

Wildland Firefighter Health:

Smoke Exposure Monitor



White Paper 2026
Air Alert Technologies



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The Problem

Wildland firefighters routinely operate in dense smoke environments for extended periods of time, often during shifts lasting twelve to sixteen hours or longer. Unlike structural firefighting, respiratory protection in wildland operations is limited, and exposure to smoke and combustion byproducts is often treated as an unavoidable part of the job. As wildfire frequency and intensity continue to increase, firefighters are spending more time in these conditions, leading to repeated exposure across multiple incidents and fire seasons.

Despite this persistent exposure, wildland firefighters often have little awareness of the level of risk they are experiencing in real time. Smoke conditions can change rapidly, and harmful exposure is not always visible or immediately noticeable. Without simple, reliable monitoring tools, firefighters and crew leadership must rely on experience and judgment rather than measurable data. This lack of awareness makes it difficult to recognize dangerous conditions, manage exposure, or understand long-term health risks associated with repeated smoke exposure.



Long Shifts

Wildland firefighters often work 12-16 hour shifts



No Protection

Respiratory protection is often impractical or ignored in wildland operations



Cancer Rate

9% increase in cancer diagnosis for firefighters with even higher rates associated with wildland



Mortality Rate

14% increase in mortality rate from cancer for firefighters

Design Process

Design Requirements

The development of the Air Alert system is driven by the extreme environmental conditions of wildland firefighting and the need for improved exposure awareness in the field. The engineering approach prioritizes reliability, usability, and durability to ensure the device remains effective during extended operations in harsh wildfire environments.



Environmental Constraints

- High temperature exposure
- Dense smoke and particulates
- Dust and moisture ingress
- Impact and vibration during transport
- Extended operation times



User Requirements

- Minimal user interaction
- Lightweight wearable design
- Clear visual alerts
- Secure mounting to firefighter gear
- Operable with gloves and PPE



Functional Requirements

- Continuous exposure monitoring
- Real-time alert notifications
- Wireless data transmission
- Data logging
- Low power consumption



Operational Requirements

- 12+ hour battery life
- Rugged field reliability
- Quick and simple start up
- Minimal maintenance requirements
- Compact form factor

Requirements Influencing Design Decisions

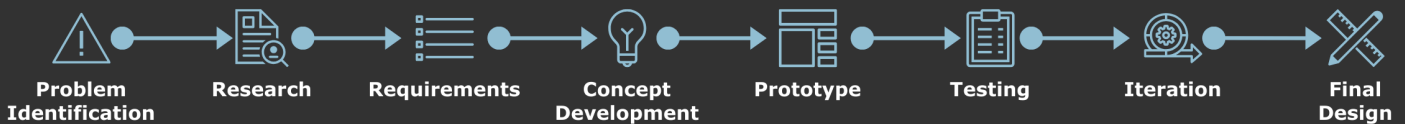
Environmental & User Constraints → Engineering Requirements → Design Decisions → Final System

Design Process

Development & Iteration

The development of the Air Alert system followed an iterative engineering approach focused on reliability in harsh wildfire environments. Initial concepts were developed based on stakeholder input and environmental constraints, followed by prototype development and field-informed refinement. Each design iteration focused on improving usability, durability, and system performance to ensure the device could operate effectively during extended wildland firefighting operations.

