Transit Bus Structure and Operator Vision

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This NY MTA 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
bing
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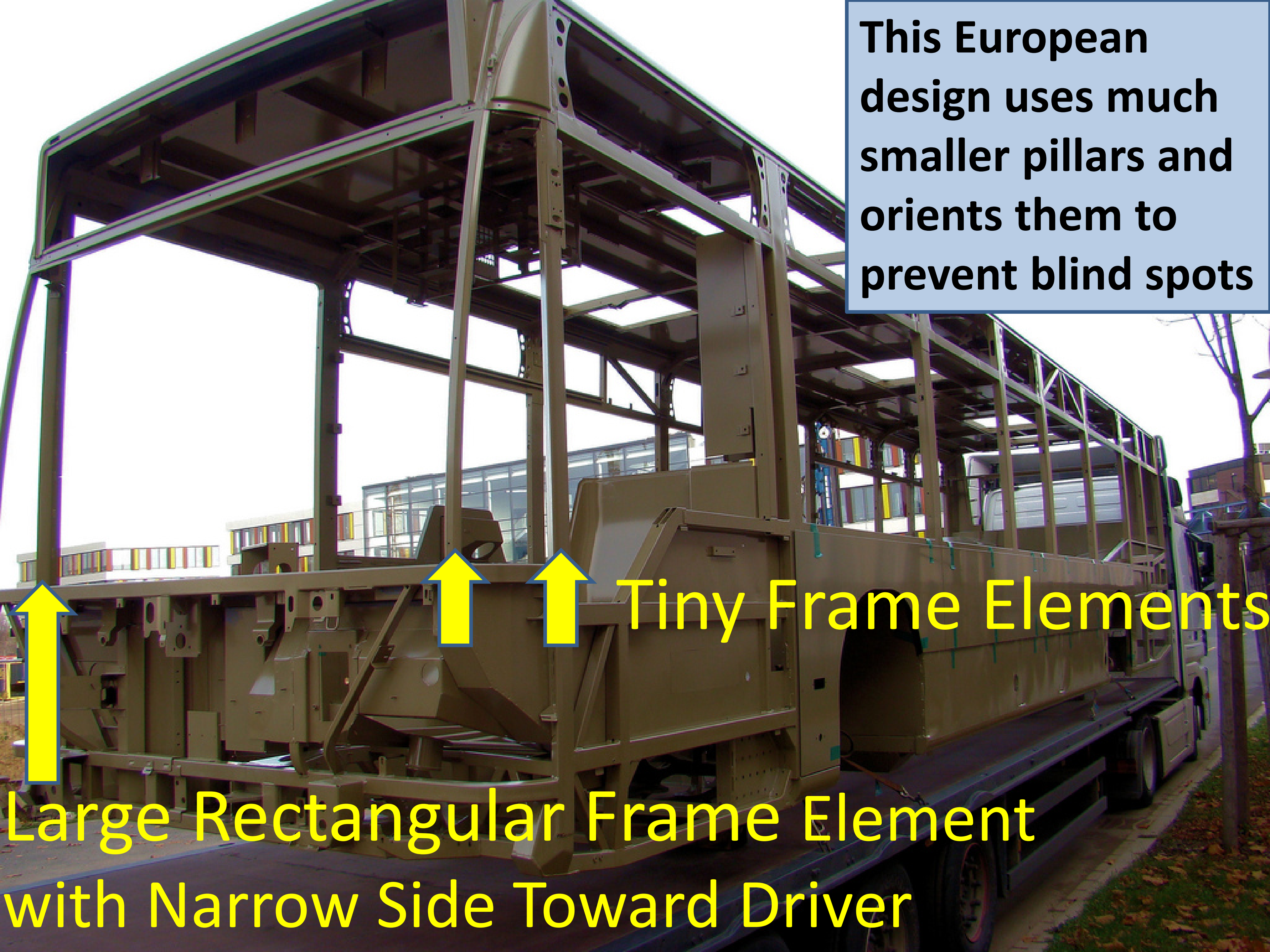
The Frame

and

Body Structure

The frame elements within typical pillars are quite small by comparison.


This European design uses much smaller pillars and orients them to prevent blind spots
Tiny Frame Elements
Large Rectangular Frame Element with Narrow Side Toward Driver

Orion Blind Spot 12” to 14”

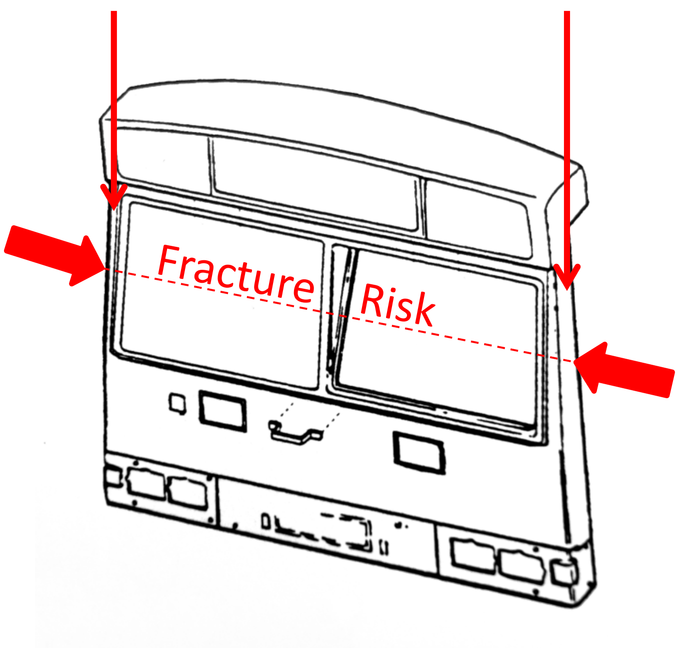
Frame 1.5” x 2” – Shown to scale in blue

A tiny portion of one percent of total construction costs are saved by making wide pillars.

Gillig Phantom
"Front Clip"

"A" Pillar

"A" Pillar

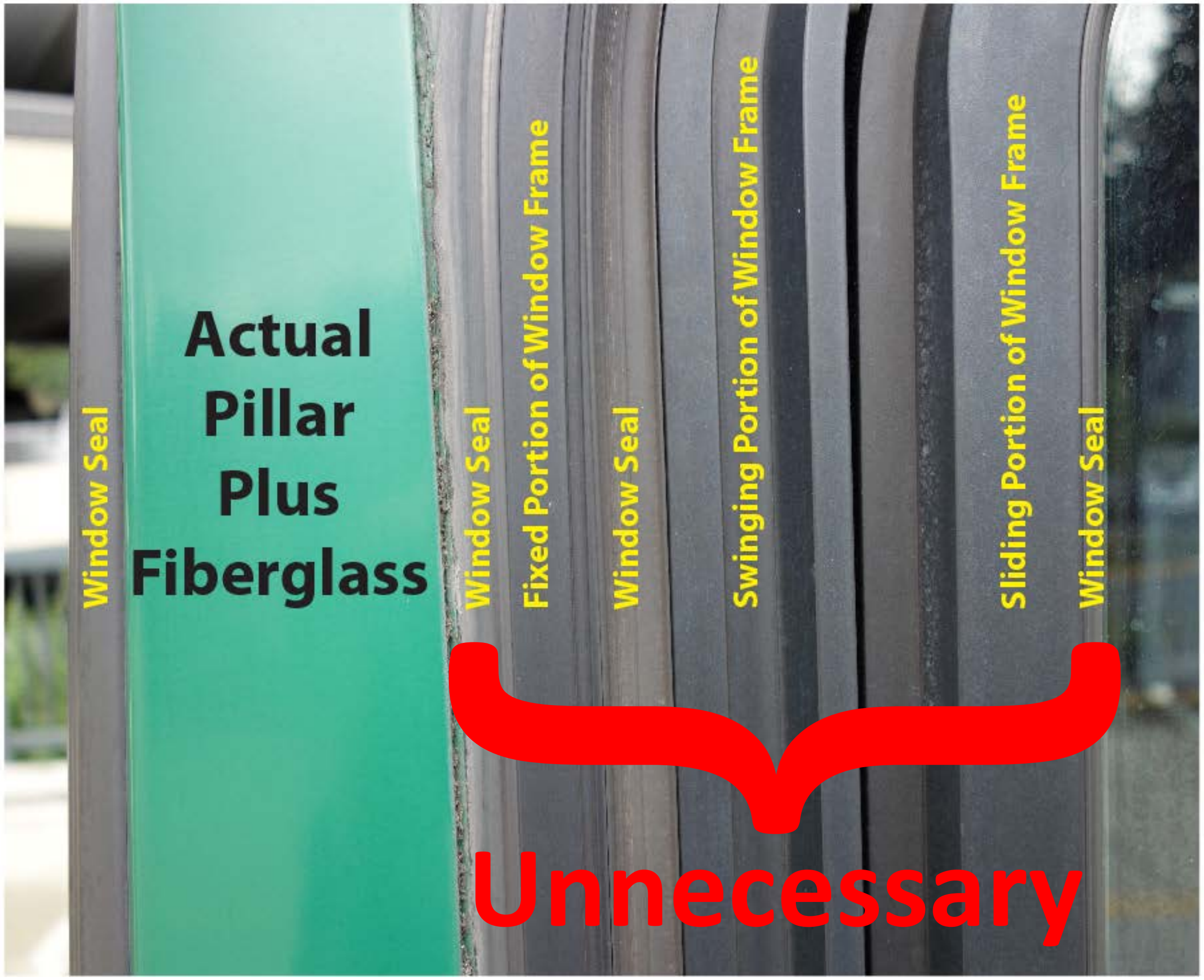


At left is an engineering drawing showing the fiberglass sheet forming the front of a typical bus. Because of the large windshield openings, the part can easily fracture. Making large pillars on the left and right prevents this prior to attachment to the frame, at which point the steel supports the fiberglass. Omitting the windshield openings until assembly and then routing them out, eliminates the need for the huge fiberglass elements of the pillar but adds a very small amount to the build costs.

