

From passive detection to decision-making

System architecture for counter-UAS in RF-denied environments

Whitepaper · October 2026
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Summary. Radio-based drone detection reaches its limits where drones fly without a radio link, follow pre-programmed routes, or where the radio environment is jammed. Passive methods detect drones through their physical traces (image, sound, heat, residual emissions) without transmitting themselves. What matters, however, is not the individual measurement but the chain from detection through assessment to action. This paper describes a system architecture that makes this chain traceable and keeps the decision with the human.

1. Starting point

Protecting against unmanned aircraft has turned from a specialist task into a permanent one: airports, utilities, armed-forces facilities, public events, prisons. Many current systems rely on analysing the radio link between drone and controller. This works well against commercial drones using standard protocols. It fails when

- the drone flies autonomously on a pre-loaded flight plan,
- radio links are encrypted, unusual or switched off,
- the operating environment itself is jammed or radio-poor (RF-denied),
- own active sensors (e.g. radar) must not transmit because they reveal the position or disturb other systems.

2. Passive detection at a glance

Passive methods do not transmit. They use what the drone emits or causes anyway:

Method	Uses	Strength	Limit
Optical / thermal imaging	Visible image, heat signature	Classification, evidence	Visibility, weather, field of view
Acoustic	Rotor noise	Direction estimate, also without line of sight	Ambient noise, range
Passive RF	Residual emissions, control and video signals	Early detection of known protocols	Blind to radio-silent drones

No single method is sufficient. The strength lies in **fusion**: when two sensors contradict each other, that is information in itself.

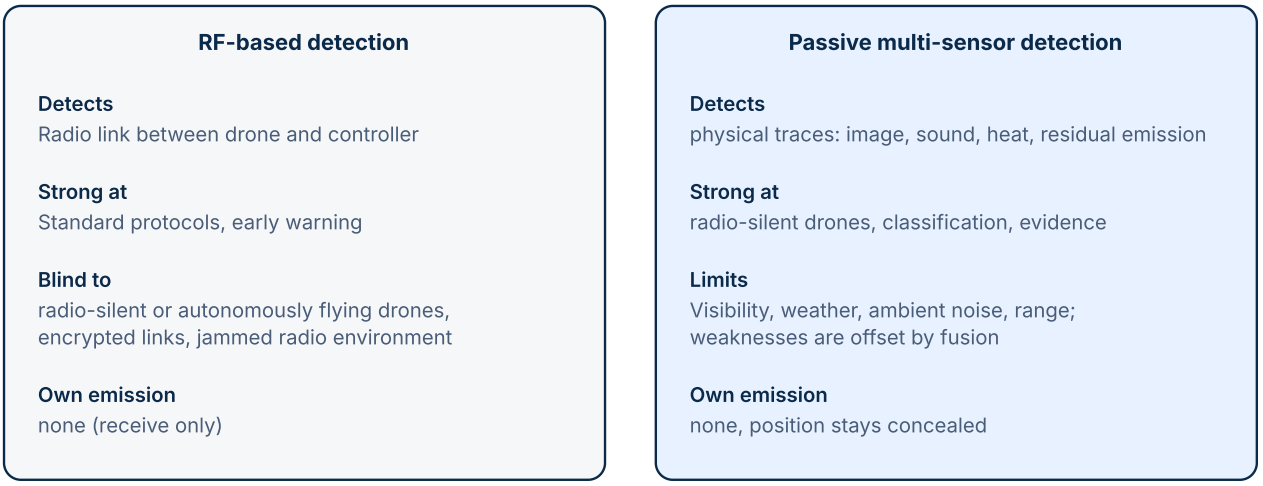


Figure 1: RF-based detection compared with passive multi-sensor detection.

3. From measurement to decision

Most errors in counter-drone operations arise not in the sensors but in the decision: too late, on an unclear picture, without clear responsibility. A sound architecture therefore separates three stages:

1. **Detect:** sensors deliver tracks with timestamp and quality.
2. **Decide:** fusion and rule set assess the situation; the release remains with the human. The system proposes, the responsible person decides.
3. **Defeat:** measures only by the competent authorities and within the legal framework.

Every stage logs what it knew and when. This makes decisions verifiable afterwards, which is essential for authorities and liability questions.

