Longwall Dust Control

KY Professional Engineers in Mining Seminar

September 11, 2015

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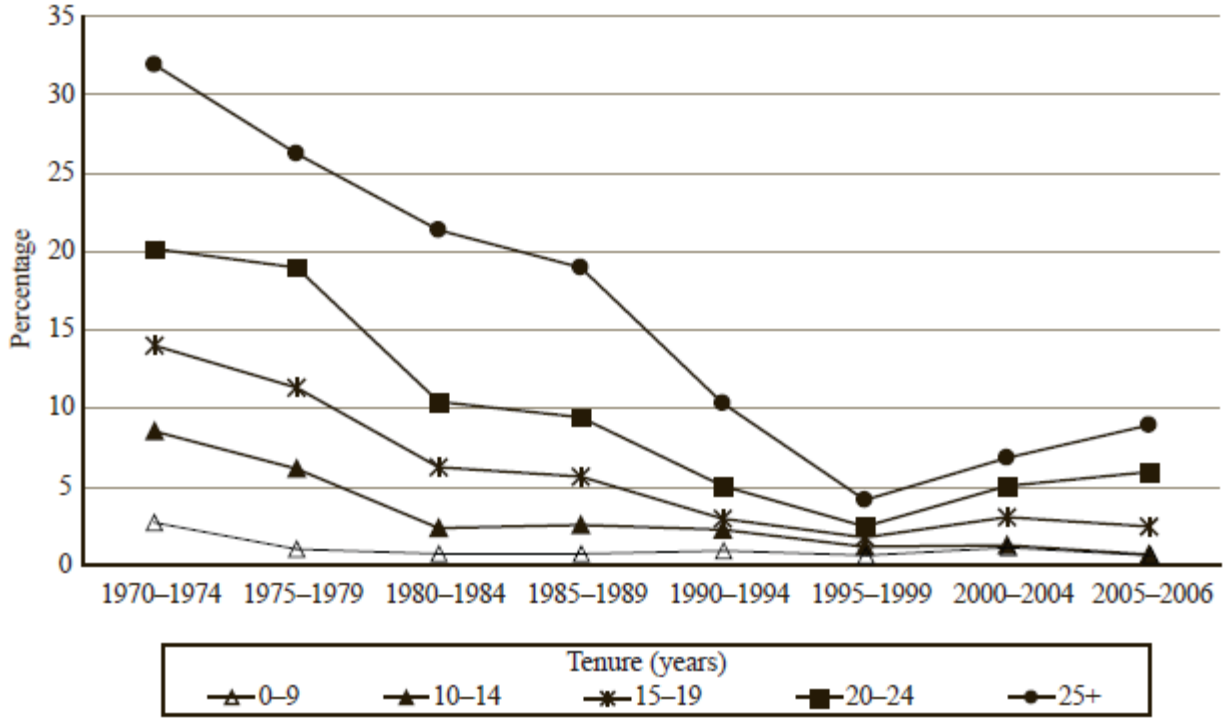
PEM

Moving Kentucky Forward

UK UNIVERSITY OF KENTUCKY

Trend in CWP through 2006



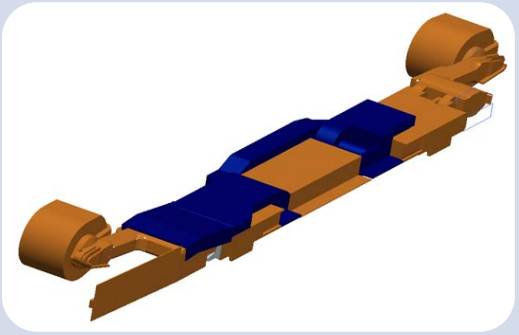
Percentage of examine miners with coal worker's pneumoconiosis (category 1/0+) by tenure in mining, 1970 – 2006 (NIOSH, 2008)

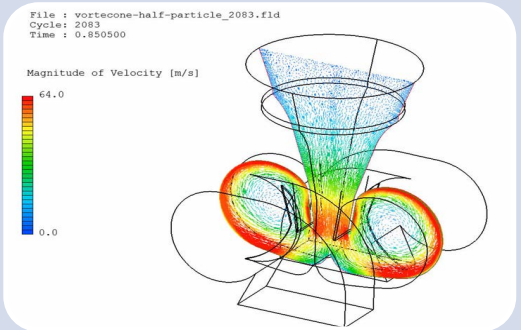
MSHA New Dust Rule

August 1st, 2014	• Revised full shift samplingImmediate corrective actions • Improved record keeping • Increased medical surveillance
February 1st, 2016	• Continuous personal dust monitor (CPDM) • High exposure occupations- more sampling.
August 1st, 2016	• Overall dust standard: 2.0 - 1.5 mg/m^3 • Miners workplace: 1.0 - 0.5 mg/m^3

Source: http://www.msha.gov/endblacklung/docs/summaryEffectiveDates.pdf

UK Dust Mitigation Research





Flooded Bed Scrubber for Longwall Shearer

Novel Vortecone Scrubber Technology Transfer

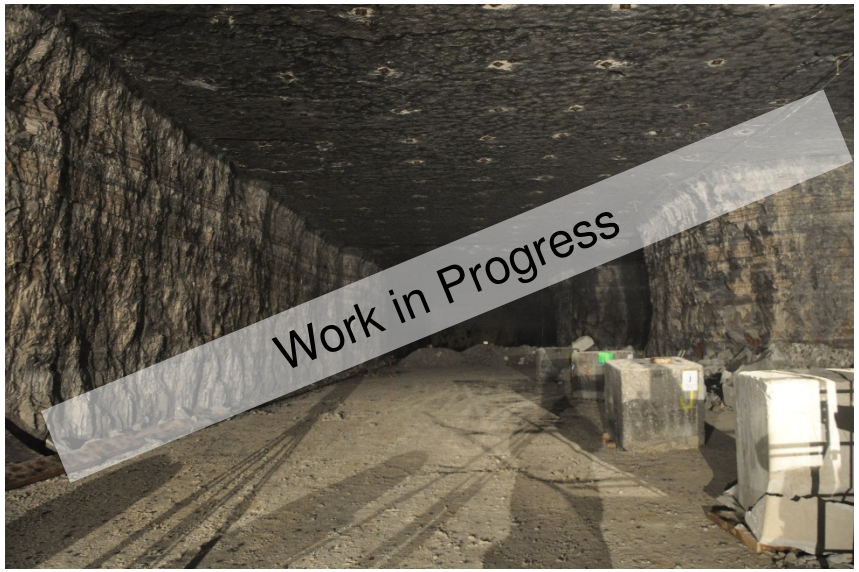
Passive 'Wing' Regulator

Vortecone Scrubber for Mining

- UK/Toyota Joint development
- Applicable for respirable size fraction
- High cleaning efficiency
- Minimal maintenance
- Scalable in match air requirements
  - From 200 cfm lab models to 60,000 cfm at Toyota

Passive ‘Wing’ Regulator

- Full scale test gallery for testing dust and methane controls
- 1:1 continuous miner
  - Body sprays
  - Rotating drum
- Combination of engineering controls
  - Scrubber
  - Wing Regulator
  - Sprays