Window Seal Choice Plays a Part

The design at left utilizes the method just described, routing out the excess fiberglass. A narrower and safer pillar results. However, the choice of a “rope seal” as seen at left, clearly makes this pillar much wider than necessary. It is designed for 10 minute windshield replacement, not safety. None of us would purchase a car using this ancient type of seal. Modern vehicles use bonded windshields for vision, passenger safety and rigidity. That bond can be placed behind the structural element of the pillar, contributing nothing to the blind spot. It takes longer to replace a windshield but the safer design saves lives.

Similar Hazards are Common on the Left Side



Side windows can omit the aluminum frame as on modern cars, trucks and the bus below, on the right.

Eye position is a very important issue. At left, the seat is fully forward and on the right, it is fully back and reclined. For the shorter operator, as at left, the blind spot is much wider and it blocks the path of travel in a “square” turn.

Blind Angle = Path Ahead

Blind Angle

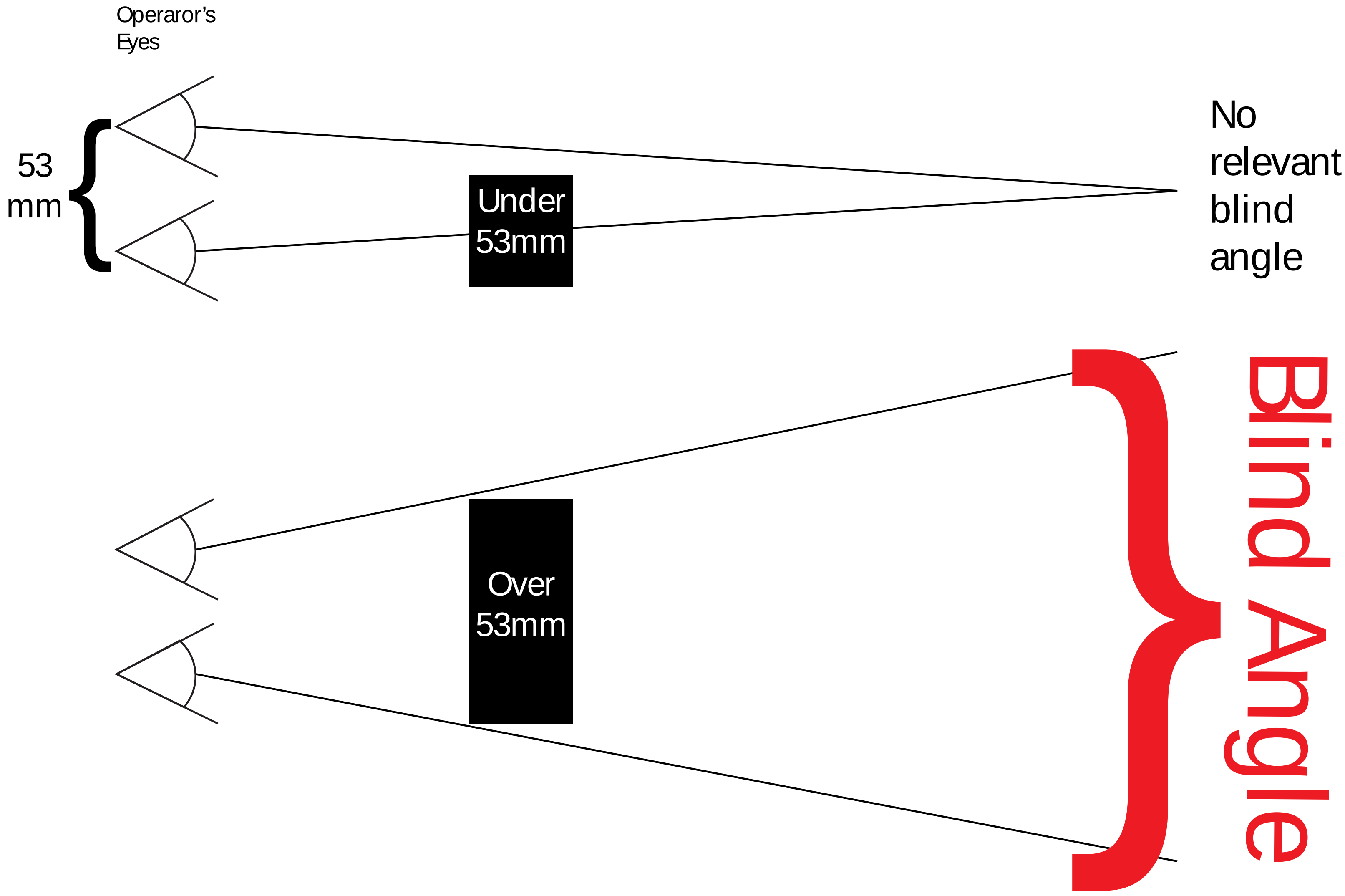
Path Ahead

The angle of the front tire is precisely the blind angle.

This very tall operator is just barely visible from the angle of a pedestrian at risk.

What is the Optimal Pillar Size?

With the 5th percentile female interpupillary distance being 53mm, obstructions under that size allow one eye or the other to see any angle in question



How are drivers taught to overcome the hazard?

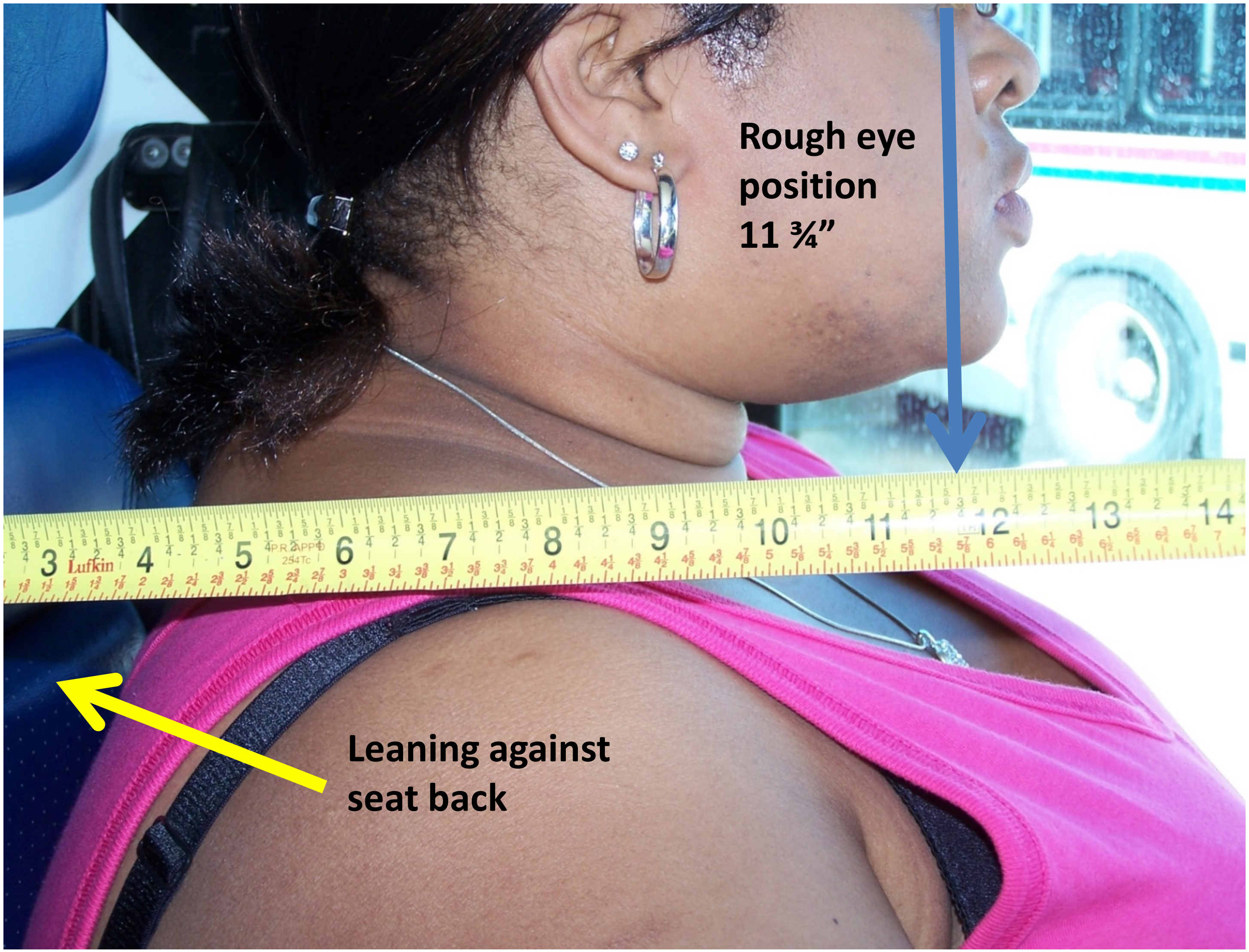
Operators are taught to take left turns at walking speed or 3-5 mph. Below, video of a “square turn” taken as instructed:

