TTC Bus Seating Plan

Date: December 27, 2020
To: TTC Board
From: Ryerson's Engineering Competition Winners **(Yajurva Trivedi, Kevin Dang, Ryan Pacheco, Wayne Sie)**
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Summary

This report provides details of a mock TTC bus seating plan which is a modified version of the original bus seating design that won first place for Ryerson's Engineering Competition. The original bus seating plan was approved by Ryerson's University judges: Hosam Sennah (member of the Ontario Ministry of Transportation), Shima Ghaffari (PhD Chemical Engineering Research Assistant at Ryerson), and Himanshu (Kris) Sharma (MASc Aerospace Engineering Student Research Assistant at Ryerson). This design plan is in alignment with combating and minimizing Covid-19 exposure that everyday TTC commuters currently face in the pandemic.

The design will implement a low-cost and efficient design which maximize social distancing between one passenger to another; protective Covid-19 barriers made out of plastic fibers; A.I assisted seat guiding light strips that help passengers find their seats; 360° standing pod with barriers and built-in protruding seats; hands-free feet lever mechanical seats; designated compartment priority seating where elderly, pregnant women, people with disabilities, and people with children are separated from the masses as they are more susceptible to Covid-19.

Initial Competition Design Summary

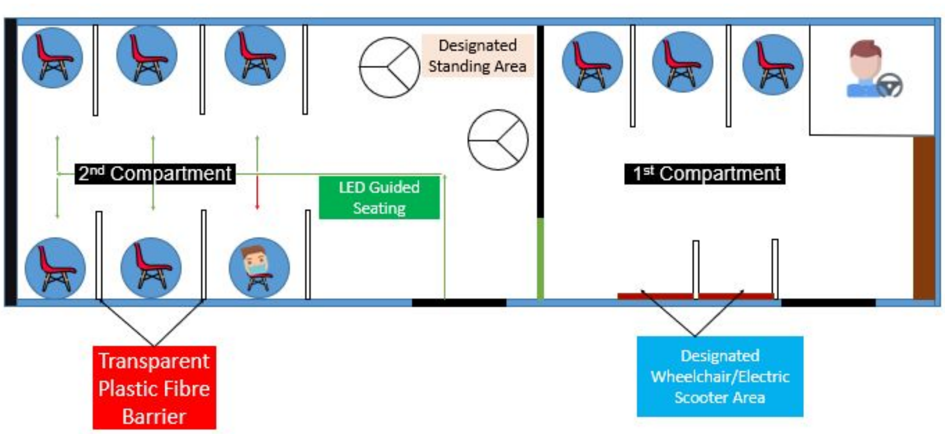

Figure 1 General Mock Bus Seating Design

- Separated seating compartments
- Two 360° Standing Tripods
- 2 Wheelchair Positions
- Seat guiding light strips
- 11 seats with/without hands-free retractable seats

It is known that Covid-19 has greatly affected the way people have taken local transportation along with how transportation services, like the TTC, have handled the situation thus far. And so, the Ryerson's Engineering Competition has designated a task for the competitors to innovate a reliable and cost-effective seating plan for today's pandemic. This general seating plan design was initially created for the Ryerson's Engineering Competition with only the resources (materials) and only 8 hours of designing time provided by the competition committee. The objective of the design in **(figure 1)** is a visual representation of what the team believes to be the best case scenario to minimize Covid-19 exposure.

One of the first features of the design is having 2 designated compartments for the passengers **(figure 1)**. The first compartment design is nothing new from the original TTC other than the fact that the first compartment will consist of priority seating strictly for passengers who identify as elderly, pregnant women, people with disabilities, and people with children. This concept was because studies have shown that older adults, disability groups, and even children are at a higher risk of being infected by Covid-19. The retractable seats in the wheelchair/electric scooter designated area will not be removed but will be implemented with a hands-free mechanical foot lever that helps the seats decline. The idea behind this design was to minimize the amount of surface contamination needed to retract the seats. Lastly, plastic barriers will be implemented to minimize face-to-face passenger contact as well as protect the overall safety of the commuters. These plastic barriers are currently practiced everywhere from local grocery stores to local shops.