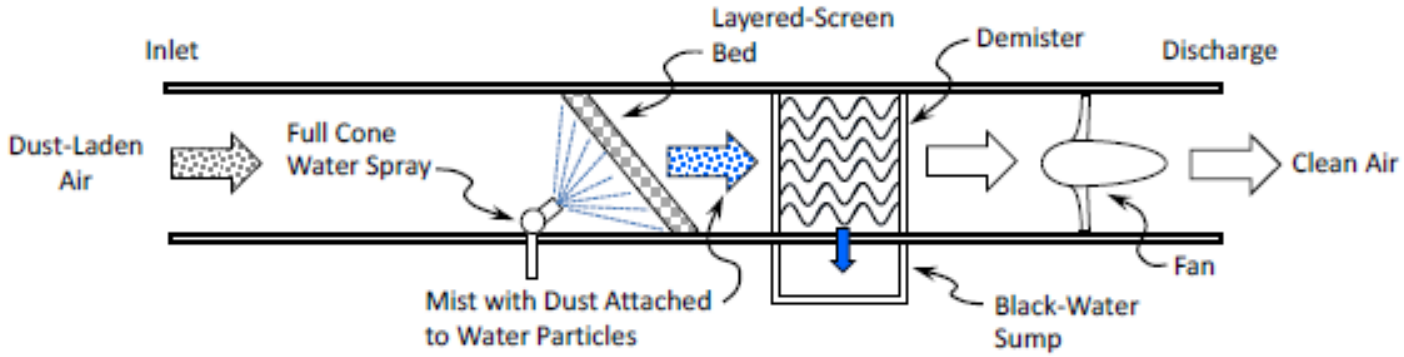
Longwall Dust Control Challenges

Longwall

Air Quantity, 67 kcfm	Air Quantity, 7 kcfm
High Production	Relatively lower production
Airflow along the face	Blind heading
Multiple, scattered sources of dust	Localized source

Room and Pillar

Flooded Bed Scrubber for Longwall Shearer



- Along with dilution and water sprays, common dust capture technology for continuous miner units
- Cleaning efficiencies between 60% and 90% (NIOSH 1997)(USBM, 1990)
- Potential for longwall shearer

ACARP Project

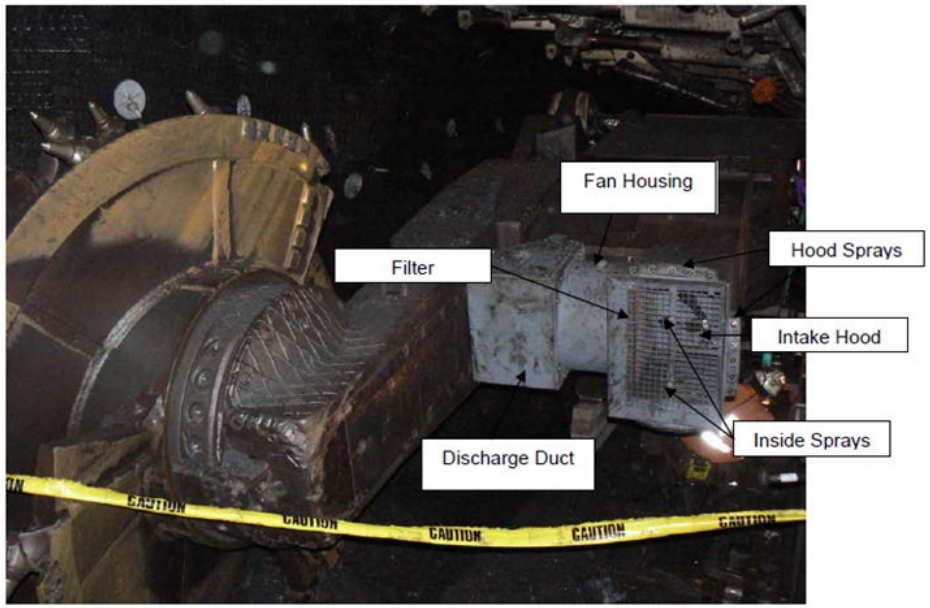
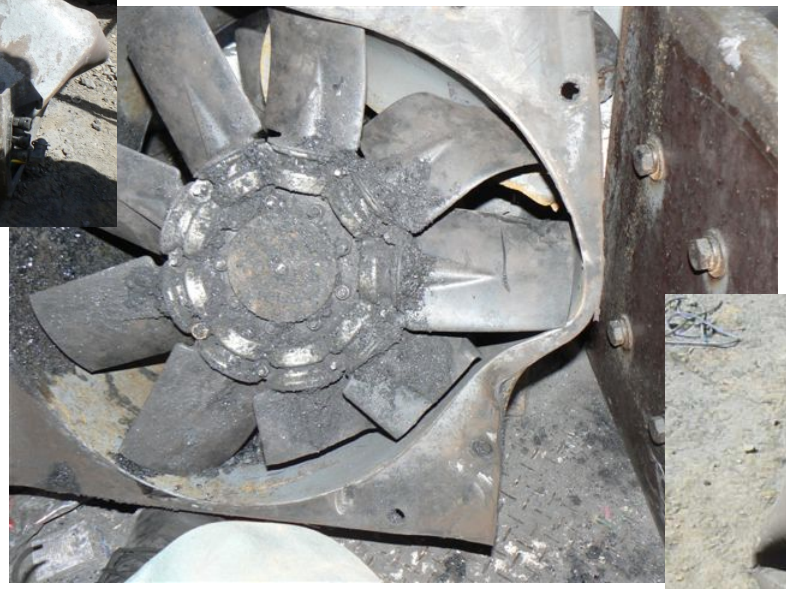


Figure 7. The installation of the final scrubber design

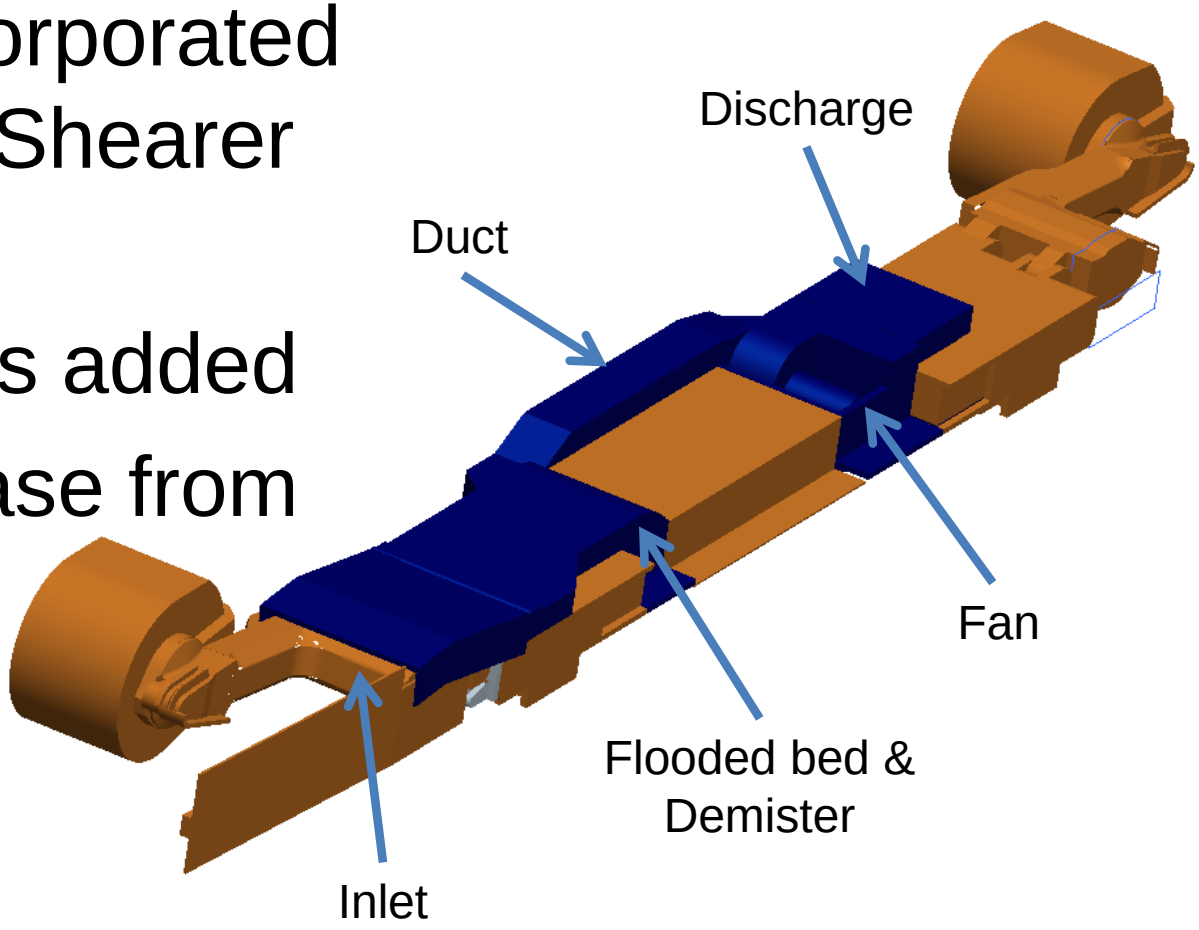
- Following on from an Australian Project ending in 2009
- Compact modular scrubber added to the ranging arm
- Reduction in dust concentration from 14% to 56% measured outby the shearer operator

