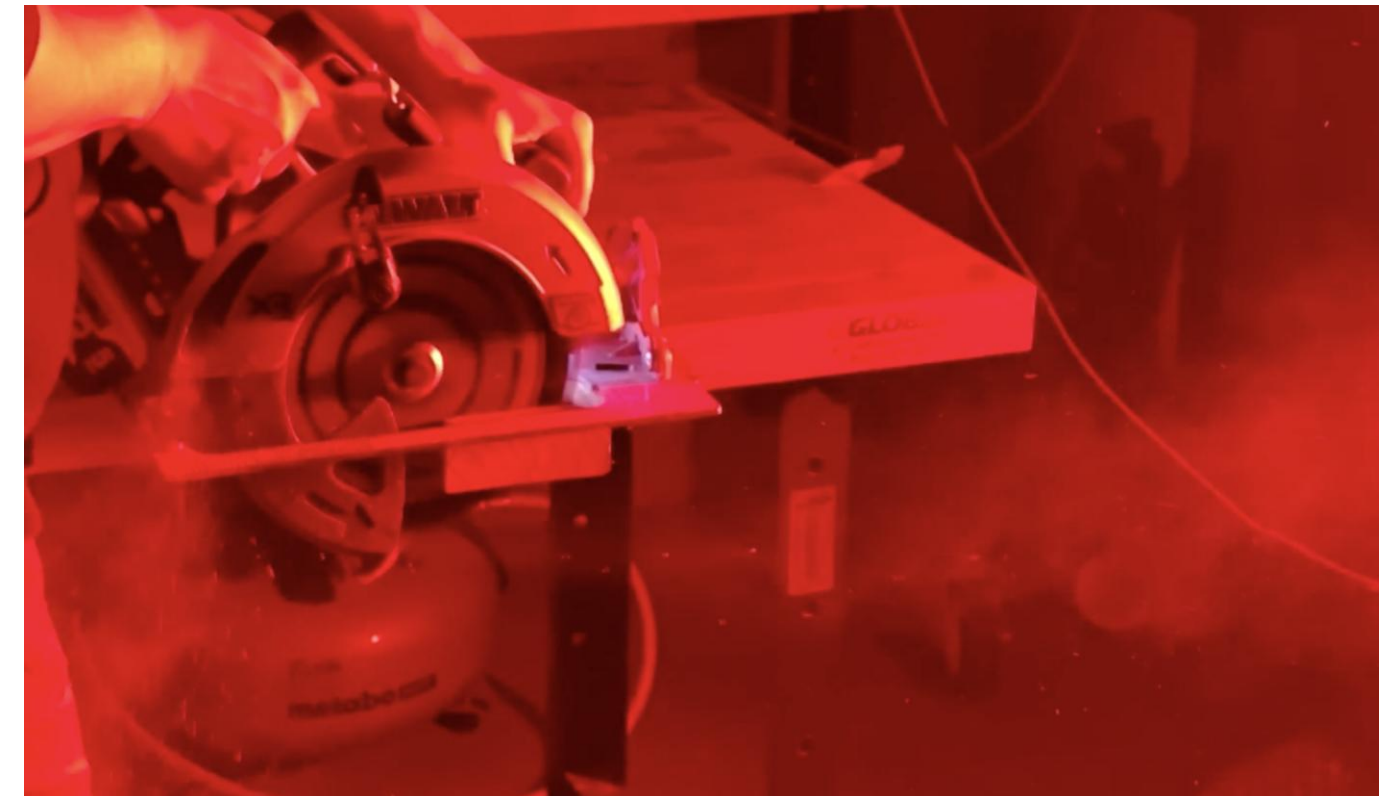


Introduction

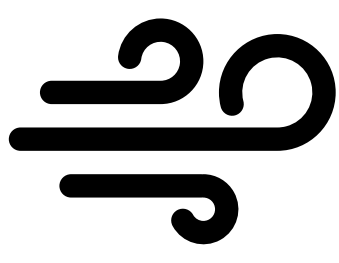
Stanley Black & Decker (SBD) wanted to visualize the dust cloud produced by a power tool to compare iterations of dust management systems. The device should validate SBD's existing Computational Fluid Dynamics (CFD) simulations.



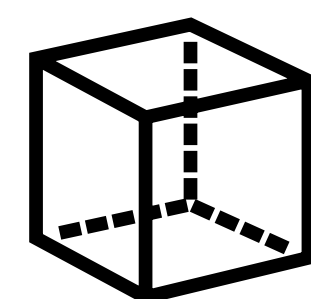
Key Design Requirements



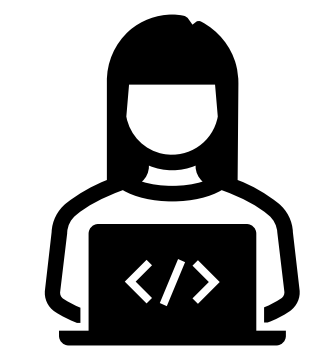
Allows for unobstructed **operator tool use** and natural **dust cloud expansion**



Simulates the behavior of **inhalable dust particles** (diameter between 0.5 - 5 μ m)



Tracks the dust cloud in the area **between the tool and the operator's face** (estimated as 1 cubic meter)



Conveys raw data results in an **intuitive 3D simulation**

What is PTV (Particle Tracking Velocimetry)?

