A Survey of RF Convertible CSRS Fit in School Buses

Introduction

Babies as young as 6 weeks old ride on school buses to attend Early Head Start and teen parent programs. Children this young must ride rear facing, and are safest riding this way as long as they fit the size limits of their RF child safety restraint systems (CSRS). The box below describes why this is essential.

Since the reasons children must ride rear facing are developmental, there is not a general milestone when all children are safe to turn forward facing. However, most sources, including AAP, NHTSA, Head Start, and CSRS manufacturers, indicate 1 year and 20 pounds as the *minimum*. In addition, best-practice guidelines from NHTSA and the AAP recommend that children ride rear facing as long as they still fit the CSRS by weight and height. CSRS manufacturers also recommend this, and some set age limits to discourage forward-facing use of their products by children who are too young. Also, note that children with certain special needs benefit from staying rear-facing longer than their age-mates.

Unfortunately, installation of rear-facing CSRS is often difficult on school buses. The two major challenges are lack of appropriate anchorage options (seat belts or LATCH) in many buses, and narrow spacing for a reclined CSRS, fore-to-aft. The latter problem is the subject of this survey.

A RF-only CSRS, especially when used without its base, is relatively small fore-to-aft and is likely to fit in many buses. However, some children who must ride rear facing are too large for a RF-only CSRS. In particular, many children outgrow a RF-only CSRS by height (when the head comes to an inch below the CSRS shell) before weight. A convertible CSRS used rear facing, which typically allow taller children to ride rear facing, can then be used. This is important for some young bus riders, including children under age 1 who outgrow a RF-only CSRS by height, and a child of any age who, due to special needs, must ride rear facing to higher heights/weights than allowed by a RF-only CSRS.

However, along with this increased capacity for rear-facing children comes a larger overall CSRS size. These bulkier CSRS are often a much bigger challenge to installation on a bus.

Hypotheses

The purpose of this survey was to find out which, if any, CSRS were usable on bus seating with respect to fore-aft constraints imposed by compartmentalization. (See box on page 2.) The researchers hypothesized:

- Convertible CSRS are too large fore-aft to use on school buses; few model options exist.
- Less expensive, lower size-capacity models would be more likely to fit than higher-end models and/or ones with a greater overall child-size capacity (height/weight).
- Because conventional CSRS are made anticipating the sloped seats of passenger vehicles, but bus seats are flat, some RF CSRS might need to be used in a more upright adjustment setting than what is described/allowed in instructions when used on the bus to achieve the correct angle.
- Because bus seating is rather shallow (at a standard 15 inches), the footprint of many convertible CSRS would overhang more than the maximum allowed. (Many CSRS use an 80/20 rule, meaning no more than 20 percent of the CSRS footprint may overhang the support of the seat cushion.)

This survey found these hypotheses to be unsupported on all counts.

Methodology

Three CPST researchers measured and tested six CSRS in three buses on June 13, 2018.

CSRS

Survey samples were limited to readily available, inexpensive-to-mid-price convertible CSRS, surmising that these are more likely to be appropriate for use in a school system setting than specialty or high-end models. Models gathered for the survey included Evenflo Titan, Cosco Scenera Next, and Graco My Ride 65, Size4Me, Contender, and Extend2Fit.

Key measurements of these CSRS were taken, as provided in Table 1. Additional details and photos of the CSRS are provided in Exhibit A.

Why is riding rear facing so important for babies and toddlers, even on a bus?

Very young children must ride rear facing because they have different body characteristics than older children and adults. First, a baby's head is larger and heavier in proportion to its body than an adult's. This means that, in a crash, the head would be thrown forward with great force if the baby was riding foward facing. This could happen even during a sudden stop.

Another important difference is that a baby's bones are soft and the ligaments undeveloped. In a crash, the force of the head pulling on the vertebrae can pull them apart, leaving the spinal cord unprotected. An infant's spinal cord can stretch only a quarter of an inch before it ruptures, causing permanent injury or death. *These outcomes are not mitigated by the features of compartmentalization, so babies need to ride rear facing on the bus, just like they would in other vehicles.*

By turning a child rearward in an approved CSRS, the head is cradled and force is absorbed by the child's entire torso as it presses into the CSRS in a crash. A baby riding rearward can be very well protected from the same force that might have otherwise caused serious injury if the child had been facing forward. Because of the crucial safety benefits, babies should ride rear facing as long as they fit their CSRS this way—well into toddlerhood.

