SAFE SERVICE NOW
AMALGAMATED TRANSIT UNION

The COVID-19 Pandemic and Biohazard Containment

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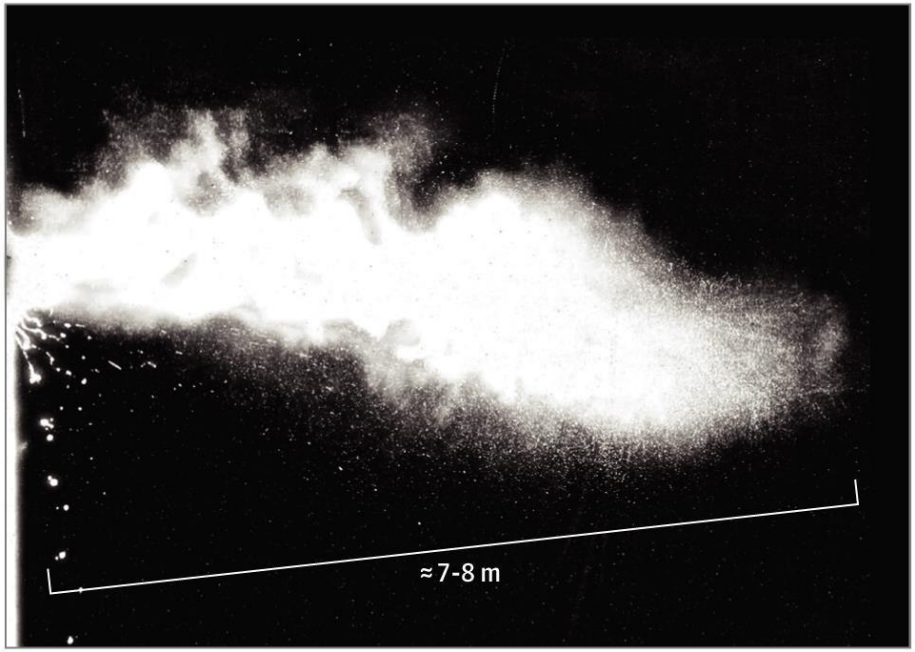
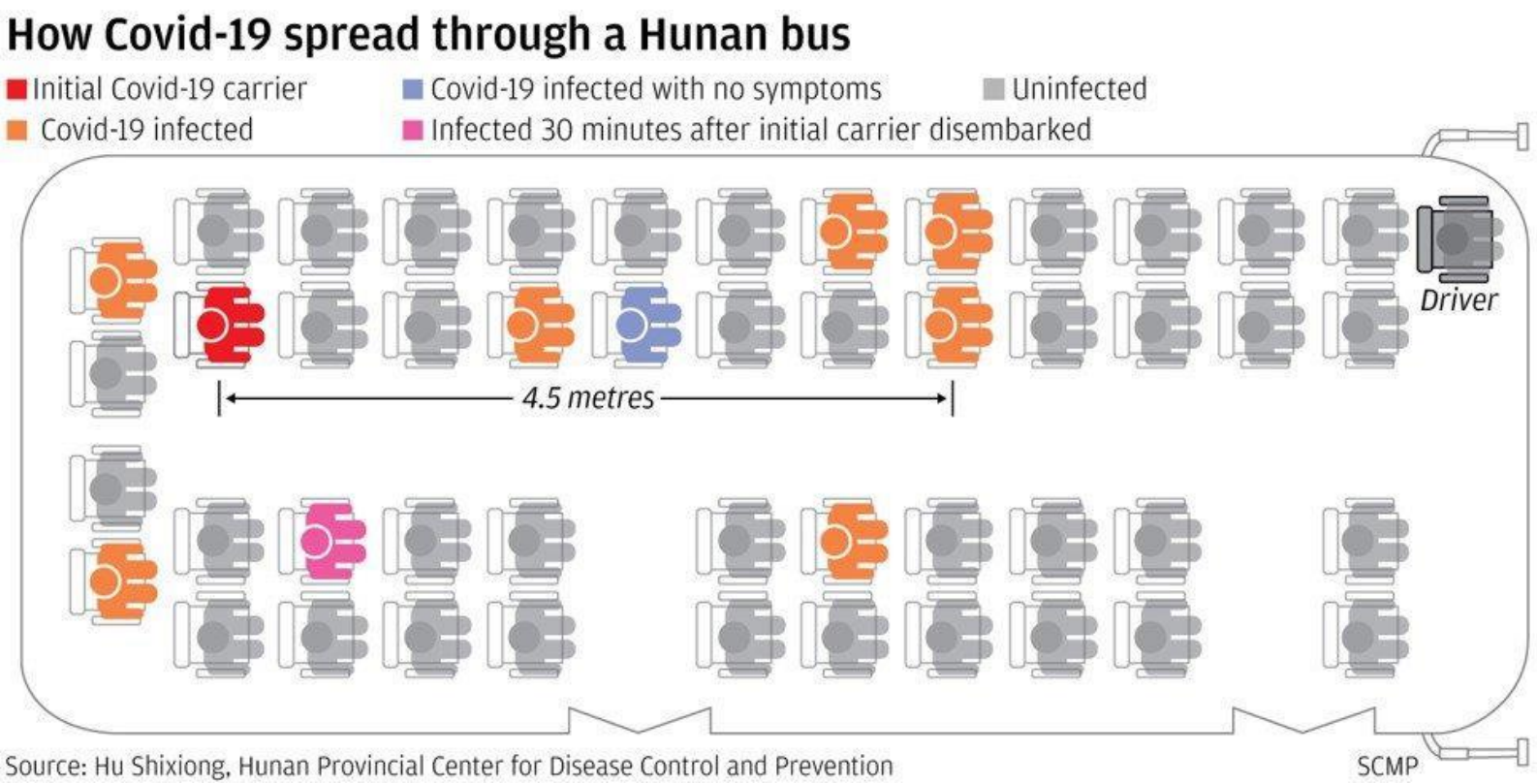
1. Exposure and Transmission



A sneeze can project respiratory droplets 7-8 meters (23-27 feet) in still air.

