Applications of a Scaled Aerodynamic Model for Simulations of Airflows in a Longwall Mine

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June 13th, 2017

Longwall USA Conference

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Outline

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- Measurement and Instrumentation
- Scaling of Airflow
- Development of LIAM
- Experiment Design
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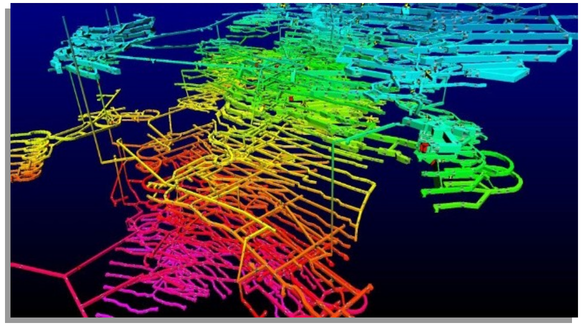
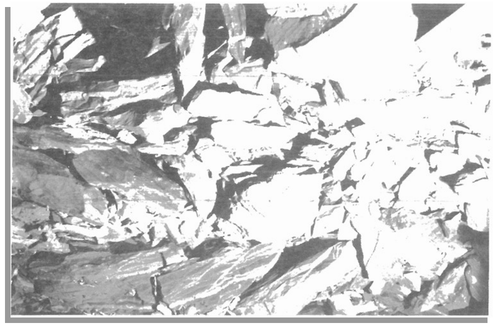
Introduction

- Ventilation systems are complex and dynamic which makes it difficult to conduct accurate and detailed field experiments
- Simulate inaccessible areas of a longwall panel through physical modeling
- Simulating the performance of a ventilation system under controlled conditions
- A 1:30 scale Longwall Instrumented Aerodynamic Model (LIAM) was designed and constructed to simulate a portion of a longwall operation
- LIAM is built with critical details of the face and face machinery


Source: Chasm Consulting


Source: Pappas and Mark (1993)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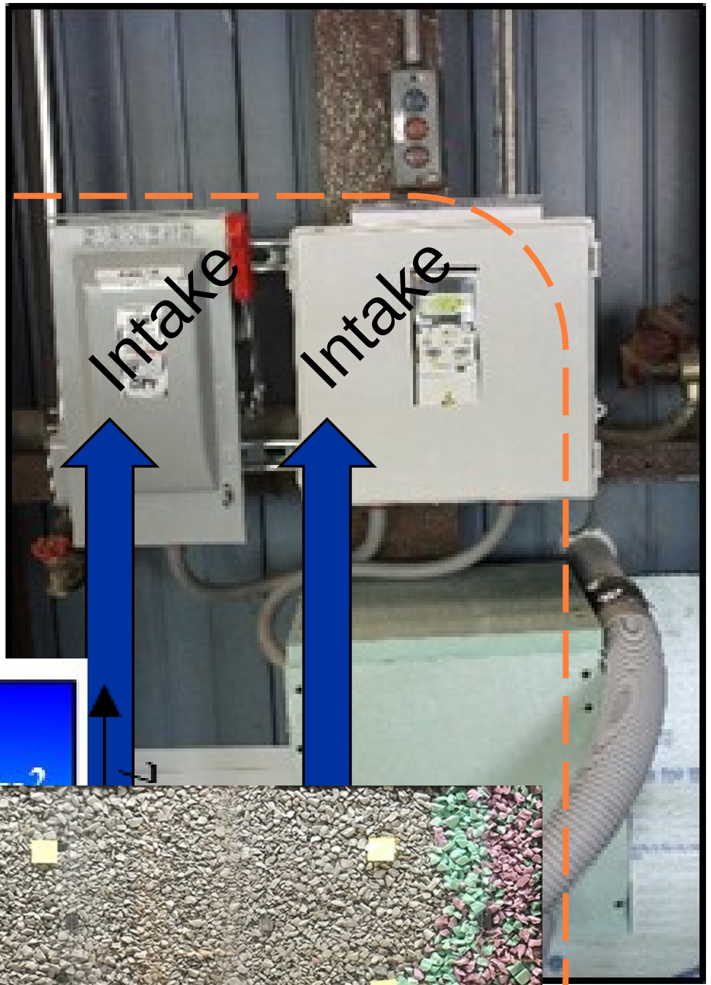
Layout and Design

