Improving Student Safety: School Bus Seat Belt Pilot Program

UTC(s): UTCA – University Transportati on Center for Alabama, Tuscaloosa
Publication Date: March, 2010
PDF Version: spotlight_1003.pdf

The University Transportation Center for Alabama (UTCA) is conducting a 3-year pilot study to assess the impact of lap/shoulder seat belts on the safety of students in school buses. After a tragic school bus accident in Huntsville, Alabama, Governor Bob Riley appointed a seven member study group to review laws in other states, interview seat belt experts, and suggest further actions. The group found that there were no comprehensive studies on the subject. The Alabama State Department of Education awarded a project to UTCA to conduct such a study. The Department also provided allocations to 10 participating local school systems to purchase 12 new buses equipped with lap/shoulder seat belts, to provide fuel and maintenance services for these buses, and to provide aides in several of the buses. Four ceiling-mounted video cameras were installed on each bus to gather data on the percentage of students using the seat belts properly. "This is a ground-breaking research project in safety," explained Dr. Dan Turner, principal investigator of the research team. "Eight states throughout the country now have laws that require some form of seat belts in school buses, and other states would like to require them, but there are no scientific studies on this topic. The UTCA team is reviewing the effectiveness of different types and uses of seat belts, and the team is using technology to gather information about school bus seat belt use and safety in Alabama." All aspects of the pilot study will be determined and completed by UTCA researchers:

- gather seat belt use rate data,
- prepare an analysis of national and Alabama school bus crash data to determine trends and to predict the reduction of fatalities due to seat belts,
- determine the loss of seating capacity and alterations needed in the Alabama school bus fleet if lap/shoulder seat belts were adopted, and
- prepare a cost-benefit analysis.

The project began in 2007 and will conclude in 2010. During the 2008–2009 school year, UTCA student researchers made 65,000 observations of individual pupils to determine whether they were wearing their seat belts. "The first 2 years of our study have given us insight into the basic pattern of school bus seat belt use by Alabama's school children. The third and final year will allow us to vary some of the basic parameters of the study to determine how that affects results," explained Dr. Jay Lindly, Executive Director of The University Transportation Center for Alabama. "For example, does changing the bus driver on a route affect seat belt usage, or does adding an aide to a route affect seat belt usage? Will mandatory use be effective? That is what we will be testing this next year." For the study, each rider was trained and encouraged in seat belt use, but belt use was not required. On the advice of previous researchers, students were observed on Tuesday through Thursday afternoons, when belt use is most consistent (Mondays and Fridays, national test days, and other factors make seat belt use less consistent). However, in one control bus, students were observed both morning and afternoon, Monday through Friday. The preliminary results for 2008–2009 show the following characteristics:

- 63 percent of students wore belts appropriately.
- 8 percent wore belts inappropriately (with the strap behind their backs, with arms and legs in the aisle, etc.).
- 29 percent did not wear belts.
- Use varied widely by bus, with a high of 95 percent usage and a low of 5 percent usage.
- Usage dropped as the route progressed because students changed seats, became fidgety, etc. Usage at the beginning of the route averaged 64 percent but dropped to 55 percent by the end of the route.
- When data from the control bus allows researchers to estimate belt usage during the entire week (not just Tuesday through Thursday afternoons), appropriate belt usage decreased from 63 to 53 percent, reflecting the lower use rates on morning routes and on Mondays and Fridays.

Dr. Dan Turner explained that detailed results will not be released until the study is completed so that seat belt use during the remainder of the study does not arbitrarily change as the result of a news article. That would make it impossible to measure the effectiveness of the third year's experimental safety treatments. UTCA has been in contact with multiple states, the National Transportation Safety Board, the National Highway Traffic Safety Administration, and other national agencies. They are awaiting the results of the study to help determine whether or not the adoption of seat belts in school buses is feasible and safety cost-effective. In effect, this project will inform national decisions.

About This Project

Dr. Jay K. Lindly is the Executive Director of The University Transportation Center for Alabama and a co-Principal Investigator on this project. Leading the research project is Dr. Daniel Turner, Professor Emeritus at The University of Alabama and current member of the Technical Activities Council of the Transportation Research Board of the National Academies. Two professors from The Center for Advanced Public Safety (CAPS) at The University of Alabama complete the research team – Dr. Allen Parrish and Dr. David Brown, both Professors of Computer Science. The faculty members of the research team gratefully acknowledge the indispensible contributions of the nine undergraduate, four graduate, and two staff team members.

Summary Report
Alabama School Bus Seat Belt Pilot Project

For the
ALABAMA SCHOOL BUS SEAT BELT PILOT PROJECT
conducted for the
Alabama State Department of Education
and the
Governor's Study Group on School Bus Seat Belts

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UTCA Report Number 07407-1
October 25, 2010

Technical Report Documentation Page

1. Report No 07407-1	2. Government Accession No.	3. Recipient Catalog No.

4. Title and Subtitle Summary Report: Alabama School Bus Seat Belt Pilot Project	**5. Report Date** October 25, 2010
	6. Performing Organization Code
7. Authors Dr. Daniel S. Turner, Dr. Jay K. Lindly, Ms. Elsa Tedla, Mr. Kenneth Anderson, and Dr. David Brown	**8. Performing Organization Report No.** UTCA Final Report Number 07407
9. Performing Organization Name and Address University Transportation Center for Alabama Department of Civil and Environmental Engineering The University of Alabama; Box 870205 Tuscaloosa, Alabama 35487-0206	**10. Work Unit No.**
	11. Contract or Grant No. GR22172
12. Sponsoring Agency Name and Address Alabama State Department of Education 5303 Gordon Persons Building PO Box 302101 Montgomery, AL 36130-2101	**13. Type of Report and Period Covered** Final Report: 10/1/2007 – 9/30/2010
	14. Sponsoring Agency Code
15. Supplementary Notes	

16. Abstract

The University of Alabama (UA) conducted a three-year project for the Governor's Study Group on School Bus Seat Belts and the Alabama State Department of Education. The project explored the implementation of lap/shoulder belts on newly purchased large school buses. It included topics like the rate of seat belt use, the effects on bus discipline, the attitudes of stakeholders, the loss of capacity attributable to seat belts, the cost effectiveness of the belts, and other pertinent issues. A list of some of the most pertinent study findings follows:

- In 2009-10 in Alabama, 7,341 route school buses averaged 51 pupils each and traveled 457,258 miles daily (82.3 million miles annually).
- Pupil deaths inside school buses are rare in Alabama. Since 1977, when major advancements were made to school bus safety, there have been only five fatalities for pupils riding inside school buses at the time the crash occurred.
- School buses are the safest form of transportation to school. Students are six to eight times safer riding to school in a school bus than riding to school in their parents' cars.
- Nationally, up to three times more school bus-related pupil deaths take place outside the bus (loading/unloading) than inside the bus.
- The addition of seat belts would make already-safe school buses even safer.
- Stakeholders (parents, children, drivers, aides, and transportation supervisors) believe school buses are already safe and adding seat belts will make them safer.
- School bus drivers cannot see pupils as well in buses equipped with seat belts due to the taller seatbacks required for seat belts. They are concerned this will lead to increased discipline problems, for which they may be held responsible.
- Based on 170,000 observations of pupils in pilot-project buses, this project established an average seat belt-use rate of 61.5%.
- Adding seat belts increases the thickness of seatbacks, leading to fewer rows of seats. Also, the fixed spacing between seat belt buckle latches negates the option of placing three small pupils or two large pupils on a seat, leading to the loss of one seat per row.
- This study found thicker seatbacks and fixed buckle spacing could cause capacity losses of 5% to 18%, depending on the configuration of seats and rows. The bus fleet would need to expand 5% to 18% to offset the capacity loss.

- A cost-effectiveness study was performed using the National Highway Transportation Safety Administration methodology. Two metrics were calculated:
    - The cost of an "equivalent life saved" from seat belt implementation in Alabama is $32 million to $38 million.
    - The "net benefits" for seat belt implementation over one fleet life cycle are -$104 million to -$125 million. The net benefits are negative because the costs exceed the benefits. This suggests using more cost-effective safety measures rather than implementing seat belts across the large-school bus fleet.

Most school bus pupil fatalities occur outside buses in or near loading zones. If funding is to be spent on school bus safety, it appears more lives could be saved by investing in enhanced safety measures in loading/unloading zones. These treatments are likely more cost effective than seat belts, and this report includes several examples.

Three pilot-project initiatives contributed significant new knowledge to the topic of seat belts on school buses: seat belt use rates, the impact of seat belts on school bus capacity, and the cost effectiveness of various seat belt configurations.

17. Key Words School bus, lap/shoulder belt, safety		**18. Distribution Statement**	
19. Security Class **unclassified**	**20. Security Class.** unclassified	**21. No of Pages** 48	**22. Price**

Contents

Tables

Figures

Executive Summary

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- Nationally, up to three times more school bus-related pupil deaths take place outside the bus (loading/unloading) than inside the bus.
- Stakeholders (parents, children, drivers, aides, and transportation supervisors) believe school buses are already safe and adding seat belts will make them safer.
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Section 1
Introduction

On November 20, 2006, a 71-passenger school bus was enroute to a vocational school in Huntsville, Alabama. It crashed nose first over a concrete barrier at an Interstate interchange and plunged 30 feet to the ground below. The driver was ejected during the crash and seriously injured. Of the 40 pupils on board, 4 were killed and 33 were injured. Three pupils were not injured in the crash.

