To Belt or Not To Belt: Should Florida Mandate Installation of Safety Restraints in Large School Buses?

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A summary of a report that focused on the many issues related to the installation of safety restraints and various other feasible safety investment options for large school buses in Florida to make a safety investment option recommendation to the Florida legislature is presented. To accomplish this objective the existing literature was reviewed and evaluated to draw conclusions from the accumulated evidence. In addition, two supplemental analyses were performed: a safety investment cost–benefit analysis and a descriptive analysis of Florida school bus accident data. Based on the evidence gathered from the literature review and the results from the two supplemental analyses, it was concluded that the installation of safety restraints will not significantly improve the overall safety performance of large school buses in Florida. The potential benefit to be obtained from the installation and use of safety restraints, quantified by the annual fatalities and injuries prevented per annual dollar invested, was shown to be diminutive and thus not cost-effective. However, other feasible safety investment options were shown to be significantly more cost-effective in terms of their potential to prevent fatalities and injuries per annual dollar invested.

For the last 25 years approximately 40,000 people have died annually as a result of traffic crashes in the United States. Although airplane crashes and train accidents receive a greater portion of the media spotlight, the number of fatalities and life-threatening injuries involving passenger cars greatly exceeds those sustained in all other modes of surface transportation combined. Data compiled by the National Center for Statistics and Analysis reveal that in the United States in 1991

- 6.1 million traffic accidents occurred, a rate of 1 every 5 sec;
- severe or fatal injuries occurred at a rate of 1 every 88 sec; and
- minor or moderate injuries occurred at a rate of 1 every 19 sec.

NHTSA estimates that approximately 50 percent of all traffic fatalities could be prevented annually if all front-seat outboard occupants wore safety restraints. Also, NHTSA estimates that between 1983 and 1990 safety restraints saved nearly 25,000 lives and prevented about 650,000 moderate to critical injuries.

The ability of safety restraints to reduce fatalities and serious injuries to automobile occupants when accidents occur has been recognized (*1–9*), resulting in their mandatory use in all but two states. According to information disseminated by NHTSA, as of July 1994 the states of Maine and New Hampshire do not require the mandatory use of safety restraints in passenger cars. The federal government requires that three-point safety restraints (lap belts with shoulder harnesses) be installed as standard equipment in the front outboard seating positions of automobiles, light trucks, and vans. By 1995 all automobile manufacturers will be required to install three-point safety restraints in the rear outboard seating positions as standard equipment as well; currently, only lap belt safety restraints are required. Although safety restraints in passenger cars, light trucks, and vans have proven to be effective life-saving and injury-mitigating devices, their effectiveness in other heavier vehicles, such as heavy trucks, transit buses, and large school buses has not been substantiated empirically. Large school buses are Type B, C, and D school buses [gross vehicle weight (GVW), >4,540 kg (10,000 lbs)]. Type A [GVW, <4,540 kg (10,000 lbs)] school buses are required by federal law to have seat belts.

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This summary paper involves the investigation of the available literature to date from technical reports, journals, and periodicals pertaining to the issue of large school bus safety. It should be made clear to the reader that the scope of the report and this summary paper focuses only on those issues associated with safety on board large school buses and not on the development of programs and safety devices to protect children in the loading and unloading zones. In addition to the comprehensive review of the pertinent literature, two supplemental analyses were performed: a safety investment cost–benefit analysis and a descriptive analysis of Florida school bus accident data. The results of this research effort are summarized in this paper.

PROPONENT AND OPPONENT VIEWS

It is frequently assumed by the general public that since safety restraints have proven their effectiveness in passenger cars and other small vehicles, their availability and use in large school buses will produce the same fatality- and injury-mitigating benefits. The installation of safety restraints and the issue of safety restraint use is a frequent topic of discussion among school transportation professionals and a topic frequently raised by concerned parents of school children. The states of New York and New Jersey, as well as numerous school districts (the number of school districts in the United States that operate all or a proportion of their large school bus fleet with safety restraints is unknown) across the United States, have recently implemented legislation or policies mandating the installation and use of safety restraints (lap belts only) in their large school buses. Interestingly, the state of New York requires that lap belts be installed in all newly purchased large school buses but does not mandate their use. Controversy exists, however, regarding just how effective the provision of safety restraints and mandatory safety restraint use laws would be in reducing fatalities and injuries to occupants of large school buses. The debate is heated, and both sides make strong appeals in support of their views.

