

Team 510: Indoor Air Quality of Hotspots

April 1st 2021

Eric Grogans, Leon Johnson, Emma Martin,
Razhan Matipano, Whitley Pettis

Team Introductions



Eric Grogans
Electrical Engineer



Leon Johnson
Test Engineer



Emma Martin
Project Engineer



Razhan Matipano
*Research
Engineer*



Whitley Pettis
*Manufacturing
Engineer*

Whitley Pettis

Sponsor and Advisor

Honeywell



FAMU-FSU
College of Engineering



Engineering Mentor
Alfred Guerrero
Honeywell

Engineering Mentor
Danny White
Honeywell

Engineering Mentor
Danny Mims
Honeywell

Academic Advisor
Neda Yaghoobian, Ph.D.
Professor

Senior Design Professor
Dr. McConomy, Ph.D.
Professor

Whitley Pettis



Objective

The objective of this project is to measure and modify air quality in the FAMU-FSU College of Engineering to promote a healthy building environment.

Whitley Pettis



Project Background

Whitley Pettis



Location



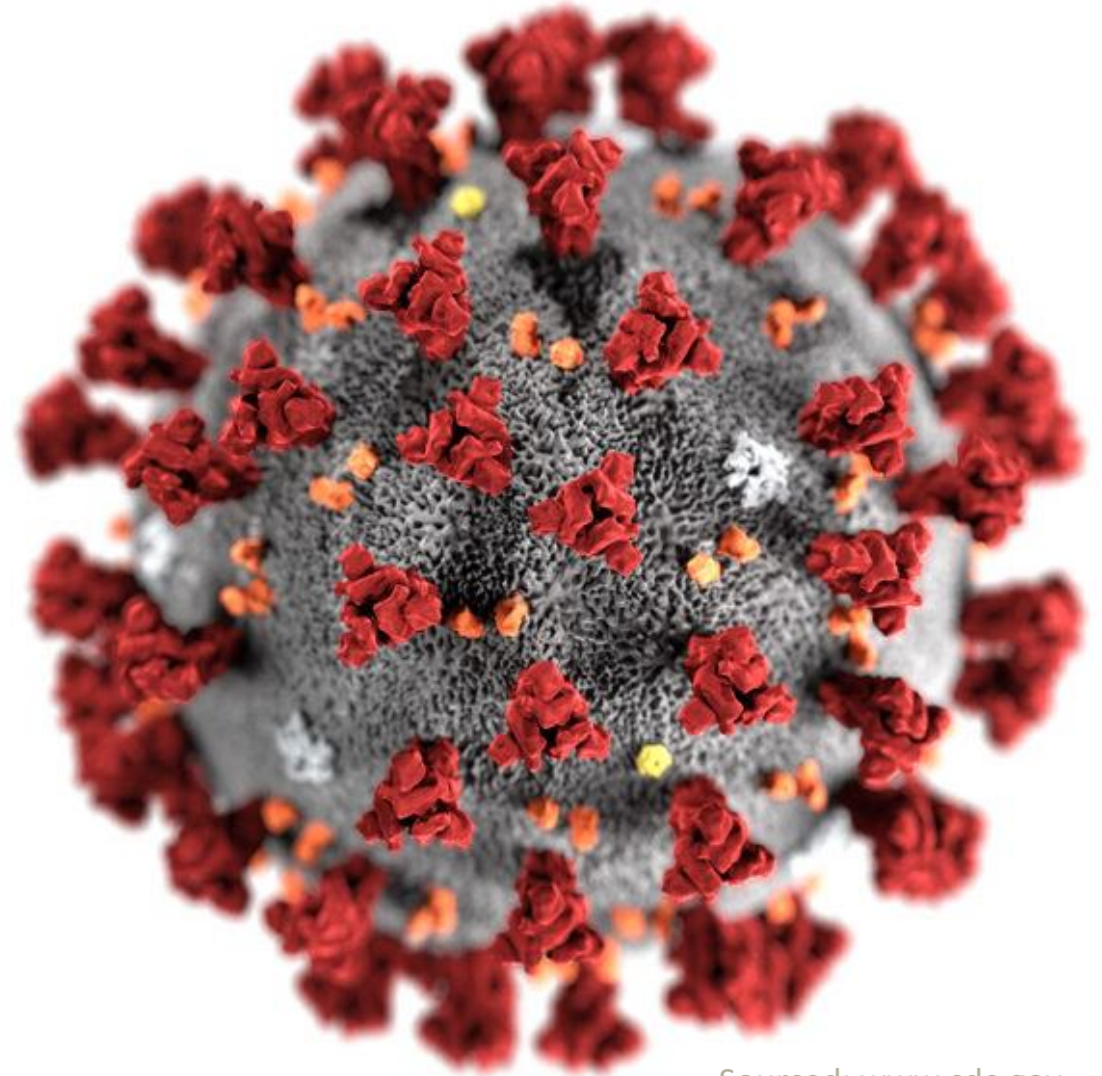
- The FAMU-FSU College of Engineering is used by thousands daily
- There are several types of spaces around the college

Sourced: eng.famu.fsu.edu, www.thebluebook.com

Whitley Pettis

COVID-19

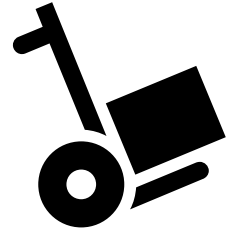
- Air quality is especially important
- Caused by the pathogen SARS-CoV-2
- Carried by respiratory droplets in air



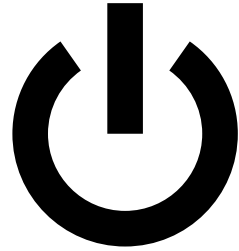
Sourced: www.cdc.gov

Whitley Pettis

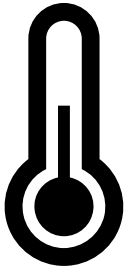
Facilities' Needs



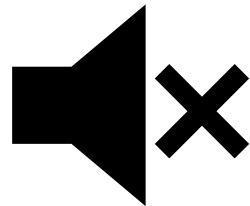
Portable



Internal
Power Source



Limited
Heat

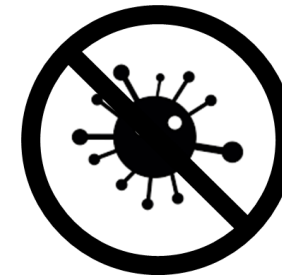


Limited
Volume

Honeywell's Needs



Monitors
Air Quality



Reduces
Contamination

Whitley Pettis

Functional Decomposition

Control System

Ventilate room

**Improve Air
Composition**

Whitley Pettis



Functional Decomposition

Control System

Ventilate room

**Improve Air
Composition**

Sense and measure
air quality

Whitley Pettis



Functional Decomposition

Control System

Ventilate room

**Improve Air
Composition**

Control hardware



Sense and measure
air quality

Whitley Pettis

Functional Decomposition

Control System

Control hardware



Sense and measure
air quality



Ventilate room

Propel air
through device

**Improve Air
Composition**

Emma Martin

Functional Decomposition

Control System

Control hardware

Sense and measure
air quality



Ventilate room

Propel air
through device

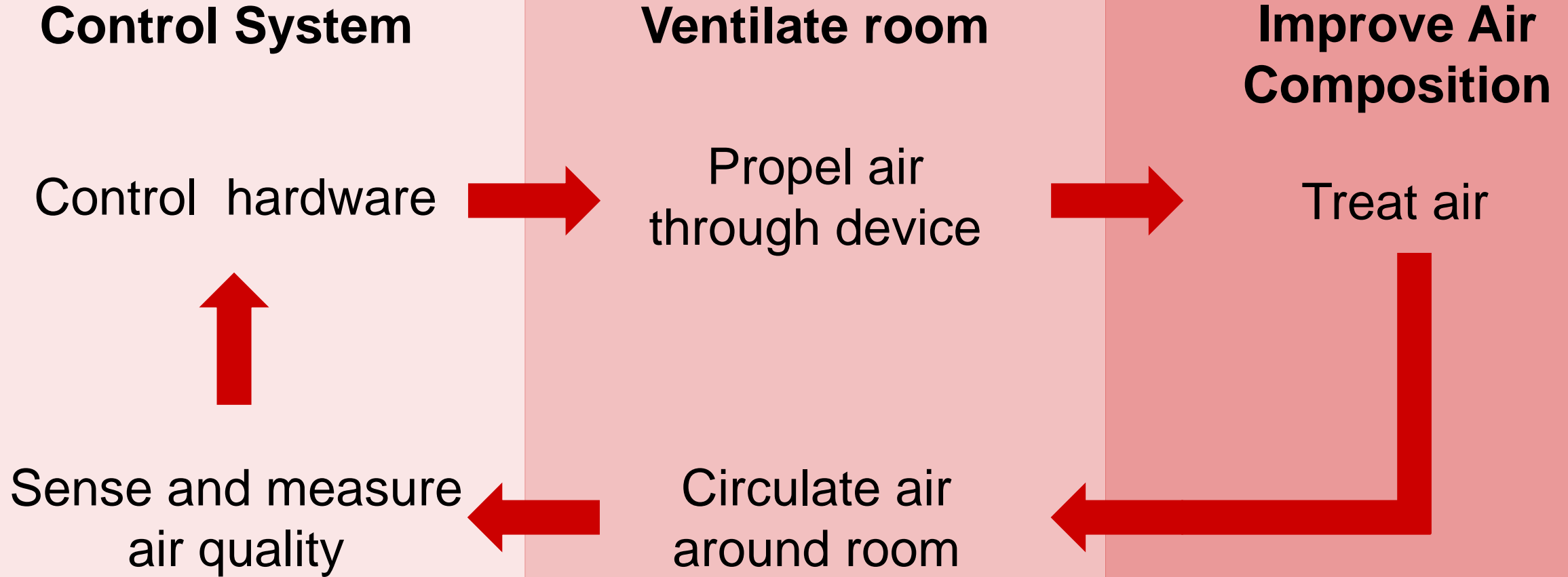


**Improve Air
Composition**

Treat air

Whitley Pettis

Functional Decomposition



Whitley Pettis

Targets and Metrics

Emma Martin



Control System



Sense Air Quality

Concentration range of sensors

- Particulate: $0.1 \mu\text{g}/\text{m}^3$ and $1000 \mu\text{g}/\text{m}^3$
- Gas: 0 ppm to 250 ppm



Measure Air Quality

Accuracy of sensors

- Particulate: $\pm 15\%$
- Gas: $\pm 3\%$



Control Hardware

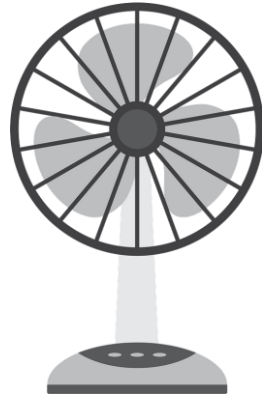
Reaction time of hardware

- 6 seconds

Sourced: Honeywell.com

Emma Martin

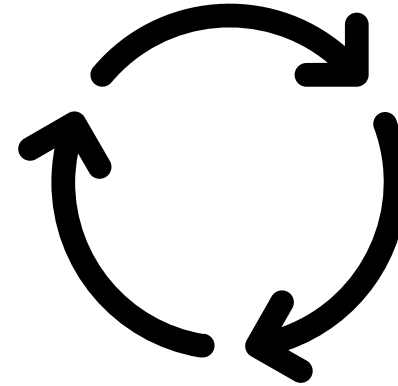
Ventilate Room



Propel Air

Volumetric flowrate per person

- 40 cfm per person



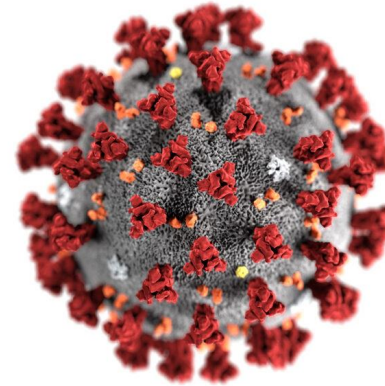
Circulate Air

Number of air changes per hour

- 7

Emma Martin

Improve Air Composition



Treat Air

Number of Filters

- 3

Sanitize

Contaminants

Particulate removal percentage

- 99%

Control Air

Humidity

Humidity range

- 40% to 60%

Filter Particulates

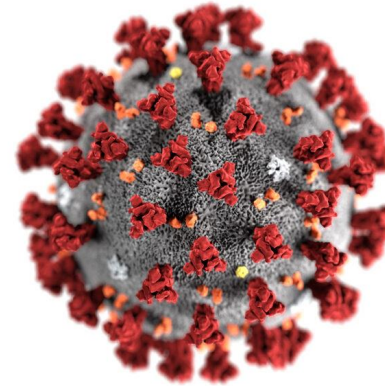
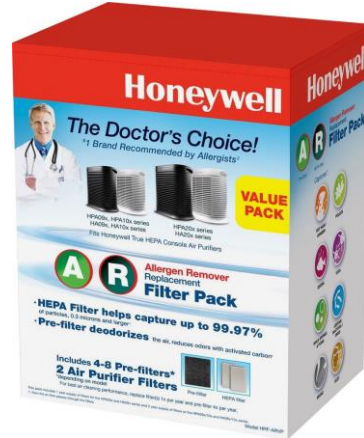
Minimum diameter of filterable particles

- 0.1 μm

Sourced: Honeywell.com, www.cdc.gov

Emma Martin

Improve Air Composition



Treat Air

Number of Filters

- 3

Sanitize Contaminants

Particulate removal percentage

- 99%

Control Air Humidity

Humidity range

- 40% to 60%

Filter Particulates

Minimum diameter of filterable particles

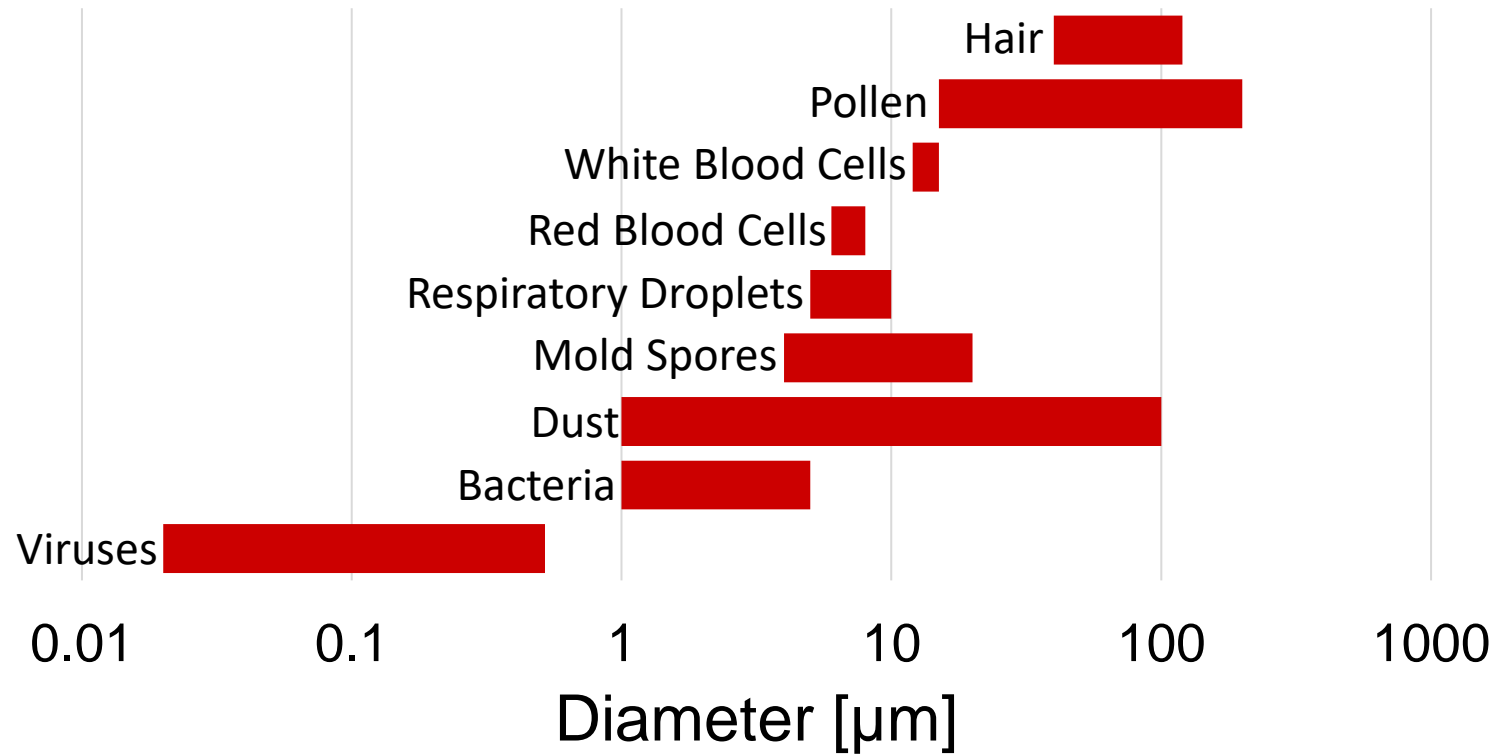
- 0.1 μm

Sourced: Honeywell.com, www.cdc.gov

Emma Martin

Improve Air Composition

Particle Diameter Range



Filter Particulates
Minimum diameter of filterable particles

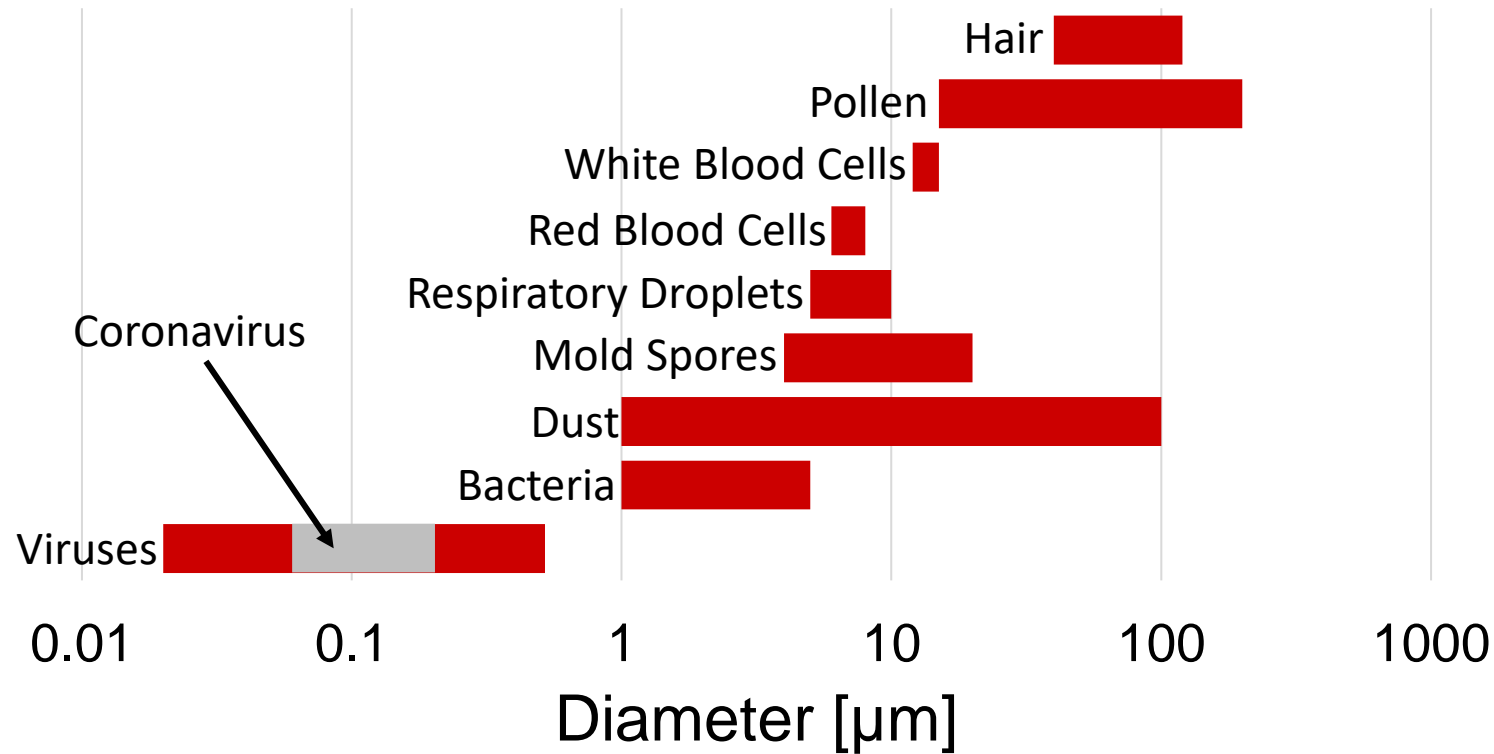
- 0.1 μm

Emma Martin

Sourced: Honeywell.com

Improve Air Composition

Particle Diameter Range



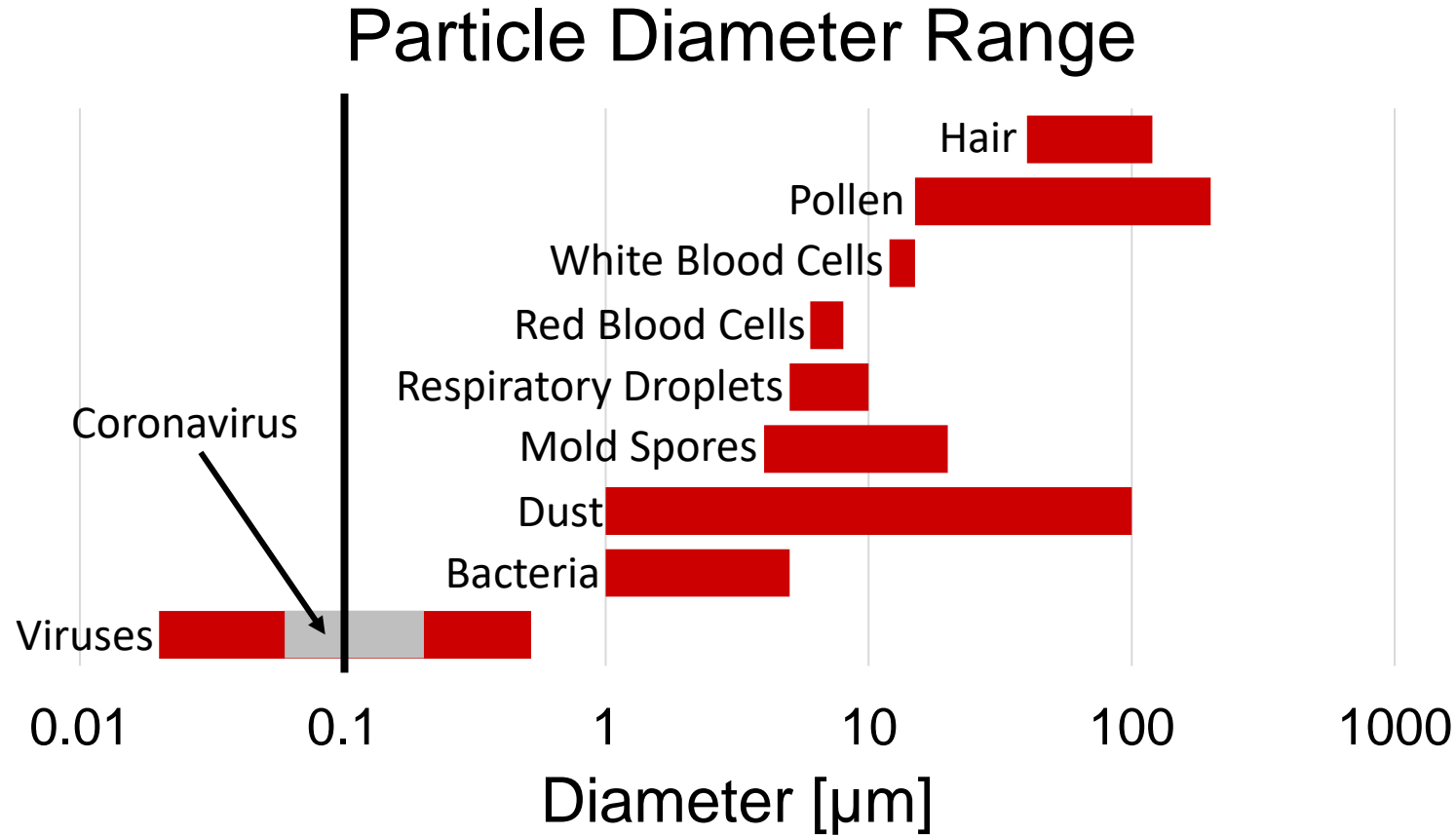
Filter Particulates
Minimum diameter of filterable particles

