# White Paper

University of Colorado Boulder

## Team 40 - Trail Blaze Technologies


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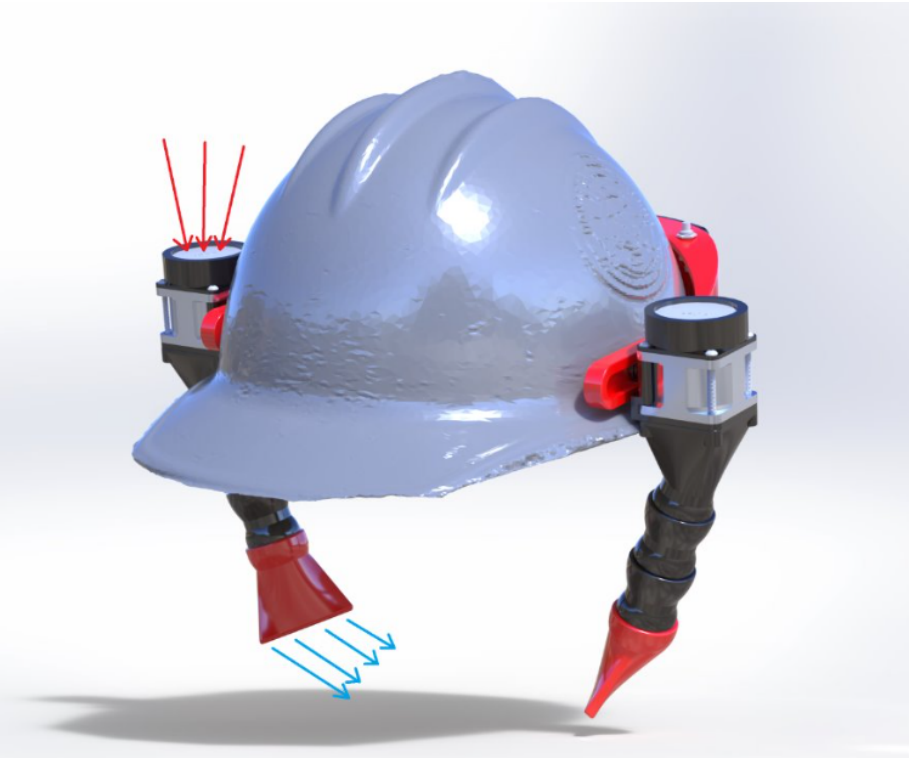

Figure 1: SmokeCloak V1

# Background and Motivation

Climate change is intensifying wildfires, as seen in Southern California's devastation in 2024, when 10 million acres burned. The U.S. employs 11,000 wildland fire- fighters and 1.2 million registered personnel. Wildland firefighters face significant health risks from inhaling smoke and harmful particles. To enhance firefighter safety and efficiency, Trail Blaze Technologies created the SmokeCloak with advice and input from the largest Wildland Firefigher team in Colorado: Boulder Mountain Fire Protection District (BMFPD). Their most relevant input, in terms of the design, was that the device should not touch the face, interfering with breathing and vision. This eliminated masks and respirators.

# Design Overview

SmokeCloak is a helmet-mounted air curtain device filtering particles as small as 4 micrometers and creating a protective air barrier around the user's nose and mouth. Powered by eight AA batteries, it delivers 3.72 watts to two fans, complying with NFPA 1977 standards and firefighter requests. Designed for easy maintenance, its adjustable air ducts allow user control over placement and angle, ensuring an efficient and direct airflow.