Proponents of safety restraints in large school buses concede that the current practice of compartmentalization is effective in reducing fatalities and injuries, but they argue that when combined with safety restraint use, fatality and injury rates could be reduced even further. Compartmentalization, as set forth in Federal Motor Vehicle Safety Standard (FMVSS) 222, requires that seats must be spaced no more than 60.96 cm. (24-in.) apart, as measured from the seating reference point (the point at which the human torso and thigh pivot), and seat-back height must be a minimum of 50.8 cm (20-in.) to the top of the seat back, as measured from the seating reference point. Also, limitations are placed on the amount of seat-back deflection both forward and backward. By adhering to these specifications, a compartment is created that is intended to restrain the school bus occupant, thereby limiting the severity of injuries in the event of an accident. They contend as well that requiring safety restraints in large school buses will reinforce the habit of buckling up in young children when they ride with their parents, and as a consequence safety restraint usage will carry over to other vehicles through adulthood. Also, they assert that safety restraint use will improve on-board school bus occupant behavior and decrease driver distractions, translating into the possible avoidance of accidents. Lastly, proponents argue that the cost of installing safety restraints (lap belts) is minimal, that is, no more than $1,000 to $1,500 per large school bus.

Opponents of safety restraints in large school buses maintain that because of their weight and large size, distinct yellow color, carefully selected routes for pick-up and drop-off, governed operating speed, lighting features, and unique FMVSSs, 220, 221, and 222, they are inherently safer than passenger cars, vans, and light trucks and, consequently, do not need safety restraints to improve occupant safety. FMVSS 220, School Bus Rollover Protection (49 CFR 571.220), specifies performance requirements for the structural integrity of the passenger compartment of school buses when subjected to forces that may be encountered in rollover crashes. FMVSS 220 applies to all school buses (Types A, B, C, and D). FMVSS 221, School Bus Body Joint Strength (49 CFR 571.221), requires interior and exterior body panel joints to prevent or reduce panel separation in a crash. FMVSS 221 applies only to large school buses, those with GVW ratings greater than 4,540 kg (10,000 lbs). FMVSS 222, School Bus Seating and Crash Protection (49 CFR 571.222), sets occupant protection standards for passengers and establishes passive barriers to prevent or reduce injuries from the impact of school bus occupants against structures within the vehicle during crashes and sudden driving maneuvers. Large school buses must meet all of the requirements of FMVSS 222; however, Type A school buses, those with GVWs less than 4,540 kg (10,000 lb), must meet all of the specified requirements except the 50.8-cm (20-in.) maximum distance between the seating reference point and seat back or passive barrier in front of it.

Opponents also contend that, in the case of serious accidents, safety restraints may actually increase the likelihood of injury and can imperil occupants of large school buses, especially young occupants, in accidents involving fire and rollovers. Also, they assert that if school bus drivers do not insist that occupants wear the safety restraints, the potential carry over effect will be lost. And could cause the children to become desensitized to safety restraint usage and could carry over the wrong message, that is, that it is not important to wear safety restraints in other modes of transportation. Lastly, opponents question the cost-effectiveness of safety restraints, arguing that the funds would be better spent on other, more effective safety investment options such as improved driver training, higher seat backs, crossing control arms, increased enforcement of laws against passing stopped school buses, and adult school bus monitors.