- Single panel with a three-entry headgate and tailgate configuration
- LIAM is 29 ft. long, 16 ft. wide, and is 2.75 ft. in height
- Face length is 24 ft., which represents a 720 ft. in full scale with 127 shields
- Gob represents an early stage of mining for near face studies before
- Ve
  va

Return
Return
Return
Belt
Intake
Intake

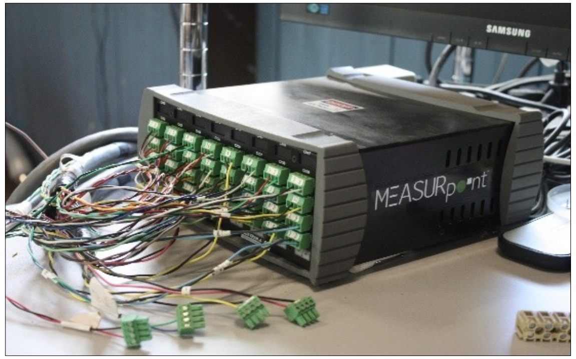



Back Bleeder
Gob
Curtain
Tailgate

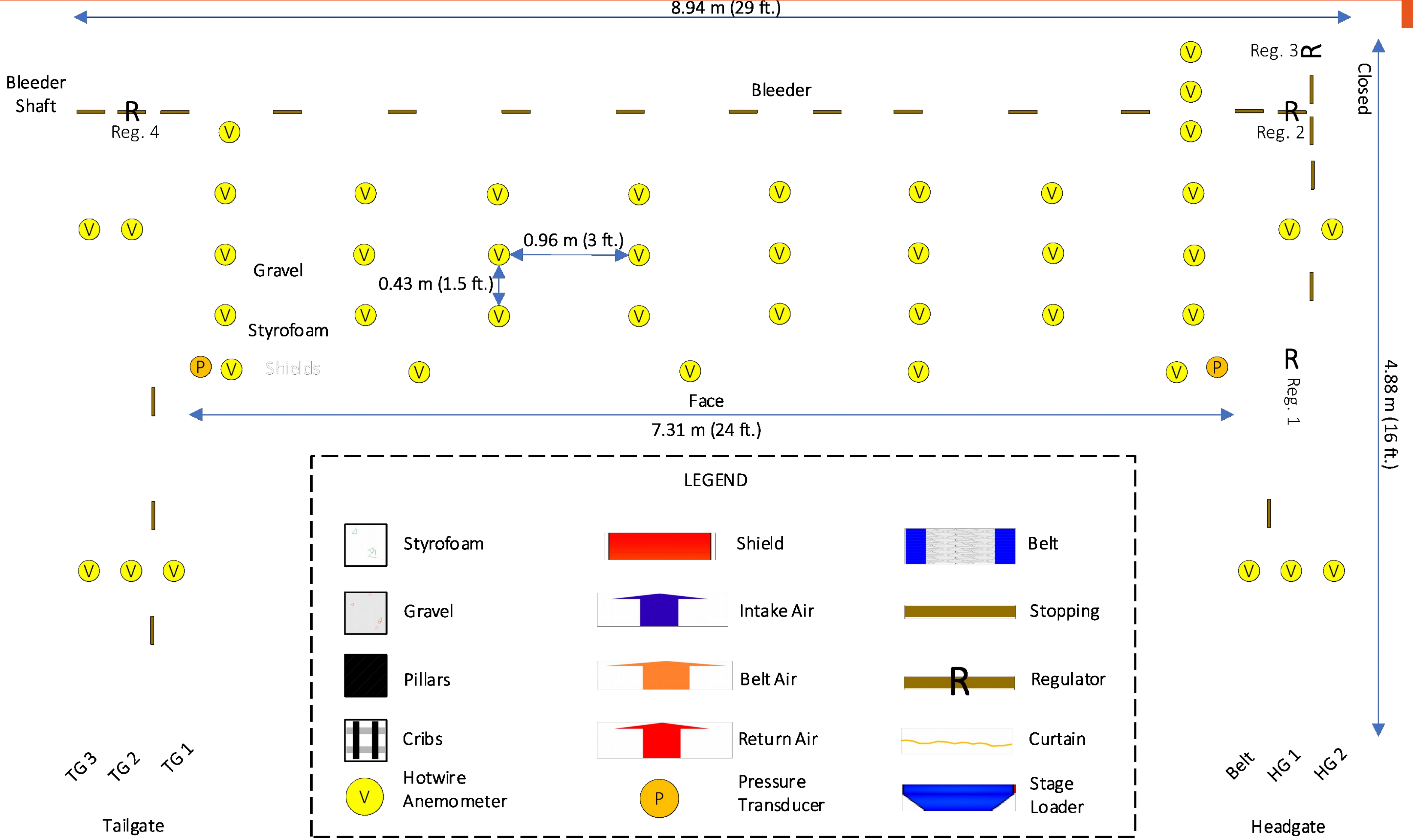
Visual Recording using Smoke

Measurement and Instrumentation

- Velocity: 19 hotwire anemometers are located in different entries and 24 hotwire anemometers are located in the gob
- Pressure: Differential pressure across the face is recorded
- Temperature: Two thermocouple record air temperature
- Data Acquisition System: 45 sensors connected to the computer
- Smoke Generator: Theatrical smoke is used for visualization of airflow paths, eddy currents, and gob-face interaction
