Leveraging CNL’s Capabilities for Nuclear Forensics
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Leveraging CNL’s Capabilities for Nuclear Forensics

Outline

Background
- Canadian National NF Capability Project

Operational Exercise
- Objectives
- Initial phase of response
- Evidence examination
- Conclusions

Next steps

On-going capability development
- CSSP Projects
- AECL FNST Program
- CNL Facilities

Summary
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Background - CNNFCP

Under the Canadian Safety and Security Program, Defence R&D Canada's Centre for Security Science initiated the Canadian National Nuclear Forensics Capability Project (CNNFCP) in 2012.

Scope includes establishment of (a) a National Laboratory Network capable of comprehensive NF analysis and classical forensic analysis of radiologically-contaminated evidence, and (b) a National Nuclear Forensics Library cataloguing characteristics and signatures of RN materials under regulatory control.

Whole-of-government approach involving several federal S&T agencies (DRDC CSS & DRDC Ottawa, AECL/CNL, CNSC, NRC, RMC, HC), with the active participation and guidance of military, public security, and law enforcement (RCMP, CAF, PSCan, GAC).
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CNNFCP Outcomes

*Canada has made significant progress in working towards a coordinated and comprehensive national nuclear forensics capability.*

- Leveraging existing capabilities within government, the Lab Network demonstrated the following:
  - Identified/prioritized deficiencies in the existing capability,
  - Developed guidelines and procedures,
  - Delivered training courses, and
  - Evaluated the NF lab network capability through a materials exercise.

- Prototype NNFL for UOC materials was created
  - Novel techniques for both chemistry-driver data analytics and higher-order mathematical approaches
  - Significant advancements in the comparative assessment of UOCs while identifying the critical signatures.
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Operational Exercise Overview

• Through the Canadian Safety and Security Program, an exercise was held in February 2016
  o Verify the inter-operability of NF Lab Network with RCMP in response to an illegal radioactive source.
  o Test activating the network and conducting traditional forensic exam in a nuclear facility.

• Event:
  o Package flagged at the Parliamentary Mail Room (Ottawa); RCMP response.
  o Dense container, probably lead, inside cardboard
  o High radiation field when lead pig was opened

• Initial inspection:
  o Package sent to RCMP mobile lab for initial inspection.
  o Gamma spec confirmed the material was a 60Co source.
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Exercise – Lab Network Activation

- Given the high radiation field, decided to bring the lead pig to the CNL hot cells in Chalk River (200 km NW of Ottawa).
- NF Lab Network activated (CNL, CNSC, RMC, HC, NRC)
  - Analytical plan developed
  - Evidence into the hot cells at CNL
  - Attention to maintain chain of custody at all times
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Evidence Examination in Hot Cell

- Visual/dimensional inspection
- Traditional forensic analyses
  - Fingerprint & DNA swab
  - Serial number recovery
- Nuclear forensic analyses
  - Source age determination
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Exercise Conclusions

The exercise demonstrated successful achievement of the main objectives:

- SOPs were effective to provide common guidance for NFLN.
- Inter-operability of lab network with RCMP was verified.
- Traditional and nuclear forensic capabilities in the hot cell facilities were demonstrated.

Best practices generated from the exercise include:

- Engaging the appropriate experts in the entire conduct of the exercise, from design to actual play.
- Use of realistic scenarios, equipment, and locations.
- Excellent teamwork and cooperation between traditional forensics and nuclear specialists.
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Next Steps

• Formalization of an operational national NF capability
  o Led by CNSC and DRDC CSS
• Ongoing NF capability development through the Canadian Safety & Security Program
  o Nuclear Forensics Capability Advancement Project (2016-19)
    ✓ Led by the CNSC; Partners – NRC, NRCan, AECL/CNL, DND
    ✓ Enhance Canada’s national nuclear forensics capability, particularly in terms of facilities for evidence contaminated with RN, radiochronometry (U), certified reference materials, and post-detonation forensics
  o Nuclear Material Signature and Provenance Assessment Capability Project (2017-20)
    ✓ Led by the CNSC; Partners – NRC, AECL/CNL, Univ. Ottawa
    ✓ UOC signatures and data analytics approaches and algorithm development.
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AECL Federal Nuclear S&T Program Contributions to NF Development