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; <u>this is with a low mirror - most blind spots are twice this wide</u>

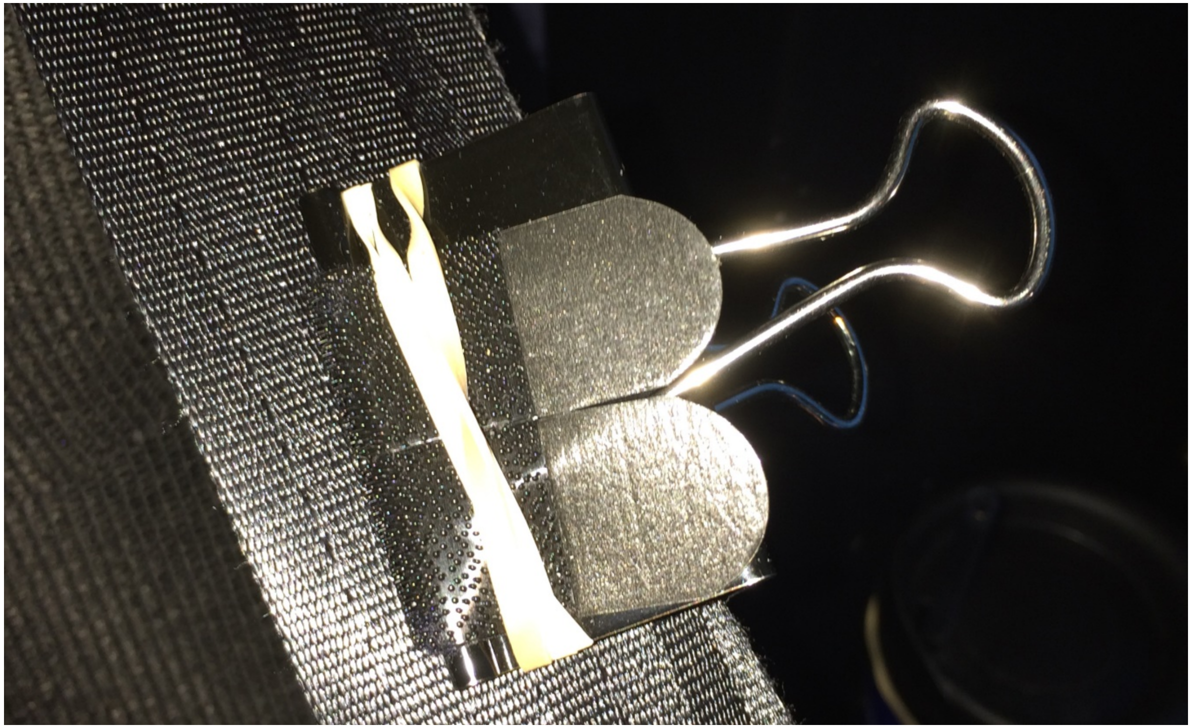
Operators are Expected to Overcome the Hazard Is that Possible?



For This Operator, Leaning Far Enough to Impede Steering Moves the Eyes Only Half the Width of Some Obstructions

19.5” – 11.75” = **7.75”**

Seatbelt Inertia Locks



Decelerating toward a turn , going up or down a grade, leaning or turning can all cause seatbelts to lock, unpredictably, putting pedestrians at risk. Both agencies and drivers are resorting to an assortment of methods to defeat the belts.

Leaning Forward Doesn't Solve the Problem; How about Leaning Right?

Leaning right while turning left risks falling out of the seat despite the seatbelt being worn. (Please see shoulder and lap belts at red arrows.)

How About Other Leaning other directions?

Lean left while a pedestrian moves right and the hazard remains. Leaning does not eliminate or overcome the blind spot – it just moves it.

A potential solution? – the high mount mirror

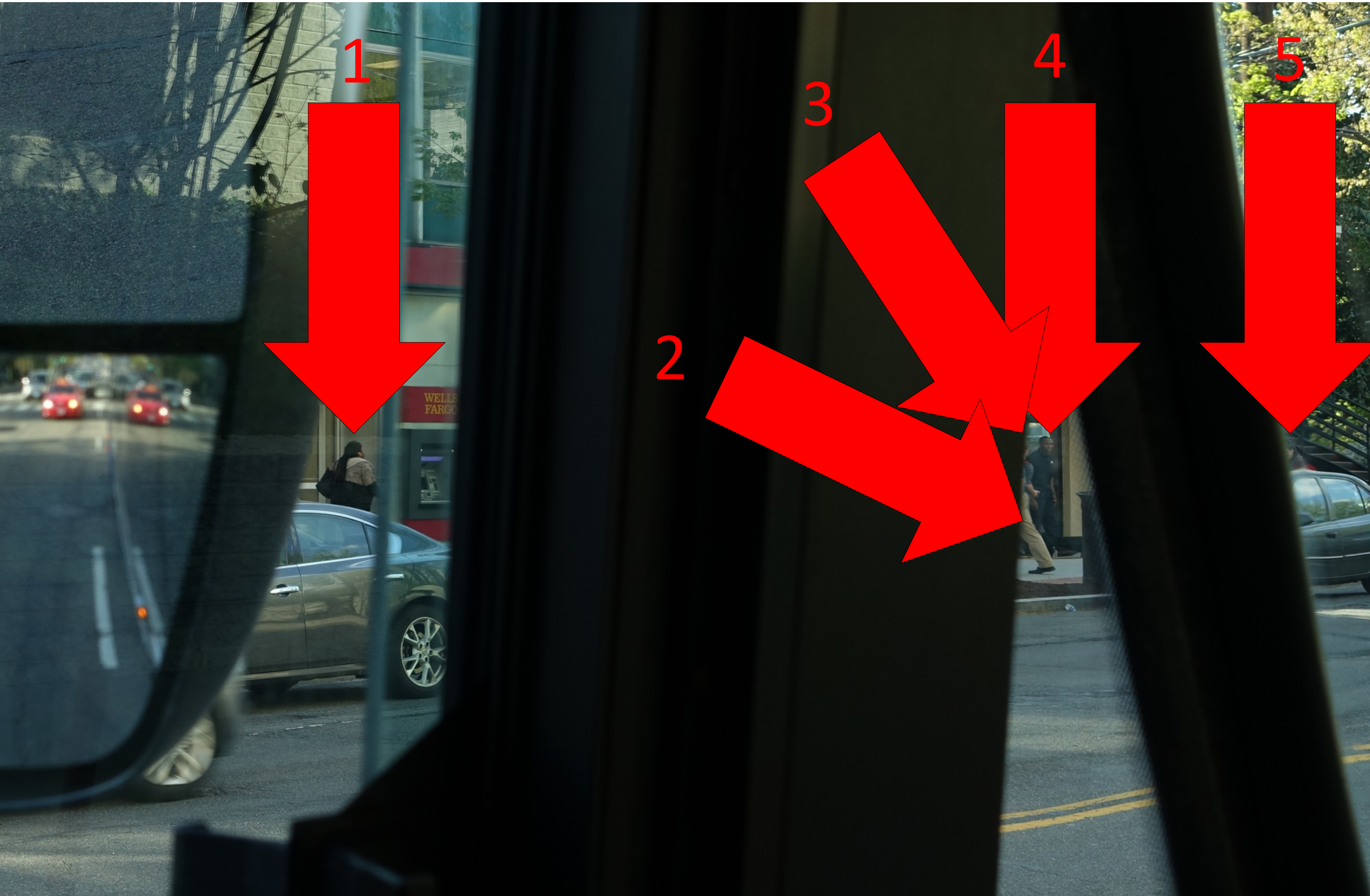
A view from outside the bus and the blind angle