- Video: Each test is recorded using a ceiling mounted wide-angle camera that helps in validating the airflow patterns



LIAM Schematic



Scaling of Airflow

Model	Specification	Characteristic
Scale for geometry	x 1/30th	3 inch high face in LIAM represents 7.5 ft face in full-scale. 24 ft face length in LIAM represents 720 ft in full-scale
Scale for velocity	x 0.56	280 fpm in LIAM represents 500 fpm in full-scale
Scale for flow	x 0.00062	62 cfm in LIAM represents 100 kcfm in full-scale
Turbulent dispersion	Reynolds number > 6000	Similitude for turbulent dispersion. Reynolds number ~12000 in headgate entry.
Layer formation	Conservation of the Richardson number	Similitude for layering

Development of LIAM

Construction of geometrically scaled model based on 1:30 scale

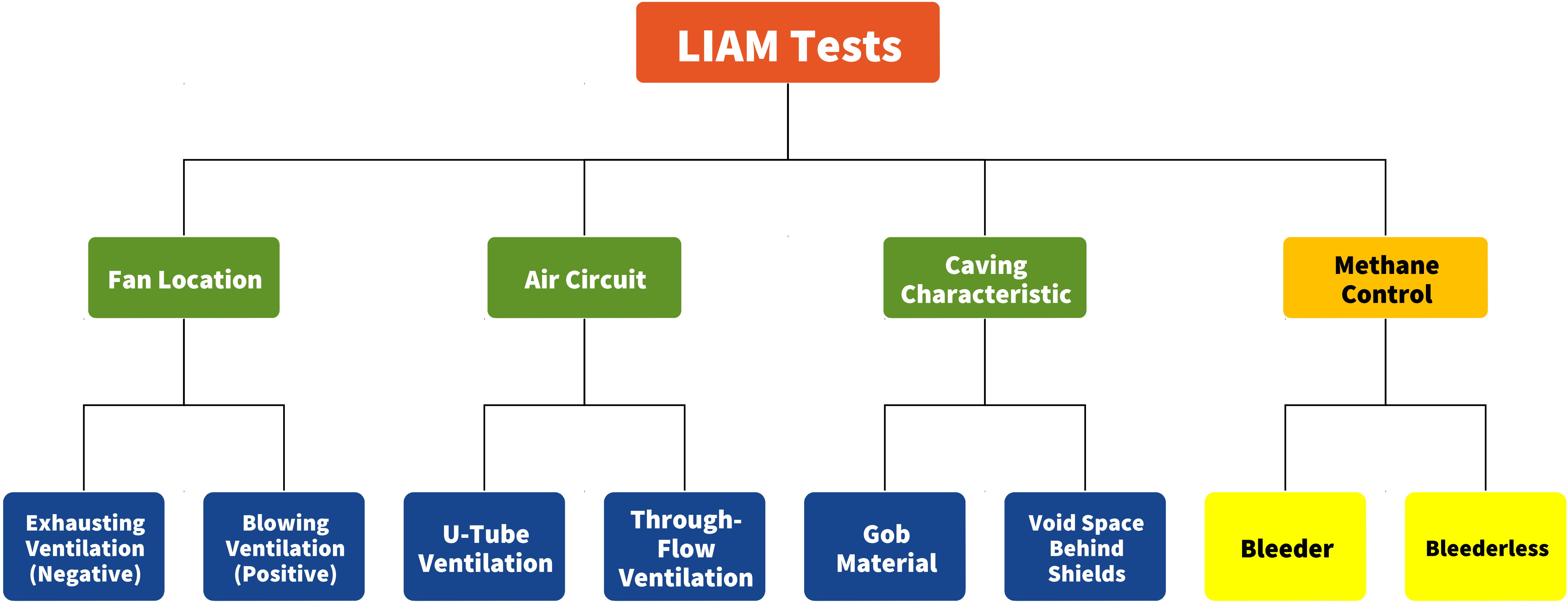
Standard testing procedure and scaling of airflow using gob material of known properties