STATISTICAL SAFETY RECORD OF SCHOOL BUSES

An analysis of the crash performance of large school buses in 1987 led the National Transportation Safety Board (NTSB) to state that "poststandard large school buses are an extremely safe form of transportation when compared to other modes of transportation" (*10*) (*poststandard* refers to school buses manufactured for sale in the United States after the implementation of FMVSSs 220, 221, and 222 on April 1, 1977). NTSB's contention is supported by 1986 data pertaining to national occupant fatality and fatality rates by vehicle type compiled by the TRB committee that investigated large school bus safety (*11*). It was estimated by the TRB committee that passenger cars had a fatality rate of 1.9 and that large school buses had a fatality rate of 0.5 per 161 million km (100 million mi) traveled, statistically making large school buses four times safer than passenger cars on a vehicle mile basis, and accordingly, many more times safer on a passenger mile basis, because of the higher occupancy of large school buses.

Furthermore, Gutoskie reports that in Canada, for the period 1982 through 1985, "motor vehicle occupants were approximately 16 times more likely than school bus occupants to be injured in road accidents per passenger kilometer of travel" (*12*), and Farr concluded that "a student is 8 times more liable to be injured while travelling to or from school in a vehicle other than a school bus" (*13*). In an analysis of California accident data, Urcell deduced that "school buses without seat-belts are 16.2 times more safe than automobiles" with front and rear seat-belts (*14*).

REVIEW OF SCHOOL BUS ACCIDENT STUDIES

Recognizing the need for and the importance of studying school bus accidents, the Texas Transportation Institute (TTI) (*15*) and NTSB (*10*) each conducted comprehensive studies that investigated real-world school bus accidents.

TTI's case-by-case evaluation included 13 school bus accidents that involved 19 fatalities. That analysis suggested that 12 of the 19 fatalities would have been prevented had safety restraints (lap belts) been available to those who were fatally injured and that an additional 4 deaths might have been prevented had safety restraints (lap belts) been available or proper student disciplinary procedures exercised. In the remaining three cases Hatfield and Womack (*15*) discerned that the effect of safety restraints, had they been available, could not be determined "based on the limited data available and the fact that real world collisions are extremely difficult to evaluate on the basis of laboratory tests or subjective opinions."

TTI also assessed "accident characteristics and/or injury patterns which might be related to the seat belt issue in all injury-producing [Texas] school bus accidents" (*15*). That analysis produced insight into impact modes, which are relevant to assessing the effectiveness of safety restraints (rear-end, side, and frontal impacts and rollovers). The results rendered that approximately 46 percent of all fatal injury-causing school bus accidents in Texas (over the 12-year period of study) were accounted for in either side impact or rollover collisions. Moreover, although rollover accidents represented a small share (6 percent) of all injury-causing school bus accidents in Texas, they accounted for a much higher proportion of all fatal and incapacitating injuries to Texas school bus occupants in Texas, 15 and 18 percent, respectively. It is particularly important to emphasize this finding, because safety restraints generally are considered to improve occupant safety in accidents involving either a side impact or a rollover.

NTSB reviewed 43 accidents that involved 1,119 unrestrained occupants "to evaluate the real-world performance of school buses built to the 1977 Federal school bus standards" (*10*). The objective of the study was to focus primarily "on events *during* the crash: how well did the bus perform; how did occupants sustain their injuries, if any; and how serious were the injuries" (*10*). NTSB also examined the question of whether lap belts are needed for the occupants of large school buses manufactured for sale in the United States after the implementation of FMVSSs 220, 221, and 222 on April 1, 1977.

Based on the evidence accumulated from the investigation, NTSB concluded that FMVSS 222, which provides for compartmentalization, worked well in the NTSB-investigated crashes in protecting occupants of poststandard large school buses from injury in all accident types. They also recommended that federal safety standards not be amended to require that all newly purchased large school buses be equipped with safety restraints and that such actions (requiring safety restraints), in terms of reduced fatalities and injuries to the occupants of large school buses, have not been empirically proven.

SCHOOL BUS CRASH AND SLED TESTS

In 1984 Transport Canada (TC) performed full-scale crash testing of three different-sized school buses to evaluate the effect that safety restraints might have on improving school bus occupant protection and to assess whether current Canadian school bus standards provide a passable level of occupant safety (*13*). Data were collected on the relative severities of injuries to occupants both with and without safety restraints and with the use of three different seat spacings. The TC researchers concluded that compartmentalization affords occupants ample protection in frontal collisions and that the use of lap belts may result in more serious head and neck injuries to restrained occupants of large school buses in frontal collisions.

