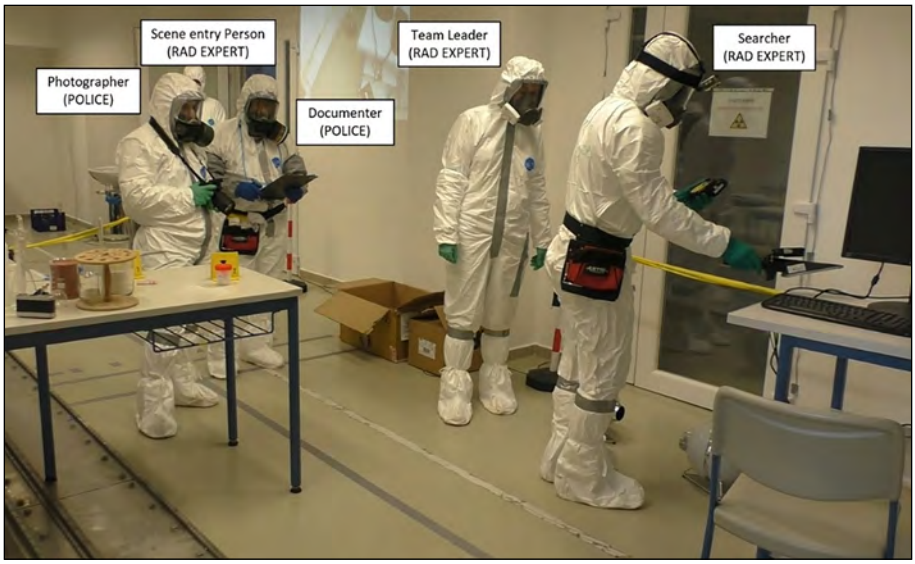

Fig. 3: Onsite team at the crime scene (hazard control area)

Elements of the radiological crime scene management can be seen in Fig. 4.