Field Trials

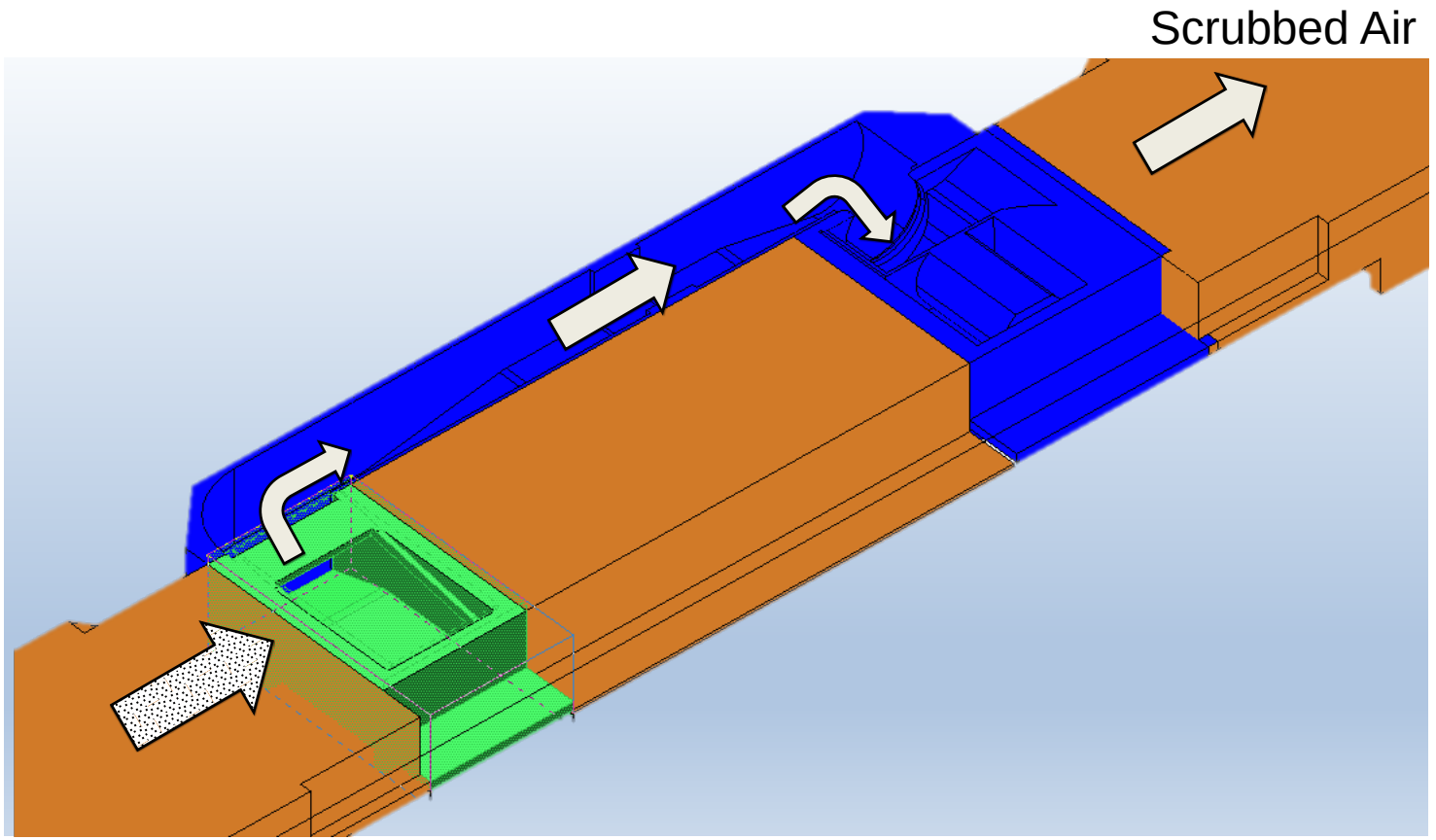


Conceptual Layout

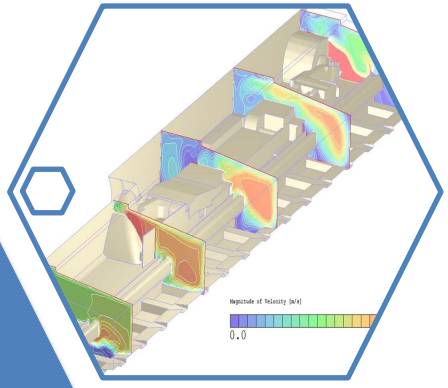
- Scrubber incorporated into Joy 7LS Shearer
- Two new compartments added
- Length increase from 55’ to 62’



