



Bus Driver Work Stations: How to Retain Drivers through Effective COVID Modifications and Ergonomics

February 25, 2021, 2:00-3:00 PM ET



U.S. Department of Transportation
Federal Transit Administration

Agenda

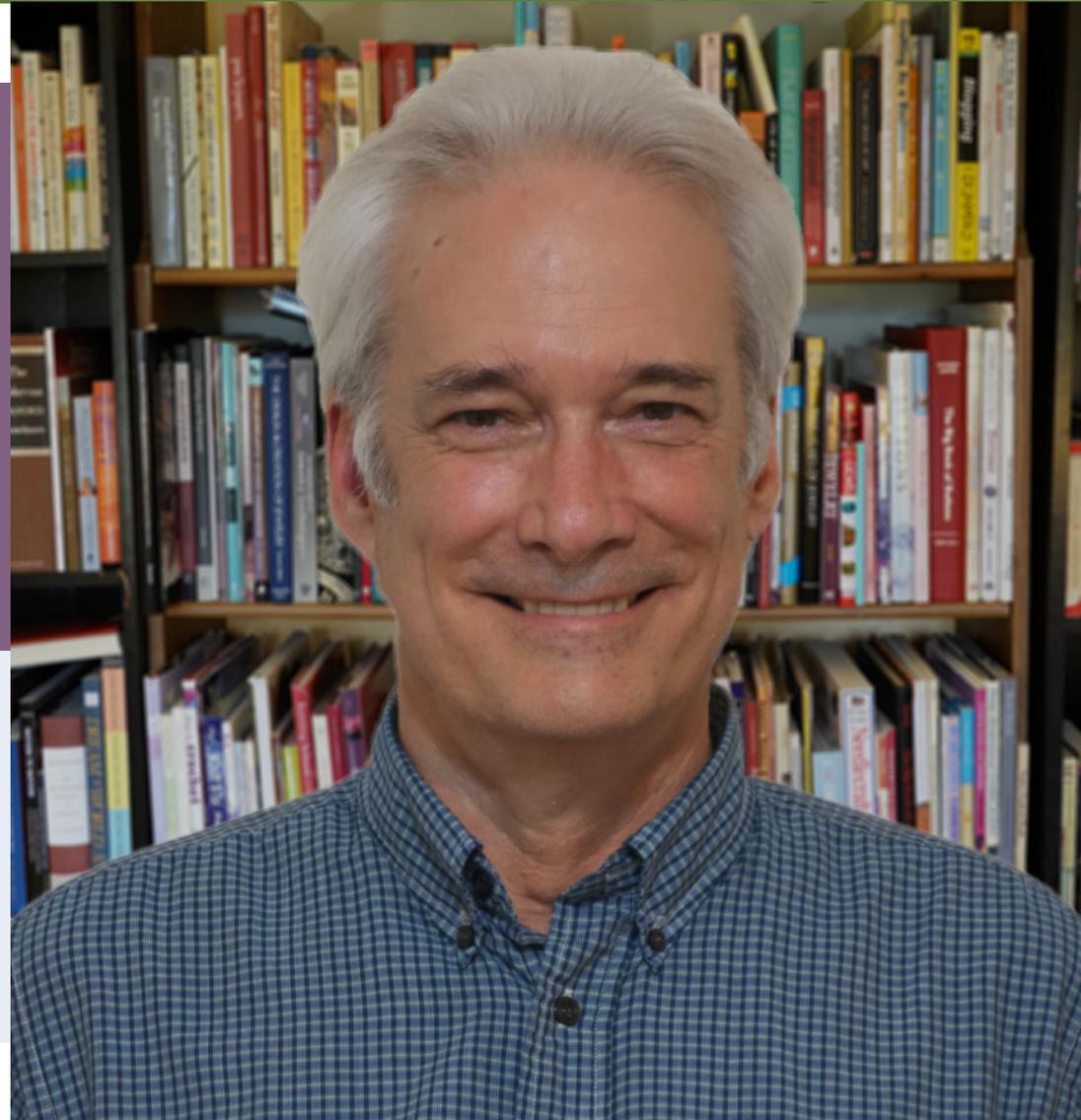
- National RTAP Overview
- Speaker Introduction
- Bus Driver Workstations: Seating and Ergonomics
- Bus Driver Workstations: COVID-19 Modifications
- The Bottom Line
- Questions
- National RTAP Resources
- Survey

National RTAP Overview and Introduction

What is National RTAP?

- Section 5311 (Formula Grants for Rural Areas) Technical Assistance Center funded by FTA
 - Rural and Tribal Transit Organizations
 - State RTAP Programs
- We provide free training and technical assistance resources
 - Training books, eLearning courses, and webinars, and more
 - Free web applications and tools to manage websites and GTFS data, and to assist with procurement and financial management
 - Peer technical assistance network, forums, and roundtables
 - Comprehensive resource library for rural and tribal transit

Brian Sherlock



Quick Poll- Please tell us a bit about yourself.

Transit Bus Procurement

**Design Hazards and Solutions:
Protecting lives, health and agency budgets**



Analysis by Brian Sherlock
ATU International

Workstation Ergonomics

Pain and cost reduction

King County Metro (Seattle) and the University of Washington Ergonomics Department Found:

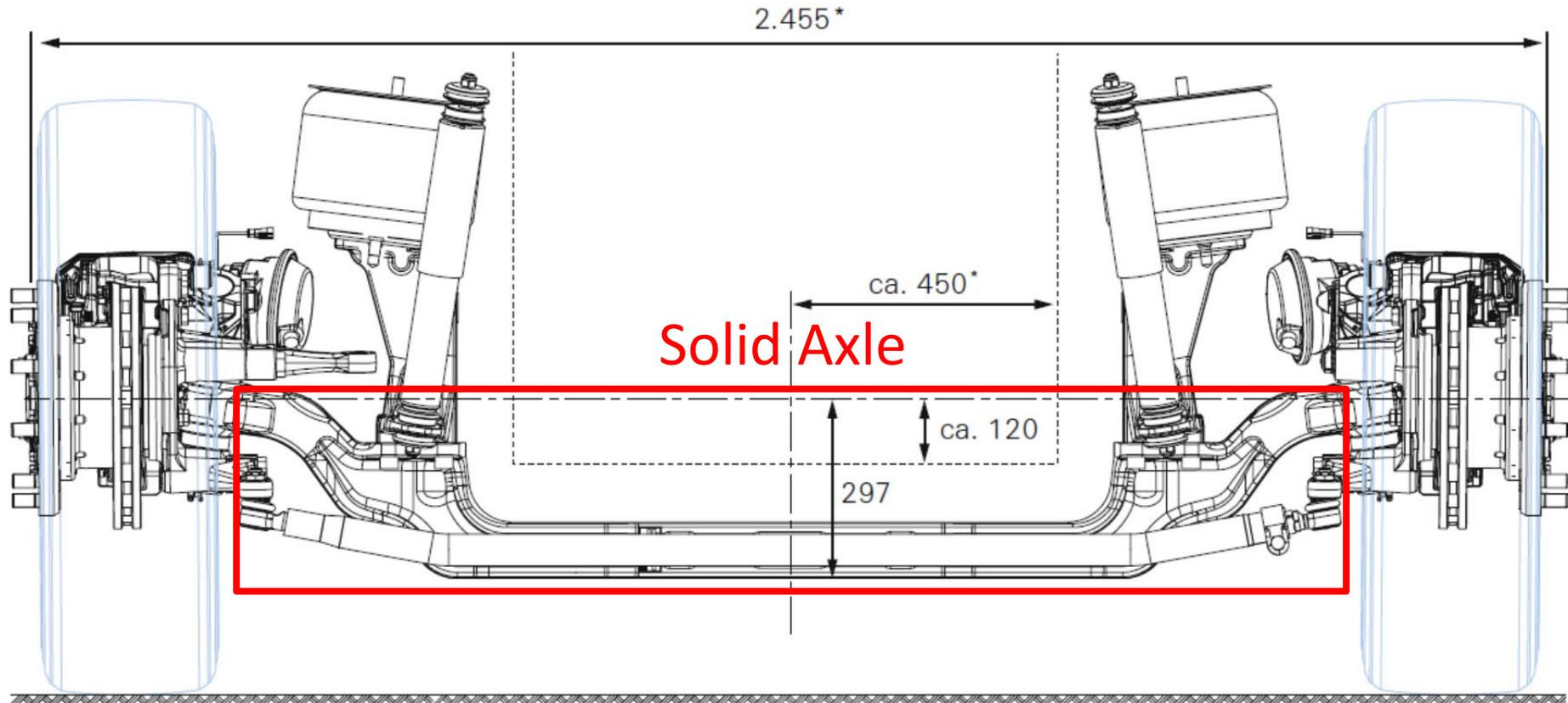
- Rates of low back pain are:
 - 81% for bus drivers
 - 50% for truck drivers
 - 42% for sedentary workers
- 263 paid disability days is the average for a back claim in Washington State
- Bus driver claim rates are 200 per 1,000 FTE annually. 50 is average.
- Back injury claims account for 12.8% of ALL COSTS for King County Metro Transit

Whole Body Vibration Demonstration

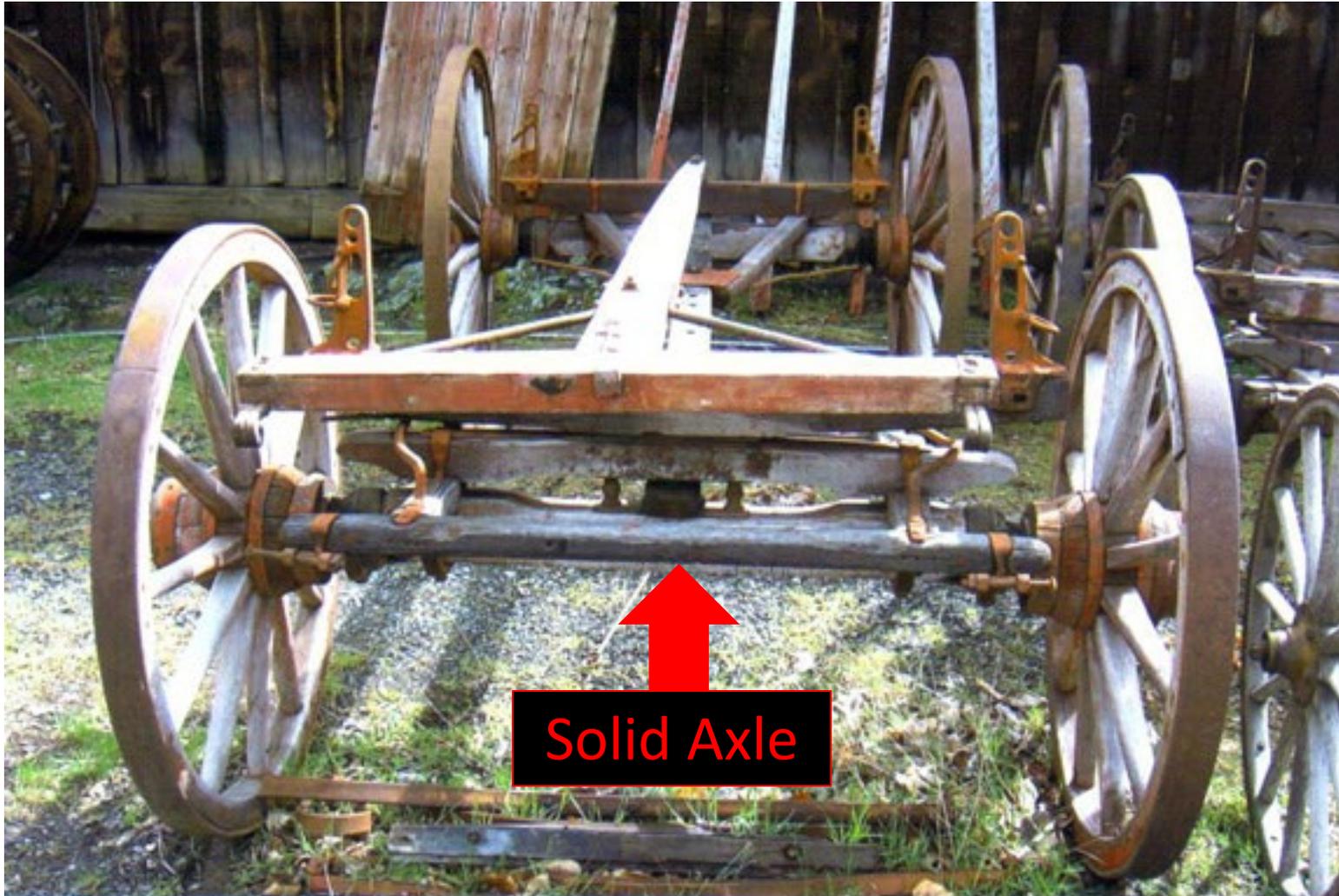
Prof. Dupuis,
Dr. Christ
edited
by Dr. Johanning
1969

Bad Design and the Battle of the Masses

A typical North American transit bus uses a solid front axle like a Conestoga wagon did. This is heavy and a bump on one side disturbs both sides.



Conestoga Wagon Suspension



Low Back Solutions

- Modern suspension reduces the force by over 50%.
- Active seats cut that in half again to under 25% of current levels in the seat. These are sequential filters.