The crash galvanized the state. There were calls for increased safety, including installation of school bus seat belts. Governor Bob Riley appointed the Governor's Study Group on School Bus Seat Belts (Governor's Study Group): Dr. Joseph B. Morton, State Superintendent of Education; Dr. Mary Jane Caylor, Member of the State Board of Education; the Honorable Richard Dorrough, Commissioner for the Alabama Department of Children's Affairs (deceased); Mr. Joe Lightsey, Director of Pupil Transportation for the Alabama State Department of Education (ALSDE); Mr. Joe McInnes, Director of the Alabama Department of Transportation (ALDOT); Dr. Ann Roy Moore, Superintendent of Huntsville City Schools; and Colonel Chris Murphy, Director of the Alabama Department of Public Safety.

The study group determined the facts of the crash and began gathering data on which to base a decision. Virtually no data were available on school bus seat belt use rates or the belts' effect on safety, even after queries to multiple agencies within the US Department of Transportation (USDOT).

1.1 Study Group Findings and Recommendations

At that point, the study group identified issues and policies in which they had confidence. They agreed school buses are the safest mode of surface transportation and the State should take no action that would cause pupils to leave school buses and travel in less safe modes. They also agreed lap/shoulder belts had the potential to save lives and prevent injuries, especially if accompanied by training and practice on proper use of the belts. At the close of its initial review, the Study Group found school buses are safe even if nothing is done and recommended, above all else, to do no harm; to push the National Transportation Highway Safety Administration (NHTSA) to act expeditiously on school bus design and performance standards; and to conduct a pilot study in Alabama because there were no national data on the effectiveness of school bus safety belts.

1.2 The Pilot Project

Based on the recommendations of the Governor's Study Group, the 2007 Alabama Legislature authorized $1.4 million dollars to conduct a pilot study. The research was not to be a crashworthiness study. Instead it was to explore lap/shoulder belts by determining the rate of seat belt use, effects on bus discipline, attitudes of stakeholders (students, parents, drivers, etc.), loss of capacity attributable to seat belts, the cost effectiveness of the belts, and other pertinent issues.

The Governor's Study Group issued a request for proposal in the summer of 2007 and a contract was awarded to the University of Alabama (UA). The research was conducted over three years through UA's University Transportation Center for Alabama (UTCA) and the CARE Research and Development Laboratory, which was renamed during the project as the Center for Advanced Public Safety (CAPS).

The ALSDE used a portion of the legislative funds to purchase 12 type C and D school buses for 10 local school systems: Autauga County, Boaz City, Calhoun County, Conecuh County, Decatur City, Dothan City, Elmore County, Madison City, Perry County, and Tuscaloosa County. The buses were fitted with three- and four-point restraints and ceiling-mounted digital camera systems. The seats were taller and thicker than typical school bus seats to accommodate the seat belt hardware. In addition, ALSDE paid for bus aides for half the buses and the operating costs for all 12 buses.

The project was initiated in November 2007. The remainder of 2007 and the spring of 2008 were devoted to project organization, purchase and fit of school buses, training, development of detailed protocols for receiving and processing data, and similar issues. Data collection to calculate the seat belt-use rate began in the fall of the 2008-09 school year and continued through the 2009-10 school year. Other elements of the study continued through September 2010.

1.3 Snapshot of Alabama School Bus Use and Safety

Alabama is a typical state regarding school bus travel, with 7,341 buses traveling 457,258 miles daily (82 million miles annually) to transport about 378,000 pupils daily. Additional information is displayed in Table 1-1.

One highlight of the fleet is its low average age. The ALSDE promotes aggressive maintenance and cost-effective bus replacement. Buses are generally replaced after 10 years of service.

"Every year in the US, approximately 450,000 school buses travel an estimated 4.3 billion miles to transport 23.5 million children to and from school" (NHTSA 2002). Even though approximately 20 children die in school bus crashes annually (25% as passengers and 75% as pedestrians), school bus transportation of children is far safer than other modes (NHTSA 2002; Turner, *et al.* 2005). In fact, children riding in their parents' automobiles are seven times more likely to be killed in a crash than if they were riding in a school bus (NHTSA 2006).

Table 1-1. Snapshot of public-school bus travel in Alabama (2009-10 data)

Public school enrollment	741,115
Students transported annually	67,797,000
Average students/bus	51
Regular school buses	7,341
Spare school buses	2,081
Total school buses	9,422
Route buses 10 yrs or less in age	6,535 (97%)
Annual cost/transported student	$873.93 (FY08)
Daily cost/transported student	$4.86 (FY08)
Daily cost/mile	$4.00 (FY08)

Since 1977, when NHTSA required compartmentalization as a safety treatment for school buses, there have only been five fatalities involving students inside school buses in Alabama (Turner, *et al.* 2010). A study conducted in 2005 by Turner, Jones, and Wood provided a snapshot of Alabama school bus crashes. The researchers reviewed school bus crashes for 1999-2003. Of the 1,876 crashes in the data, only about 15% included injuries and only 0.5% included fatalities. The injuries and fatalities involved persons in the buses, persons in other involved vehicles, or pedestrians, and were much less likely for school bus crashes than for non-school bus crashes in Alabama. Moreover, the majority of school bus crashes were caused by other vehicles, not school buses. The most frequent type of school bus crash occurred at low speed in a school zone, with run-off-road, pedestrian, left-turn-into-traffic, and fail-to-heed-stop-sign crashes occurring with some frequency. Either the bus driver or the driver of another vehicle could have caused these crashes.

Section 2
Overview of the Research Project

UTCA and CAPS have extensive histories of research and training projects for Alabama and national agencies, and safety is a prominent expertise for both centers. The centers combined their efforts and conducted the following research steps over three years:

- Assess data for pre-project and post-project surveys of stakeholder attitudes.
- Review pertinent literature.
- Investigate the characteristics of Alabama school bus crashes.
- Estimate Alabama school bus seat belt use rates and the factors contributing to those rates.
- Estimate the safety effectiveness of Alabama school bus seat belts.
- Determine the effects of seat belts on Alabama school bus capacity.
- Determine the cost effectiveness of lap/shoulder seat belts on large Alabama school buses.

In effect, each of these efforts was a research project. Sometimes multiple efforts were jointly conducted, and often the results from one effort became key data for another.

Individual reports document each research effort of these research efforts, and this summary report compiles key information from those reports. One report – the summary of Alabama seat belt-use rates – is in preparation; however, the results of that research effort are known and are addressed in this summary.

Three research efforts are noteworthy. The seat belt-use study used 170,000 individual observations of pupils to estimate the seat belt-use rate, the capacity study provided the nation's most accurate estimates of capacity loss from installation of seat belts, and the cost-effectiveness study provided the first estimate of the costs and benefits of placing seat belts on a state's fleet of school buses.

This report provides a brief overview of the individual research efforts, along with findings and recommendations from their reports. Since the information in this report is abbreviated, readers should consult the individual reports for a more complete description of research methodologies, data, findings, recommendations, and applicable constraints.

Section 3
Literature Review

Researchers completed an exploratory literature review in 2008 to determine the state of knowledge on school bus seat belts. It is excerpted below. This information was valuable in determining courses of action and in identifying the types of data to be pursued during the pilot program. As additional information became available during the project and the literature review was extended, the new information was included in the reports for individual research efforts.

3.1 Safety Statistics

"Every year, our nation's 450,000 public school buses travel more than 4.3 billion miles to transport 23.5 million children to and from school and school-related activities" (NHTSA 2002). Even though approximately twenty children die in school bus crashes annually (25% as passengers and 75% as pedestrians) (National Academies 2002), school bus transportation of children is far safer than any other mode (NHTSA 2002).

In fact, children riding in their parents' automobiles are seven times more likely to be killed in a crash than if they were riding in a school bus (NHTSA 2006). Approximately 152,000 school children per year are injured in crashes during typical school travel hours. Only about 4% of those injuries are school bus-related, though school buses account for 28% of student-miles traveled each year. In comparison, injuries to school children traveling in passenger vehicles account for 89% of student injuries, though traveling in passenger vehicles accounts for 67% of student-miles traveled. Walking and bicycling to school produce even higher injury rates (National Academies 2002).

Roughly six US children die as school bus passengers each year (NHTSA 2006). An additional 17 die when in loading and unloading areas when hit by other vehicles illegally passing stopped school buses or by school buses. That represents roughly a 3:1 ratio of fatalities in loading/unloading areas compared to bus passenger fatalities. NHTSA (2006) references an earlier National Academy of Sciences (NAS) publication that suggests funds might be better directed to other school bus safety programs rather than to installing seat belts. "NHTSA agrees with the NAS that States and localities should focus their efforts toward improving school bus loading zones" (NHTSA 2006).

School buses provide protection because of their visibility, size, and weight. The added protection of compartmentalization was adopted in 1977 under Federal Motor Vehicle Safety Standard 222 (FMVSS 222). Compartmentalization provides crash protection for children on large school buses by providing strong, closely-spaced seats that have energy-absorbing backs to protect children in front- and rear-end crashes.

3.2 Differing Opinions

Installation of school bus seat belts is an emotional and heated issue because the lives of small children are at risk. Despite the strong school bus safety record, there is disagreement about whether seat belts are the best way to protect these children. One school of thought believes the introduction of seat belts will help save lives and prevent injuries, but another school of thought does not see a justifiable reason for going beyond the current safety requirements that make school buses the safest mode of road transportation.

