Application of California Bus Accident Data in the Study of Intercity Bus Passenger Safety

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It is well documented that seat belts can save lives in automobile accidents, and some people consider the lack of passenger restraints on buses to be a safety hazard. However, many technical experts argue against seat belts because lap/shoulder belts cannot be installed on buses. The effectiveness of lap belts alone is questioned, and there is evidence that they may actually induce injury. Arguments for and against seat belts on buses are reviewed in this paper, which focuses on intercity coaches. The potential effectiveness of lap belts on intercity coaches was assessed by examining statistics and reports for severe bus accidents in the California Highway Patrol "other bus" (nonschool bus) category. The potential effectiveness of lap belts was assessed after classifying accidents by type because lap belts are not considered effective in head-on or rear-end collisions. Lap belts were judged to have potential effectiveness in 15 to 25 percent of the 1975 through 1984 accidents. Two problems were encountered in applying the available data. First, buses were not classified by body type in the data base and, second, many accidents occurred in the "hit object" classification where the direction of impact was not specified. To facilitate future study it is recommended that statistics for bus accidents identify the bus by body type rather than by function and that records for hit object accidents identify the direction of impact on the bus and the depth of penetration by the object.

This paper is based on a study of the need for passenger restraints on intercity buses (*1*). In that study the existing body of knowledge on the effectiveness of seat belts on buses and arguments for and against the installation of seat belts on buses were reviewed. In addition California bus accident records and reports were analyzed and a subjective evaluation of the likely effectiveness of seat belts, had they been available and in use, was made.

During the analysis of the California accident records, difficulties were encountered. The classification of buses for the accident records placed all "nonschool buses" in a category called "other buses." The "other bus" category included intercity buses, transit buses, farm labor buses, and miscellaneous types of buses owned and operated by private groups. In this paper, the author presents a discussion of the controversy regarding seat belts for buses, describes how the data for intercity buses were obtained and used, discusses the problems encountered in using the available data, and presents some conclusions that have been drawn from the study.

BUS SAFETY RECORD

Accident statistics show that buses are one of our safest modes of transportation. The American Bus Association reports 0.04 passenger fatalities per 100 million vehicle-miles for buses in 1982, compared with 0.08 for railroads, and 1.10 for automobile transportation in the same year (*2*). The low bus passenger fatality rate is confirmed by Bureau of Motor Carrier Safety (BMCS) data for the period 1975 to 1983, which shows an average of 16.6 bus passengers killed each year in the United States (*3*). During the same period an average annual 35,000 million passenger-miles were traveled, resulting in an average of 0.047 passenger fatalities per 100 million passenger-miles.

This good safety record for commercial bus carriers of passengers is well documented. Although the types of buses used by the commercial bus carriers are not specifically mentioned in the references used, the implication is that the buses are intercity coaches.

A similarly good safety record is documented for school buses. School buses, however, are the center of a controversy regarding the need for seat belts, and this subject has been studied by many groups over several decades. In the late 1960s the interior and body of the old-style school bus were determined to be hazardous to passengers, and in 1976 a school-bus-occupant protection rule, Federal Motor Vehicle Safety Standard (FMVSS) 222, was issued. This rule, which took effect April 1, 1977, introduced the use of a concept known as compartmentalization, a type of passive occupant protection developed from work done at the University of California, Los Angeles (*4*). This type of protection works by containing children within a structurally sound passenger compartment with fully padded, high-back seats and high padded barriers for front seats. The NHTSA believes that FMVSS 222 "sets requirements . . . which provide children a high level of protection, without the need to buckle-up" (*5*). School buses on the road today are often referred to as prestandard and poststandard buses.

SEAT BELT CONTROVERSY

Legislation requiring installation of seat belts in automobiles was first enacted in 1964, and the first FMVSS for seat belts was issued in 1966. In the United States three-point lap/shoulder belts are now required on front outboard seats of automobiles, and lap belts are required for other seating locations. Some European countries require lap/shoulder belts for rear outboard seats.

The prevention of fatalities and reduction of injuries through the use of seat belts in automobiles is well documented. The preference for lap/shoulder belts in front seats was quickly

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established because severe head and facial injuries were sustained by lap belted passengers whose heads and faces impacted with the front dashboard. The use of lap belts for rear seats of automobiles in the United States, however, was continued.