Airflow Arrangement



Research Approach



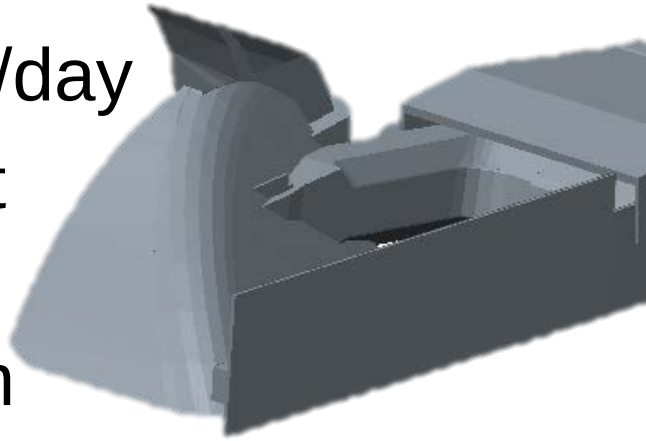
CFD Modeling

Reduced Scale Modeling

Full Scale Prototype

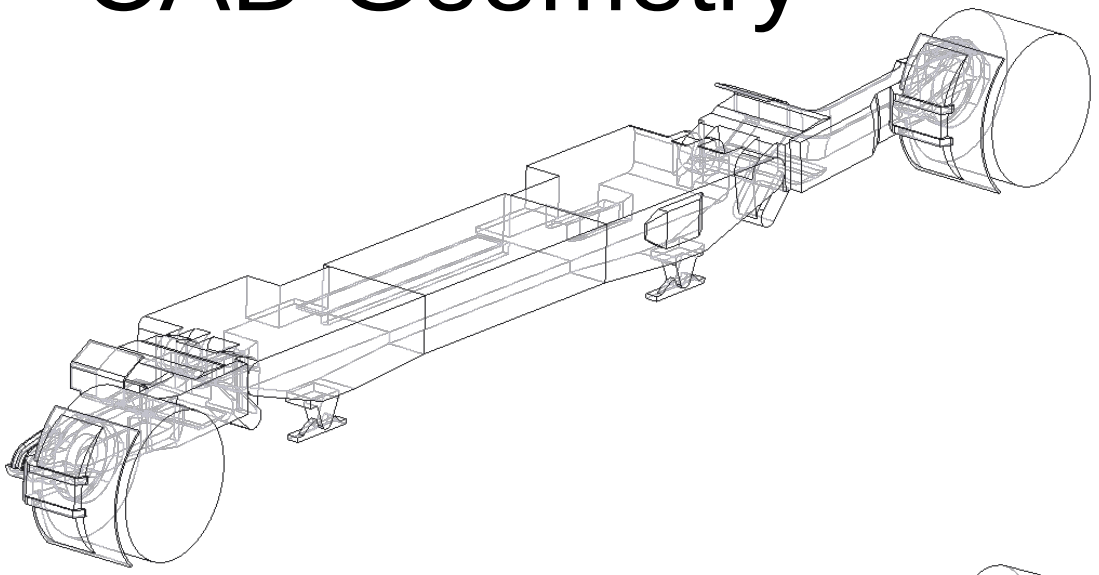
CFD Modeling: Site Visit

- Pittsburgh seam: 7’ thick
- Average production: 42,000 Ton/day
- Bidirectional cutting with 1,000 ft panels.
- Shearer drums rotating at 45 rpm
- AFC moving at 355-400 fpm
- Airflow velocities, per ventilation plan 500 fpm 20 shields inby the headgate
- Muck profile generated by the leading drum, primary source of dust