Table 1: Car seats surveyed, with key measurements

Brand	Model	Footprint Length	Fore-to-Aft Distance	RF Seated Height (range if headrest adjusts)	Other
Evenflo	Titan	15 inches	30 inches	24 inches	Only one recline level: 27" fore-to-aft in upright mode.
Cosco	Scenara Next	8 inches	29.5 inches	21.5 inches	Only one recline level: 27.5" fore-to-aft more upright.
Graco	My Ride 65	11 inches	28.5 inches	22 inches	
Graco	Size4Me	15 inches	28.25 inches	21-27 inches	
Graco	Contender	15 inches	29 inches	19-26 inches	Only two recline level; 26.5" fore-to-aft in upright mode
Graco	Extend2Fit	14 inches	26.5 inches	21-27 inches	Used in angle-position #3 on flat surface, angle indicator was in perfect zone (light blue).

Buses

Sample buses were provided by the Oak Harbor School District Transportation Department in Oak Harbor, Washington. Three buses were tested:

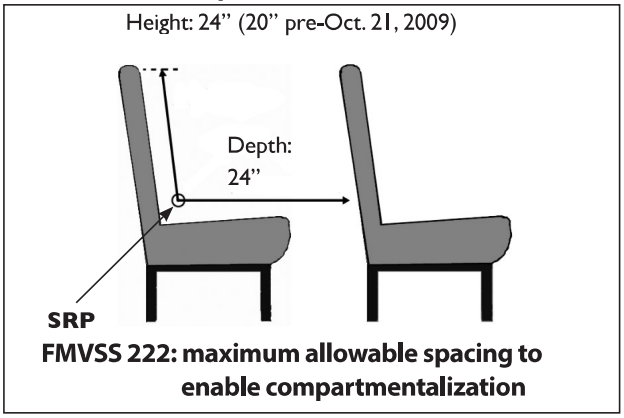
1. Micro Bird, made December 2012, 14,500 GVWR, 34 passenger, standard seating made by HSM.
2. Micro Bird, Inc., made May 2016, 14,500 GVWR, 21 passenger, seating with integrated CSRS and lap-shoulder belts made by HSM.
3. Blue Bird, MY 2019, 84 passenger, standard seating made by HSM.

On each bus, measurements were taken of the row depth. (See box to the right for a description of this technique and expected findings, given the constraints imposed by federal regulation FMVSS 222.)

Researchers measured with a carpenter's tape measure and pushed in with reasonable force into the back of the padded seatbacks to get a rough measurement. On the bus with integrated seating with a fold-down padding, the padding was folded up (held by Velcro) to flatten the seatback to the extent possible.

All seating was 39 inches wide and had seating height that meets the current stardard (as described in the box, right).

How Bus Row Depth Measurements Were Taken



FMVSS 222: maximum allowable spacing to enable compartmentalization

Per FMVSS 222, the maximum space allowed between rows (24 inches) is measured from a point that represents a crash dummy's hip joint (the seating reference point, or SRP, shown above). To get a rough idea of how a bus's rows are spaced, measure horizontally from about 2 inches above the lower cushions from one seatback to the other. Push the end of the measuring tape into the back of the seat ahead until it hits the foam pad underneath the cover. This measurement will be approximately 28 inches if rows are at maximum allowed spacing (also called maximum knee spacing) and less if not (maximum capacity spacing).

For this survey, researchers used this technique to measure the spacing of seats in the sample buses. Row depth ranged from roughly 24 inches to roughly 28 inches.

Findings

The findings contradict each of the research hypotheses:

- Many convertible CSRS will fit in buses. All but one of the models tried would fit seating with maximum spacing. Even with seats spaced as close as 26 inches apart (two inches less than maximum) some models could fit. One model out of five fit in the bus with closest seat spacing, 25 inches.
- Neither price nor the size capacity range predicted fit well.
- All CSRS that would fit fore-aft were okay with respect to footprint/overhang. The Size4Me was right at at 80%.
- The "trick" of using a more upright position and using a noodle or towel to prop to the approved recline position did not work in terms of helping make CSRS fit fore-aft. The space between rows is narrower higher up because of the slope of the seatback ahead, so making the CSRS more upright did not help as much as predicted because it also made the CSRS taller (in narrower space). So the benefit of putting the CSRS in a more upright mode is offset by the sloping seatback.