- Respiratory droplets, larger particles of mucus, and water containing viral particles
  - Can survive on surfaces and in the air after coughs and sneezes
- There is growing evidence of asymptomatic transmission and aerosolization of COVID-19
- Viral particles are only .06-.140 microns (60-140 nm)

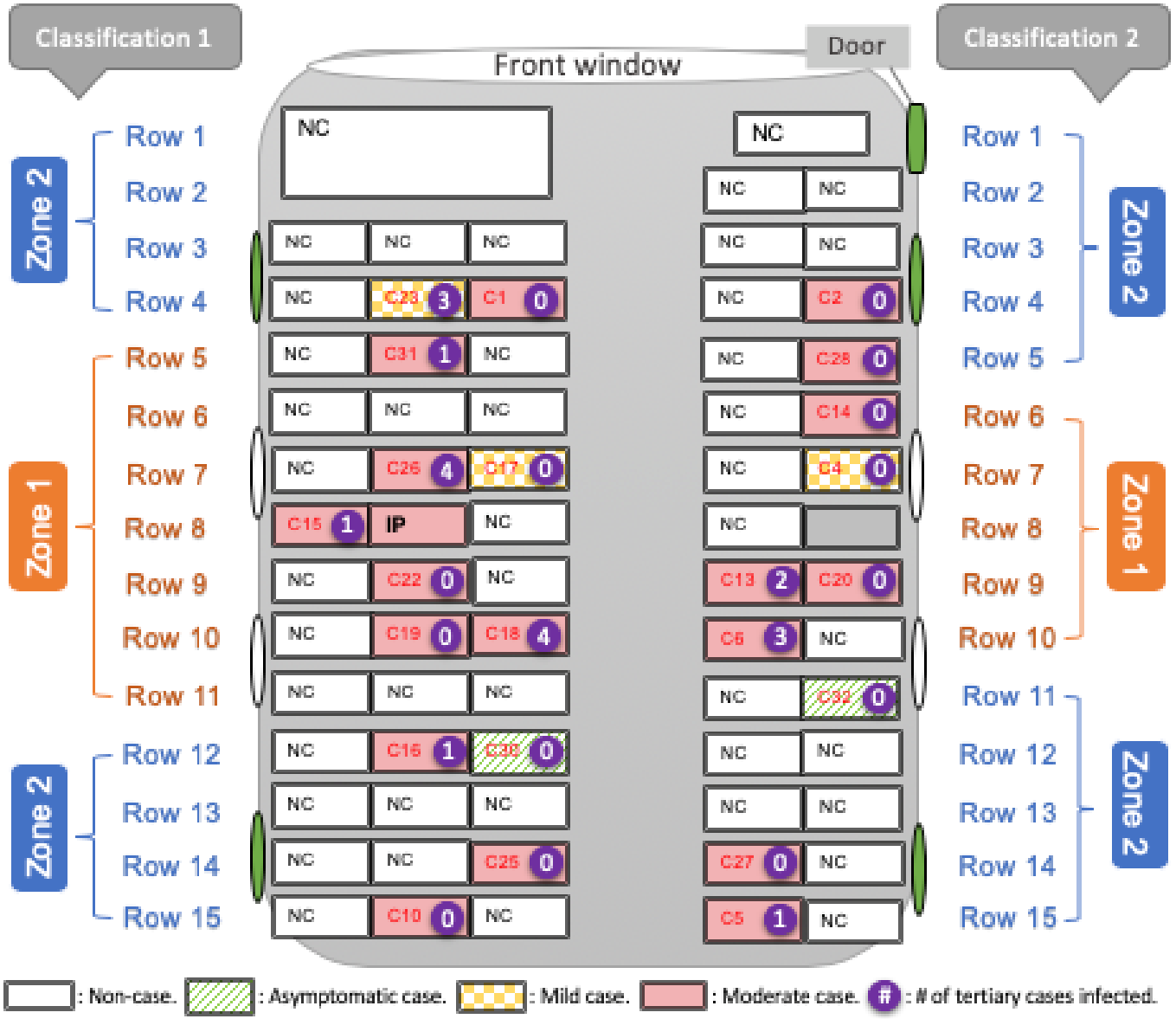
1 meter = 3.3 ft. 1 **µm (**micron) = 1/1,000,000 meter 1 **Nm** nanometer = 1/1,000,000,000 meter



6-Foot Social Distancing is Insufficient

- The passenger in **red** infected others ***15 feet (4.5 meters) forward*** in the bus.
- HVAC recirculation spread viral particles throughout bus.
- This discovery came from expert contact tracing!!!