The second compartment is separated for the general commuters with new features and changes of its own. For example, the new addition would be the 360° standing tripods and these tripods were designed to keep in mind that there will be passengers that may wish to stand or there are no seats available. The tripods, as seen in **figure 1**, will allow up to 3 passengers to stand or lean on a wall protruding seat (seen on TTC trains) that help minimize surface contact. Moreover, the tripods have plastic barriers that shield the 3 designated passengers from having a face-to-face contact. The seating plan in the posterior side of the bus was initially designed to increase social distancing as close as 6 metres apart from seats adjacent to one another. Additionally, the seats will face towards the front of the bus along with plastic shields installed for every seat. The last feature of the second compartment is including LED strips **(figure 1)** that provide guidance for current and new passengers entering the bus towards empty seats. To explain, there will be motion sensors by the seats that activate to notify passengers if the seats are occupied or not.

To conclude on the competition design explanation, the design team realized that this would reduce normal seating roughly by 50% for normal local buses. However, this general limited mock design was planned to ultimately decrease the risk of Covid-19 exposure whether its through airborne contact or surface contact. To increase seating or keep the same number of seats on the bus will only further allow Covid-19 to thrive in such a close space environment. The following pictures below were presented to the judges to help ultimately win Ryerson's Engineering Competition.

Initial TTC Bus Seating Design

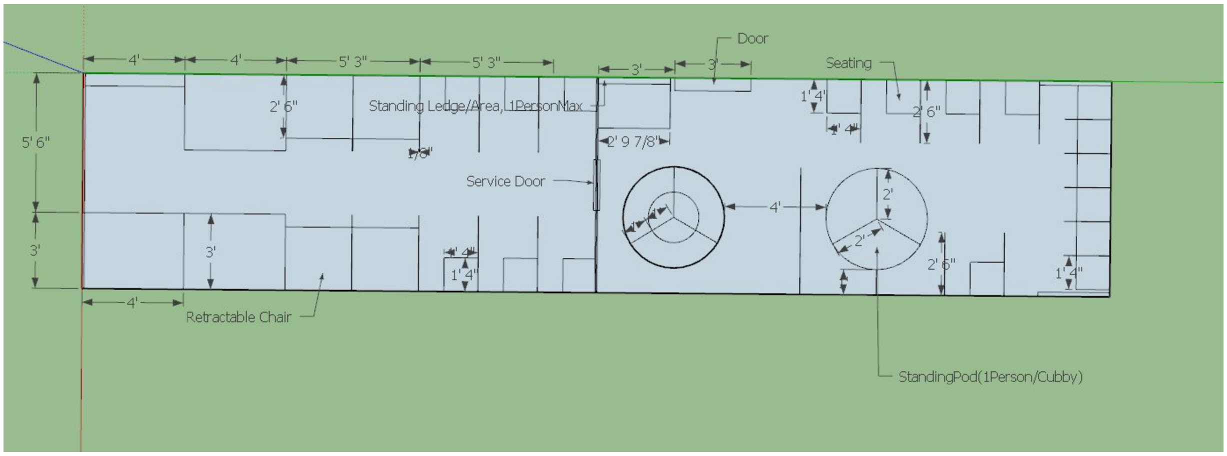

Figure 2 2D Initial Mock Bus Seating Design

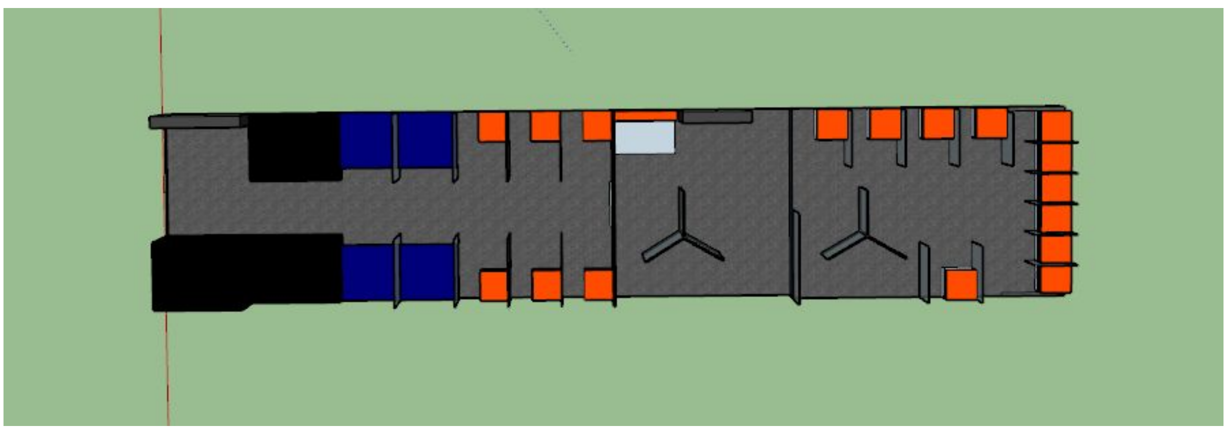

Figure 3 3D Initial Mock Bus Seating Design

The plan for the TTC is designed to incorporate the priority safety guidelines enforced by the Government of Ontario relating to Covid-19 Virus, and the transferability of it. The bus is designed to protect all passengers while maintaining its ability to provide services to all passengers including those with disabilities, pregnant women, and last but not least the elderly, this entire design builds on the 2 compartment design which TTC tries to implement with their current Orion 7 Bus.

Studies have shown that Covid-19 is an airborne disease and can be easily transmitted to a mass population through simple interactions as particles of the virus remain in the atmosphere for a selective period. For this reason, to limit the amount of people susceptible in contracting the virus, we designed the bus in a way where we cut in half as we dividing the bus in 2 compartments connected by a Plastic Fibre Infused Compound Barrier, and a locked door which only a TTC Driver has access. The first half of the compartment uses cutting edge technology, Hands-Free Mechanical Seats, which help the elderly, pregnant women, and people of disabilities, and all those who are primary targets of the virus. The bus is divided in 2 by a Protective Barrier composed of Plastic Fibre Transparent Barrier, which allows for no transmission of Covid-19 particles to go from one compartment to another unless the door is opened. Both compartments have vents separated for the sole purpose of ensuring that no particles are leaked.