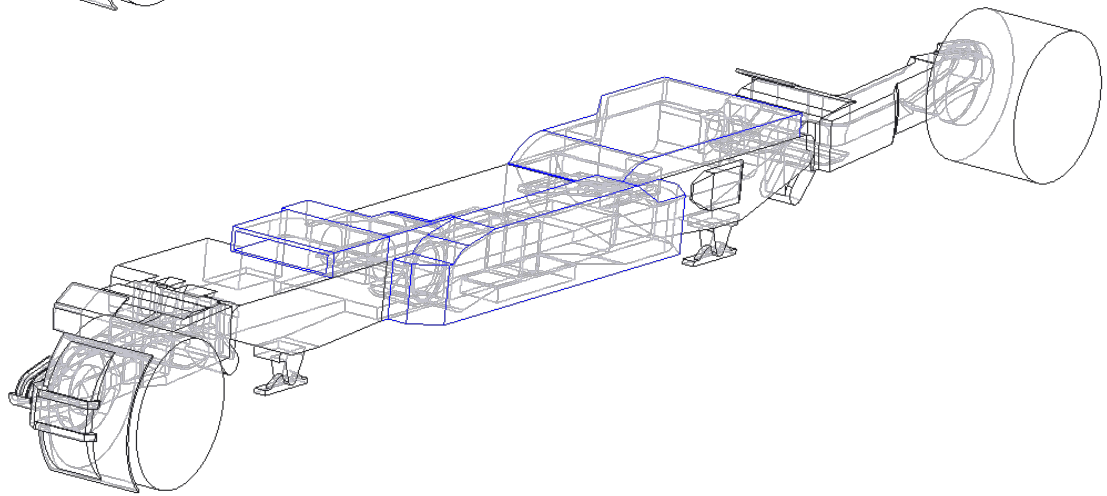


CAD Geometry

Original

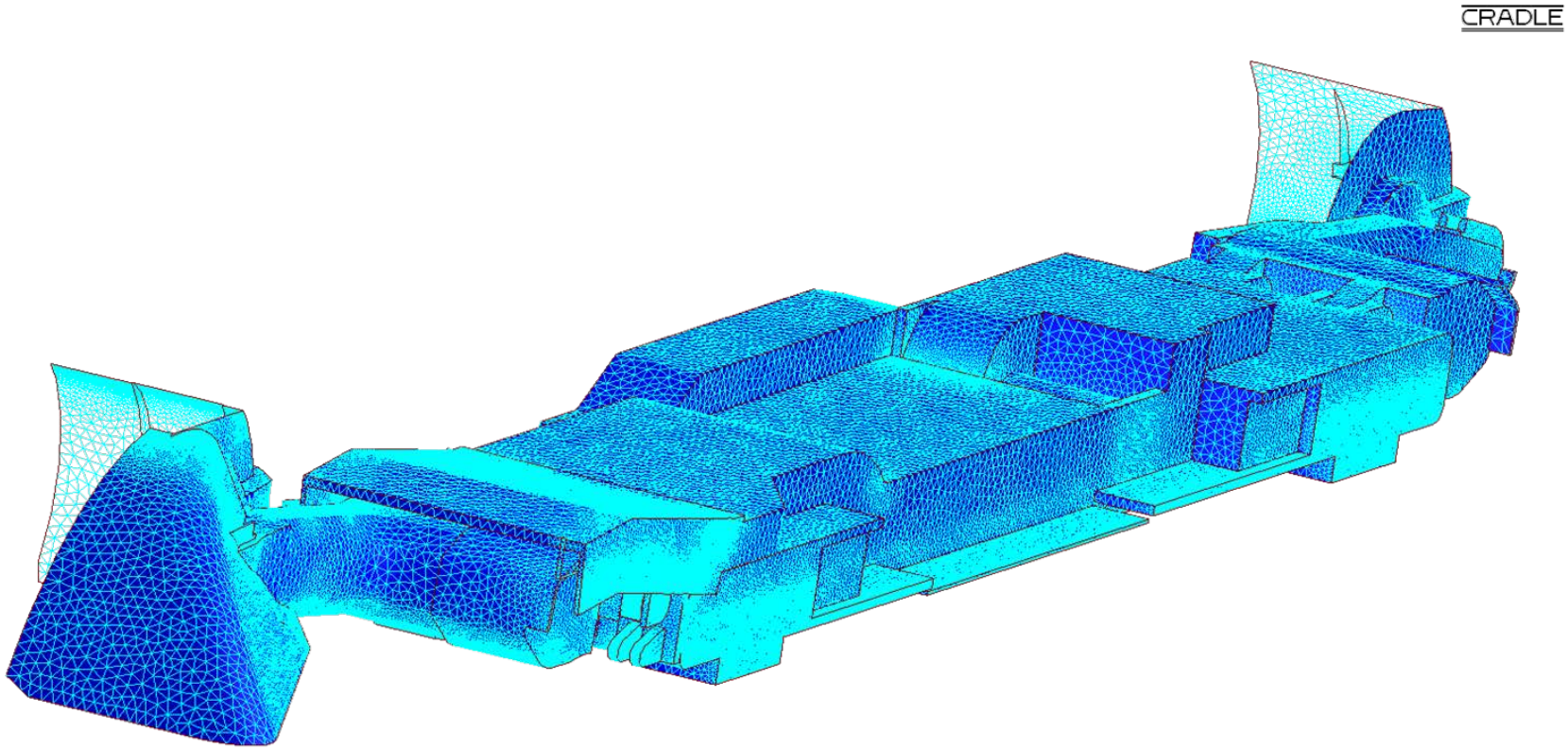


UK Modifications



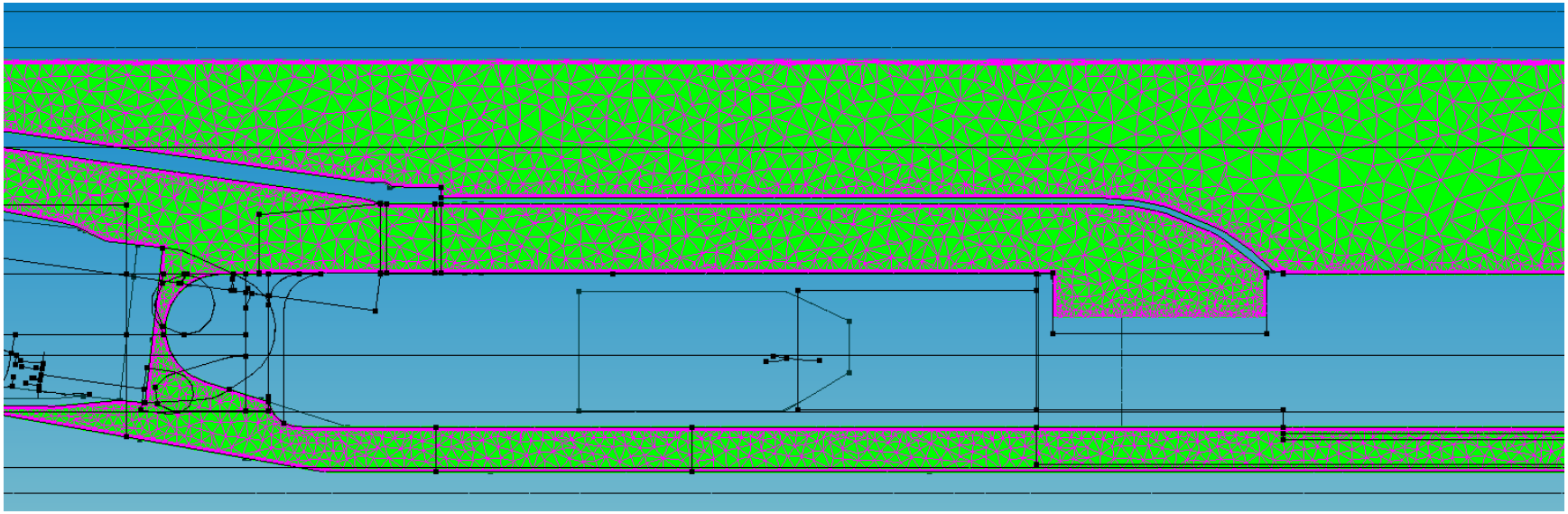
Original shearer model provided by JOY

CFD Model Preparation



