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Augmenting Nuclear Forensics Capacity Building in a Virtual Engagement Environment

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ABSTRACT

In support of measures to prevent, detect, and respond to nuclear security events, nuclear forensic science, or nuclear forensics, provides the technical information necessary to assess on the origin and history of nuclear and other radioactive materials out of regulatory control in the context of international legal instruments and national laws related to nuclear security. In order to help partner countries meet their nuclear security objectives, the Los Alamos National Laboratory (LANL) and the Lawrence Livermore National Laboratory (LLNL), through partnership with the U.S. Department of Energy's National Nuclear Security Administration (DOE/NNSA) Office of Nuclear Smuggling Detection and Deterrence (NSDD), have assisted over 20 countries to develop, sustain, and advance indigenous nuclear forensic capacities through in-person scenario-based policy discussions and workshops, hands-on laboratory-based trainings, and material sample exchanges and laboratory peer interaction. The ongoing global COVID-19 pandemic has adversely impacted the ability of NSDD to execute hands-on capacity building activities and carry out in-person interaction. As nuclear forensic examinations support law enforcement investigations and nuclear security vulnerability assessments, unique strategies for virtually developing, exercising, and sustaining nuclear forensic capacities are essential to ensure that partner countries are able to respond to nuclear security events. In order to meet the challenge, the LANL and LLNL developed and implemented virtual interaction engagement methods for continued engagement with international partners, with an emphasis on practical applications of nuclear forensics in support of investigations. To ensure a sufficient nuclear forensics workforce, LANL and LLNL continue to build capacity in a time where traditional, in-person delivery mechanisms are not available, and continue to develop the next generation of nuclear forensic practitioners by creating virtual pathways for dedicated and cross-disciplinary capacity building opportunities.

1. INTRODUCTION

Real and attempted seizures of illicit nuclear materials continue to cause widespread concern over the possibility, however remote, of a non-State actor acquiring and using nuclear or radioactive material with malicious intent. Despite global efforts to protect and remove nuclear and radioactive material, material quantities and the amount of material sites - some of which are poorly secured and are potentially vulnerable - continue to grow. No single country can hope to address this critical 21st century problem without global engagement.

For over ten years, the U.S. Department of Energy's National Nuclear Security Administration (DOE/NNSA) Office of Nuclear Smuggling Detection and Deterrence (NSDD) has supported partner countries in identifying, developing, and sustaining capacities and capabilities that can be used in a nuclear forensics examination, should the need arise. NSDD maintains the U.S. Government's only international nuclear forensic analytical capacity-building program.

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In support of measures to prevent, detect, and respond to nuclear security events, nuclear forensic science, or nuclear forensics, provides the technical information necessary to assess on the origin and history of nuclear and other radioactive materials out of regulatory control (MORC) in the context of international legal instruments and national laws related to nuclear security. Further, by strengthening global nuclear forensics capacity and adopting best practices, NSDD helps the international community develop a potential deterrent to prospective proliferators.

In order to help partner countries meet their nuclear security objectives, the Los Alamos National Laboratory (LANL) and the Lawrence Livermore National Laboratory (LLNL), through NSDD leadership, have assisted over twenty countries to develop, sustain, and advance indigenous nuclear forensic capacities through in-person scenario-based policy discussions, table-top exercises, hands-on laboratory-based trainings, material sample exchanges, and laboratory peer interaction.

The ongoing COVID-19 pandemic has adversely affected the ability of NSDD nuclear forensic subject matter experts to implement hands-on capacity building activities and carry out in-person laboratory interactions. As nuclear forensic examinations support law enforcement investigations and nuclear security vulnerability assessments, unique strategies for virtually developing, testing, and sustaining nuclear forensic capacities are essential to enable sustained assurances that partner countries are able to respond to nuclear security events in line with national and international responsibilities. In order to meet this challenge, LANL and LLNL developed and implemented virtual interaction engagement methods for continued engagement with international partners, with an emphasis on the practical applications of nuclear forensics in support of investigations.

2. SCENARIO-BASED POLICY DISCUSSION (SBPD)

NSDD focuses primarily on leveraging existing analytical capabilities in partner in support of a nuclear security investigation of MORC.