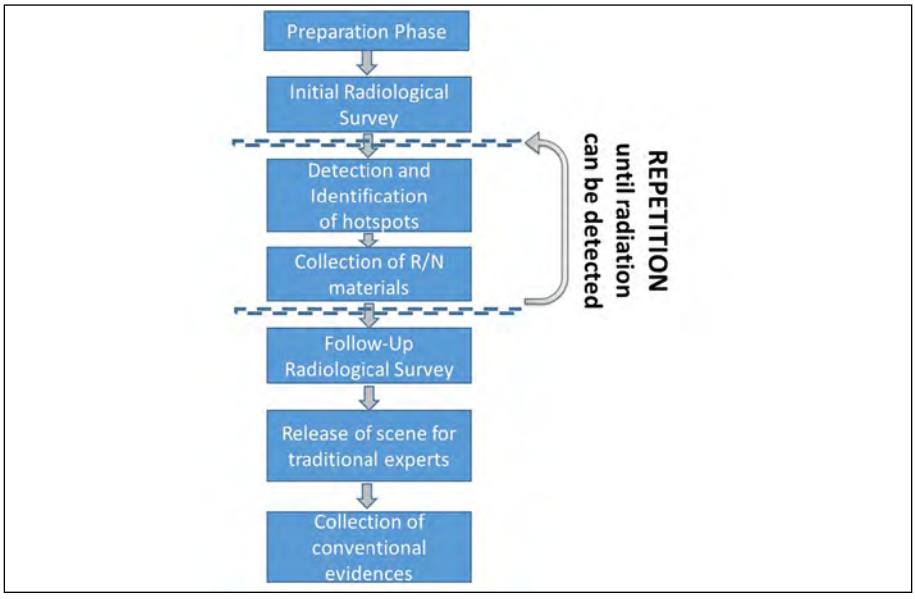

Fig. 4: Elements of the Radiological Crime Scene Management

Preparation phase includes the establishment of perimeters, first radiation survey, instrument calibration and determination of background radiation level. Besides, the establishment of clean areas, exit and entry corridors, covering corridors with plastic foil (outside the crime scene area) to avoid possible contamination of equipment and personnel by radionuclides after leaving the scene. Determination of level of hazard, type of PPE and time which can be spent at the scene inside. Besides, establishment of decontamination and evidence custodian station. A very important part is the zone control: dose logging absorbed by the personnel working inside the hazard control area. Further key elements are the briefing and detailed planning. All team members need to be aware of their own tasks very clearly. Without detailed planning and knowing clear tasks unexpected situations can cause failures and accidents during the radiological crime scene investigation. During the initial radiation survey, level of radiation is measured at the scene using telescopic dose meter (remote measurement). In addition, a camera can be attached to the telescopic system to pre-map/record the scene for detailed planning of the procedure. After evaluating the situation, determination of PPE and worktime and detailed planning of investigation the next step is the first entry to the scene. The radiation expert (searcher) enters first and checks surface contamination and possible hazards. Searcher is closely followed by a police officer who is responsible for recording the scene as first essential step. It can be carried out by taking photos and video recording, as well as using 3D laser imaging system. In the latter case, a special attention must be paid to possible contamination of the instrument. Use of drones is generally not recommended because the airflow can disperse radioactive contamination at the scene causing air contamination.

Highly suggested to follow a track in one direction by the team on a contamination-free area if possible. In the case of large-scale surface contamination use of anti-contamination stepping plates can be required at the scene (Fig. 5).

During the detection of hotspots (radiation search), radioactive materials are localized and identified by special instruments. Radioactive materials as evidences should be indicated by special evidence marking plates (with radiation symbol, see in Fig. 6). Material should be handled like conventional evidences (taking photos with marking plate and number, metric scale, instrument screen with dose and identified isotope, etc.).

Next step is the collection of radiological materials. The location of all radioactive material found, their dose and the identified isotope should be marked on the sketch of scene map. The team leader (radiation expert) in continuous

Fig. 5: Pathway during surface contamination mapping and dose measurement

Fig. 6: Detection and marking of radioactive material

communication with the crime scene manager will decide on the order of collection, taking into account the situation (level of measured doses, location of materials, contamination and prevention of conventional evidences). Materials are collected with the assistance of two people: the primary evidence collector and the assistant evidence collector. Using long tweezers or manipulators, the material is placed by the radiation expert in a bag with a pre-opened and unwrapped mouth, which is kept by the assistant evidence collector (Fig. 7). Thereafter, the assistant person seals the bag, being careful not to touch its inner surface. Then he/she places the bag in a second, clean plastic bag together with the filled evidence label which contains information on dose, isotope, location of material and the trefoil symbol. Second bag is also sealed and handed out to the scene entry person who checks the surface contamination on the bag using swipe material analysing it by surface contamination monitoring device. If the bag is clean, it will be placed in the official evidence collection bag sealed, labelled to ensure chain-of-custody (Fig. 8) and transferred to dose measurements, as well as gamma-spectrometric analysis. Finally, it will be located in the interim secured storage container. If the bag surface is contaminated with radionuclides, it should be placed in a third, clean bag, seal, and check surface contamination again. Contamination on the second bag surface should be indicated in the label.

It is very important to change the top layer of gloves between collection of each radioactive material to avoid radionuclide cross-contamination of samples collected (contamination means here: '*radionuclides on surfaces or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable*' (IAEA, 2014, 1-93.).

It is also necessary to take a sample of the surface contamination at the scene as evidence for further examination. It can be done by swiping, swabbing, or using a spatula or pipettes depending on the form and phase of the material. In the case of solid samples, it is highly suggested to use wet swab instead of dry wipe material to avoid contamination of crime scene personnel and air contamination. During collection of contaminating material from surfaces, conventional evidences (like fingerprints) must be taken into account due to the fact that they can be easily destroyed during this operation. Before swiping for sampling or decontamination of contaminated surfaces, it can be suggested to use forensics lights to check the surface for latent prints or DNA. Collection and in-field or laboratory-based examination of these radiologically contaminated evidences in simpler cases can be carried out i.e. they can be preserved and used for the investigation. Contaminated surfaces at the scene should be marked as they

Fig. 7: Packaging of radiological evidence

Fig. 8: Ensuring chain-of-custody (right)

Fig. 9: Special procedures for undressing of PPE (1. radionuclide contamination control on the surface, 2. opening of the safety coverall, 3. removing of the coverall by another person who touches only the inner surface of it, 4. careful removing of gloves, 5. step out to the clean area, 6. careful removing of the respirator using plastic bag)

could be a potential source of hazard. Following the collection and elimination of all radioactive material, crime scene manager will decide whether these surfaces can be decontaminated or treated another way during the conventional crime scene investigation (e.g. taping with plastic foil and covering with lead plates). Another special rule is that any closed boxes, containers, or packages with radiation symbol or just showing radiation found at the scene must not be opened there. They should be transported to the nuclear forensics laboratory and opened there under safe conditions for further examination. Preliminary X-Ray analysis is also often required before opening. The final step is the follow-up radiation survey, leaving and release the scene for conventional crime scene investigation. After collection of all radioactive hotspots, radiation expert should check the scene once again for any presence of radiation. All locations of hotspots should be checked again with the isotope identifier and surface contamination monitor. If only background radiation level can be measured and no contaminated area available, the scene can be released for conventional crime scene investigation. Since radioactive materials are also handled as evidence, the numbering of conventional evidences is continuous.