Note: the blind angle is the path in a turn

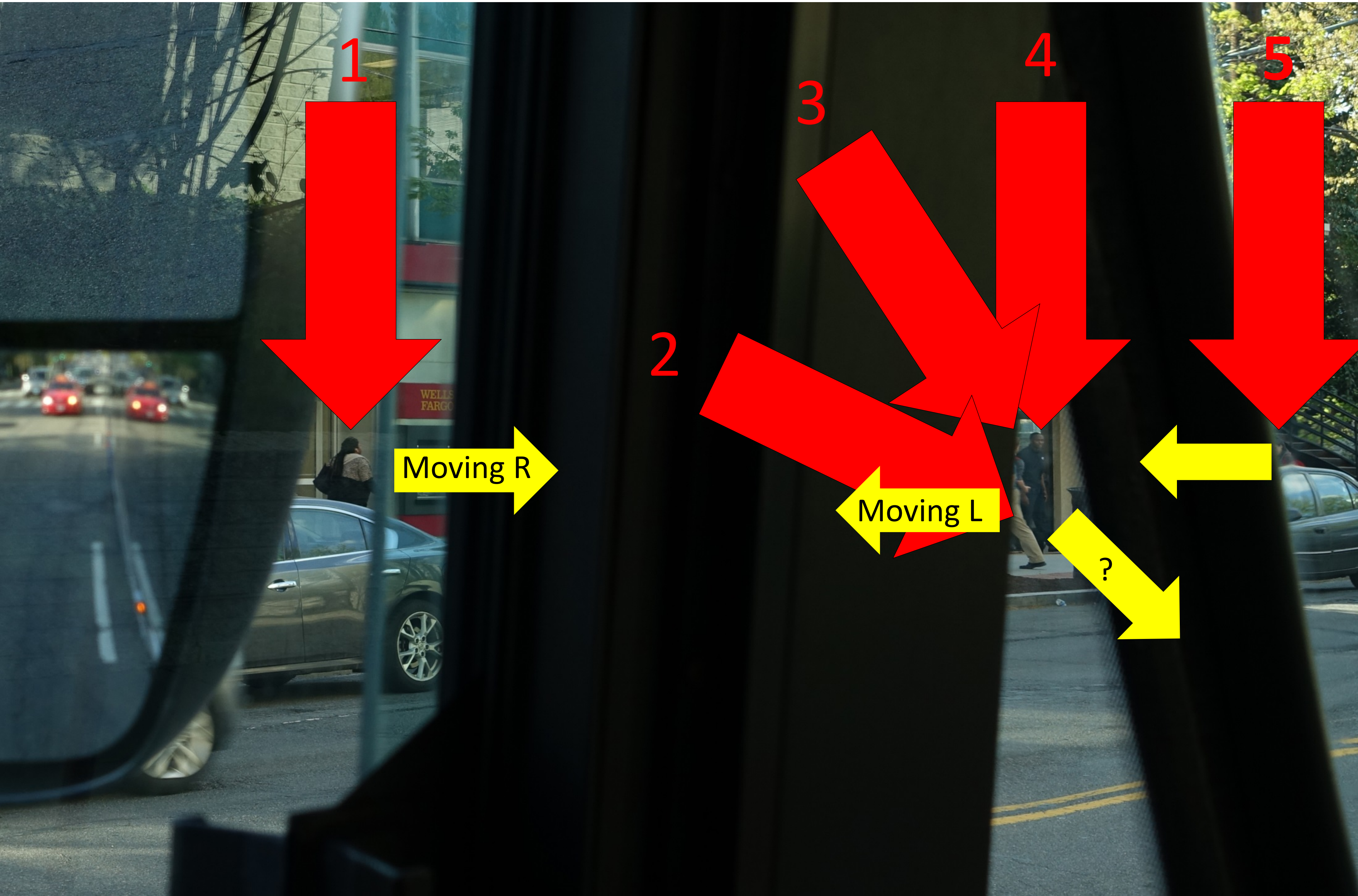
Can you spot any pedestrians?

Did you see 5?

Note: this is the path in a turn.



Operators are told to lean to overcome this problem. What direction do you lean? Any choice will track one or more of these. How many more are hidden?



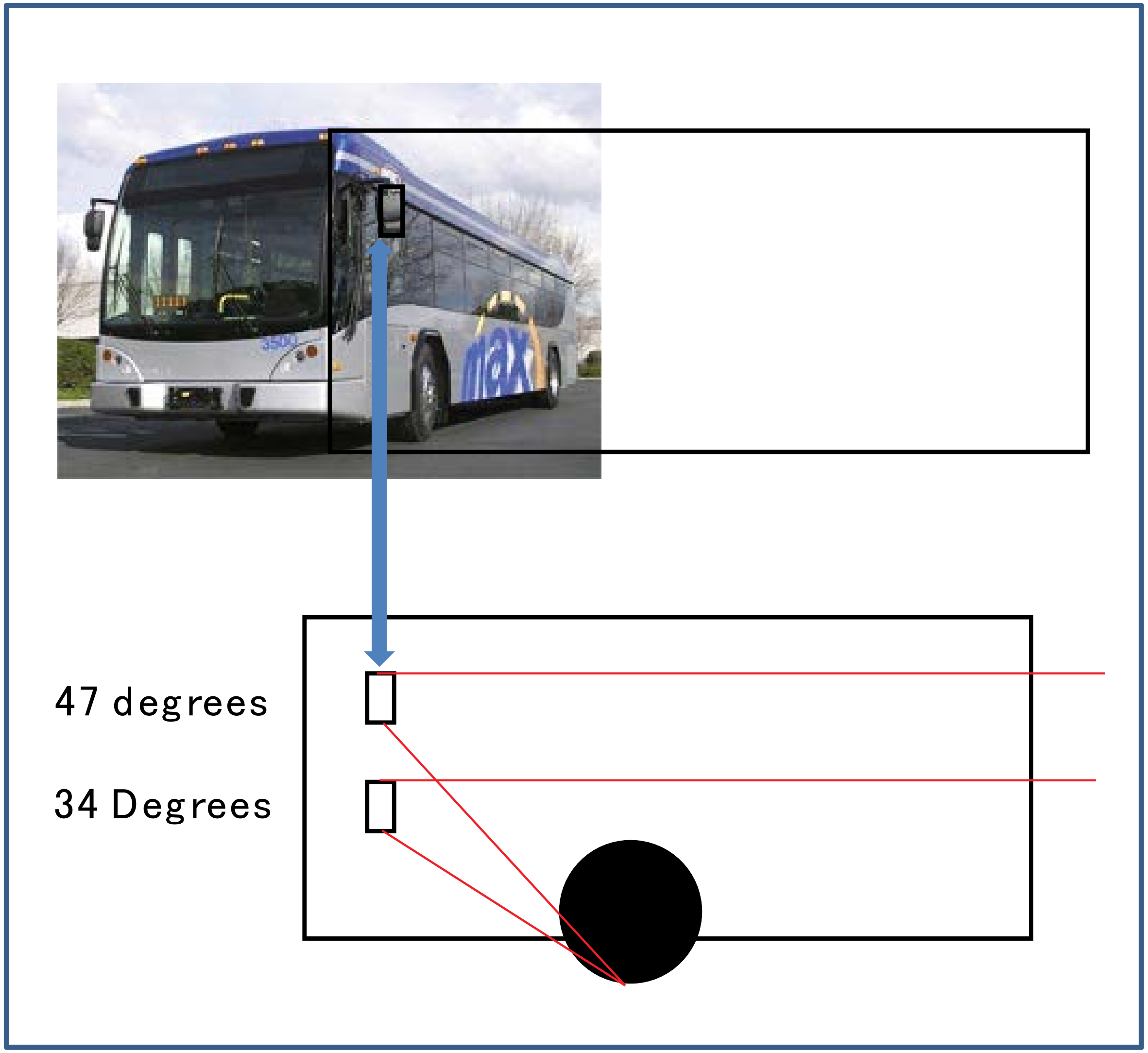
These magnified sections of the previous photos confirm the presence of the barely-visible pedestrians numbered 2 through 5

The Rule of Seven Plus or Minus Two

The "rule of 7 plus or minus two" states our ability to track multiple items. We are able to keep track of 5 to nine blips on a radar screen, for example. The same is true for pedestrians. Both videos show more pedestrians than we can reliably track, if following nothing else. However, as tasks become more complex, the number falls rapidly. Add a couple pedestrians to all the traffic, to the stop request, etc. and something *will* be missed. Add a question or other slightly more complex issue and tracking ability can collapse.