Other interesting findings:

The barriers (in front of the front row) were all sloped. Some sloped even more than normal seatbacks. For instance, in Bus 3 the front 2 seats were basically the same in terms of doing our standard fore-aft measurement (at the SRP), but the measurement at the top of the CSRS was much smaller for the seat behind driver because the barrier was more sloped.

When measuring, we didn't find the front seats to be consistently more spacious than other seats. In fact, the spacing varied throughout the buses. In the three buses we saw, the spacing of the seating at the wheel wells was roomier, though this could have been just a coincidence.

Although seats in bus 1 and 2 had similar spacing, the integrated seat pads had a negative affect on fitting the CSRS. The padded panel made the CSRS install a little further forward of the seat bight.

Seatback design varies. The MY 19 Blue Bird bus (#3) had a large amount of framing around the outer edges, so installation in the center was easier than in outboard positions because the seat ahead doesn't give due to the framing.

Table 2: Car seats surveyed in each bus/seating position

Brand	Model	Bus 1 Front row, door/driver side 28.5"	Bus 1 2nd row 27"	Bus 1 4th row wheel well 28 "	Bus 2 Front row, door side 26"	Bus 2 Front row, driver side 28"	Bus 3 Front row, door/driver side* 25"	Bus 3 2nd row, door side 26"
Evenflo	Titan	No	No	No	No	No	No	No
Cosco	Scenara Next	Yes	Yes	Yes	Yes	Yes	No	No
Graco	My Ride65	Yes	No	Yes	No	Yes	No	No
Graco	Size4Me	Yes	Yes	Yes	Yes	Yes	No	No
Graco	Contender	Yes	No	yes	No	Yes	No	No
Graco	Extend2Fit	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 3: Car seats surveyed, by likelihood of fitting various row spacing

Brand	Model	28" (max)	27"	26"	25"	Summary
Evenflo	Titan					Does NOT work RF on buses
Cosco	Scenara Next	•	•	maybe		Works in buses with 27-28" spacing; might also work with 26" spacing if seatback gives enough.
Graco	My Ride65	•				Works in buses with maximum row spacing
Graco	Size4Me	•	•			Works in buses with 27-28" spacing
Graco	Contender	•				Works in buses with maximum row spacing
Graco	Extend2Fit	•	•	•	•	Works well in spacing as low at 25"; at maximum row spacing, the height adjuster can be raised fully.

Limitations

This was an exploratory survey only, and there were many limitations:

In most cases, the CSRS weren't installed. The objective was merely to see if the depth of the convertible CSRS was compatible with the space alotted. Only one of the buses was equipped with seat belts. (When a CSRS was installed using the lap-shoulder belt, this did not seem to change the measurement findings.)

This survey also looked at a very limited number of CSRS (6) and buses (3). The buses were fairly homogeneous, all being relatively new models, meeting current standards, made by Blue Bird/Micro Bird, and having seating made by HSM Solutions.

Our measuring tools were rudimentary and non-calibrated. (We used a regular carpenter's tape measure and followed the procedure described on page 2 when measuring seating.)

Our time was limited to one afternoon (before afternoon pickup).

Further Research

Although these findings were enlightening, further research is needed to confirm results. In general, the initial hypotheses seem to be unfounded, so new hypotheses need to be tried. Additional testing should focus on a wider array of CSRS models and different bus manufacturers.

Acknowledgements

The research was organized by Denise Donaldson, CPST-I, owner of Safe Ride News. The research team, which also provided the CSRS models, included Tina Wieldraayer-Provoncha, CPST and Mercedes Teder, CPST-I. Sharlie Tassie also assisted by providing a CSRS.

The researchers are very grateful to Francis Bagarella, director of the Oak Harbor School District, for providing access to the buses used during this survey.

Exhibit A: CSRS Models

Brand	Model	MSRP
Evenflo	Titan 50	disc.
Cosco	Scenara Next	$56
Graco	My Ride 65	$120
Graco	Size4Me	$180
Graco	Contender	$140
Graco	Extend2Fit	$200

Graco Contender 65
RF: 5-40 lbs, FF 20-65 lbs.