During leaving the scene, crime scene personnel, PPE and all equipment used inside should be checked for any surface contamination. Removing of PPE should follow special rules to avoid any contamination of crime scene personnel causing any radiation hazard, like incorporation (Fig. 9).

The final important point that should be mentioned is the nuclear forensics which always starts at the scene with the first in-field identification and categorization of radioactive materials. It is a key activity of further operations like safe interim storage at the scene and special transport of radioactive materials, as well as informing the nuclear forensic laboratory. To know the type and amount of radioactive material is essential for the laboratory for proper preparation of receiving and examination of radiological evidences. It can have essential importance in such urgent cases like a dirty bomb explosion or prevention of a second event.

Conclusions

In this article, the Hungarian operating procedure for radiological crime scene management was presented which is based on international trends, guidelines (IAEA, 2014, 1-93.) and adapted to the Hungarian legal system and experiences. The procedure has been developed in collaboration with the staff of the Criminal Forensics Department of the Hungarian Police and the Nuclear Forensics Laboratory of the Centre for Energy Research in Hungary. The main goal was to establish a harmonized common procedure in which each actor (conventional and nuclear forensic experts) performs his or her own task in which he or she has practice and experience, all in such a way that best serves safety and the purposes of the criminal investigation. There are some unique characteristics in the Hungarian RCSM procedure like in our case police officers and radiation/nuclear forensic experts work together at the crime scene. Besides, our onsite team leader is a scientist, a radiation expert who helps the teamwork personally inside according to the radiological aspects in continuous communication with the crime scene manager. We put great emphasis on detailed contamination control (surfaces, PPE, personnel, evidences, etc.) and therefore, e.g. on special rules for packaging and undressing procedure because we find radioactive contamination as the highest source of hazard. Even only some radioactive particles can cause problem if they can get into the human body. By our experiences, to avoid particle contamination needs to follow very special and accurate contamination control. For this reason, we decided that the clean area for preliminary storing of collected evidences and clean tools should be estab-

Fig. 10: Presentation of the Hungarian Radiological Crime Scene Management Procedure in Vienna, at the headquarters of the International Atomic Energy Agency (ICONS, February 2020)

lished outside the border of the hazard control area and never inside (except the scene is very large). In our procedure a radiation protection expert helps the teamwork from the clean area by giving in/taking out devices and assisting in glove changing, as well as contamination control. The operating procedure was tested and practiced during field exercises of different type of scenarios. The aim was to establish a harmonized and practiced procedure that can be used successfully and safely in a variety of complex real-life situations. The procedure was presented in February 2020 at the request of the International Atomic Energy Agency, at its headquarters in Vienna, as a side event in the frame of the International Conference on Nuclear Security (ICONS, 2020), see in Fig. 10. Further developments on this procedure involving international observers and more partner authorities in Hungary is in progress. In addition, implementation of various research programs, e.g. in-field and laboratory-based analysis of radioactively contaminated conventional forensic evidences (such as fingerprints, DNA and material residues) has been started in cooperation with the Hungarian Police and the Centre for Energy Research.

Acknowledgement

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Online links in this article

URL1: *International Atomic Energy Agency*. https://www.iaea.org/resources/databases/itdb

URL2: *Nuclear Security Summit*. http://www.nss2016.org/2016-joint-statements

URL3: *Government Decree 490/2015 (XII.30.) On 'notifications and measures related to lost, found and seized nuclear and other radioactive materials, as well as measures following other notifications related to nuclear and other radioactive materials*', 4.§ (3); 6§ (3); 9.§ (1) and (3). https://net.jogtar.hu/jogszabaly?docid=a1500490.kor

URL4: *Government Decree 100/2018. (VI. 8.) On 'on the detailed rules for the investigation and the preparatory procedure'.* 63.§ (2). https://net.jogtar.hu/jogszabaly?docid=A1800100.KOR