- 0.1 μm

Emma Martin

Sourced: Honeywell.com

Improve Air Composition



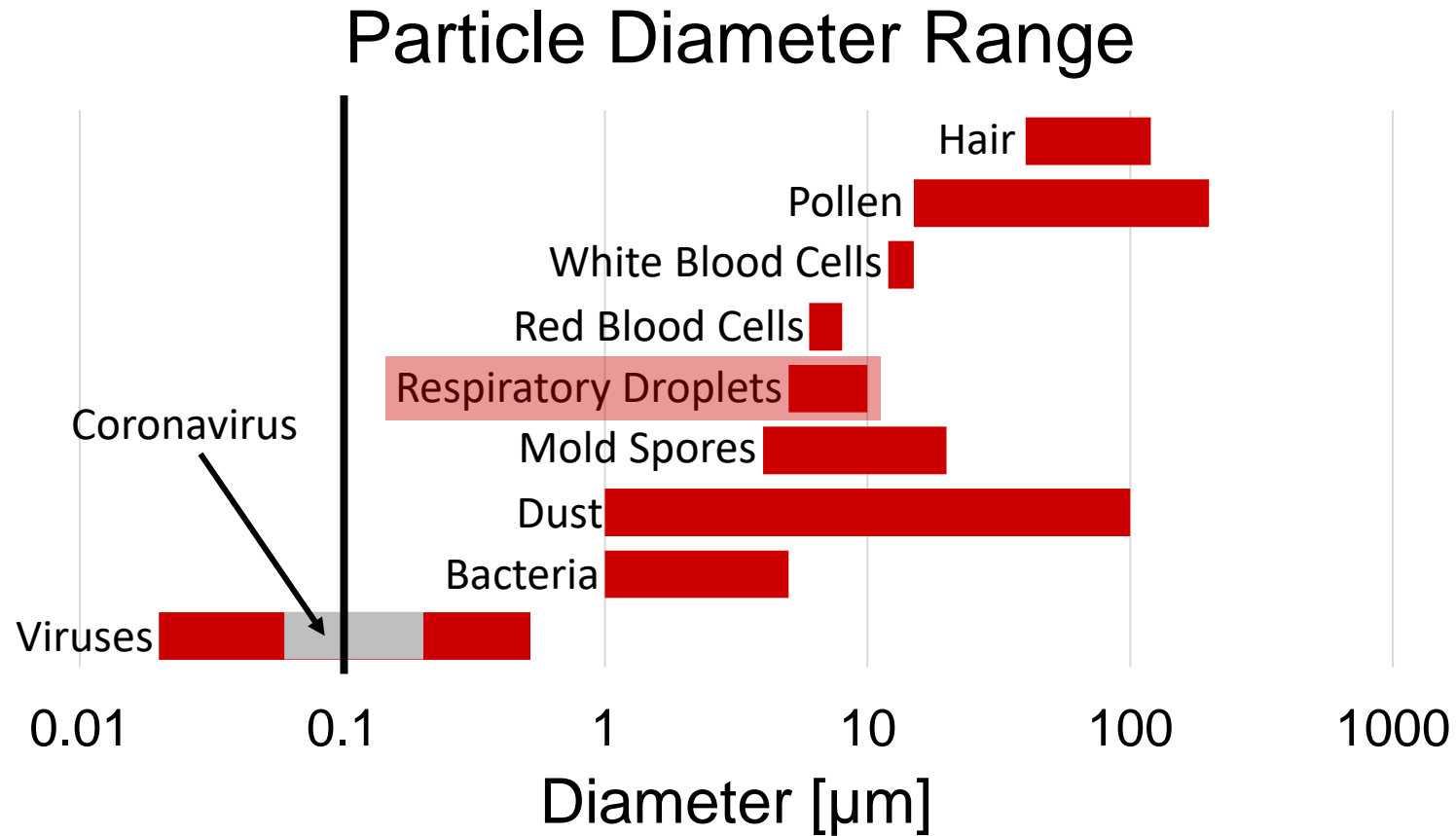
Filter Particulates
Minimum diameter of filterable particles

- 0.1 μm

Emma Martin

Sourced: Honeywell.com

Improve Air Composition



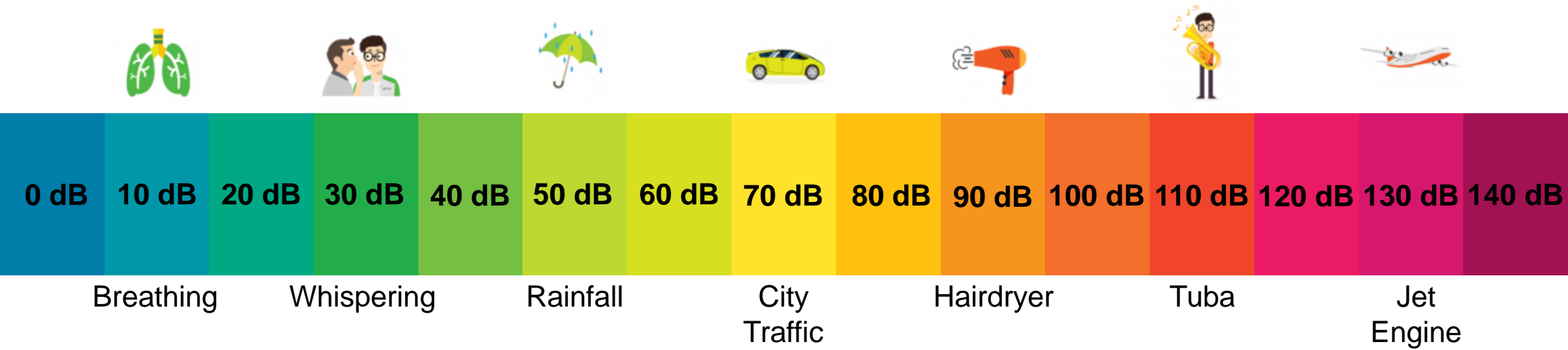
Filter Particulates
Minimum diameter of filterable particles

- 0.1 μm

Emma Martin

Sourced: Honeywell.com

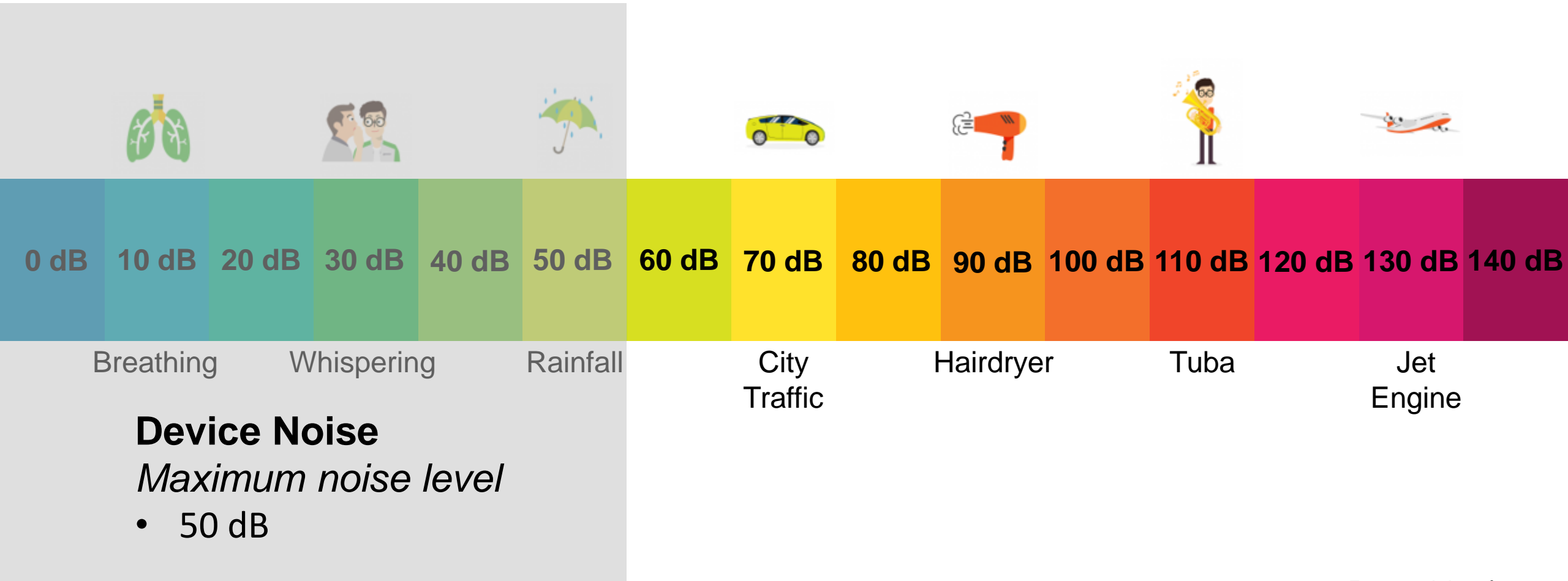
Noise



Sourced: LetsTalkScience.ca

Emma Martin

Noise



Sourced: LetsTalkScience.ca

Emma Martin

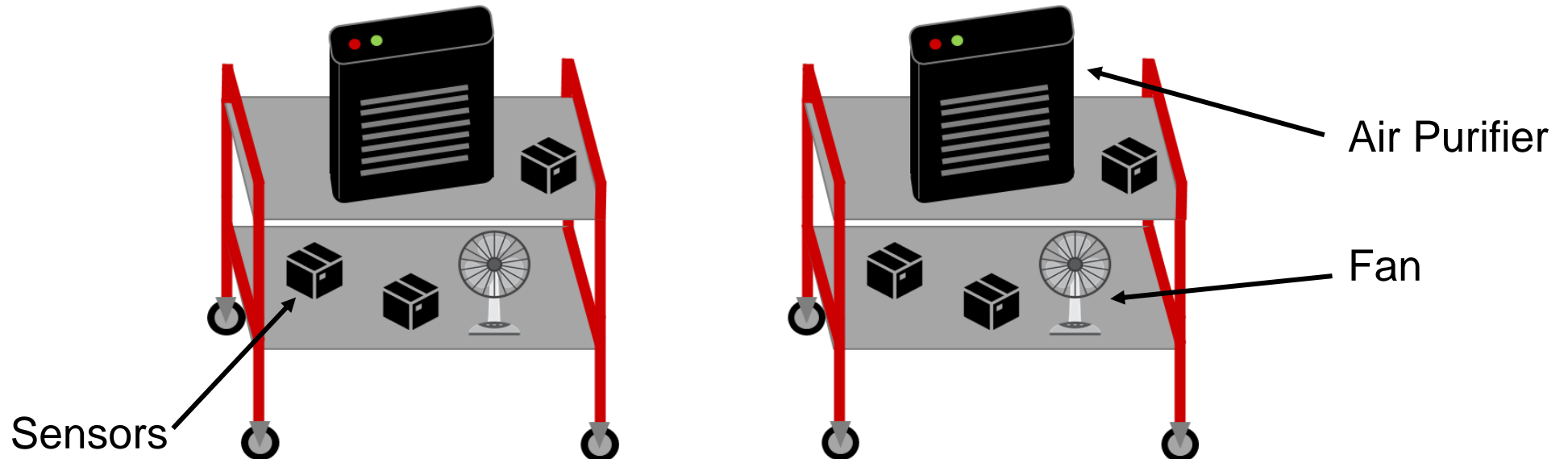
Concept Selection and Bill of Materials

Eric Grogans



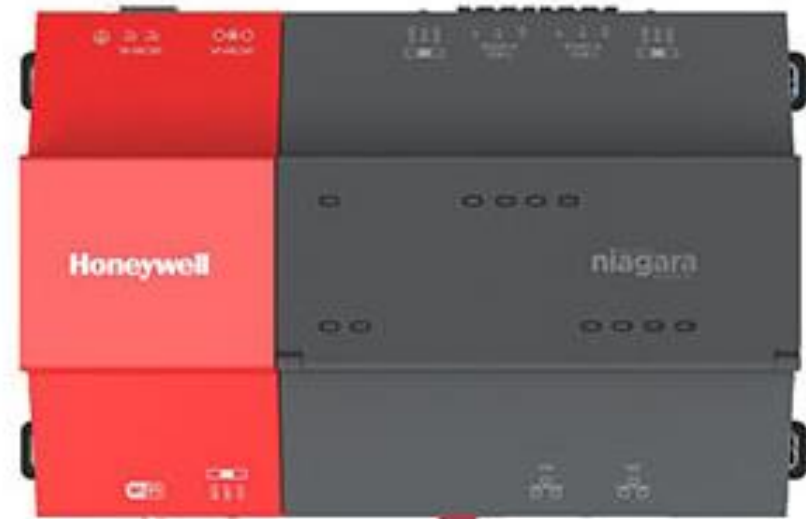
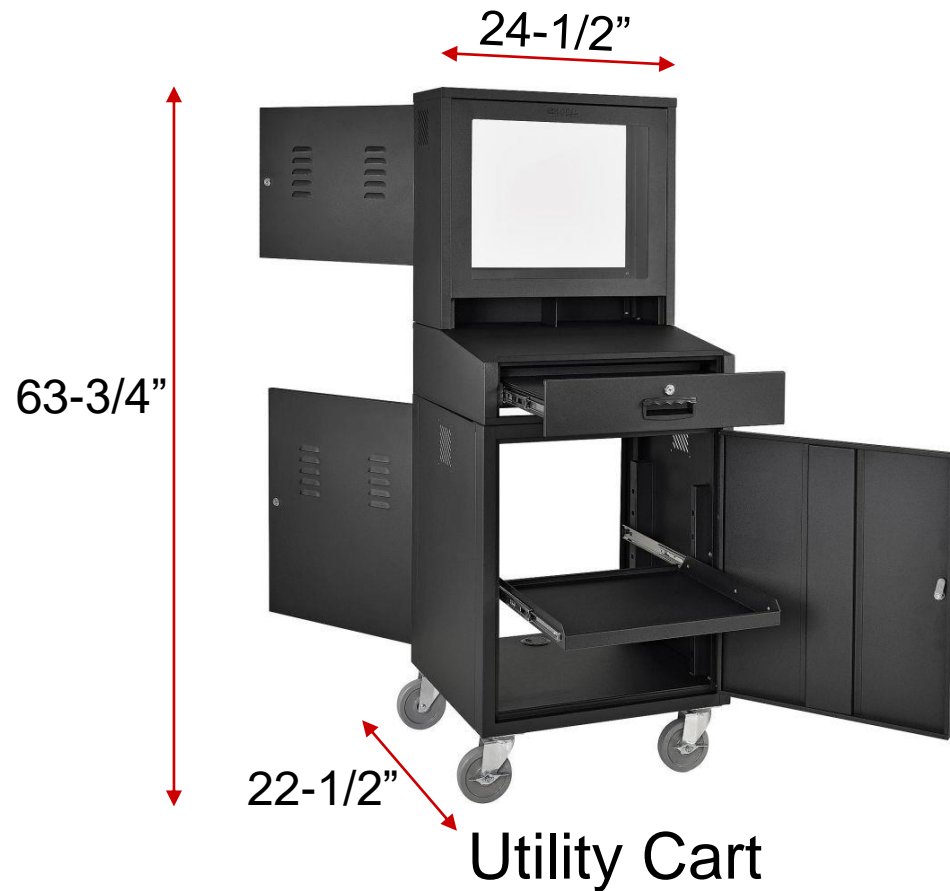
Final Concept

- Dual Cart Sensing and Cleaning Stations
- Each cart contains identical equipment
- One cart for short-term testing and one for long-term testing



