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How to Build Wildfire or Earthquake Early Detection From Multiple Sensors

If you are building early-warning detection for wildfire, earthquake, structural failure, or any other environmental event, your hardest problem is not the sensor. It is trusting the sensor: a single blinded, jammed, or drifting channel can silently mask the very event you deployed to catch. This guide describes an architecture, disclosed in U.S. Provisional Application No. 64/049,409, that fuses independent sensing media so no one degraded channel can hide an event. It is a design you implement yourself, not a shipping library. The home inventive step is the Environmental Disruption inventive step.

What You Are Building

You want a system that raises an early, trustworthy alarm for a physical event: a wildfire igniting at the edge of a coverage area, an earthquake beginning to shake a structure, a bridge starting to fail, an explosion or gas release at an industrial site. The developers who need this are building for environments where a missed event is catastrophic and a false alarm is expensive: utilities, transportation authorities, wildfire agencies, facility operators, and infrastructure teams.

The naive version of this is one sensor and a threshold. That is easy to build and easy to fool. What you are actually building is a detector that treats the sensed environment as several independent physical channels at once, so that agreement across channels raises your confidence and the failure of any single channel does not blind you. The disclosed approach frames this as a general primitive: detecting a departure of a sensed field from its characterized baseline, corroborating that departure across multiple independent media, and emitting a governed, auditable determination rather than a raw alarm.

Why the Obvious Approaches Fall Short

The obvious approach is a single-medium threshold detector. A smoke sensor with a trip point. A seismometer with a magnitude cutoff. A camera with an image model. Each of these is a real, useful tool, and none of them is wrong on its own terms. The structural gap is that each is scoped to one physical channel, and each channel has its own failure modes.

A smoke or optical channel can be blinded by fog, dust, glare, or an obstruction. A radio-frequency channel can be jammed or can suffer propagation artifacts. A seismic channel can drift off its baseline or pick up unrelated machinery. Any single detector also cannot, by construction, tell the difference between a genuine field measurement and a fabricated one fed into it; a spoofed input looks like a real reading. And because each detector emits an isolated, unstructured alarm, a downstream operator has no principled way to weigh a lone smoke trip against a lone seismic blip, no record of why the alarm fired, and no way to reconstruct the event afterward.

The consequence is that single-channel systems fail in exactly the two ways early-warning systems must not: they miss real events when their one channel is degraded, and they cry wolf when their one channel is noisy. Stacking several independent single-channel alarms side by side does not fix this by itself, because nothing in that arrangement reasons about whether the channels agree, how fresh each reading is, or which source is authorized to speak. Fixing it requires an architecture that combines channels as first-class evidence.

The Architecture

The disclosed architecture, in U.S. Provisional Application No. 64/049,409, treats detection as an environmental disruption sensing primitive. A disruption is defined as any departure of a sensed field from its governance-characterized baseline attributable to a source. Crucially, the primitive is defined to be medium-agnostic: the same mechanism operates across radio-frequency, optical, acoustic, thermal-infrared, magnetic, electric, seismic, barometric, chemical, radiological, and gravitational field classes, and admits new field classes through policy-defined detector registration rather than a rewrite.

The primitive is disclosed as a set of composable mechanisms. The load-bearing ones for an early-warning build are:

- A baseline-characterization mechanism that establishes a characterized baseline for each sensed field class across defined spatial, temporal, and operational conditions. This is what "normal" looks like for each channel.
- A departure detector that flags when a sensed field departs from its established baseline beyond a policy-defined threshold.
- A disruption classifier that maps each departure to a disruption class.
- A multi-source corroboration evaluator that aggregates departure detections across a plurality of sensing agents and produces corroboration scores.
- A source-attribution mechanism that localizes the source through multi-sensor triangulation or signature matching.
- A spoofing-detection mechanism that evaluates signal-integrity attestation and temporal and spatial coherence to distinguish genuine field measurements from fabricated ones.
- A graduated-response generator that produces a response proportional to the classified disruption, rather than a binary alarm.

- A disruption-lineage recorder that records each detection, classification, attribution, and response.

The central mechanism for the "no single channel can mask the event" goal is cross-medium composite disruption detection. Here, disruption observations from a plurality of field classes are combined to produce composite determinations that no isolated field-class detection alone can produce. The spec describes a cross-medium observation aggregator that ingests observations across two or more field classes, a correlation evaluator that identifies temporal, spatial, and causal correlations among observations of different field classes, a library of composite signatures, and a classification engine that maps correlated multi-medium observations to composite disruption classes.

The disclosure gives concrete composite signatures directly relevant to your use cases. A thermal-and-chemical composite signature is disclosed for a combustion event, which produces both thermal-infrared departures and chemical-sensor departures at once: this is the wildfire pattern. A seismic-and-acoustic composite signature is disclosed for structural failure or explosive events, which produce correlated ground-vibration and airborne-acoustic signatures: this is the earthquake, structural-collapse, and blast pattern. A barometric-and-acoustic composite signature is disclosed as characteristic of weather and atmospheric phenomena.