The bus is designed to protect those who are more vulnerable to the virus, by separating them from the bulk or majority of passengers commuting using the TTC. Our first method of checking the problems associated with the current TTC bus, which is that we do not have a way to protect passengers from direct contact with people who are already infected with Covid-19. So, our team designed the bus with eyes on detecting the Virus on entry in the bus, along with reducing chances of contracting the virus while in the public bus operated by the TTC. With current restrictions on indoor and outdoor spaces, it's best if people maintain safe distance throughout their journey on the bus. Thus, we designed the bus in such a way that it ensured the safety of people by eliminating extra seats, and excess standing rooms, all this while maintaining a moderate amount of passengers in order to maintain revenue. The creation of said buffers will act as buffers posing as a way to protect passengers from suspected encounters.

Our design of the TTC Bus highlights the new feature we believe in being the most crucial component in our design: 360 Standing Pods. The 360 Pod doubles as a private cubby area for passengers who do not want to take a seat and/or if all seats are taken. All the pods come with built in sensors which detect whether a pod is occupied or not, along with motion sensors which allow for the use of built in ledge technology. Once a passenger enters the proximity of a motion sensor, it allows the ledge to be released from the back wall of the 360 Pod. The pod allows passengers to use the walls around them to maintain stability in the bus while in motion, eliminating the handles and curled up braces used in current busses across Toronto. These areas specifically call for immediate removal as people with unknown substances on their hands and fingertips have chances of transmitting the virus around. By using the pod, passengers can use the center of gravity from their mass, along with the fact they can lean on the walls and the motion-controlled ledge at the back of the wall for stability and a safer experience in the bus. The 360 Pod is providing standing room for 3 passengers all interchanged by 120° around the pod, this allows barriers to be placed in between people while standing/occupying the 1 section of 360 POD. The entire bus allows for 2 pods to be placed in the 2nd Compartment of the bus, all angled in different ways to allow minimized confrontation amongst passengers in the bus.

As a part of creating an overall pleasing experience for the users, we have designed a way to create a much smoother flow of passengers in and out of the TTC Bus. We designed the bus with integrated AI to assist passengers, in finding seats or designated seating to allow for a safer experience using the bus. Empty Seats will have led pathways leading up to them for the passenger to follow, and safely enter without entering another passenger 2 Feet Radius, cutting the transmission of Covid-19 significantly. Seats that are occupied by passengers will be seen through our Plastic Fibre Infused Compounded Barriers (PLEXI Glass).