Recently, the usefulness of lap belts in providing protection has been thrown into serious doubt by a 1986 National Transportation Safety Board (NTSB) report (*6*), which documents lap-belt-induced injuries in 26 frontal crashes of automobiles and vans. Lap-belt-induced injuries occurred to the abdomen and also the head of many of the passengers.

The conclusion that can be drawn from the available data is that lap/shoulder belts are preferred over lap belts. The data assembled by the NTSB do not lead to any conclusion regarding the use of lap belts versus no seat belt. Lap belts may prevent fatalities and injuries in accidents other than head-on collisions, and the question becomes one of net benefits.

As a result of the well-documented evidence of the life-saving and injury-reducing capabilities of seat belts in automobiles, parents of schoolchildren began calling for seat belts on school buses as far back as the 1960s. Research into the problem of passenger protection on school buses led to issue of the 1977 FMVSS known as compartmentalization. In addition to requiring improvements to bus bodies and seats, this standard required the installation of lap/shoulder belts for the driver's seat. This enables the driver to maintain control of the bus during an accident. Parents continue to press for passenger seat belts, and there are now approximately 78 school districts with lap-belt-equipped large school buses. Some of the buses are new and others are poststandard school buses retrofitted with lap belts. (Retrofitting prestandard school buses with lap belts is not considered feasible.) The state of New York recently became the first state to enact legislation requiring the installation of lap belts on all new school buses.

In addition to the argument that seat belts save lives, proponents of lap belts on school buses argue that there is educational value in providing the belts. The use of safety belts on buses, they argue, will teach children good safety habits that will continue into their adolescent and adult driving years.

In addition to the primary argument that the lap belts do more harm than good, there are several arguments used by those who oppose the installation of lap belts on school buses. They argue that buses are already safe; lap belts are too costly (costs exceed benefits); and belts cannot be safely anchored, can be misused or abused, increase liability costs, and are so inconvenient that people will not use them.

The controversy regarding the need for seat belts on school buses continues. However, a recent (1987) study of poststandard school buses conducted by the NTSB (*7*) resulted in the conclusion that, overall, passengers in the 43 school bus accidents that were studied in detail would have received no net benefit from the use of lap belts. (Note: only lap belts are seriously considered for buses because of technological and cost factors that inhibit the installation of lap/shoulder belts.) This study did not include consideration of the possibility of lap-belt-induced injuries that have been found to occur in automobiles and vans (*6*).

In its 1987 study, NTSB found that the 1977 federal school bus standards providing for "compartmentalization" worked well in the crashes investigated (*7*, p. 97). They also found that the federal school bus standards requiring increased side panel and roof strength appeared to have been successful in eliminating the structural failure responsible for many of the ejections in prestandard buses. Further improvements were recommended for joints of the interior maintenance access panel and floor panel and for seat cushion attachments.

The poststandard school bus has undoubtedly improved passenger protection. Unfortunately many prestandard school buses continue to be used by school districts and private social organizations.

In comparison with the prestandard school bus, the intercity coach affords better passenger protection because of the heavier bus body and padded seats with high seat backs. This is not the case, however, with the transit bus, which often has low seat backs with exposed metal bars. Transit buses, designed for city use, are today being used on freeways at speeds that can result in severe accidents. The passenger protection afforded by many transit buses in such an accident would be very poor. Some transit districts with high freeway mileage are using coach-type buses, but many transit districts use the typical transit bus on the freeway. Improvement of the typical transit bus seat is necessary and is being evaluated.

In recent years the minibus and van-type bus have been gaining in popularity. Passengers in smaller vehicles are subjected to greater crash forces. This was taken into account when the 1977 FMVSS standards were being set for school buses. Type II buses (under 10,000 lb gross vehicle weight) constructed after April 1, 1977 are required to be equipped with lap belts at each seating position. Recent evidence has shown that the performances of rear-seat lap belts in frontal collisions of automobiles and vans is very poor (*6*). Thus the use of lap belts in minibuses may need to be reevaluated.

Passenger protection provided by the interior of buses on the road today clearly varies with the type and age of the bus. Arguments exist both for and against the installation of lap belts on school buses. Transit bus seats need improvements to provide passenger protection when the buses travel at higher speeds on the freeway. Lap belts on minibuses and van-type buses may place passengers at risk in head-on collisions. This paper, however, deals with intercity motor coaches, which have no lap belts for passengers but which have high-backed, padded seats and a strong body. This type of construction provides passive protection for passengers in the event of accidents. Nevertheless, in view of the fact that intercity buses are used for long-distance travel, often at high speed and often on mountainous roads, careful consideration of passenger protection is important.