A newer study – the initial patient (IP) is in row 8. There is no statistical difference in risk by distance. Again, recirculation and aerosol transmission

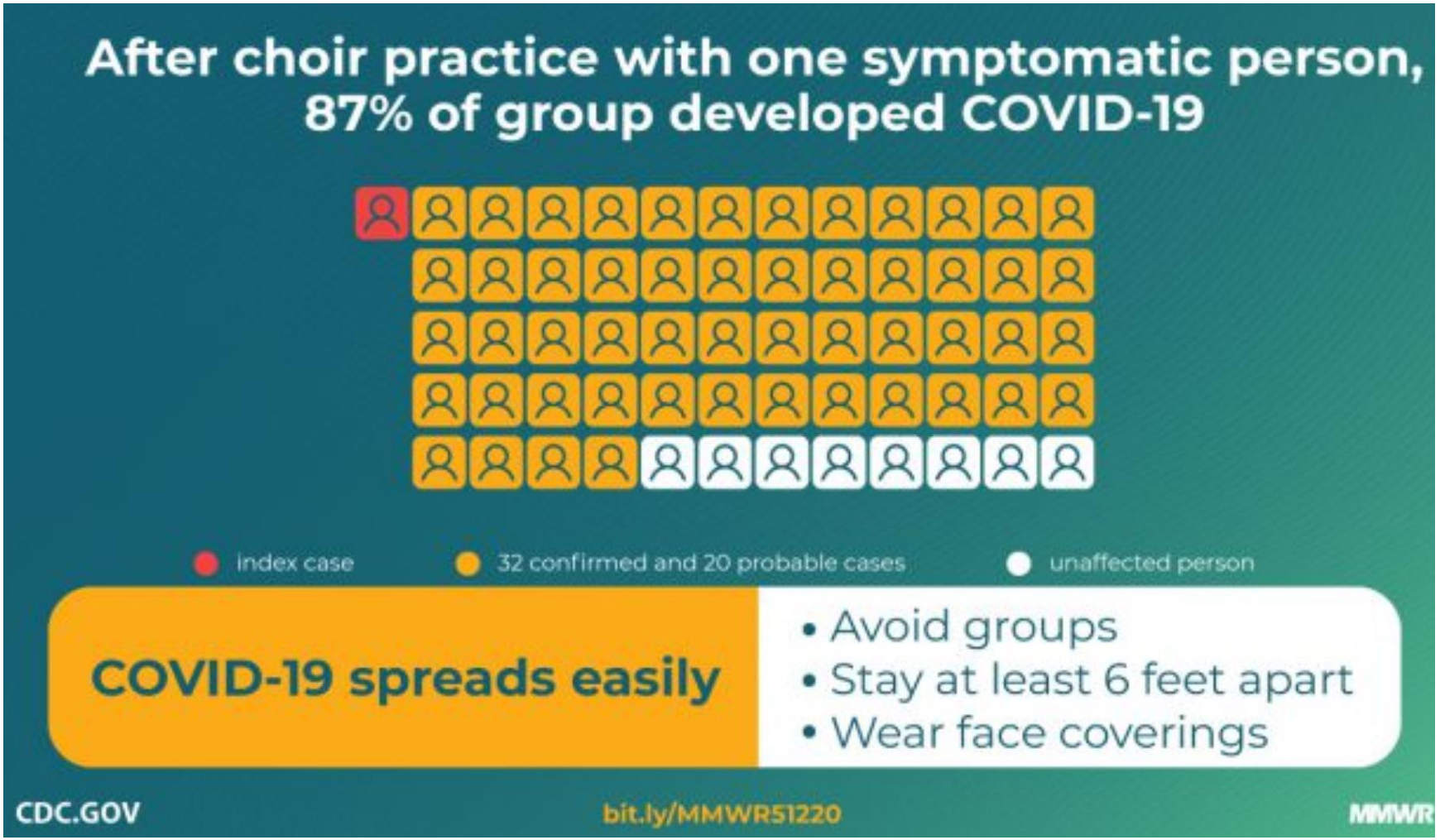


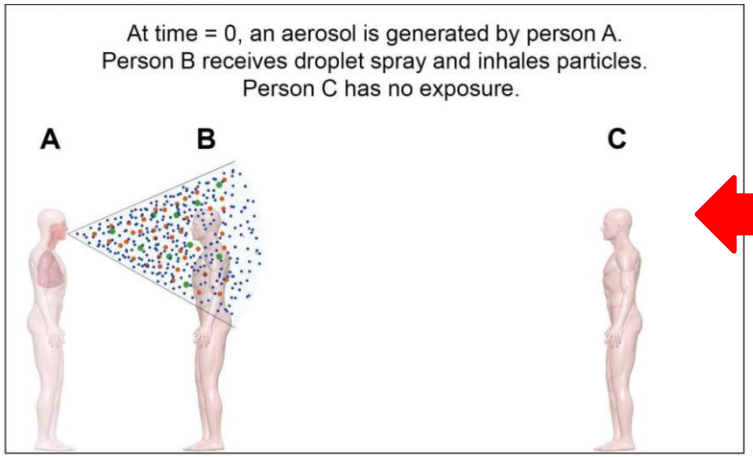
22 Direct Infections

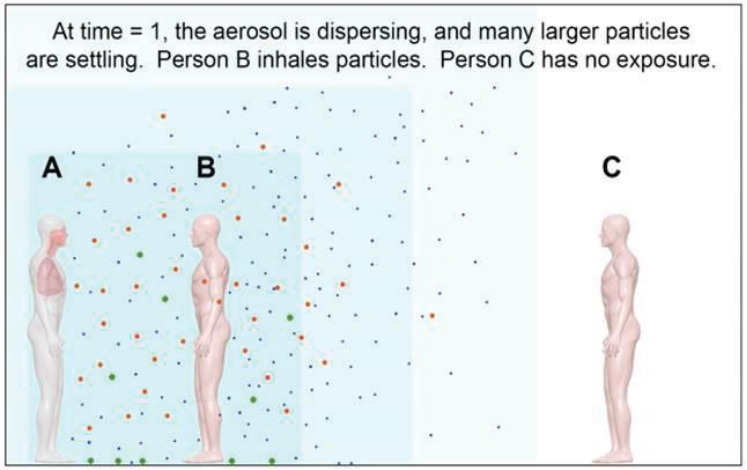
20 Secondary Infections

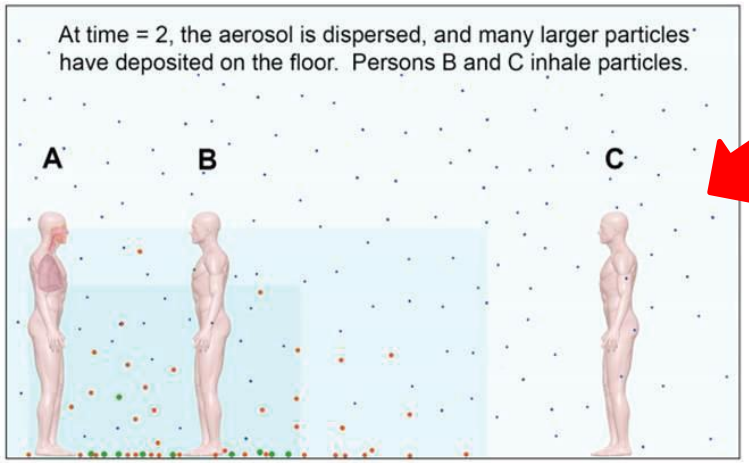
A US Example of Aerosol Transmission

1 index case, 52 confirmed and probable cases, 8 unaffected







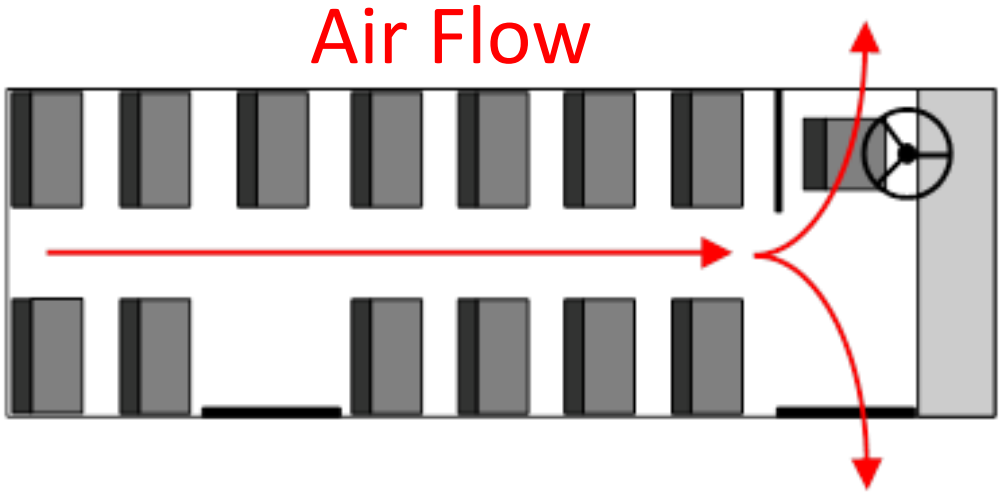


- Highest risk comes from nearby exposure to droplets.
- Infected individuals produce infectious aerosols by simply breathing.
- Aerosols remain suspended and carried by air currents.[1]