The University of California at Los Angeles (UCLA) in 1967 conducted three crash tests in which different impact modes: a frontal, a rear-end, and a side impact (90 degree), were fabricated "using research techniques and engineering methodology designed to provide realistic and objective findings relating to [large] school bus passenger safety" (*16*). On the basis of the test data gathered, the UCLA research team concluded that "the greatest single contribution to school bus passenger collision safety is the high-strength, high-back safety seat. Next in importance is the use of a three-point belt, a lap-belt or other form of effective restraint" (*16*).

In 1972 UCLA conducted a second series of crash tests, the Series II tests. The second series of tests involved two types of collisions, a head-on and a side impact (90 degree) absent the rear-end impact collision scenario. The school bus seat types, safety restraints, anthropomorphic testing devices (ATDs), and data-gathering procedures were similar to those of the Series I tests. In addition to the similarities to the Series I tests, however, a rearward-facing seat without a lap belt and a seat positioned sideways along the school bus wall were evaluated as well. Based on the accumulated evidence, the UCLA researchers concluded, "For buses provided with safety seats having a performance profile comparable to the UCLA design, seat-belts [lap-belts] will contribute a significant measure of safety, especially during severe upset [rollover] collision exposures" (*17*). It is important to note that the Series I and Series II UCLA tests were conducted many years (1967 and 1972) before the issuance of FMVSSs 220, 221, and 222 on April 1, 1977.

In 1985 Thomas Built Buses, Inc., conducted three crash impact tests: a frontal impact into a fixed barrier, a right-side impact by a moving barrier, and a left-side impact by a moving barrier. Based on the results of the three crash impact tests, the Thomas Built research group concluded that compartmentalization performs as it was designed in frontal and side impacts. They also found that in the case of the side impacts, very little difference exists between the restrained and unrestrained ATDs relating to the severity of head and chest injuries (*18*).

In 1978 NHTSA conducted sled tests to evaluate the restraint performances of various production school bus seats designed to satisfy the requirements of FMVSS 222 (*19*). They concluded that the use of lap belts did not reduce head injury criteria (HIC) values but, in fact, actually caused an increase in them. The data showed that the average restrained (lap belt) ATD HIC value was 278 and the average unrestrained ATD HIC value was 157.5, a measured difference of 120.5. They attributed these higher HIC values to the fact that the contact point for the ATD's head is moved upward as a result of using the lap belt. Also, the results indicated that compartmentalization worked as intended and that there were no additional benefits that could be derived by the use of lap belts.

ALTERNATIVE SEAT AND RESTRAINT SYSTEMS

To further investigate the issue of large school bus safety, TC conducted several tests that used five alternative seat types, each of which incorporated a restraint system (*20*). These five seat types included:

- contoured and padded seat back with lap belt,
- less aggressive (more easily collapsible) seat back with lap belt,
- rearward-facing seat with a lap belt,
- three-point restraint system (passenger car-type lap and shoulder belt restraint system), and
- multiple-point restraint system (harness-type restraint system that consisted of a lap belt and dual torso restraint).

In addition to the five alternative seat and restraint types, an unmodified standard school bus seat (39-in. bench seat) affixed with manual lap belts was tested for the express purpose of providing an experimental control mechanism used to make simple comparisons with the five alternative seating systems.

The TC tests evidenced that contoured and padded and less aggressive seats fitted with lap belts are not the answer for increased occupant safety. With respect to three-point restraint systems, the TC researchers concluded that they possess the necessary potential to increase occupant safety but that further reflection must be given to testing and design before they can become a viable large school bus safety investment option. However, the TC test results revealed that rearward-facing seats fitted with lap belts can significantly augment school bus occupant safety. This finding contests the results of the Series II tests performed at UCLA in 1972. The TC team again emphasized that continued research is required if rearward-facing seats fitted with lap belts are to become standard issue in Canadian school buses. In the United States FMVSS 222 would have to be amended before rearward-facing seats fitted with lap belts could become a tangible safety investment option for large school buses.