Clearly the controversy regarding the need for seat belts on buses will continue. Because the types of buses provide for passenger safety in different ways, a data base that reflects the body type of buses is needed.

DEFINING THE INTERCITY BUS

Buses can be classified by body type, function, and mode of operation. The term "intercity bus" refers to function in the sense that it means a bus that travels between two cities. A transit bus is a bus that is used by commuters to travel to and from work. A transit bus may, however, also travel between two cities, as may a school bus, a minibus, and a van-type bus. A school bus has a distinctive body shape and is constructed on a truck chassis. A bus of this type may, however, be used by private social groups or to transport farm laborers. On the other hand, a transit bus or a commercial coach may be used to transport school children.

The California Department of Transportation (Caltrans) has grouped buses by body type for the purpose of classification counts (*8*). Body types defined by Caltrans are motor coach, transit bus, minibus, and truck-type bus (school-type bus, which is built on truck chassis).

For accident records, California statewide vehicle classification distinguishes between school buses and other buses. In this context classification as a school bus is based on the legal definition. School children may also be transported to special activities and after school activities in buses that are not legally classified as school buses. For this reason the California Highway Patrol (CHP) introduced (in 1977) the school pupil activity bus (SPAB) classification. An SPAB may be a motor coach, transit bus, minibus, or even a school-type bus, which was not, at the time, legally classified as a school bus.

The CHP classifies buses as commercial, farm labor, school bus, SPAB, and (since 1983) "youth" bus. School buses are further subdivided into public, private, and contractual. This classification is used only for CHP-reported accidents and is not, therefore, applicable to all accidents in the California data base.

The "other bus" category used for California statewide accident reporting includes motor coaches, transit buses, minibuses, and (before 1977) SPABs. After CHP introduced the new classification, SPAB buses were included in the school bus category of the statewide classification. For the purpose of the study on which this paper is based, the term "intercity bus" was used to mean full-size motor coaches used for long-distance travel, including pleasure trips. The classification of accidents in the available data was not compatible with this definition.

EXTRACTING THE DATA

Ten years of accident records (1975 through 1984) for the "other bus" category were provided on magnetic tape by the CHP. These data were from the Statewide Integrated Traffic Records System (SWITRS). There were 13,325 records in this category; 4,821 involved at least one victim. The data base classifies victim condition as fatality, severe injury, other visible injury, and complained of pain. There were 62 deaths, 275 severe injuries, and 2,056 with other visible injuries in the records for "other bus." The data are summarized in Table 1. These data include victims on the bus and in other vehicles.

The most severe accident in the "other bus" category occurred in May 1976 and is known as the "Martinez" accident. In this accident 29 passengers were killed, 19 severely injured, and 4 received other visible injury. The bus was a school-type bus carrying school children but was not legally classified as a school bus. Since that time the CHP has introduced the SPAB classification for use in CHP-reported accidents, and SPAB buses are now classified as school buses in the statewide classification. Had this accident occurred after 1977 it would have been included in the school bus category. Excluding the Martinez accident, the number of passengers killed and severely injured in the "other bus" category is 33 and 256, respectively.

From the "other bus" accident records, 88 severe accidents were identified. A severe accident is defined as one involving one or more bus passenger deaths, or one or more bus passengers severely injured, or five or more visible injuries to bus passengers, or a combination of any of these three scenarios. Pertinent data for these 88 accidents were extracted and produced on hard copy for examination and analyses. A sample of the data extracted is shown in Figure 1.

TABLE 1 1975 THROUGH 1984 STATEWIDE "OTHER BUS" ACCIDENTS

YEAR OF COLLISION	KILLED	SEVERE INJURY	VISIBLE INJURY	COMPLT-PAIN	TOTAL INJURED
1975	2	36	208	935	1179
1976	31	42	219	1031	1292
1977		16	170	936	1122
1978		20	207	1055	1282
1979		35	273	1048	1356
1980	1	15	185	1097	1297
1981	4	36	144	766	946
1982	16	12	157	826	995
1983	3	35	250	963	1248
1984	5	28	243	1114	1385
TOTALS	62	275	2056	9771	12102
AVERAGES	6	28	206	977	1210

In addition to these aggregate accident records, the CHP made available several major accident investigation team (MAIT) reports. It was necessary to request these reports individually by accident date and location. In order to do this, specific accidents were selected from the 88 previously identified as severe. Ten MAIT reports were provided (no reports were available for accidents before 1980).