Advocacy groups and the medical community believe seat belts will reduce the probability of serious injury and death and will improve the behavior of child passengers. They point to the record of lives saved from installation of the belts in passenger vehicles, and they feel children should learn to use the seat belts in both automobiles and school buses.

In general, the education and transportation-safety communities have been less enthusiastic toward school bus seat belts. These groups contend there is little scientific research demonstrating seat belts will significantly reduce severe injuries and deaths among bus passengers. They believe compartmentalized seats provide excellent safety for child passengers. They also note that studies indicate the large expense of installing seat belts could be less cost effective than other types of safety countermeasures for school buses.

3.3 School Bus Configurations

Choosing the most cost-effective configuration of rows and seats inside different sizes and types of school buses is a primary issue in the cost of installing seat belts. The following information is helpful in understanding the key considerations.

There are four types of school buses: A, B, C, and D. Types C and D are large buses. Their passenger capacity is generally 48-71. They account for over 90% of all the buses and are the type of buses considered in this study. Types A and B are smaller school buses with typical capacities of 8 to 24 (Nordberg 1998).

Today's typical large school bus seats are configured with rows of seats flanking a central aisle. Each seat is 39 inches wide, has seatbacks 20 inches high, and holds 3 elementary-age children. Rows are typically spaced up to 24 inches apart, and the aisle is normally 12 to 14 inches wide. This seat/aisle arrangement is called a 3/3 configuration and an example is shown in Figure 3-1a (ITRE 2007). When larger school children are present, this configuration may only allow two occupants per seat.

The configuration changes when large school buses are equipped with lap/shoulder belts. First, to accommodate the belt system, the seatbacks are usually 28 inches or higher rather than the traditional 20 inches. The buckle latches are set 15 inches apart, so the belts cannot accommodate 3 elementary-age children in 39 inches. This means fewer children can be accommodated on each row. One configuration allows five children per row, with three children on a wider seat on one side of the aisle and two children on a narrower seat on the other side of

the aisle. This is called a 3/2 configuration and is shown in Figure 3-1b. Another configuration used when larger students are anticipated is the 2/2 configuration, with equal-width seats flanking a central aisle.

There appears to be a way to overcome the loss of capacity due to seat belts: flex seating. "Two manufacturers have introduced school bus seats with lap/shoulder belts on the common 39-inch-width bench seats, which allow the configuration of the belts to be flexible" (NHTSA 2008).

a: A typical 3/3 school bus seat without belts. b: A typical 3/2 school bus with belts (ITRE 2007).

Figure 3-1. Typical large school bus seating configuration

3.4 Rules and Legislation

3.4.1 Rules and Regulations

Rules for school buses change periodically, after study and analysis of the benefits, costs, and other issues. The primary regulatory agency for school buses is the National Highway Transportation Safety Administration (NHTSA). This agency has done many school bus-safety analyses, and UA researchers have reviewed virtually all the recent NHTSA reports on school buses. A good example is contained in the Notice of Proposed Rule-making for school bus safety issued by USDOT (STN Media Group 2007) just before the beginning of this pilot project. The Notice called for five changes:

- Increase seatback heights from 20 inches to 24 inches.
- Require lap/shoulder belts on type A buses.
- Require a minimum 15-inch seat width for passengers on school buses.
- Require seat belt standards for anchorage, seat strength, belt retraction, and belt adjustability.
- Require self-latching mechanisms for seat cushions that flip (for cleaning).

NHTSA conducted a thorough analysis of all five proposals, plus an analysis of the cost-benefit of voluntarily installing lap/shoulder belts on large school buses, and issued a report of its findings (NHTSA 2008). That report was a key resource for the pilot project.

3.4.2 Sample State Legislation

In 1987, New York became the first state in the nation to enact a law that required two-point seat belts on large school buses. "Use of the lap belts is not made mandatory but is dependent on individual school districts adopting a policy requiring their use" (STN Media Group 2007). New Jersey was the second state to require lap belts on large buses in 1992. Unlike New York, the use of seat belts in New Jersey is mandatory. Both states require seatbacks to be 28 inches high (STN Media Group 2007).

"Florida passed a state law in 1999, but the law did not specify whether a lap belt or lap/shoulder belt was required" (ITRE 2007). The law required that all school buses purchased after December 2000 "must be equipped with safety belts or with any other restraint system approved by the Federal Government" (STN Media Group 2007). By February 2007 however, implementation of this law was only 50% complete. The "Florida law requires belts only on newly purchased buses, so there is no retrofitting, and new bus purchases are staggered around the availability of funds" (Governor's Study Group 2007).

In 2001, California passed legislation requiring three-point lap/shoulder belts to be used on all new school buses. The California law required that by July 1, 2005, all new school buses regardless of size be equipped with three-point seat belts (STN Media Group 2007). However, by February 2007, "only 3% of the buses in California [complied] with the state law.... Some school districts in California purchase used buses only so they never have to comply with the state law requiring seat belts on new buses" (Governor's Study Group 2007).

Louisiana school bus seat belt legislation took effect in 2004 (STN Media Group 2007). However, the Louisiana legislation is subject to appropriation of funds, and it is not enforced because no appropriation legislation has been approved (ITRE 2007).

On June 8, 2007, Texas enacted a school bus seat belt law requiring all Texas school buses purchased on or after September 1, 2010, to be equipped with three-point lap and shoulder seat belts for passengers. "The new law was a result of the tragic school bus accident that occurred on March 29, 2006, near Devers, Texas" (Cherry 2007).

3.5 Additional Information

UTCA report 07407-3 documents the literature review conducted at the beginning of the pilot project. Readers will find additional topics and additional details in that report.

Section 4
Stakeholder Attitudes

This portion of the project was conducted to determine the attitudes of stakeholders involved in the project before and after the installation of seat belts. It included parents, children, drivers, aides, principals, and transportation supervisors over the life of the pilot project. ALSDE administered surveys to these stakeholder groups, collected the completed surveys, and forwarded them to UTCA for analysis and report preparation.

The survey was performed twice. The pre-survey was administered in April 2008, before any students rode in buses equipped with the seat belts. The post-survey was administered in April 2010, after two years with the seat belts. In general, each question offered respondents five possible answers – strongly agree, agree, neither, disagree, and strongly disagree. Respondents also had the opportunity to provide written comments.

4.1 General Overview of Responses

There was a good response to both the pre-survey and post-survey. Many stakeholders provided insightful comments to support their ratings.

The overall tone of the responses was positive. The strongest and clearest message from all stakeholder groups is that they believe school buses are safe and seat belts will make them even safer.

This section provides a brief overview of stakeholder attitudes. Five areas in particular reveal relevant information, and they are highlighted in the following paragraphs. Those interested in stakeholder attitudes are referred to more complete discussions in UTCA reports 07407-2, 07407-7, and 07407-8, which were prepared to document the results of the surveys.

4.2 Parents' and Children's Opinions

Parents believe school buses are safe. They express more concern with bullying on the bus than with the possibility of traffic accidents: Over 90% of parents in both surveys believe "my child's bus ride to and from school is safe with respect to traffic accidents," while only 68.4% of parents in the pre-survey and 66.2% of parents in the post-survey believe "the bus ride to/from school is acceptable with respect to bullying/fighting with other children."

4.3 Drivers' Opinions

Drivers are the backbone of the system. UTCA student workers viewing digital images to monitor seat belt use rates continually noted that a good bus driver set the tone for the entire bus, especially seat belt use.

Drivers expressed belief in the ability of seat belts to improve school bus safety. However, their ratings and written comments also indicated two concerns with seat belts: 1) higher seatbacks reduce the driver's ability to see pupils and 2) drivers may be held responsible for ensuring students wear their belts. The following comments exemplify these points:

- "I feel that if seat belts are used on the bus then the principals will need to back the bus drivers concerning the rules of the seat belts and enforcing them."
- "For every advantage there is a disadvantage. Enforcement by the driver is almost impossible. Aides will be necessary to make this successful. High seatbacks are a visibility problem for the driver!"
- "Seats are too high. Cannot see what children are doing."

4.4 Principals' Opinions

Although principals were among the strongest supporters of belt use, they were not as optimistic about seat belts in the post-survey as in the pre-survey. Their comments do not provide insight into the reason, but it could have been because fewer principals participated in the post-survey. General observations can be made about principals' views toward seat belts:

- Principals believe school buses are safe with respect to traffic accidents.
- Participating principals tend to believe school bus seat belts will make children safer with respect to traffic accidents.
- Responding principals tend to believe school bus seat belts will improve student behavior and decrease discipline problems.

4.5 Transportation Supervisors' Opinions

Transportation supervisors believe school buses are already safe. Several expressed concern for adding seat belts in their written comments:

- They believe adding seat belts will cause a serious loss of capacity for their fleet.
- They believe adding seat belts will increase expenses, require more resources, and increase the time required for the buses to run their routes.

4.6 Who Sets Expectations?

Principals, transportation supervisors, and drivers/aides were asked "who is most responsible for setting expectation for pupils to use lap/shoulder belts on school buses?" The questionnaire listed

six possibilities: the State Board of Education, principals, teachers, drivers/aides, parents, and other children.