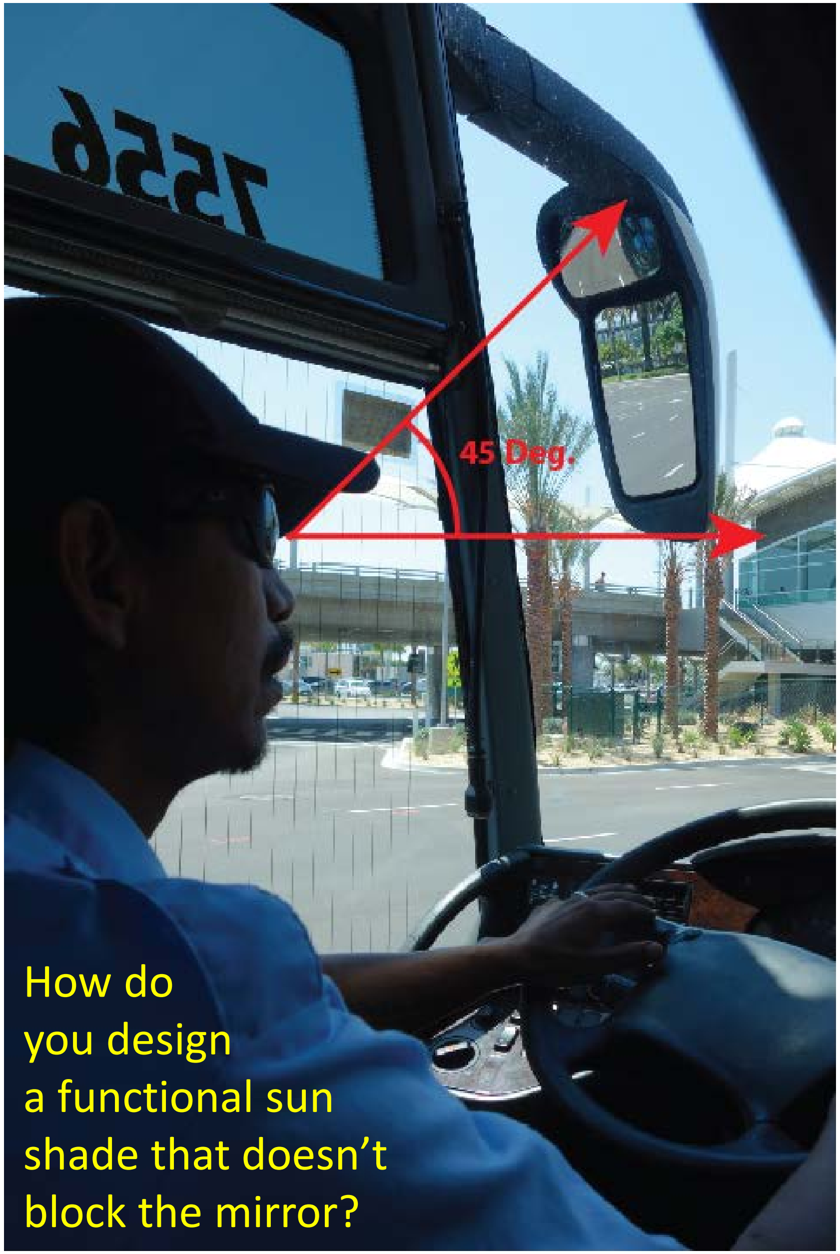
Options for Mirrors

Double the Height – Double the Size



High-mounted mirrors are a tempting option. They need to be quite a bit larger than a low-mounted mirror to provide the needed field of view. The proposed minimum necessary view is from the horizon to the front wheel contact point.

For the flat mirror element, twice the elevation requires twice the mirror vertical length.



At left is a relatively well-designed high-mounted mirror. It is out of the sight lines to pedestrians and shows the large scale needed for high mounting. For even this relatively tall operator, it requires looking well above the horizontal, an ergonomic risk factor. This is especially true if it is to be checked every 7 seconds throughout a shift that commonly extends well beyond 8 hours and can be as long as 16. An example for only 9 hours:

9 hour shift = 540 minutes

Subtracting one hour of hypothetical break time yields 480 minutes or 28,800 seconds. With a left and right high-mounted mirrors, the required total is 8,228 upward movements of the neck!

Current WMATA mirrors are both high and low mount. Both needlessly block the operator’s view of pedestrians

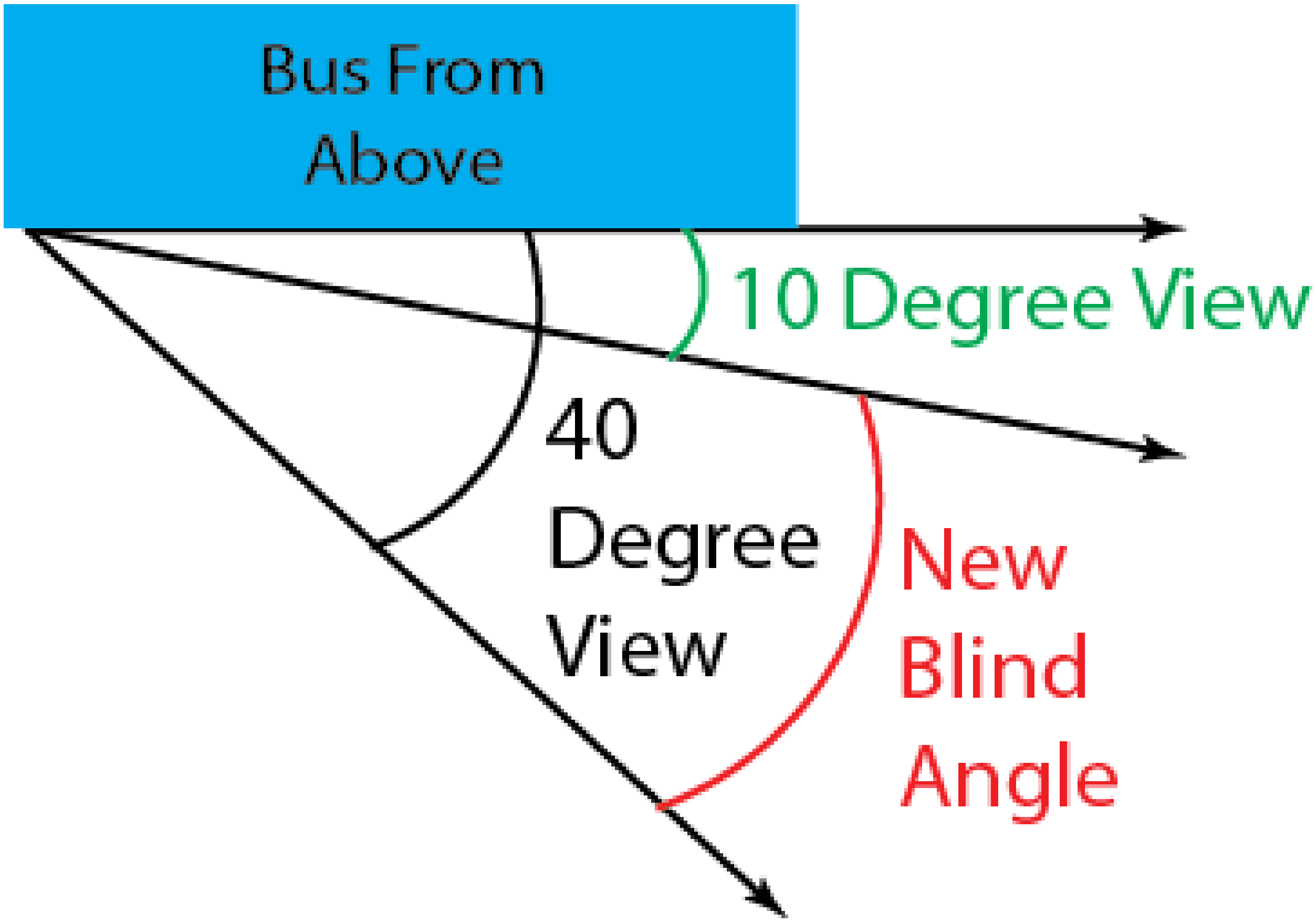
High Mount Too Low

Low Mount Too High

Another Potential Solution – Cut the Mirror in Half?

Above is the New York MTA solution; change the size of the mirror through elimination of the convex element. At right, the problem is clear. The very large SUV is not visible with just the flat element.

A standard convex mirror provides roughly 40 degrees of view and an 8” flat gives 10 degrees. Both are critical for slow moving buses constantly merging with higher speed traffic.



Operators Required to Lean – Does That Work?

Leaning returns only half of the 40 degree view provided by the missing convex mirror. Most agencies require checking every 7 seconds.