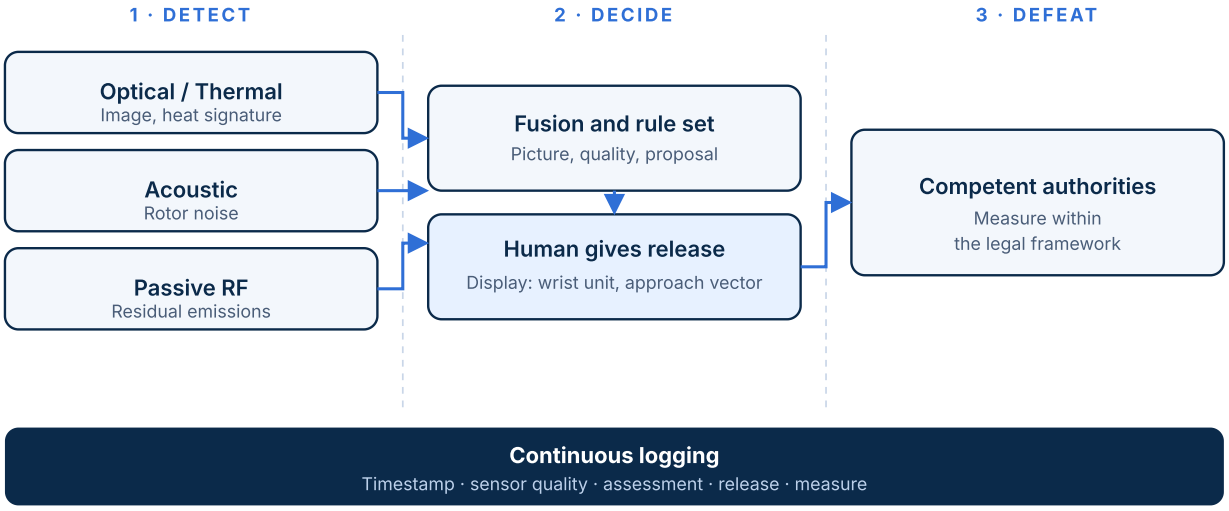


Figure 2: Detect – decide – defeat chain with continuous logging.

4. From practice: own prototypes

SitGuardAir has not only described concepts for detection and effect but built them as prototypes. The design follows the principle of a modular system: interchangeable sensor nodes, a central assessment, a clearly delimited interface to the effect. Two designs are registered as utility models (Gebrauchsmuster) at the German Patent and Trade Mark Office (DPMA):

- **Portable multi-sensor system with modular vehicle cassette system:** A modular, body-worn device that combines several passive sensors into one situational picture, for mobile forces without fixed infrastructure. A wrist display shows the approach vector. The system can be docked to a vehicle cassette system. The exchangeable cassette on the vehicle contains sensors and effectors and thus extends the carrier into a vehicle solution.
- **Net launcher in service-pistol format:** A hand-held effector for close range, designed for authorised users. The compact form is made possible by a special arrangement of the capture-net elements, which is also registered. A second registration covers the complete device.

Utility model no.	Title (translated from German)	Registered
20 2026 001 419	Portable multi-sensor drone detection system with modular vehicle cassette system	19 Jun 2026
20 2026 001 418	Person-carried non-lethal counter-drone device (cartridge system)	26 Jun 2026
20 2026 002 743	Block arrangement of net bolts for net launcher	18 Aug 2026

Registered utility models (selection). Holder: Dirk-Peter Sander. Legal status and scope of protection can be checked in the DPMA register (www.dpma.de); the DPMA does not examine patentability when a utility model is registered.

For reasons of controlled disclosure, technical parameters, components and performance data are not published here.

Important: prototypes are not a product offer. Effectors against drones are subject to strict legal requirements in Germany (including weapons and aviation security law) and are a matter for the competent authorities and the armed forces. This paper addresses those bodies.

5. Legal framework and responsibilities (brief overview)

Detection is legally far less problematic than countermeasures. Interference with air traffic, jamming of radio and the use of effectors are reserved for sovereign authorities. Operators should clarify responsibilities, reporting channels and escalation levels before an incident. This section is an overview and not legal advice.

6. Outlook

Detection technology is developing quickly; decision structures are not keeping pace. Anyone procuring systems should first ask: who decides, on what basis, and how can this be reconstructed later?

Further reading: Dirk-Peter Sander, *Drohnenabwehr – Entscheiden unter Druck* (technical book in German, 3rd edition), drohnenabwehr-buch.de.

About SitGuardAir Systems. Development of passive detection systems for RF-denied environments, critical infrastructure and authorities. Contact: info@sitguardair.eu · sitguardair.eu
Status of information: October 2026. Not legal advice. Technical data is not published.