No group was consistently identified as most responsible for encouraging or requiring seat belt use. However, aggregating the top three votes from each post-survey stakeholder group yielded the following results:

- Parents were deemed most responsible by two groups (including one tie).
- Drivers/aides were deemed most responsible by two groups (including one tie).
- Principals were deemed the third most responsible.
- Other children were deemed fourth most responsible (receiving only the drivers/aides third-place vote).
- Respondents did not feel the State Board or teachers were responsible for setting seat belt-use expectations.

Only the opinions of the drivers/aides changed from pre-survey to post-survey. In the pre-survey, they voted themselves most responsible and parents least responsible. In the post-survey, they voted themselves and parents as tied for most responsible.

4.7 Summary

Pre- and post-surveys were used to assess the attitudes of stakeholders in the decision to implement seat belts on school buses. Parents and children, drivers and aides, principals, and transportation supervisors participated in the surveys.

The strongest finding was a consistent belief across groups that school buses are safe and that seat belts will make them even safer.

Again, readers who desire details should consult the three UTCA project reports on this topic.

Section 5
Seat Belt-Use Rates

Determining the percentage of students who use seat belts was an important part of this study. If a large percentage of students do not use seat belts on the school bus, then the potential safety gains from seat belts would be compromised.

This section of the report describes the seat belt-use rates for two time periods. Over 64,000 observations of individual students were made during the *2008-09* school year, and an additional 105,500 observations were made in the *2009-10* school year, for a total of almost 170,000 observations. The *2009-10* data and findings were generally similar to those of *2008-09*.

This section briefly reviews important findings from the analysis of school bus seat belt-use rates and the factors that influence them. Additional details may be found in UTCA reports 07407-4 and 07401-10.

5.1 Research Protocols

The study was designed to investigate a variety of situations. It included a representative cross section of 10 local school systems representing elementary, middle, and high schools; rural and urban locales; city and county systems; and small and large populations across the state. Three manufacturers provided 12 type C and D buses, three manufacturers provided alternative seat configurations, and three manufacturers provided digital camera systems. Bus aides were hired for six of the buses; the other six buses did not have aides.

Discussions with national school bus experts and Alabama school transportation supervisors and examination of early digital video from the buses were used to establish the data-collection process. The research team collected data at the times suggested by experts as most typical: the Tuesday, Wednesday, and Thursday afternoon routes. Data were not collected on Monday or Friday, the first or last week of the school year, special-event days, school holidays, school placement-test days, and similar events because student behavior and belt use would not be normal on those days. The "normal" rate determined in this manner would be the highest rate that could be expected during a normal school week.

In 2008-09, UA researchers used 11 buses for data collection on the Tuesday-Wednesday-Thursday afternoon route. Data were collected from the beginning until the end of the route. One bus was designated as a control (control bus one) and data were collected from it for all weekdays, morning and afternoon routes, from the beginning to the end of routes. This allowed a thorough evaluation of belt use during "atypical" times. It also provided a way to adjust the "normal" use rate to represent all time periods. Data collection for the 2009-10 school year was

slightly different. Data from "normal" times were collected for 10 route buses, and two buses (control buses two and three) were used as controls. The third control bus provided additional data in case there was disagreement between the first two.

5.2 Data Collection

The 12 school buses were configured with four fish-eye digital cameras mounted in the ceilings. One camera was placed at the front left of the bus to observe the driver and to count the number of students entering and exiting the bus. The other three were spaced along the center of the bus. Periodically, the hard drive for each camera system was removed and replaced with a backup hard drive, while the original drive was mailed to UA for data processing. This allowed UA undergraduate research assistants enough time to observe the images, capture the data, and place it in a database. The hard drive was then mailed back to the school system.

All twelve school systems captured data for both school years, but not all school systems provided large amounts of data. Typically, this was due to difficulties in the installation or operation of the camera systems. One bus was not in operation for most of the first year due to such difficulties.

5.3 Data Analysis

5.3.1 Variability in Use Rates

As shown in Table 5-1, more than 64,000 individual observations of seat belt use were recorded during the first school year. Most of the observations were for the afternoon route. The large number of observations provides reliability to the study results.

The most striking result in the table is the extreme variability from bus to bus. Examination of the third column shows that the appropriate use of seat belts ranged from a high of 94.5% on one bus to a low of 4.8% on another bus. Likewise, the cumulative number of pupils observed on individual buses ranged from a high of almost 24,000 to a low of less than 100. (Low values were because some buses experienced continuing difficulties in installing the seats and operating the camera system.)

The most important piece of data in the table is the average seat belt use for the first year of the project. Although it is informative to compare the belt use rates from bus to bus, the system average for afternoon routes is the value desired for this study (62.8% from Table 5-1). This value tells us that on a normal day, on the afternoon route, an average of 62.8% of students are buckled appropriately, 7.8% are buckled inappropriately, and 29.4% are not buckled.

Table 5-1. School bus seat belt use observations (*2008-09*)

Bus	Pupils observed	Used Properly %	Used Improperly %	Not Used %
Bus A	24,851	87.5	7.2	5.3
Bus B (Aide)	6,705	71.2	15.0	13.8
Bus C (Aide)	2,093	59.4	2.2	38.6
Bus D (Aide)	838	94.5	2.5	2.9
Bus E (Aide)	1,353	16.1	2.7	81.2
Bus F	12,984	38.8	2.8	58.4
Bus G	81	8.6	2.5	88.9
Bus H (Aide)	1,742	78.9	4.9	16.2
Bus I	5,438	4.8	1.9	93.4
Bus J (Aide)	3,588	58.9	19.5	21.6
Bus K	3617	73.3	24.4	2.3
Bus L	952	20.5	5.6	73.9
Total	64,242	40,351	5,023	18,870
Average of Buses*	5,354	51.0%	7.6%	41.4%
Standard Deviation	7094	32.0%	7.7%	35.7%
Coef. of Variation	1.33	0.63	1.02	0.86
System Average**		**62.8%**	7.8%	29.4%

*Average of buses = average of the individual use rates of the 12 buses
**System average = total pupils belted ÷ total pupils observed

There were many similarities in the two data samples (2008-09 and 2009-10), including extreme variability. There was variability from bus to bus, but there was also variability for some buses from year to year. Figure 5-1 shows that for bus D the use rate fell almost 40% from the first year to the second, while for Bus I the use rate increased about 33%. These dramatic changes were due to loss of an aide for Bus D and change of the driver for Bus I.

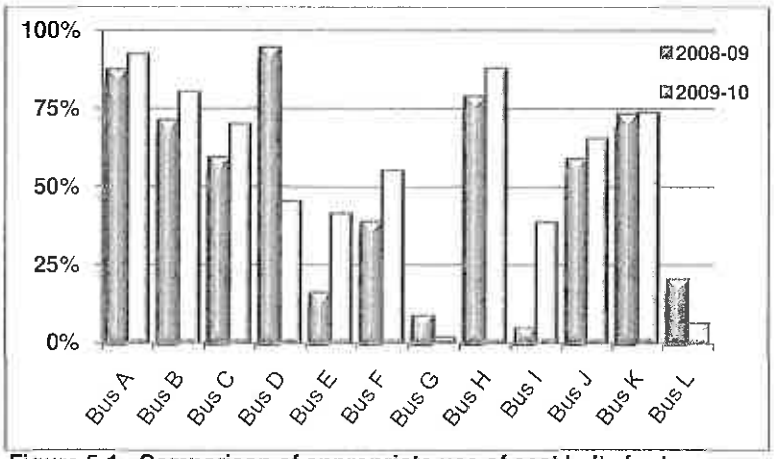

Figure 5-1. Comparison of appropriate use of seat belts for two years

5.3.2 Average Rate of Seat Belt Use

For the 2008-09 year, the bus with the highest rate of appropriate use was 94.5% and the lowest rate was 4.8%. During 2009-10 the highest rate was 92.4% and the lowest rate was 1.9%. The

spread from high to low was about 90% both years. Interestingly, these four values came from four different buses.

The average rate of appropriate seat belt use was 62.8% in the first school year and 60.7% in the second school year. These are similar values. When all 170,000 observations are considered, the average rate of appropriate seat belt use is 61.5%. This value is taken as the rate for the entire study period and is used in cost-effectiveness determinations and other analyses.

5.3.3 Pupil Visibility Issues

In states that have enacted school bus seat belt legislation, drivers have expressed concern about bus discipline because it is more difficult to see the pupils. The drivers in the Alabama pilot project expressed the same concerns in the stakeholder surveys. The loss of visibility is due to increased height of the seatbacks to provide a secure place to attach the top anchor of three- and four-point belts. Typically, the seatback height is increased from 20 inches to 28 or 32 inches.

The visibility issue was investigated in 2008-09 using two buses. UA researchers determined the number of pupils on a bus at any one time by counting pupils as they entered and exited the bus. Then each seat was examined to determine whether a pupil could be seen on the digital camera system. If a pupil could be seen, he or she was observed for the presence of a seat belt.

For the first bus, UA student assistants could not determine belt use for 34.7% of pupils, even using extensive observation time. For the second bus, UA researchers could not see or identify seat belt use for 30.6% of them. Bus drivers on an average bus (without overhead digital cameras) will almost certainly have considerably less success in determining belt use. This finding implies that the high seatbacks and other conditions pose a considerable challenge for drivers in enforcing belt use, regardless of the bus loading or pupil ages.