The reason this beats stacked single-channel alarms is stated plainly in the disclosure: cross-medium detection produces elevated confidence relative to isolated single-medium detection through independent corroboration across orthogonal physical channels. Each participating field class is governed by a physically distinct sensing apparatus with distinct failure modes, so the composite determination is robust to single-medium sensor failure, single-medium jamming, and single-medium spoofing. That property is the whole point: an attacker or an environmental condition that takes out one channel cannot take out an orthogonal channel, so the composite still fires.

Two further disclosed mechanisms make the fusion principled rather than ad hoc. First, the composite admissibility evaluator of the cross-domain coherence chapter computes an evidential weight for each observation from multiple factors (authority, staleness, modality, dispositional context, reputation, integrity, and continuity), and produces one of several outcomes rather than a binary pass or fail: admit, gate at reduced weight, defer pending corroboration, solicit more observations, reject with a classified reason, or escalate. The defer outcome is directly useful for early warning: a lone departure can be held pending corroborating observations within a deferral window, promoted to admit if enough corroboration arrives, and demoted to reject if conflicting observations arrive.

Second, cross-domain observation escalation lets the combination of observations from independent sensing domains converging on a common spatial-temporal region produce an escalated classification that no single domain could produce in isolation. The disclosure gives a worked structural-integrity example: a strain-gauge observation, an unusual-vibration observation from a seismic sensor, and a traffic-volume observation, all pertaining to a common bridge, together satisfy an escalation rule classifying an incipient structural-integrity event and triggering traffic-routing and inspection dispatch.

How to Approach the Build

You are implementing this yourself. The following ordered steps follow the disclosed mechanisms.

1. Enumerate your independent media. Pick field classes whose failure modes do not overlap. For wildfire, thermal-infrared plus chemical (combustion products) plus optical, and optionally acoustic. For earthquake and structural events, seismic plus acoustic plus strain. The disclosed robustness comes from orthogonality, so avoid two sensors that share a blinding condition.

2. Characterize a baseline per channel. For each field class, build a model of "normal" across the spatial, temporal, and operational conditions you expect. Baselines are per-channel; a departure is defined relative to that channel's own baseline.
3. Build a per-channel departure detector. Each detector should emit a structured observation, not a bare boolean: what departed, by how much, where, when, and with what confidence. This structured emission is what the later stages consume.
4. Add a spoofing and integrity check per channel. Before an observation is trusted, evaluate signal-integrity attestation and temporal and spatial coherence, so a fabricated or physically implausible reading is caught at the channel rather than propagated.
5. Aggregate and correlate across media. Feed the per-channel observations into a cross-medium aggregator that looks for temporal, spatial, and causal correlation between departures in different field classes pertaining to a common region and time window.
6. Match against composite signatures. Maintain a library of composite signatures (thermal-and-chemical for combustion, seismic-and-acoustic for structural failure or blast) and classify correlated multi-medium observations against it. An illustrative, non-runnable sketch of the rule shape, faithful to the disclosed signatures:

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# Illustrative only. You implement the detectors, thresholds, and windows
composite_signature "wildfire_ignition":
    requires thermal_infrared.departure within region R, window W
    and      chemical.departure         within region R, window W
    yields   class = "combustion_event", elevated_confidence = true