Like their TC counterparts, the 1972 UCLA researchers also investigated the effectiveness of numerous alternative restraint systems and a single alternative seat system in conjunction with testing the effectiveness of lap belts (*17*). Conclusions similar to those of TC regarding the three-point restraint system were reached by the UCLA researchers. UCLA test results also established that restraint bars, gate-bar lap restraints, armrests, airbags, and airseats do not have the capability of offering increased protection to the occupants of large school buses.

SUMMARY OF LITERATURE REVIEW

Collectively, the body of literature reviewed provided inconclusive and at times contradictory evidence relating to the effectiveness or potential effectiveness of safety restraints in large school buses. In addition, it raised the prospect that safety restraint use might result in harmful epidemiological consequences to school bus occupants in certain accident types, particularly if the accident type is frontal in nature (*13*). Moreover, the results from some studies reviewed have been criticized regarding their methodological soundness (*21*). Specifically, the authors criticized the 1984 TC test. Also, the relevance of results inferred (UCLA Series I and II tests) before the issuance of FMVSSs 220, 221, and 222 on April 1, 1977, should be seriously questioned.

SAFETY COST–BENEFIT ANALYSIS

Even if the literature review allowed one to draw the conclusion that safety restraints, primarily lap belts, are beneficial in terms of their ability to consistently mitigate the fatalities and injuries sustained by occupants of large school buses, their installation and the installation of other safety investment options such as crossing control arms and external loud speaker systems must involve weighing the costs against the overall potential benefits in absolute terms, that is, a quantifiable number of children's lives preserved and injuries prevented or lessened by the installation of each safety investment option.

Although the concept of placing a monetary value on the life of a child is offensive and unthinkable to most of the general public, public investment decisions ranging from roadway safety improvements, police and fire protection, sanitation, and large school bus occupant safety involve an implicit financial trade-off between spending and the benefits to be gained. Thus, it is crucial to determine the relative worth of each safety investment option by calculating a quantifiable number of lives saved and injuries prevented for a specified capital outlay and unit of time.

Method

The safety cost–benefit analysis examined nine different safety investment options to determine a quantifiable number of fatalities and injuries that might be reduced in Florida per safety investment option per year. The safety investment options evaluated included

- lap belts,
- lap-shoulder belts (three-point restraints),
- lap-dual shoulder belts (multiple-point or four-point restraints),
- higher seat backs ("New York" seats),
- adult school bus monitors,
- electrically operated crossing control arms,
- dual stop signal arms,
- external loudspeaker systems, and
- rearward-facing seats with a lap belt.

The installation cost estimates for the nine safety investment options investigated are only for newly purchased large school buses. The cost of retrofitting large Florida school buses with the nine safety investment options was not explored. The nine safety investment options were analyzed by using several parameters. The parameters are identified in Table 1.

Because so few deaths or serious injuries are sustained by occupants of large school buses in a typical school year in Florida or the

TABLE 1 Safety Cost–Benefit Analysis Parameters

Safety Investment Option	Annual Investment	Installation Cost/Bus	Annual Maintenance Cost/Bus	Discount Rate	Residual Value	Economic Life Span (years)
Lap-belt	$1,000,000	$1,500	$35	7%	$0	15
Lap/shoulder belts	$1,000,000	$3,800.77	$40	7%	$0	15
Lap/dual shoulder belts	$1,000,000	$4,643.94	$40	7%	$0	15
Higher seat-backs	$1,000,000	$250	$0	7%	$0	15
Adult school bus monitors	$1,000,000	$3,825	$0	n/a	n/a	n/a
Crossing control arms	$1,000,000	$350	$25	7%	$0	15
Stop signal arms	$1,000,000	$475	$15	7%	$0	15
Rearward-facing seats w/lap-belt	$1,000,000	$3,113.26	$35	7%	$0	15
External loud speaker systems	$1,000,000	$350	$15	7%	$0	15

TABLE 2 TRB Safety Investment Option Effectiveness Rates (*11*)