5.3.4 Other Factors

UA researchers examined trends and factors that might be important in encouraging seat belt use. Examples include the effectiveness of the driver or aide, the ages of pupils, the time of day and day of week, the length of the route, and types of inappropriate belt use (leg in aisle, wearing back pack, etc.). The roles and relationships between many of these factors could not be determined statistically, typically because of small sample sizes (only 12 buses and 6 aides).

Video observation brought clarity to some of these issues. For example, the video observers concluded the most important factor in the rate of seat belt use was the bus driver. A driver who cared for pupils and consistently encouraged seat belt use overcame much of the resistance to belt use.

5.4 Summary

This brief overview has documented several findings. First, there can be high levels of variability in the appropriate use of school bus seat belts from bus to bus and, for some buses,

year to year. Second, based on almost 170,000 individual observations of pupils, the average rate of appropriate seat belt use in the Alabama test buses during two combined test years was 61.5%. Third, many factors affect seat belt-use rates. The data were sufficient for UA researchers to identify many of them and to document the specific effects of some of them. Extensive visual observations by research assistants provided clarity to others.

Section 6
Bus-Capacity Analysis

The bus-capacity analysis was conducted to determine the percentage of buses with insufficient capacity to carry their current pupil loads after installation of seat belts. The analysis was also intended to recommend strategies and fleet-size requirements for optimal utilization of school buses. The study was limited to type C and type D school buses with capacities ranging from 71 to 84 elementary-school pupils, which are typical in Alabama.

Seat belts require stronger seats (3,000 pounds on each belt anchor [NHTSA 2008]) to handle the shock loads at impact. These loads require stronger frames with thicker seatbacks. Seat manufacturers report the seatbacks will be five to seven inches thick, meaning each row of seats will require two to four more inches of space. A normal bus needs to be extended 24 to 48 inches to accommodate all 12 of its rows. If bus passenger compartments are not extended, at least one row of seats would be lost and possibly two. This would be a loss of 8% to 17% of current seat capacity.

Additionally, the belt buckle latches are installed at fixed locations, 15 inches apart, which makes it impossible to seat three elementary-school pupils on a standard, 39-inch-wide bench seat. To compensate, manufacturers are producing configurations with three seats on a wider bench on one side of the bus and two seats on a narrower bench on the other side (loss of one seat per row).

6.1 Previous Research

UTCA researchers located previous studies by NHTSA; the Governments of Indiana, North Carolina, and Texas; and the Congressional Research Service (CRS). These studies identified important issues and provided general estimates of capacity reduction and costs to install seat belts.

Table 6-1 compares the costs and potential reductions in capacity from the five studies. The cost-per-bus column shows more recent studies place the cost of adding seat belts to a school bus at roughly $10,000 to $15,000. Additionally, the possible-capacity-reduction column indicates that up to 33% of a bus's capacity could be lost with the addition of seat belts.

6.1.1 Congressional Research Service

The CRS (2007) report "Seat Belts on School Buses: Overview of the Issue" indicated that three-point lap/shoulder seat belts for a large bus could cost from $8,000 to $15,000. With annual sales of roughly 31,000 new large school buses, the additional cost of equipping the nation's

fleet of large school buses with these belts could be between $250 million and $465 million per year. This is an increase of about 10% to 20% in annual spending on large school buses.

Table 6-1. Summary of reported costs for installation of 3-point seat belts and possible reductions in bus capacity

Study	Date	Cost per Bus	Possible Capacity Reduction
NHTSA Report to Congress (2002)	2002	$2440 to 3550*	17%
Indiana School Bus Study (Steiger 2005)	2005	-	0 to 33%
NC State School Bus Study (ITRE 2007)	2007	$7,700	8 to 17%
CRS Report for Congress (2007)	2007	$8,000 to 15,000	16 to 33%
Texas State Government (LBBS 2009)	2009	$9,300 to $14,000	-

* Cost of a lap/shoulder seat belt, $40 to $50, multiplied by 60 to 71 seats gives total cost for a bus.

CRS proposed several options: (1) maintain the status quo, (2) require lap/shoulder belts on large school buses, (3) encourage the purchase of large school buses with lap/shoulder belts, or (4) pursue alternative safety initiatives. Alternative safety initiatives include shifting pupils from more dangerous modes of transportation (bicycles, walking, and riding in passenger vehicles driven by teens) to safer modes (school buses). Other options include making school bus pick-up and drop-off locations safer, implementing and enforcing graduated licensing programs for teen drivers, and equipping school buses with onboard data recorders. These alternative safety techniques may prove applicable in Alabama if seat belts are not added to the school bus fleet.

6.2 Alabama Capacity Analysis

The capacity-analysis procedure created for this study compares current student loads on buses (by student size) with the seats available after seat belts are added in multiple configurations. If the current student load exceeds the estimated seating capacity, then the bus is over-crowded and the school district must consider purchasing an additional bus.

Four seat-row arrangements were considered. The standard configuration – 12 rows of 3 seats on each side of the aisle (a "3/3-12 configuration") – serves as a baseline for the other configurations:

- 3/3-11 (one row of seats is lost)
- 3/2-12 (one seat per row is lost)
- 3/2-11 (one row and one seat per row is lost)

Most school systems prepare seating charts and assign pupils to specific seats. When a 3-2 configuration is used, elementary-school pupils are assigned to the three-seat side of the bus to prevent two older students from occupying a three seat, thereby reducing capacity. When the three-seat side of the bus is full, elementary-school pupils may spill over to the two-seat side. The Alabama study assumes that this precaution has been taken to ensure efficiency in seating.

6.2.1 Data for the Study – Number of Buses and Pupils per Bus

To conduct this study, UA researchers needed to know the number of students in the bus, their size (either two middle/high-school pupils or three elementary-school pupils can sit on a 39-inch-wide seat), and other pertinent information. ALSDE asked school transportation supervisors to provide these data. There was a good response rate, but it was clear that in some cases supervisors used different terminologies and different methods for handling non-standard routing situations. UA researchers screened the data extensively and removed those data that clearly failed to meet the route and pupil-load definitions provided by UA. The 2,222 buses remaining in the data represent almost 28% of the fleet and constitute a generous sample size for the study.

6.2.2 Configuration Effect on Capacity

After the capacity analysis was performed, the capacity of each bus after seat belt installation was established. Table 6-2 compares the estimated percentage of buses without sufficient capacity to handle their current loads once seat belts are implemented.

Table 6-2. Initial estimates of buses not meeting capacity after seat belt installation (Transportation Supervisor data)

Source of Data	Sample Size	Seat/Row Configuration	Estimate of Buses Not Meeting Capacity
Transportation Supervisors Detailed Data	2,222 Buses	3/3 - 12 rows*	68 (3.1%)
		3/3 - 11 rows	365(16.4%)
		3/2 - 12 rows	145 (6.6%)
		3/2 - 11 rows	445 (20.0%)

*Current configuration, no loss of capacity

The results suggest 3.1% of the fleet's buses are over capacity. This number should be near zero, but some buses in the data may be carrying more than their theoretical capacities given their mix of pupils. For example, three middle-school students may be small enough to share one bench, putting more students in the bus than it can theoretically hold. Other probable causes of the discrepancy are clerical mistakes and number padding by bus drivers or transportation supervisors.

Assuming approximately 1% of the current buses legitimately exceed their theoretical capacity, clerical and other errors have been made for 2% of the buses. UA researchers then reduced the overload percentages in Table 6-2 to 1%, 14%, 5%, and 18% for the 3/3-12, 3/3-11, 3/2-12, and 3/3-11 configurations respectively.

6.2.3 Reducing the Number of Additional Buses Needed

Many school buses will have insufficient capacity once seat belts are installed. However, Table 6-3 shows some buses would exceed their capacity by only a few pupils. For a 3/2-11 configuration, 95 buses (21% of the sample) would be over capacity by only one pupil, and 238 (53% of the sample) would be overloaded by three or fewer pupils. For a 3/3-11 configuration, almost half the overloaded buses would no longer be overloaded if two pupils could be moved to

another bus or another seat configuration could be adopted. Removing only a few pupils can change the "over capacity" status of many buses.

Table 6-3. Buses by number of pupils overloaded (2,222 buses in sample)

Range of Pupils Beyond Capacity	3/2-11	3/2-12	3/3-11	3/3-12
1	95	77	92	68
2	75	20	71	0
3	68	6	73	0
4-6	140	22	129	0
7-12	41	30	0	0
13-17	26	0	0	0
>17	0	0	0	0
Theoretical max loss of capacity (pupils)	17	12	6	0
Buses > max theory loss of capacity	0	0	0	68
Total	445	144	365	68

Shaded areas indicate buses overloaded beyond theoretical capacity.

Given the results of Table 6-3, school systems might be able to minimize the capacity loss due to seat belts, especially when capacity is exceeded by only a few pupils. The following suggestions might help reduce the number of additional buses needed:

- For buses carrying only middle- and high-school pupils, capacity could be maximized with a 2/2 configuration, which avoids the 30-inch-wide seat of a 3/2 configuration.
- Transportation supervisors might change bus routes by shifting three to six pupils to an adjacent route that is under capacity.
- Some buses could run additional short routes without exceeding the drivers' allotted work hours. Drivers' salaries and benefits are the greatest cost item over the life of a school bus, and this provides more driver service without driving up cost.
- Some capacity could be gained if the State stops granting exceptions to its prohibition on school buses for pupils who live within two miles of school.