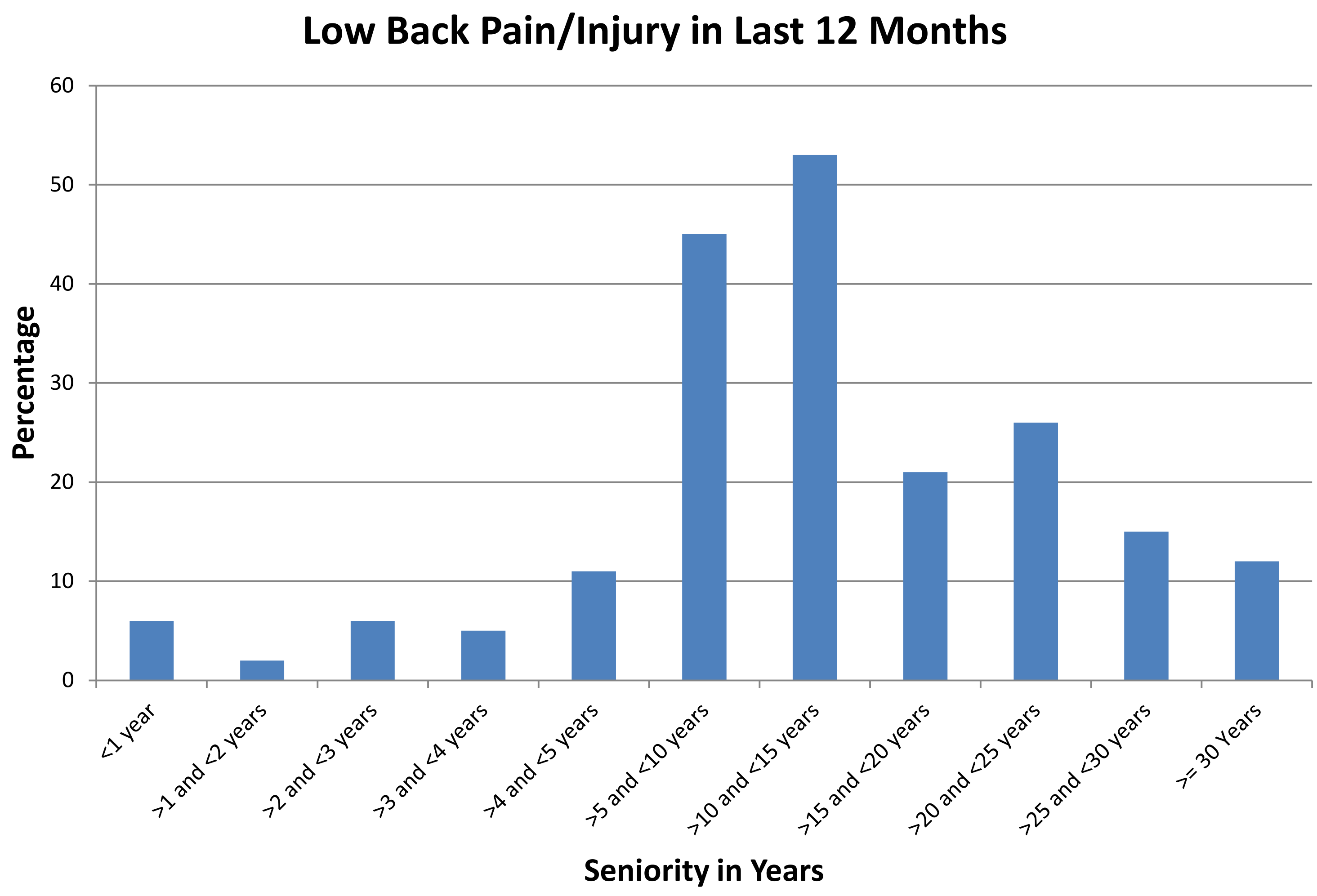
Leaning creates a huge blind spot. Operators are required to do this twice in each left turn – to overcome the blind spot!

Leaning Forward

Sitting Normally

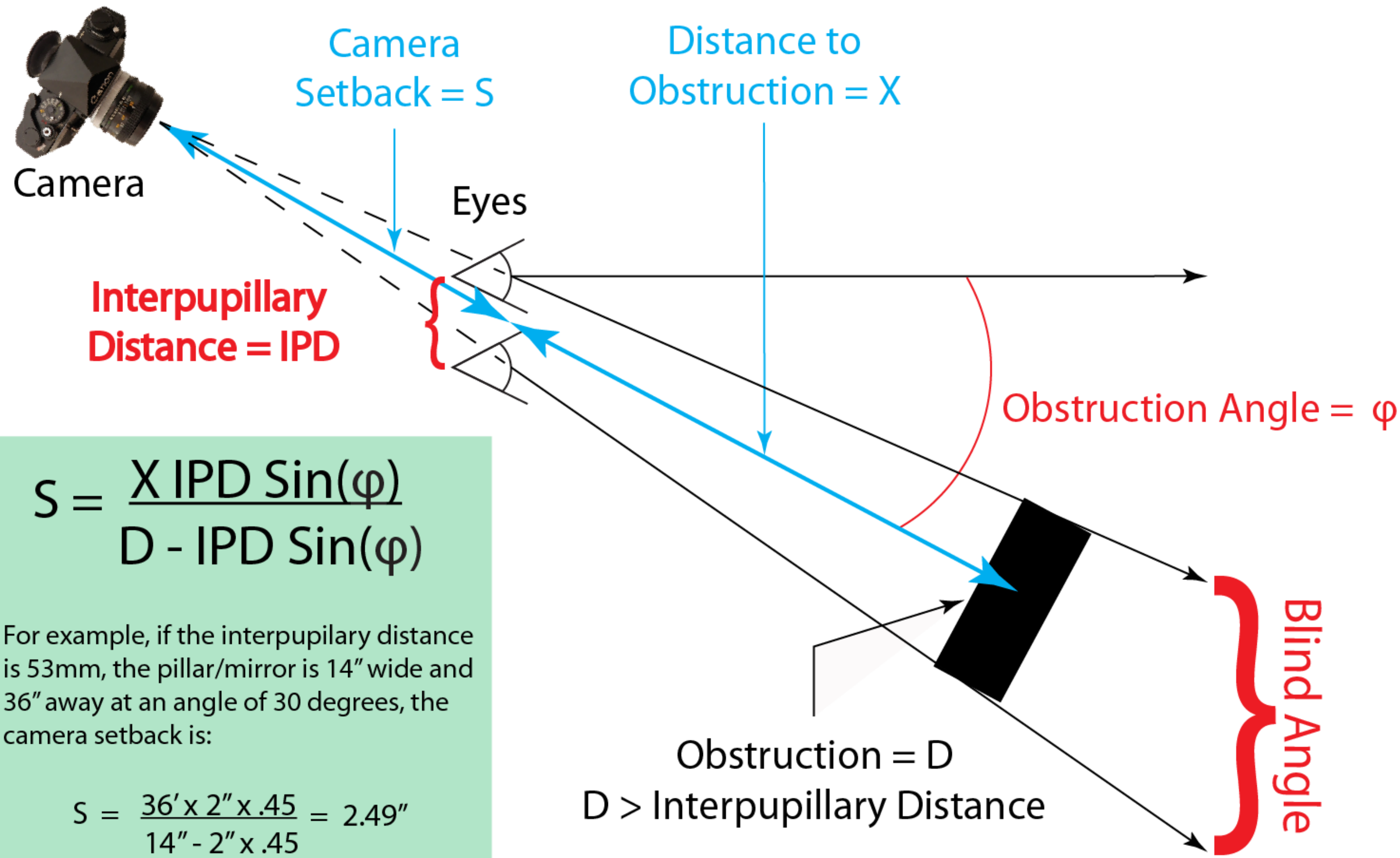
A NIOSH Symptom Survey at King County Metro Quantifies a Huge Problem.

Leaning multiple times every minute is an extreme risk for the low back.