Safety Investment Option	Percent Effective at Reducing Fatalities and Injuries
Lap-belts	0-20%
Higher seat-backs	0-20%
Adult school bus monitors	25-75%
Crossing control arms	5-25%
Stop signal arms	0-30%
External loud speaker systems	0-20%

United States (the TRB committee that investigated the issue estimated that 10 school bus occupants are fatally injured each year in the United States), a dearth of comprehensive accident data is available to determine empirically the effectiveness of restraint systems and other safety investment options for large school buses. On the other hand, however, there is a prodigious amount of statistical and empirical literature that demonstrates quite conclusively that safety restraints save lives and reduce injury severity in passenger cars, vans, and light trucks (*1–9*). Again, because of the infrequency of death and serious injury to the occupants of large school buses, estimates of how much supplemental protection that might be provided by safety restraints or other safety investment options are, by circumstance, purely conjectural. Therefore, because of this problem the identical effectiveness rate assumptions used by the TRB committee that investigated large school bus safety were used in the cost–benefit analysis calculations (Table 2).

Results of Safety Cost–Benefit Analysis

Lap belts would potentially prevent up to 0.032 fatalities per $1 million annual investment (Table 3). This translates into one child's life being saved approximately every 31 years. The annual fatality and injury reduction results for the other eight safety investment options are summarized in Table 3.

The marginal improvement in safety to the occupants of large school buses in Florida associated with the use of the three safety restraint types resulted in their falling outside of the range of cost-effectiveness that would provide a compelling basis for an investment recommendation. However, the results of the cost–benefit analysis indicate that higher seat backs [60.96 cm (24-in.), as measured from the seating reference point] are the safety investment option that could offer the most benefits in terms of fatalities prevented and injuries reduced to occupants of large school buses in Florida. They have the potential to prevent up to 0.3 fatalities, 7 incapacitating injuries, 42 nonincapacitating injuries, and 104 possible injuries per year. Similar conclusions were reached by the TRB committee that investigated large school bus safety (*11*).

DESCRIPTIVE ANALYSIS OF FLORIDA SCHOOL BUS ACCIDENT DATA

The descriptive analysis of Florida school bus accident data is based on the supposition that impact mode (i.e., direction of impact) is directly related to the severity of the injury sustained. The available research on frontal and rear impact collisions does not produce a result favorable to the installation and use of safety restraints in large school buses. In actuality, the literature points to the fact that an occupant of a large school bus restricted by a safety restraint (lap belt) in a frontal collision would have a tendency to bend forward (jackknife) and strike the top of the seat back ahead with the head, face, and chest, thereby increasing the forces and thus the injuries to these parts of the body. In contrast, an occupant of a large school

TABLE 3 Annual Fatality and Injury Severity Reduction per Safety Investment Option

Safety Investment Option	Injury Severity Reduction			
	Fatal	Incapacitating[1]	Non-incapacitating[2]	Possible[3]
Lap-belts	0.032	0.73	4.5	11
Lap/shoulder belts	0.028	0.634	3.9	9.6
Lap/dual shoulder belts	0.03	0.66	4.05	10
Higher seat-backs	0.3	7	42	104
Adult school bus monitors	0.006 - 0.018	0.09 - 0.3	0.58 - 1.8	1.44 - 4.3
Crossing control arms	0.0148 - 0.074	0.0221 - 0.111	0.0289 - 0.145	0.067 - 0.333
Dual stop signal arms	0.042	0.063	0.082	0.2
External loud speaker systems	0.035	0.05	0.07	0.16
Rearward-facing seats w/lap-belts	0.0169 - 0.047	0.38 - 1.06	2.37 - 6.5	5.8 - 16.03

1 Severe lacerations, broken or distorted limbs, skull, chest or abdominal injuries, unconscious at or when taken from the accident, or unable to leave the scene without assistance.
2 Lump on head, abrasions, minor lacerations, etc.
3 Momentary unconsciousness, complaint of pain, nausea, hysteria, etc.