Eric Grogans

Equipment and Data Storage



JACE 8000 Controller

Sourced: Honeywell.com

Eric Grogans

Power



120 VAC Power Supply



120 V Power Station



Energy Monitor

Sourced: Grainger.com, APC.com, Kele.com

Eric Grogans

Sensing



Gas and Humidity Monitor



Particulate Matter Sensor



Motion Detector

Sourced: Honeywell.com

Eric Grogans

Cleaning



HEPA Air Purifier

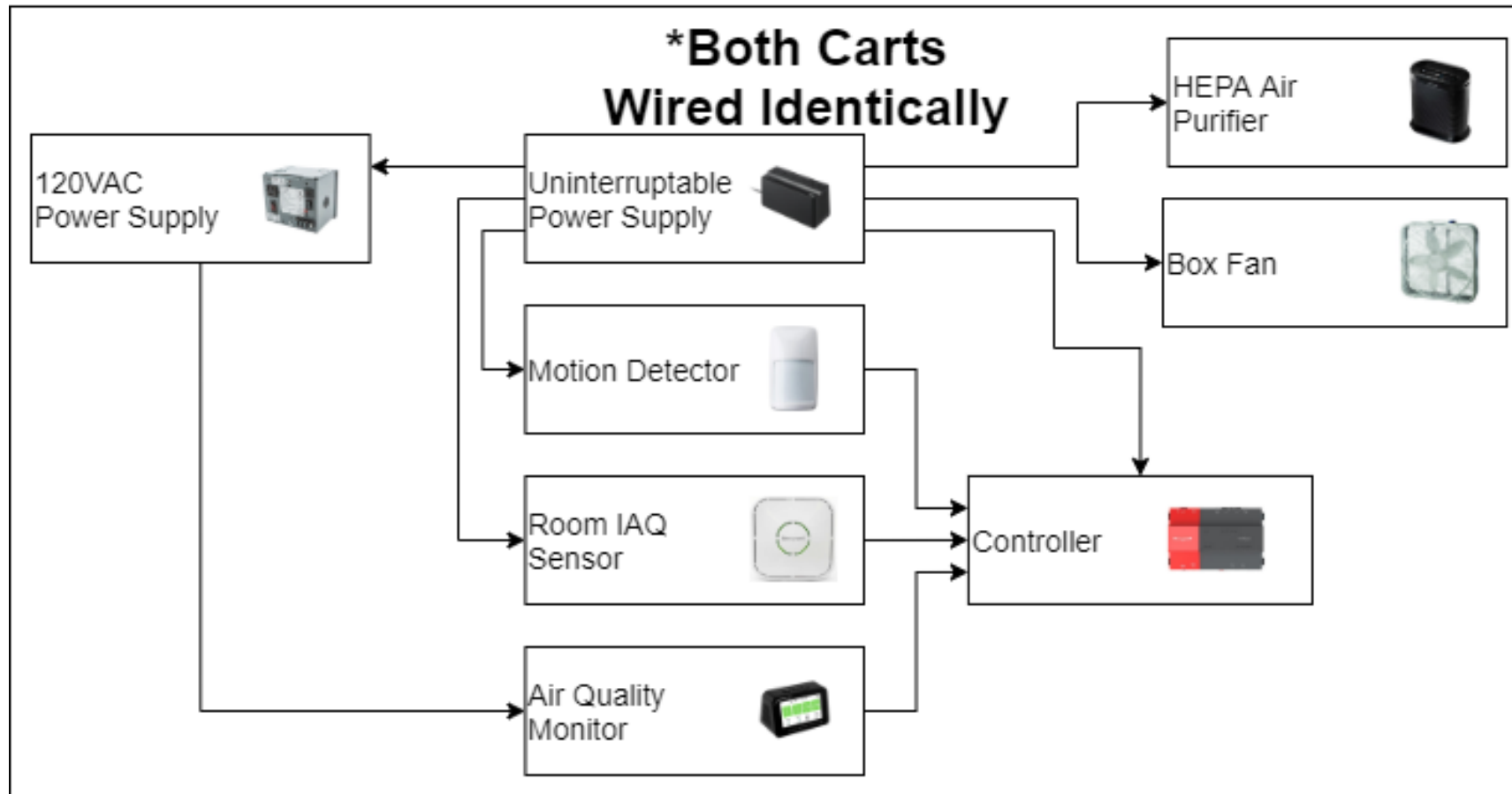


Box Fan

Sourced: Honeywell.com, Overstock.com

Eric Grogans

Wiring Diagram



Sourced: Honeywell.com, APC.com, Grainger, APC.com, Overstock

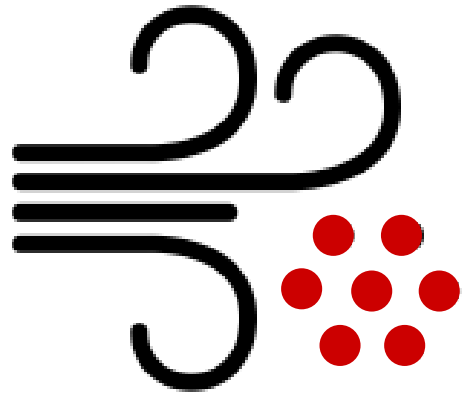
Eric Grogans

Testing Plans

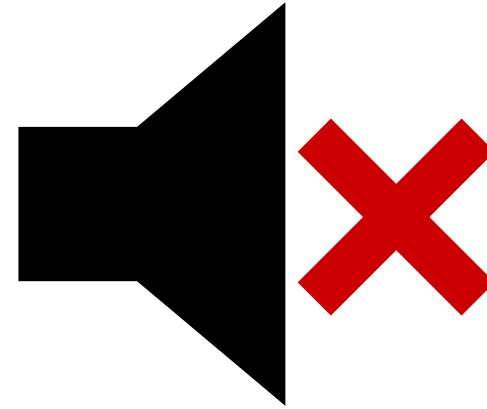
Whitley Pettis



Preliminary Tests



Measure air quality
before cleaning

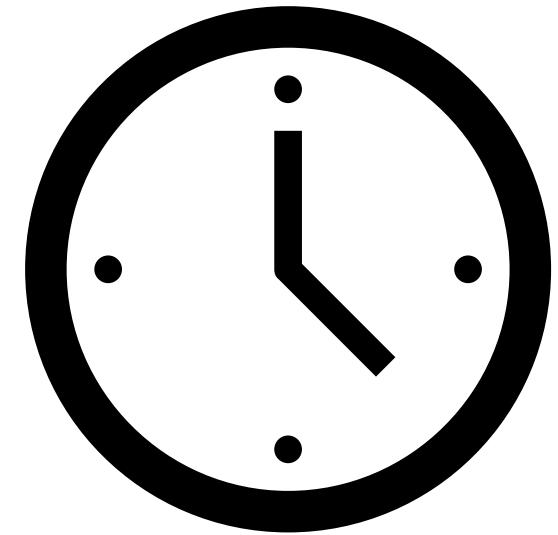


Measure equipment
noise levels before
placement

Whitley Pettis

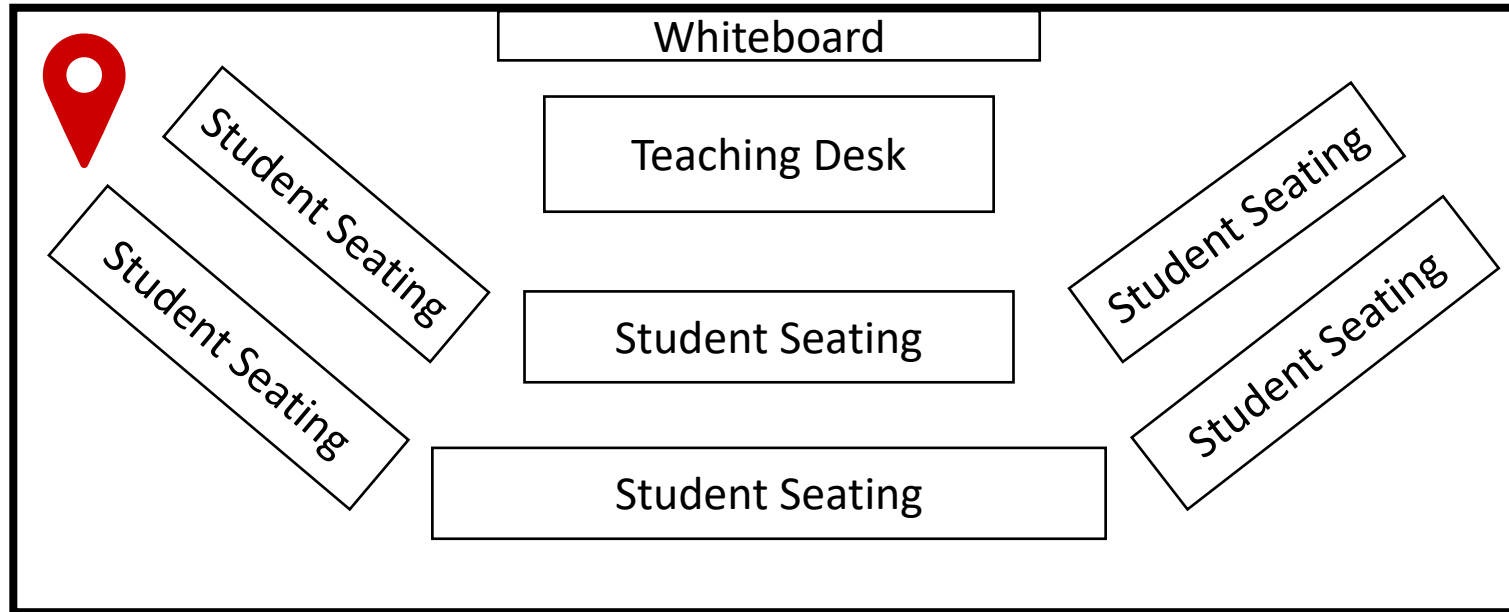
Testing Procedures

- Measure air quality in the same location at different times of day
- Track any changes and note corresponding times
- Attempt to relate changes in air quality to specific activities:
 - Class meetings
 - Lab experiments
 - Equipment usage



Whitley Pettis

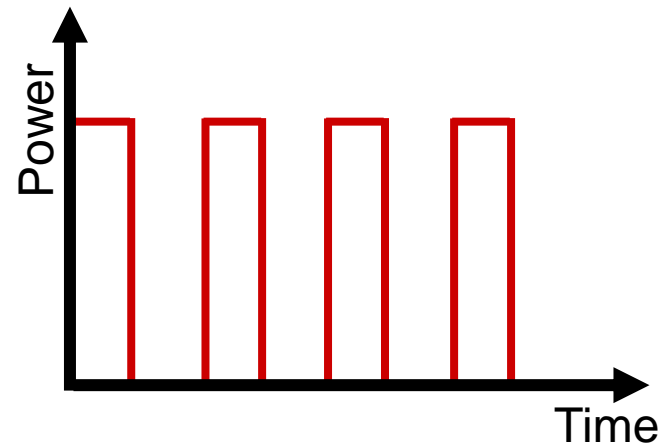
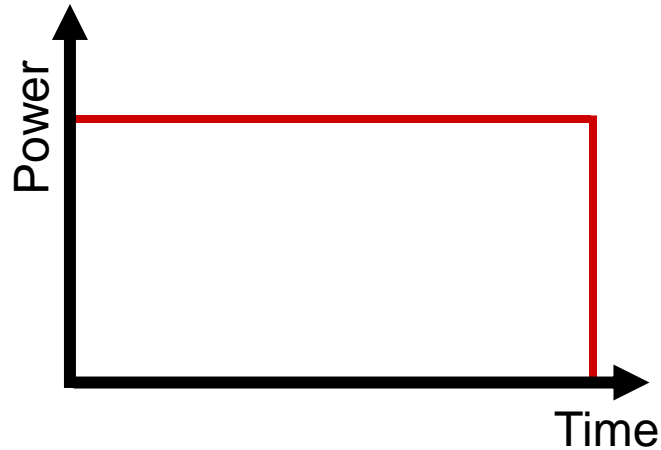
Testing Procedures



- Move cleaning equipment to different locations in the same room
- Monitor whether certain locations are more effective for improving the room's air quality

Whitley Pettis

Testing Procedures



- Run cleaning equipment constantly then intermittently in the same location
- Compare recorded air quality from the tests
- Use results to find the balance between energy consumption and cleaning efficiency

