

# Contested-Environment Autonomy

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## What Contested-Environment Operation Requires

Contested environments are operating contexts where adversaries actively contest sensing channels. GPS jamming and spoofing in defense theaters. RF interference in critical-infrastructure attack scenarios. Optical disruption (laser dazzlers, smoke, deliberate glare). Acoustic interference in submarine operation. Each medium that the autonomous system depends on is potentially contested.

Operating successfully in such environments requires architectural primitives that the system can use to detect, classify, and respond to contested-channel events. The primitives must operate at the operational tempo of the environment — milliseconds to seconds — and must produce reliable diagnostic information rather than ambiguous failure signals.

## Why Single-Medium Hardening Doesn't Scale

Single-medium hardening (Galileo OSNMA for GPS, frequency hopping for RF, anti-laser optics for cameras) addresses specific attack classes within specific media. Each hardened system operates better against attacks within its medium; none provides cross-medium diagnostic information.

When the actual operating environment includes coordinated multi-medium attack — common in modern peer-conflict scenarios — single-medium hardening produces fragmented partial resilience. The autonomous system has hardened GPS, hardened RF, hardened optics, and yet cannot tell whether the cumulative anomaly pattern indicates coordinated adversarial action or coincidental multi-medium environmental disruption. The diagnostic gap is the operational gap.

## **How Architectural Cross-Medium Sensing Composes**

The disruption-modeling primitive consumes contributions across multiple media simultaneously. Cross-medium correlation against credentialed composite signatures produces attribution. The attribution feeds composite admissibility, which produces graduated response across the unit's operational mode set.

Importantly, the architecture composes with single-medium hardening rather than replacing it. Galileo OSNMA continues to authenticate GPS within its medium. Frequency hopping continues to operate within RF. Anti-laser optics continue within their medium. The cross-medium primitive sits above the medium-specific hardening and consumes their outputs as governance-credentialed observations.

## **What This Enables for Defense and Commercial Drone Resilience**

Defense autonomy operating in contested environments gains structural diagnostic capability. The autonomous system can distinguish 'GPS-spoofing-in-progress' from 'urban-canyon-multipath-event' and respond appropriately to each. Commercial drone delivery operating in increasingly contested airspace (anti-drone deployments at events, restricted-zone enforcement, hostile-actor-targeted attacks) gains the same capability scaled to civilian use.

The architecture is also the foundation for cross-coalition operations. Allied forces sharing credentialed signature libraries gain attributed disruption events that single-nation libraries cannot produce. The patent positions the primitive at the layer contested-environment autonomy requires as adversarial sophistication continues to grow.