- These aerosols can remain infectious for hours.[1]

1. Fears, A.C. et. al. Comparative dynamic aerosol efficiencies of three emergent coronaviruses and the unusual persistence of SARS-CoV-2 in aerosol suspensions.

Graphics from the Center for Infectious Disease Research and Policy (CIDRAP) at the University of Minnesota and Absolute Science.

2. Dangerous Air Flow, Poor Aerodynamics and Increased Risks of Infection in Transit.

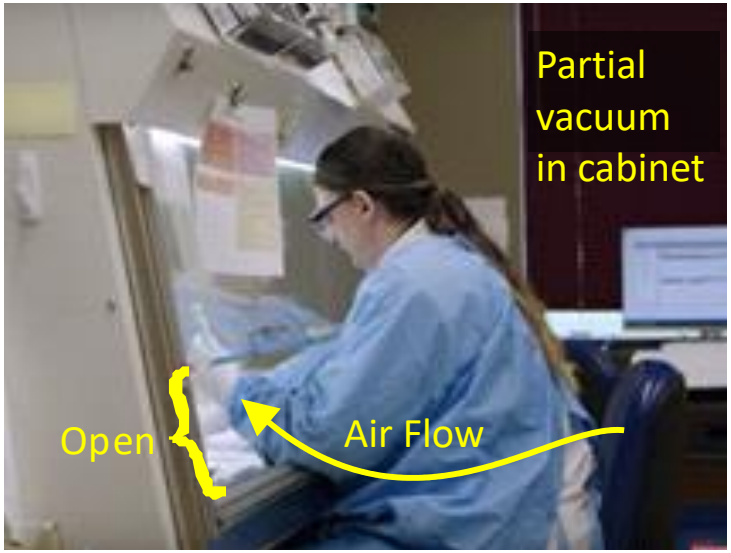


As buses go down the road the approaching air is forced to the sides and top with too much momentum to sharply turn the square front corners. It shoots out to the sides, creating a **partial vacuum** which **pulls air in the bus forward and out near the front.**