6.3 Impact of Flex Seats and Longer Seating Compartments

Flex seats are adjustable and can accommodate two large pupils or three small pupils on every bench on both sides of a bus. UTCA evaluated flex seats using video observations, phone interviews with school systems in other states, and a field observation. The evaluation found that flex seats work well, especially for smaller pupils. However, the four Alabama pilot-project buses with flex seats used minimum row spacing to provide 12 rows of seats, and the aisles were narrow.

Other states identified row spacing and aisle width as flex-seat issues when carrying middle- and high-school pupils. The narrow aisle can be partially overcome by staggering rows on either side of the bus (that is, the left and right benches are not directly across from each other). ALSDE

prefers max row spacing, which would require a 3/3-11 configuration for typical bus lengths, resulting in a loss of one row of seats.

There may be a second way to mitigate loss of capacity due to seat belts. School bus manufacturers can lengthen school bus seating compartments to restore the row of lost seats. However, that change would require lengthening the wheel base, making the bus more difficult to control, requiring a larger turning radius, and causing the rear of the bus to scrape on some rail road crossings or dips in the road. This is a detriment to bus movement, especially in small, crowded school areas and on narrow, crooked rural roads. As individual school systems contemplate using flex seats, they can examine their bus movements to determine where a longer bus wheelbase is possible.

Taken together, flex seats and longer seating compartments offer the possibility of maintaining each bus's current capacity while using seat belts. However, the degree of local success will be linked to configuration decisions made by individual school systems when they purchase school buses.

6.4 Summary

Installing seat belts on school buses reduces capacity in two ways. First, the thicker seatbacks take more floor space and result in the loss of one or more rows. Second, three elementary-school pupils cannot sit on one bench with the minimum fixed width between belt-buckle latches, so seats must be a little narrower (for two pupils) on one side of the aisle and a little wider (for three pupils) on the other side. As a result, one seat is lost per row.

The potential for losing school bus capacity has been known for some time, but the inability to obtain accurate pupil-load data for each bus in the system has limited the ability of previous studies to accurately estimate losses for various seat/row configurations. The pilot study overcame these limits by using the number and sizes (elementary and middle/high school) of pupils on 2,222 route buses operating in Alabama. This study was more analytical and used better data than any study identified in the literature.

Data screening and testing limited the estimated error rate to a maximum of 2%. This maximum error rate was subtracted from the estimated rate of buses failing to meet capacity after seat belts are installed (Table 6-2) to yield the percentage of buses overloaded following implementation of seat belts: 3/2-12 (5%), 3/3-11 (14%), and 3/2-11 (18%). In other words, depending on the configuration selected, between 5% and 18% more buses would be needed.

There are two ways to possibly regain lost capacity. The first way is to use flex seats, which accommodate either three small pupils or two large pupils on each bench seat. UA researchers confirmed the operation of these seats during the pilot study. However, they cost more than other types of seats and they occupy more floor space, leading to less leg room and narrower aisles.

The second way is to lengthen the passenger compartment to offset the loss of a row of seats. However, this requires a longer wheelbase, which could lead to difficulties in small school drop-off areas or on narrow roads with sharp curves.

In summary, this study was the most analytical and used the best data of any configuration/capacity study conducted to date. It has provided the best estimates of capacity loss when seat belts are installed. It has also suggested ways to overcome part or all of those losses.

6.5 Additional Information

Readers interested in additional information about the effects of seat belts on school bus capacity should consult UTCA report 04704-7.

Section 7
Cost Effectiveness

7.1 Introduction

The key piece of missing information in the decision to implement school bus seat belts is cost effectiveness. This section of the report provides an overview of the pilot project cost-effectiveness study. Complex issues are involved, such as determination of the costs and benefits of seat belts, effects of various seat configurations and resulting capacity losses, sizes/ages of pupils, seat belt-use rates, and the anticipated number and severity of crashes with and without the belts. For more details, please consult UTCA report 07407-9.

For this study, UTCA researchers adopted the cost-effectiveness methodology used in NHTSA (2008): "Final Rule to Upgrade School Bus Passenger Protection in FMVSS Nos. 207, 208, 210, and 222."

Table 7-1 gives a simplified outline of the methodology used. In general, the steps are addressed in sequence in the remainder of this report.

Table 7-1. Outline of cost effectiveness methodology for the Alabama pilot project

1	Define the specific goal(s) of the study
2	Identify sources of potential benefits and costs and the data needed to conduct the study
3	Determine if data are available and in the appropriate format (crash, fatality, and injury statistics on the MAIS scale)
4	Determine the effectiveness of available countermeasures
5	Apply safety-effectiveness ratios of countermeasures to determine potential lives saved and injuries prevented
6	Determine the costs of implementation
7	Determine the benefits (NHTSA Value of a Statistical Life)
8	Determine the benefit/cost ratio and the time value of benefits
9	Identify best use of funding (including alternative safety uses, if appropriate)
10	Summarize study and prepare recommendations

7.2 Data Sources

Once the goal of the study (a NHTSA-type cost-effectiveness review) was defined, the next step was to identify the required data and to obtain that data.

7.2.1 Cost Data

ALSDE compiled cost information from its records and from quotes obtained from school bus vendors (Table 7-2). Most entries in the table are self-explanatory, but others require explanation. The entries under the heading "additional cost of seat belts" refer to the additional expense of seat belts beyond the cost of traditional seats. For example, "3/3 with max seat spacing" refers to 11 rows of seats, 3 seats on each side of the bus aisle.

Table 7-2. Average 2010 costs for school bus purchase and operation

Expense Category	Cost
New school bus, average cost	$79,890
Operating costs – annual fuel per bus	$4,867
Operating costs – annual maintenance/other per bus	$3,106
Average salary/wages – driver:	$14,106/$12,165; total $26,271
Average salary/wages – aide:	$10,092/$12,165; total $22,257
Additional cost of seat belts	
3/3 with max seat spacing:	$12,000
3/3 without max spacing:	$15,000
3/2 with max seat spacing:	$11,000
3/2 without max spacing:	$13,000
Additional cost of extending passenger compartment to offset loss of a row of seats due to thicker seatbacks	$1,000
Fleet replacement cycle is 10 years Growth/year: Pupils transported = 0%; Buses **purchased =0%; miles traveled = 1.1%** Source: ALSDE	

7.2.2 Capacity-Loss Data

Seat belts reduce the number of seats available on buses, with the size of the reduction related to the seating configuration chosen. Similar studies have been limited by the complexity of seating configurations and the lack of accurate data. The pilot project used actual pupil loads (the number and sizes of pupils) on individual buses. The data were carefully screened and tested, and erroneous or questionable data were removed. The 2,222 buses remaining in the sample were analyzed to determine the percentage of overloaded buses for each configuration. To restore capacity, a new bus must be purchased to replace each overloaded bus.

The initial results indicated 3% of existing buses were already beyond capacity (see Section 6). UA researchers were aware that up to 1% of buses were over running over capacity. This meant that the baseline estimate (for the current 3/3-12 configuration) contained as much as 2% error. UA researchers concluded that it was reasonable apply a 2% reduction to the calculated overload percentages in Table 6-2. This produced overload estimates of 1%, 14%, 5%, and 18% for the 3/3-12, 3/3-11, 3/2-12, and 3/3-11 configurations respectively.

7.2.3 Crash Data

The primary benefit of seat belts is reduced fatalities and serious injuries, so the data needed for this study are the numbers of fatalities and injuries to pupils inside school buses when crashes occur. Drivers were not considered in the analysis because they have seat belts, and pupils outside the bus were not considered because the belts cannot help them.

Sufficient Alabama school bus-injury data were available to perform the analysis. However, fatal school bus crashes in Alabama are too rare for statistical analysis, so the national school bus-fatality pattern was used as a proxy for the Alabama school bus-fatality pattern.

Table 7-3 shows 10 years of Alabama injury data (1999-2008). The injuries are sorted by the severity level assigned by crash investigation officers using the KABCO injury scale.

Table 7-3. Pupils injured in Alabama school bus crashes (1999-2008)

Year	K killed	A visible or carried from scene	B bruise or abrasion or swelling	C minor pain or faint	O not injured	Total
1999	0	80	13	60	319	472
2000	0	53	9	14	290	366
2001	0	17	2	26	251	296
2002	0	36	4	42	235	317
2003	0	23	5	38	304	370
2004	0	15	1	37	288	341
2005	0	44	1	45	292	382
2006	4	82	10	23	306	425
2007	0	19	17	30	319	385
2008	0	33	4	39	231	307
Total	4	402	66	354	2835	3661
% all crashes	0.1%	11.0%	1.8%	9.7%	77.4%	100.0%
Average	0.4	40.2	6.6	35.4	283.5	366.1

At this point, 10 years of Alabama injury and fatality data were available. The injury data included injury severity and crash characteristics. However, the KABCO injury scale used by crash-investigation officers cannot be directly related to injury treatment or injury costs, so the data must be transformed so it can be used.

The data transformations were performed using NHTSA's (2008) method. Some of the transformations were complex and cannot be described easily in the limited space available in this report. They are briefly described:

- The KABCO data were translated to the Maximum Abbreviated Injury Scale (MAIS) (Table 7-4).

- Fatalities/injuries were associated with crash impact points on school buses (which was needed because seat belts are unequally effective for front, side, and rear impacts and rollover crashes).
- Fatalities/injuries were associated with pupil age groups (which was needed because younger pupils have more serious injury consequences).
- Fatalities/injuries were associated with principal body part injured (which was needed because injuries to the head, thorax, and trunk are more serious than to other body parts).