- Capability Enhancements for the National Nuclear Forensics Program (2016-19)
  - Potential signatures in nuclear materials, including irradiated fuel
  - National and international exercises, e.g., CMX, inter-comparison studies, virtual TTX
  - Analytical techniques for NF
- New Techniques in Nuclear Forensics (2017-20)
  - Bio-markers for attribution
  - Capability to analyze DNA samples containing radioactive materials
  - Signatures of radioactive sources based on age or impurities
  - Certified reference materials
  - Isotope Ratio Method for attribution of various threat materials
- Advanced Methodologies for Nuclear Forensics (2018-21)
  - Signatures of UOC based on physical properties (e.g., powder morphology) and relative abundances of Pb and Sr isotopes
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CNL Facilities for NF

- Hot Cells
  - Visual and microscopic examination
  - Sample preparation for chemical analysis and metallography
  - Corrosion film thickness & integrity measurements
  - Calorimetry
  - Traditional forensics (demonstrated)
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CNL Facilities for NF

- Recycle Fuel Fabrication Laboratories and Fuel Development Laboratories
  - Glovebox facility capable of handling alpha-active fuel (e.g., MOX)
  - Pilot-scale fuel fabrication line
  - Sample preparation for chemical analysis and metallography
  - Traditional forensics (potential)
  - Characterization techniques
    - Fuel pellet dimensions and density
    - Powder particle size and morphology
    - Optical microscopy
    - SEM (Scanning Electron Microscopy)
    - X-ray diffraction
    - Oxygen-to-metal ratios
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CNL Facilities for NF

- **Analytical Chemistry Laboratories**
  - Chemical and Isotopic Analysis for bioassay, environmental, and fuel samples
  - Mass Spectrometry for H/D, U, Pu, FG, trace HM (Quadrupole, Thermal Ionization MS, Inductively Coupled Plasma-MS)
  - Multi-element analysis for U, Pu, major & trace elements (High-Performance Liquid Chromatography, Ion Chromatography, ICP-Atomic Emission Spectroscopy)
  - Analysis of radioactive liquids (nuclear magnetic resonance, infra-red spectroscopy)

- **Radiochemical Analysis**
  - Actinides and fission products for bioassay, fuel, and environmental samples
  - Gross alpha/beta counter
  - High resolution alpha spectrometry
  - Gamma spectrometry
  - Liquid scintillation counting
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CNL Facilities for NF

- **Surface Science Analysis**
  - Nuclear and non-nuclear material characterization
  - Scanning Electron Microscopy (SEM) with Energy Dispersive Spectrometer (EDS), Wavelength Dispersive Spectrometer (WDS) and Electron Back Scattered Diffraction (EBSD).
  - Scanning Auger Microscopy (SAM)
  - Secondary Ion Mass Spectrometry (SIMS)
  - X-ray Photoelectron Spectroscopy (XPS)
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CNL Facilities for NF

- Fuel Cycle Analysis
  - Primarily for fuel irradiation testing and fuel cycle management studies
  - Prediction of fuel composition during/after irradiation using reactor physics codes
  - Development of signature models for interpretation of isotopic data
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Summary

- Canada is working towards a coordinated and comprehensive national NF capability by leveraging existing RN capabilities
  - Established the Lab Network and demonstrated inter-operability with the RCMP in an exercise.
  - Created a prototype NNFL for UOC.
- Initiative led by CNSC and DRDC, in partnership with other agencies, to establish an operational national NF capability on behalf of the Canadian Government.
- CNL, on behalf of AECL, is contributing towards development and enhancement of national NF capabilities.
Thank you. Merci.
Questions?

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