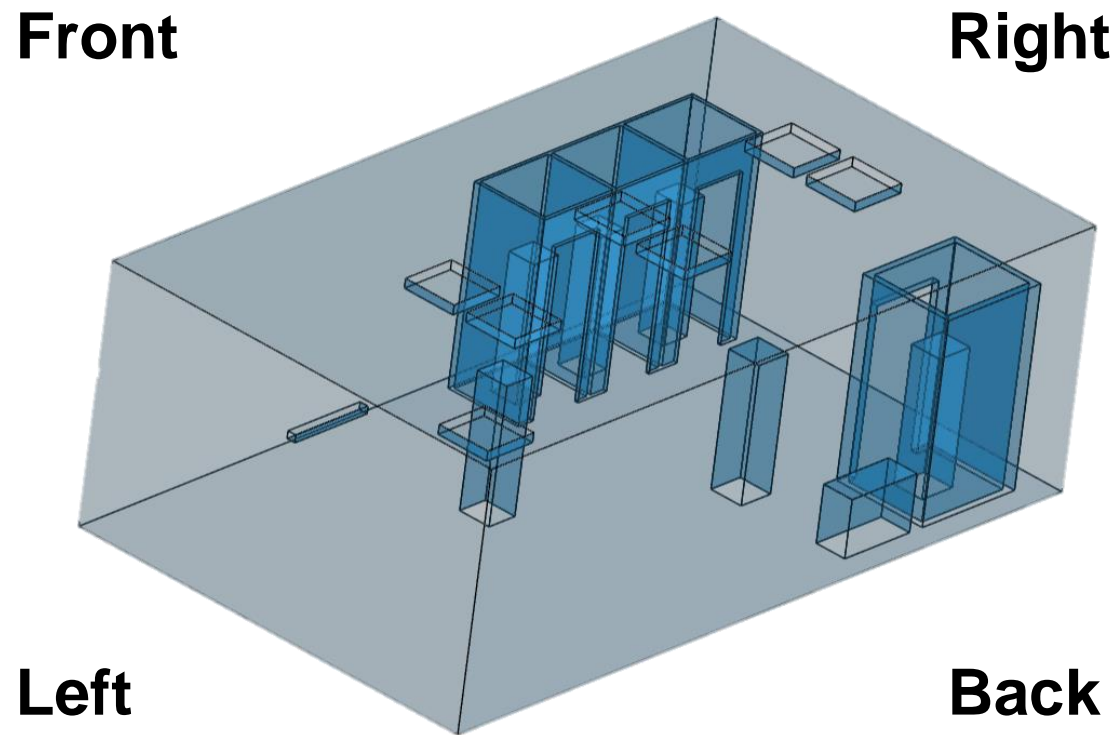
Whitley Pettis

Simulations

Razhan Matipano & Leon Johnson

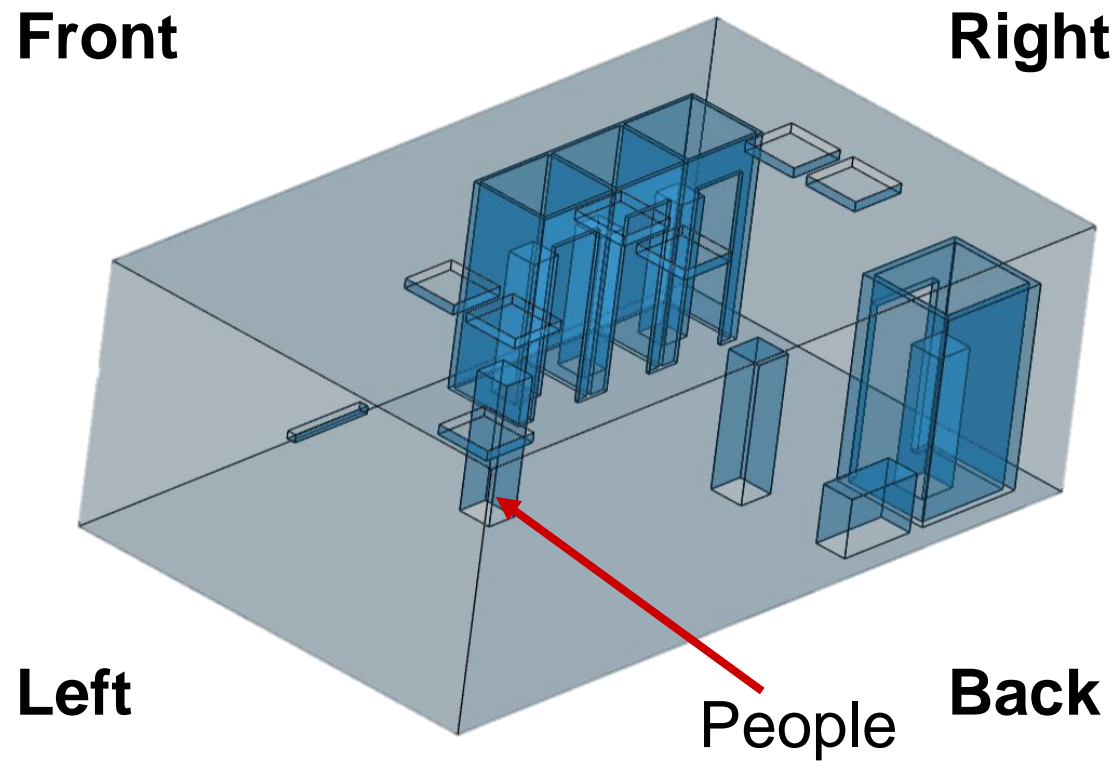


Senior Design Lab Model



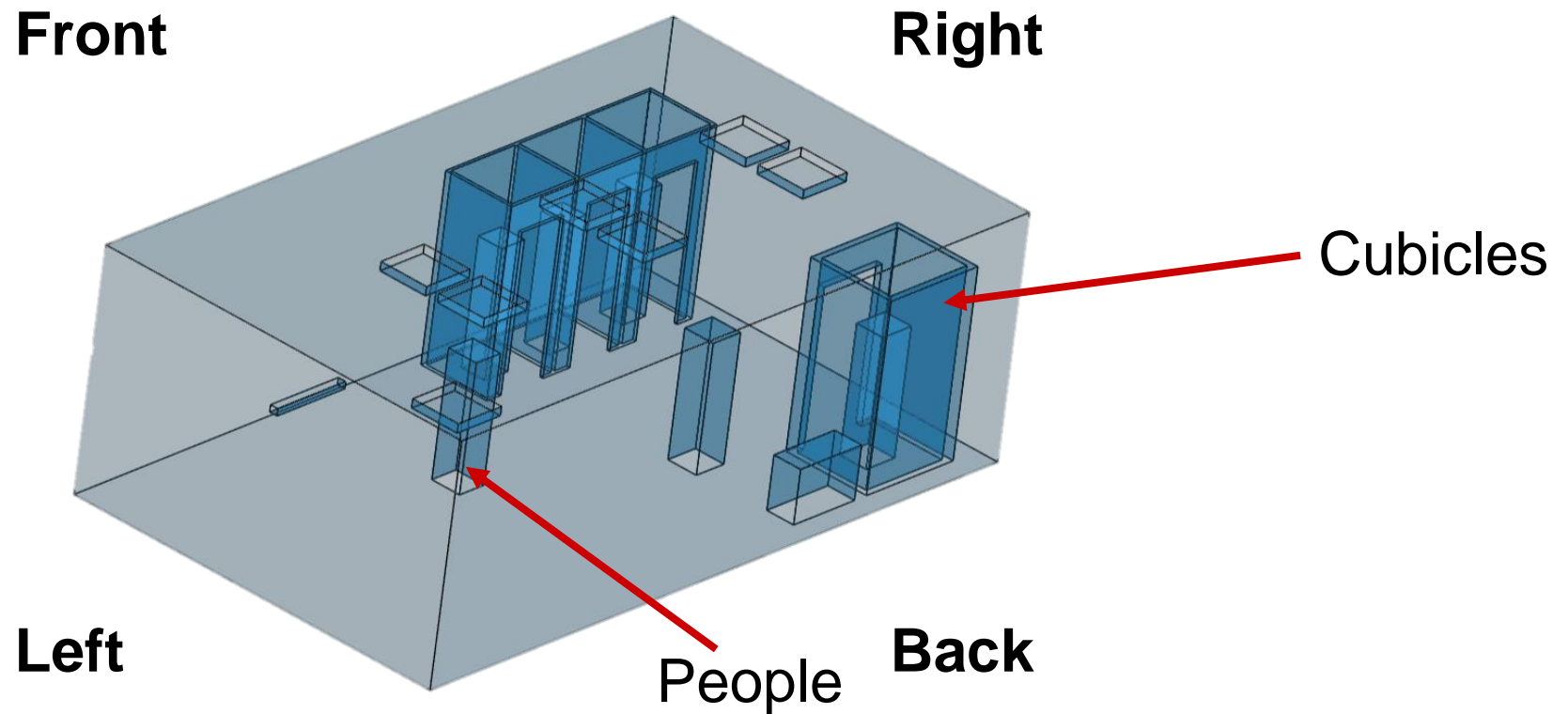
Razhan Matipano

Senior Design Lab Model



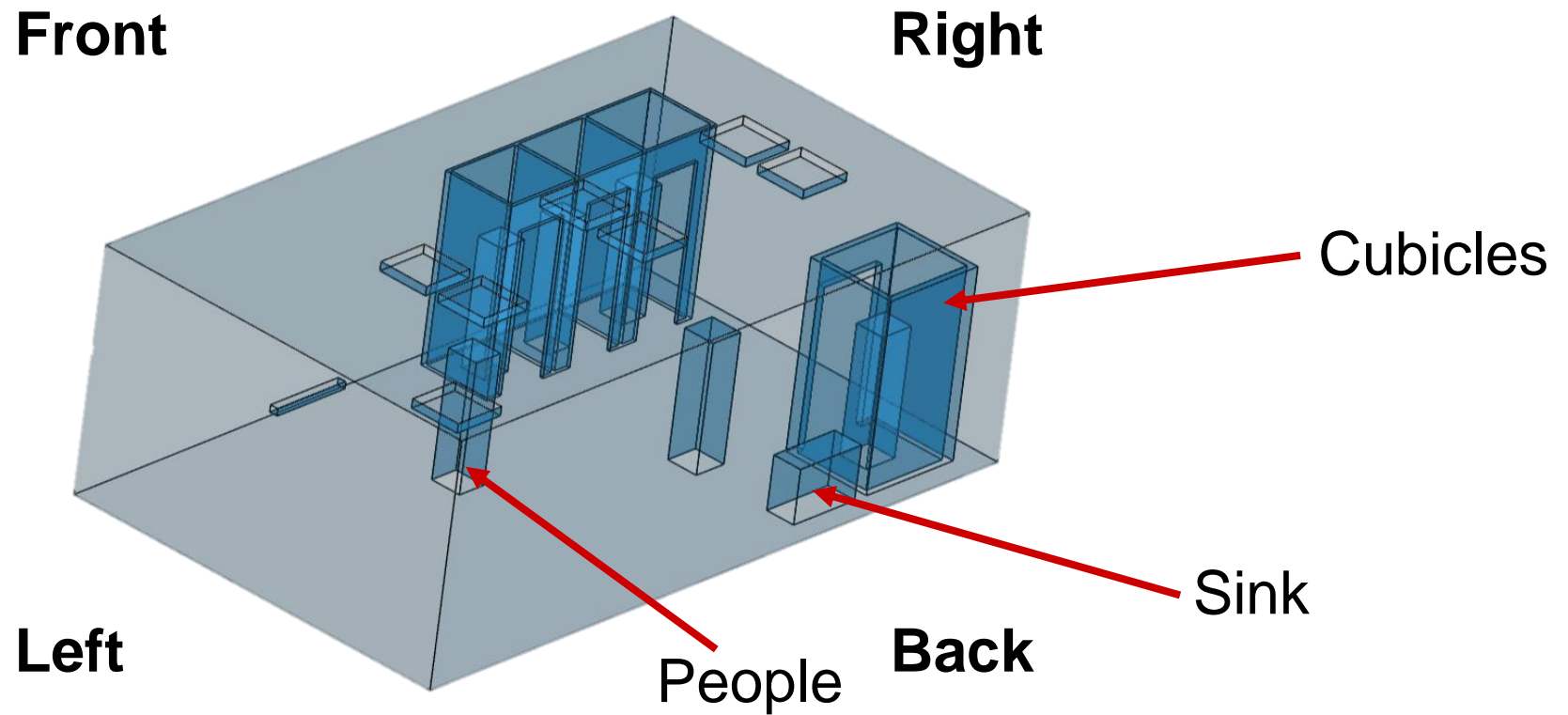
Razhan Matipano

Senior Design Lab Model



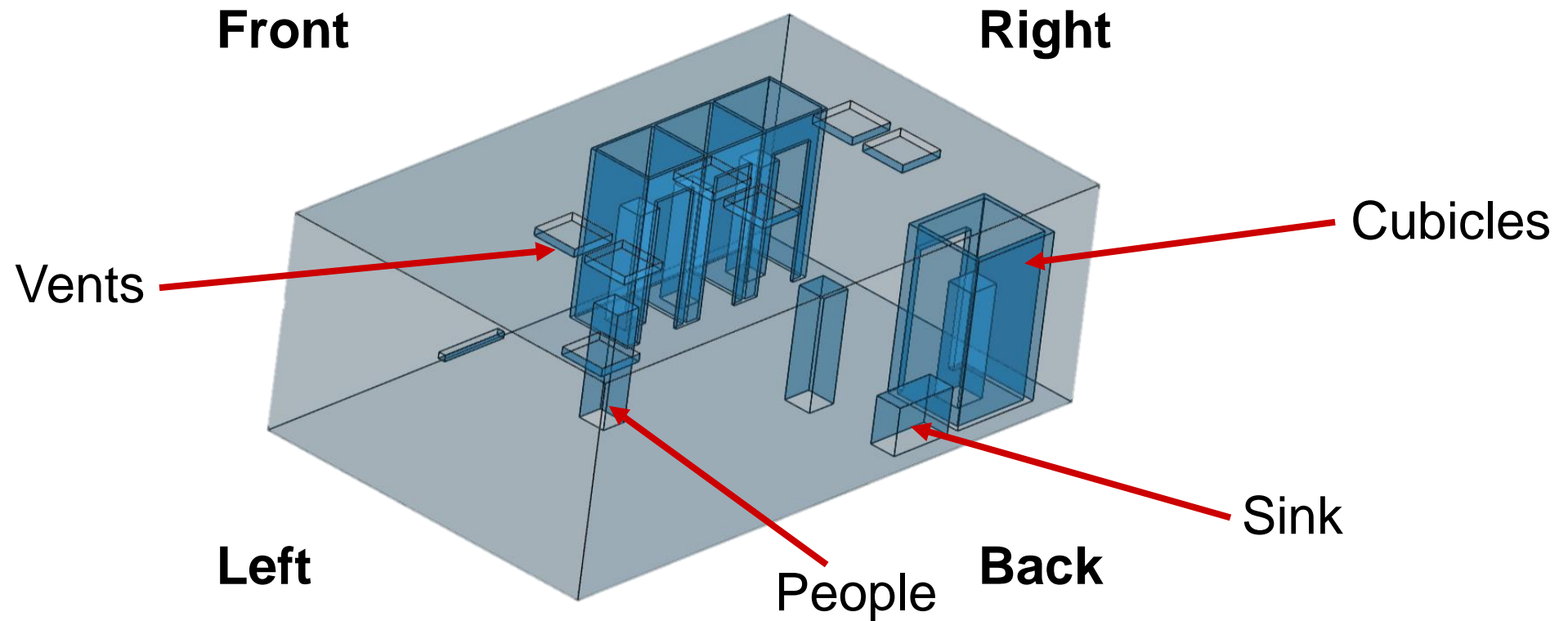
Razhan Matipano

Senior Design Lab Model



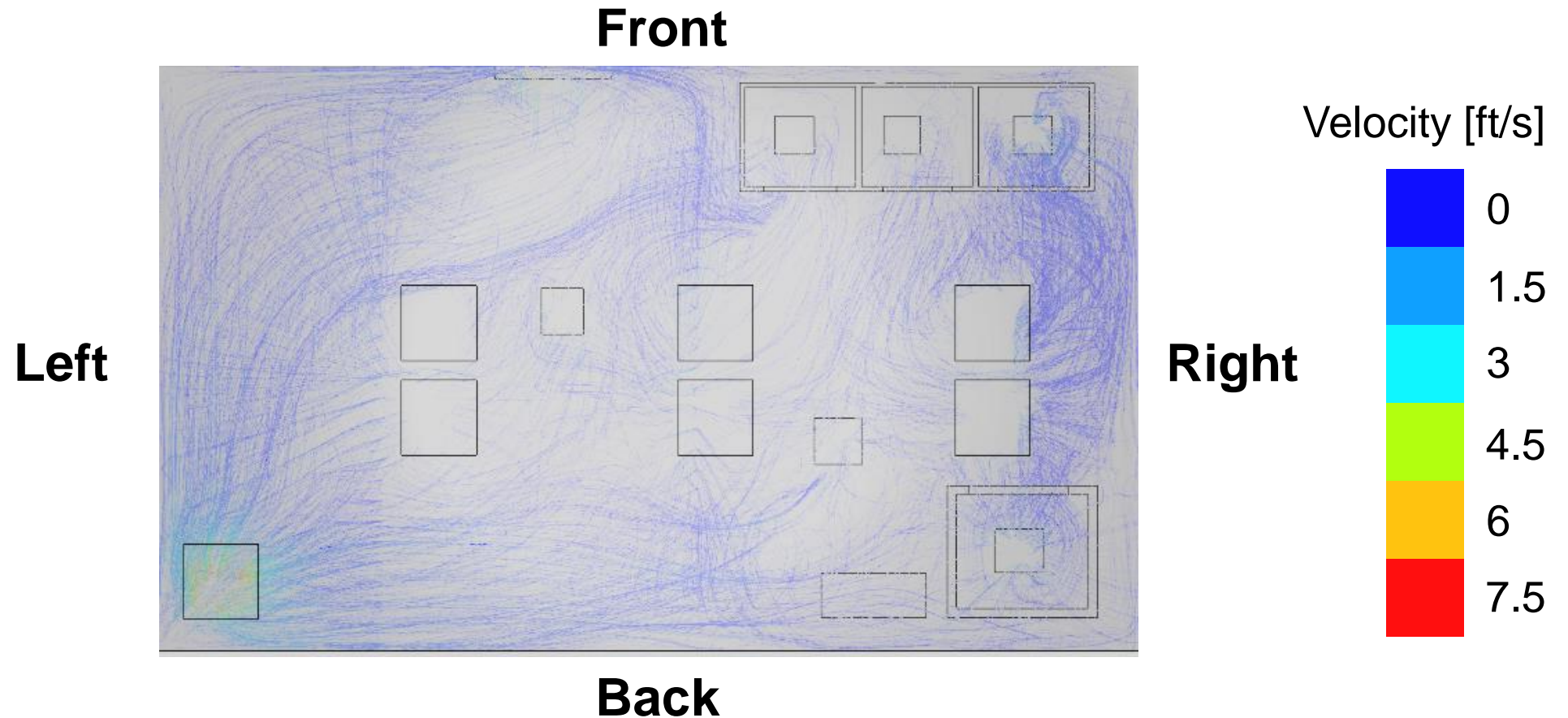
Razhan Matipano

Senior Design Lab Model



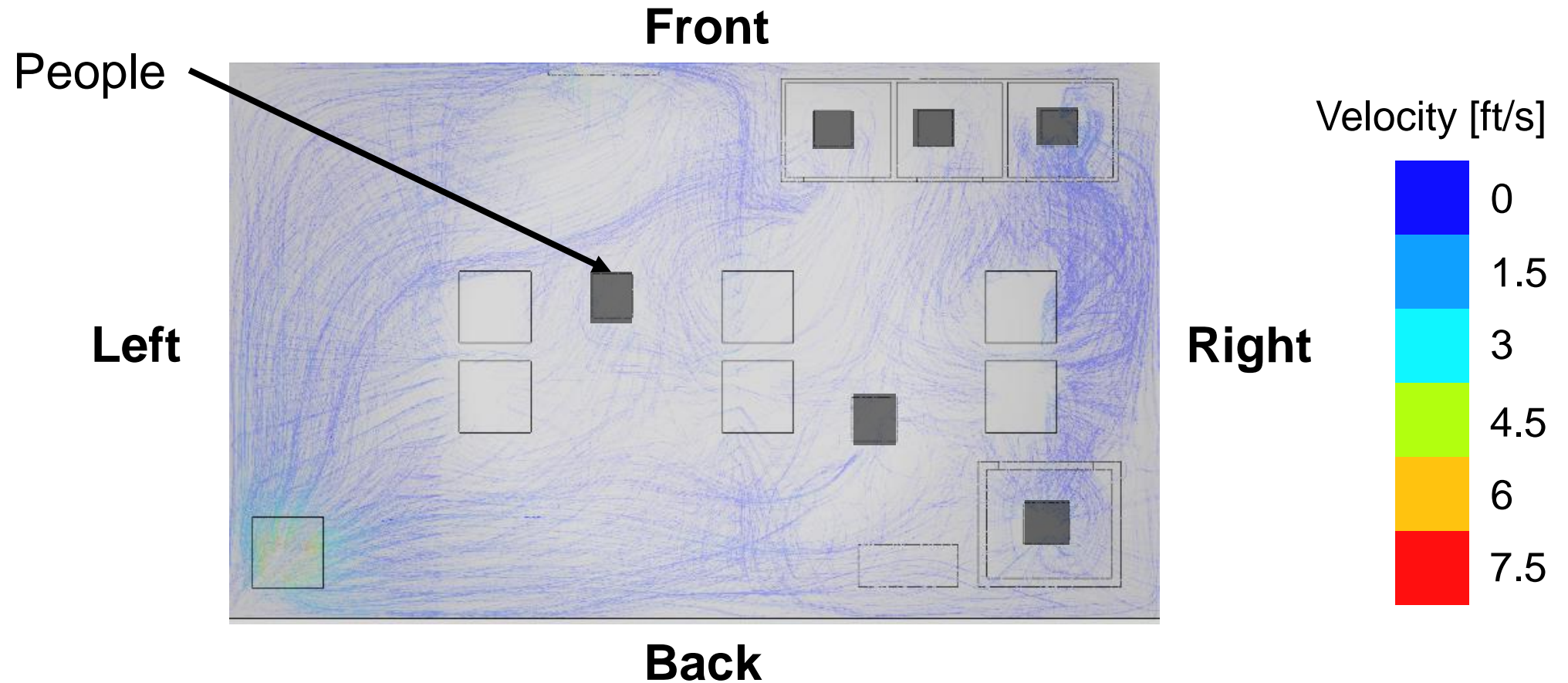
Razhan Matipano

SD Lab Simulation Top View



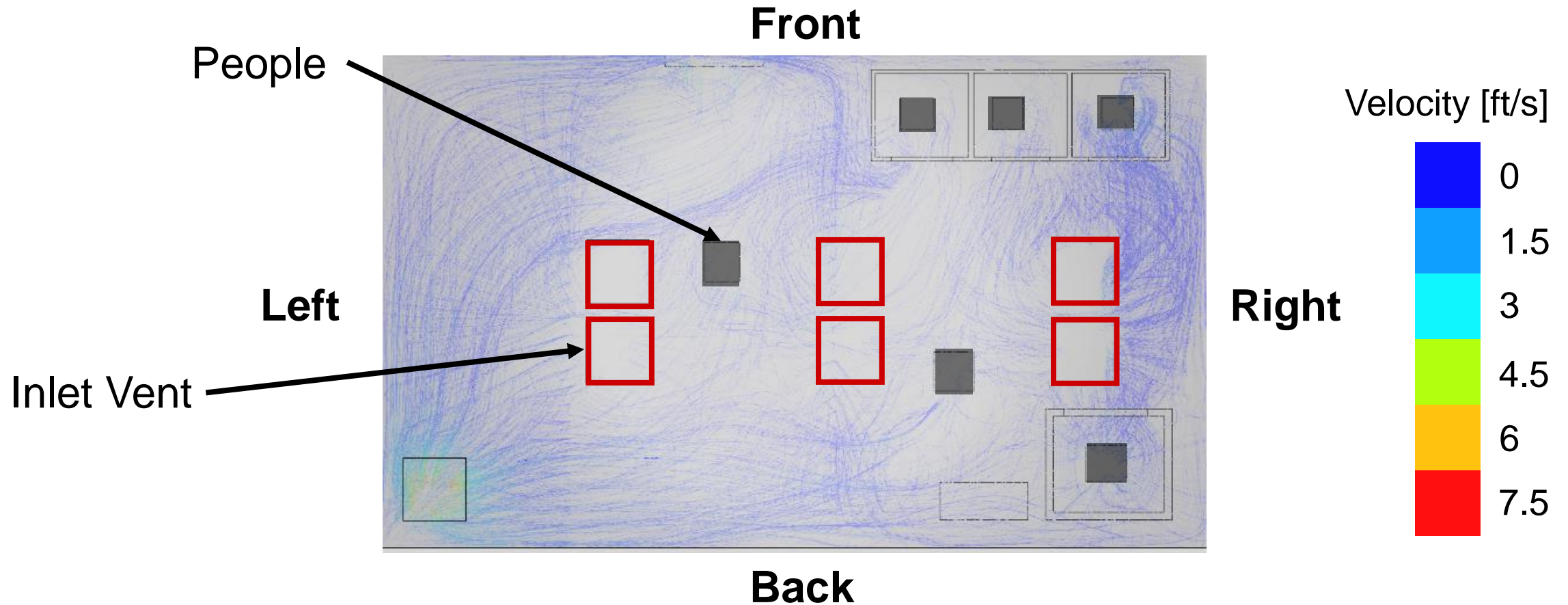
Razhan Matipano

SD Lab Simulation Top View