It turned out that there were no catastrophic accidents involving intercity buses in California during the 1975 through 1984 period. Since that time, however, there has been one severe accident. Occurring on May 30, 1986, in Sierra Nevada, this accident resulted in 21 deaths, 16 severe injuries, and 4 moderate injuries. The bus ran off the road, rolled down a steep embankment, and landed in the Walker River. Passengers were thrown around inside the bus, and many were ejected into the river. Clearly, a single severe accident such as this has a large effect on the average incidence of fatalities.

DATA ANALYSIS

Classification by Collision Type

In order to evaluate the need for and potential effectiveness of lap belts on intercity buses, the 88 severe accidents were classified by collision type. These are hit object, overturned, head-on, broadside, rear-end, sideswipe, and other automobile/pedestrian. The other party (or fixed object) involved in the collision was also recorded. The detailed MAIT reports were analyzed for bus type, direction and severity of impact, and seating positions of passengers killed and injured.

The 88 severe accidents isolated for detailed study involved 56 bus passengers killed, 187 bus passengers severely injured, and 777 bus passengers with other visible injuries (including the Martinez accident). Because all accidents with one or more bus passenger fatality or severe injury were included in

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COLLISION SEGMENT ***************************************

COLLISION NUMBER ON THIS FILE                               87
JURISDICTION (REPORTING NCIC NR.)                         9835
COLLISION DATE (YYMMDD)                                 750820
COLLISION TIME (HHMM)                                     0845
BADGE NUMBER                                             07257
DISTRICT WITHIN JURISDICTION                              0000
COLLISION LOCATION 00=UNINCORPOR.                         3600
COUNTY (CALTRANS)                                          SBD
CALTRANS DISTRICT 00=NOT STATE HWY                          08
STATE ROUTE 000=NOT STATE HWY                              040
LOCATION TYPE                             RAMP (OR COLLECTOR)
INJURY, FATAL, OR TOW-AWAY                                 YES
COLLISION SEVERITY                       OTHER VISIBLE INJURY
NUMBER OF VICTIMS KILLED                                    00
NUMBER OF VICTIMS INJURED                                   13
NUMBER OF VICTIMS                                           13
NUMBER OF PARTIES                                           02
COLLISION TYPE                                        REAR-END
MOTOR VEH. OF 1ST CONTACT INVOLVED        OTHER MOTOR VEH.

PARTY SEGMENT **********************************************************

BUS 1, PARTY NUMBER                    1              OTHER PARTIES
EXTENT OF INJURY          COMPLAINT PAIN         PARTY         STATEWIDE
VICTIMS KILLED                        00         NUMBER     VEHICLE TYPE
VICTIMS INJURED                       10
STATEWIDE WEH. TYPE            OTHER BUS

BUS 2, PARTY NUMBER                    2
EXTENT OF INJURY               NO INJURY
VICTIMS KILLED                        00
VICTIMS INJURED                       03
STATEWIDE WEH. TYPE            OTHER BUS

VICTIM SEGMENT ********************************************************************************

VICTIM NUMBER                1         2         3         4         5         6         7         8         9        10
VICTIM TYPE          PASSENGER PASSENGER PASSENGER PASSENGER PASSENGER PASSENGER PASSENGER PASSENGER    DRIVER PASSENGER
EXTENT OF INJURY     VIS. INJ. VIS. INJ. VIS. INJ. VIS. INJ.      PAIN VIS. INJ. VIS. INJ. VIS. INJ.      PAIN      PAIN
VICTIM IN PARTY          BUS 1     BUS 1     BUS 2     BUS 1     BUS 1     BUS 1     BUS 1     BUS 1     BUS 1     BUS 1

VICTIM NUMBER               11        12        13
VICTIM TYPE          PASSENGER PASSENGER PASSENGER
EXTENT OF INJURY          PAIN      PAIN      PAIN
VICTIM IN PARTY          BUS 2     BUS 1     BUS 2

VICTIM NUMBER
VICTIM TYPE
EXTENT OF INJURY
VICTIM IN PARTY

VICTIM NUMBER
VICTIM TYPE
EXTENT OF INJURY
VICTIM IN PARTY

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VICTIM NUMBER
VICTIM TYPE
EXTENT OF INJURY
VICTIM IN PARTY

VICTIM NUMBER
VICTIM TYPE
EXTENT OF INJURY
VICTIM IN PARTY
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FIGURE 1 Sample of data extracted from the Statewide Integrated Traffic Records System (data extracted from six California Highway Patrol reports of accidents involving seven intercity buses).

these 88 accidents, the remaining 6 deaths and 88 severe injuries are assumed to have occurred to passengers of other vehicles. An unknown number of the 2,056 other visible injuries also occurred to passengers of other vehicles. For the purpose of this study the 88 severe accidents were considered to be the data base for other bus accidents in which lap belts may have been effective.