2.2 Million Elements Used

CFD Model Preparation



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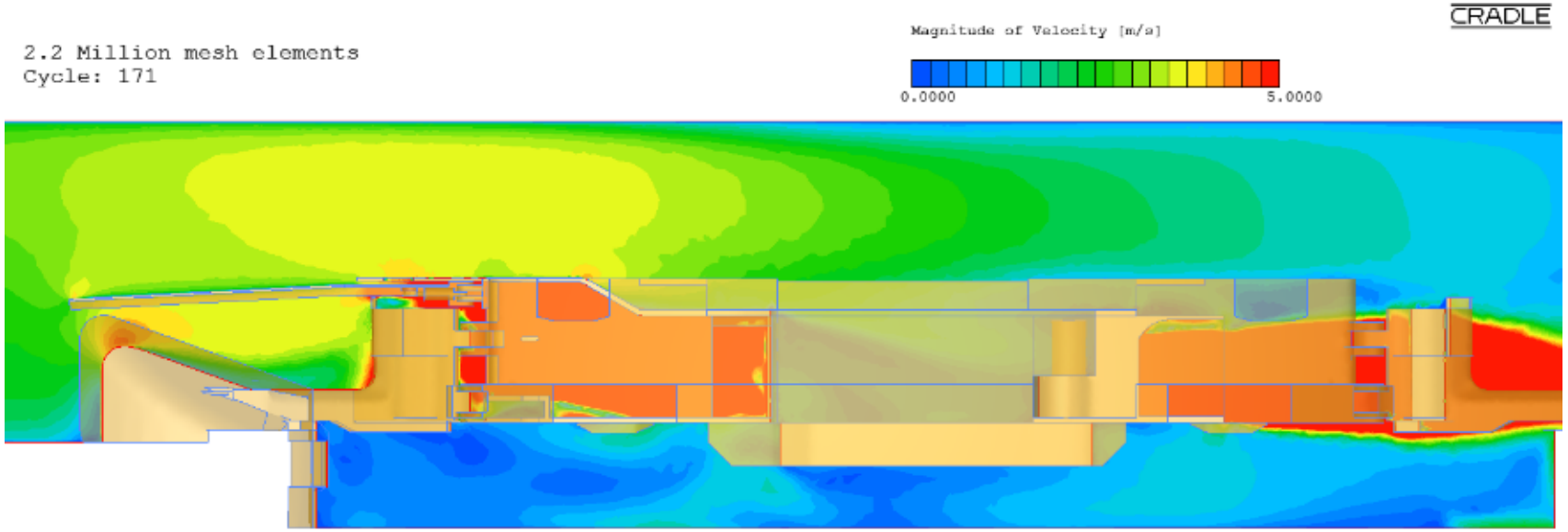
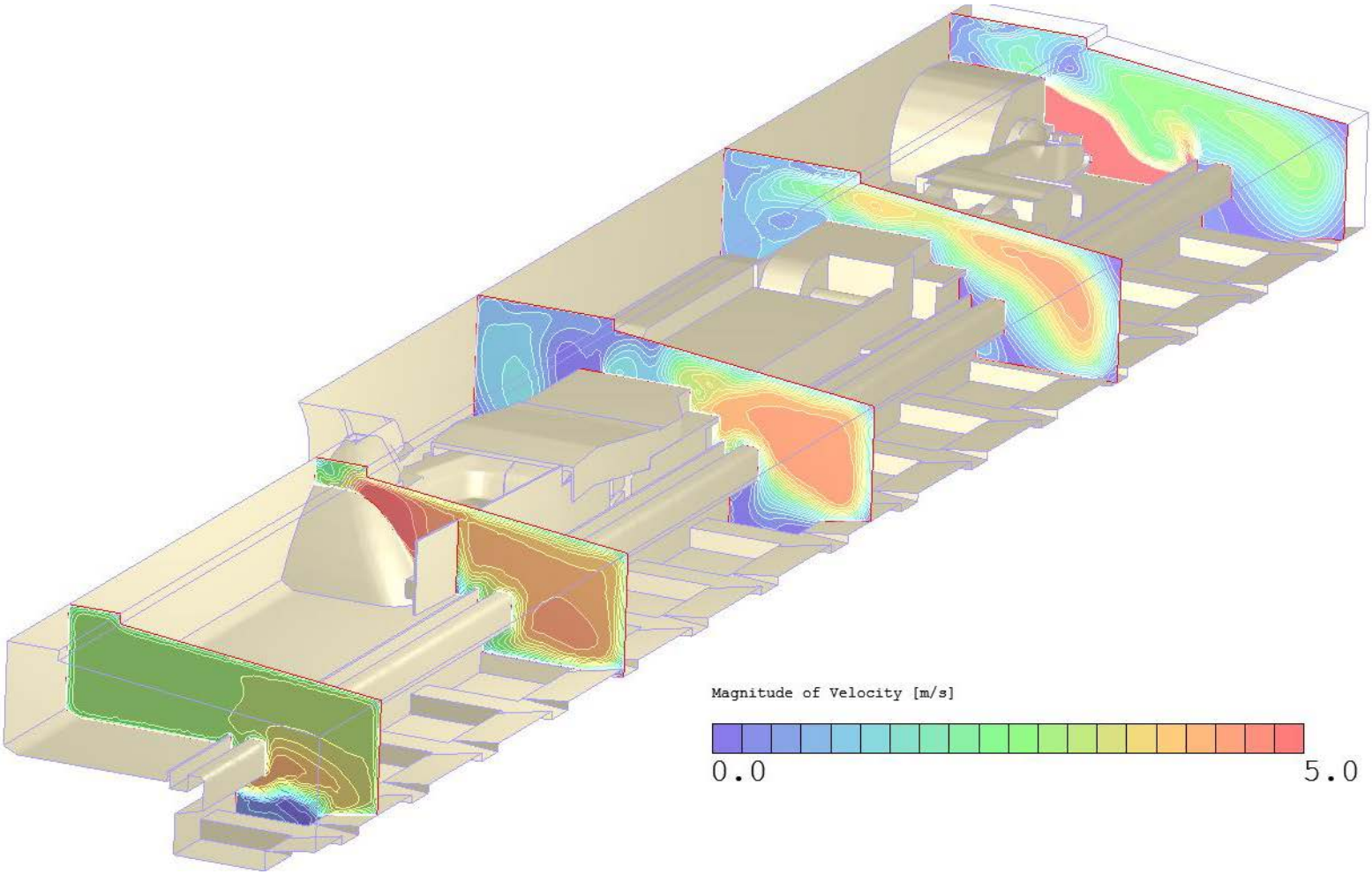
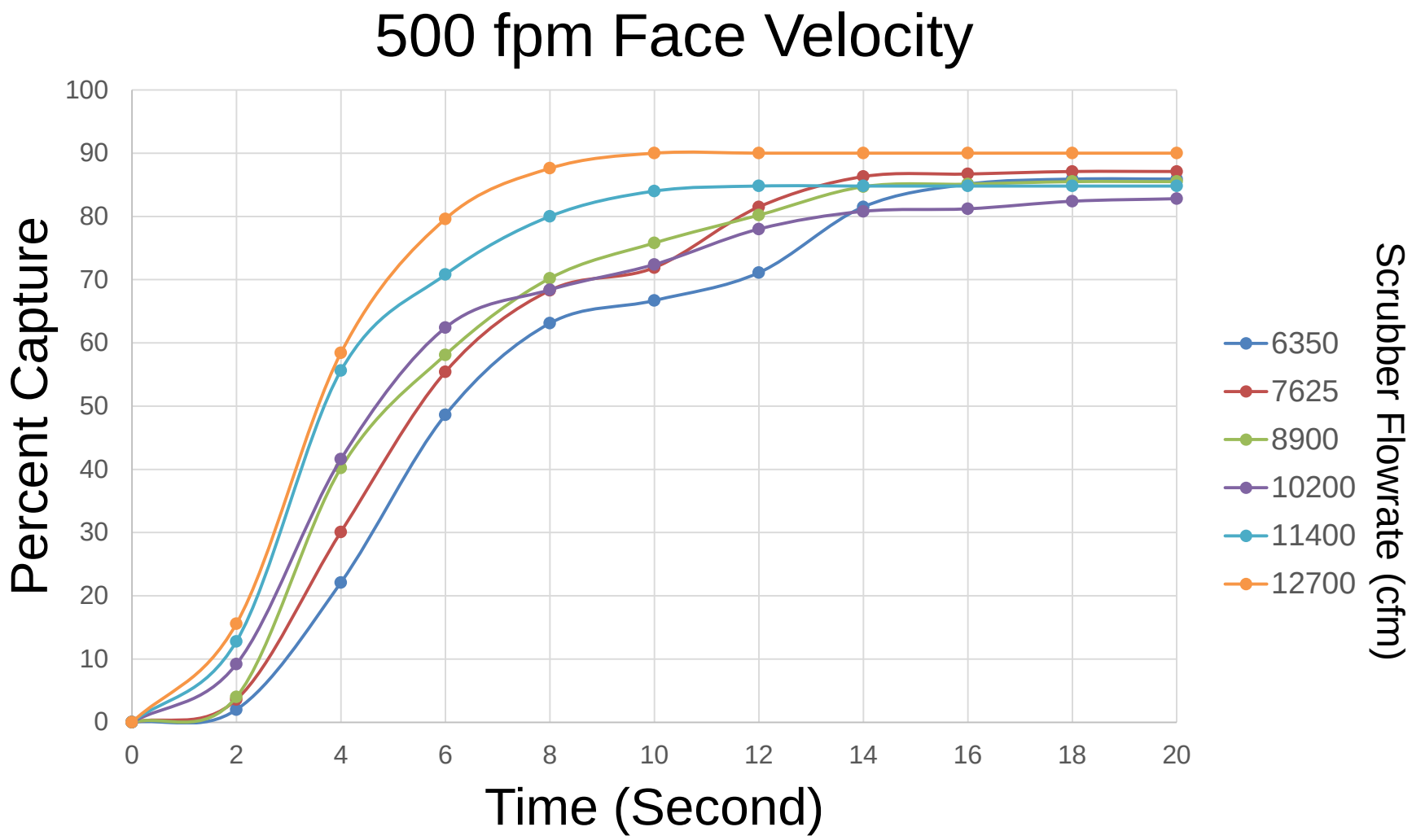
Velocity Contours