composite_signature "structural_or_blast":
    requires seismic.departure  within region R, window W
    and      acoustic.departure within region R, window W
    yields   class = "structural_failure_or_explosive", elevated_confiden
```

7. Weigh and resolve with a multi-outcome evaluator. Instead of a single threshold, compute an evidential weight per observation from factors such as authority, staleness, and modality, and choose among admit, gate, defer, solicit, reject, and escalate. Use defer for a single lone channel: hold it, wait for a corroborating orthogonal channel inside a bounded window, and promote or demote based on what arrives.
8. Escalate on convergence. Encode escalation rules so that independent departures converging on a common region and time produce an escalated classification and a routed response, as in the disclosed bridge example.
9. Record lineage for everything. Persist the contributing single-medium observations, the correlation evidence, the composite classification, and the response, so any determination is reconstructible after the fact. The disclosure treats this lineage as intrinsic to each derived observation, which is what makes the system auditable.
10. Optionally, model propagation. The disclosure describes a separate cascade-propagation primitive that projects a detected disruption at one region to connected regions of a topology (for example, fire spread or structural load redistribution) and produces coordination directives downstream. Treat that as a later layer on top of detection.

What This Does Not Give You

This is an architecture, not a drop-in library or an SDK. There is nothing here to install. You implement the sensors, the baselines, the departure thresholds, the correlation windows, the signature library, and the response wiring yourself, and those choices are where the real engineering lives.

It is disclosed in a patent filing. It is not a benchmarked or productized system, and this guide states no performance numbers, detection rates, or latency figures, because the disclosure does not state them and inventing them would be dishonest. The robustness claim is architectural: because the channels are physically orthogonal, the failure of one channel does not by construction blind the others. That is a design property, not a measured guarantee, and it holds only to the degree that the media you choose are genuinely independent. Choose two channels that share a blinding condition and you forfeit the benefit.

The approach also does not remove the need for good single-channel detectors, well-characterized baselines, or sound thresholds. A composite of poorly tuned detectors is still poorly tuned. And it is scoped to events that manifest as a departure across more than one sensed field. A phenomenon that only ever shows up in a single medium gains corroboration robustness but not a second independent confirmation.

Disclosure Scope

The architecture described here, including environmental disruption sensing, cross-medium composite disruption detection, multi-source corroboration, and the composite admissibility and cross-domain escalation mechanisms, is disclosed in U.S. Provisional Application No. 64/049,409. This guide is educational. It explains an approach a developer can build; it is not a warranty, a benchmark, a promise of fitness for any purpose, or an offer of software. Every mechanism described above is drawn from that filing, and any implementation choices, thresholds, and integrations are the reader's own.

Environmental Disruption (/environmental-disruption) All 40 steps → (/inventive-steps)

Cross-medium signatures. Governed active probing. Adversarial-aware sensing.

Provisional application

PRIMARY TECHNICAL DISCLOSURE

- Environmental Disruption: Cross-Medium Sensing With Governed Active Probing (/articles/environmental-disruption-cross-medium-sensing-with-governed-active-probing)

SECONDARY TECHNICAL

- Multi-Medium Environmental Sensing (/articles/environmental-disruption/multi-medium-sensing)
- Baseline Departure Detection (/articles/environmental-disruption/baseline-departure-detection)
- Governed Active Probe (/articles/environmental-disruption/governed-active-probe)
- Spectrum-Licensing-Gated Probing (/articles/environmental-disruption/spectrum-licensing-gating)
- Adversarial Awareness in Governed Active Probing (/articles/environmental-disruption/adversarial-awareness-cost)
- Cross-Medium Composite Signatures (/articles/environmental-disruption/cross-medium-composite-signatures)
- Multi-Source Corroboration (/articles/environmental-disruption/multi-source-corroboration)
- Lineage Evidence Admissibility (/articles/environmental-disruption/lineage-evidence-admissibility)
- Graduated Environmental Response (/articles/environmental-disruption/graduated-response)

APPLICATIONS · GENERAL

- Critical Infrastructure Protection: Cross-Medium Environmental Disruption Detection for the Power, Water, and Communications Grid (/articles/environmental-disruption/critical-infrastructure-protection)
- Multi-INT Fusion for Contested Defense ISR: A Multi-Medium Sensing Architecture (/articles/environmental-disruption/defense-isr-environmental)
- Multi-Medium Disaster Monitoring: Cross-Hazard Sensor Fusion for Earthquake, Wildfire, and Flood Early Warning (/articles/environmental-disruption/disaster-monitoring-multi-medium)
- Multi-Source Earthquake Detection and Early Warning Without Trusting Any Single Sensor (/articles/environmental-disruption/earthquake-multi-source-detection)
- Maritime Domain Awareness: Multi-Medium Sensor Fusion With Verifiable Evidence Lineage for Dark-Vessel and IUU-Fishing Enforcement (/articles/environmental-disruption/maritime-domain-awareness)
- Multi-Medium Wildfire Detection: Cross-Modality Sensor Fusion for Early Ignition Alerts (/articles/environmental-disruption/wildfire-detection-multi-medium)
- CISA Critical Infrastructure Cybersecurity Compliance: Cross-Modality Detection and CIRCIA Incident Reporting (/articles/environmental-disruption/cisa-eo-13800)

- GNSS Jamming and Spoofing Detection: Architecting FCC and EO 13905 PNT Resilience (/articles/environmental-disruption/fcc-gnss-protection)
- FCC Part 15 Unlicensed RF Compliance: Adversarial-Resistant Sensing for DFS and 6 GHz AFC (/articles/environmental-disruption/fcc-part-15-unlicensed)

APPLICATIONS · SPECIFIC

- Anduril Sentry Tower vs Multi-Medium Credentialed Disruption Sensing (/articles/environmental-disruption/anduril-sentry-tower)
- Dedrone Alternative: Governed Multi-Medium Counter-UAS Detection Beyond Single-Vendor Fusion (/articles/environmental-disruption/dedrone-counter-uas)
- HawkEye 360 Alternative: Multi-Medium Credentialed Sensing Beyond RF-Only Geolocation (/articles/environmental-disruption/hawkeye-360-rf)
- Capella Space SAR vs governed multi-medium fusion (/articles/environmental-disruption/capella-sar)
- Maxar Imagery vs Governed Multi-Medium Disruption Sensing (/articles/environmental-disruption/maxar-imagery)
- Planet Labs Imagery vs Multi-Medium Governed Sensing (/articles/environmental-disruption/planet-labs-imaging)
- Slingshot Aerospace vs Governed Multi-Medium Space Sensing (/articles/environmental-disruption/slingshot-aerospace)
- Spire Global vs Governed Multi-Medium Environmental Disruption Sensing (/articles/environmental-disruption/spire-rf-monitoring)
- Cognex Machine Vision vs Governed Multi-Medium Sensing (/articles/environmental-disruption/cognex-machine-vision)
- Keyence Vision Sensors vs Governed Multi-Medium Sensing (/articles/environmental-disruption/keyence-vision-sensors)

Environmental Disruption overview → (/environmental-disruption)