Classification by collision type (see Tables 2 through 8) was undertaken because lap belts are considered to be effective in accidents involving passenger ejections and passengers being thrown about inside a bus. These events can occur when a bus is impacted from the side and especially in roll-over accidents. On the other hand, the effectiveness of lap belts in head-on and rear-end collisions is questionable. As can be seen from the data, 4 were killed and 19 severely injured in head-on and rear-end collisions, whereas 7 were killed and 61 severely injured in broadside, sideswipe, and roll-over accidents. The majority of deaths and severe injuries (16 and 78, respectively, and excluding the Martinez accident) occurred in the hit object category of accidents.

For "hit object" accidents the direction of impact is not known. This makes it impossible to draw any conclusions regarding the likely effectiveness of lap belts in these accidents. The importance of the direction of impact has been recognized by the U.S. Department of Transportation in its Fatal Accident Reporting System (*9*). The distribution of accidents by direction of primary impact has been reported for automobiles, motorcycles, and trucks for many years, and starting in 1986 this is also done for buses.

As mentioned earlier 10 MAIT reports were obtained for this study. Accidents for which MAIT reports were obtained

TABLE 2 COLLISION TYPE: HIT OBJECT

OTHER PARTY	KILLED	SERIOUS	VISIBLE	MAIT
FIXED OBJECT	2	14	6	
FIXED OBJECT	1		24	07/07/84
FIXED OBJECT			8	05/09/84
FIXED OBJECT			13	
FIXED OBJECT		2	9	03/20/83
BUS	3	7	58	
FIXED OBJECT		1	6	
FIXED OBJECT		15	27	
FIXED OBJECT		1	8	
PASS CAR			11	
TRUCK	10		1	10/08/82
PASS CAR		3	8	
PASS CAR			6	
PASS CAR			6	
PASS CAR		3	10	
FIXED OBJECT		6	10	
FIXED OBJECT		4	11	
FIXED OBJECT		4	9	
PASS CAR			7	
FIXED OBJECT	29	19	4	05/12/76
FIXED OBJECT		18	18	

SUMMARY: 21 ACCIDENTS 45 KILLED
97 SERIOUS INJURIES
260 OTHER VISIBLE INJURIES

TABLE 3 COLLISION TYPE: OVERTURNED

OTHER PARTY	KILLED	SERIOUS	VISIBLE	MAIT
NON COLLISION	1	7	4	
NON COLLISION			6	
NON COLLISION		3	12	
NON COLLISION	3		7	10/17/82
NON COLLISION		8	8	
NON COLLISION	1	10	16	01/11/81
NON COLLISION			11	
MULTIPLE			15	
NON COLLISION		1	17	

SUMMARY: 9 ACCIDENTS 5 KILLED
29 SERIOUS INJURIES
96 OTHER VISIBLE INJURIES

TABLE 4 COLLISION TYPE: HEAD-ON

OTHER PARTY	KILLED	SERIOUS	VISIBLE	MAIT
PASS CAR			14	
PASS CAR			4	
PASS CAR	2	7	4	08/08/81
PASS CAR			5	
PASS CAR		2	17	
PICK-UP + CAR		4	1	
TRUCK			8	
PASS CAR		1	9	
TRUCK/TRAILER	1		18	
PASS CAR		2	5	

SUMMARY: 10 ACCIDENTS 3 KILLED
16 SERIOUS INJURIES
85 OTHER VISIBLE INJURIES

are identified in Tables 2 through 8. The MAIT report accidents involved 51 bus passenger deaths, 77 severe injuries, and 168 other visible injuries, thus accounting for 91 percent of the deaths, 38 percent of the severe injuries, and 22 percent of the other visible injuries sustained in the 88 accidents.

