Abstract

For many years, the CBRN risk-management domain has remained partially anchored to technological concepts, equipment architectures and operational assumptions inherited from the Cold War period. While these systems have provided an essential baseline for detection, protection and response, the current threat landscape — characterized by hybrid risks, high-impact low-probability events, intentional releases, industrial accidents, emerging pathogens and complex public events — requires a new generation of capabilities. Innovation in this field cannot be limited to the adaptation of laboratory technologies to the field: it must start from the operational needs of first responders.

The Italian-led rescEU CBRN-DSIM-IT capacity provides a concrete example of this approach. Within the project, the operational experience of the Italian Fire and Rescue Service has been used to identify the gap between traditional CBRN equipment and the real needs of modern emergency response. This process has led to the design of an integrated fleet of mobile laboratories, detection and sampling platforms, command-and control systems, communication assets, robotic tools and deployable support modules. The objective is not only to improve single instruments, but to build an interoperable response architecture able to connect field sampling, analytical identification, real-time monitoring, modelling, reach-back expertise and decision making.

In this framework, nanotechnology should be considered not as an isolated research domain, but as a potential enabling layer for future CBRN capabilities. Possible applications include anti-contamination and self-decontaminating materials for equipment surfaces, advanced filtration media, lightweight protective components, miniaturized sensors, functional coatings for drones and robotic platforms, and smart materials for sampling, detection and containment systems. However, their successful adoption depends on early co design with operational users: reliability, decontaminability, maintainability, deployability, interoperability and safety in contaminated environments are as important as analytical performance.

The key lesson from the rescEU CBRN-DSIM-IT experience is that future CBRN innovation, including nanotechnology-based solutions, must be developed through a continuous dialogue between researchers, industry, public-health experts and first responders. Only this approach can transform advanced materials and emerging technologies into usable, robust and mission-ready tools for real CBRN risk mitigation.