Once these transformations were made, it was possible to estimate fatality reductions and reductions in the severity of injuries.

Table 7-4. Transformed annual Alabama school bus injuries and fatalities by MAIS injury level and point of impact on the bus

MAIS Injury Level	Front-End Impact	Side Impact	Rollover	Total
0	79.08	122.76	0.08	201.92
1	14.22	28.82	0.72	43.76
2	4.10	5.24	0.35	9.69
3	2.06	2.37	0.24	4.67
4	0.26	0.32	0.05	0.63
5	0.18	0.18	0.04	0.40
Level 1 - 5 Injuries	20.82	36.93	1.40	59.15
Fatalities	0.10	0.09	0.14	0.33

MAIS Level 0 indicates no injury

7.3 Implementation Phasing and Associated Costs

The cost of installing seat belts on every bus at once is prohibitive. Moreover, the frames of existing buses were not designed to anchor the new seats or to absorb shock forces from the new seats during a crash. It is more realistic and more cost-efficient to phase in seat belts as new buses are purchased. The ALSDE policy is to replace its school bus fleet over a 10-year period, so each year an additional 10% of the fleet will have seat belts. This means 10% more safety benefits and 10% more costs. It also means increasing the school bus budget each year.

A second cost issue is that individual school systems have choices to make: bus type, bus manufacturer, seat manufacturer, seat configuration, seat spacing, bus length, whether to employ an aide, and similar issues. UA researchers conducted analyses to determine the direct (purchase) and indirect (offset loss of capacity) costs of each seat configuration and minimum/maximum row spacing.

Table 7-5 tabulates the costs for phased implementation for the four seat configurations under study. A fifth configuration was added during this portion of the study. It is a flex-seat bus with an extended passenger compartment to offset the loss of a row of seats. It was the least costly option for implementing seat belts, at a 10-year cost of $117,600,000. After the phase in, annual costs stabilize at $11,760,000. The most costly option was the 3/2-11 with aides, at a 10-year

cost of $1.4 billion. After the phase in, annual costs stabilize at $236,790,000. Regardless of the configuration, the table reflects large costs, especially when the nation is dealing with an economic downturn.

Table 7-5. Summary of costs of school bus seat belts by configuration over a 10-year installation period, without consideration of the time value of money (2010 dollars)

Column 1	2	3	4	5		6	
Configuration	Year	Fleet Rotation (x $1000)	Restore Capacity (x $1000)	Added w/o Aides (x $1000)	Added w/ Aides (x $1000)	Cumulative w/o Aides (x $1000)	Cumulative w/ Aides (x $1000)
3/3-12 Flex[1,2]	1st	$11,025	$759	$12,058	$27,990	$12,058	$27,990
	Continue for years 2 – 9						
3/3-12 Flex[1,2]	10th	$11,025	$759	$14,524	$182,916	$132,909	$1,055,300
3/3-11[3]	1st	$8,820	$9,465	$21,812	$39,781	$21,812	$39,781
	Continue for years 2 – 9						
3/3-11[3]	10th	$8,820	$9,465	$53,566	$223,985	$376,839	$1,319,601
3/2-12[4,2]	1st	$9,555	$3,437	$14,259	$30,813	$14,259	$30,813
	Continue for years 2 – 9						
3/2-12[4,2]	10th	$9,555	$3,437	$25,662	$194,676	$199,606	$1,128,216
3/2-11[5]	1st	$8,085	$12,088	$24,728	$43,340	$24,728	$43,340
	Continue for years 2 – 9						
3/2-11[5]	10th	$8,085	$12,088	$65,718	$236,790	$452,228	$1,401,424
3/3-12 Long[6]	1st	$11,760	$0	$11,760	$0	$11,760	$27,521
	Continue for years 2 - 9						
3/3-12 Long[6]	10th	$11,760	$0	$11,760	$0	$117,600	$1,038,277

[1]Standard length bus, flex seats at min spacing
[2]Min spacing of seats does not meet ALSDE spacing criteria
[3]Standard length bus, flex seats at max spacing, loss of one row of seats due to seatback thickness
[4]Standard length bus, standard seats at min spacing
[5]Standard length bus, standard seats at max spacing
[6]Extended length bus to accommodate flex seat with max spacing, no loss of a row due to seatback thickness

7.4 Estimates of Benefits

7.4.1 Reduction of Injuries and Fatalities

Seat belts give better protection for some types of crashes (points of impact) than for others. For front-end crashes, NHTSA (2008) related the impact forces on un-restrained crash dummies in sled tests to the transformed data and predicted injuries and fatalities. By repeating the test with restrained (lap/shoulder belts) dummies, it was possible to predict the reduction in fatalities and injuries.

Sled-crash testing was not available for other points of impact, so NHTSA used proxy values. For side impacts and rollover crashes, belt-effectiveness rates for automobiles were taken from Kahane (2000). For rear impacts, seat belts do not offer additional protection above that of compartmentalization. Nor are seat belts effective for "non-collision events." These last two categories accounted for about 15% of fatalities and injuries but were omitted from further study because seat belts do not produce benefits for them. Table 7-6 shows the values used by NHTSA.

Table 7-6. NHTSA (2008) crash reduction factors by point of impact

Point of Impact	Front	Side	Rollover	Rear	Non Collision
Crash Reduction	Sled tests	21%	74%	N/A*	N/A*

*Seat belts do not provide meaningful reductions for these points of impact

Researchers applied the reduction factors for front-end, side, and rollover crashes to the transformed (KABCO to MAIS) Alabama data in Table 7-4 to estimate the number of injuries and deaths prevented by seat belts, assuming 100% seat belt use. But the average seat belt-use rate was 61.5%, as determined through 170,000 observations of individual pupils (see Section 5). Accordingly, the fatality/injury-reduction estimates were reduced to 61.5% their initial value. The results are shown in Table 7-7.

Table 7-7. Annual reductions of injuries and fatalities, reflecting average seat belt use of 61.5%

Injury Levels	Front	Side	Rollover	Totals
MAIS 1	0.61	3.72	0.33	4.66
MAIS 2	0.75	0.68	0.16	1.59
MAIS 3	0.59	0.31	0.11	1.00
MAIS 4	0.15	0.04	0.02	0.21
MAIS 5	0.10	0.02	0.02	0.14
Total Injuries	2.20	4.77	0.64	7.60
Fatalities	0.05	0.01	0.06	0.13

On average, the belts will save 0.13 lives and 7.60 injuries per year. The seat belts were 39% effective in reducing fatalities and 13% effective in reducing injuries. However, the change in injuries was better than it first appeared. Although few injuries were prevented, many serious injuries were made less serious by the belts.

7.4.2 Economic Value of Benefits

NHTSA determines the economic value of reductions in fatalities and injuries using the "Value of a Statistical Life" (VSL). This is a well-documented process that uses 10 factors – such as medical costs, loss of household productivity, and loss of business productivity – to assign an economic cost for loss of life and a relative cost for each MAIS injury level.

UA updated the VSL estimates in NHTSA (2008) to 2010 dollars using the Consumer Price Index and applied them to the reduction of fatalities and reductions for each MAIS injury class. This procedure estimated that seat belts reductions would save, on average, $2,744,521 per year in Alabama.

7.5 Benefit/Cost Analysis

NHTSA (2008) conducts two types of analyses for rule-making: "A cost-effectiveness estimate that measures the cost per equivalent life saved ... [and] the benefit-cost estimate that measures the net benefit, which is the difference between benefits and net costs in monetary values."

Because future values of benefits are included in the analysis, they are discounted. NHTSA performs the discounting using a range of discount rates.

7.5.1 Cost Effectiveness

The determination of the cost per equivalent life saved is based on comprehensive values and comprises economic impacts and lost quality of life. Non-fatal injuries are transformed to fatalities using ratios, where MAIS injury ratios are defined as the cost of preventing each class of MAIS injury divided by the cost of preventing a fatality.

The MAIS ratios are multiplied by the number of MAIS injuries to produce the number of equivalent lives saved. This process is shown in Table 7-8, and the resulting undiscounted value of equivalent lives saved is 0.427 per year. Because the analysis covers the life cycle of a bus (10 years in Alabama), the value is expressed as 4.27 equivalent lives over 10 years.

Table 7-8. Calculation of Alabama equivalent lives saved

	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal	Equivalent Lives per Year
Number of Injuries	4.66	1.59	1.00	0.22	0.15	0.12	
Relative*	0.0028	0.0436	0.0804	0.1998	0.6656	1.0000	
Equivalent Fatalities	0.013	0.069	0.081	0.043	0.098	0.123	0.427

*Relative is the ratio described in the above narrative

The number of equivalent lives saved must be discounted over time. School bus mileage was selected as the measure of use because it is a measure of exposure to crashes. Alabama motor vehicles have recently traveled 1.1% farther each year, and in the 2009-10 academic year the average Alabama school bus traveled 11,212 miles. The 2009-10 mileage was extended 10 years into the future (the life of an Alabama school bus) at a 1.1% growth rate per year. Using NHTSA's (2008) standard 3% and 7% discount rates, the discounted values of mileage were calculated as 0.8636 and 0.7725 respectively. These values were applied to the 4.27 equivalent lives saved and multiplied by the Value of a Statistical Life ($6,443,964 in 2010 dollars). This produced an estimate of the cost per equivalent Alabama pupil life saved as $32 million to $38 million.

