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Celestial Skónis: the 6th Collaborative Materials Exercise of the Nuclear Forensics International Technical Working Group

The Nuclear Forensics International Technical Working Group (ITWG) recently completed its sixth Collaborative Materials Exercise (CMX-6) –Operation Celestial Skónis. This latest CMX also represented the largest exercise on record in the 25-year history of the ITWG and included participation by 22 laboratories and 15 law enforcement (LE) agencies from 21 countries and one multinational organization. Celestial Skónis was a paired-comparison exercise, in which more than one sample is distributed to participating laboratories for comparison purposes. As is customary with past CMXs, laboratories participating in Celestial Skónis were asked to analyze nuclear and radiological materials as part of a mock nuclear forensic investigation. However, participants of Celestial Skónis were also asked to examine contaminated and radioactive items for conventional forensic evidence (e.g., fingerprints, toolmarks, etc) –an activity that had only been incorporated once before during CMX-2 (2001). A primary outcome of CMXs, participants identify and share best practices in nuclear forensic science during the Data Review Meeting following the exercise (see Figure 1).

Nuclear materials distributed to participants included depleted uranium (DU) metal and minute amounts of DU- and plutonium (Pu)-oxy-fluoride powders. Nonradioactive items comingled/contaminated with these materials were also distributed to support examinations for conventional forensics evidence. A scenario was developed in which authorities discovered radioactive materials (DU metal) out of regulatory control at a metal recycling facility. This discovery led to additional seizures of nuclear materials and contaminated evidence at a nearby metal foundry and storage locker. Forensic examinations of contaminated evidence and analysis of the nuclear materials were requested by LE to connect people, places, things, and events.

Laboratories used a total of 36 nuclear forensic protocols, procedures, and analytic techniques to examine contaminated evidence and analyze materials. Results from these examinations were used to characterize evidence and compare sample characteristics with each other and with a mock library of declared material holdings. Participants submitted preliminary reports after 24 hours, and again after one week, with a final report due to the exercise organizers after two months.

Gamma spectroscopy was an indispensable tool during Celestial Skónis, representing the only "State-of-Practice"technique (defined as a technology used by more than half of the exercise participants) capable of categorizing nuclear forensic evidence nondestructively within 24 hours. Gamma spectroscopy was also valuable at the one week reporting timeline, providing more accurate and precise measurements of several Pu and U isotopes than mass spectrometry over the same time period. However, by the two month period, mass spectrometry regained its standing as the most accurate means for measuring most U and Pu isotope ratios within a bulk sample. This level of precision, while not needed to conclude Exercise Sample (ES)-1 and ES-2 were linked, was eventually needed to confirm with high confidence the consistency of ES-1 and ES-2 to library of holdings.

There were several other noteworthy observations related to nuclear forensic analysis during Celestial Skónis. For instance, particle analysis by secondary ion mass spectrometry (SIMS) was again demonstrated by a small minority of laboratories to be one of the most powerful nuclear forensic tools available today. The ability of this technique to separate comingled sources of radioactive surface contamination during Celestial Skónis and allow laboratories to exploit Pu and U isotopic distributions of individual particles is unmatched by any other analytical technique today. The use of alpha spectroscopy by participants experienced a bit of a resurgence during Celestial Skónis as well, driving by the need to measure 238Pu and 241Am after decline in the use of this technique over the past three (U-only) materials exercises.

A special thank you is extended to the laboratories and LE agencies that participated in Celestial Skónis.

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