Calibration of sensors by conducting baseline testing

Calculation of porosities of various gob materials

Experimental tests to simulate airflow in a longwall panel

Experiment Design



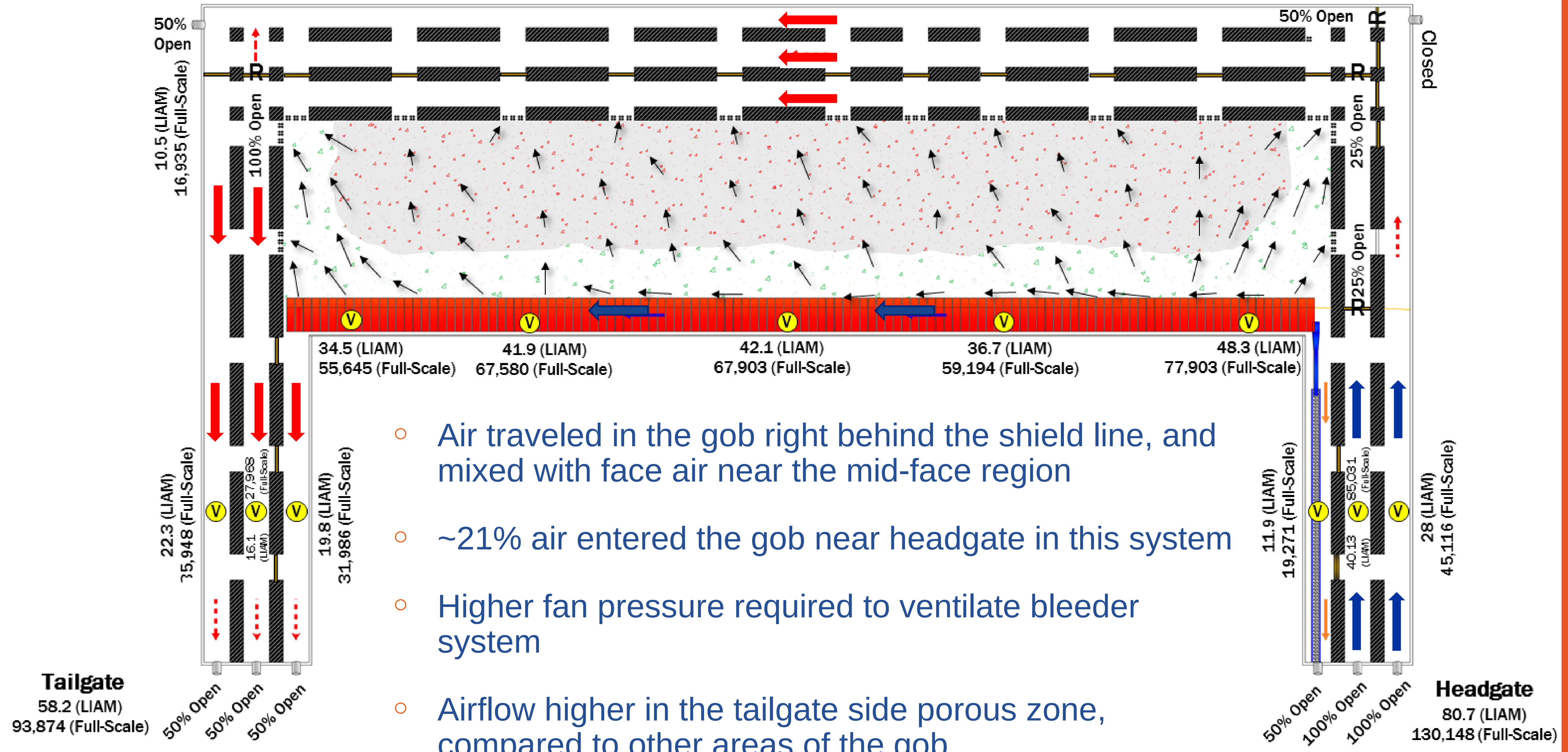
Test Conditions

- Objective: Measure the air velocities within the gob, quantify the gob-face interaction, and measure airflows on face
- LIAM offers the unique opportunity to easily modify and compare different ventilation systems
- Bleeder System: Exhaust on the tailgate side used to simulate a bleeder shaft
- Bleederless System: Stoppings added around the gob

