Defence-related Research Action - DEFRA

ACRONYM: RADIATE

Title: Remote Analysis & Detection for the Identification of rAdioactive maTErials in the Field

Duration of the project: 01/12/2025 – 01/03/2030	**Budget:** € 1 402 000 €
Key words: CBRN, Raman, LIBS, radioactive, minerals, standoff detection	**of which RHID contribution:** 986 000 €

PROJECT DESCRIPTION

Context

Remote detection of radioactive materials remains a major challenge in defence and security operations. Current field-deployable systems—gamma detectors, mobile dosimeters or UAV-mounted sensors—can measure radiation levels and identify radioisotopes, but they offer no information on the chemical form of a material. This distinction is vital in operational contexts: uranium ore, industrial residues, weathered fuel debris or a “dirty bomb” precursor can emit similar gamma signatures while representing very different risks. Recent advances in laser-based spectroscopy now make it possible to remotely obtain molecular (Raman) and elemental (LIBS) fingerprints of unknown materials at distances of several meters and even longer depending on the conditions. Belgium is uniquely positioned to exploit this technological shift thanks to its large radioactive-mineral collections (Royal Belgian Institute of Natural sciences and Royal Central Africa Museum), strong radioprotection and CBRN expertise, and industrial know-how in ruggedised instrumentation. The RADIATE project builds on these assets to deliver a new standoff identification capability directly relevant to Defence.

General Objectives

The project aims to develop and validate a dual-mode Raman/LIBS instrument capable of remotely analysing radioactive materials between 0.5 and 30-50 m. Its scientific objectives include:

- establishing radiological-safety protocols enabling safe handling of diverse radioactive samples;
- designing and building a field-deployable Raman/LIBS prototype with automated alignment and focusing;

- building a spectral library from hundreds of natural and anthropogenic radioactive materials;
- training a machine learning (ML)/artificial intelligence (AI) -based classifier able to recognise pure, altered, mixed or weathered radiological materials;
- integrating the system on a tripod and a robotic platform, and evaluating its performance in realistic scenarios at Defence facilities.

Methodology

The project begins with joint definition of system specifications, radioprotection procedures and training for all staff involved in sample handling under the supervision of the DLD partner and in collaboration with FANC (Belgian Federal Atomic and Nuclear Control). RBINS and RMCA select representative uranium- and thorium-bearing materials from their collections while EPSLOG explore the best ML/AI methods to build the classifier based on reference spectra acquired using existing Raman/LIBS lab instrumentation. DLD study operation safety aspects (including a LIBS measurements radiological safety assessment), and defines field-testing scenarios. In a second phase, a state-of-the-art Raman/LIBS standoff instrument in designed together by RBINS and EPLSOG and set up in a controlled environment for calibration and acquisition of a large training dataset on natural radioactive minerals, industrial residues and sealed reference sources. These spectra feed a supervised machine-learning model combining molecular and elemental information for robust identification. In a third phase, the validated prototype is then integrated on a Defence robotic platform and tested in controlled operational environments. Iterative improvements follow from joint evaluation sessions, ensuring alignment with Defence user needs.

Potential Impact on Defence

RADIATE directly strengthens CBRN reconnaissance capabilities by enabling remote identification of radiological materials without physical contact, improving operator safety, situational awareness and decision-making. It complements existing gamma-spectrometric tools by adding chemical-form identification, a key asset for distinguishing harmless geological materials from engineered or illicit radiological compounds. The instrument's integration on mobile platforms supports ongoing Defence initiatives in remote RECCE missions and contributes to NATO-aligned preparedness for radiological emergencies. The spectral library and operational procedures developed in the project will support long-term capability development, training, and doctrine evolution.

Expected Final Results and Valorisation

The project will deliver:

- a fully functional Raman/LIBS prototype for standoff identification of radioactive materials;
- a validated AI-based classification model;
- a spectral reference library from >2000 natural and anthropogenic radioactive materials;
- operational procedures for radiological-safe laser measurements;
- scenario-based demonstrations and training modules for Defence personnel;
- scientific publications, technical reports, workshops and open-access datasets (where security allows).

Short-term valorisation includes direct adoption of the prototype and datasets by Defence laboratories. Medium-term exploitation may include pre-series production by EPSLOG, integration of the technology into Defence robotic systems, and opportunities for further R&D (e.g., extending detection to chemical agents or explosives).

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