Graco Extend2Fit
RF: 4-50 lbs, FF 22-65 lbs.

Graco MyRide 65
RF: 4-40 lbs, FF 20-65 lbs.

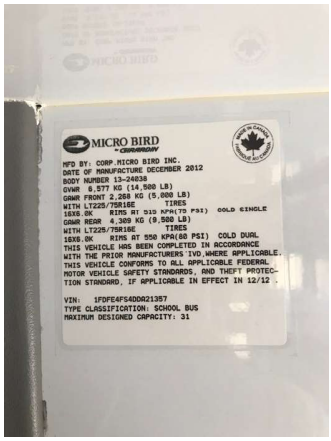
Cosco Scenera Next
RF: 5-40 lbs, FF 22-40 lbs.

Graco Size4Me
RF: 4-40 lbs, FF 20-70 lbs.

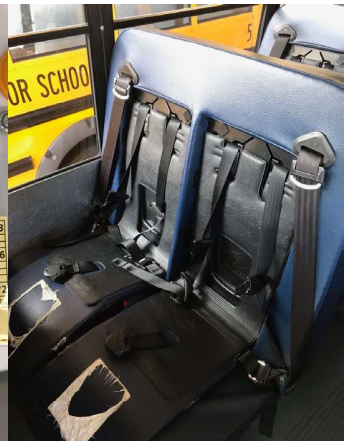
Evenlfo Titan (disc.)
RF: 5-35 lbs, FF 20-50 lbs.

Exhibit B: Buses

Bus One: Micro Bird, MY2013



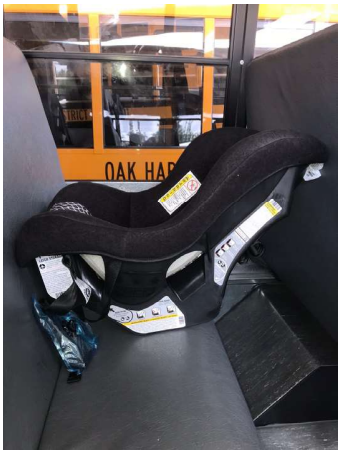
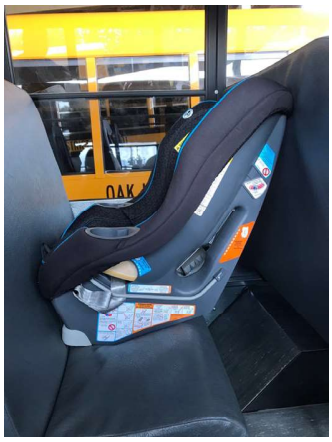
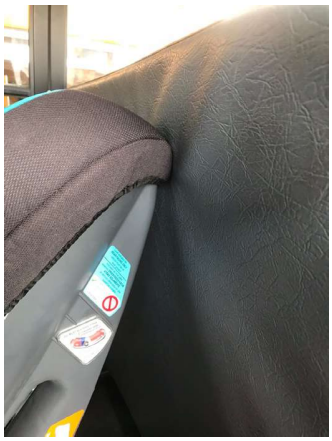
Bus Two: Micro Bird, MY2016

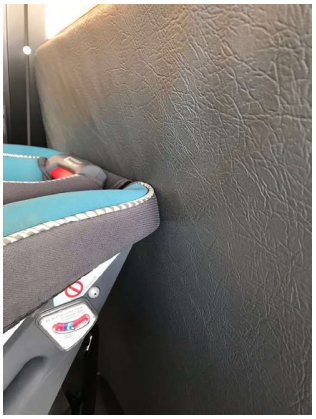
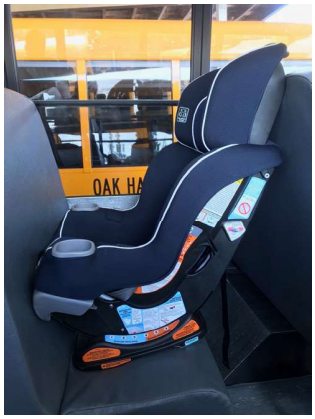