Parameter	Bleeder	Bleederless
Fan speed	2400 RPM	2160 RPM
Velocity at Face (Headgate)	280 fpm	269 fpm
Intake Airflow	80.6 cfm	80.7 cfm
Stoppings	No stoppings around the gob	Stoppings added between the gob and back entries
Gob Material	Gravel and Styrofoam	Gravel and Styrofoam

Results from Bleeder System

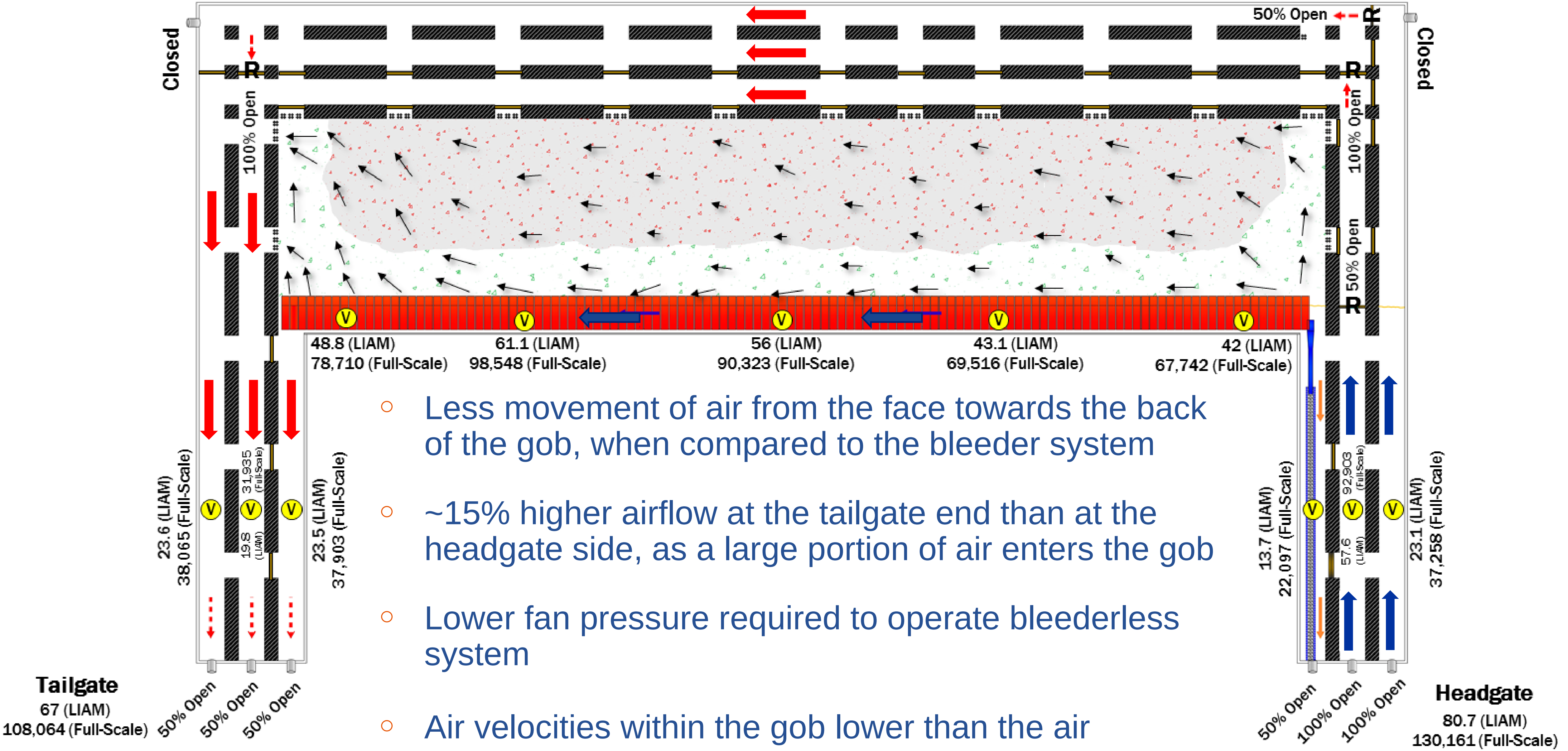
(All airflows are in cfm)