Independent Suspension

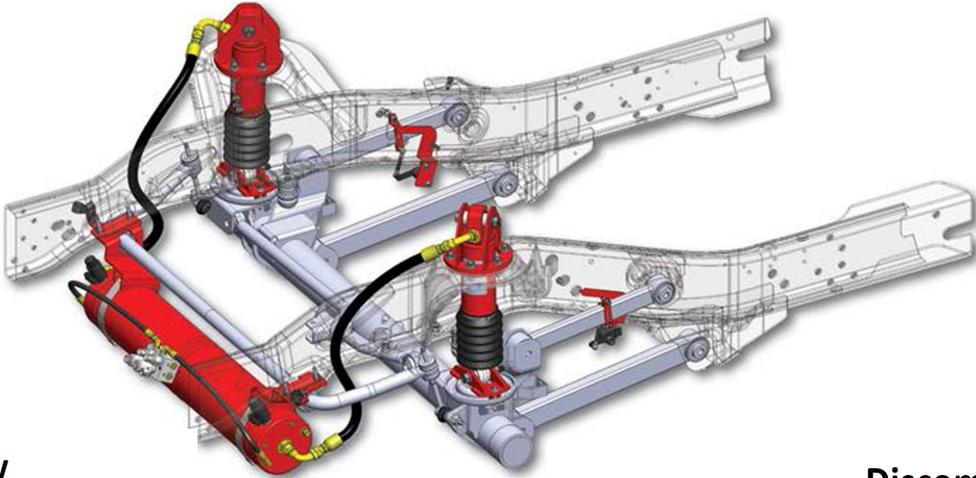
Standard in Europe and over a 50% reduction



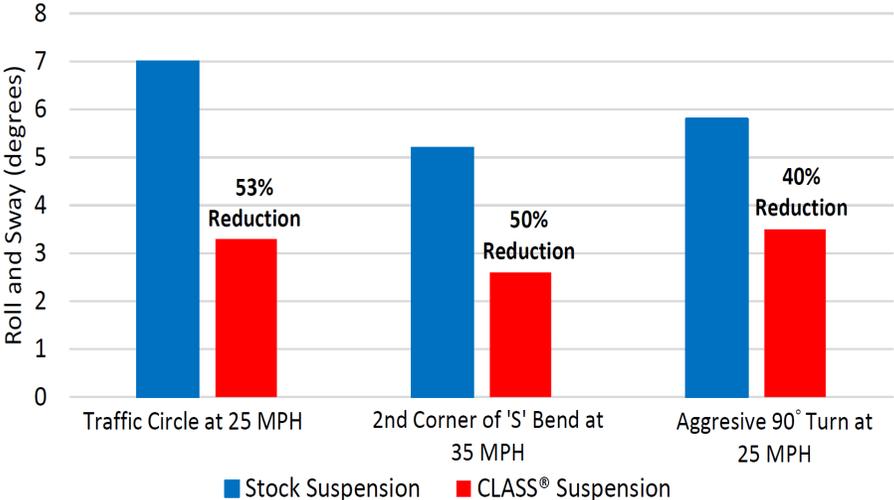
Active Seat

50% Reduction

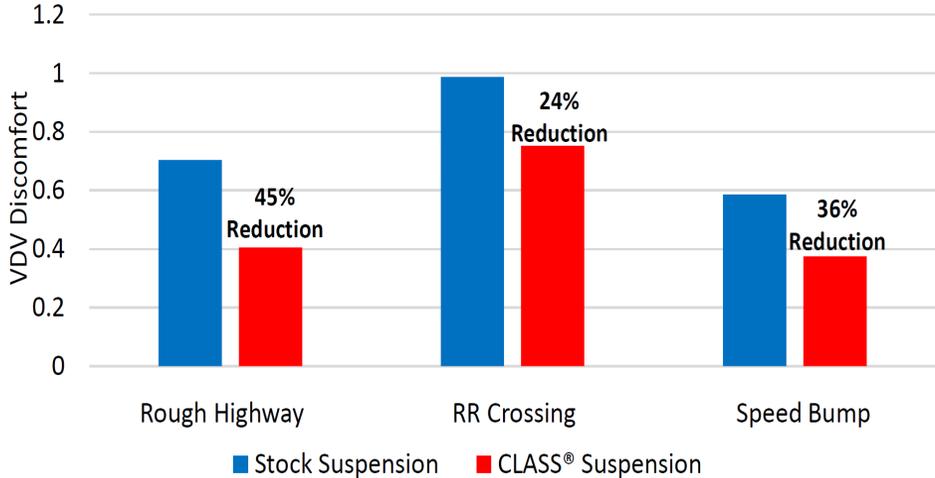
Similar improvements can be made in the safety and comfort of cutaway vans. Below is a greatly improved rear suspension that both improves stability and ride quality. Testing from F-550



Safety due to Handling and Stability
Less Roll/Sway = More Safety



Discomfort due to Shock and Vibration
Less VDV = Less Discomfort



Upper Quadrant Solutions



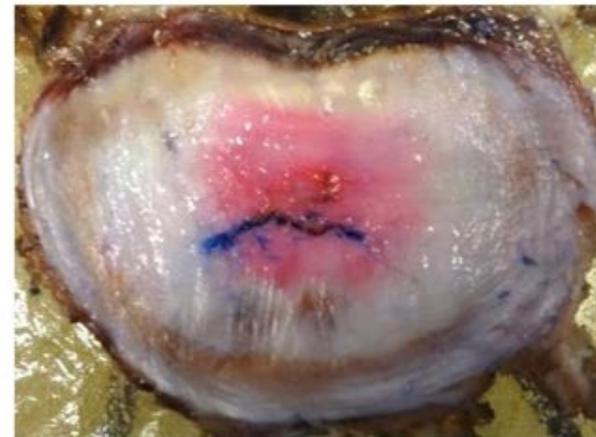
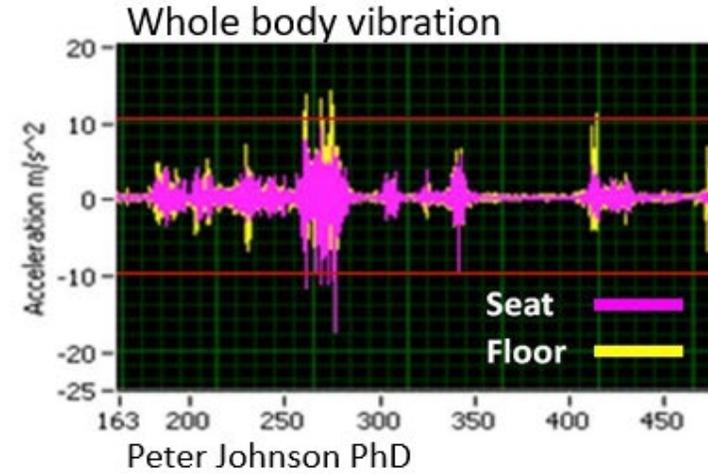
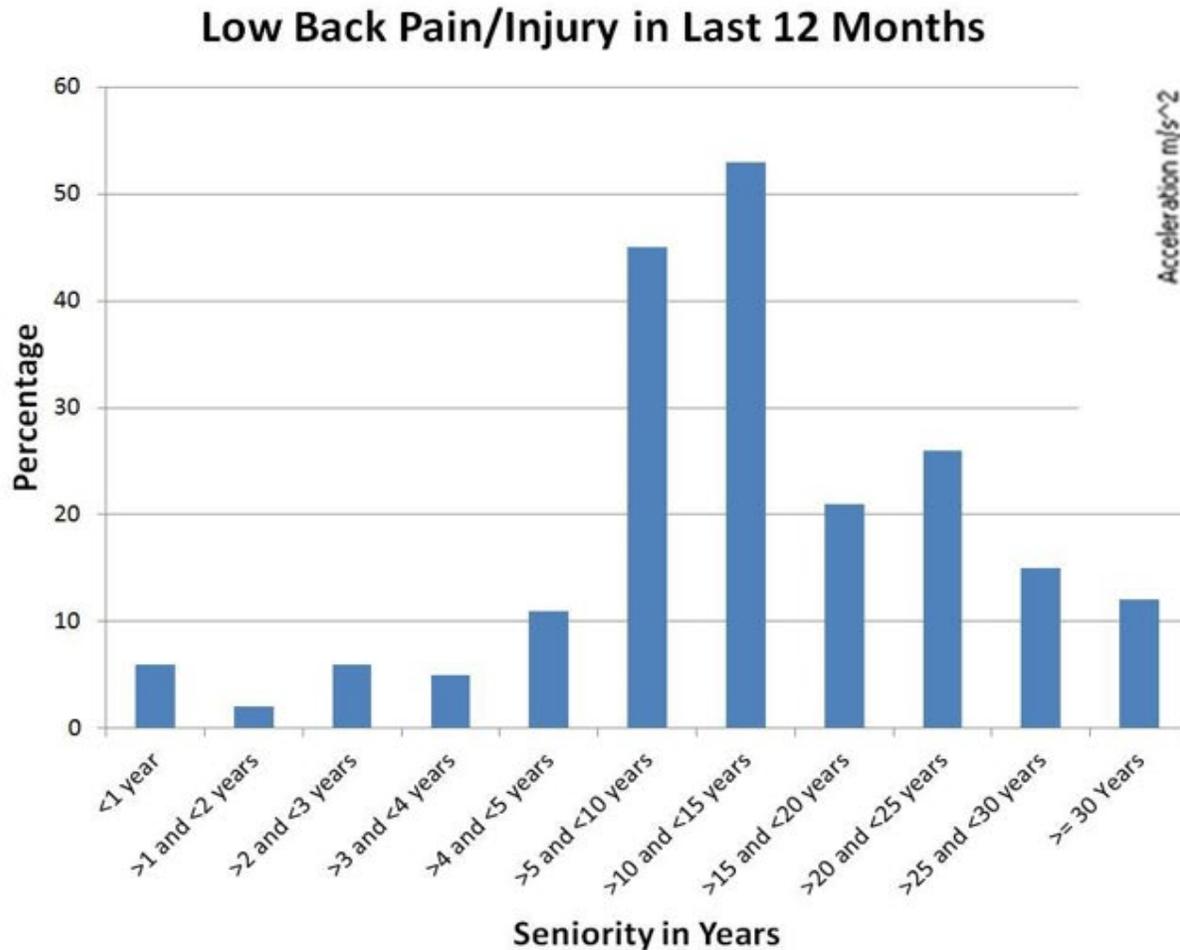
TRW Adjustable Dash



TRW Active Steering Column

- On the left is an example of excellent reach ergonomics, a reasonable size steering wheel and an adjustable dash/steering wheel which comes back to sit in the driver's lap.
- On the right is a powered electric steering column which goes on top of our hydraulic steering. This reduces total effort to less than 1/6 current levels and provides other injury-reducing improvements.

A NIOSH Symptom Survey at King County Metro Quantifies a Huge Problem. University of Washington Ergonomists Show Why it Happens.



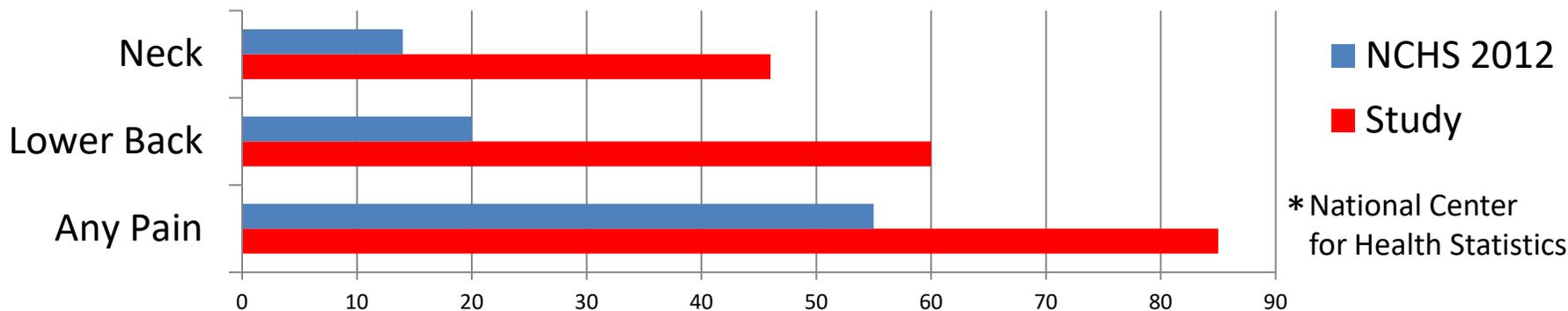
LS Aulck

Table 3. Frequency of Musculoskeletal Pain by Body Area

	Right (Last 12 Months)	Left (Last 12 Months)	Both (Last 12 Months)	Total (Last 12 Months)	Total (Last 7 Days)
	Frequency (%)				
Neck	--	--	--	46	23
Shoulders	19	13	19	51	26
Elbows	6	4	6	16	7
Wrists/Hands	10	5	17	32	14
Upper Back	--	--	--	29	14
Lower Back	--	--	--	60	28
Hips/Thighs	16	5	12	33	17
Knees	23	5	18	47	24
Ankles/Feet	12	4	12	28	14
1 or More	--	--	--	85	56

Data from the Mineta Transportation Institute paper, *Not Just an Ache: Examining the Rates of Musculoskeletal Pain in City Bus Drivers.*

US population average v study population

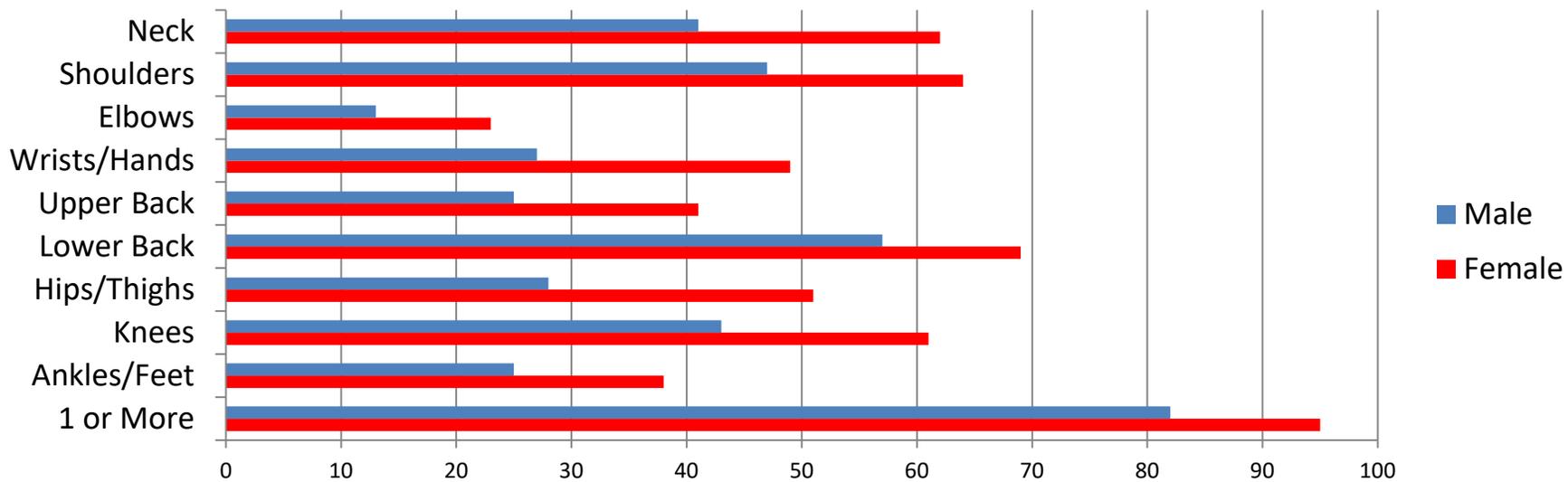


<https://transweb.sjsu.edu/research/1892-Musculoskeletal-Pain-Bus-Drivers>

Table 4. Rates of Pain, by Body Area, by Gender

	Frequency: Last 12 Months (%)		Frequency: Last 7 Days (%)	
	Male	Female	Male	Female
Neck	41	62**	20	34**
Shoulders	47	64**	22	42**
Elbows	13	23**	5	13**
Wrists/Hands	27	49**	11	24**
Upper Back	25	41**	12	21**
Lower Back	57	69**	25	41**
Hips/Thighs	28	51**	14	34**
Knees	43	61**	21	34**
Ankles/Feet	25	38**	12	24**
1 or More	82	95**	50	78**

