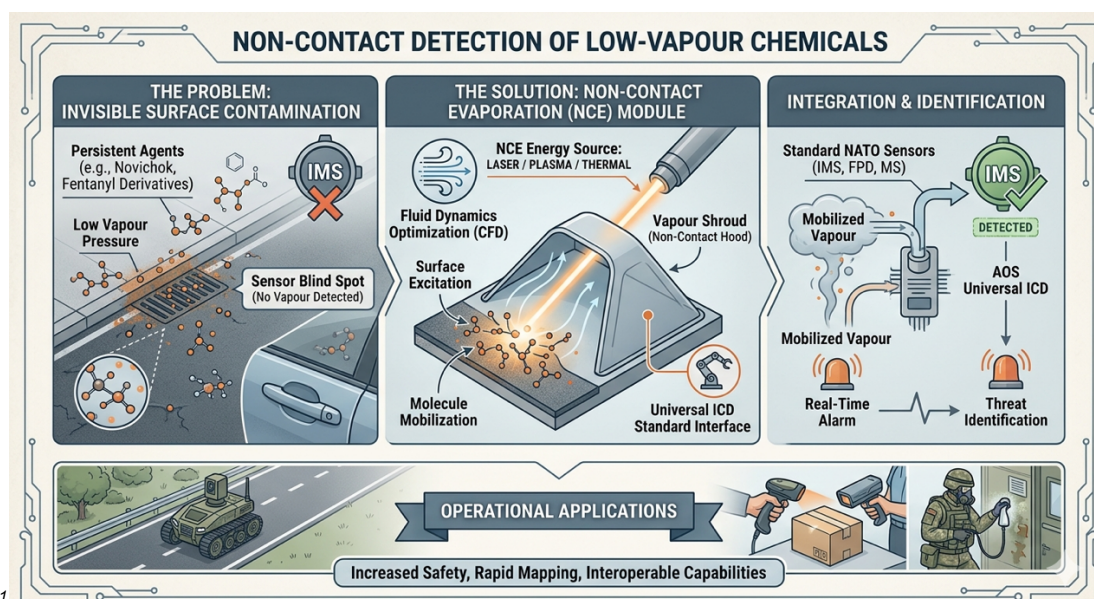


Uncovering the Invisible: Non-Contact Detection of Persistent Chemicals

In CBRN defence and internal security, traditional air detectors face a lethal blind spot: they cannot see persistent chemical agents and synthetic opioids that remain anchored to surfaces without evaporating. The revolutionary Non-Contact Evaporation (NCE) technologies are reshaping civilian and military doctrines to eliminate contact contamination risks. By analysing dramatic historical cases and addressing industrial fragmentation, this paper outlines a strategic roadmap to implement a universal, plug-and-play European interface. It is an essential technical analysis for intelligence and homeland security professionals, providing the keys to finally make the invisible visible and safe.

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Introduction: The Blind Spot of CBRN Defense

In the landscape of CBRN (Chemical, Biological, Radiological, and Nuclear) defence and Homeland Security, operational readiness has historically been tied to the ability to intercept gaseous or aerosol threats. The standard detectors available to reconnaissance teams (ion mobility systems - IMS, flame photometry - FPD, and portable mass spectrometers - MS) are extraordinary machines, but they share a fundamental "blind spot": they depend on the presence of vapor in the air.

What happens when a threat doesn't evaporate? Low-Vapour Chemical Substances (LVCs), such as persistent nerve agents or the latest generation of synthetic opioids, remain rigidly anchored to surfaces. For standard sensors, asphalt or sheet metal contaminated with these substances simply appears "clean," exposing operational personnel to lethal contact contamination risks.

Past Techniques and Their Critical Issues: Two Historical Examples

To understand the urgency of a paradigm shift, it is necessary to analyse how manual, contact-based handling has dramatically

¹ AOS is an Independent company registered in Belgium since 2012. It delivers technical, engineering, operational and management support for defence and security sector at national, European & transatlantic levels. In systems engineering & programme management for the development of complex & innovative projects. In last 5 years, AOS has carried out more than 80 NATO studies and EU projects in interoperability, emerging technologies, air defence, energy management, UAVs, & dual-use solutions. AOS team consists of senior managers & engineers from Belgium, the Cz. Rep., France, Germany, Italy, Luxembourg, Portugal & Spain with extensive experience in defence industries, Ministries of Defence, and EU institutions (www.aofs.org)

demonstrated its limitations in real-world civilian and military scenarios.

The Case of the Persistent Agent Novichok (2018)

In March 2018, a serious poisoning incident in the UK highlighted the dangers of Novichok (A-234) agents, which were applied to the door handle of a home. Novichok A-234 is an extremely persistent LVC substance. In the early stages of the scientific and Homeland Security investigation, the absence of vapours in the environment rendered traditional detectors ineffective in immediately identifying contamination points.

