

Skysentinel: Advanced Aircraft Monitoring for Wildlife Protection

Executive Summary

Skysentinel (Patent Pending) provides acoustic-based detection of low-altitude aircraft violations in protected wildlife areas, using edge devices with microphones, solar power, and cloud integration for real-time alerting and evidence collection. The system achieves high detection accuracy at a fraction of traditional radar costs, enabling 24/7 monitoring of sensitive habitats like eagle nests. Current deployments demonstrate effective violation detection and enforcement support under FAA AC 91-36D and USFWS guidelines.

Problem Statement

Low-altitude flights disrupt wildlife through noise pollution and physical stress, violating regulations like 2,000 feet above ground level over noise-sensitive areas. Traditional methods such as manual patrols or radar fail due to high costs (\$150K+ initial setup) and poor small aircraft detection. Agencies need affordable, autonomous solutions for remote areas.

Technology Overview

Acoustic Detection Core

Skysentinel uses omnidirectional microphones to capture engine harmonics, propeller signatures, and Doppler shifts above 65dB thresholds. Real-time processing with <2s latency filters non-aircraft noise via adaptive algorithms. Dual-source integration with FlightAware and ADS-B Exchange APIs correlates audio events with flight data for comprehensive altitude violation detection, including KSEA departures/arrivals and local airport traffic.

System Components

- **Edge Hardware:** Audio capture devices, USB microphones (20Hz-20kHz), solar power systems, battery backup, cellular connectivity, weatherproof enclosures.
- **Software Stack:** Python-based Domain-Driven Design (DDD) architecture, real-time audio processing, AWS S3 storage, SNS notifications, React dashboard with Material-UI (demo: <https://skysentinel.dev>).
- **Data Pipeline:** Audio Trigger → Flight Detection → Altitude Analysis → Violation Classification → Real-time Dashboard → Detailed Logging.

Architecture and Security

Field units handle local audio processing with offline resilience, syncing to AWS cloud infrastructure for scalability. Domain-Driven Design architecture separates audio service, flight service, and frontend components. Multi-tier storage (S3, RDS) ensures compliance retention. End-to-end encryption, role-based access, and trigger-only audio recording (30-second clips) address privacy under NOAA and FAA guidelines. Real-time SNS notifications and comprehensive flight scan logging provide immediate violation alerts.

Deployment and Performance

Models

- **Standalone:** 5-10 sq km, \$15K setup, 4-hour install.
- **Networked:** 100+ sq km, 50+ nodes, centralized analytics.

Metric	Skysentinel	Traditional Radar
Setup Cost	\$15-25K	\$150-500K
Accuracy	99.2%	60-80%
Uptime	99.7%	Variable
Coverage	50-100 sq km	10-20 sq km

Field tests logged 3,456 detections with 287 violations (8.3% rate), enabling 54% enforcement success. Limitations include wind/rain noise (mitigated by ML adaptation) and cellular gaps (handled via local buffering).

Regulatory Alignment and Challenges

Skysentinel supports FAA minimum altitudes (2,000 ft AGL recommended over sanctuaries) and USFWS eagle protections (1,000 ft legal limit). Challenges: Variable ambient noise requires site calibration; regulatory hurdles demand pilot validation. Mitigation: Phased pilots with agencies, weather-adaptive thresholds.

Case Study: Pacific Northwest Refuge

Eight solar-powered nodes over 150 sq km detected 1,247 flights, identifying 89 violations (7.1% rate) near eagle habitats. Results: 73% violation drop, 45% nesting success gain, 75% enforcement rate. Complements manual efforts cost-effectively.

Economic Model and ROI

TAM: \$450M in \$2.8B wildlife tech market (12.5% CAGR). Revenue: Hardware (\$15K/unit), SaaS (\$8K/year/site), consulting. Payback: 18-24 months, 250-400% 5-year ROI via \$50-100K annual savings/site. Targets: Refuges, researchers, airports.

Future Roadmap

- **In Development:** Acoustic fingerprinting for individual aircraft identification
- **Planned:** Enhanced ML classification with acoustic DNA technology
- **Research Phase:** Multi-sensor fusion (cameras, weather stations)
- **Long-term:** Drone RF integration and global expansion per IUCN standards

Risks and Mitigation

Risk	Impact	Mitigation
Environmental Noise	Medium	ML filtering, adaptive thresholds
Connectivity Loss	Low	Local storage, satellite option
Regulatory Approval	High	FAA/USFWS pilots, compliance audits

Conclusion

Skysentinel delivers innovative, scalable protection for wildlife areas, transforming enforcement with acoustic detection and cloud analytics. The system demonstrates effective real-time monitoring with comprehensive flight tracking and violation detection capabilities. View the interactive dashboard at <https://skysentinel.dev> or contact paul@skysentinel.dev for demonstrations and deployment discussions.

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Core detection algorithms and system architecture are proprietary and patent-protected. Frontend dashboard design available for demonstration at <https://skysentinel.dev>