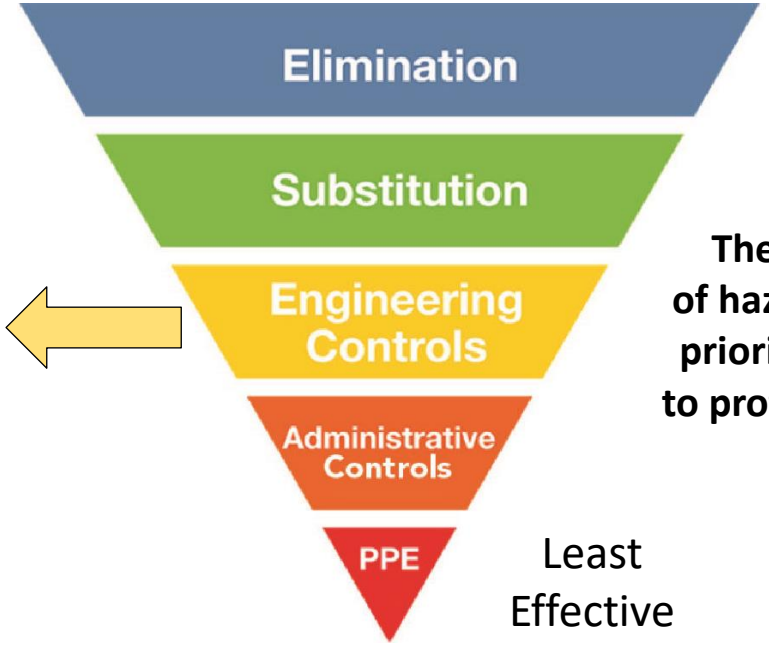
Results of reverse air flow:

- 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.**

Air Flow Control = Risk Control



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



Most Effective

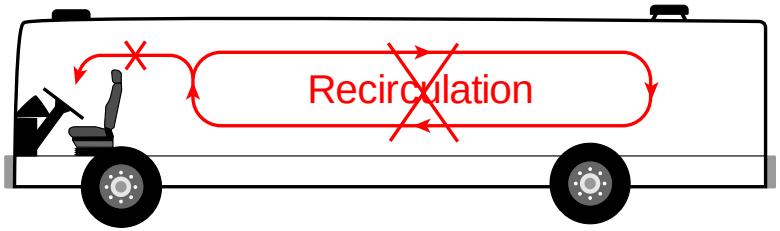
Least Effective

The hierarchy of hazard controls prioritizes efforts to protect workers.

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.

End Hazardous Air Flows

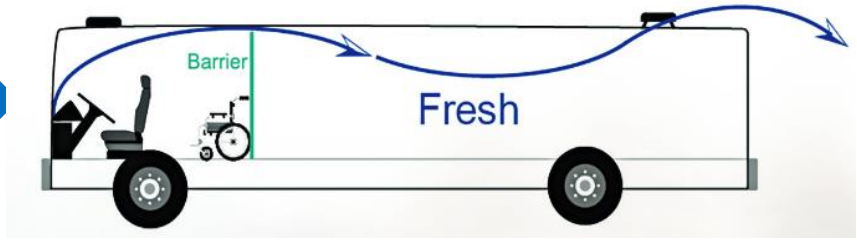
Current Flow



Air flows spread viral particles throughout bus.

- Few sources of fresh air
- Recycled air with ineffective filtration
- Reverse airflow
- Driver is in danger, next to window where flows exit

Needed Fresh Flow



Safer air control settings with fresh air from front vents.

- Positive air pressure prevents reverse air flow
- Back blowers off and hatch open allow fresh air to be pulled to rear of the bus
- Barriers increase positive pressure, creating safer flow

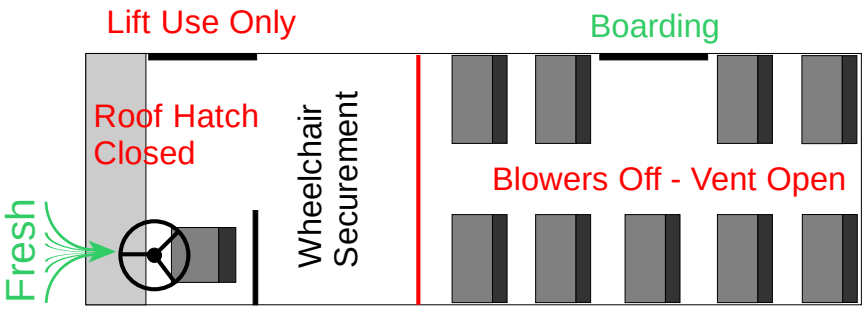
4. Barrier Design and Installation

When asked about operator protection, Dr. Bradley King of the CDC said that "**engineering controls such as permanent or temporary physical partitions or barriers between the driver and passengers, as well as ventilation improvements, would be considered as a first choice**…"

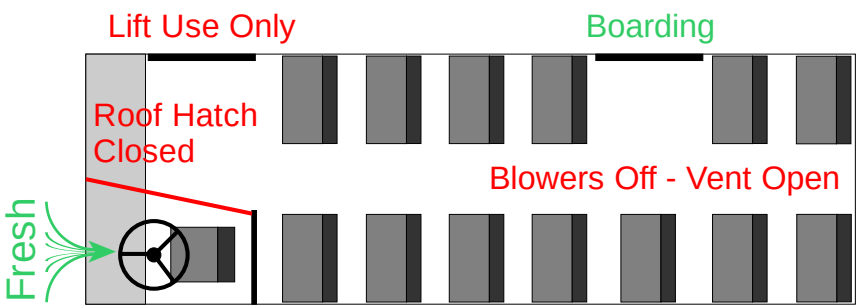
- Plastic sheeting, such as shower curtains should be installed immediately to protect operators.
- It is not necessary for this to seal absolutely.
- Leaving roughly 2 sq. ft. of total leakage past the barrier allows fresh air to enter the passenger area, while building a very slightly higher pressure in the driver's area.
- This can prevent viral particles moving upstream and infecting the operator.
- Simple flow testing will be needed to confirm that no air from the back flows past the barrier toward the operator.