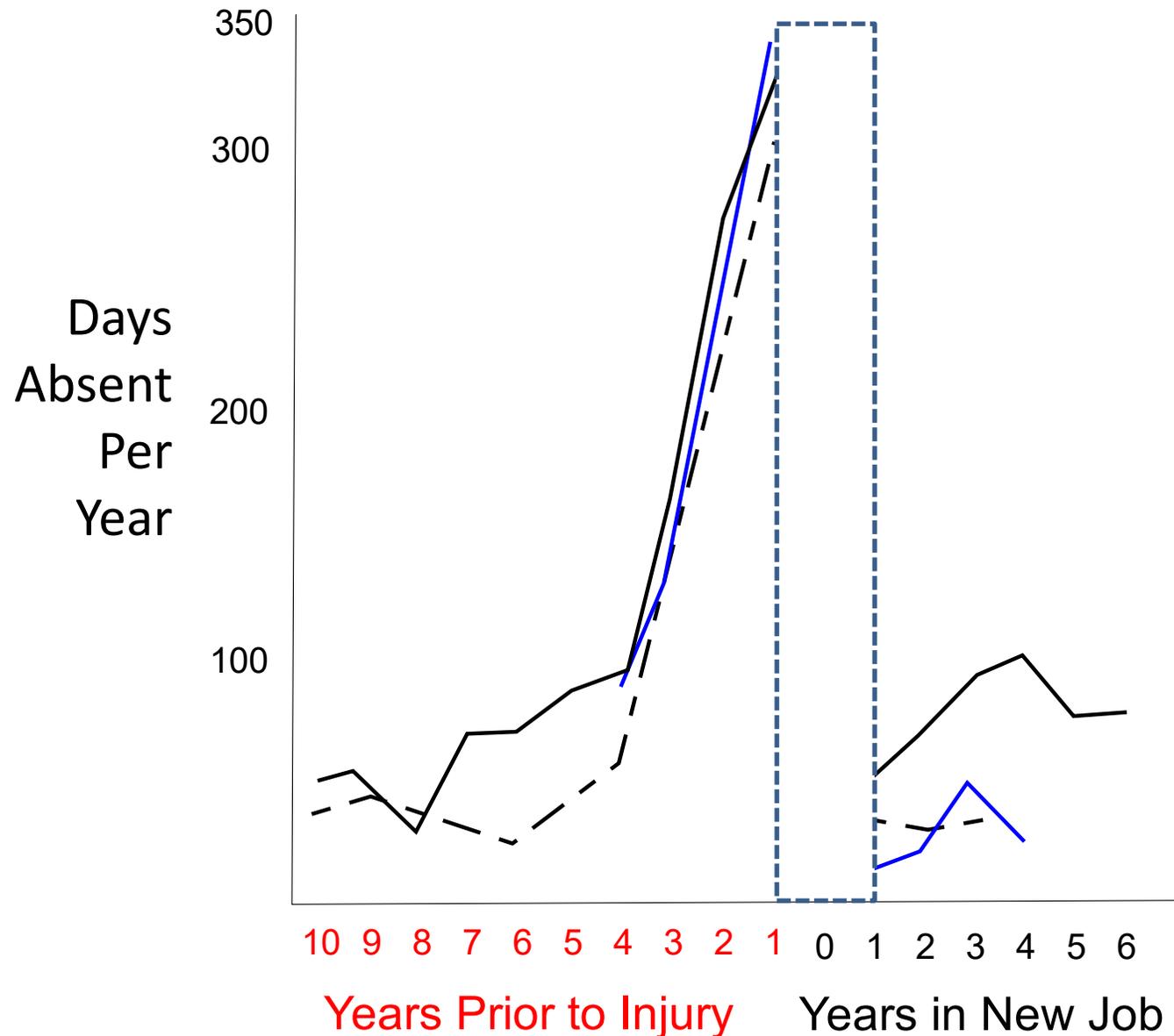
** indicates a significant difference between men and women, at $p < .01$.



Not only are bus driving exposures worse than those for the general population, women are harmed significantly more than men on average. It is critical for the industry to recognize both the total scale of pain and injuries, and the more serious impacts on women.

Sick, Lame and Lazy, or Hard Working and Injured?

Note: Charting in years January 1st to January 1st creates the gap in the dashed box



Injured workers have increasing days of absence as conditions lead to partial disability. After recovery and moving to another position, they return to previous attendance performance.

Data from Groningen and Amsterdam in the Netherlands

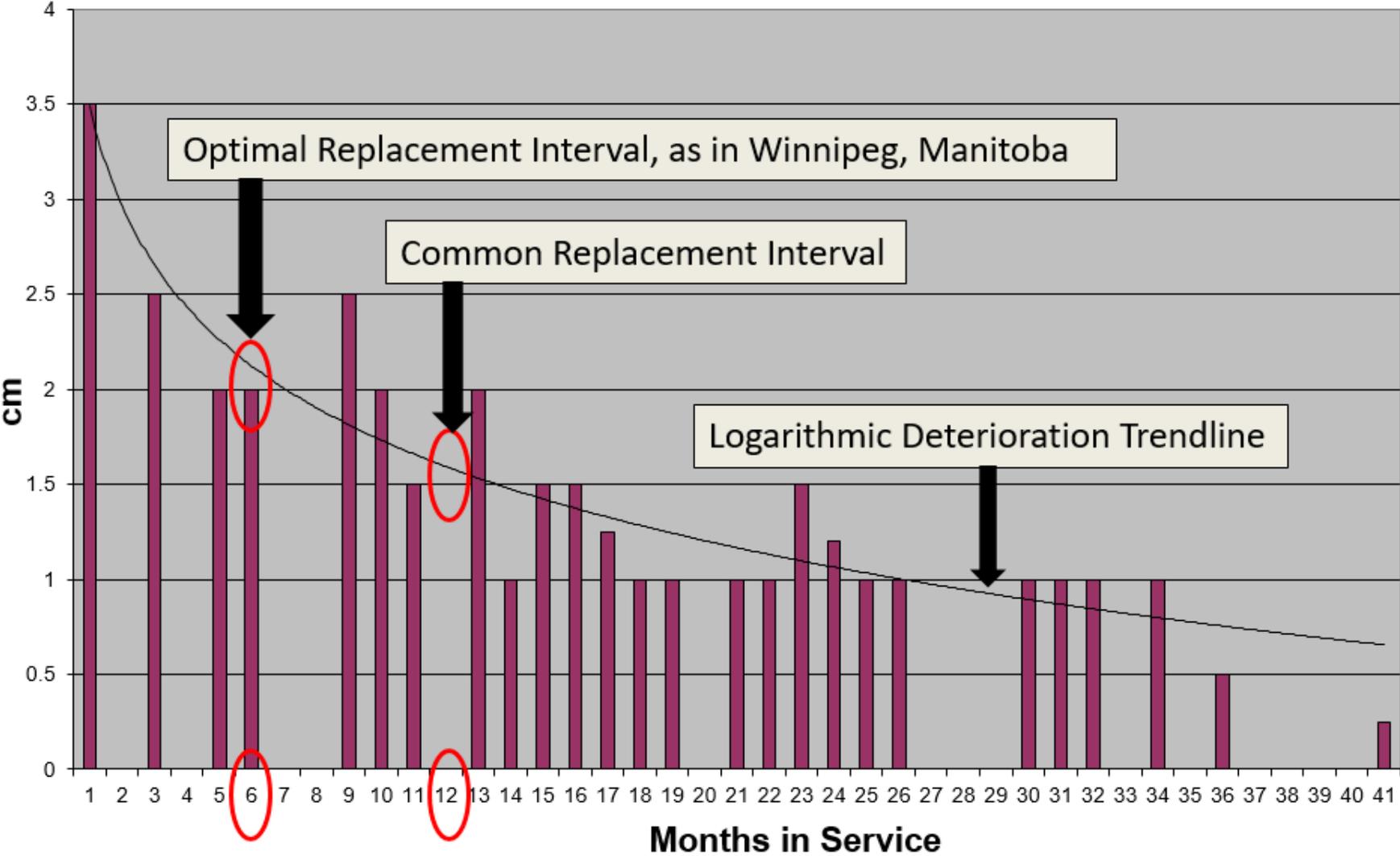
Maintenance issues are another significant risk to back health



Collapsed seat foam is a common problem in transit vehicles. We are all familiar with the problem of sitting on a wallet. It creates uneven loads and spinal problems. Common wear has seats uneven by much larger amounts. This is compounded by the high whole-body vibration levels.

Seat Foam Deterioration Rate

Foam Depth by Months in Service



Visibility

**This Orion has a pillar and mirror 1.1 feet wide.
The pillar alone contributes over a third of a foot.**



19 Pedestrians Hidden by the Pillar and Mirror





Bus Location

Blind Angle

New Flyer (3600) Left Front Pillar Structure

(From Outside)



The aluminum frame for side windows can be omitted, as on modern cars, trucks and the bus below, on the right.





Suggested Mirror Set

Low mounting prevents blocking the view of pedestrians (typically at the top of this photo).

The offset prevents the side of the bus blocking the view of the lower mirror. The reflected angles extend from the horizon to the front wheel.

Operators are taught to take square left turns at walking speed or 3-5 mph.
Below, video of a “square turn” taken as instructed:



Does the “bob and weave” technique always work?

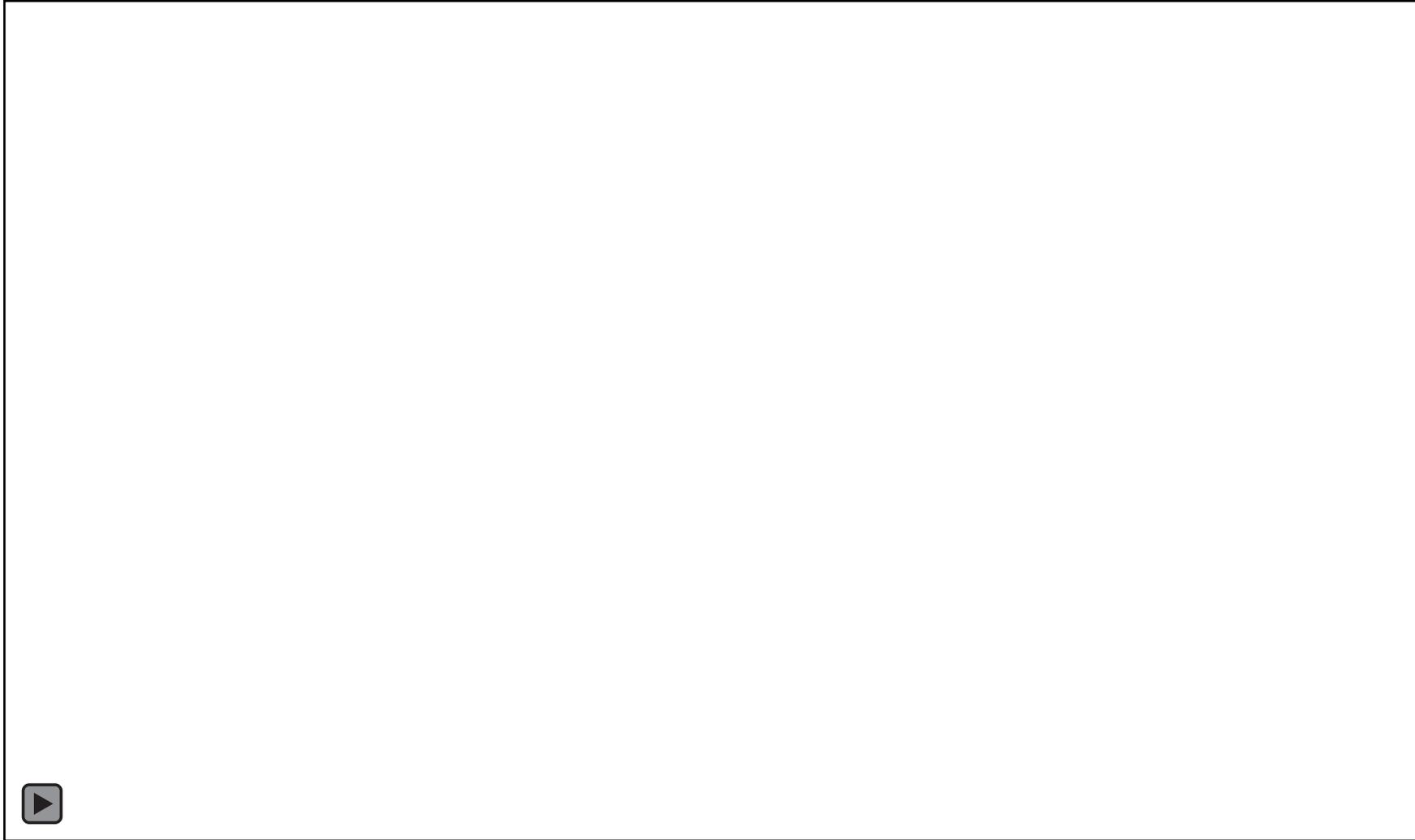
Video of a pedestrian hidden for 12 seconds despite a full lean.