TABLE 4 Florida Large School Bus Accident Frequency by Impact Mode, 1986–1991

	Impact Mode					
	Frontal	Rear-end	Side	Rollover	Other	Total
Number of Accidents	63 (1.3%)	1,482 (31.3%)	1,334 (28.2%)	15 (.32%)	1,838 (38.8%)	4,732 (100%)

Note: Percent does not equal 100 due to rounding error.

bus not restricted by a safety restraint (lap belt) during a frontal impact collision would have a tendency to slide forward in the seat and strike the seat back ahead with the upper torso and knees, causing the force of impact to be more evenly spread across the upper torso (the intent behind compartmentalization). In side impact collisions, however, the available research indicates that the use of safety restraints (lap belts) would be only slightly beneficial, contingent on the occupants not being seated in the direct impact zone during an accident. In rollovers the available research tends to be based more on conjecture than on fact. Deductions favoring lap-belt use in rollovers are grounded on the benefits of diminished tossing about and the elimination of partial ejection and, in extremely rare instances, the full ejection of an occupant. Therefore, to determine the potential effectiveness of safety restraints in large school buses in Florida, two objectives were defined: determine the frequency and distribution of accidents by four primary impact modes (frontal, rear-end, side, and rollovers) and determine occupant injury severity by the same four impact modes.

In Table 4 the frequencies of large school bus accidents in Florida by frontal impact, rear-end impact, side impact, and rollover are identified. As reported in Table 4, 63 (1.3 percent of all large school bus accidents in Florida during the 6-year period of study were frontal in nature. Table 4 also illustrates that a higher proportion of accidents involving large school buses in Florida were either rear-end or side impact collisions: 1,482 (31.3 percent and 1,334 (28.2 percent), respectively. Not surprisingly, school bus accidents that resulted in rollovers constituted the smallest proportion of all accident possibilities. Of the 4,732 reported accidents between 1986 and 1991, only 15 (0.32 percent) involved an overturned school bus. One plausible explanation for this result, in part, may be the flat nature of Florida's topography.

Table 5 provides a frequency distribution of the level of injury severity sustained by occupants in the 4,732 accidents that involved large school buses in Florida. Over the 6-year period of study, 9 (0.02 percent) fatalities, 202 (0.45 percent) incapacitating injuries, 1,251 (2.8 percent) nonincapacitating injuries, 3,091 (7 percent) possible injuries, and 39,878 (89.7 percent) no injuries (none) were reported. A total of 7 (0.015%) injuries sustained by occupants of large Florida school buses were of unknown injury severity.

The distributions of fatalities, incapacitating injuries, nonincapacitating injuries, possible injuries, and no injury (none) are identified according to impact mode for the 6-year period of study (Table 6). These data represent the actual number of school bus occupants in Florida who sustained a particular level of injury as determined by one of the four primary impact modes. The figures for side impact collisions were derived by using the aggregate of angle and sideswipe impacts as provided by the state of Florida school bus accident data base.

The nine reported deaths to occupants of large school buses in Florida were the result of three separate accidents. Because of this small number of accident cases, it was possible to obtain and review the actual accident reports for each of the accidents. Excerpts written by the reporting officers as well as accident circumstances were taken from the accident report narratives to better judge whether the deaths could have been prevented had safety restraints been available to those occupants. It was concluded that the three accidents were so catastrophic and freakish in nature that it is doubtful that the presence of safety restraints of any configuration or design would have altered the tragic outcomes.

By comparing the frequencies in Table 4 and Table 6, it becomes apparent that frontal impact collisions represent the second smallest number (63 or 1.3 percent) of all injury-producing school bus accidents but account for a disproportionate number (11.15 to 1 ratio) of incapacitating injuries to school bus occupants. Rollover accidents represent the smallest number (15 or 0.32 percent) of all injury-producing school bus accidents but account for the second highest proportion (9.375 to 1) of incapacitating injuries to school bus occupants. In contrast, rear-end and side impact collisions

TABLE 5 Large Florida School Bus Occupant Injury Severity by Year

	Year						
Injury Severity	1986	1987	1988	1989	1990	1991	Total
Fatal	0	5	1	0	0	3	9 (0.02%)
Incapacitating	17	29	33	19	57	47	202 (0.45%)
Non-incapacitating	163	295	166	271	235	121	1,251 (2.8%)
Possible	499	543	363	454	776	456	3,091 (7%)
None	5,976	6,724	6,868	6,428	7,096	6,786	39,878
Unknown	0	2	0	2	0	3	7 (0.015%)
Total	6,655	7,598	7,431	7,174	8,164	7,416	44,438 (100%)