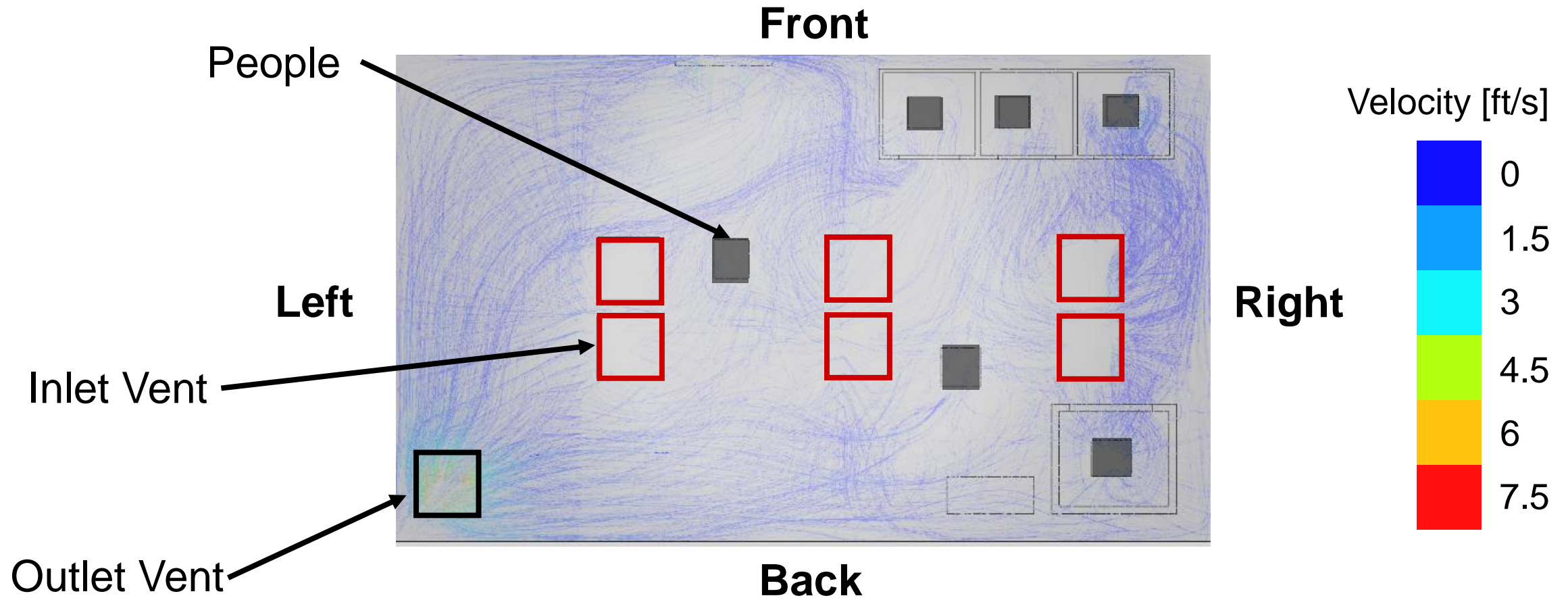
Razhan Matipano

SD Lab Simulation Top View



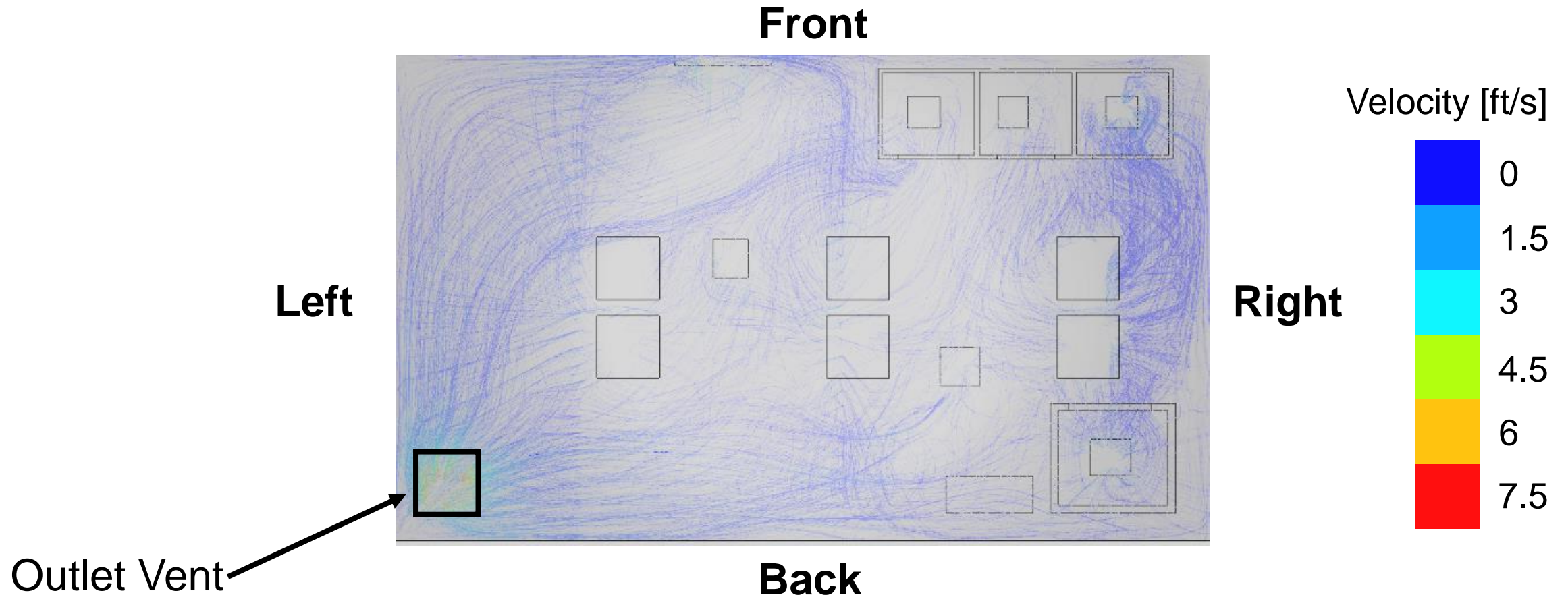
Razhan Matipano

SD Lab Simulation Top View



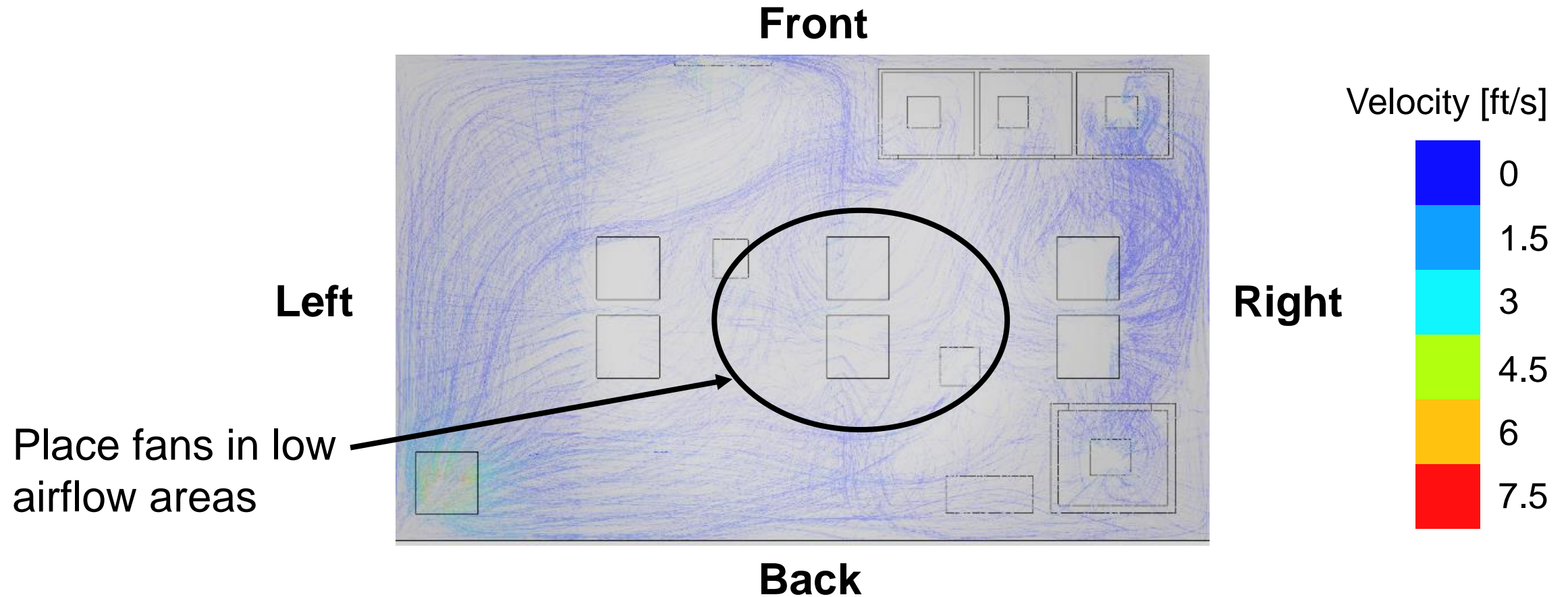
Razhan Matipano

SD Lab Simulation Top View



Razhan Matipano

SD Lab Simulation Top View



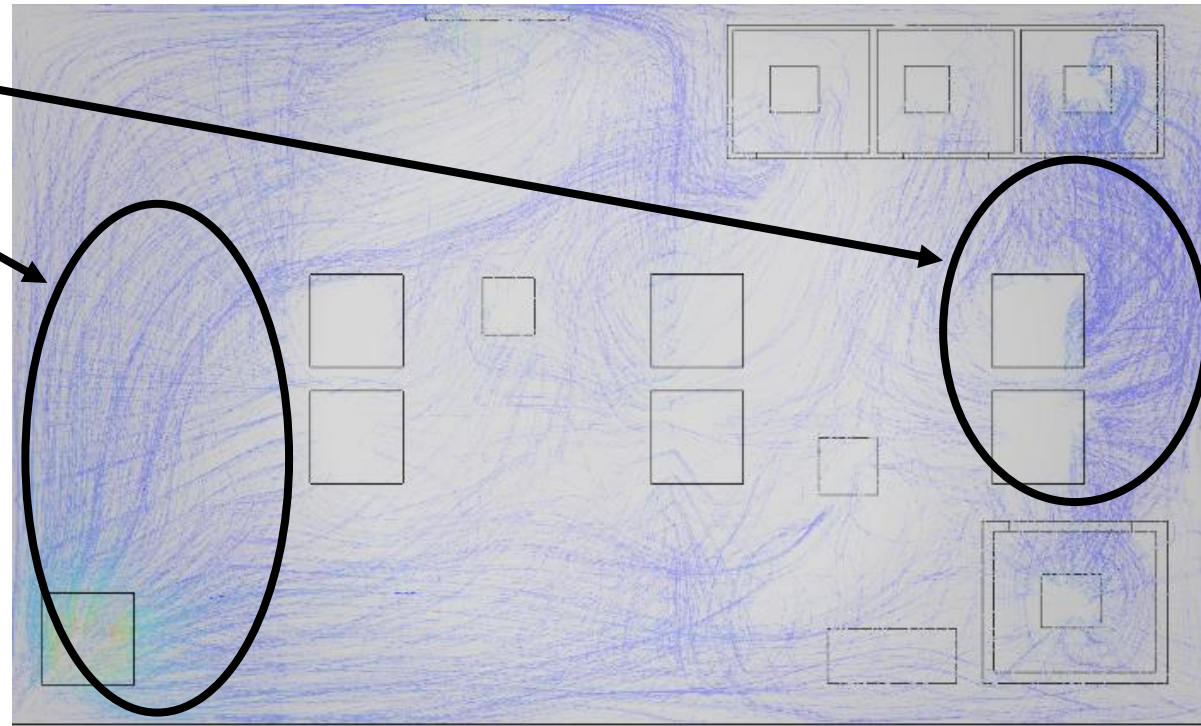
Razhan Matipano

SD Lab Simulation Top View

Front

Place air purifiers
in high airflow
areas

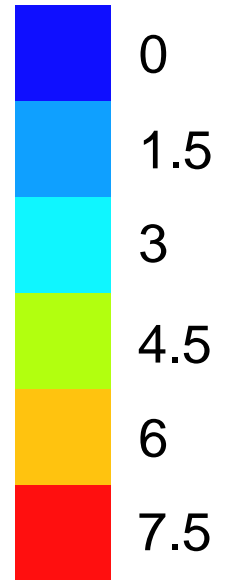
Left



Back

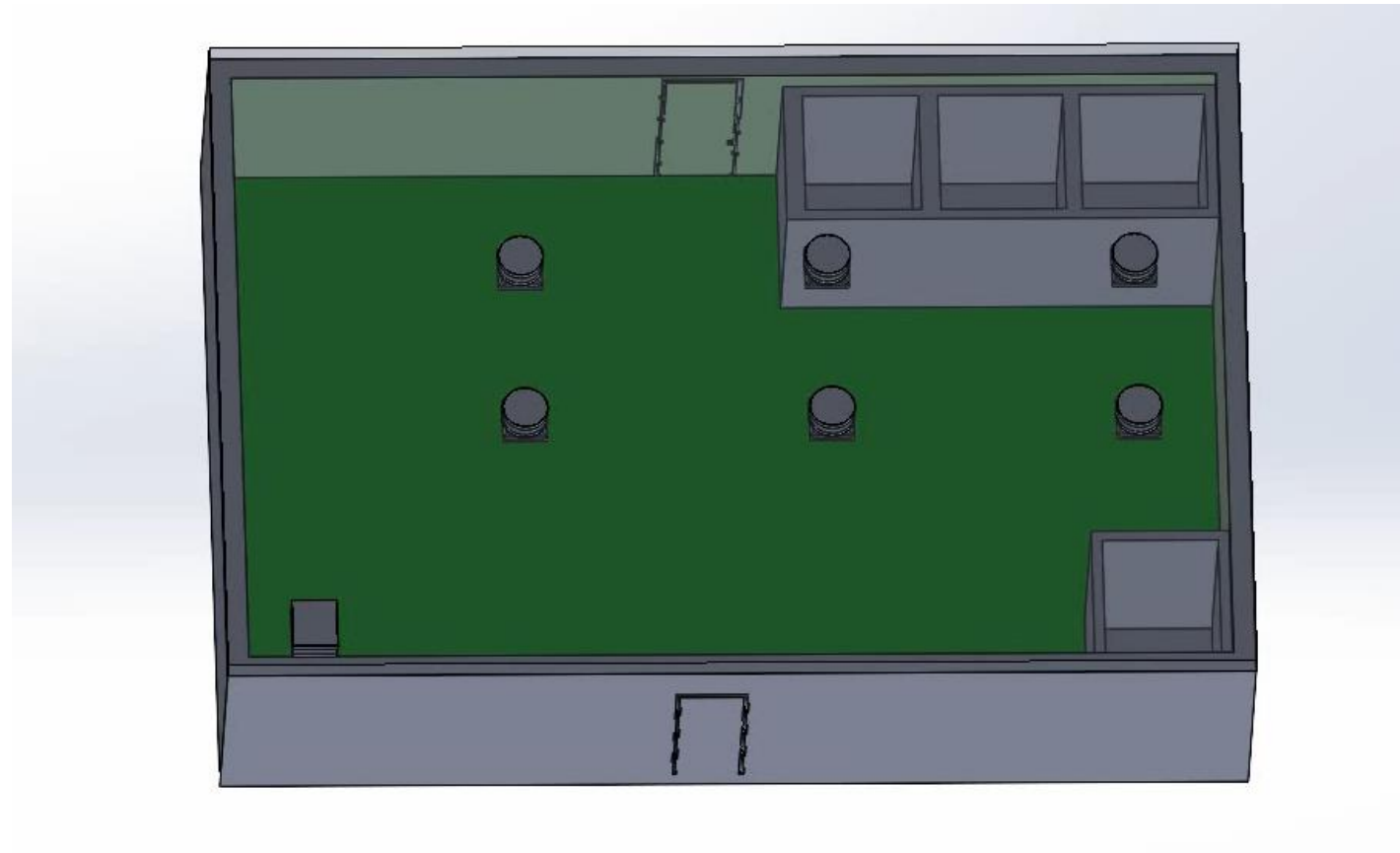
Velocity [ft/s]

Right

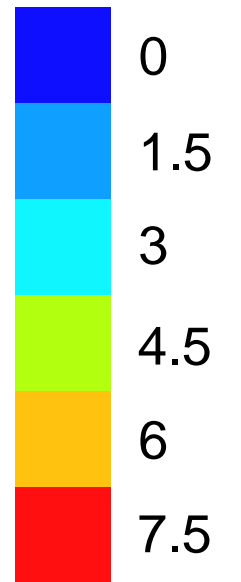


Razhan Matipano

SD Lab Simulation Top View

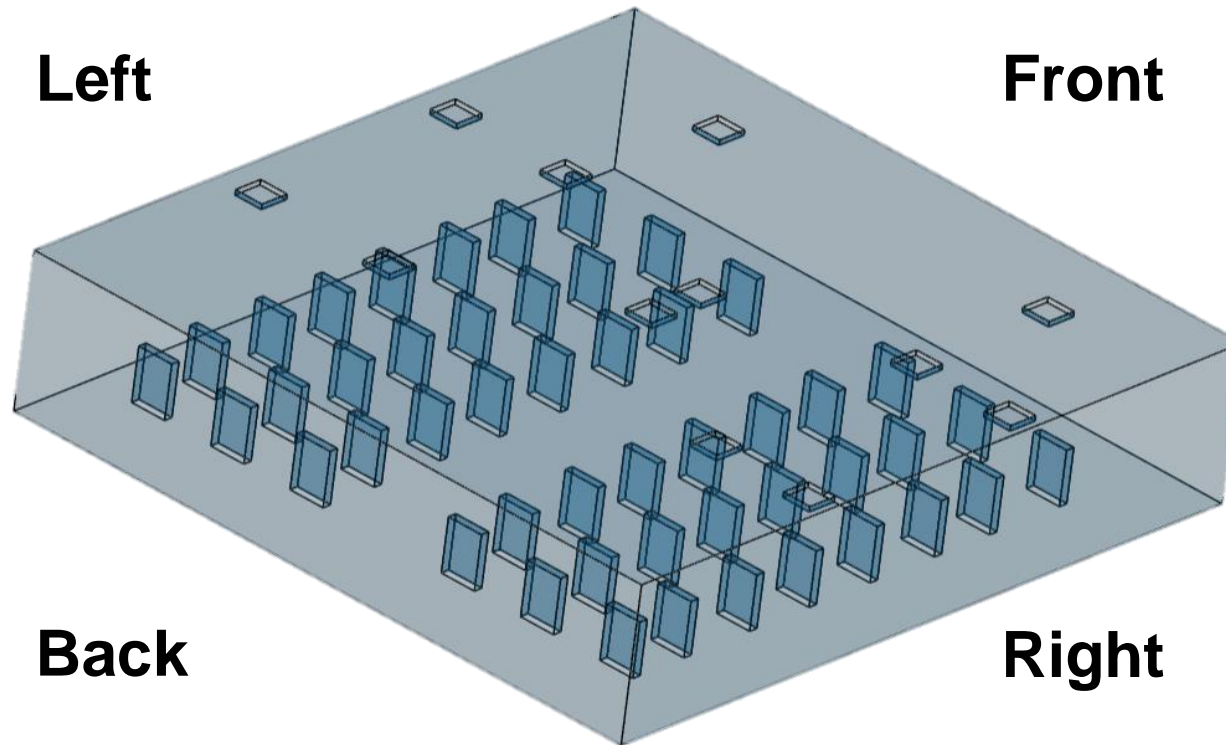


Velocity [ft/s]