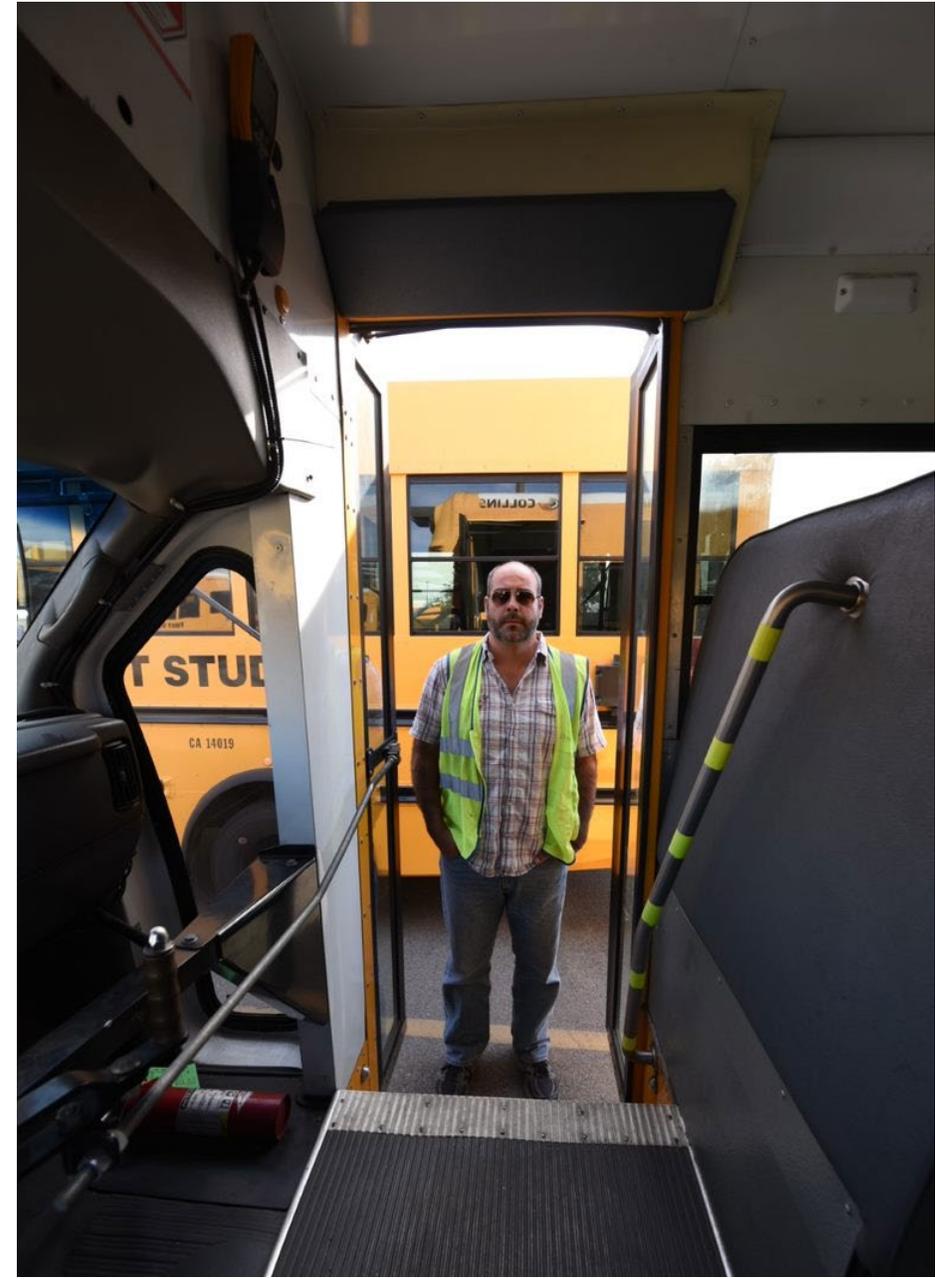
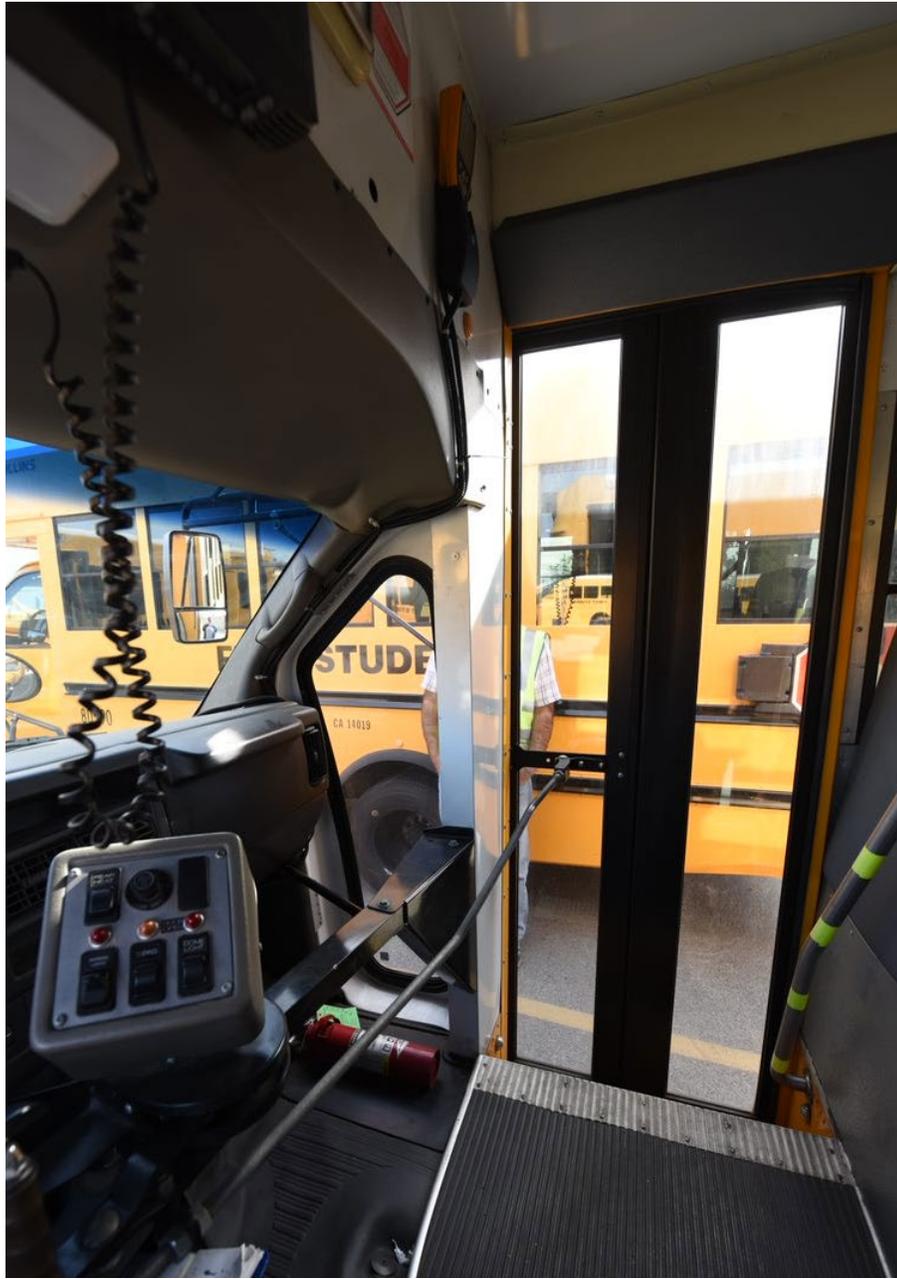
Please note the young man in a white shirt to the left of the pillar. Once he moves into the blind spot, leaning as far as possible, when sitting fully forward, does not reveal him. This is due to the large steering wheel confining those who have to sit close. Note also; this is with a low mirror - most blind spots are twice this wide

Blind on the right

Video proof, a 60 foot bus hidden

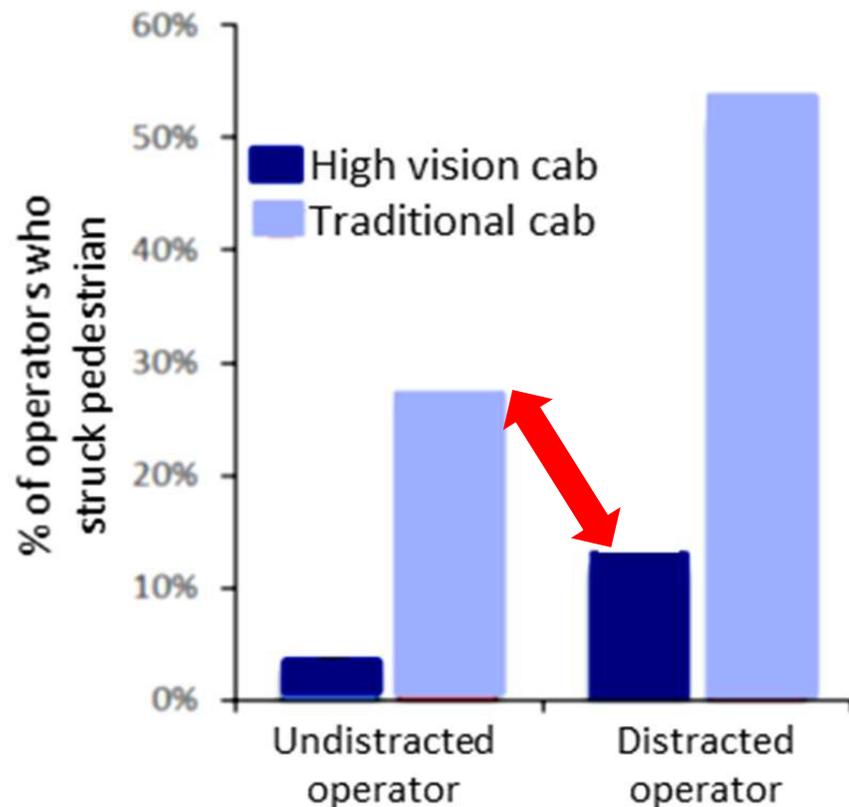


Similar problems exist in cutaway vans

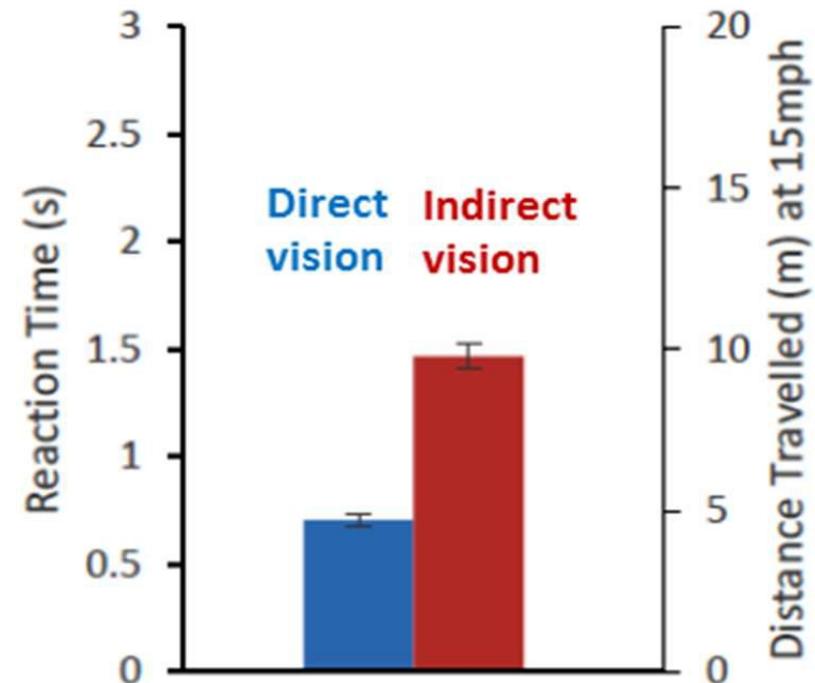


A University of Leeds Study for Transport for London showed that five times more drivers struck simulated pedestrians in traditional truck cabs than in high-vision cabs.

**Operators struck simulated pedestrians
~80% less often in a high vision truck cab**



**Operators reacted to stop for a pedestrian
~50% faster through direct vision**



**This design from 60 years ago,
the “Fishbowl,” had no meaningful blind spots.**



Glass and thin pillars where we have a wall.



Europe



Thin Pillars
Bonded Windshield
Safe Mirror

The US



We saved \$300
If you ignore
the real cost

Security

Window Closed



A MAN bus with pneumatically closing security window

Window Open



Careful design prevents the barrier interfering with views of the windshield or right side mirror



View from
RF Pillar
(Mirror is
ahead of
pillar)