Barrier Options With Front Lift Access (barrier shown as a red line)

Option 1



Option 2



Option 1 prevents obstruction of vision to the right front and allows wheelchair boarding.

- Should be installed immediately using plastic and adhesive.

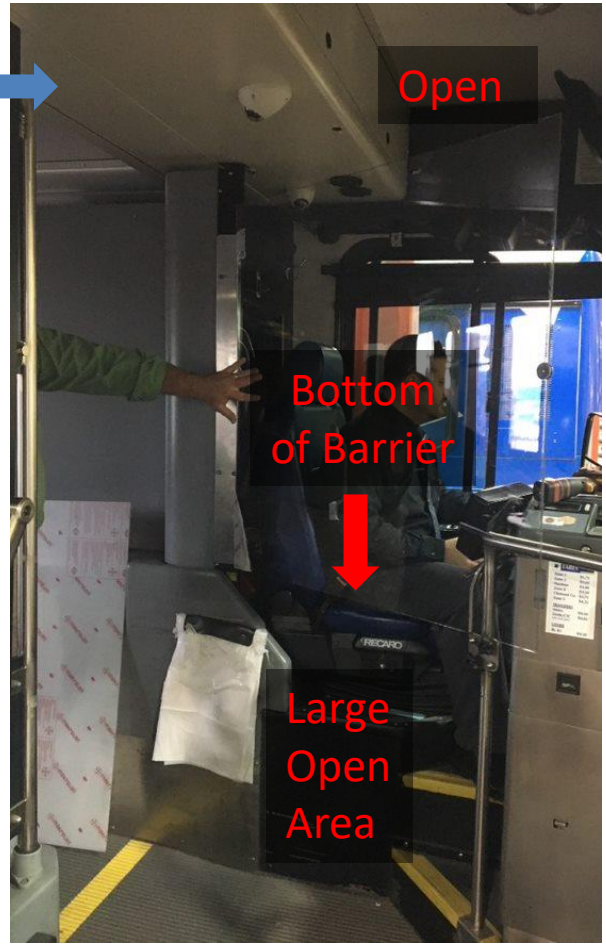
Option 2 obstructs vision to the right but still allows wheelchair boarding.

- This design can be implemented by blocking off open areas around security barriers.
- Please note that this design goes to the windshield many stop short

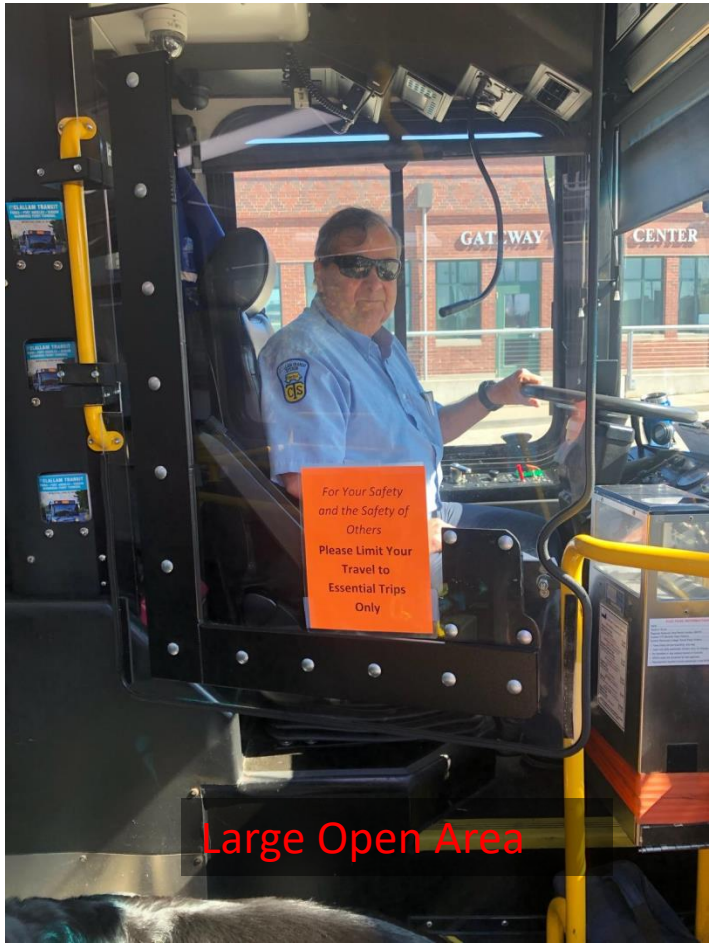
***Flow testing should be done both with the bus stationary and while driving at 30 mph or faster with recommended air control settings.**