Velocity Contours

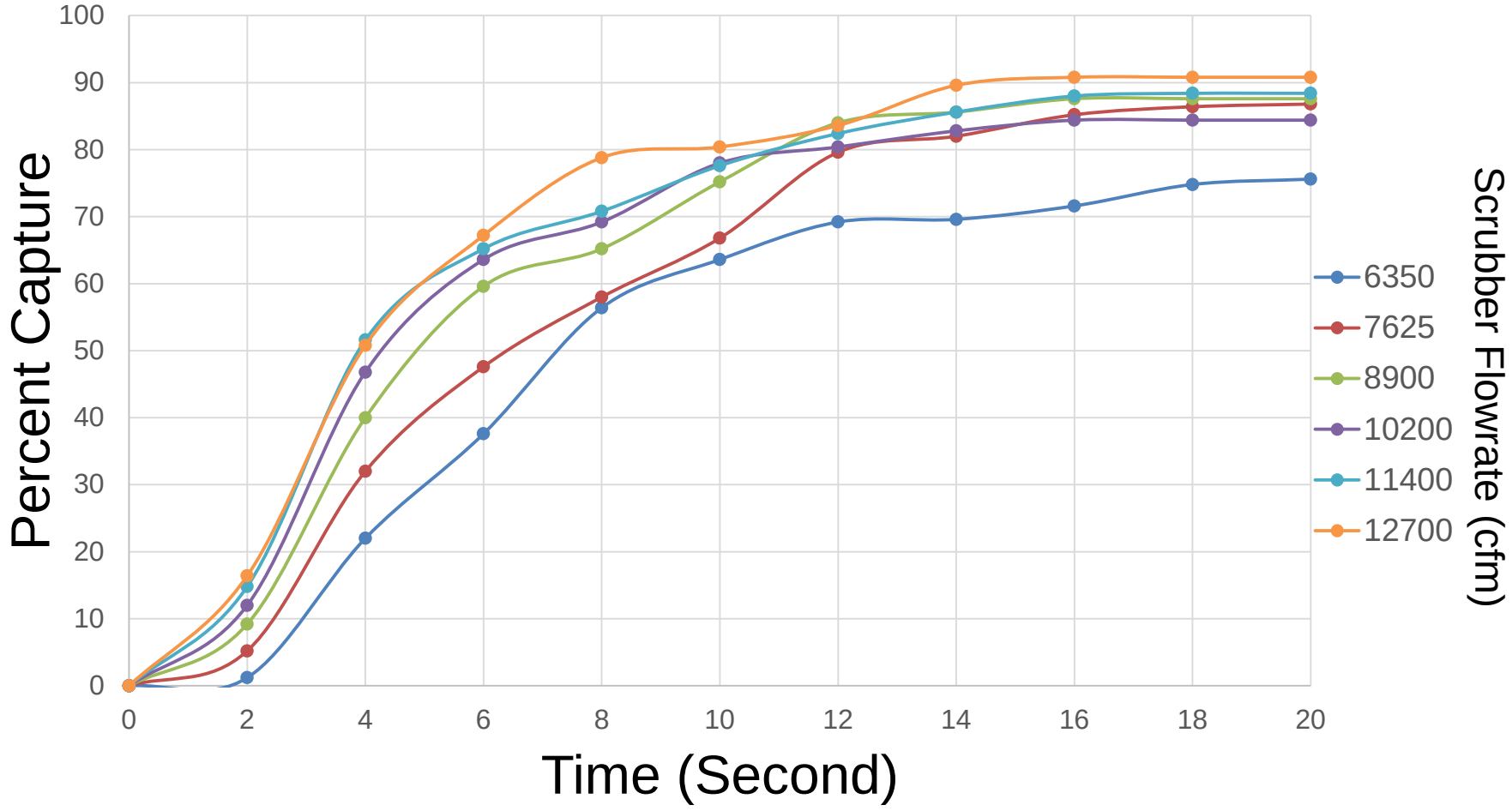


Dust Capture wrt Time & Flow through Scrubber

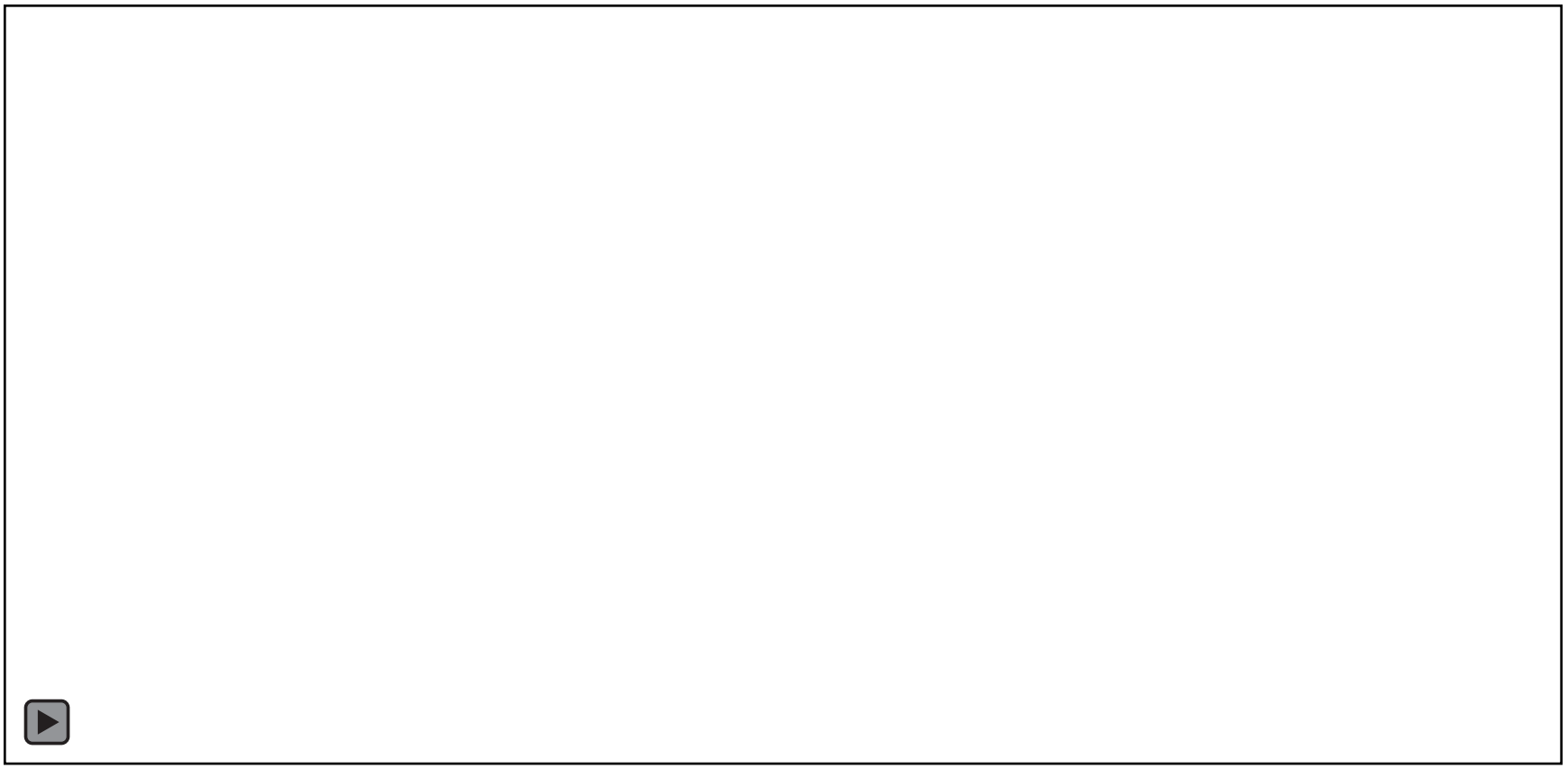


Dust Capture wrt Time & Flow through Scrubber

580 fpm Face Velocity



Dust Capture

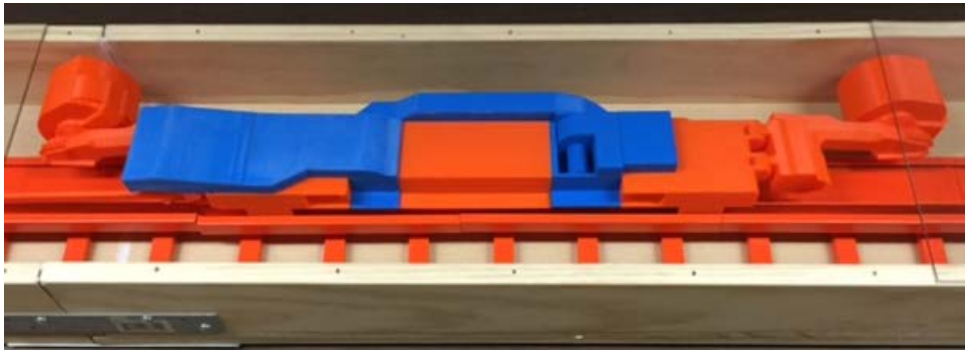


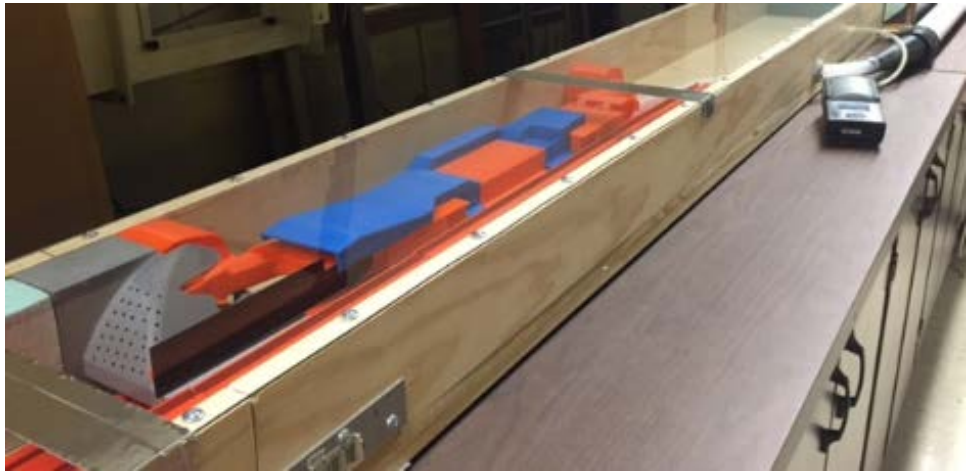
Projected Captures

Scrubber Flow Rates							
Average flow at the face		6,350 cfm	7,625 cfm	8,900 cfm	10,200 cfm	11,400 cfm	12,700 cfm
	500 fpm	85.9	87.1	85.5	82.8	84.8	90.0
	580 fpm	75.6	86.8	87.6	84.4	88.4	90.8

Reduced Scale Modeling

- 1:20 scaled model of the setup
- Replicates problem set up in CFD
- Used the same velocities encountered in the mine, all other surfaces stationary.
- CO2 [tracer gas] mimics the dust particles under the suction of shop vacuum [scrubber].
- Flow volumes calculated and concentrations measured using gas monitors.





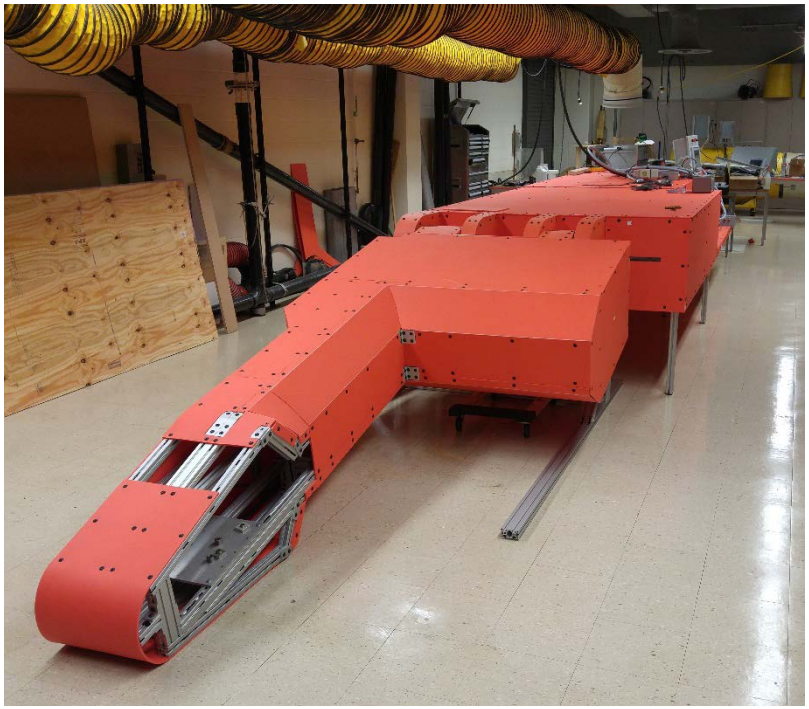
Reduced Scale Results

No Scrubber w/CO2			Scrubber w/CO2			Capture Efficiency
Air Velocity		CO2 Content (%)	Air Velocity (fpm)		CO2 Content (%)	
m/s	fpm		m/s	fpm		
2.06	405	0.60	2.06	406	0.08	94.55%
2.32	456	0.52	2.34	460	0.11	87.23%
2.54	500	0.52	2.57	505	0.11	87.23%
2.82	555	0.47	2.79	550	0.14	78.57%