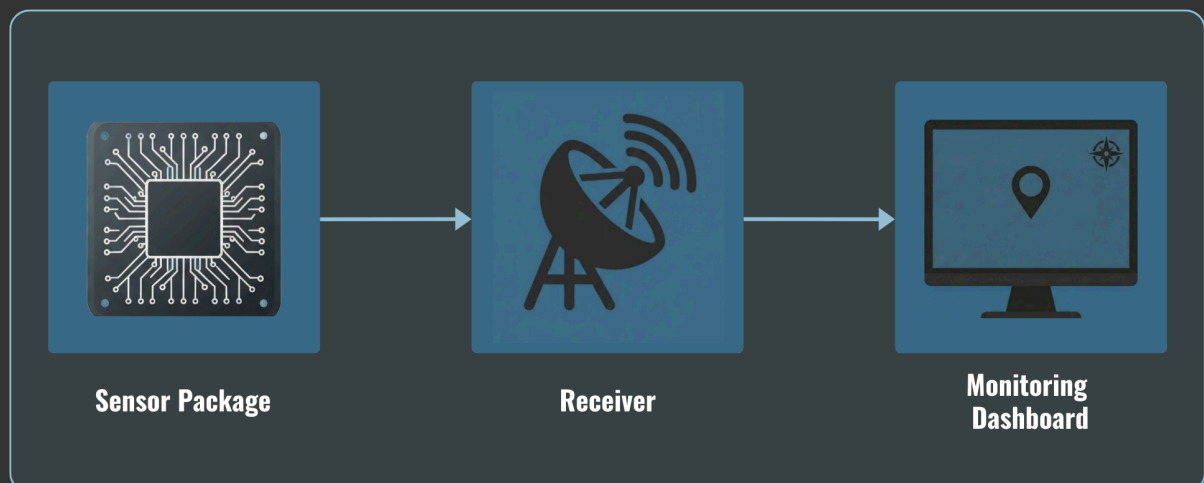
Process Flow



System Architecture

The Air Alert system is designed around a modular architecture that prioritizes reliability, simplicity, and low power consumption. A wearable sensor package continuously monitors environmental conditions and processes exposure data using an onboard microcontroller. When exposure thresholds are reached, the device provides immediate visual alerts while simultaneously logging exposure data for later analysis.

Key information is also transmitted wirelessly to a receiver, allowing crew leadership to monitor exposure conditions in real time. This distributed architecture improves situational awareness while maintaining a simple, rugged device suitable for field deployment.



The Solution

The Air Alert system provides a practical solution for improving exposure awareness in wildland firefighting environments. Designed as a rugged, wearable monitoring device, Air Alert continuously tracks carbon monoxide levels as an indicator of changing smoke conditions. By providing real-time alerts, exposure logging, and wireless reporting, the system enables firefighters and crew leadership to better recognize hazardous conditions and make informed operational decisions in the field.



Precision Monitoring

Continuous monitoring of carbon monoxide provides real-time awareness of changing smoke conditions. By tracking exposure levels throughout an incident, the device helps identify hazardous environments and supports improved understanding of cumulative exposure.



Rugged Design

The device is designed for harsh wildfire environments, with a compact enclosure capable of withstanding heat, dust, moisture, and impact. The wearable form factor allows firefighters to operate normally without additional burden or distraction.



Smart Alerts

Simple visual alerts provide immediate feedback when exposure levels increase. This intuitive system allows firefighters to quickly recognize changing conditions without needing to interpret complex sensor data during active operations.



Field Application

The Air Alert device is designed to integrate with standard firefighter gear, allowing hands-free operation during extended deployments. Real-time exposure awareness supports safer decision-making in dynamic wildfire environments while maintaining minimal impact on workflow and mobility.

Summary

Air Alert provides a practical approach to improving exposure awareness in wildland firefighting environments. By delivering real-time monitoring, intuitive alerts, and exposure data logging, the system helps firefighters better understand changing smoke conditions and reduce long-term health risks. This combination of immediate feedback and long-term tracking supports safer operational decisions and improved understanding of cumulative exposure over time.



Long-term Wellness

Tracks exposure over time to better understand cumulative smoke and combustion risks. Logged data supports long-term health monitoring and improved exposure management.



Real-time Safety

Immediate visual alerts notify firefighters as conditions change. This allows crews to reposition, rotate personnel, or adjust operations to reduce exposure.



Data-Driven Insights

Exposure data is logged throughout operations for post-incident review. This information supports operational planning and improved decision-making.

As wildfire frequency and intensity continue to increase, improving exposure awareness becomes increasingly important. Air Alert is designed to provide a simple, rugged, and practical solution for monitoring smoke-related hazards in the field. By combining real-time alerts with long-term exposure tracking, the system supports safer operations and helps protect firefighter health across extended deployments.



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