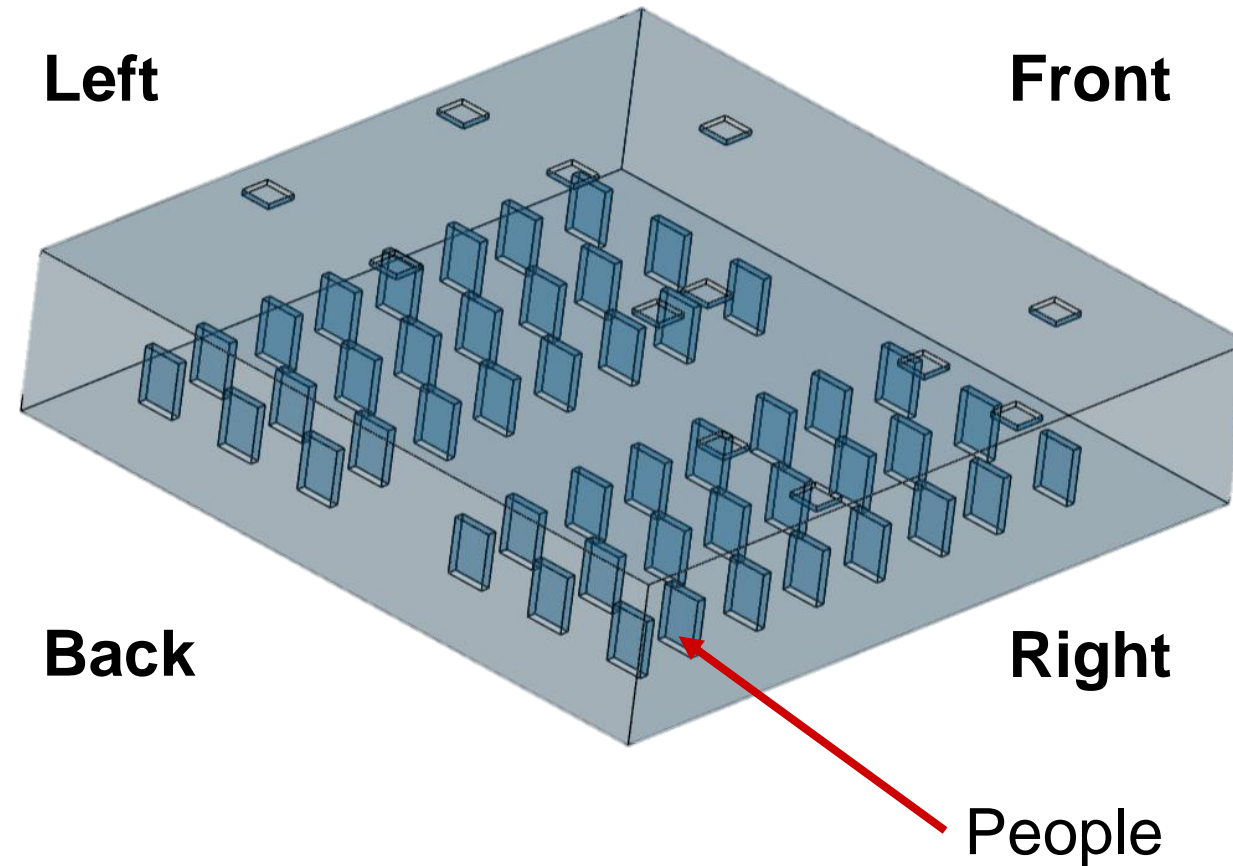
Razhan Matipano

B135 Model



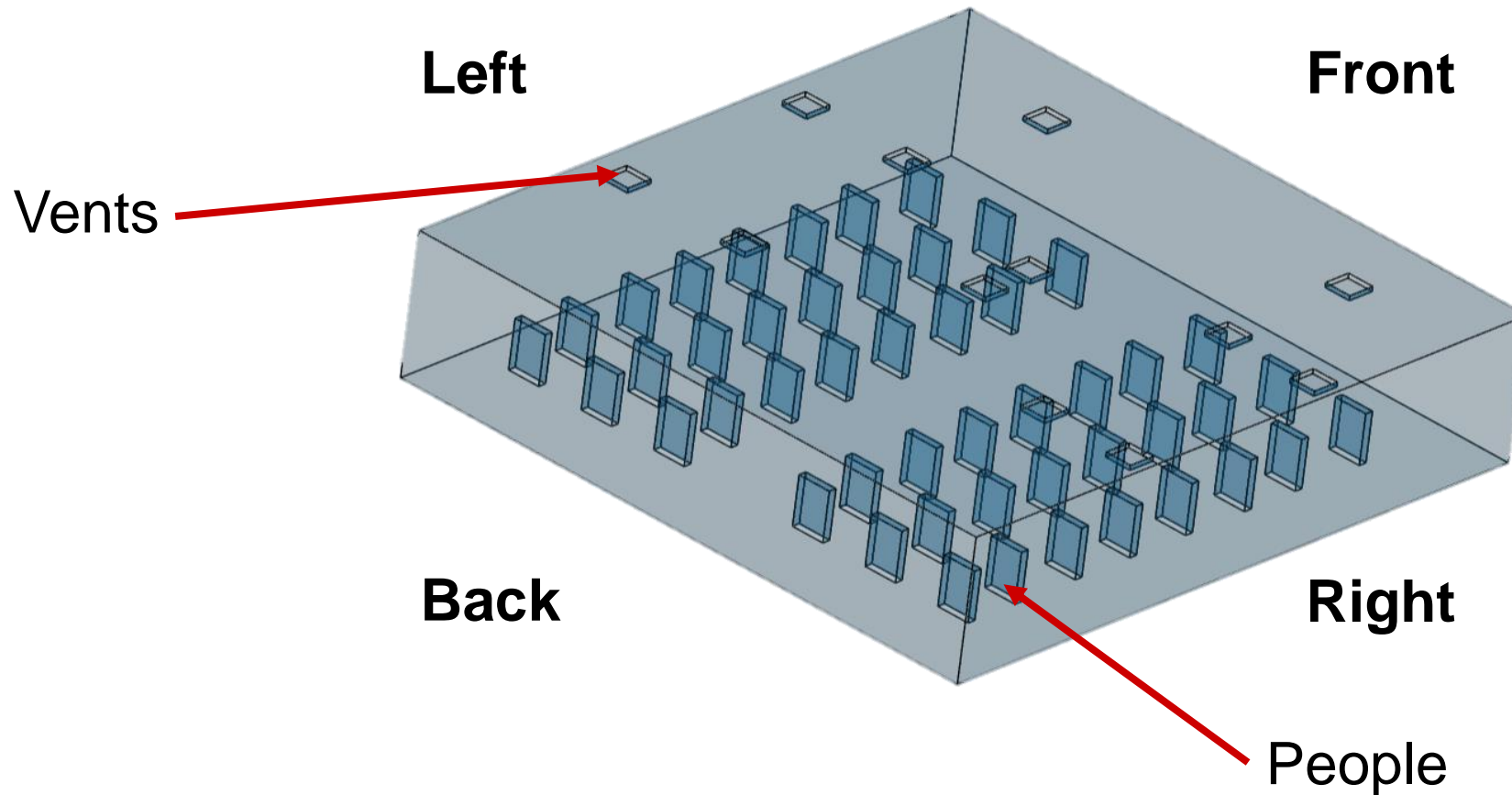
Leon Johnson

B135 Model



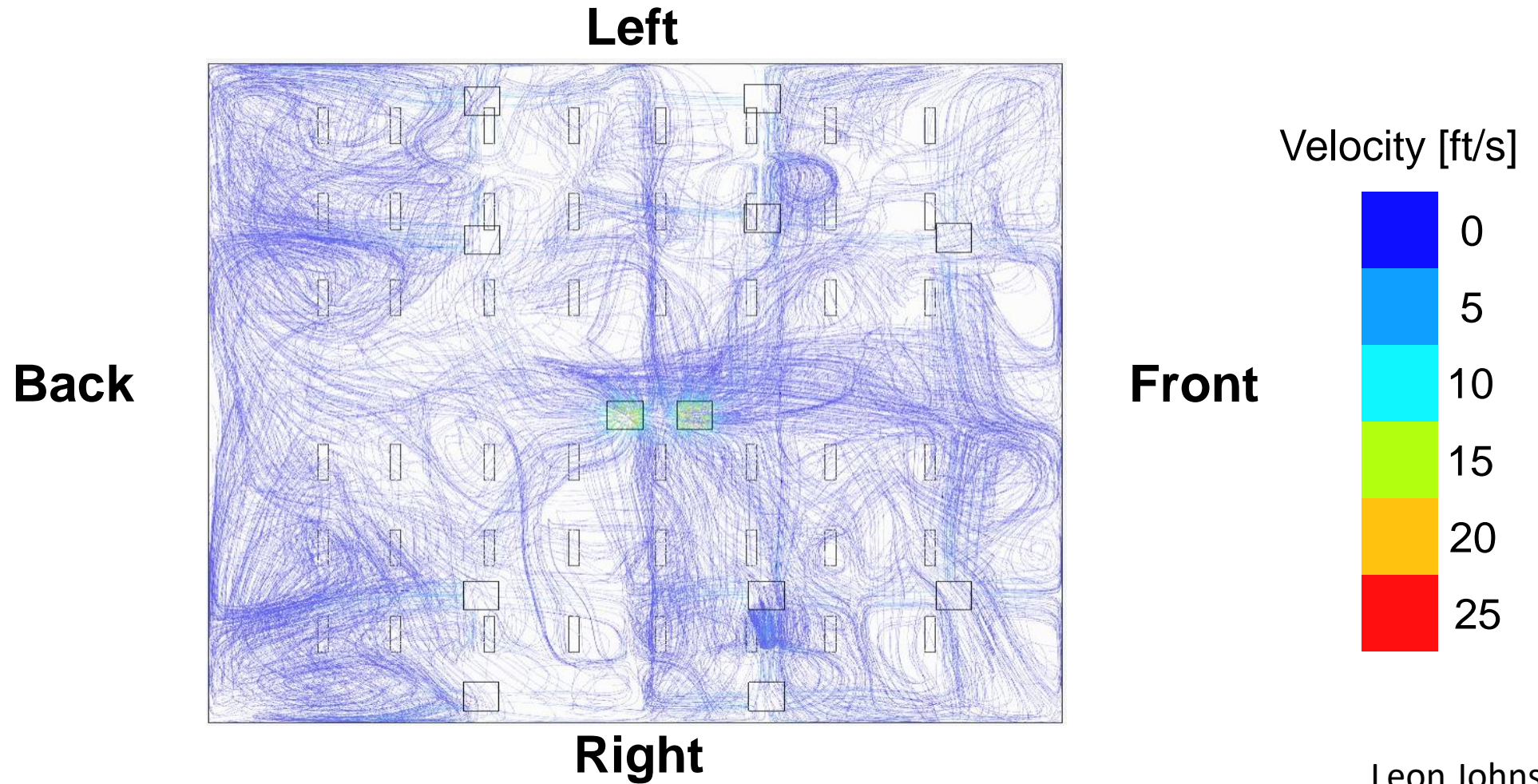
Leon Johnson

B135 Model



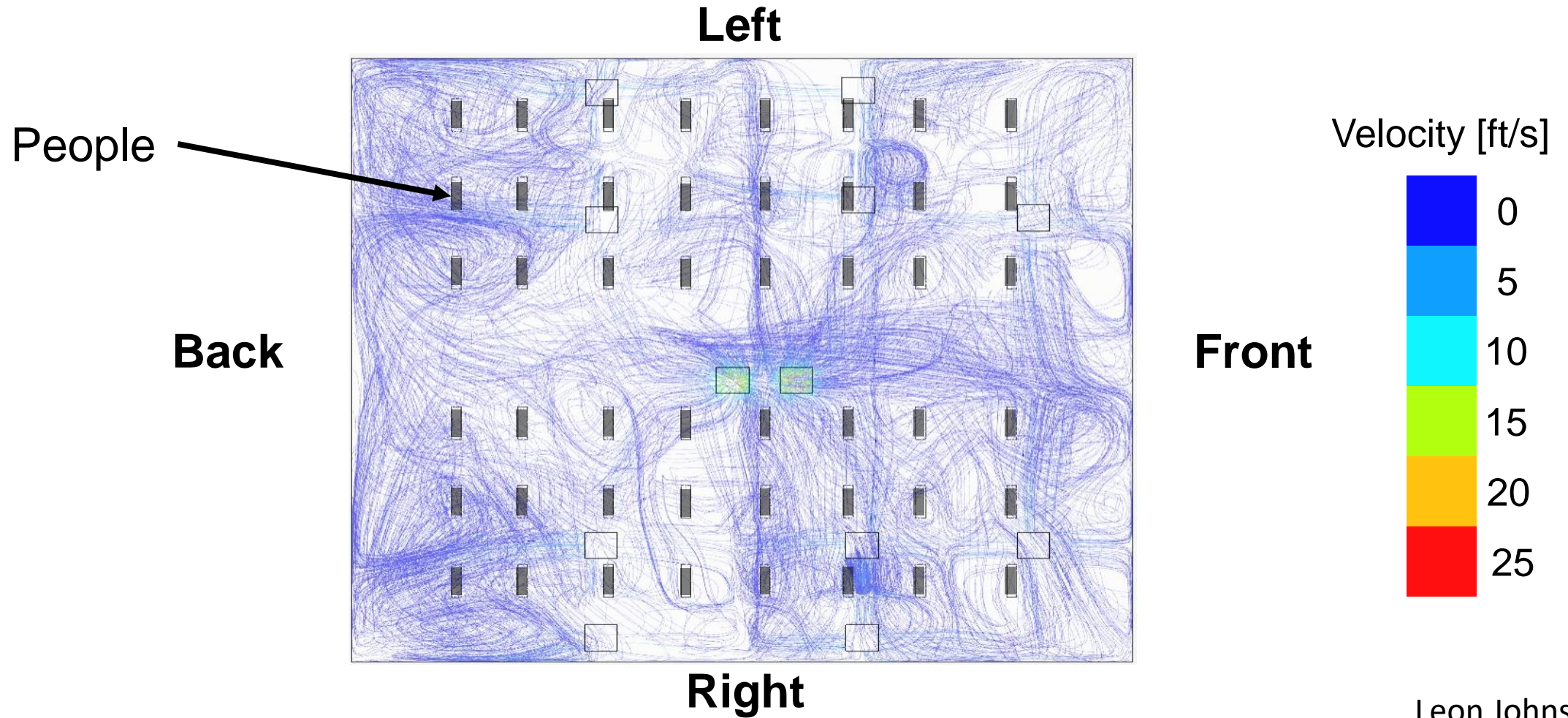
Leon Johnson

B135 Simulation – Top View



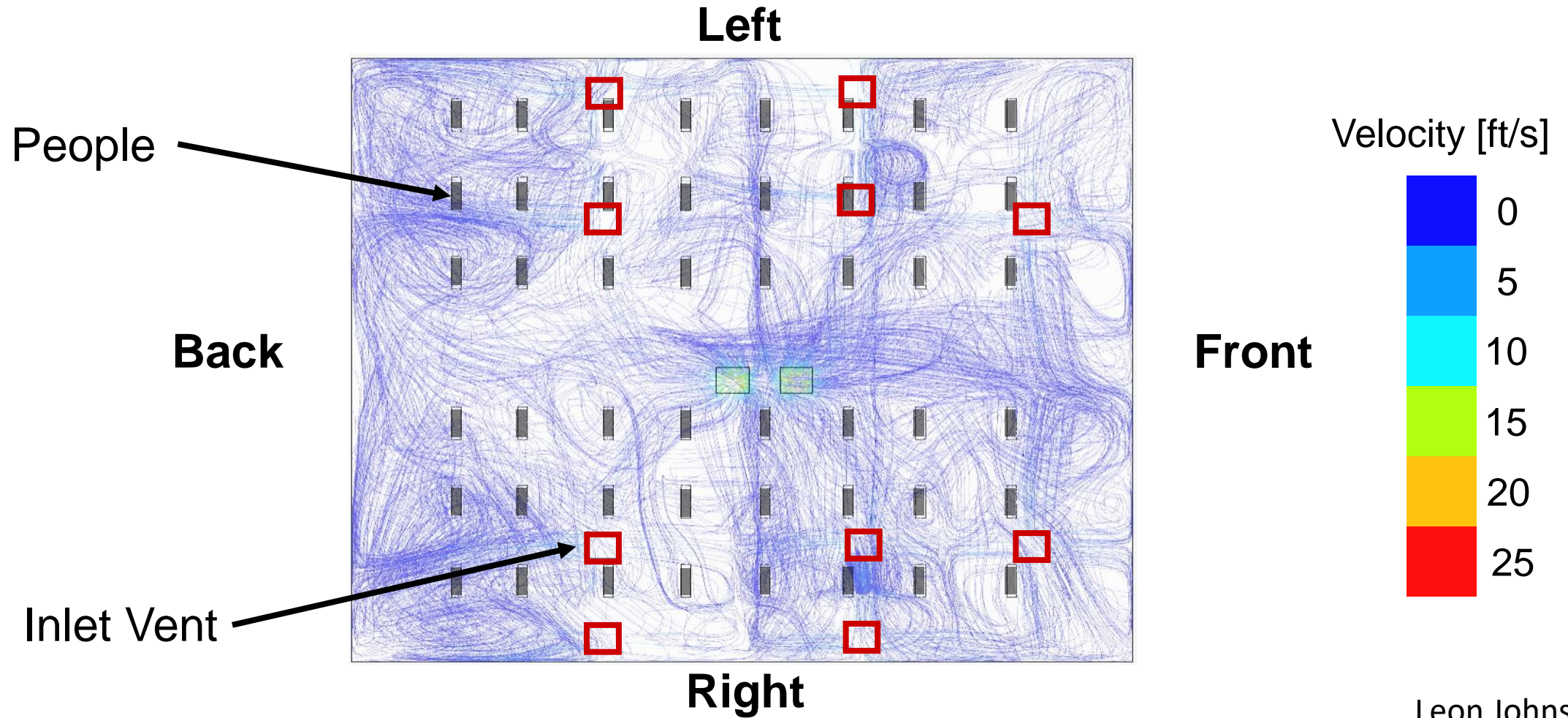
Leon Johnson

B135 Simulation – Top View



Leon Johnson

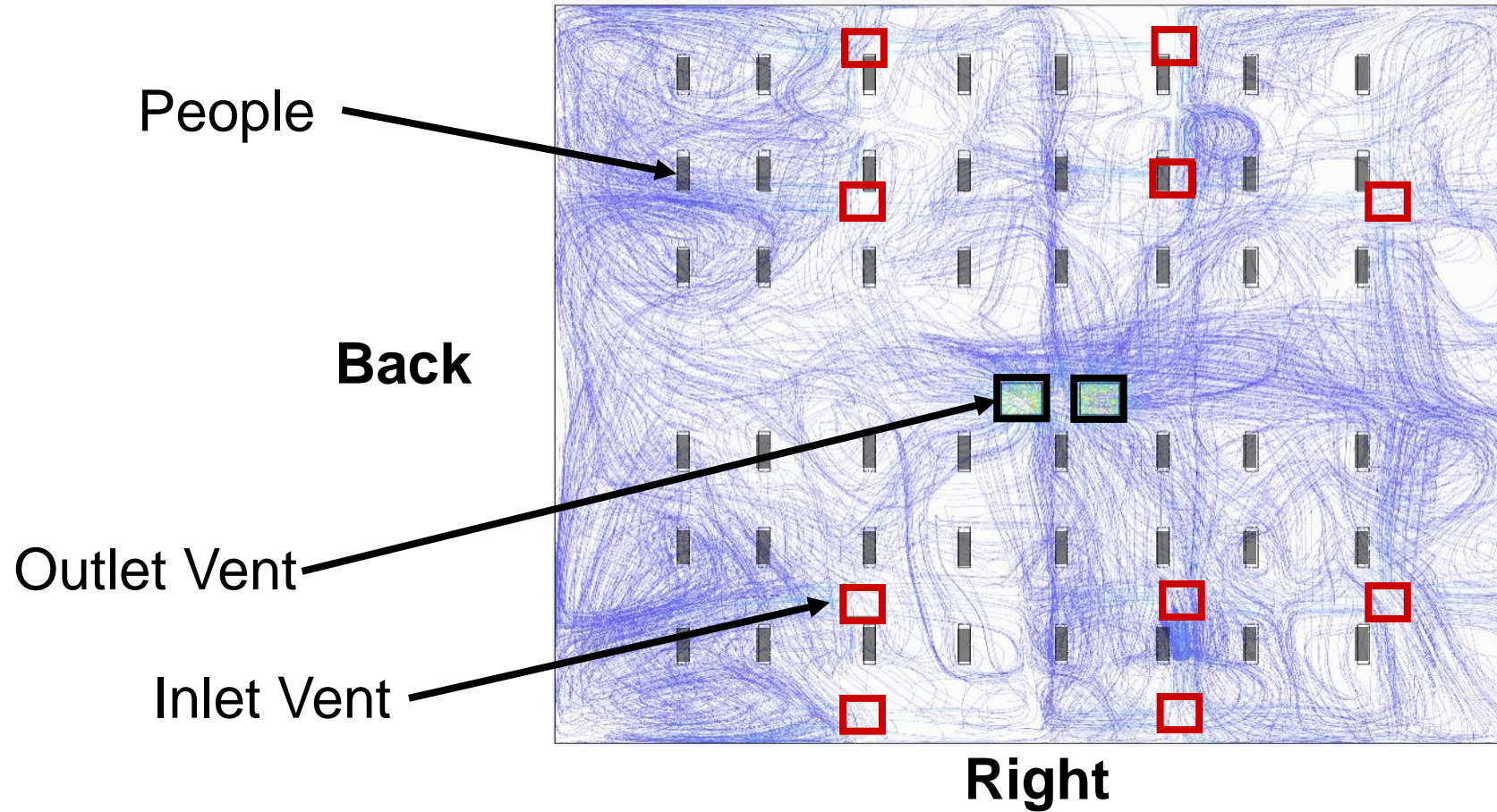
B135 Simulation – Top View



Leon Johnson

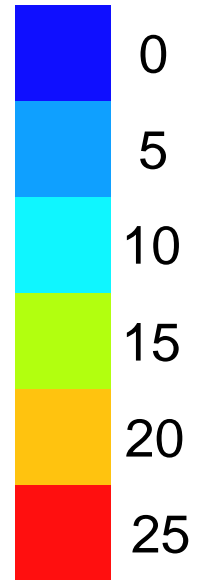
B135 Simulation – Top View

Left



Velocity [ft/s]

Front



Leon Johnson

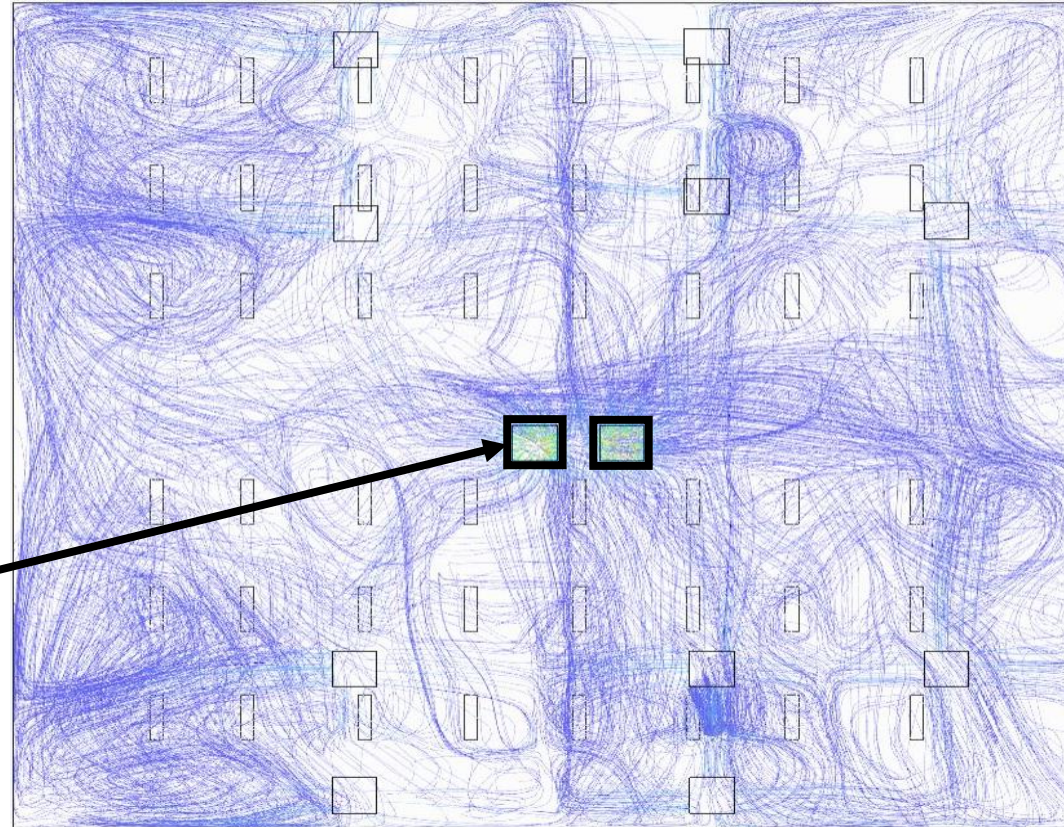
B135 Simulation – Top View

Left

Back

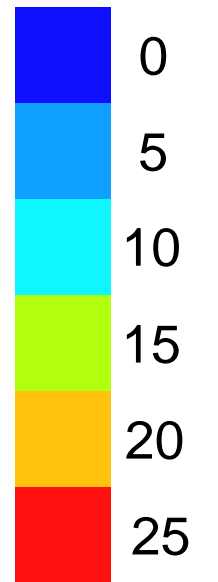
Right

Outlet Vent



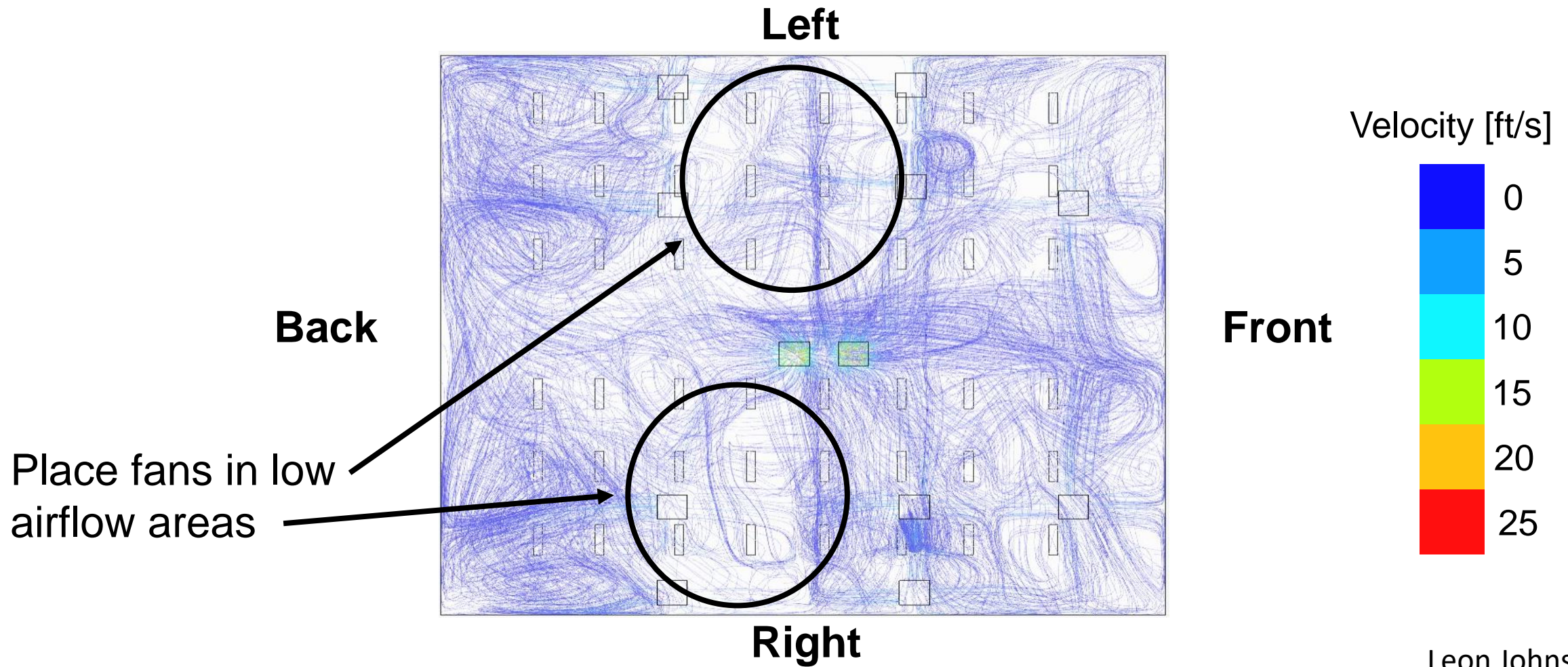
Velocity [ft/s]

Front



Leon Johnson

B135 Simulation – Top View



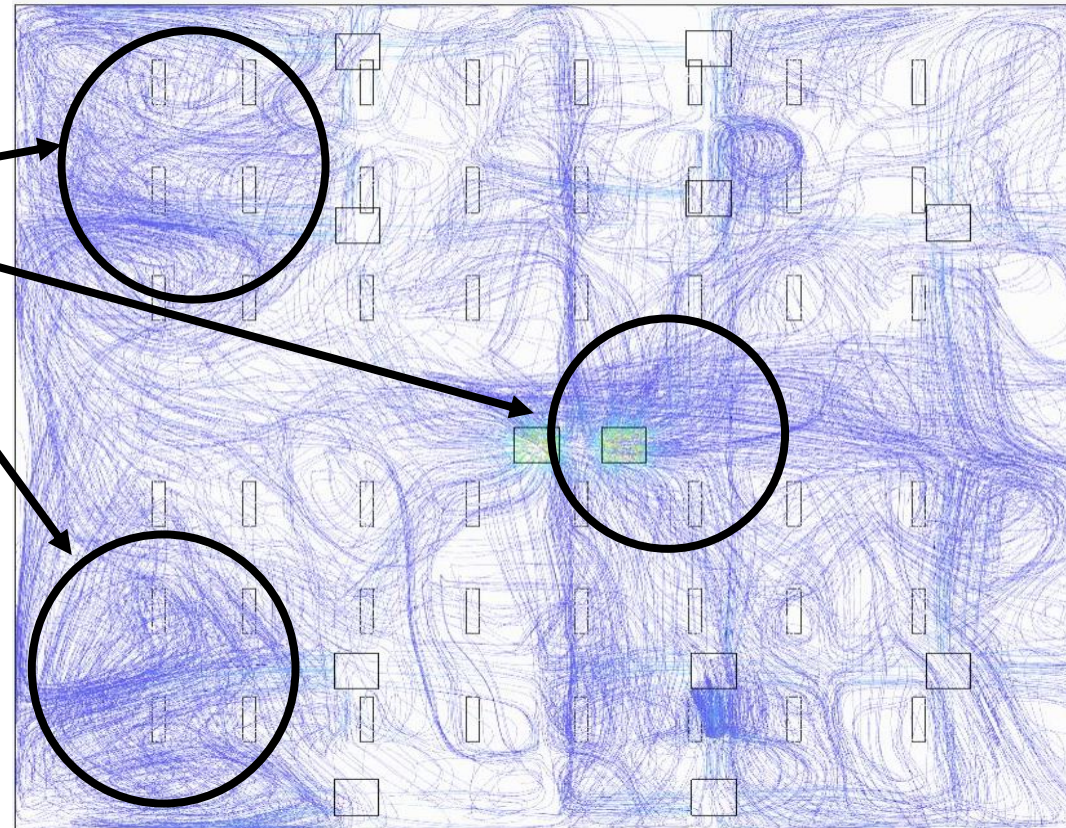
Leon Johnson

B135 Simulation – Top View

Left

Place air purifiers
in high airflow
areas

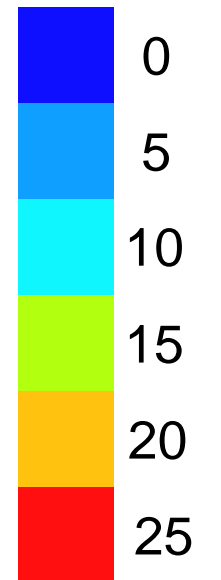
Back



Right

Velocity [ft/s]

Front



Leon Johnson

Preliminary Data

Eric Grogans



Future work

Complete Tests

Leon Johnson



Future work

Complete Tests

Process and Present
Data

Leon Johnson

Future work

Complete Tests

Process and Present
Data

Validate Design

Leon Johnson



Lessons Learned

- The ability to apply engineering skills across disciplines
- Building systems engineering skills
- Gained knowledge of technical simulation software
- Improved research skills
- Developed presentation skills
- Increased productivity through consistent work
- The importance maintaining good relationships with suppliers

Razhan Matipano

References

Blueair. (n.d.). *Pro M*. Retrieved from blueair: <https://www.blueair.com/us/pro/pro-m/1408.html?cgid=pro>

Environmental Protection Agency. (1990, July). *Ventilation and Air Quality in Offices*. Retrieved from https://www.epa.gov/sites/production/files/2014-08/documents/ventilation_factsheet.pdf

Environmental Protection Agency. (1989). *Report to Congress on Indoor Air Quality*.