Decontamination and sampling teams had to rely on manual swabs on hundreds of potential surfaces. This "contact" approach not only slowed cleanup operations by months, but also resulted in the accidental contamination of field workers and the subsequent fatal poisoning of a civilian who came into contact with a dispersed contaminated object.

The Moscow Theatre Crisis (2002) – The Fentanyl Threat

During the 2002 Moscow theatre hostage crisis, special forces used a fentanyl derivative (carfentanil/remifentanil) to neutralize the hostage takers. Although initially released in a volatile form, fentanyl and its analogues tend to rapidly settle on fabrics, seats, walls, and ventilation filters in the form of solid micro-particulates with very low volatility.

In the hours following the attack, the inability to map residual contamination on internal surfaces using air sensors turned the theatre environment into a persistent toxic trap. Medical and rescue personnel operated without a clear mapping of the superficially contaminated areas, greatly amplifying the difficulties in managing patients and compromising the safety of the rescuers themselves.

Non-Contact Evaporation (NCE) Technology

To eliminate manual sampling and protect operators, in-depth international studies in the field have paved the way for the development of systems based on Non-Contact Evaporation (NCE). The key idea is to force the evaporation of the surface substance in situ without any physical contact, then

conveying the generated vapours directly to standard sensors already in use in departments.

The main lines of research analyse three technological vectors for energy transfer to the surface:

- a) **Thermal Evaporation (IR/Halogen):** Simple and cost-effective, but it suffers from high energy consumption and the risk of not reaching the desorption temperatures required for heavy molecules (such as Fentanyl) on substrates with high thermal dissipation (e.g., armoured plates or thick metals).
- b) **Laser Evaporation:** Highly directional and precise. Using targeted pulses (e.g., laser microchip), it locally heats the substance, causing flash evaporation. However, it requires optical scanning systems (rastering) to cover significant areas.
- c) **Cold Plasma (LTAP - Low-Temperature Atmospheric Plasma):** This is the most versatile emerging technology. The plasma heats moderately but acts through ion bombardment and reactive species, breaking down the surface bonds of the substance and causing broad-spectrum desorption, minimizing the risk of thermal decomposition of the molecule (which would make subsequent identification by the sensor impossible).

Application Experiences: Military Integration and Homeland Security

The introduction of NCE technology is reshaping operational doctrines in both the defence and civil defence sectors:

In the Military Sector: Mobile CBRN Reconnaissance on Vehicles and Robotics

The primary application lies in the integration of NCE modules aboard robotic platforms (UGVs) or specialized reconnaissance vehicles.

- A laser or plasma module is mounted on a robotic arm positioned a few centimetres from the ground or the body of a vehicle to be inspected. A special aerodynamic intake hood (shroud) isolates the micro-area, preventing wind (even above 1 m/s) from dispersing the generated vapor. The combined system allows the vehicle to

map road routes or landing areas without the crew having to disembark to collect physical samples, dramatically reducing reconnaissance times.

In Civilian and Homeland Security: Infrastructure Security and Logistics

For homeland security agencies and law enforcement agencies, the focus is on protecting critical transportation hubs (airports, subways) and customs control against the trafficking of highly lethal synthetic narcotics.

- Portable NCE architectures, similar to industrial handheld devices, are being tested for the rapid screening of suspicious baggage, containers, or postal packages. The operator passes the instrument over the surface of the object: the NCE pulse mobilizes invisible traces of fentanyl or chemical precursors deposited during handling, and the integrated sensor provides a real-time alarm. This approach eliminates the risk of accidental inhalation or contact by customs officers.

The Key to the Future: Institutional Dialogue

The true technological leap lies not in the creation of a single, isolated sensor, but in the integration and synergy of systems at the EU level. Currently, the internal security sector suffers from marked fragmentation, with each manufacturer developing proprietary and closed solutions, limiting the flexibility and effectiveness of operational response on the ground.

To break down this barrier, it is imperative to initiate a structured and ongoing dialogue between the main European security stakeholders. This synergy must see the active and coordinated participation of DG HOME (Directorate-General for Migration and Home Affairs of the European Commission) in terms of political guidelines, along with the relevant operational agencies: Europol, for the centralization of intelligence and the fight against terrorism and illicit trafficking, and Frontex, for the monitoring and protection of the Union's external borders.

The joint efforts of these organizations must converge toward a common goal: the establishment of a regulatory and technical

framework for the definition of a universal European Interface Control Document (ICD).

This open standard will unambiguously regulate the geometric profiles, mechanical connectors, aerodynamic flow rates, and software protocols of sampling hoods (shrouds). Through this harmonization effort led by EU institutions, the Ministries of the Interior, Customs Corps, and research institutions of individual Member States will have a truly "plug-and-play" architecture.

In the future, any advanced evaporation module (be it laser or plasma) will be able to instantly interface with the IMS detectors or mass spectrometers already purchased and used by law enforcement agencies, regardless of their manufacturer. Promoting institutional dialogue and standardizing the universal interface is the only way to provide European operational units with a flexible and uniform technological shield, capable of finally making visible and identifiable what has until now remained dangerously invisible.