7.5.2 Net Benefits

NHTSA calculates net benefits as the monetary difference between benefits and costs. Because it deals with future benefits, it is discounted in the same manner as the calculation of the cost of an equivalent life saved.

There are two differences. First, seat belts affect the crashworthiness of the bus; they do not affect items such as property damage or traffic jams. So unlike the calculation of the cost to save an equivalent life, comprehensive crash costs are not used. Instead, injury and fatality costs are used because they exclude property damage and traffic jams. The NHTSA (2008) value of

preventing a fatality, updated by UA researchers to a 2010 value of $6,418,670, was used for calculations in this report.

Second, researchers calculated net benefits only for the 3/3-12 long configuration without aides. It is the least expensive seat/row arrangement and provides the greatest net benefits. All other configurations have lower net benefits.

NHTSA determines total present benefits by multiplying the value of a statistical life by the equivalent lives saved. For this analysis, 4.27 lives were multiplied by $6,418,670. The cost of installing the seat belts over the 10-year replacement cycle for Alabama schools is $117.6 million (Table 7-5). Subtracting costs from benefits provides a range of discounted net benefits of -$104 million to -$125 million.

Because the costs exceed the benefits, the net benefits have negative values. One reason the values are so large is there have been few fatalities to Alabama pupils inside school buses. Only five pupils inside school buses have been killed in crashes since 1977, when school bus compartmentalization was first required. Another reason is seat belts cannot save all lives in a crash. This research determined that, on average, seat belts could reduce Alabama pupil fatalities by 39%, not 100%.

7.6 Summary

The cost-effectiveness portion of the pilot project was patterned after NHTSA's (2008) methodology. It used *2009-10* costs from ALSDE files and vendor quotations and estimated the economic costs of benefits (fatalities and injuries reduced).

Five configurations of seats were analyzed with and without aides to determine the most and least cost-effective configurations. The following conclusions were drawn:

- The cost of an equivalent life saved from seat belt implementation is $32 million to $38 million.
- The net benefits from seat belt implementation over one cycle of fleet life are negative, ranging from -$104 million to - $125 million.
- The most cost-effective configuration for installation of seat belts is the 3/3-12 long. The least cost-effective configuration for installation of seat belts is the 3/2-11.
- Costs far exceed benefits, indicating school bus seat belts may not be as cost effective as other types of safety treatments.

The economic portion of these findings implies that the cost of implementation of seat belts is a dominant consideration. It might be more prudent to identify and use more cost-effective types of safety treatments to enhance school bus safety.

Section 8
Summary and Conclusions

8.1 Summary

The Alabama pilot project has been the nation's longest and most intense investigation of the implementation of seat belts on school buses. It was conducted through eight initiatives:

- Pre- and post-project surveys of stakeholder attitudes.
- Literature review.
- Characteristics of school bus crashes.
- Alabama school bus seat belt-use rates and factors contributing to them.
- Safety-effectiveness estimates for school bus seat belts.
- The effect of seat belts on school bus capacity.
- Cost effectiveness of lap/shoulder seat belts on large school buses.

Eleven UTCA reports were prepared to document the findings of each initiative. This summary report has overviewed all eight initiatives. Three of the topics deserve additional attention because they contributed significant new knowledge to school bus seat belts. These key findings of these studies are outlined in the following paragraphs.

8.1.1 Seat Belt Use Rates

Using ceiling-mounted fish-eye cameras on 12 pilot-project buses, UA student researchers made 170,000 independent observations of pupil seat belt use. The average rate of seat belt use was 61.5%. A second important finding was the strong variability in belt use from bus to bus (from 4.8% on one bus to 92.5% on another bus), and, for some buses, from year to year (belt use dropped by almost half on one bus).

Additional findings included ratings for the effectiveness of drivers and aides in encouraging belt use, effects of pupil age, trends for time of day and day of week, decay of belt use over the length of a bus route, and similar factors.

8.1.2 Seat Belt Effects on School Bus Capacity

A typical school has 12 rows with 3 small pupils on each side of the aisle for a maximum of 72 small pupils. This is called a 3/3-12 configuration. When two large pupils sit on either side of the aisle, the configuration carries 48 pupils. Pupil age is important to school bus capacity.

Seat belts can reduce capacity two ways. First, the seatbacks are two to four inches thicker with seat belts, so buses need to be 24 to 48 inches longer to accommodate twelve rows of seats with belts. One or two rows are lost because this addition is not possible on existing buses. Second, the belt latches are located 15 inches apart, negating the possibility of seating three small pupils or two large pupils on one side of the bus. Consequently, several types of seat/row configurations have been introduced to accommodate seat belts.

This initiative utilized pupil load data (number of pupils and their sizes) for 2,222 current buses in Alabama. The data were carefully screened and tested to minimize errors. UA researchers created a methodology to place each current bus load on five proposed seat/row configurations, and records were kept of the number of buses unable to carry their current loads after the belts were installed. New buses must be purchased to replace this lost capacity. The following results were obtained:

- 3/3-12 (current configuration) 1% buses overloaded
- 3/3-11(lose one row of seats) 14% additional buses needed
- 3/2-12 (lose one seat per row) 5% additional buses needed
- 3/2-11 (lose one row of seats and 1 seat per row) 18% additional buses needed

These findings use the most analytical methodology and the most accurate data of any study to date, and the findings are noteworthy.

8.1.3 Cost Effectiveness

The most important piece of information for widespread implementation of seat belts on school buses is the cost effectiveness of the belts. This is a complex issue, and progress has been limited by the variety of configurations, insufficient or missing data, and other complications.

This initiative was patterned after an analysis by NHTSA (2008) to support potential rule-making for school bus safety. Cost data were obtained by ALSDE from its files and from quotes from vendors. Benefits were attributed to reductions in fatalities and injuries. Benefits were estimated using data transformations and partitioning to produce the number of fatalities and injuries prevented. The reductions were converted to economic values using the Value of a Statistical Life procedure.

Five configurations of seats were analyzed with and without aides to determine the most and least cost-effective configurations. The following conclusions were drawn:

- The cost of an equivalent life saved from seat belt implementation in Alabama is $32 million to $38 million.
- The net benefits from seat belt implementation over one cycle of Alabama fleet life are negative, ranging from -$104 million to -$125 million.
- The most cost-effective configuration for installation of seat belts is the 3/3-12 long. The least cost-effective configuration for installation of seat belts is the 3/2-11.

- Costs far exceed benefits, and school bus seat belts appear to be less cost-effective than other types of safety treatments.

The large economic values imply that the cost of implementation of seat belts is a dominant consideration and that it might be more prudent to identify less more cost-effective types of safety treatments to enhance school bus safety.

8.1.4 Alternative Safety Treatments are Recommended

This study documented that school bus seat belts are costly and have negative net benefits (that is, the costs exceed the benefits). If funding is to be used to improve school bus safety, other treatments will likely return higher net benefits.

The literature finds there are more pupil fatalities in loading/unloading zones than inside school buses. Alabama crash data follow the same fatality pattern. In addition, in the current school year ALSDE conducted a one-day state-wide survey that identified 1633 vehicles that illegally passed school buses which were loading or unloading pupils, even though a state law requires them to stop. If funding is to be spent on school bus safety, more lives could be saved by investing in enhanced safety measures in loading/unloading zones rather than in installation of seat belts. These treatments are almost certainly less expensive than seat belts. Examples of such treatments include the following:

- New safety technology applicable to loading/unloading pupils to new bus purchases.
- Additional driver training.
- Additional education/training for students and teachers.
- Additional training of crossing guards.
- Upgraded traffic control at school crossings.
- Public education about passing a school bus that is loading/unloading pupils.
- Enforcement efforts by the Department of Public Safety, local police agencies, and school districts.
- Analysis of school loading areas for difficult bus maneuvers, mixing vehicles and child pedestrians in the same traffic streams, and other potential contributors to pedestrian crashes.

Section 9
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Appendix A
Acknowledgments

The authors express admiration and appreciation for the support of the Governor's Study Group on School Bus Seat Belts; the State Superintendent of Education; and the Pupil Transportation Section of ALSDE, especially Mr. Joe Lightsey and Mr. Brad Holley. Likewise, appreciation is extended to the local school system drivers, aides, and transportation directors who participated in the project. Finally, deep appreciation is expressed to the 5 faculty members, 4 staff members, and 19 students who worked diligently on the study.

Appendix B
Publications Produced during the Alabama School Bus Seat Belt Pilot Project

Lindly, J.K., D.S. Turner, and D.B. Brown. *Summary Report: Alabama School Bus Seat Belt Pilot Project.* University Transportation Center for Alabama, University of Alabama, Report 07407-1. September 2010.

Tedla, E., D.S. Turner, J.K. Lindly, D.B. Brown, and A. Parrish. *Results of the "Pre-Project" Survey of Parents/Children, Principals, Transportation Supervisors, and Drivers/Aides.* University Transportation Center for Alabama, University of Alabama, Report 07407-2. August 15, 2008.

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Anderson, K., D.S. Turner, and J.K. Lindly. *Post-Project Survey of Stakeholder Attitudes: Parents/Children, Principals, Transportation Supervisors, and Drivers/Aides.* University Transportation Center for Alabama, University of Alabama, Report 07407-8. July 31, 2010.

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