- Air traveled in the gob right behind the shield line, and mixed with face air near the mid-face region
- ~21% air entered the gob near headgate in this system
- Higher fan pressure required to ventilate bleeder system
- Airflow higher in the tailgate side porous zone, compared to other areas of the gob

Results from Bleederless System

(All airflows are in cfm)



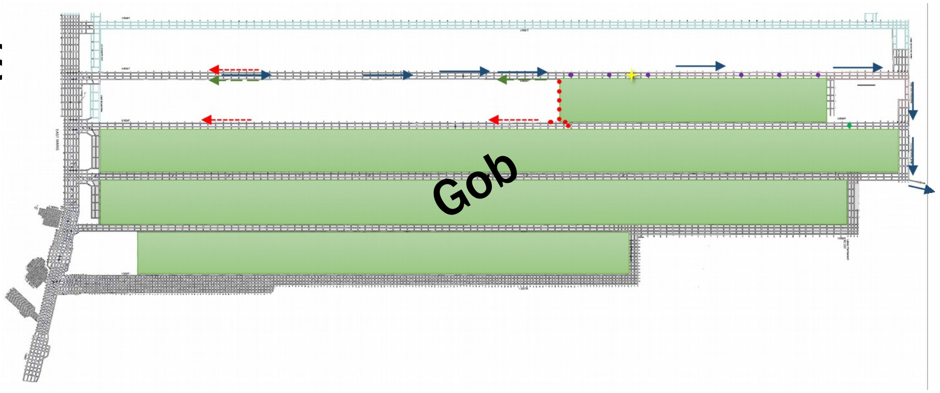
- Less movement of air from the face towards the back of the gob, when compared to the bleeder system
- ~15% higher airflow at the tailgate end than at the headgate side, as a large portion of air enters the gob
- Lower fan pressure required to operate bleederless system
- Air velocities within the gob lower than the air velocities in the bleeder system

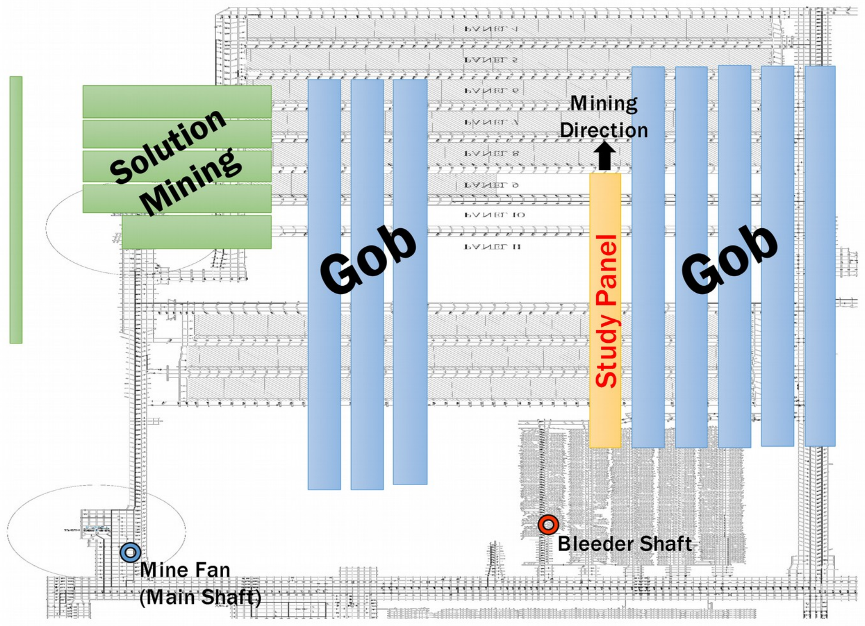
Summary

- An aerodynamically and geometrically scaled physical model was successfully developed with critical details of a longwall panel
- Scaling relationships were successfully derived to preserve the physical and dynamic similitude
- Simulated airflow streams within the gob, gob-face interaction for bleeder and bleederless ventilation systems were demonstrated
- Bleeder and bleederless ventilation systems were compared for the same mining configurations

Future Work

- Complement field and numerical modeling studies
- Caving characteristics and void space behind the shields
- Mine specific studies to optimize and mitigate problems in a longwall mine
- Study of gas emission in the gob





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NIOSH Mining Webinar:

Improvement of Longwall Ventilation

September 21, 2017

For more information,
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Thank you for your attention!

Questions?

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Aerial view of the NIOSH Pittsburgh Laboratory