3.07	605	0.41	3.05	600	0.14	75.00%

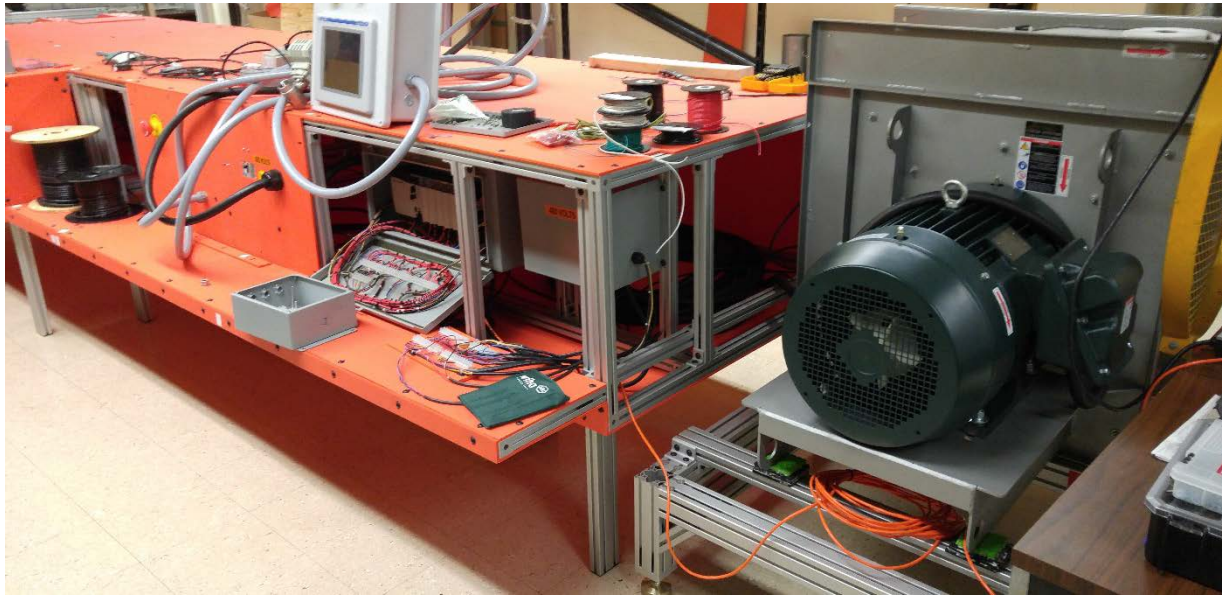
Reduced scale results agree with CFD model results

Full Scale Prototype

- Concept verification to be completed at the NIOSH campus in Pittsburgh
- Full-scale testing with functional scrubber prototype
- Mock up miner constructed from 80/20 Al extrusion and PVC plastic



Full Scale Prototype



- 50HP centrifugal fan with VFD for powering scrubber
- Allen Bradley PLC for control and instrumentation

Full Scale Prototype

- Completed:
  - Miner body
  - Controls
  - Fan
- To be completed:
  - Rotating Drum with sprays
  - Flooded bed / demister components
  - Ductwork
  - Outlet silencer
- Testing to begin early 2016

Results / Conclusions

- Solid concept for flooded bed scrubber incorporated into a longwall shearer
- Capture efficiency of dust generated from the headgate drum exceeds 80%
  - CFD and reduced scale model
- Concept has the potential for reducing overall dust concentrations at the face by up to 40%

Acknowledgement

On behalf of those who have worked on the material presented, I would like to express our gratitude to those who have made our research possible.

- Alpha Foundation
- Alliance Coal
- NIOSH
- JOY Global