Partial Barriers Create Risk

Barrier Closed



Barrier Open

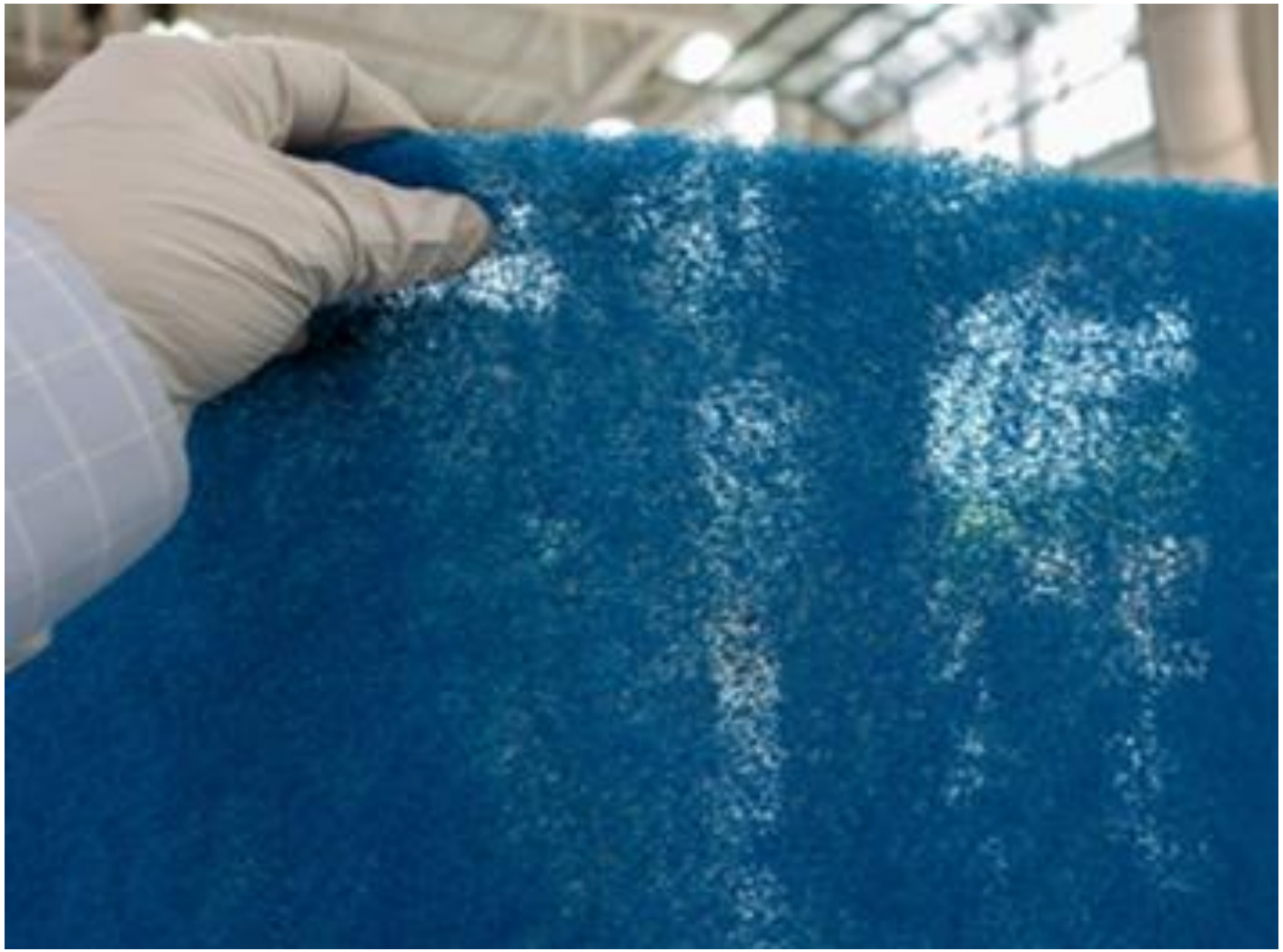


2nd Example

Partial barriers can cause circular air currents and reverse flows. Careful testing is needed to prevent this. These could have panels added at the bottom. That closure could also be a flexible, but durable, transparent sheet, should impediments like the small step next to the farebox (as in the middle photo) be in the way.

At left is a barrier prototype in development in Toronto. The panels are transparent with a protective white sheet that will be removed when construction is completed. Extraction fans for the back roof hatch, UV sterilization and high quality filtration will also be added.