To better understand what existing capacities and capabilities a partner country can employ to meet its counter nuclear smuggling responsibilities, LANL and LLNL subject matter experts have for many years traveled to partner countries in order hold discussions on a variety of nuclear forensics aspects, and visit laboratory sites in order to familiarize themselves with capacities and capabilities of the partner country. Since the start of the COVID-19 pandemic in early 2020, with associated restrictions on travel and face-to-face meetings, these types of in-person interactions have been impossible.

In an effort to continue to respond to partner country needs in nuclear forensics, LANL and LLNL developed a virtual pilot approach for NSDD to achieve its goals and objectives of understanding a countries nuclear forensics capacities and capabilities in a virtual environment. This virtual pilot approach followed a staged methodology during which NSDD first gathers specific information with regard to various capacities and capabilities a partner country could bring to bear to respond to MORC, implement administrative and technical assessment activities , develop gap analyses, and finally map out a multi-year capacity building plan to remediate identified gaps. The strength of this approach is that it provides NSDD with an empirical basis for understanding administrative and technical gaps, a remediation plan, and subsequently being able to carry various levels of evaluation. Further, this pilot approach

reinforced NSDD metrics related to policies and procedures, training, maintenance, and assessment.

2.1 Assessment of Current a Partner Country's Nuclear Forensics Capacity and Capability Capabilities

The first step of this pilot approach is an initial information exchange related to nuclear forensics capabilities. This activity is designed to provide NSDD stakeholders with an initial understanding of the partner country administrative and technical nuclear forensic capacity and capability to respond to incidents of MORC. The conduct of this activity takes the form of a series of information requests to the partner country in order to make preliminary determinations on the status of nuclear security response and nuclear forensics capabilities and capacities. Information requests take the form of a review of existing documentation, as well as the population of the Investigation Support Questionnaire. The Questionnaire would include questions with regard to:

a. Nuclear and other radioactive material holdings
b. Overview of Nuclear and other radioactive material out of regulatory control incidents
c. Legal mandates and instruments, and basis for operations
d. Current national response procedures
e. Stakeholders involved, and roles and responsibilities description
f. Interagency coordination mechanisms
g. Radiological crime scene management capabilities
h. Nuclear and other radioactive material analysis capabilities for categorization and characterization
i. Nuclear and other radioactive material analysis interpretation
j. Traditional evidence material analysis capabilities
k. Prosecutorial procedures

2.2 Multi-Agency Nuclear and Other Radioactive Material Out Of Regulatory Control Interdiction Scenario-based Policy Discussion

The second stage of this approach is a multi-agency scenario-based policy discussion (SBPD) based on a fictitious MORC interdiction scenario (inspired by real case studies). Taking into account the country-specific threat scenario and based upon the information received as part of the initial information exchange, LANL and LLNL have developed and facilitated a multi-stakeholder SBPD. This SBPD would exercise, via a fictional MORC interdiction SBPD activity, a partner country's existing policies, procedures, and plans, roles and responsibilities of competent authorities and support organizations, and operational coordination and information sharing protocols in response to MORC. The aim of the SBPD is to review the information provided in the questionnaire, compare it to the results and outcomes of the SBPD, and develop an administrative gap analysis. Topics discussed during the SBPD include, but are not limited to:

a. The nuclear forensics model action plan (i.e. legal mandates, response plans, roles and responsibilities, material analysis procedures, etc.)
b. Conduct of operations at the radiological crime scene
c. Transport of evidence to a designated nuclear forensic analytical laboratory
d. Evidence examination and nuclear forensics analytical plans

e. R/N material analysis and traditional forensics analysis procedures
f. Development of nuclear and tradition evidence findings
g. Communication of findings to law enforcement and development of subsequent nuclear forensics conclusions