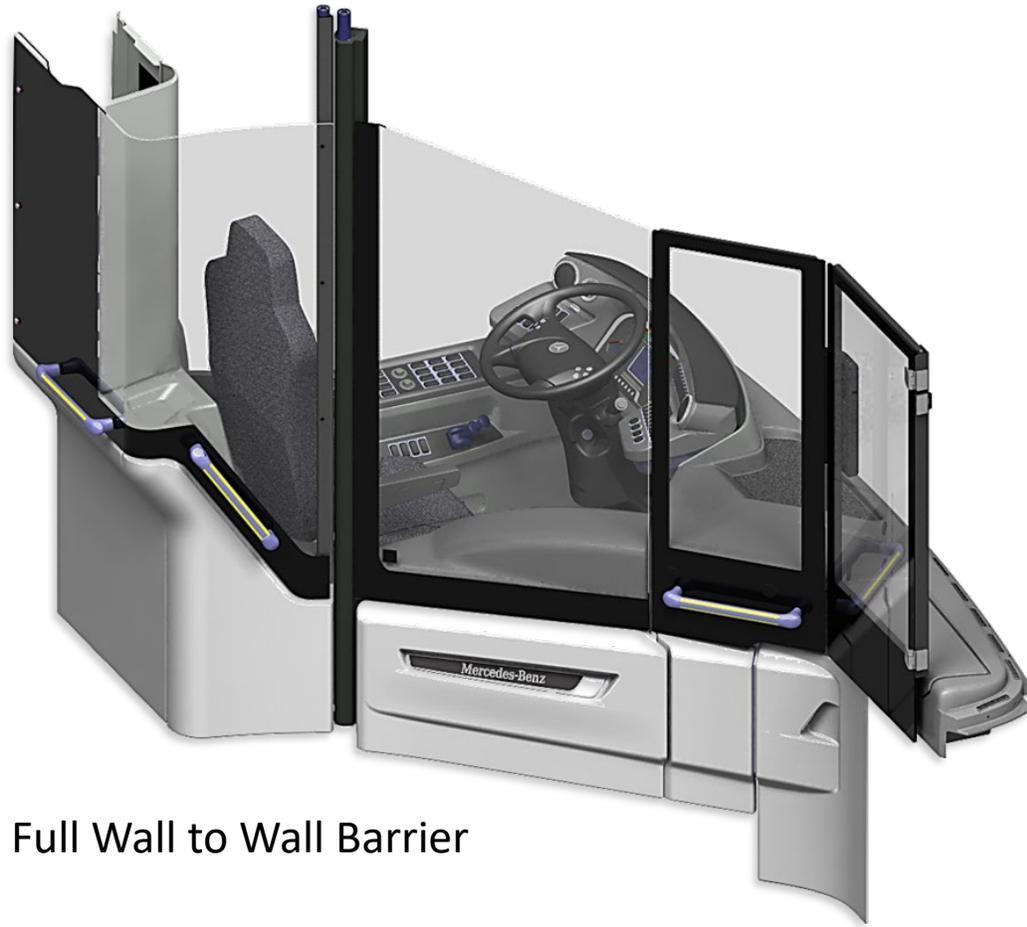
Edge of Security Door



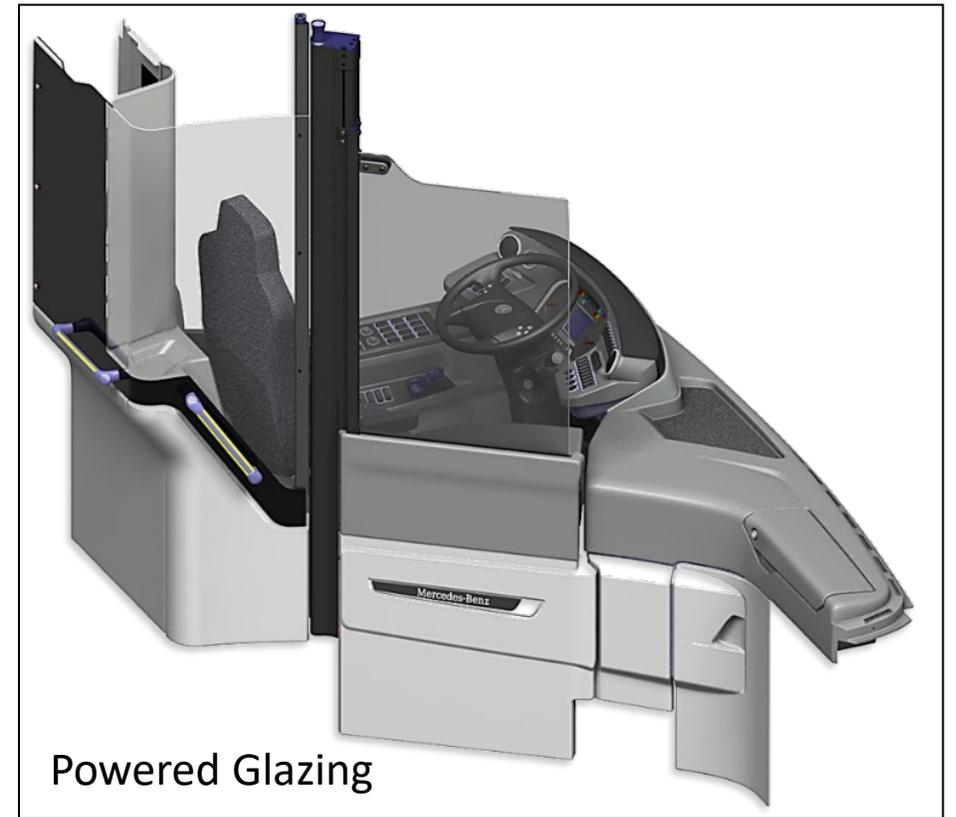
Barrier Creates Protected Exit

- Barrier door can latch to stanchions dividing the entry
- Driver can operate only the back half of door for passengers
- Driver can escape through the protected front half
- Powerful electromagnetic latch connects barrier door to either the dash or the stanchion

A wide range of barrier options including powered glazing on the driver security door and a full-width barrier.

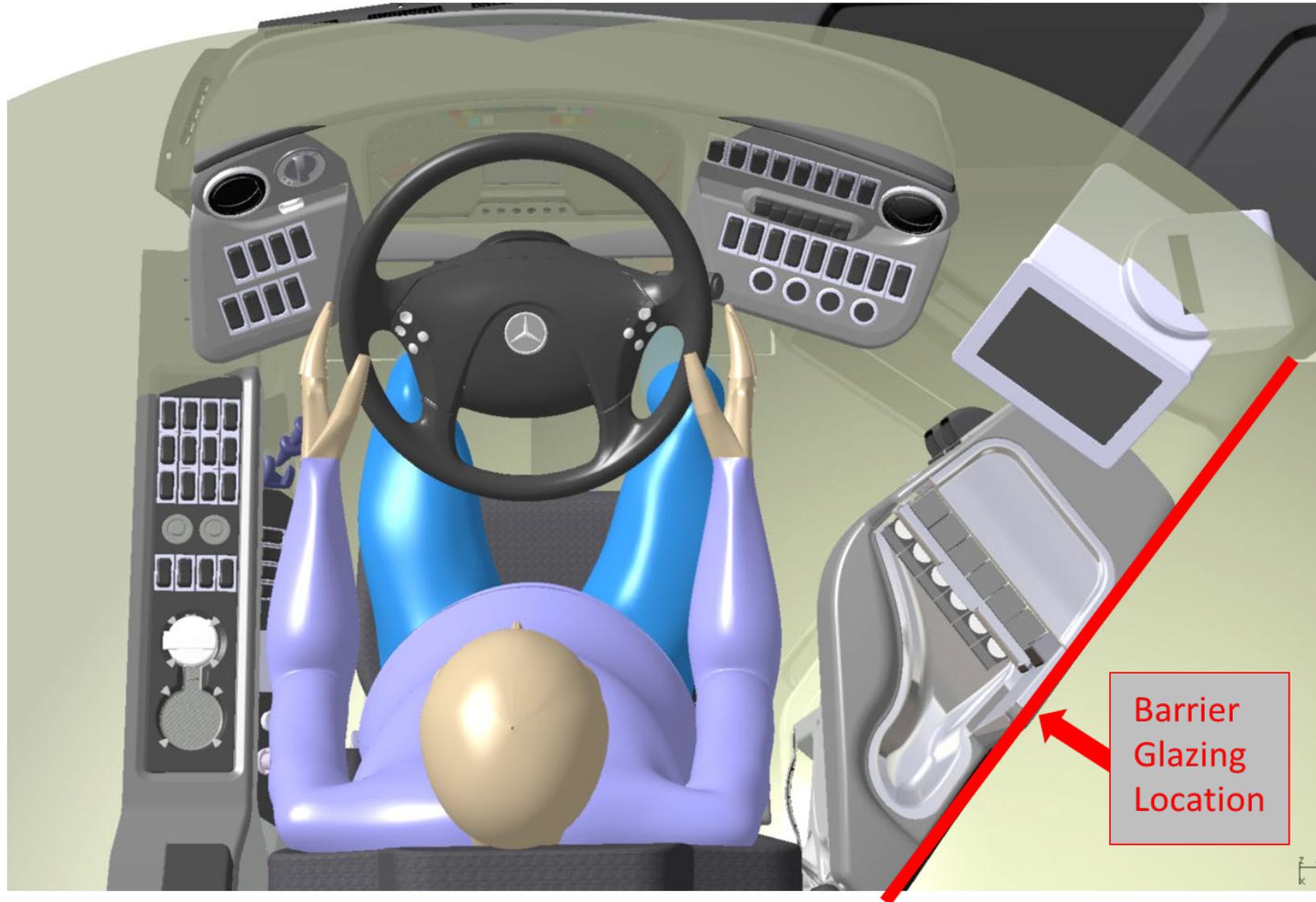


Full Wall to Wall Barrier



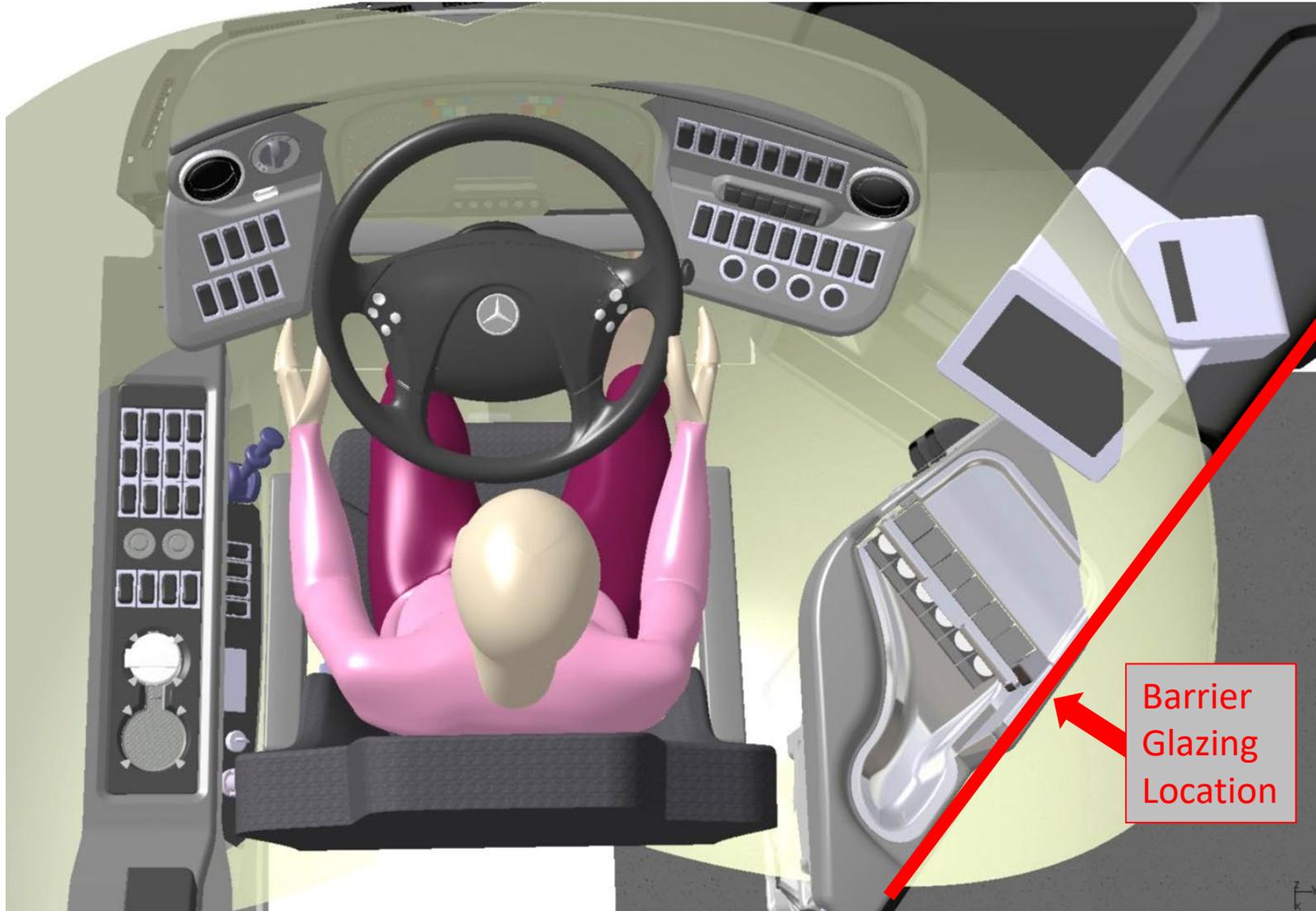
Powered Glazing

95th Percentile Male Ergonomics



Spacious Driver Compartment

This example is for a 5th Percentile Female



Complete Barriers From England





The British Complete Barrier from Another Angle

COVID-19

CNN aired a news clip of a bus driver who was outraged over coughing passengers and died days later.

A study from JAMA showed that there is no statistical difference in risk by distance. Again, recirculation and aerosol transmission.

Shen Y, Li C, Dong H, et al. Community Outbreak Investigation of SARS-CoV-2 Transmission Among Bus Riders in Eastern China. *JAMA Intern Med.* 2020;180(12):1665–1671. doi:10.1001/jamainternmed.2020.5225

The number infected increases with the duration of exposure to aerosols:

1 bus trip*: 8 infected out of 49 = **16%**
(note - one infected on a subsequent trip)

50 Minutes x 2 trips: 23 infected out of 69 = **33%** (note – 20 secondary infections)

150 Minutes: 52 infected out of 60 = **87%**

* unknown duration

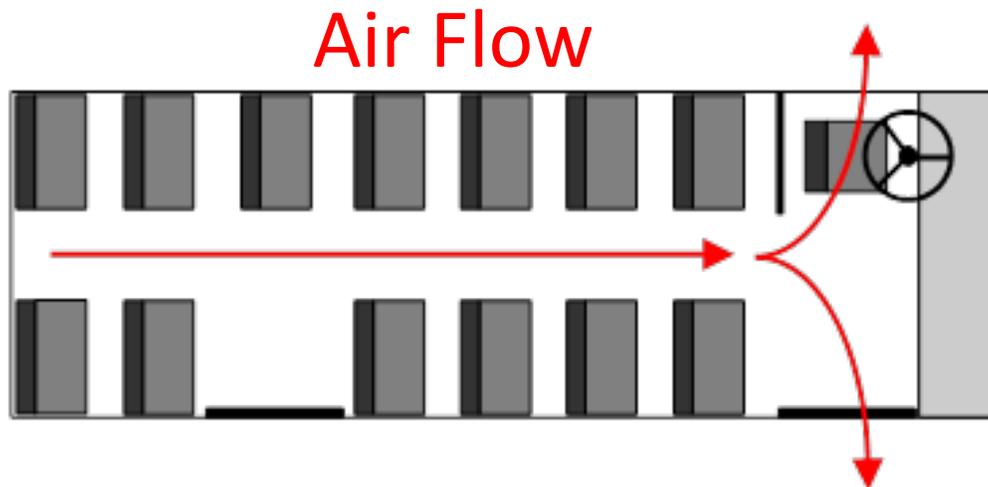
Reverse Airflow Increases Driver Risk



As buses go down the road the approaching air is forced to the sides and top with too much momentum to sharply turn the square front corners. It shoots out to the sides, creating a **partial vacuum** which **pulls air in the bus forward and out near the front.**

Results of reverse air flow:

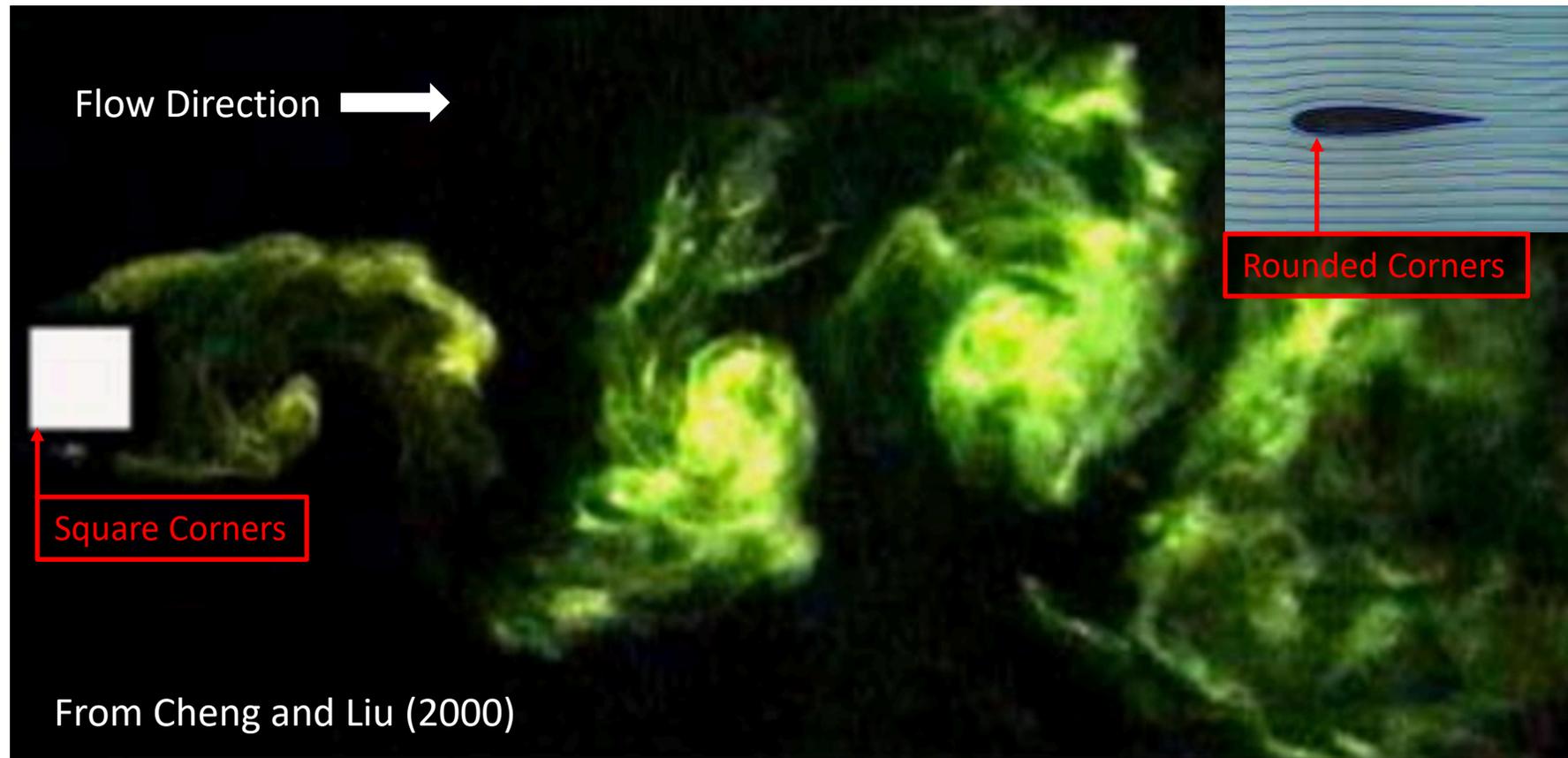
- Driver exposure to fumes, dust, and other particles which come through the back of the bus forward to the driver's area.
- High rates of respiratory illness among drivers – a COVID risk factor.
- Viral and bacterial loads of the passengers flow forward exiting past the driver.



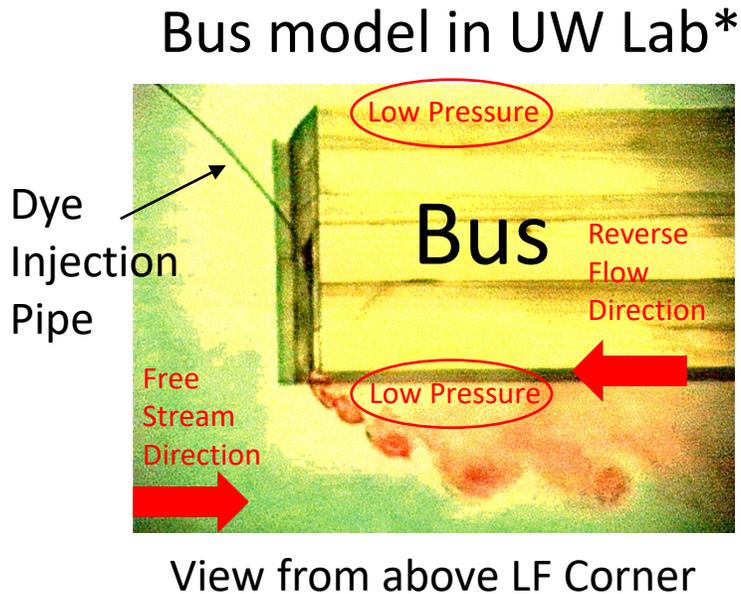
Bus Aerodynamics

Like a Brick!

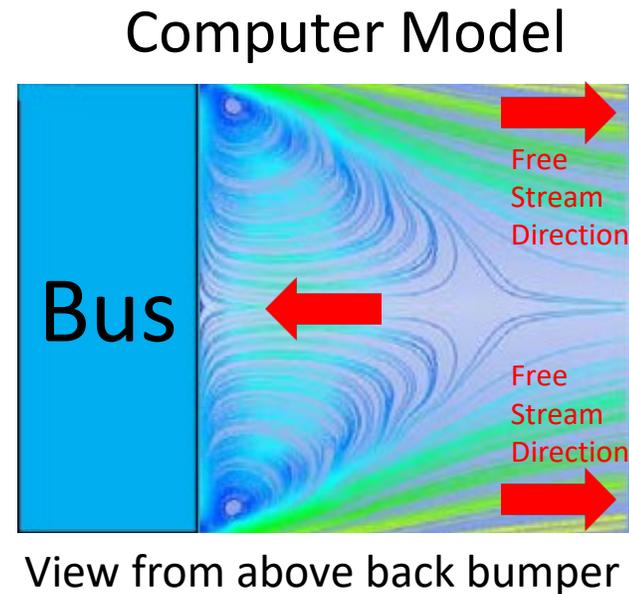
The white square is in a fluid flow, similar to air, moving from left to right. The sharp front corners (at left) cause the flow to separate from the surface of the square, creating the huge turbulent wake. It also causes surprising problems in buses. Inset; rounded front corners mean no wake.



Counterintuitive Flow Directions and Leading Edge Suction



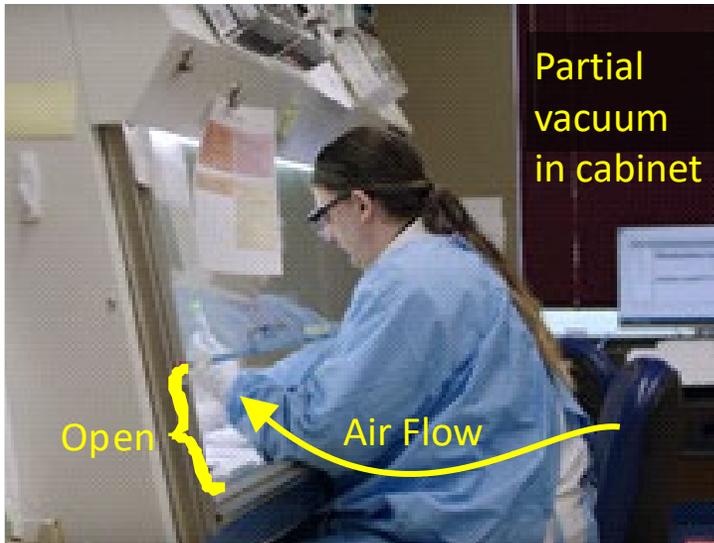
Both Flows Moving Left To Right



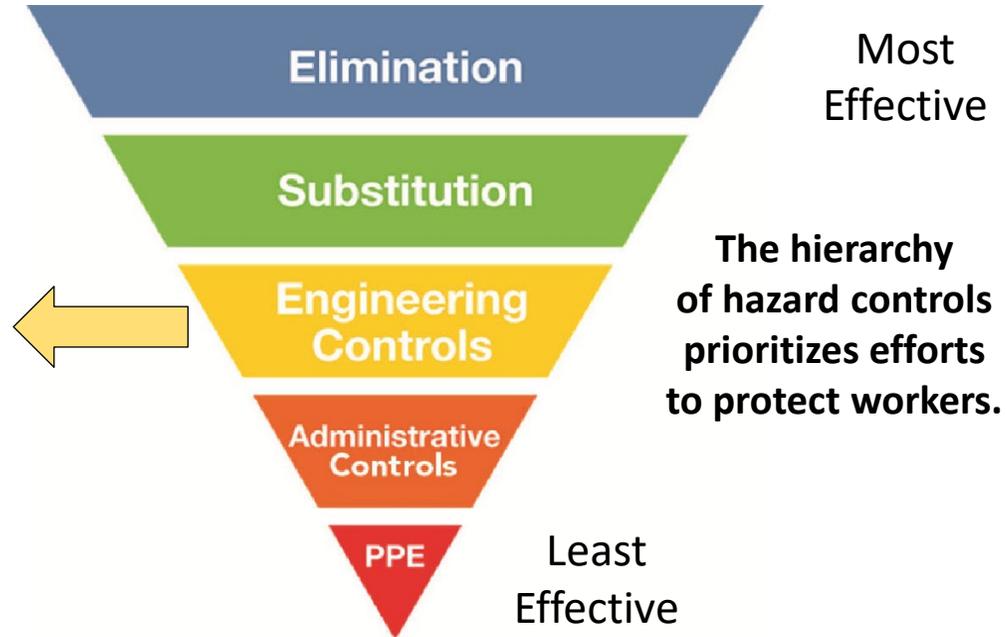
The square leading edges of buses cause the airflow to “separate” from the surface as at left. This causes the flow to move away, (note red dye) creating a low pressure zone all the way around the front. Low pressure pulls the layer near the surface forward along with the air inside the bus. The interior flow from back to front means that the driver is at the exit of the flow of exhaust, dust and infectious agents drawn forward.

*Thanks to Professor Robert Breidenthal, Department of Aeronautics and Astronautics

Air Flow Control = Risk Control



Biohazard Containment need not be absolutely sealed, It only has to carefully control flow.

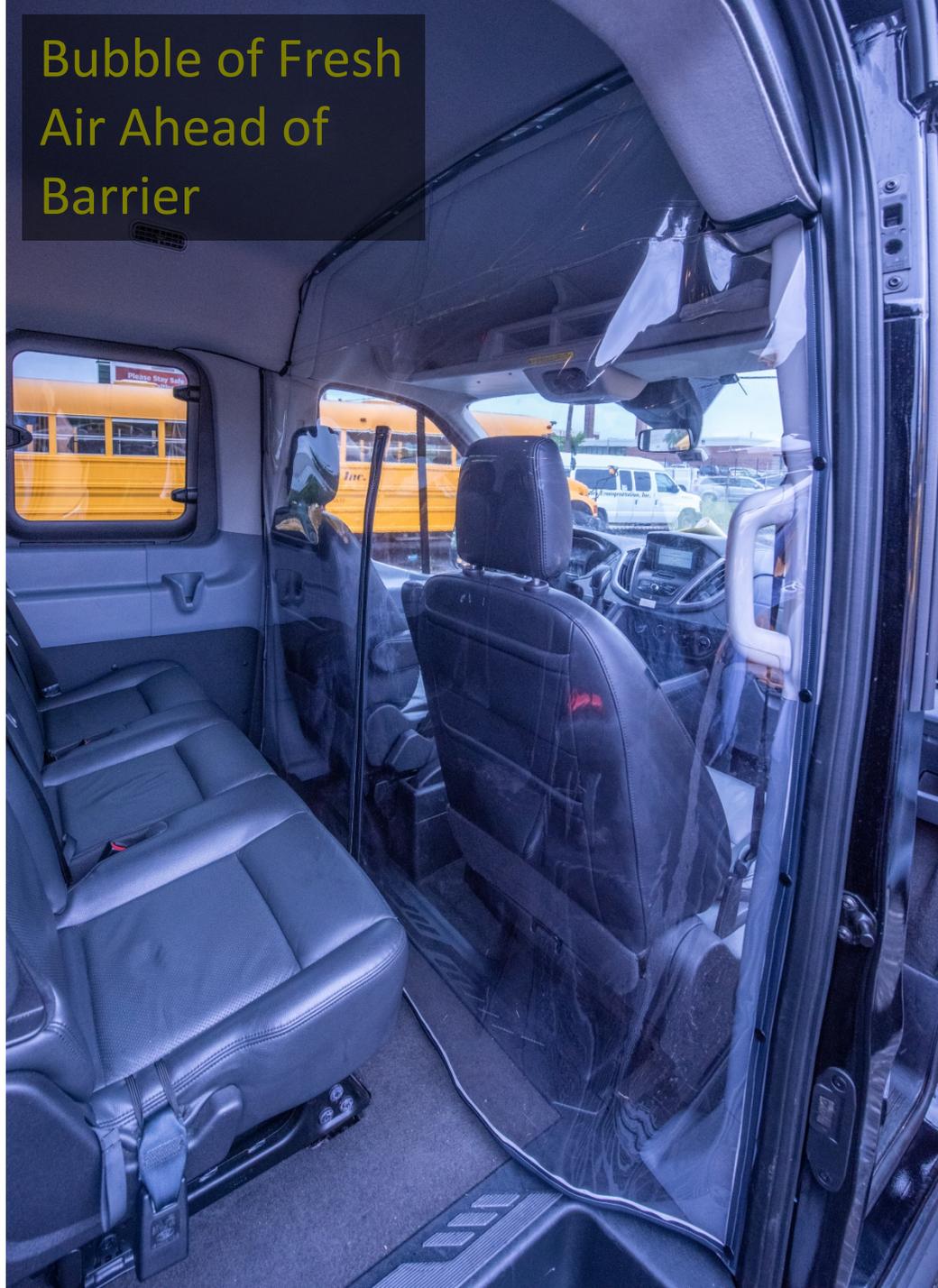


- Elimination** – Physically remove the hazard. Requires a vaccine; 1-2 years from now.
- Substitution** - Replace the hazard. No current examples for this pandemic.
- Engineering Controls** – Isolate workers from the hazard with barriers and corrected airflow.
- Administrative Controls** – Change workplace policies to reduce risk. Rear door boarding, limiting bus capacity, and recordkeeping and communication of positive cases.
- PPE** – Last line between worker and hazard. N95 masks, gloves, goggles, and gowns.

In most vehicles, fresh air is available through the front HVAC. Here the flow is 861 feet per minute from this vent.