Current Filters Ineffective



5. HVAC Filtration and Sterilization

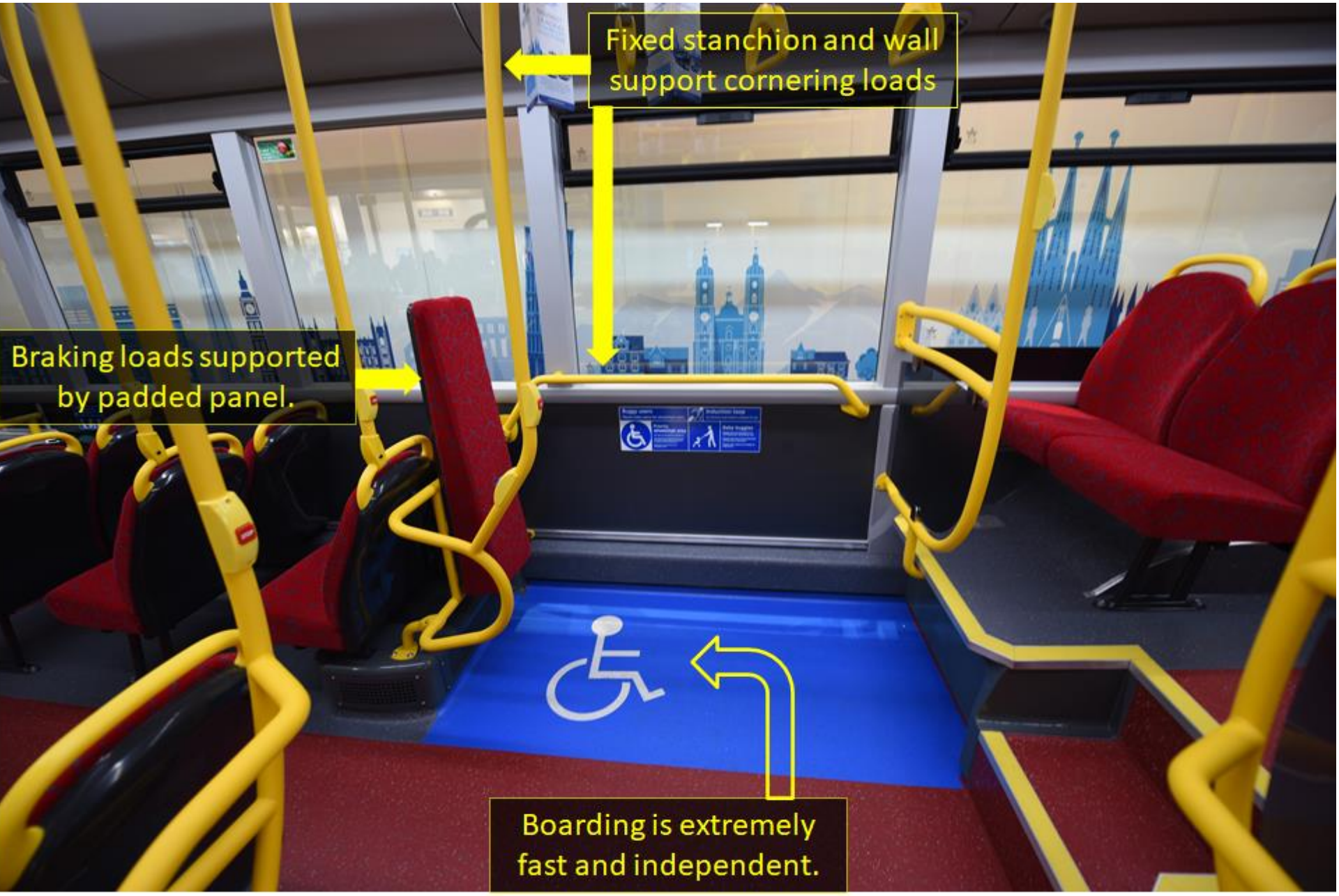
At left is a system for using ultraviolet light to destroy viral and bacterial hazards. It destroys the DNA, or in the case of SARS-CoV-2, the RNA necessary to replicate. UV is commonly used in home and business HVAC.

- UV is hazardous, so it is contained in the HVAC ductwork.
- UV should be paired with an electrostatic or equivalent filter to trap small viral particles.
- TCRP Idea Project 53 found that retrofitting of UV, plus an electrostatic filter, was over 99% effective (N95 is 95%) and paid for itself in reduced HVAC cleaning in only 18 months.

Images from DART Transit in Dallas

Wheelchair Securement

Rear Facing Wheelchair Securement – Independent, Safer and Quick

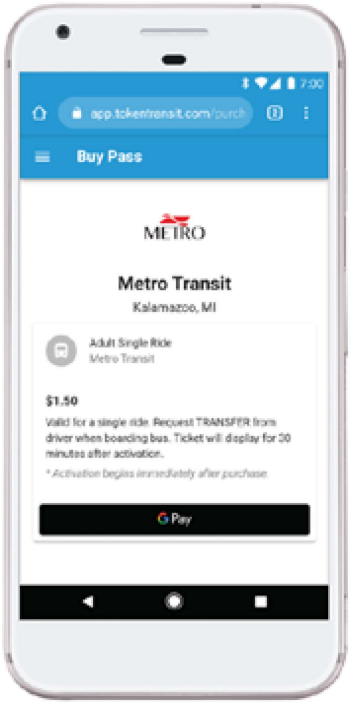


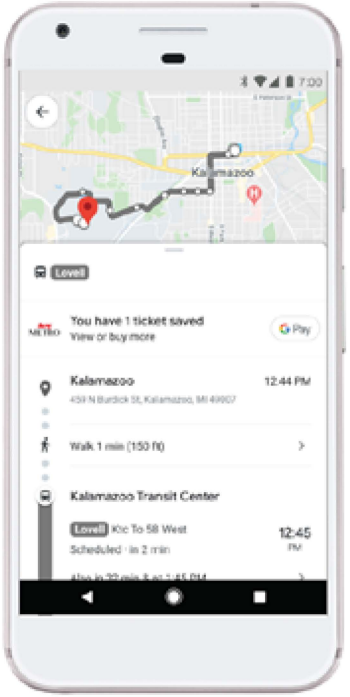
Self-serve fareboxes can offer extensive options without requiring the operator to be exposed to infection or assault

For Near Instant Electronic Fare Collection, Implementation a Cell Phone App Can Be Used.

One example is Token Transit

- In place in over 100 agencies
- No hardware installation required
- Optional bluetooth validator for collection of ridership data
  - Data is provided in any format desired by the transit agency
  - Installation and maintenance provided by vendor
- Integrated into Google Maps and several other travel apps for route planning and fare payment





The Air Flow Solution:
Every Passenger in Their Own Column of Filtered Air