2.3 Nuclear and other Radioactive Material Out of Regulatory Control Technical Assessment

The third stage of this approach includes a country-specific analytical measurement technical assessment. Taking into account a country's national legal mandates, law enforcement needs, and prosecutorial requirements, and based upon the information received as part of the initial information exchange, LANL and LLNL developed a technical assessment activity to baseline partner country analytical capabilities. Under the scope of this activity, NSDD and the partner country exchange procedures, jointly analyze nuclear fuel cycle material(s) accessible to LANL, LLNL, and the partner country laboratory, and compare specified analytical data associated with tasks. By jointly analyzing an actual fuel cycle material - often in the form of a certified reference material - and reviewing and exchanging the results, NSDD is able to make determinations on specific measurement gaps and develop targeted capacity building activities that would seek to remediate those gaps. Technical assessment areas include, but are not limited to:

a. Initial physical measurements
b. Gamma spectrometry
c. X-ray fluorescence
d. X-ray diffraction
e. Scanning or transmission electron microscopy
f. Alpha spectroscopy
g. Mass spectrometry

2.4 Development of Empirically Informed Multi-Year Nuclear Forensics Capacity Building Engagement Plan

The fourth and final stage of this approach is the development of an empirically informed, multi-year nuclear forensics capacity building engagement plan. Using the outputs of the information gathered from the scenario-based policy discussion exercise and technical assessment, and the subsequently developed gap analyses covering procedural and analytical capacities, NSDD, in partnership with the national labs, develops a capacity building engagement plan for various stakeholders involved in the nuclear security investigation support process, which would include, but is not limited to:

a. Applications of Existing Capabilities to a Nuclear Forensics Investigation (virtual or in-person)
b. Analytical Plan Development workshop (virtual or in-person)
c. Joint sample analysis and data comparison (virtual or in-person)
d. Gamma spectral Flavor of the Month Exercise (virtual)
e. Nuclear Forensics Technical [Gamma Spectroscopy] Measurement Training (in-person)
f. Nuclear Forensics Alpha Spectrometry Training (in-person)
g. Nuclear Forensics Mass Spectrometry Training (in-person)
h. National nuclear forensic library (NNFL) activities

    i. NNFL workshop (in-person)
    ii. Information exchange and expert advice on development and population of an NNFL (virtual or in-person)
i. Peer-to-peer activities focused on the development of new and improved nuclear forensics analytical methods, and deepening understanding of nuclear forensics signatures
j. Participation in Nuclear Forensics International Technical Working Group (ITWG) activities:
    i. Annual Meeting
    ii. Collaborative Material Exercise (CMX)
    iii. Galaxy Serpent Exercise
    iv. Virtual Seminars

3. VIRTUAL ANALYTICAL PLAN DEVELOPMENT WORKSHOP

As described in the previous section, the Analytical Plan Development (APD) workshop is a tool that is used early in the nuclear forensics country engagement process. It allows for more detailed discussions between LLNL, LANL, and partner country lab experts and management on the available analytical capabilities and other resources in support of nuclear forensics examinations, and it offers an opportunity for LLNL and LANL subject matter experts to get more acquainted with and exchange ideas with the scientific staff, lab technical experts and lab management in the (new) partner country.

The goal of the workshop is to provide guidance to participants in the development and execution of an analytical plan for performing a nuclear forensics examination of MORC. The intended audience of the workshop consists of the technical laboratory staff that would participate in the physical, chemical, and isotopic examination of the MORC, alongside supervisors and other related personnel (e.g. law enforcement, regulators, etc.). Following the guidance of the key document International Atomic Energy Agency Nuclear Security Series 2-G Rev.1: Nuclear Forensics in Support of Investigations, participants are guided through a three-stage scenario-based discussion, where they are asked to put themselves in the roles of the laboratory staff performing a nuclear forensics examination of a sample recovered from a fictitious nuclear material interdiction. Participants are given the opportunity to work with and interpret real nuclear forensics data, derived from the Nuclear Forensics International Technical Working Group (ITWG) collaborative material exercise (CMX) 4. Data are presented to participants in a way that simulates the actual flow of data generation in nuclear forensics, with the goal of providing data to assist the fictitious investigative authority in answering key questions about the MORC under examination. To this end, the development of a nuclear forensics capacity greatly enhances the ability of the partner country to respond and investigate incidents of MORC, and deter future incidents.