As indicated earlier the worst accident during the analysis period, the Martinez accident, was sustained by a school-type bus listed with "other bus" because it was not, at the time, legally classified as a school bus. Analysis of the MAIT reports revealed that three of the accidents involved minibuses or van-type buses and one involved a transit bus (see Table 9). As seen from this table, nonintercity buses accounted for 45 deaths, 26 severe injuries, and 24 other visible injuries. Intercity buses accounted for 6 deaths, 51 severe injuries, and 144 other visible injuries. The bus type is unknown for accidents resulting in the remaining 5 deaths, 109 severe injuries, and 609 other visible injuries.

TABLE 5 COLLISION TYPE: BROADSIDE

OTHER PARTY	KILLED	SERIOUS	VISIBLE	MAIT
PASS CAR			5	
PASS CAR		2	11	
PICK-UP			6	
PASS CARS	1	2	8	
PASS CARS			7	
PASS CAR			8	
PICK-UP W/TRAIL		3	9	
PICK-UP W/TRAIL			5	
PASS CAR			5	
PASS CAR		5	19	06/22/80
PASS CAR			5	
TRUCK			7	
PASS CAR		1	9	
PASS CARS		2	3	
PASS CARS		3	4	
PASS CAR			6	
TRUCK W/TRAIL		2	4	
PASS CAR			8	
BUS			13	
TRUCKS W/TRAIL		4	16	
PICK-UP			8	
PICK-UP	1		1	
PICK-UP			5	
PASS CAR			11	
PASS CARS		4	1	
PASS CAR			5	

SUMMARY: 26 ACCIDENTS 2 KILLED
28 SERIOUS INJURIES
189 OTHER VISIBLE INJURIES

TABLE 6 COLLISION TYPE: REAR-END

OTHER PARTY	KILLED	SERIOUS	VISIBLE	MAIT
BUS			5	
BUS		1	4	
BUS			6	
PICK-UPS			8	
PASS CAR		1	5	
TRUCK	1		1	
TRUCK W/TRAIL			6	
PICK-UP W/TRAIL		1	4	
MULTIPLE			17	
PASS CAR			5	
BUS			7	

SUMMARY: 11 ACCIDENTS 1 KILLED
3 SERIOUS INJURIES
68 OTHER VISIBLE INJURIES

TABLE 7 COLLISION TYPE: SIDESWIPE

OTHER PARTY	KILLED	SERIOUS	VISIBLE	MAIT
PASS CAR			5	
TRUCK W/TRAIL		1	4	
TRUCK W/TRAIL			5	
TRUCK W/TRAIL			9	
TRUCK W/TRAIL		1	5	
TRUCK W/TRAIL		1	6	
TRUCK + CARS		1	5	

SUMMARY: 7 ACCIDENTS 0 KILLED
4 SERIOUS INJURIES
39 OTHER VISIBLE INJURIES

TABLE 8 COLLISION TYPE: OTHER

OTHER PARTY	KILLED	SERIOUS	VISIBLE	MAIT
PEDESTRIAN			6	
PICK-UP		1	7	
TRUCK W/TRAIL			8	
ANIMAL		8	19	

SUMMARY: 4 ACCIDENTS 0 KILLED
9 SERIOUS INJURIES
40 OTHER VISIBLE INJURIES

Reliability of Data

Classifying unknown bus types as intercity buses results in totals of 11 deaths, 160 severe injuries, and 753 other visible injuries being attributed to intercity bus passengers during 1975 through 1984 (see Table 9). As shown in Table 10, the BMCS reports 11 deaths and 711 injuries to passengers in California during the 1975 through 1983 period (*3*). The BMCS data appear to be compatible with the CHP data. Closer analysis, however, reveals discrepancies in the number of deaths reported on a year-by-year basis as shown in Table 11.

These discrepancies may arise from differences in bus classification. In 1982, for example, a total of 16 deaths are reported by the CHP (see Table 1); 13 of these have been attributed to minibus accidents (see Table 9). Only three deaths, occurring in accidents involving unknown bus types, have been attributed to intercity buses. The BMCS reports 10 deaths in California in 1982. Presumably, then, the CHP minibus was a "motor carrier of passengers," whereas the other buses were not. Thus, the category "motor carrier of passengers" may not be compatible with the category "intercity bus." Existing data bases do not classify buses by body type.

Lap Belt Effectiveness

In considering the need for lap belts on intercity buses the question is how many, if any, of these fatalities and severe injuries would have been prevented by the use of lap belts.