Binocular Vision Correction

Using a camera to record visually obstructed angles may require a small correction based on face orientation, distance to the obstruction and interpupillary distance. Adjusting the camera location can provide that correction.



$$S = \frac{X\ IPD\ \mathrm{Sin}(\varphi)}{D - IPD\ \mathrm{Sin}(\varphi)}$$

For example, if the interpupilary distance is 53mm, the pillar/mirror is 14″ wide and 36″ away at an angle of 30 degrees, the camera setback is:

$$S = \frac{36' \text{ x } 2'' \text{ x } .45}{14'' - 2'' \text{ x } .45} = 2.49''$$

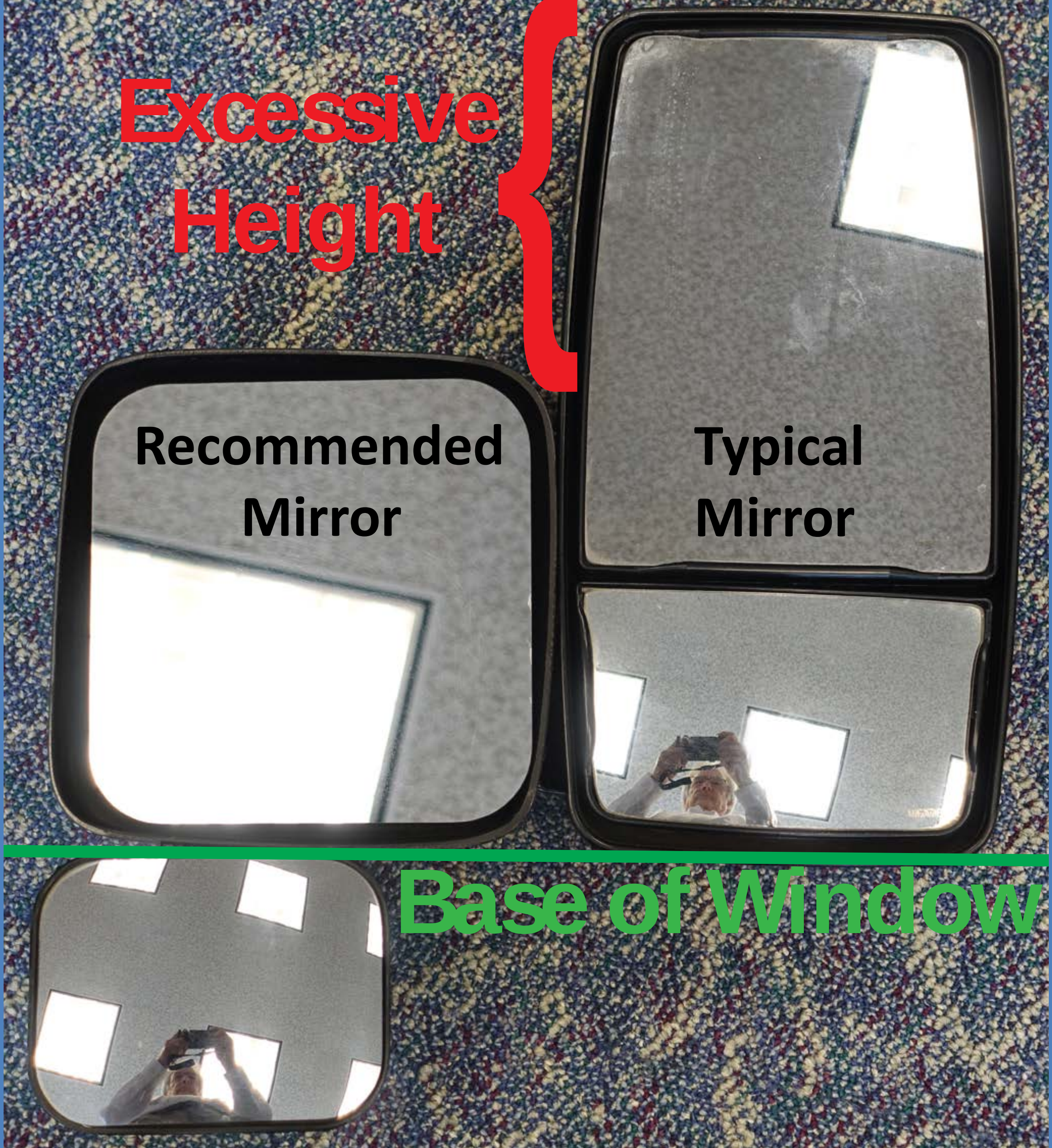
Suggested Mirror Set

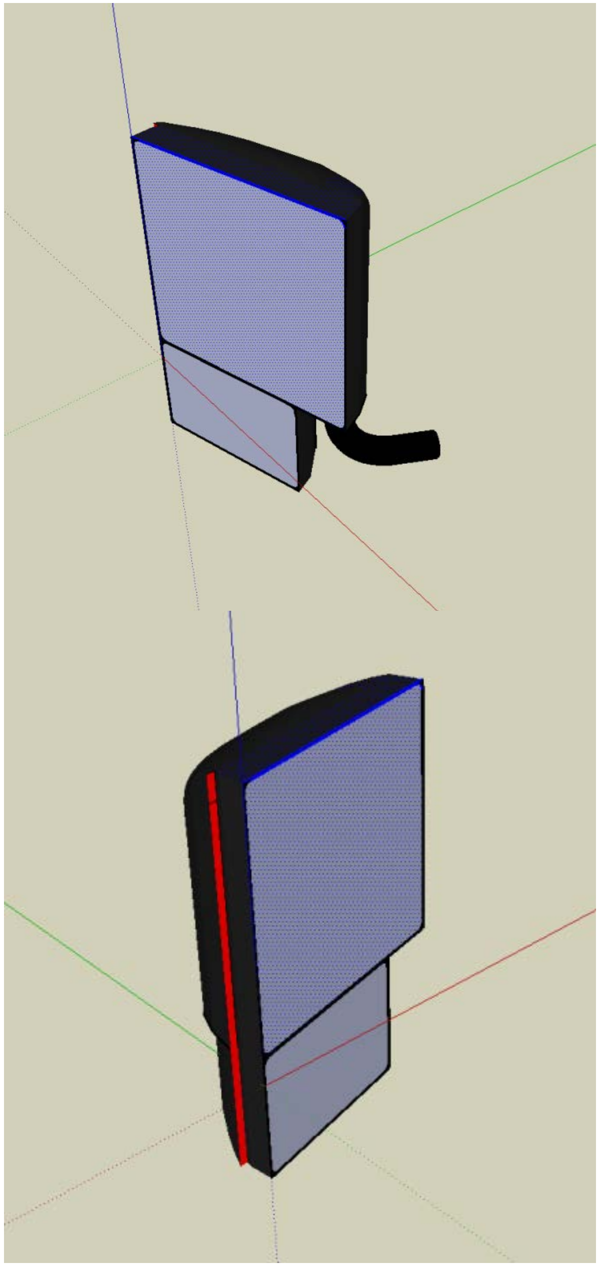
Low mounting prevents blocking the view of pedestrians (typically at the top of this photo).

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.

Mounting below the window opening is critical to not blocking the view of pedestrians.

Note: Behind the mirror, an airfoil, developed in conjunction with ATU 587 and Professor Robert Breidenthal of the U of W, prevents road debris coating the mirror. It is behind the left-front pillar and does not block vision.


Excessive
Height
Recommended
Mirror
Typical
Mirror
Base of Window



Recommended Left Mirror

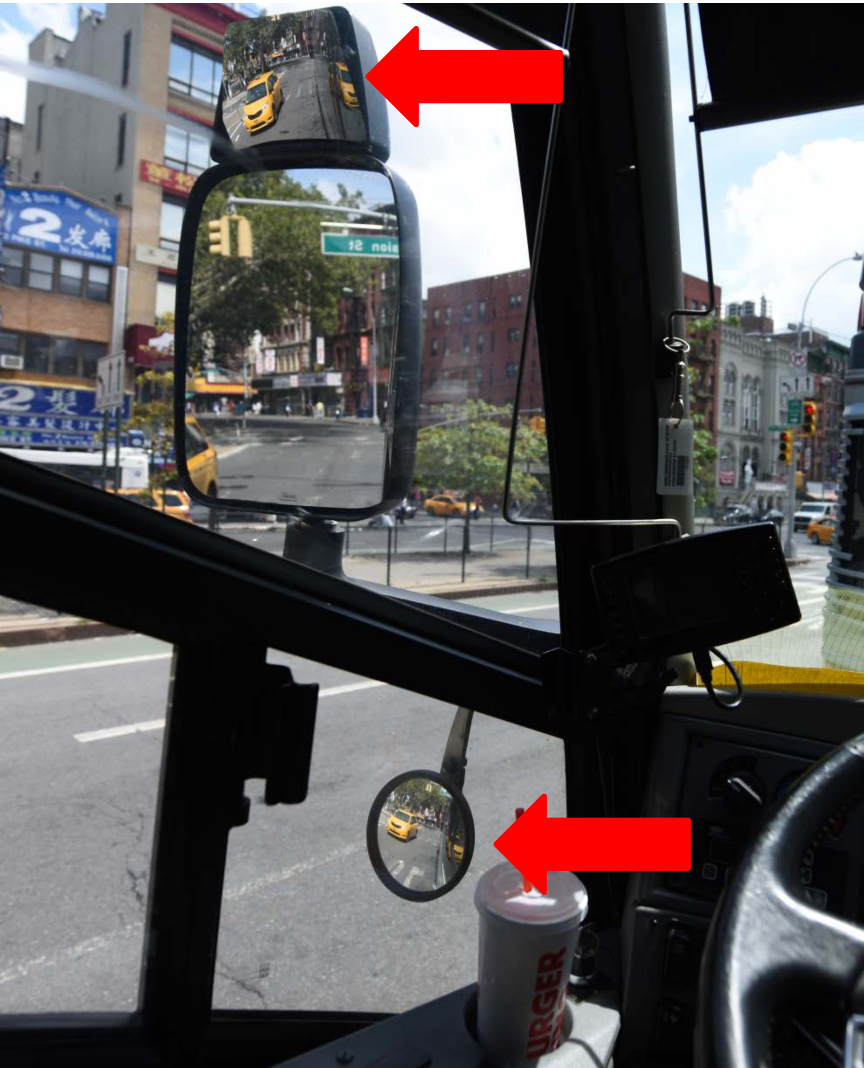
The prototype design at left incorporates the offset lower mirror, allowing mounting below the window opening. The offset is utilized as the arm attachment point, allowing a short, and thereby strong support arm. The upper and lower mirrors are as close as possible, to minimize overall height. Last, there is an LED strip on the outside edge serving as an additional turn signal. It is not visible to the operator, as seen in the perspective at top.