3.1 In-Person to Virtual Development and Execution

The APD workshop was initially developed in 2015 by LLNL and LANL for NSDD to support nuclear forensics capacity-building efforts in Kazakhstan. Since then, the workshop has been offered in four other NSDD partner countries, but had not been conducted virtually until the spring of 2021. The pilot virtual APD Workshop was conducted in April 2021 in collaboration with the Netherlands. The workshop took place via Zoom over the course of three-hour sessions over three consecutive days. Laboratory scientists and team leaders from the National Institute for Public

Health and the Environment (RIVM) participated in the workshop, alongside supervisors and observers from the Netherlands Forensics Institute (NFI), and the Belgian Federal Agency of Accounting and Control (FANC). The workshop was led by nuclear forensics experts from LLNL and LANL.

The pilot virtual offering for the Netherlands made use of several innovative approaches to instruction, most notably the development of a dedicated web portal that served as the "landing spot" for the virtual workshop. Participants used the web portal to obtain read-ahead materials (narrated PowerPoint presentations and other materials) that gave participants detailed explanations on how specific types of analytical instrumentation (e.g. gamma spectrometry, mass spectrometry) can be used to support a nuclear forensics examination. In an effort to "gamify" the workshop and make it more engaging in a virtual setting, workshop facilitators made heavy use of Mentimeter polling, which created a fun, competitive environment for discussion of key nuclear forensics concepts. Participants were also able to ask facilitators questions during and after presentations, as well as through the chat function on Zoom and on the web portal.

The feedback from the Dutch participants was overwhelmingly positive. Participants felt that the workshop was the correct length for a virtual offering, and especially appreciated the interactive elements of the workshop. They enjoyed participating in the Mentimeter polling, and they felt it gave them even more incentive to study the read-ahead materials to gain an edge in the competition. Participants also enjoyed working with real nuclear forensics data in a simulated MORC examination, and they stated that it gave them a much greater understanding of their specific technical roles should an examination be conducted in the Netherlands. Following the successful execution of this workshop, NSDD is planning future nuclear forensic capacity-building and peer-to-peer activities in partnership with the Netherlands.

Since then, the LLNL and LANL nuclear forensics team has also supported a virtual APD workshop with the Republic of South Korea, with all the materials translated to Korean, including the Mentimeter polling exercises. The discussions were facilitated through simultaneous interpretation. A total of thirty-three scientists, terrorism responders, and military personnel from the Korean Institute of Nuclear Nonproliferation and Control (KINAC), the Korea National Police Agency (KNPA), and the Republic of Korea Army (ROKA) participated in the workshop.

4. LOOKING FORWARD

Despite difficulties presented by ongoing COVID-19 pandemic, LANL and LLNL were able to adapt quickly and creatively to the emerging situation over the past seventeen months, and successfully ensured continued delivery of NSDD nuclear forensics capacity building activities. LANL and LLNL were also able to identify and leverage on 'positive' impacts of the COVID-19 pandemic, by identifying and bringing on new internal staff to participate and facilitate capacity-building activities at little to no cost increase, and creating opportunities and removing hurdles for increasing participation for partner countries.

Despite successes, looking forward, LANL and LLNL judge that while virtual events to continue to play a role when in-person interaction fully resumes, they will not wholly replace in-country events due to lack of in-person interactions. Virtual interaction and events allow for a certain degree of capacity building but there are shortcomings that cannot be overcome. In a technical

subject matter like nuclear forensics, face-to-face, hands-on interaction are critical to ensuring robust communication of best practices and lessons learned, as well as building long-term partnerships and a network of nuclear forensic practitioners. As material analysis is a physical process, physical interaction will continue to be a mainstay of nuclear forensic capacity building.

5. CONCLUSION

Nuclear forensics is a key element of a robust national nuclear security architecture. In order to address the challenge of MORC, it is incumbent on the international community to continue to develop the next generation of nuclear forensic practitioners by creating pathways for dedicated and cross-disciplinary capacity building opportunities. LANL and LLNL, through partnership with NSDD, are developing and sustaining the international nuclear forensics workforce by continuing to deliver high-quality capacity building in a time where traditional in-person capacity building curriculum delivery is not available.

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