Final TTC Bus Seating Design

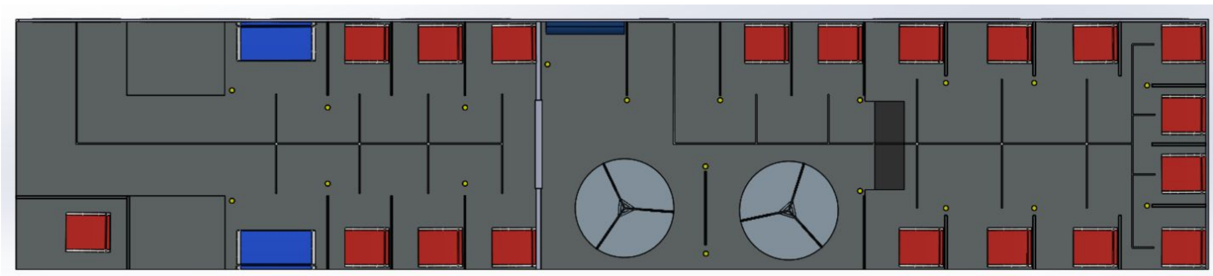

Figure 4 Final Overview Bus Seating Design

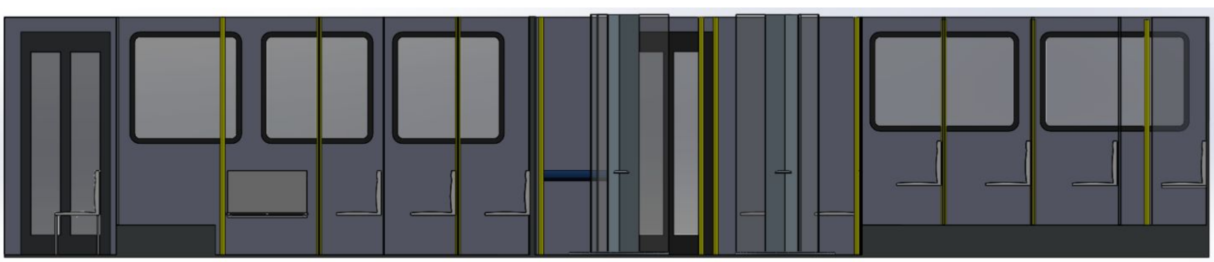

Figure 5 Final SideView Bus Seating Design

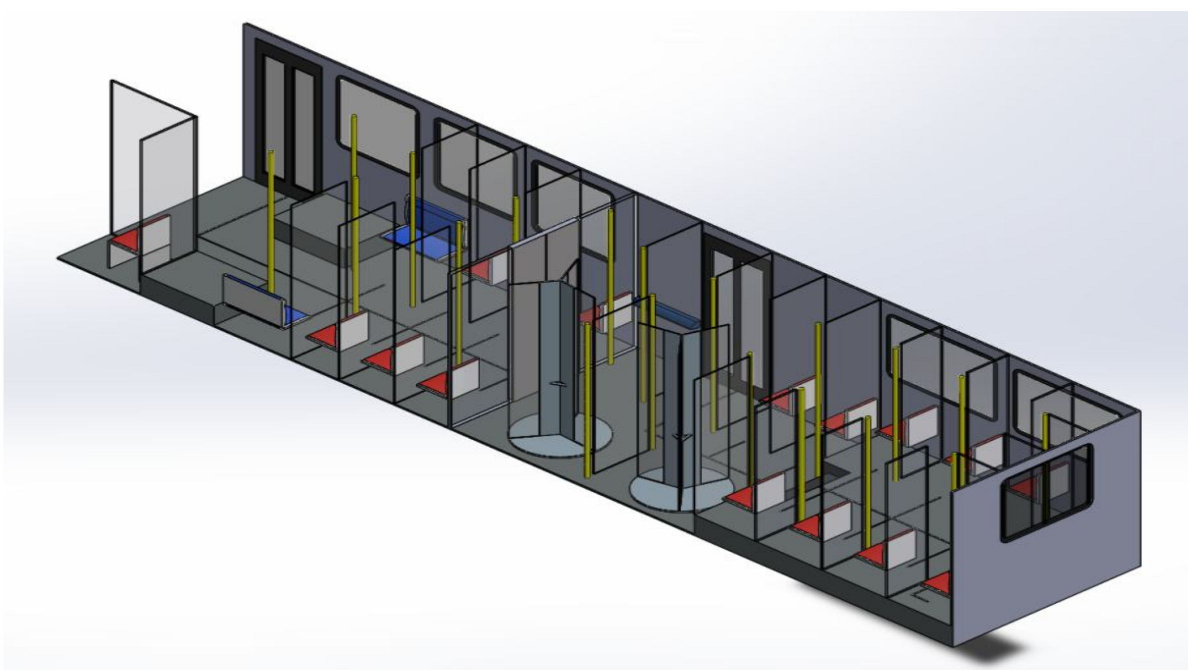

Figure 6 Final Angle View Bus Seating Design

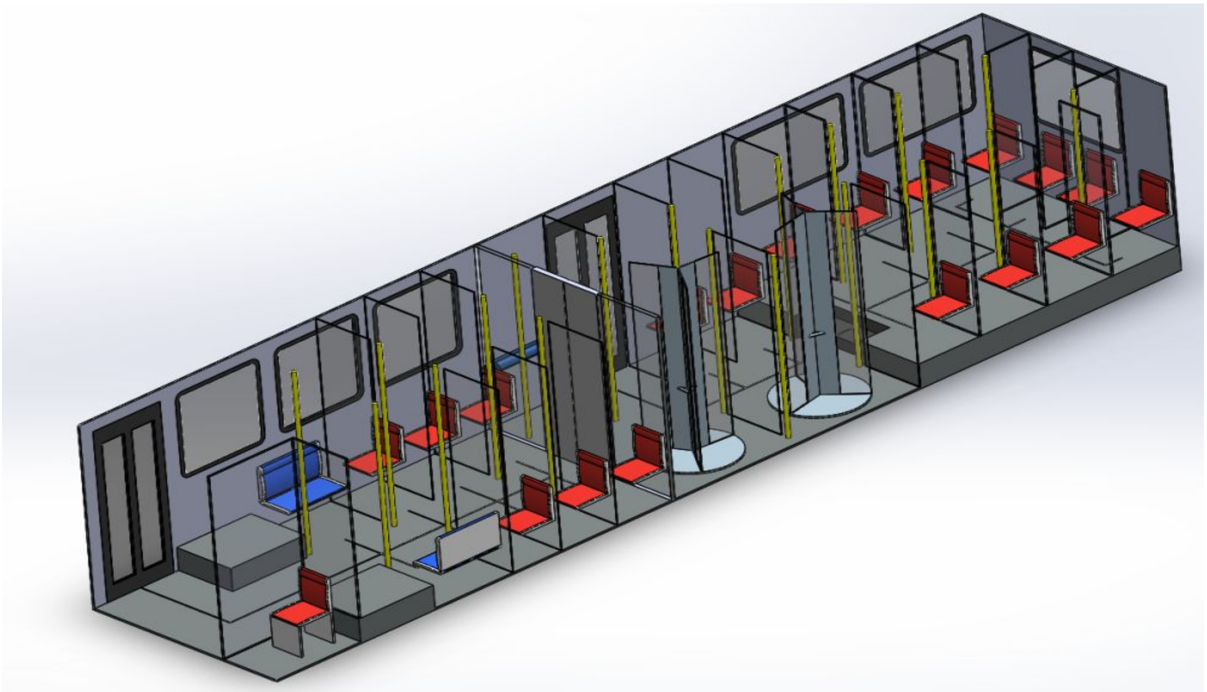

Figure 7 Final Angle View Bus Seating Design

In this final iteration of the bus seating design, it is mostly similar to the initial design except that there are a few changes to the design. The tripod that was originally placed on the upper deck was moved to the lower area with an additional barrier in between the two tripods. This decision was made to include more passenger seats on the upper deck and create an easier access point for passengers entering the bus that want to use the standing pods. Another feature that was included into the design for visual representation is the LED strips that help guide passengers towards an unoccupied seat. Lastly, the barrier situated in between the handicap seat in the first compartment was removed as it presented too much of an inconvenience for people with disabilities. And so, the decision was to leave those retractable handicap seats there to allow wheelchairs, electric scooters, elderly people, and pregnant women to occupy the space.

Financial Summary

Inner Bus Dimension
Based on the articulated bus and bus wheel dimensions listed in the official TTC website, the following measurements were estimated to approximate the cost of the new bus design layout.

