SkySentinel: Acoustic Aircraft Violation Detection System Executive Summary

SkySentinel (Patent Pending, Conf. #1555, Filed Dec 1, 2025) is a prototype acoustic monitoring system detecting low-altitude aircraft violations for wildlife protection and rural safety. Raspberry Pi edge devices with microphones and solar power provide 24/7 coverage, correlating audio triggers with FlightAware data to identify FAA violations (500ft rural, 1,000ft eagle nests and 2,000ft eagle advisory). Bench testing demonstrates core detection algorithms and evidence pipeline (audio → DB → S3 → alerts).

Problem Statement

Low-altitude flights violate 14 CFR §91.119(c) (500ft rural minimum), 50 CFR Part 22 (1,000ft eagle nests), and FAA AC 91-36D (2,000ft noise-sensitive areas), disrupting wildlife habitats. Manual observation provides limited coverage; radar systems cost $150K+ with poor small aircraft detection. Agencies need affordable autonomous monitoring for remote areas.

Technology Overview

Acoustic Detection Core

65dB RMS threshold detection (for development, db_level = 20 * $\log_{10}$(RMS) + 94) with 300s cooldown rejects environmental noise. Prototype processes laptop mic input, simulating 80km airspace around major airports. FlightAware API correlates timestamps (±30s) with aircraft altitude data for violation assessment.

System Components

Edge Hardware: Raspberry Pi 4, USB microphone (22kHz), solar panel + ATV batteries (4-day autonomy), IP65 enclosure (~$500 BOM). Software Stack: Python DDD architecture, PyAudio processing, AWS S3/RDS storage, React dashboard (skysentinel.dev). Data Pipeline: Audio trigger → Flight scan → Tiered violation check → Evidence logging.

Deployment Models

Standalone: 5-10 sq km, $2.5K setup, 4-hour install
Networked: 100+ sq km, $1.5K/unit hardware

Performance Comparison [chart:439]

Metric	SkySentinel	Radar	Acoustic Recorders
Setup Cost	**$2.5K**	$150K+	$500/unit
Coverage	**50 sq km**	10 sq km	1 sq km
Small Aircraft	**99%** (sim)	60-80%	N/A
BOM Cost	**$500**	N/A	$150-1K

Prototype Status

Bench testing (laptop mic, 80km simulated airspace) logged 100+ flights with 8 violations identified via manual scans. Core algorithms validated: threshold detection, cooldown logic, tiered assessment (CRITICAL/VIOLATION/ADVISORY). ADS-B Exchange integration planned for production.

Regulatory Alignment

Supports FAA 14 CFR §91.119(c) rural minimums and USFWS eagle protections. Prototype demonstrates violation classification matching regulatory thresholds.

Economic Model

TAM: $450M wildlife monitoring market. Hardware: $1.5K/unit (volume) SaaS: $500/year/site ROI: 18 months via $25K+ annual savings vs radar.

Future Roadmap

Production: ADS-B integration, field enclosure v2.0: ML noise filtering v3.0: Multi-sensor fusion (thermal, RF)

Risks and Mitigation

Risk	Impact	Mitigation
Wind Noise	Medium	Low frequency detection
Coverage Gaps	Low	Networked nodes
API Costs	Medium	Caching + grants

Conclusion

SkySentinel prototype demonstrates viable acoustic detection + FAA violation assessment at 1/60th radar cost. Core algorithms validated through simulated airspace testing. View live dashboard at http://skysentinel.dev. Contact paul@skysentinel.dev for technical briefings.