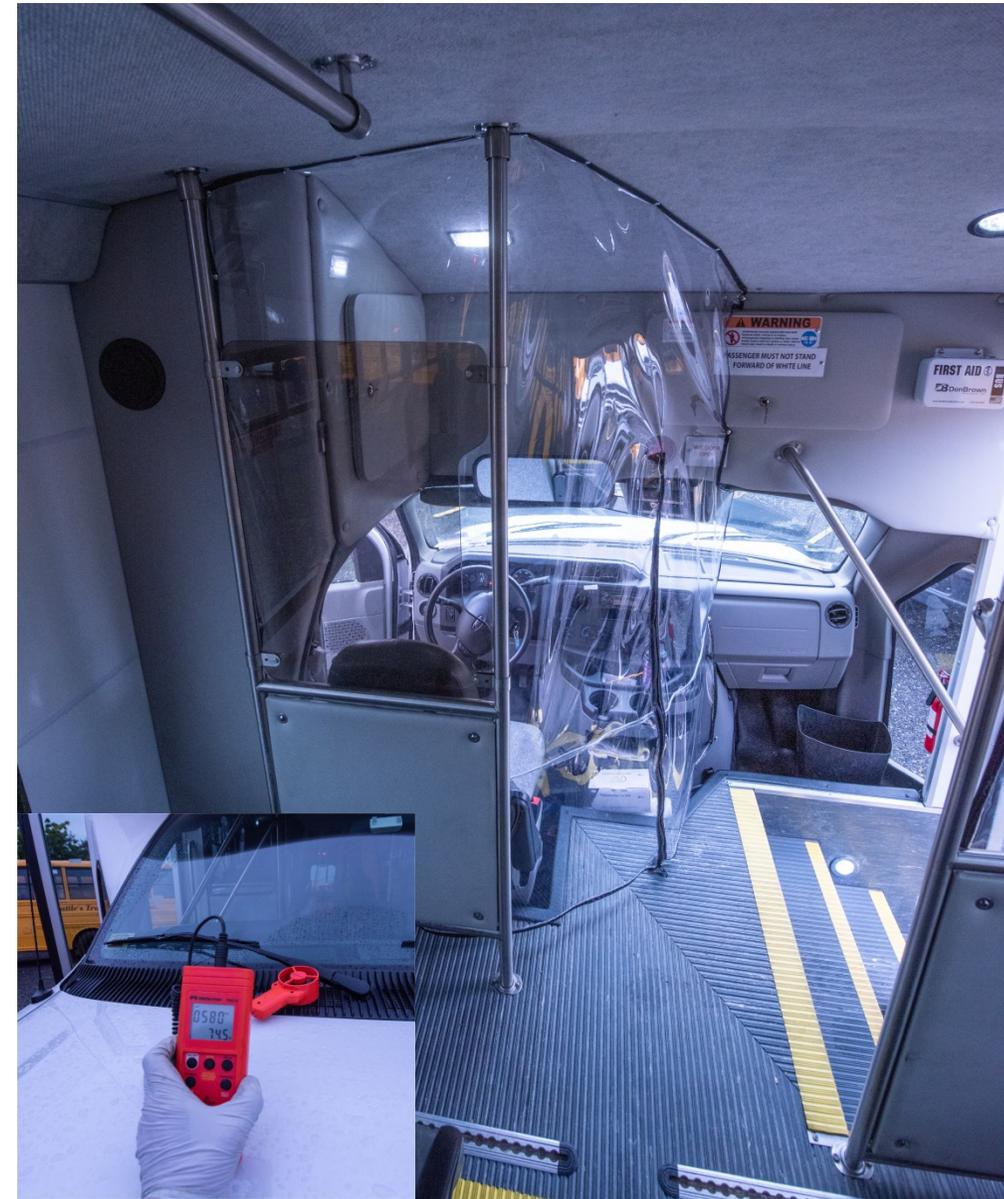
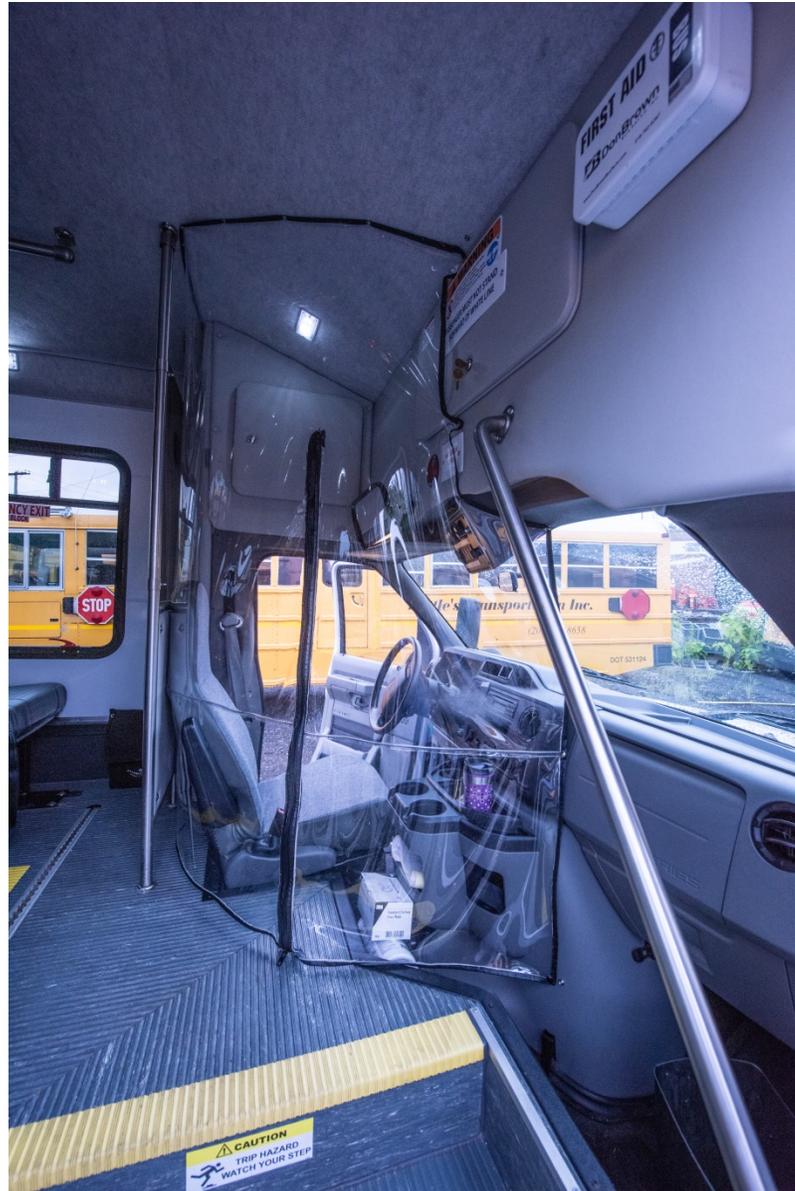
Bubble of Fresh Air Ahead of Barrier



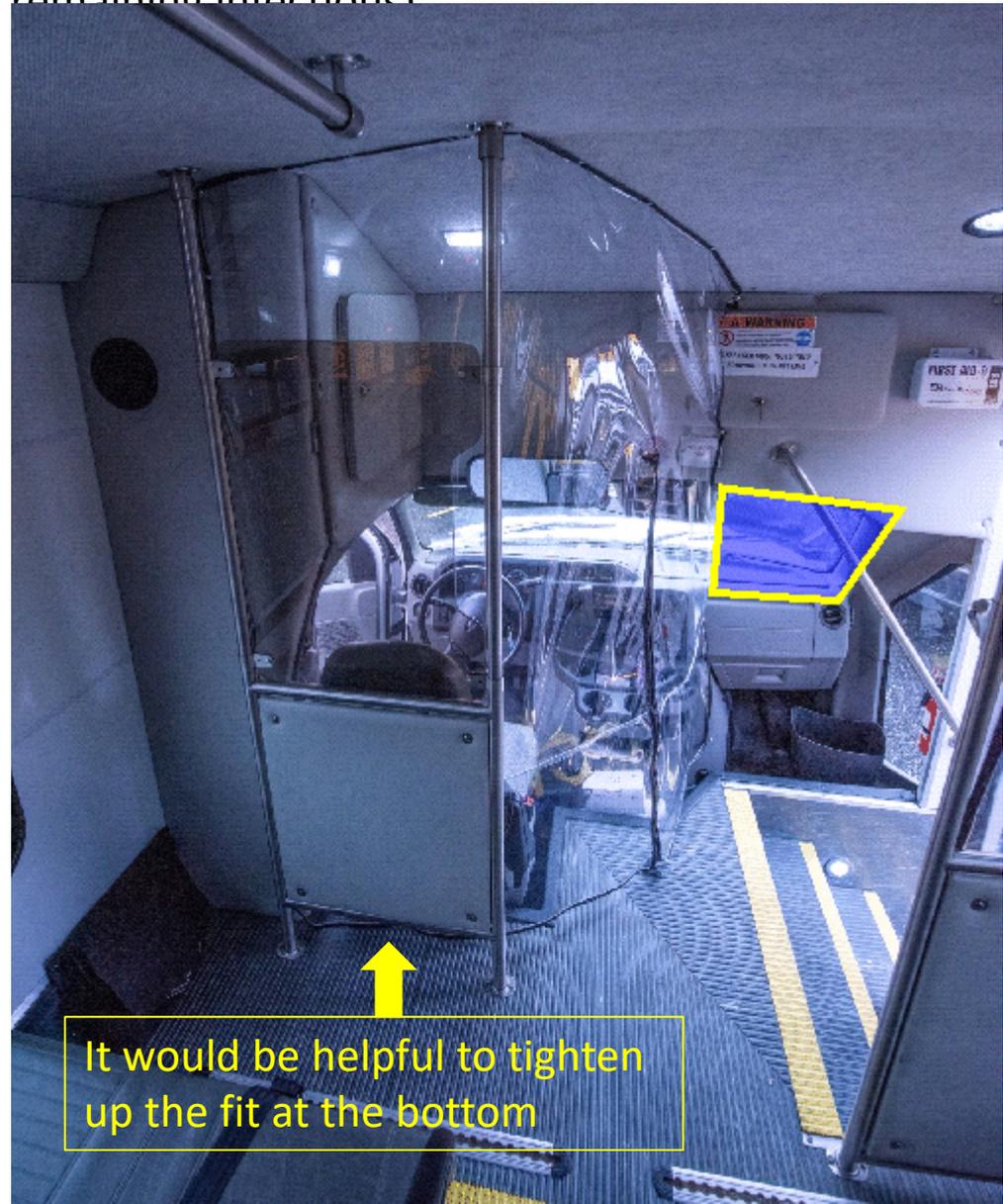
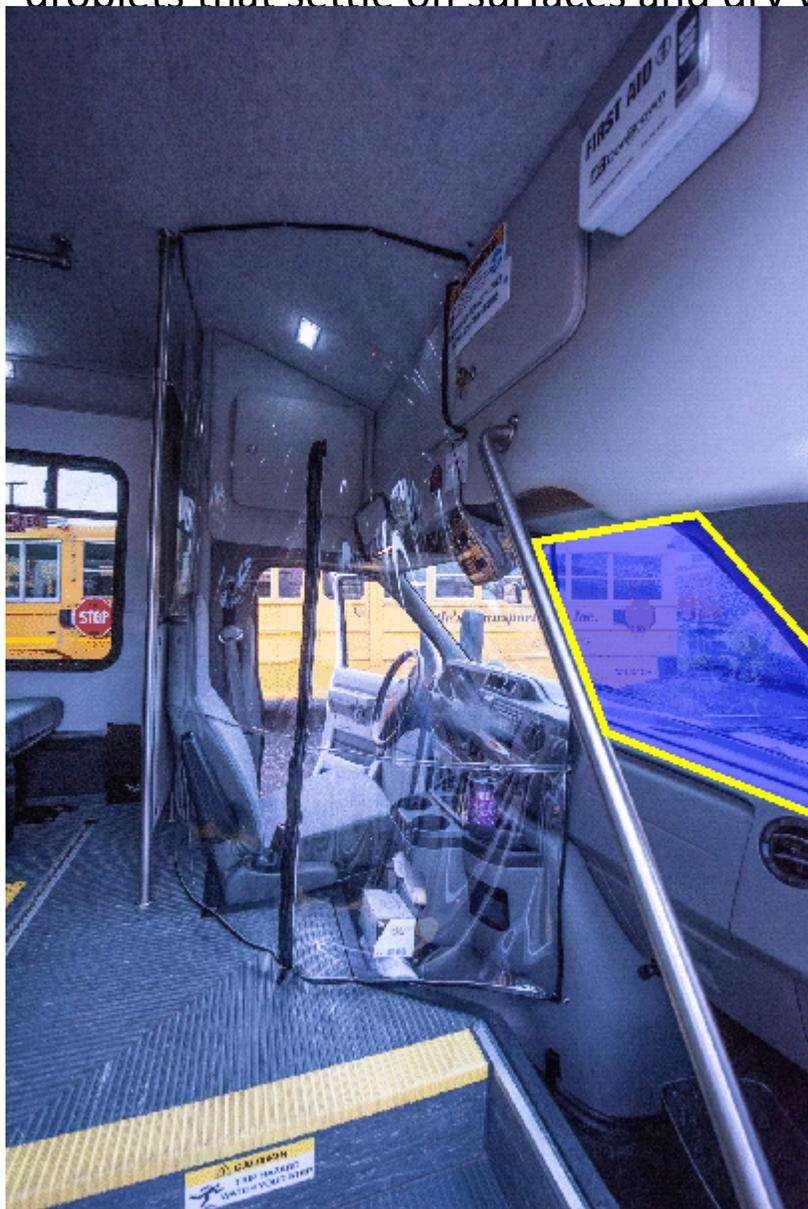
In vehicles of this configuration, the heater/defroster can combine with an easily installed and reasonably complete barrier, to provide high-grade protection for operators by preventing back-to-front flow.



Cutaway vehicles are a bit more difficult but can still be retrofitted to provide high-grade isolation. Again, fresh air is available from the front HVAC but this barrier is not sufficiently closed-off to prevent reversed flow. However, it can be easily modified to yield great results.