Falke, R. (2016, March 24). *Use the Air Changes Calculation to Determine Room CFM*. Retrieved from Contracting Business : <https://www.contractingbusiness.com/service/article/20868246/use-the-air-changes-calculation-to-determine-room-cfm>

Honeywell . (n.d.). *Honeywell Filter A Universal Carbon Pre-Filter, HRF-AP1 (Replaces 38002)*. Retrieved from Honeywell Store: <https://www.honeywellstore.com/store/products/honeywell-universal-carbon-pre-filter-hrf-ap1.htm>

Honeywell. (2012, November). *E3 Point Specifications*. Retrieved from <https://www.instrumart.com/assets/Honeywell-e3point-standalone2-datasheet.pdf>

Honeywell. (2019, May). *HPM Series Particulate Matter Sensors*. Retrieved from <https://sensing.honeywell.com/honeywell-sensing-particulate-hpm-series-datasheet-32322550.pdf>

Honeywell. (n.d.). *Honeywell True HEPA Whole Room Air Purifier With Allergen Remover, HPA300*. Retrieved from Honeywell Store: https://www.honeywellstore.com/store/products/hpa300-true-hepa-whole-room-air-purifier-with-allergen-remover.htm?gclid=Cj0KCQjwit_8BRCoARIsAlx3Rj4begs_A3wW7Kjc6ktbr_sgMQfBrl0BI7Z_4R-9y6KaVkuL60M_dTUaAmQUEALw_wcB

Blueair. (n.d.). *Pro M*. Retrieved from blueair: <https://www.blueair.com/us/pro/pro-m/1408.html?cgid=pro>

Environmental Protection Agency . (1990, July). *Ventilation and Air Quality in Offices*. Retrieved from https://www.epa.gov/sites/production/files/2014-08/documents/ventilation_factsheet.pdf

Environmental Protection Agency. (1989). *Report to Congress on Indoor Air Quality*.

Falke, R. (2016, March 24). *Use the Air Changes Calculation to Determine Room CFM*. Retrieved from Contracting Business : <https://www.contractingbusiness.com/service/article/20868246/use-the-air-changes-calculation-to-determine-room-cfm>

Razhan Matipano

References

- Honeywell . (n.d.). *Honeywell Filter A Universal Carbon Pre-Filter, HRF-AP1 (Replaces 38002)*. Retrieved from Honeywell Store: <https://www.honeywellstore.com/store/products/honeywell-universal-carbon-pre-filter-hrf-ap1.htm>
- Honeywell. (2012, November). *E3 Point Specifications*. Retrieved from <https://www.instrumart.com/assets/Honeywell-e3point-standalone2-datasheet.pdf>
- Honeywell. (2019, May). *HPM Series Particulate Matter Sensors*. Retrieved from <https://sensing.honeywell.com/honeywell-sensing-particulate-hpm-series-datasheet-32322550.pdf>
- Honeywell. (n.d.). *Honeywell True HEPA Whole Room Air Purifier With Allergen Remover, HPA300*. Retrieved from Honeywell Store: https://www.honeywellstore.com/store/products/hpa300-true-hepa-whole-room-air-purifier-with-allergen-remover.htm?gclid=Cj0KCQjwit_8BRCoARIsAlx3Rj4bega_A3wW7Kjc6ktbr_sgMQfBrl0BI7Z_4R-9y6KaVkuL60M_dTUaAmQUEALw_wcB
- M. Jeremiah Matson, C. K.-S. (2020). Effect of Environmental Conditions on SARS-CoV-2 Stability in Human Nasal Mucus and Sputum. *Emerging Infectious Diseases*.
- Moreno, T., & de Miguel, E. (2018). Improving air quality in subway systems: An overview. *Environmental Pollution* , 829-831.
- Sylvane. (n.d.). *Frequently Asked Questions About Air Purifiers*. Retrieved from Sylvane: [https://www.sylvane.com/air-purifier-faq.html#:~:text=High%20Efficiency%20Particulate%20Air%20\(HEPA,and%20pollen%20from%20your%20air](https://www.sylvane.com/air-purifier-faq.html#:~:text=High%20Efficiency%20Particulate%20Air%20(HEPA,and%20pollen%20from%20your%20air)
- Texas Instruments . (2016, May). *PM2.5/PM10 Particle Sensor Analog Front-End for Air*. Retrieved from <https://www.ti.com/lit/ug/tidub65c/tidub65c.pdf>
- Texas Instruments. (2020, 10 30). *PM2.5/PM10 Particle Sensor Analog Front-End for Air*. Retrieved from <https://www.ti.com/lit/ug/tidub65c/tidub65c.pdf>
- Uline. (n.d.). *Uline 3-Shelf Utility Cart with Flat Shelves - 27 x 18 x 34", Black*. Retrieved from Uline: https://www.uline.com/Product/Detail/H-5007BL/Utility-Carts/Uline-3-Shelf-Utility-Cart-with-Flat-Shelves-27-x-18-x-34-Black?pricode=WA9800&gadtype=pla&id=H-5007BL&gclid=Cj0KCQjwxNT8BRD9ARIsAJ8S5xZs2sqeNe-FNcf0eXoP6YRdOigzw7Grd-wCJlI4rb0sTgOXVDB29_waApxfEA
- World Health Organization . (n.d.). *Common Noise*. Retrieved from <https://www.who.int/docstore/peh/noise/Comnoise-4.pdf>

Razhan Matipano

References

Britannica. (n.d.). *Virus Size and Shape*. Retrieved from Britannica: <https://www.britannica.com/science/virus/Size-and-shape>

NCBI. (2020, April). *SARS-CoV-2 (COVID-19) by the numbers*. Retrieved from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7224694/>

Science Direct. (2015). *Pollen*. Retrieved from: <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/pollen#:~:text=Pollen%20is%20the%20male%20gametophyte,is%20generally%20oval%20or%20spherical>

Molekule. (2019, April). *HEPA Filter Air Purifiers for Mold Spores: What to Look for*. Retrieved from: <https://molekule.science/hepa-filter-air-purifiers-for-mold-spores-what-to-look-for/>

WHO. (n.d.). *Hazard Prevention and Control in the Work Environment: Airborne Dust*. Retrieved from: https://www.who.int/occupational_health/publications/en/oeairbornedust3.pdf

WHO. (2020, March). *Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations*. Retrieved from: <https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations>

Schwarzkopf. (n.d.). *Hair Dictionary: Important Facts about Hair*. Retrieved from: <https://www.schwarzkopf.com/en/hair-care/split-ends/hair-dictionary.html#:~:text=Europeans%20consider%20hair%20with%20a,is%200.08%20to%200.12%20mm>

LabCE. (n.d.). *Red Blood Cell (RBC) Size Variation*. Retrieved from: https://www.labce.com/spg579126_red_blood_cell_rbc_size_variation.aspx

Let's Talk Science. (n.d.). *What is Noise?* Retrieved from: <https://letstalkscience.ca/educational-resources/backgrounders/noise-on-earth-and-on-international-space-station>

Razhan Matipano

Backup Slides



	Major functions		
Minor functions	Control System	Ventilate Room	Improve Air Composition
Sense Air Quality	x		
Measure Air Quality	x		
Activate Propeller	x		
Deactivate Propeller	x		
Modulate Propeller	x		
Activate Purifier	x		
Deactivate Purifier	x		
Modulate Purifier	x		
Propel Air		x	
Circulate Air		x	x
Purify Air			x
Treat Air			x
Filter Particulates			x
Dehumidify Air			x
Humidify Air			x
Sanitize Contaminants			x
Total	8	2	7

Questions	Customer Statement	Interpreted Need
Would using the most outside air be efficient enough to clean air?	The best method to clean the air, would be 100% outside air utilization. This would be too expensive	Clean and recycle existing indoor air.
How do healthy buildings affect energy consumption?	Using systems to work more efficiently, increases consumption. Portable and battery powered units with data loggers.	A device that is portable and battery powered would be more appropriate.
Are there any structural or sizing limitations? e.g. volume, height, length, weight, etc.	The device cannot be added to the existing structure of mechanical equipment. Small, and lightweight to be moved on a cart.	A portable device that can be moved easily.
In what environment will the project be used? e.g. home, office, stadium, retail, etc.	The idea is to create a product that can be used at FAMU-FSU COE	The product is designed to work in classrooms, labs, and study spaces.
Should it be geared towards reducing contamination or increasing ventilation?	The device should be geared towards reducing contaminants.	The product reduces contamination and increases ventilation.

Do you have any existing products or previous research that could be used to help this project?	Similar projects are being done at other universities.	The product will resemble other products that have been installed in other universities.
Will our project be used in conjunction with an existing product or will an entirely new system need to be designed?	Since we have products already made, I do not figure that you all will create an entirely new system.	The product will work in conjunction with an existing product.
If it will be used in conjunction with another system, what type of system? Do you have any specific details?	We will donate products for you to work with.	The project will make use of existing Honeywell products.
Does the current COE mechanical system include sensors?	Some rooms have humidity sensors, but there are no Volatile Organic Compounds (VOC) or particulate sensors.	Device will measure the VOC, CO2, humidity, temperature, and particulate levels
Is there a problem with the current purifiers?	Current purifiers would only clean 10% of the air in the room, because of placement.	The device will clean and monitor more of the air in the spaces.
What is the nature of the contamination we are aiming to reduce? e.g. viruses, bacteria, fungi, odor, etc.	Reducing the replication of airborne pathogens	The product reduces viruses that are in the hotspot area.
Does the project need to be an automatic or a manual system?	It would be great for it to be automatic but if it ends up having to be manual that will work.	The product is activated automatically.

	Monitor Air Quality	Portable	No Noise	No Heat	Reduces Contamination	Internal Power Source	Compatible with Honeywell Products	Doesn't Interfere with Existing Infrastructure	Total
Monitor Air Quality	-	1	1	1	1	1	1	1	7
Portable		-	1	1					2
No Noise			-	1		1			2
No Heat				-					0
Reduces Contamination		1	1	1	-	1	1	1	6
Internal Power Source		1		1		-			2
Compatible with Honeywell Products		1	1	1		1	-		4
Doesn't Interfere with Existing Infrastructure		1	1	1		1	1	-	5



		Engineering Characteristics							
Improvement		↑		↑	↓	↓	↓	↓	↓
Units		µg/m3		ft3/min	dBA	Watts	ft3	sec	µm
Customer Requirements	Importance Weight Factor	Concentration Range of Sensors	Accuracy of Sensors	Volumetric Flowrate	Noise Level	Daily Energy Consumption	Volume of Device	Reaction Time of Hardware Components	Minimum Diameter of Particles the Device Will Filter
Monitor Air Quality	7	9	9					3	
Portable	2					1	9		
No Noise	2			1	9				
No Heat	0								
Reduces Contamination	6	3	9	9				3	9
Internal Power Source	2					3	1		
Compatiable with Honeywell Products	4	1	1						
Doesn't Interfere with Existing Infrastructure	5						1		
Raw Score (406)		85	121	56	18	8	25	39	54
Relative Weight %		20.94	29.80	13.79	4.43	1.97	6.16	9.61	13.30
Rank Order		2	1	3	7	8	6	5	4



Pugh Chart									
Engineering Characterisitcs	Datum: Air Purifier	Concept 13: Single mobile cart	Concept 14: double mobile cart	Concept 34: Air purifier on cart	Concept 36: Stationary air purifier	Concept 38: Air purifier with UV cleaning	Concept 46: rotating air furifier	Concept 47: Light-up air purifier	Concept 48: Wall mounted sensors
ability to circulate air	D a t u m	+	S	+	+	S	S	-	+
ability to purify air		+	+	S	+	+	+	+	S
ability to filter particulates		+	+	+	+	S	S	+	S
ability to humidify and dehumidify air		+	+	+	+	-	-	-	+
utilizes control systems		+	+	+	-	-	-	S	+
portable		S	+	+	-	-	-	+	-
utilizes proprietary power source		S	S	S	-	-	-	S	+
utilizes multiple sensors		S	S	-	-	-	-	+	S
Plusses		5	5	5	4	1	1	4	4
Minuses		0	0	1	4	5	5	2	1
Satisfactory		3	3	2	0	2	2	2	3



Pugh Chart				
Engineering Characterisitcs	Concept 34: Air purifier on cart	Concept 13: Single mobile cart	Concept 14: double mobile cart	Concept 48: wall mounted sensors
Ability to circulate air	D a t u m	+	S	S
ability to purify air		+	+	+
ability to filter particulates		+	+	+
ability to humidify and dehumidify air		+	+	+
utilizes control systems		S	S	+
utilizes mobility		S	+	-
utilizes proprietary power source		S	S	-
utilizes multiple sensors		S	S	S
Plusses		4	4	4
Minuses		0	0	2
Satisfactory		4	4	2



Development of Candidate Set of Criteria Weights {W}												
Criteria Comparison Matrix [C]												
Engineering Characteristics	Portability	Sense air Quality	Propeller Activation	Propeller Modulation	Purifier Activation	Purifier Modulation	Air Propulsion	Air Purification	Air Treatment	Filter Particulates	Humidify	Sanitize
Portability	1.00	3.00	0.14	0.14	0.14	0.14	0.20	0.20	0.20	0.20	0.20	3.00
Sense air Quality	0.33	1.00	0.14	0.20	0.20	0.20	0.20	0.14	0.14	0.14	0.33	5.00
Propeller Activation	7.00	5.00	1.00	7.00	1.00	3.00	0.33	0.14	0.14	0.14	0.20	0.14
Propeller Modulation	7.00	5.00	0.14	1.00	0.14	1.00	0.33	0.14	0.14	0.14	0.20	0.14
Purifier Activation	7.00	5.00	1.00	7.00	1.00	5.00	0.33	0.14	0.20	0.20	0.20	0.14
Purifier Modulation	7.00	5.00	0.33	1.00	0.20	1.00	0.33	0.20	0.20	0.20	0.20	0.20
Air Propulsion	5.00	5.00	3.00	3.00	3.00	3.00	1.00	0.33	0.33	0.20	0.20	0.33
Air Purification	5.00	7.00	7.00	7.00	7.00	5.00	3.00	1.00	1.00	0.33	0.20	0.33
Air Treatment	5.00	7.00	7.00	7.00	5.00	5.00	3.00	1.00	1.00	0.33	3.00	3.00
Filter Particulates	5.00	7.00	7.00	7.00	5.00	5.00	5.00	3.00	3.00	1.00	5.00	5.00
Humidify	5.00	3.00	5.00	5.00	5.00	5.00	5.00	5.00	0.33	0.20	1.00	1.00
Sanitize	0.33	0.20	7.00	7.00	7.00	5.00	3.00	3.00	0.33	0.20	1.00	1.00
Sum	54.67	53.20	38.76	52.34	34.69	38.34	21.73	14.30	7.03	3.30	11.73	19.30



Development of Candidate Set of Criteria Weights {W}													
Normalized Criteria Comparison Matrix [NormC]													
Engineering Characteristics	Portability	Sense air Quality	Propeller Activation	Propeller Modulation	Purifier Activation	Purifier Modulation	Air Propulsion	Air Purification	Air Treatment	Filter Particulates	Humidify	Sanitize	Criteria Weight {W}
Portability	0.0183	0.0564	0.0037	0.0027	0.0041	0.0037	0.0092	0.0140	0.0284	0.0606	0.0171	0.1554	0.0311
Sense air Quality	0.0061	0.0188	0.0037	0.0038	0.0058	0.0052	0.0092	0.0100	0.0203	0.0433	0.0284	0.2591	0.0345
Propeller Activation	0.1280	0.0940	0.0258	0.1337	0.0288	0.0782	0.0153	0.0100	0.0203	0.0433	0.0171	0.0074	0.0502
Propeller Modulation	0.1280	0.0940	0.0037	0.0191	0.0041	0.0261	0.0153	0.0100	0.0203	0.0433	0.0171	0.0074	0.0324
Purifier Activation	0.1280	0.0940	0.0258	0.1337	0.0288	0.1304	0.0153	0.0100	0.0284	0.0606	0.0171	0.0074	0.0566
Purifier Modulation	0.1280	0.0940	0.0086	0.0191	0.0058	0.0261	0.0153	0.0140	0.0284	0.0606	0.0171	0.0104	0.0356
Air Propulsion	0.0915	0.0940	0.0774	0.0573	0.0865	0.0782	0.0460	0.0233	0.0474	0.0606	0.0171	0.0173	0.0580
Air Purification	0.0915	0.1316	0.1806	0.1337	0.2018	0.1304	0.1381	0.0699	0.1422	0.1010	0.0171	0.0173	0.1129
Air Treatment	0.0915	0.1316	0.1806	0.1337	0.1441	0.1304	0.1381	0.0699	0.1422	0.1010	0.2558	0.1554	0.1395
Filter Particulates	0.0915	0.1316	0.1806	0.1337	0.1441	0.1304	0.2301	0.2098	0.4267	0.3030	0.4263	0.2591	0.2222
Humidify	0.0915	0.0564	0.1290	0.0955	0.1441	0.1304	0.2301	0.3497	0.0474	0.0606	0.0853	0.0518	0.1226
Sanitize	0.0061	0.0038	0.1806	0.1337	0.2018	0.1304	0.1381	0.2098	0.0474	0.0606	0.0853	0.0518	0.1041
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

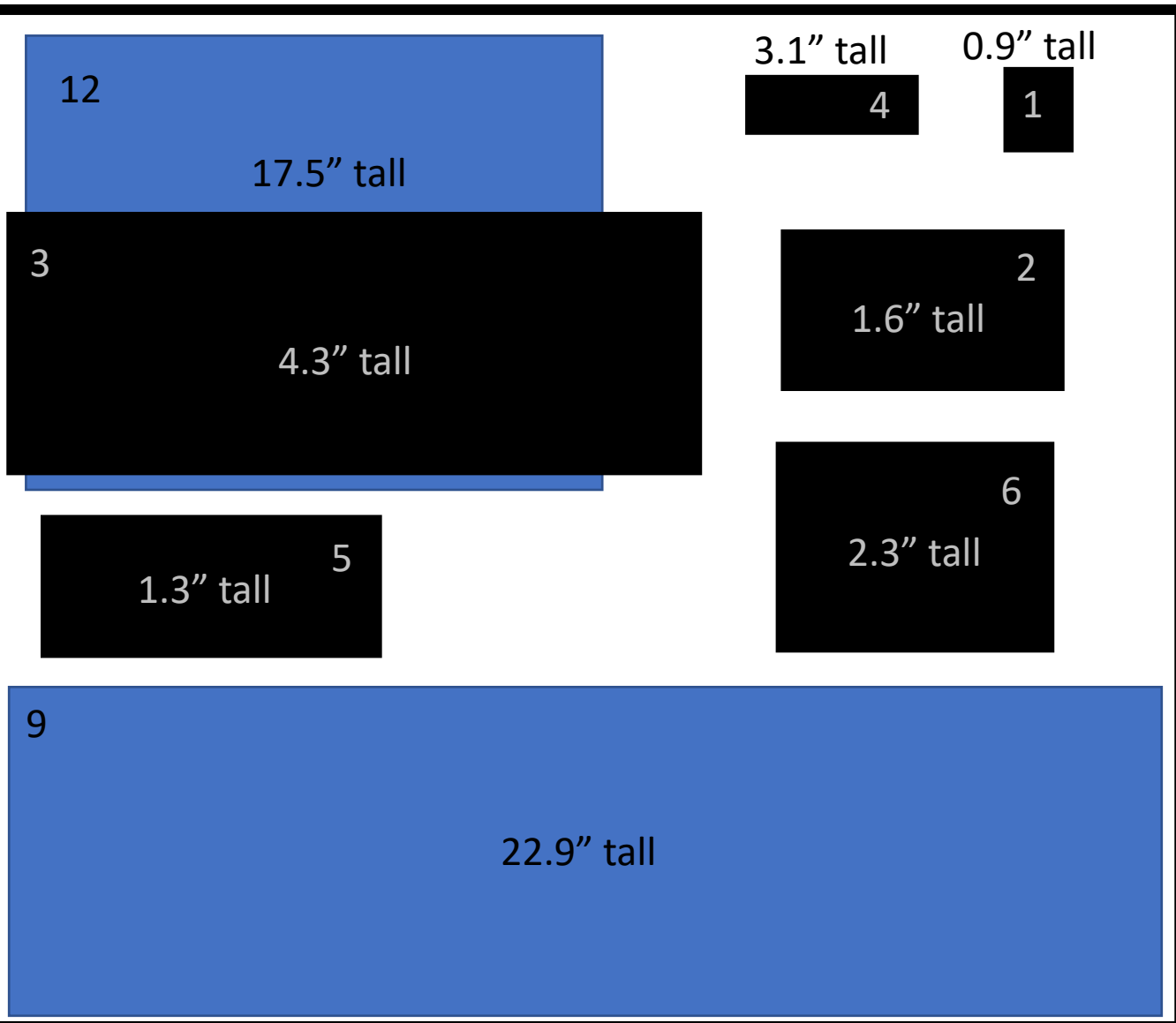


Development of Weighted Sum Vectors {Ws}													
Engineering Characteristics	Portability	Sense air Quality	Propeller Activation	Propeller Modulation	Purifier Activation	Purifier Modulation	Air Propulsion	Air Purification	Air Treatment	Filter Particulates	Air Humidification	Sanitize Contaminants	Weighted Sum {Ws}
Portability	0.0311	0.1034	0.0072	0.0046	0.0081	0.0051	0.0116	0.0226	0.0279	0.0444	0.0245	0.0312	0.3218
Sense air Quality	0.0104	0.0345	0.0072	0.0065	0.0113	0.0071	0.0116	0.0161	0.0199	0.0317	0.0409	0.0521	0.2493
Propeller Activation	0.2177	0.1724	0.0502	0.2266	0.0566	0.1068	0.0194	0.0161	0.0199	0.0317	0.0245	0.0015	0.9435
Propeller Modulation	0.2177	0.1724	0.0072	0.0324	0.0081	0.0356	0.0194	0.0161	0.0199	0.0317	0.0245	0.0015	0.5865
Purifier Activation	0.2177	0.1724	0.0502	0.2266	0.0566	0.1781	0.0194	0.0161	0.0279	0.0444	0.0245	0.0015	1.0354
Purifier Modulation	0.2177	0.1724	0.0167	0.0324	0.0113	0.0356	0.0194	0.0226	0.0279	0.0444	0.0245	0.0021	0.6270
Air Propulsion	0.1555	0.1724	0.1506	0.0971	0.1699	0.1068	0.0581	0.0376	0.0465	0.0444	0.0245	0.0035	1.0670
Air Purification	0.1555	0.2413	0.3514	0.2266	0.3965	0.1781	0.1742	0.1129	0.1395	0.0741	0.0245	0.0035	2.0780
Air Treatment	0.1555	0.2413	0.3514	0.2266	0.2832	0.1781	0.1742	0.1129	0.1395	0.0741	0.3680	0.0312	2.3359
Filter Particulates	0.1555	0.2413	0.3514	0.2266	0.2832	0.1781	0.2903	0.3388	0.4186	0.2222	0.6133	0.0521	3.3712
Air Humidification	0.1555	0.1034	0.2510	0.1619	0.2832	0.1781	0.2903	0.5647	0.0465	0.0444	0.1227	0.0104	2.2119
Sanitize Contaminants	0.0104	0.0069	0.3514	0.2266	0.3965	0.1781	0.1742	0.3388	0.0465	0.0444	0.1227	0.0104	1.9067
Sum	1.70	1.83	1.95	1.69	1.96	1.37	1.26	1.62	0.98	0.73	1.44	0.20	16.73