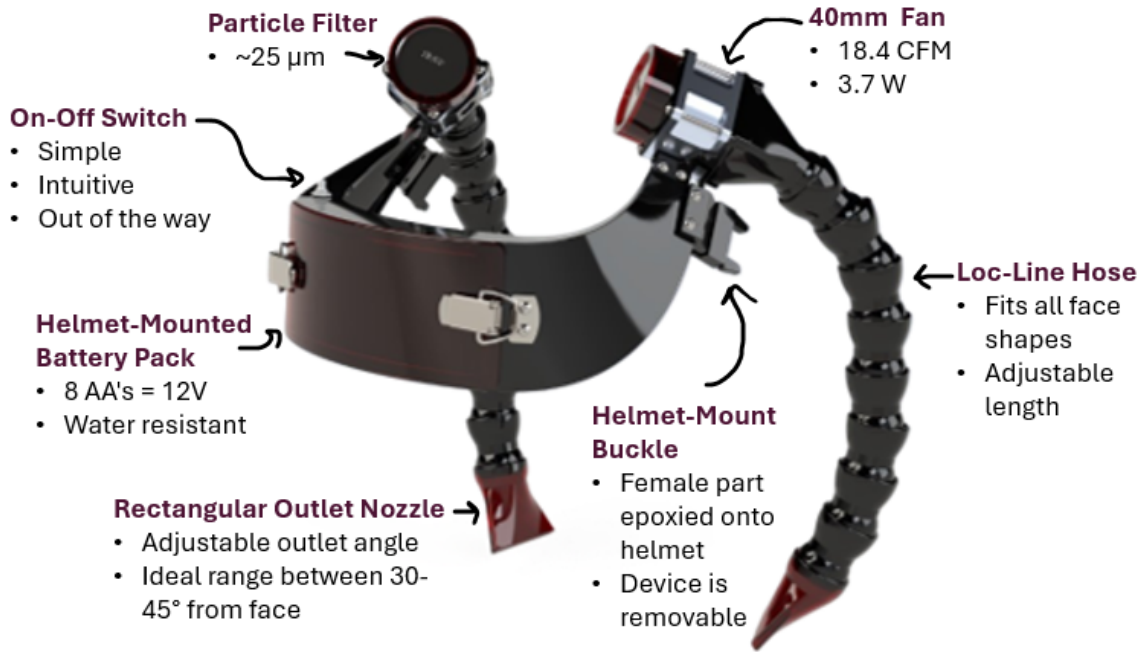


Figure 2: SmokeCloak V2 Schematic

To achieve an effective air curtain, the Reynolds number is maintained between 1700-2000, the upper limit for laminar flow, minimizing turbulence and particle mixing. With an outlet velocity of 14.45 ft/s, nozzle dimensions are optimized at 0.04" width by 1.32" length to ensure a Reynolds number of 2000.

## Testing + Manufacturing

The prototype was produced through 3D printing, though its material properties differ from those of the final injection-molded product, limiting the effectiveness of planned durability tests. The plastic prototype supports heat-stake inserts and can be assembled via soldering.

Testing showed positive results for particle deflection; a test specimen with the SmokeCloak enabled reduced the number of smoke particles in hitting the breathing zone by 85% compared to a test specimen without the SmokeCloak. The device has a runtime of 5.25 hours, exceeding the required 4 hours, and meets waterproofing standards to protect electronics.

Upcoming production steps include:

- (1) Validating the latest prototype: 4 months
- (2) Making minor adjustments for injection molding: 1 month
- (3) Partnering with an injection molding firm: 1 month
- (4) Manufacturing: 2-month lead time
- (5) Distribution: ongoing

## Business Opportunity

Producing the SmokeCloak requires an initial $95,000 investment for molds and calibration, with a production cost of $42 per unit. Streamlined injection molding reduces assembly steps. Units will sell for $80, meeting BMFPD's target and ensuring operational margins. The break-even sales volume is 2,500 units.

Firefighters often buy their own gear, which must comply with NFPA and OSHA standards. The SmokeCloak is designed to meet these requirements and aligns with requests from wildland firefighting partners. Support from the Boulder Mountain Fire Protection District provides a strong market entry point and confidence in the product.

Departments would benefit from increased efficiency, as SmokeCloak enables firefighters to work longer without lung-related issues and reduces personnel needs by improving working conditions. Retention of wildland firefighters, often affected by respiratory complications, could also improve, supporting department stability.

Early marketing relies on partnerships and word-of-mouth, while future efforts may expand with higher budgets. After entering the wildland firefighter market, the SmokeCloak could expand to secondary markets, including civilians in fire-prone areas, office and manufacturing buildings, traffic environments, and the construction industry, offering opportunities for further growth. The personal air filtration market is growing steadily, driven by pollution concerns, tech advancements, and awareness of respiratory risks, particularly in high-risk professions like firefighting.

## Competitors

Powered respirators are often heavy, expensive, and interfere with other PPE. In contrast, the SmokeCloak weighs less than 2 lbs., is helmet-integrated, cable-free, powered by 8 AA batteries, and priced at $80 compared to $450-$1600 for respirators.

Unlike masks and shrouds that hinder breathing and fog up glasses, the Smoke Cloak's air curtain technology ensures clear breathing without burdening the lungs. Competing

products like neck fans and oxygen capsules fail to address air quality or firefighting needs, making the SmokeCloak uniquely suited to wildland firefighters.

| | Breathability | Comfort | Protection | Price |
|---|---|---|---|---|
| **SmokeCloak** | ✓ | ✓ | ✓ | ✓ |
| Powered Respirators | ✓ | ✗ | ✓ | ✗ |
| Masks | ✗ | ✗ | ✓ | ✓ |
| No Protection | ✗ | ✓ | ✗ | ✓ |

Figure 3: Competition: Strengths and Weaknesses

# Conclusion

There is currently no effective respiratory protection devices tailored to wildland firefighters' needs. The SmokeCloak is designed to change that, safeguarding the health of the brave individuals who defend us against increasingly intense wildfires. By improving breathability, it enables firefighters to work more efficiently and for extended periods.

Support SmokeCloak today and help protect the heroes who protect us.

# The Team

Trail Blaze Technologies is led by six mechanical engineers specializing in areas such as HVAC design, CAD, 3D printing, project management, and marketing. The team collaborates with advisors like Tim Ruybal, an experienced engineer skilled in stakeholder management, injection molding, and validation setup.

Supported by the Mechanical Engineering Senior Design Program, they work with Daniel Riffell, a start-up expert and chair of the Rocky Mountain SolidWorks region, and Jonathan Harper, a fluid mechanics expert at CU Boulder and volunteer firefighter. Consultations with air quality specialists, firefighting volunteers, and an electrical engineer ensure the design's scientific robustness and the start-up's potential for success.


Figure 4: The Trail Blaze Technologies Team