TABLE 6 Large Florida School Bus Occupant Injury Severity by Impact Mode

Impact Mode	Injury Severity						
	Fatal	Incapacitating	Non-incapacitating	Possible	None	Unknown	Total
Frontal	0	24	55	108	398	0	585
Rear-end	0	85	370	1,207	15,774	6	17,442
Side	5	52	504	721	10,505	1	11,788
Rollover	0	5	10	95	71	0	181
Total	5	166	939	2,131	26,748	7	29,996

Note: Four of the deaths to occupants of large Florida school buses were not the result of one of the four primary impact modes utilized in the descriptive analysis of large Florida school bus accident data.

account for 1,482 (31.3 percent) and 1,334 (28.2 percent) of all injury-producing school bus accidents, respectively, but result in the smallest proportion (1 to 1 and 1.81 to 1, respectively) of incapacitating injuries sustained by occupants of large Florida school buses.

DESCRIPTIVE ANALYSIS OF FLORIDA SCHOOL BUS ACCIDENT DATA RESULTS

The descriptive analysis of Florida school bus accident data does not provide compelling evidence that safety restraints are needed in large Florida school buses to improve occupant safety. Rather, the considerable number of occupants of large Florida school buses who were either uninjured or received minor or moderate injuries (44,220, or 99 percent; 7 injuries of unknown severity were omitted) simply reiterates the fact that large school buses in Florida are an extremely safe mode of transportation. Furthermore, based on an extensive review of the accident reports, the availability of safety restraints to those occupants of large school buses in Florida who were fatally injured in 1986, 1989, and 1990 was rendered moot, since the nine fatalities most likely would have occurred even if the occupants would have been held securely in place by a safety restraint. The fact that only 9 (0.02%) fatalities (eight of the fatalities were the result of two accidents) and 202 (0.45%) incapacitating injuries were sustained by the 44,438 Florida school bus occupants involved in the 4,732 large school bus accidents reported in the statewide accident data base for the years 1986 through 1991 substantiates the effectiveness of the safety investment options already being used in and on large school buses in Florida and the reality that serious accidents involving large school buses in the state of Florida are infrequent.

CONCLUSION

This paper includes a summary compilation and review of pertinent literature pertaining to the issue of large school bus safety and two supplemental analyses, a safety investment cost–benefit analysis and a descriptive analysis of Florida school bus accident data.

Based on the evidence from the literature review, it was recommended that safety restraints of any configuration or design not be installed in large school buses in Florida until adequate testing and further design modifications are completed to justify an investment recommendation. To date it is the opinion of the author that neither adequate testing and research nor empirical evidence exists to justify an investment recommendation.

In addition, the conclusion to recommend that the state of Florida not mandate the installation of safety restraints in their large school buses was also based, in part, on the results from the two supplemental analyses. When solely considering the economics (benefits versus costs) of school bus safety, several questions must be asked: What price do we place on large school bus occupant safety? How do we measure safety? Who is going to pay for the safety? The results of the cost–benefit analysis demonstrated that the marginal improvement in safety to occupants of large school buses in Florida associated with the use of the three safety restraint designs tested resulted in their falling outside the range of cost-effectiveness, thus making them secondary safety items at best.

The statistical safety record of large school buses in Florida is impressive. The fact that only 9 (0.02 percent) fatalities and 202 (0.45 percent) incapacitating injuries were sustained by the 44,438 large school bus occupants during the 6-year period of study points to the inherent safety of large school buses in Florida.

This exemplary safety record of large school buses in Florida, however, should not permit the state of Florida to rest on its laurels. Accidents involving large school buses in Florida will continue to occur, and as long as one child is fatally or severely injured, the pursuit of increased safety must be a constant process.

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Publication of this paper sponsored by Committee on Transportation Safety Management.