Bus Three: Blue Bird, MY2019

Exhibit C: CSRS Fit Examples

Good Fit: Bus One

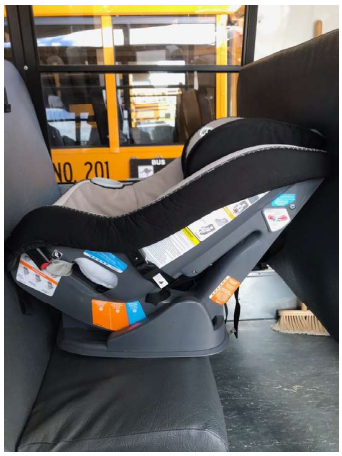
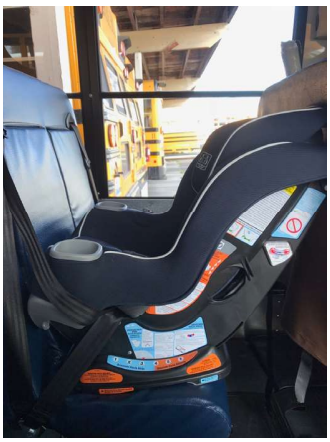



Exhibit C: CSRS Fit Examples (cont.)

Good Fit: Bus Two




Good Fit: Bus Three

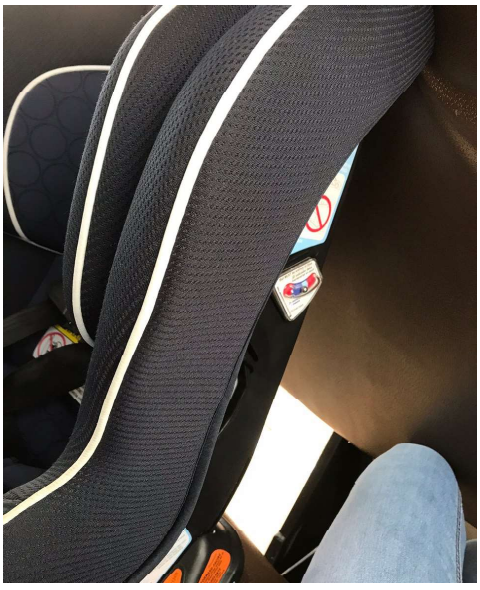
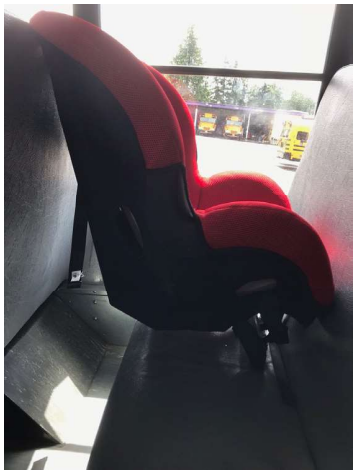
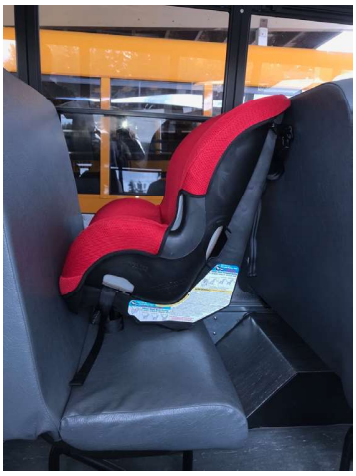



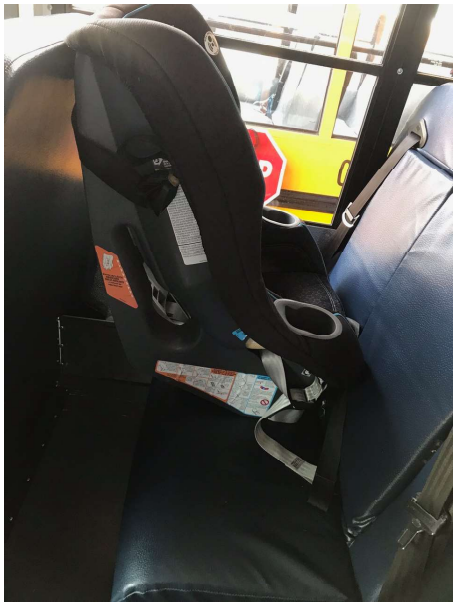
Exhibit C: CSRS Fit Examples (cont.)

Poor Fit: Bus One





Poor Fit: Bus Two



Poor Fit: Bus Three