Over the Road and Express Coaches

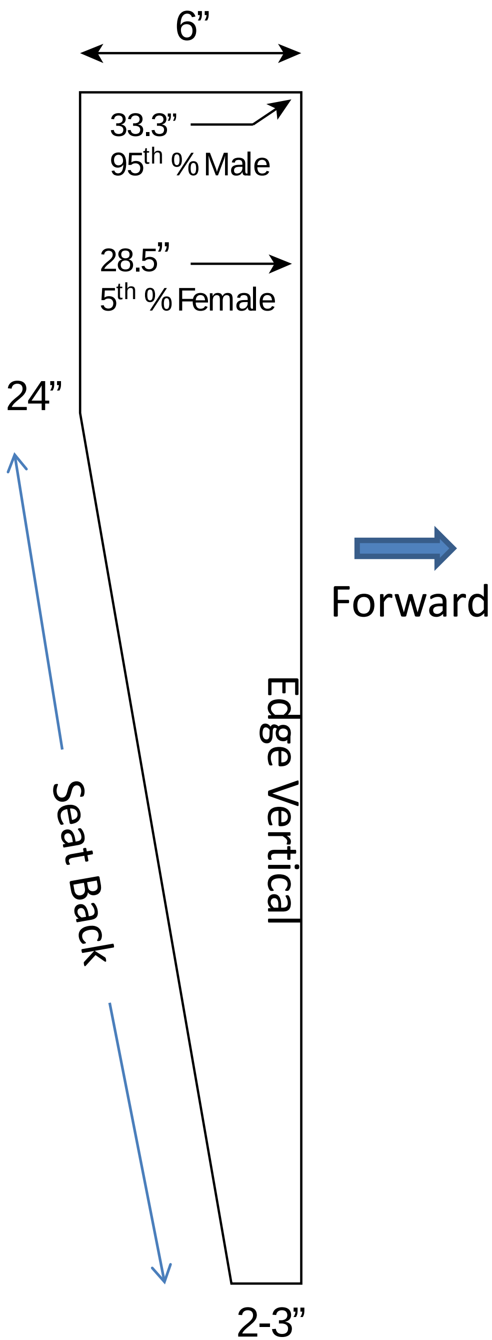
This example is a Greyhound. Here again, the mirror is too high and puts pedestrians at risk.

The round convex does not match the outline of the needed view

Is This MCI Safe?



How About Van Hool?



Eye Height Jig - $2.50

A simple jig can be made of balsawood or any other sheet material, with marks at 33.3” and 28.5” along the right side. The left side is placed in the middle of the seat, against the seat back and the recline angle adjusted to make the right side of the jig vertical. This provides a standardized seat-back angle of 10 degrees.

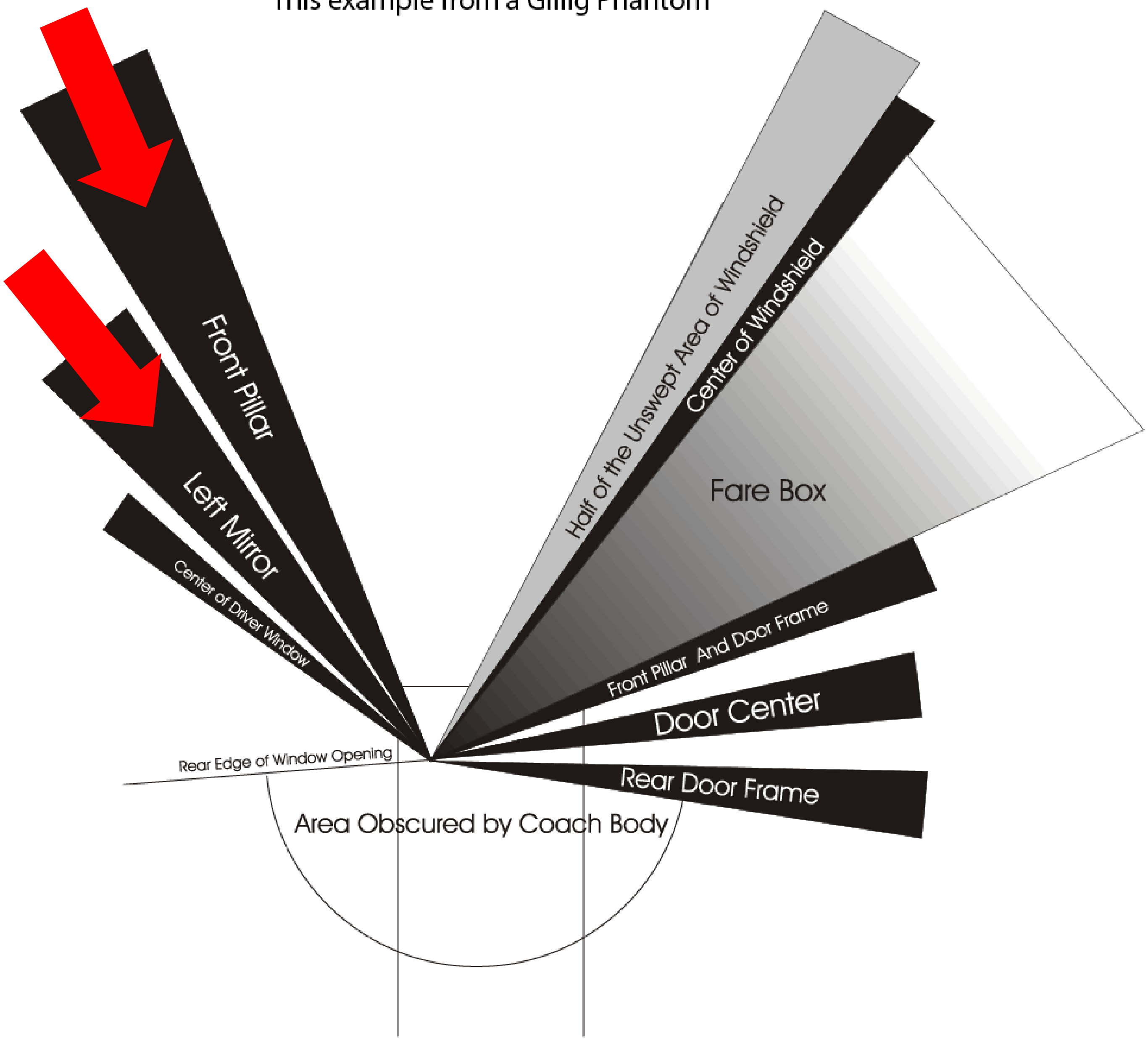
Fully lowering the seat shows the lowest eye height at the 28.5” mark. Fully elevating the seat and using the 33.3” mark shows the highest eye height. Noting these at the forward and rearward limits of seat travel provides 4 points which link to approximate the region within which all the eyes for the target population will be located.

This design ignores binocular vision but can be modified with a cross bar marked with the Interpupillary distances. For example, the average eye spacing is 1.25” on either side of the mark on this jig. For most purposes this will not be needed.

Be careful of designs or adjustments that put the mirror too far from the side of the bus:

Typical Transit Bus Blind Areas by Angle

This example from a Gillig Phantom



We have only looked at **two unnecessary hazards**, the left pillar and left mirror. These two alone are too large to overcome, yet every day, on every turn, operators are expected to overcome far more. None of us would buy a car like this!

This design from 50 years ago, the "Fishbowl," had no meaningful blind spots.

GM, in their sales literature, touted safer operation from increased visibility and smaller pillars.

Increased Visibility . . . *for safer operation . . . better sightseeing . . . and that feeling of spaciousness*

Wrap-around feature, together with slimmer body posts, increases visibility in corner areas.

70 years ago, this 1934 design did not put pedestrians at risk.
Please note the small rectangular frame element nearly identical to modern frames.
Surely modern manufacturing can do as well.

Safe Design Today

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