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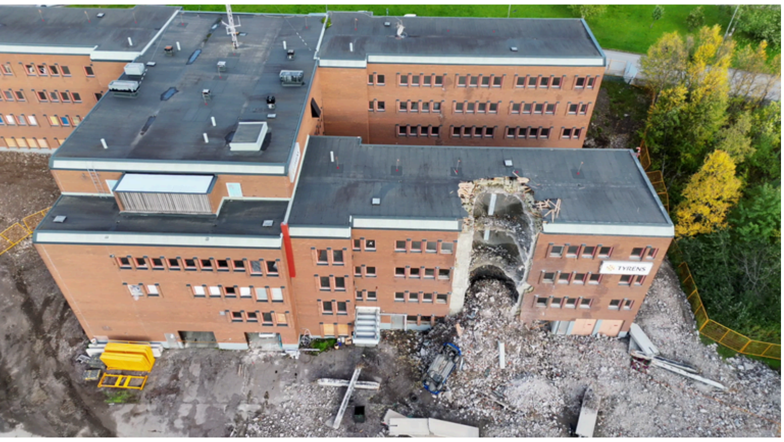
DRONE USE CASES



Credit: Södertörns Brandförsvarsförbund

Drones Detecting Unexploded Ordnance (UXO)

The term unexploded ordnance (UXO) describes potentially dangerous munitions of different sizes such as bombs, shells, grenades, or rockets that were fired or used during wars but failed to detonate, leaving them buried in the earth or stuck inside buildings, active and highly dangerous. UXO can pose a major issue when a construction or infrastructure project is being planned. Then, the requirement arises to make a special survey detecting potential ordnance and performing clearance activities until the site is safe for use. Various specialized methods, equipment and tools are used in detecting UXO such as magnetometry, electromagnetic induction, ground penetrating radar, drone and aerial surveys using magnetic, thermal or multispectral sensors to scan large and/or hazardous areas.

What is it, where and how is it used?

This use case concerns the deployment of an unmanned aerial system (UAS) to support the remote detection and visual identification of UXO and potentially hazardous materials in collapsed or structurally unstable buildings following armed attacks or explosive incidents.

The primary objectives are:

- To remotely identify and locate suspicious objects or unexploded ammunition,
- To support safe evacuation planning and the establishment of secure rescue paths,
- To provide real-time situational awareness to incident command and
- To reduce the need for immediate physical entry into hazardous environments.

Expected outcomes include improved responder safety, faster threat assessment, and more informed decision-making regarding cordoning, evacuation, and potential neutralization operations.
The solution was tested during field trials in Kiruna, Sweden, in 2025, initiated by the Swedish Civil Defense and Resilience Agency (MSB), and also involving Swedish emergency services (see this video summary). It is intended for use in high-risk post-blast or conflict-related environments where direct physical entry may expose responders to secondary explosions, structural collapse, or unknown hazards. Other stakeholders involved are: the municipal fire and rescue services, the local emergency management authorities, volunteer organizations, UAS operators and technical specialists. Coordination of these staekholders was ensured through joint planning, defined operational roles, and integration into existing incident command procedures.

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Technical and organisational aspects

The key technological components include an industrial UAS platform (DJI Matrice 4TD), a high-resolution camera with zoom capability, a thermal camera, a real-time video transmission system and a ground control station for pilot operations. Tasks performed are: aerial visual inspection of collapsed or unstable structures, identification of suspicious objects or potential UXO, transmission of live video to the remote pilot and incident command, documentation of structural damage and access routes.
The data collected includes a live video feed, still imagery and flight telemetry data. The data analysis is conducted by the UAS pilot (initial visual identification), the incident commander and technical specialists (if required). Decision-making was supported through identifying UXO or suspicious objects, determining safe access routes, assessing structural instability, and deciding to deploy a specialized ammunition disposal team. Typically, one UAS unit is deployed per operational scenario, while preparing for multiple deployments. A real-time video feed is transmitted to the UAS pilot's ground station. The pilot maintains direct radio communication with incident command. In case of signal loss, the automatic Return-to-Home (RTH) function is activated. Pre-programmed fail-safe landing procedures apply. Manual override is available if the signal is restored.

The typical operational process/workflow consists of the following steps:

- Initial Assessment: Incident command identifies a potential UXO or hazardous material risk following an explosion or armed attack. A UAS team is requested.
- Risk Zoning: A safety perimeter is established. Ground personnel remain outside the hot zone.
- UAS Deployment: The drone is launched from a secure staging area. It performs systematic aerial scanning of the structure, focusing on entrances, upper floors, debris fields, & inaccessible areas.
- Real-Time Assessment: Live video is transmitted to the UAS pilot and shared with incident command when suspicious objects are found. Suspicious objects are geo-located & documented.
- Decision-Making: Based on drone intelligence, the command determines safe access routes, the need for evacuation, and whether specialized ammunition disposal teams are needed. Deployment duration depends on building/site size and complexity. Multiple batteries and/or multiple drones are preferable to shorten deployment time.

Benefits and effectiveness

The benefits observed included: successful remote identification of suspicious objects, increased responder safety by avoiding immediate physical entry, faster situational overview compared to ground-only assessment, and improved decision-making at incident command level. During the trial scenarios, all suspicious objects placed in the exercise environments were successfully identified visually. Effectiveness is primarily driven by elevated aerial perspective, real-time information flow, reduced physical exposure risk and rapid deployment capability. While quantitative metrics are still under development, qualitative feedback from participating responders indicates increased operational confidence and safety.

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Compared to traditional ground-based inspections, using drones to detect UXO significantly reduces exposure of personnel to explosive risks, provides faster access to upper floors and unstable structures, and enables a rapid overview of large debris fields. Drone use also accelerates the detection of UXO, allowing life-saving search and rescue operations to begin earlier instead of waiting for specialized ammunition disposal teams or conducting slow manual inspection. It supports faster risk clarification, which can shorten the time for evacuation, medical response, and victim extraction. Overall, the drone-based solution enhances safety and operational efficiency by enabling earlier informed decision-making, while complementing conventional methods. It has strong potential to reduce operational risk and unnecessary deployments of specialized ammunition disposal teams, and supports safer operational planning.

Key challenges

The main challenges addressed through continued testing and knowledge sharing included the identification of suitable detection sensors beyond visual inspection, and the development of standardized operational procedures ensuring adequate pilot and responder training. Detection is dependent on lighting, visibility, and camera resolution. There are no integrated chemical or explosive detection sensors yet.

The following safety measures are in place to ensure that drones can fly safely: use of integrated obstacle avoidance and collision detection sensors, low-altitude operations within a secured airspace, Visual Line of Sight (VLOS) operations, deployment of a licensed and trained UAS pilot, pre-flight risk assessment, defined operational perimeter, and, where required, coordination with local air traffic authorities.

Future potential

Rapid technological development in sensor miniaturization and AI-supported image analysis are expected to significantly enhance detection capabilities and operational value. Further operational deployments are planned but remain limited to pilot testing scenarios. Possible future improvements include evaluating advanced sensor integration and developing standardized training procedures. The process will be shared with other Swedish fire services and international partners through the COLLARIS2 network to support replication and scaling.