PTV is a method of tracking particles in videos. It completes the following:

1. Filters video frames to only see our **"particles" (the bubbles)**
2. Detects **where those bubbles (tracers)** are in each image
3. Calculates where the bubbles are in **real space**
4. Tracks the bubble movement **from frame to frame**
5. Outputs a **time-evolving map** of the bubble flow

This map is **equivalent** to the flow of dust around the tool.

Solution

Our solution is a **PTV system** that:

- ✓ Provides **3D stereoscopic tracking** of the tracers across a 1-meter cubic volume using **three cameras**
- ✓ Enables **modularity** for different tools and focus with:
 - ✓ Adjustable side camera angles from **5° to 25°** from the center camera
 - ✓ Flexible configurations of the LED Array, Cameras, and Wands along the **80/20 rail frame**
- ✓ Provides engineers **3D plots** of the flow field and an **animation** of tracer's positions and velocity relative to the tool
- ✓ Concludes setup, calibration, testing within **1 hour** for a two-person team

System Design

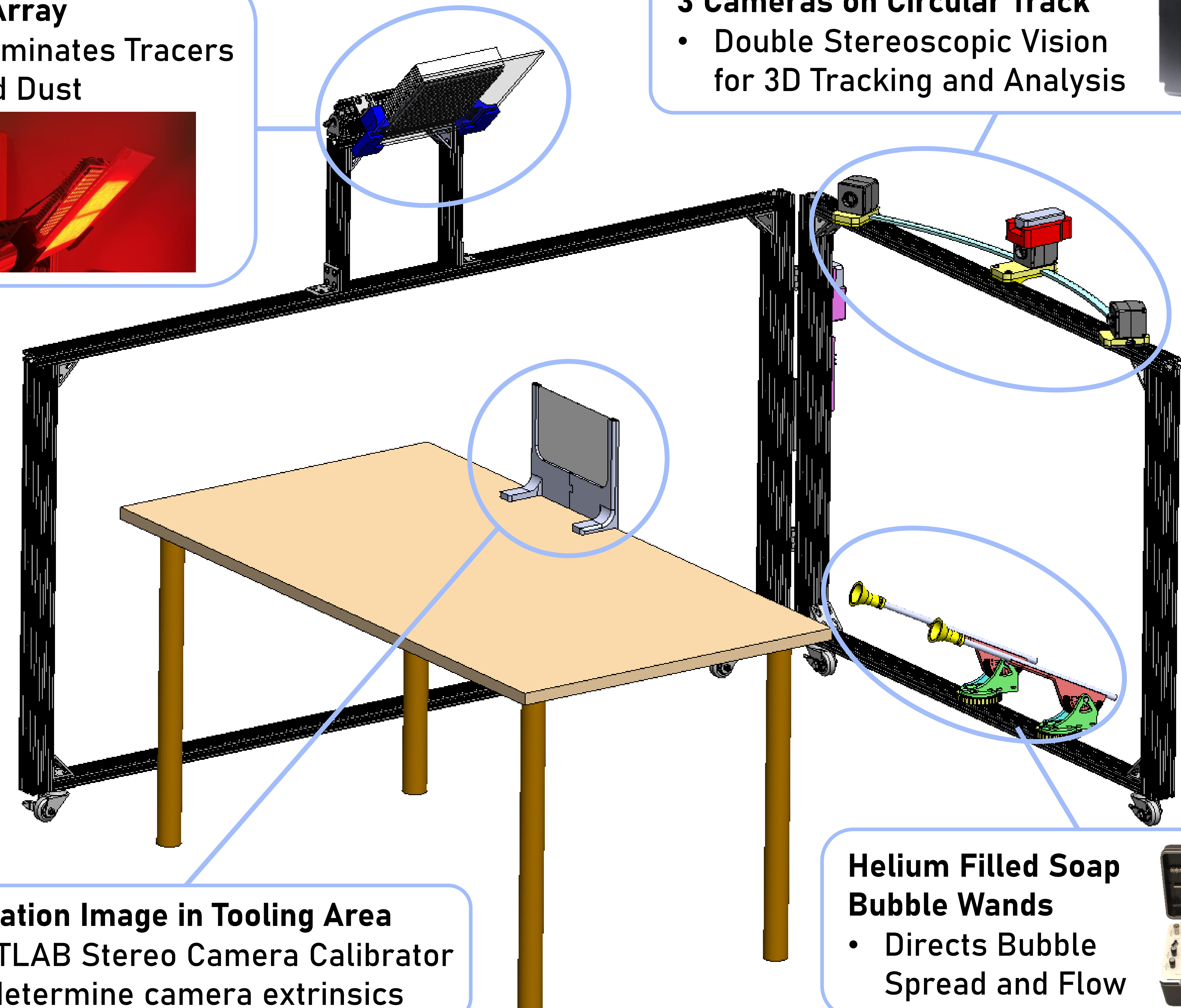
LED Array

- Illuminates Tracers and Dust



3 Cameras on Circular Track

- Double Stereoscopic Vision for 3D Tracking and Analysis



Calibration Image in Tooling Area

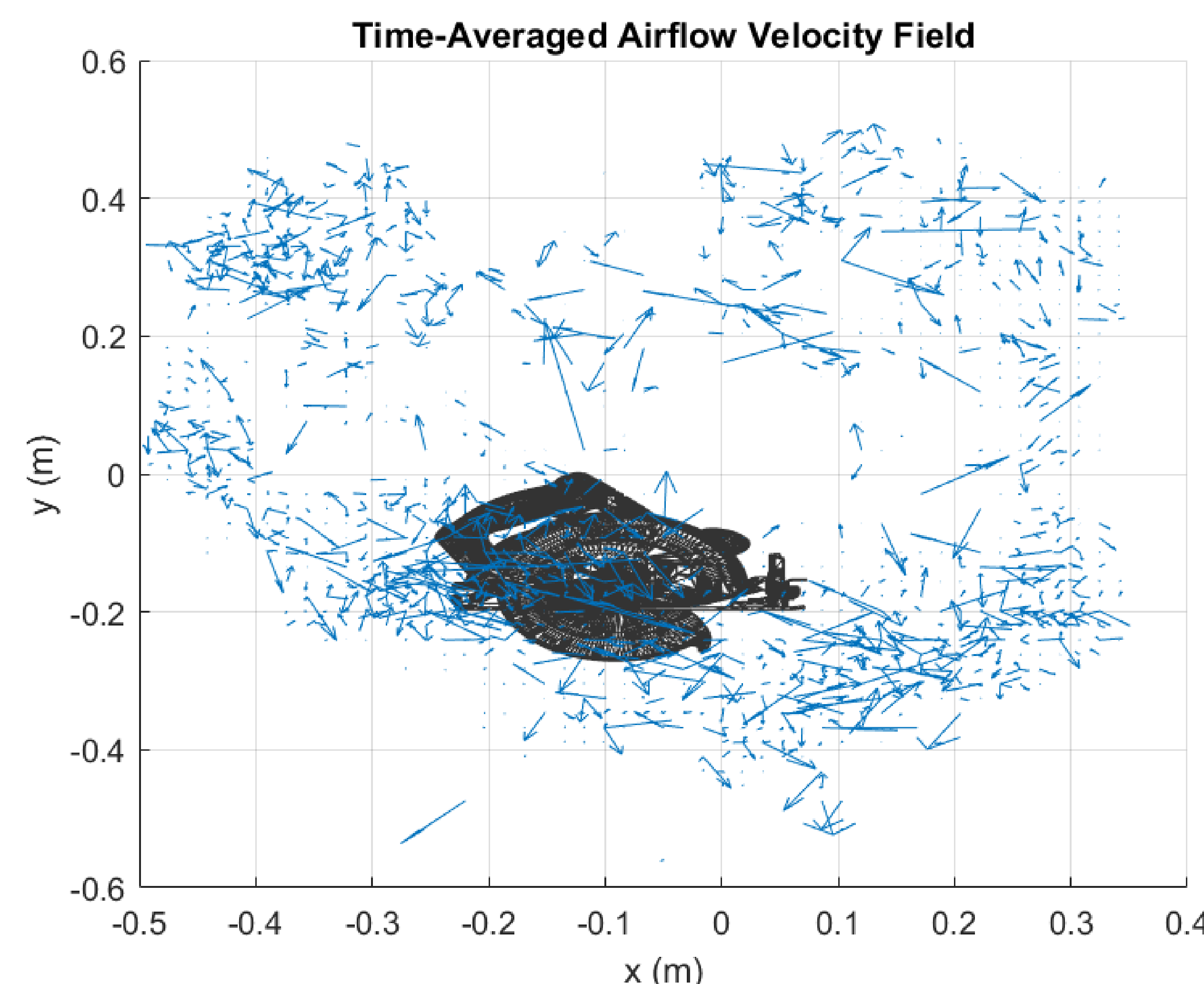
- MATLAB Stereo Camera Calibrator to determine camera extrinsics

Helium Filled Soap Bubble Wands

- Directs Bubble Spread and Flow



Results



Testing our program with footage from a circular saw's cut, we proved the program can:

- ✓ Locate and calibrate our cameras with over 90% accuracy
- ✓ Track the bubbles as they interact with the saw's airflow
- ✓ Plot the bubble pathlines in 3D space relative to the circular saw

Future Work

- Reconfigure system to physically validate bubble-dust comparison
- File patent (currently patent pending!)
- Streamline programs to be more intuitive