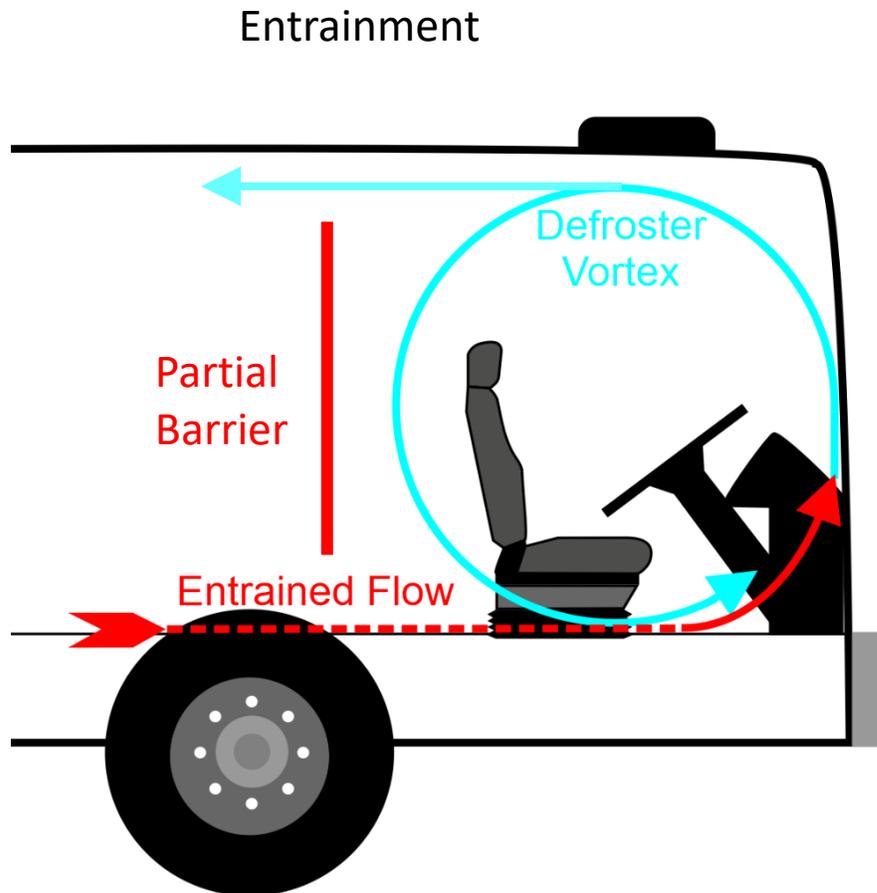
Adding an extension of the same vinyl material covering the open area at the windshield would greatly improve isolation for operators. This could be a separate panel. If a gap is left to allow fresh airflow to the back, it is optimal to have it at the top so as to not loft fomites (respiratory droplets that settle on surfaces and dry while remaining infectious)



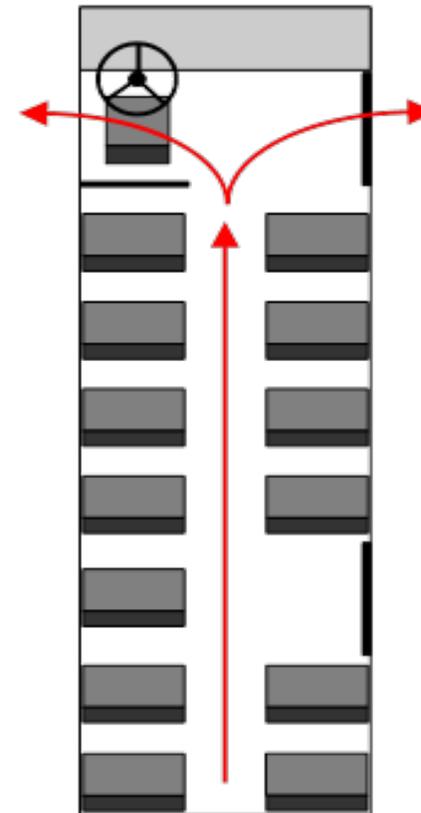
The hazard - flow from the passenger area to the driver's area.

The cause - leading edge suction and entrainment

The solution – use the fresh air from the front HVAC to create a slight positive pressure in the driver's area, to prevent passenger area air coming into the driver's area



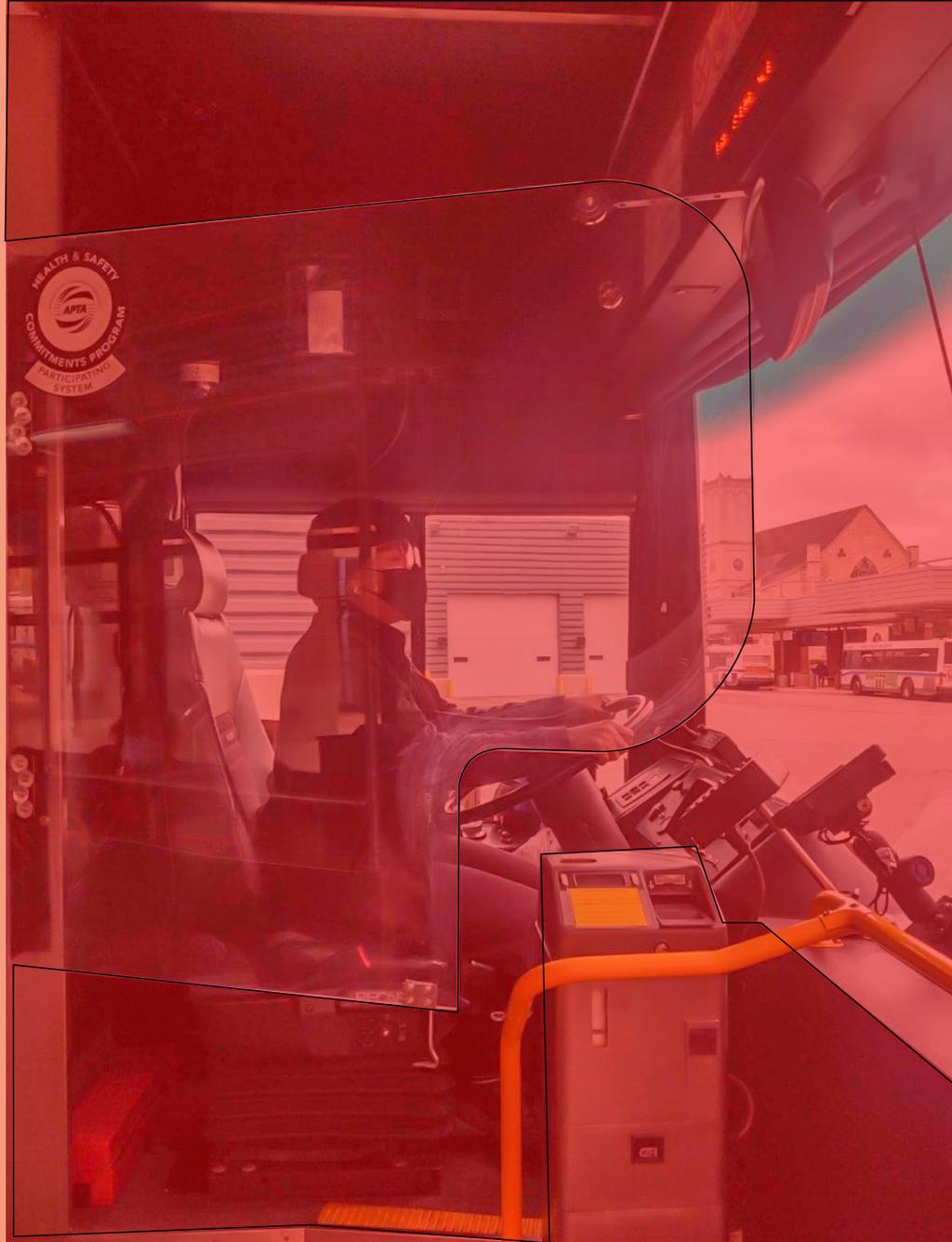
Leading Edge Suction



Entrainment is the transport of fluid across an interface between two bodies of fluid by a shear induced turbulent flux

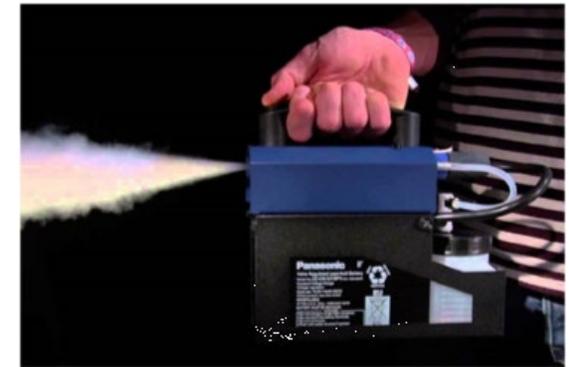
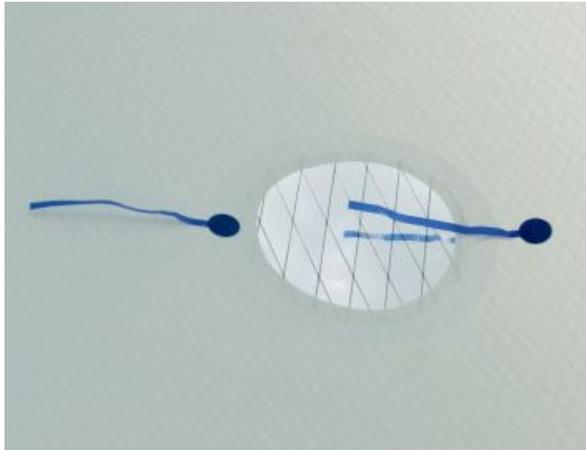
Partial Barriers Are Insufficient

Although this barrier is larger than most, there is no way to protect this operator from flow through the open areas colored red. This commendable effort could be greatly improved with a curtain from the ceiling and a skirt suspended from its lower edge. That closure could be a flexible, but durable, transparent sheet. With the rapid increase in more transmissible and hazardous strains of SARS-CoV-2 arising, improved isolation will be of ever increasing importance through this pandemic



It is Critical to do Flow Testing with Smoke or Yarn

Telltails on a sail



- Most shops will have smoke testing equipment and it will work well for flow testing.
- Even a cigarette will work, as above.
- A roughly 3" piece of lightweight yarn on a wire (like a coat hanger) works very well.
- Be sure all flow goes away from the operator. Vortices can pull air forward along walls, for example. Test all openings and gaps.

The Bottom Line

1. Poor design imposes huge costs, both human and budgetary

1. Simple solutions exist

2. The benefits far outweigh the costs of change

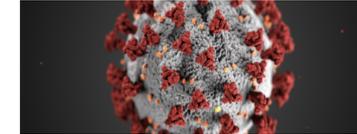
3. Agencies need to work together to demand improvements. Manufacturers will otherwise build only what serves their profit, not the public good.

Resources

National RTAP Resources

- Coronavirus Disease 2019 (COVID-19) Information
 - Bus Plexiglass Shield Examples
 - Case studies, Best Practices, Research guides
 - ADA Toolkit on COVID-19
 - Rural Transit Planning in the Time of COVID and Beyond
 - FTA COVID-19 Resources
- National RTAP Resource Guide
- Send TA questions to our Resource Center: info@nationalrtap.org

Coronavirus Disease 2019 (COVID-19) Information



Dear Rural and Tribal Transit Community,

We provide continuing support for the ongoing safety demands and economic ramifications of COVID-19 for rural and Tribal transit programs.

We have hope now and see positive change on the horizon as more of our workforce has access to vaccination and more of our community has been immunized. With the new leadership and new resources focused on safety and maintaining our transportation network, we look forward to working with all of you on implementing the new normal. As always, please contact us if there is anything we can do to assist you.

Take care and stay safe,
Robin Phillips

Executive Director

FTA COVID-19 Resources

FTA Novel Coronavirus (COVID-19) web page - includes information about the Coronavirus Aid, Relief, and Economic Security (CARES) Act, and FTA resources, press releases, blogs, announcements, and links to other federal resources

National RTAP Resources

Technical Brief - covers what is known about COVID-19 at this time and the basics of planning, prevention and treatment. This brief is updated regularly. Updated on February 4, 2021 with information about CRRSAA, updated federal deadlines, the new National Strategy for the COVID-19 Response and Preparedness, and sample survey questions for planning to return to the workplace.

Best Practices Spotlight Article - provides best practices and guidance on safety, communications, funding, and more from the perspectives of state, rural and tribal transit managers, and clinical experts. Published on June 5, 2020.

Topic Guide - selected links to FTA, National RTAP, and other national, regional and local COVID-19 resources and planning documents. Updated on February 4, 2021.

Frequently Asked Questions (FAQs) - answers to questions to our Resource Center and at our Peer Roundtables and Panel Discussions. Updated on February 8, 2021 with information about mask wearing mandates, CRRSAA, and updated federal deadlines.

ADA Toolkit Section on COVID-19 - the New Developments section of the ADA Toolkit lists recent developments related to COVID-19 and the Americans with Disabilities Act. Published on October 27, 2020.

Transit Manager's Toolkit Sections on COVID-19 - New sections are Leading during a Crisis and Lessons Learned from the COVID-19 Pandemic. Published November 11, 2020.

COVID-19 Safety Guidance for Frontline Transit Employees - This training was sponsored by NJ Transit, in collaboration with the NJ Council on Special Transportation, and was recorded on September 11, 2020 by Michael Noel of Noel Training & Consulting LLC. It is available through National RTAP eLearning.

Rural Transit Planning in the Time of COVID and Beyond - A webinar delivered on January 14, 2021 by Ken Hosen of KHF Group, which provided guidance on planning efforts that rural and tribal transit agencies can undertake through three phases: 1) During the pandemic, 2) Recovery from the pandemic and 3) Post-pandemic. It also covered transit planning basics and best practices.

Plexiglass Shield Examples - Photos of barriers implemented by rural transit agencies to enable social distancing and safety. Published April 27, 2020.

Peer Assistance - upcoming technical assistance events and summaries of previous COVID-19 Peer Roundtables and Panel Discussions for State RTAP Managers, Transit Managers, and Tribal Transit Managers

Upcoming Events

National RTAP lists COVID-19 focused events in our **Calendar of Events** and **eNews**. Events that have been cancelled or postponed are also listed in **eNews**.

Event Title	Description	Date
Problem Passengers: Managing Difficult Passengers & Situations	Instructs drivers on how to manage and respond to situations including angry passengers, passenger refusals and threats and passenger health problems. P D E	2018
<ul style="list-style-type: none"> • Learner • Facilitator 		

Date listed is date of last update. Training Modules and Technical Briefs can be downloaded from the Resource Library at nationalrtap.org

Questions?

Post-Webinar Survey

- Available at <https://app.keysurvey.com/f/41551684/6668/>
- In browser window after webinar and also to be sent via email
- Should take less than 2 minutes to complete- you may ask questions in the survey
- Questions or comments about Workstations can be sent to dcoffice@nationalrtap.org



Thank You!

National Rural Transit Assistance Program

nationalrtap.org

Technical Assistance: info@nationalrtap.org

Find us on Facebook, Twitter, YouTube, LinkedIn & Instagram

888-589-6821

For workstation webinar questions, please send us an email at dcoffice@nationalrap.org



U.S. Department of Transportation
Federal Transit Administration