1. Front Inner Height: 8 ft
2. Back Inner Elevated Height: 6 ft
3. Inner Width: 8ft 6 inches
4. Inner Length: 38 ft

Materials
The materials required to build the bus layout:

1. Plexiglass - Used for partitions for the standing pods and between seats.
2. Steel - Ledge, steel frame for standing pods, handles, dividing pole, nuts and bolts.
3. Wool - Cushioning for the ledges.
4. LED - Used for Seat Guidance

Material	**Total amount of material required**	**Cost**
Plexiglass	74520 per square inch	$0.028 per square inch
Steel	100kg	$1.36 per kg
Wool	5kg	$0.90 per kg
LED Strips	38 ft	$10.00 per 6.5ft

Cost Breakdown

Plexiglass	Quantity	Dimension (ft and inches)	Size (per square inch)	Function	Cost ($)
	1	8’ X 8’6”	9792	Middle partition	274.18
	1	8’ X 2’4”	2688	Standing area partition	75.26
	3	6’ X 2’	5184	Partition between seats (closer to rear door) in second half of bus	145.15
	4	6’ X 2’6”	8640	Partition between seats (farther from rear door) in second half of bus	241.92
	5	5’ X 1’10”	6600	Partition for seats for the back of the bus	184.48
	6	7’5 X 2’	12816	Partition for standing pods	358.85
	10	8’ X 2’6”	28800	Partitions between seats in first half of bus	806.40
Total Cost					2086.56

Steel	Quantity	Cost ($)
	100 kg	1.36 per kg
Total Cost		136.00

Wool	Quantity	Cost ($)
	5 kg	0.90 per kg
Total Cost		4.50

Motion Sensor LED Strips	Quantity	Cost ($)
	38 ft	10.00 per 6.5 ft
Total Cost		60.00

Total Cost for Materials per bus: **$2287.06**

Recommendations

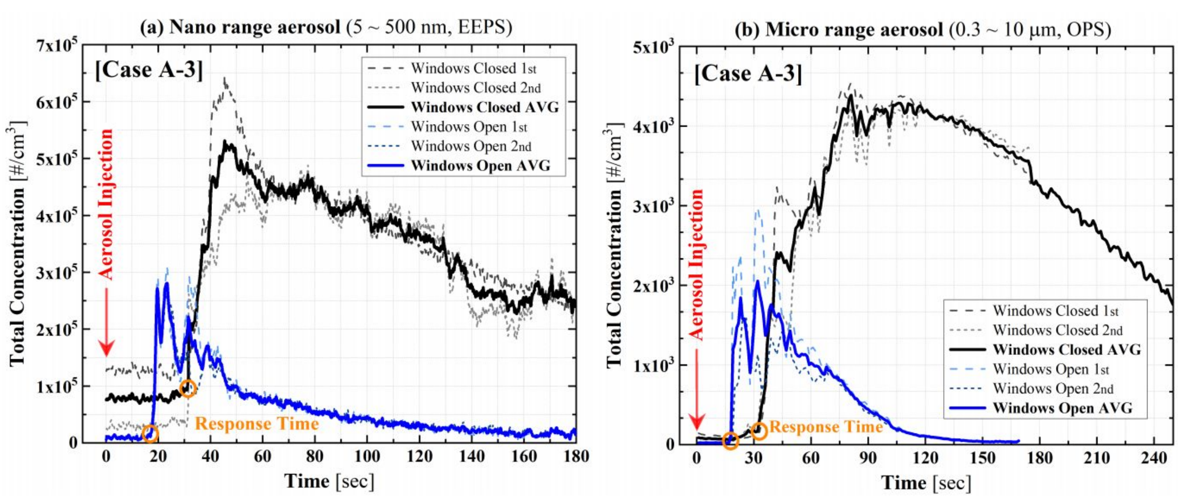

FIG. 5: Total concentrations with and without windows open: (a) nano-sized aerosols, (b) micro-sized aerosols. Case A-3.

The HVAC system of the bus plays a major role in reducing the chances of transmission. It is the primary aspect of the transport of any aero-solution (aerosol) within the bus. By enforcing an open window policy, fresh air can be added into the bus, thereby diluting the aerosol concentration in the bus. Passengers might be averse to this new restriction, especially during the winter due to the cold. However, the pros of greatly reducing chances of COVID-19 transmission far outweigh the cons. In addition, the plexiglass partitions compartmentalize the aerosol around each passenger, further eliminating the chances of disease transmission.