Function	Part Number	Part Name	Vendor	Part Model Number	Weight (lbs)	Dimensions (inches)	Unit Cost	Number of Units	Cost
storage	1	3-Shelf Utility Cart	Uline	H-5007BL	46	44 x 25 x 33	\$ 125.00	2	\$ 250.00
sensing	2	HPM Series PM2.5 Particulate Matter Sensor	Honeywell	HPMA115C0-XXX	N/A	1.7 x 1.4 x 0.9	\$ 42.01	1	\$ 42.01
	3	BW Ultra Multi-Gas Detector	Honeywell	DS01195	0.9	5.8 x 3.3 x 1.6	\$ 2,515.00	1	\$2,515.00
	4	IntelliDox Docking Station	Honeywell	DS20151112	4.2	5.4 x 14.3 x 4.3	\$ 1,890.14	1	\$1,890.14
	5	Honeywell Humidity Monitor With Digital Display	Honeywell	HHM10	0.14	3.54 x 1.18 x 3.1	\$14.95	1	\$ 14.95
	6	Anemometer	Grainger	AN100-NIST	1.6	7 x 2.9 x 1.3	\$ 342.00	1	\$ 342.00
	7	Dual UV Lamp	Honeywell	UV100E2009	N/A	19 x 15 x 8.5	\$ 446.04	1	\$ 446.04
	8	ComfortPoint Open Controller	Honeywell	CPO-PC400	N/A	5.7 x 4.3 x 2.3	By Quote Only	1	N/A
	9	CT60 Mobile Computer	Honeywell	CT60	0.77	6.3 x 3.2 x 0.7	\$ 2,050.00	1	\$2,050.00
	cleaning	10	Honeywell Professional Series True HEPA Air Purifier	Honeywell	HPA600B	32	16.73 x 9.45 x 24.25	\$ 699.99	1
11		Honeywell TurboForce Floor Fan	Honeywell	HF-910	8.58	23.8 x 6.8 x 22.9	\$ 49.45	1	\$ 49.45
12		Honeywell 70-Pint Energy Star Dehumidifier	Honeywell	TP70PWKN	43.6	15.7 x 12.4 x 25.4	\$ 374.95	1	\$ 374.95
13		Honeywell UV Cool Moisture Germ Free Humidifier	Honeywell	HCM-350	8.36	17.5 x 9.4 x 11.9	\$ 69.95	1	\$ 69.95
Power	14	APC Back-UPS	APC	BE850M2	9.04	5.5 x 12.9 x 4.1	\$ 113.99	1	\$ 113.99
								Total Cost	\$8,858.47

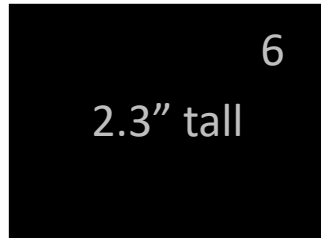
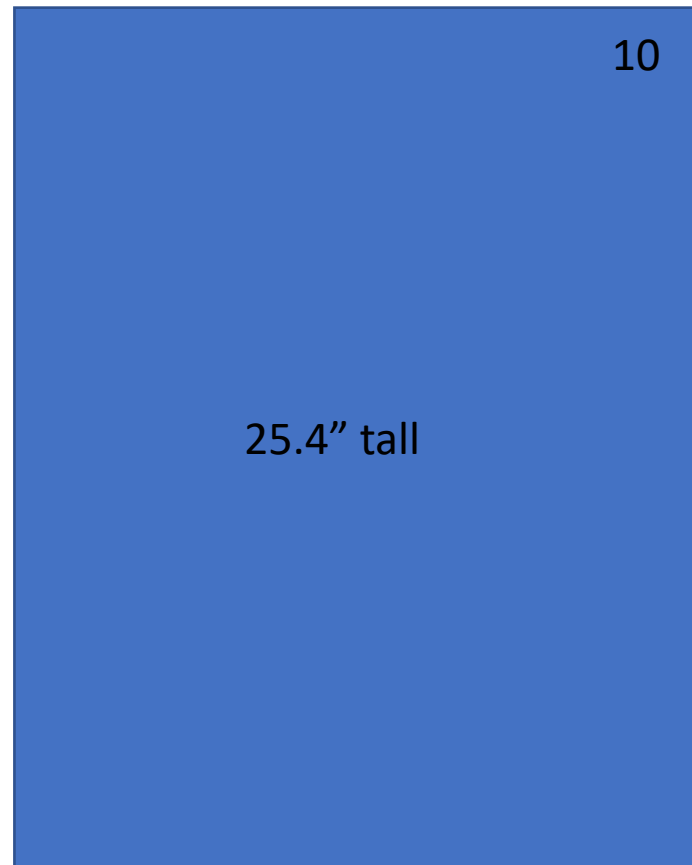




1	HPM Series PM2.5 Particulate Matter Sensor
2	BW Ultra Multi-Gas Detector
3	IntelliDox Docking Station
4	Honeywell Humidity Monitor With Digital Display
5	Anemometer
6	ComfortPoint Open Controller
7	CT60 Mobile Computer
8	Honeywell Professional Series True HEPA Air Purifier
9	Honeywell TurboForce Floor Fan
10	Honeywell 70-Pint Energy Star Dehumidifier
11	Honeywell UV Cool Moisture Germ Free Humidifier

- Lower Cabinet: Inside: 21 x 24 1/2 x 25 1/2" (L x W x H)
- 3.5 scale
- All dimensions in inches



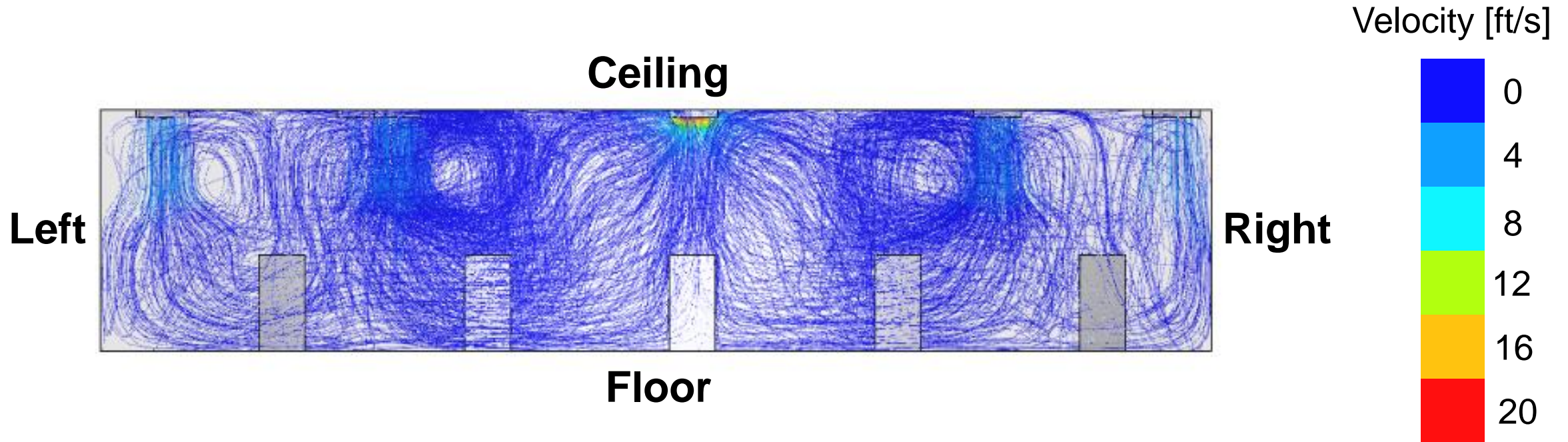


1	HPM Series PM2.5 Particulate Matter Sensor
2	BW Ultra Multi-Gas Detector
3	IntelliDox Docking Station
4	Honeywell Humidity Monitor With Digital Display
5	Anemometer
6	ComfortPoint Open Controller
7	CT60 Mobile Computer
8	Honeywell Professional Series True HEPA Air Purifier
9	Honeywell TurboForce Floor Fan
10	Honeywell 70-Pint Energy Star Dehumidifier
11	Honeywell UV Cool Moisture Germ Free Humidifier

- Lower Cabinet: Inside: 21 x 24 1/2 x 25 1/2" (L x W x H)
- 3.5 scale
- All dimensions in inches

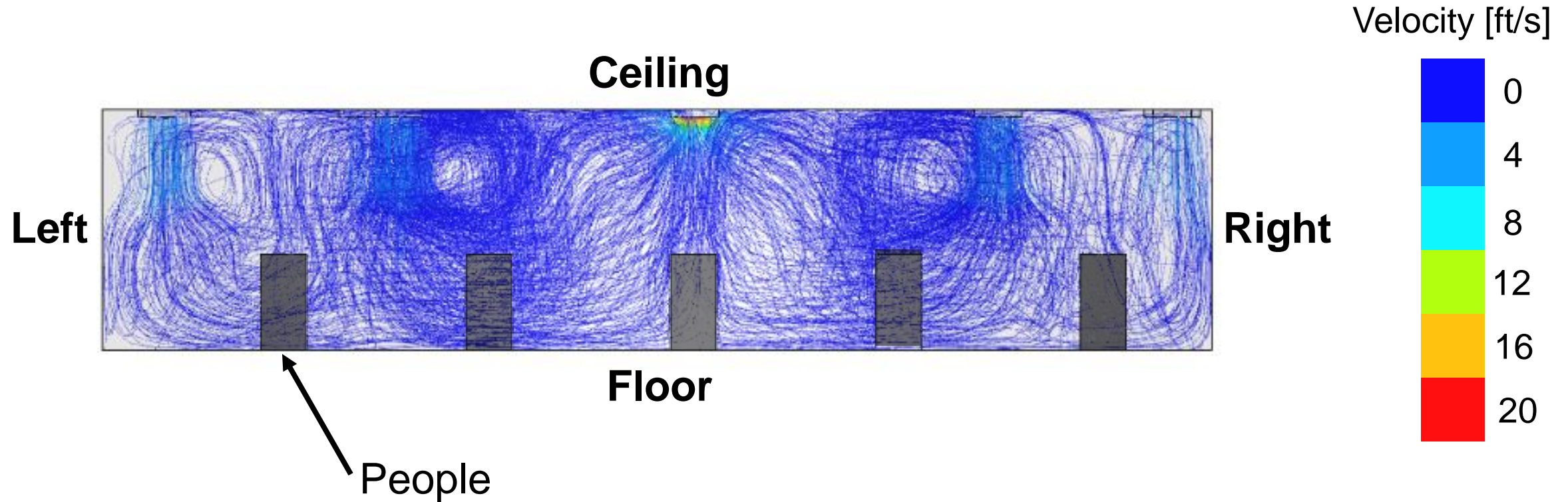


Simulation – Back View



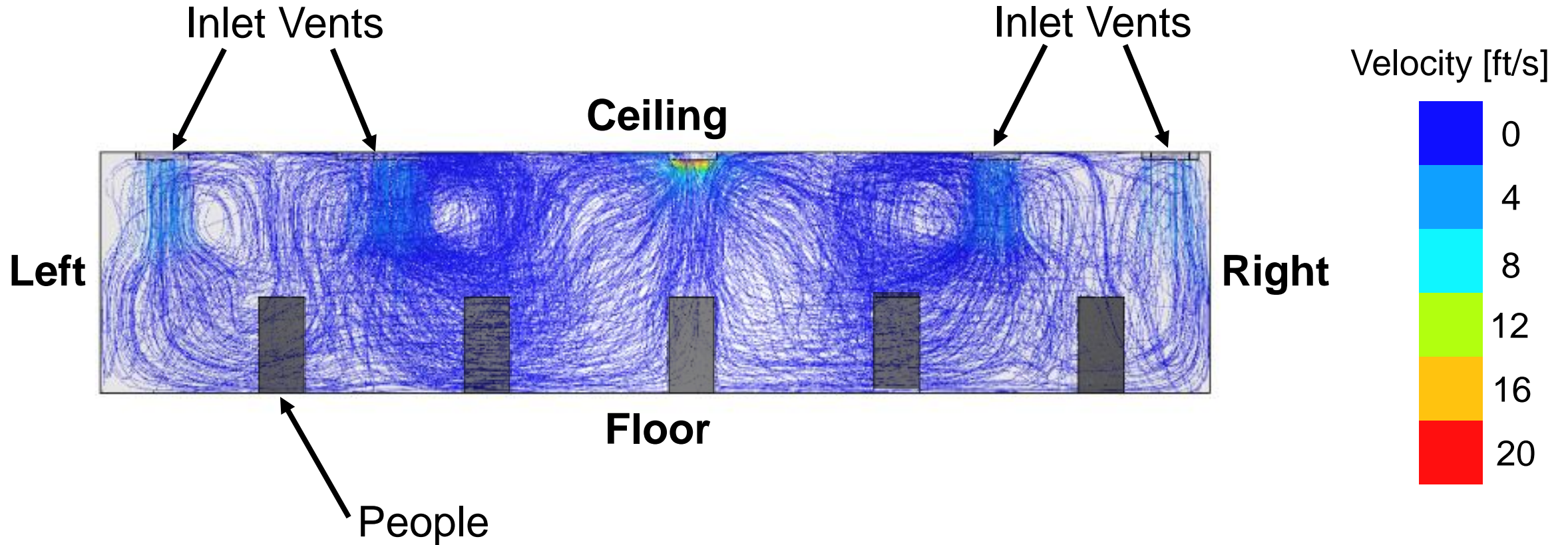
Leon Johnson

Simulation – Back View



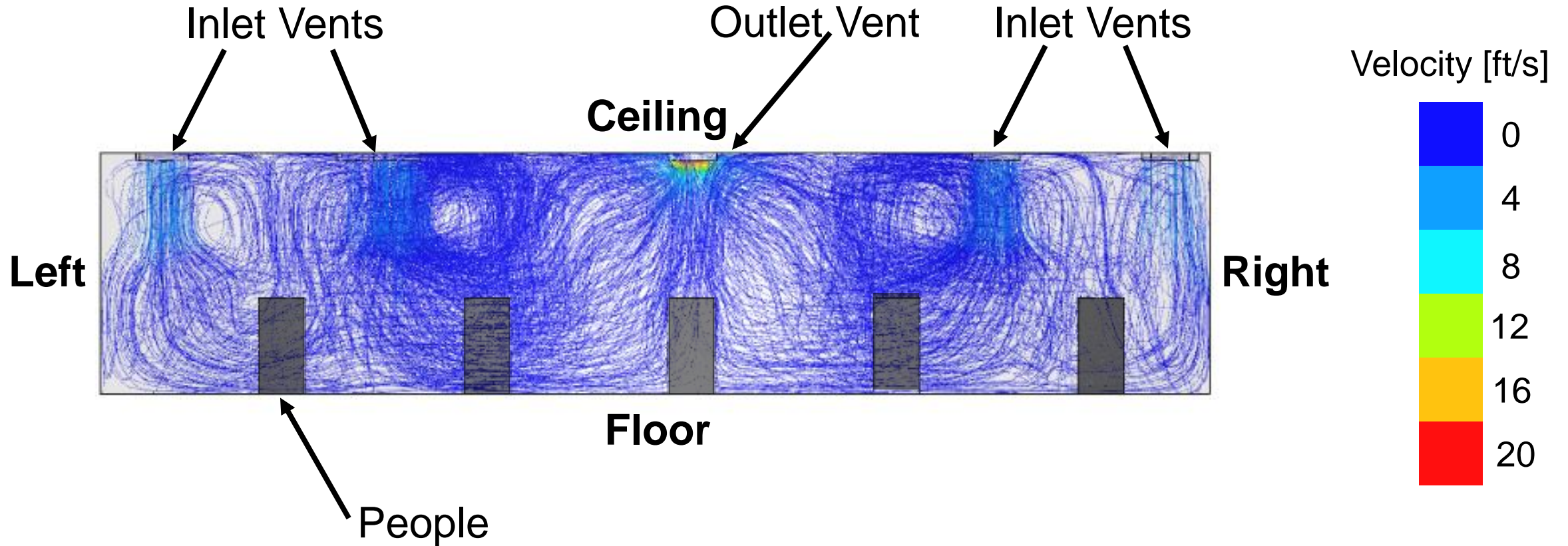
Leon Johnson

Simulation – Back View



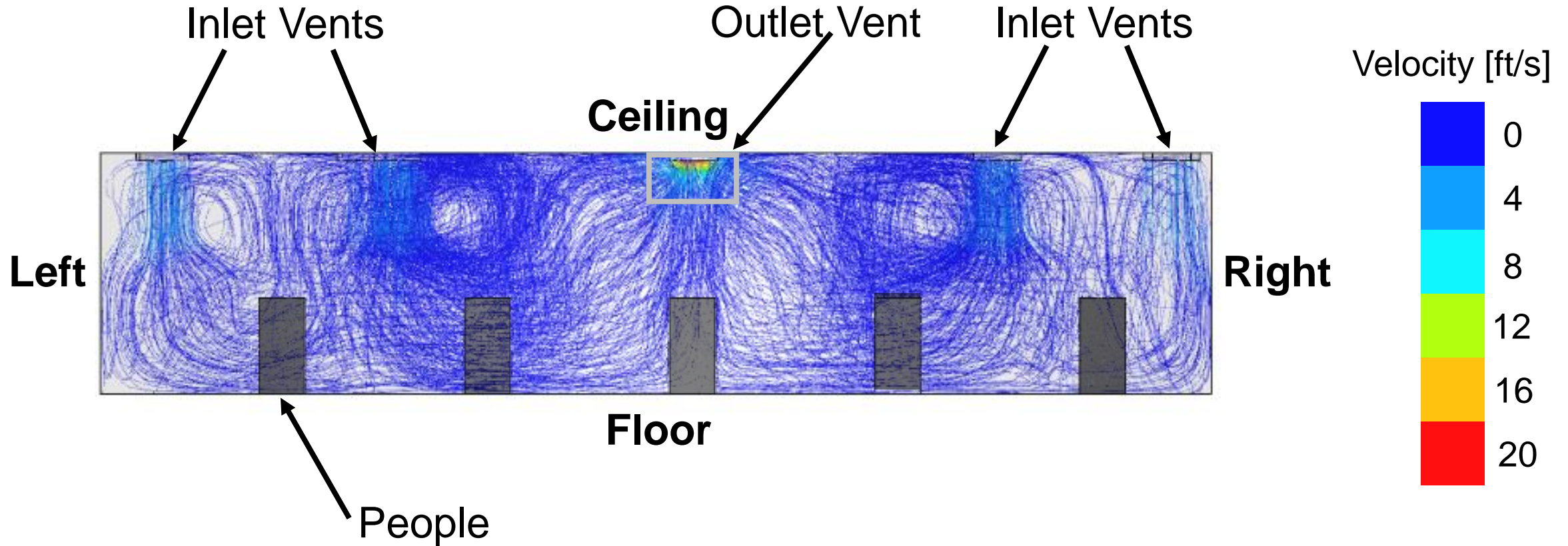
Leon Johnson

Simulation – Back View



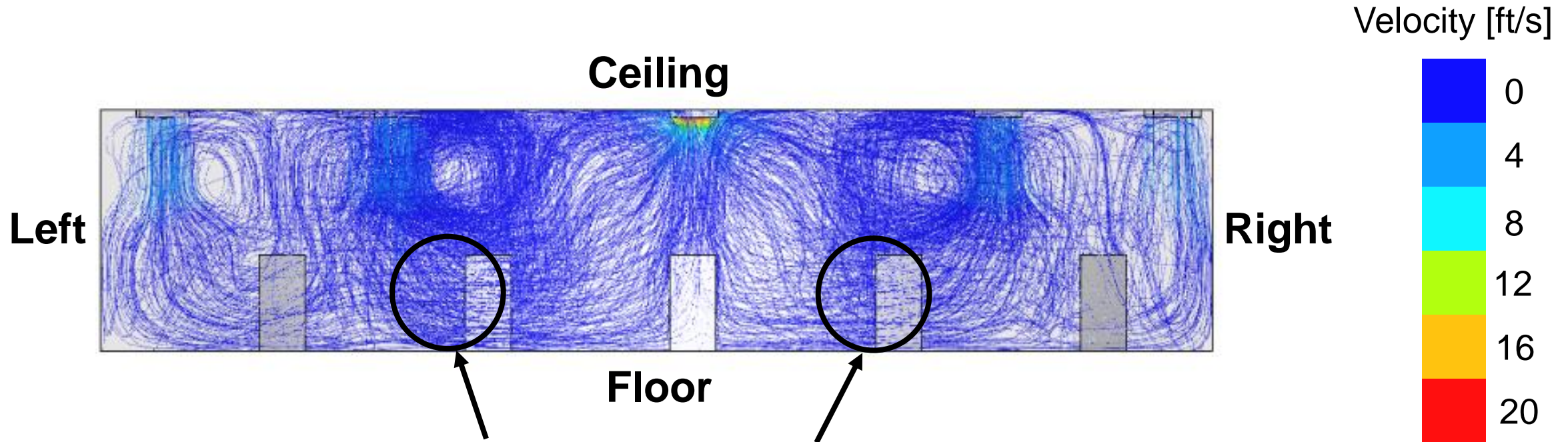
Leon Johnson

Simulation – Back View



Leon Johnson

Simulation – Back View



Place air purifiers and other cleaning devices
in high airflow areas at ground level

Leon Johnson