TABLE 9 CHP DATA SHOWING SUMMARY OF THE 88 SEVERE ACCIDENTS IN THE OTHER BUS CATEGORY IN CALIFORNIA (1975 through 1984)

ACCIDENT DATE & DESCRIPTION	KILLED	SEVERELY INJURED	OTHER VISIBLE INJURY
NON INTERCITY BUSES			
05/12/76 MARTINEZ, HIT OBJECT	29	19	4
10/08/82 SMALL VAN, HIT OBJ., EJECTION	10	0	1
08/08/81 SMALL VAN, HEAD ON, FIRE	2	7	4
10/17/82 SMALL VAN, OVERTURNED	3	0	7
5/09/84 TRANSIT BUS, HIT OBJECT	1	0	8
SUB-TOTAL	**45**	**26**	**24**
INTERCITY BUSES			
06/22/80 BROADSIDE, ROLLOVER	0	5	19
01/11/81 OVERTURNED	1	10	16
03/20/83 HIT OBJECT, 2 BUSES, MULTIPLE IMPACT	3	7	58
07/16/83 HIT OBJECT, OFF ROAD	0	15	27
07/07/84 HIT OBJECT, OFF ROAD, AIRBORNE	2	14	24
SUB-TOTAL	**6**	**51**	**144**
OTHERS (BUS TYPE UNKNOWN)			
HIT OBJECT	0	42	138
OVERTURNED	1	19	73
HEAD-ON	1	9	81
BROADSIDE	2	23	170
REAR-END	1	3	68
SIDESWIPE	0	4	39
OTHER	0	9	40
SUBTOTAL	**5**	**109**	**609**
GRAND TOTAL	**56**	**186**	**777**

TABLE 10 BMCS DATA SHOWING ACCIDENTS OF MOTOR CARRIERS OF PASSENGERS IN CALIFORNIA

		Drivers		Passengers	
Year	Accidents	Killed	Injured	Killed	Injured
1975	40	0	2	0	26
1976	52	0	6	1	89
1977	62	0	6	0	60
1978	40	0	4	0	42
1979	62	0	10	0	175
1980	62	0	6	0	49
1981	82	0	10	0	85
1982	66	0	6	10	75
1983	60	0	2	0	110
Total	526	0	52	11	711
Average	58.4	0	5.8	1.2	79

A subjective analysis of the accident reports and available information about lap belt effectiveness resulted in estimation of 15 to 25 percent effectiveness with full use of the lap belts. Analysis of the likely effectiveness of lap belts was hampered by the lack of knowledge of the direction of impact in the hit object category, which accounted for a large proportion of the passenger deaths and injuries. No estimation of possible lap-belt-induced injuries was made.

TABLE 11 COMPARISON OF BMCS AND CHP YEARLY DATA SHOWING BUS PASSENGER FATALITIES

	BMCS (passenger motor carriers)	CHP (intercity buses)
1975	0	2
1976	1	2
1977	0	0
1978	0	0
1979	0	0
1980	0	1
1981	0	1
1982	10	3
1983	0	0
1984	0	2
Total	11	11

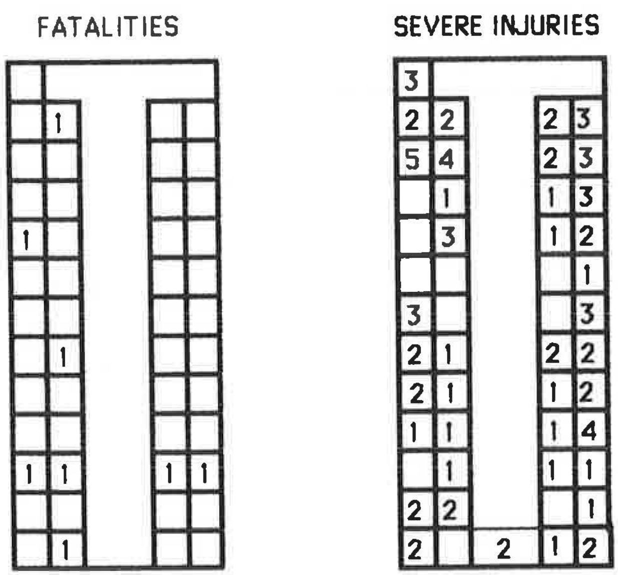

FIGURE 2 Deaths and severe injuries by seat location in intercity buses.

A March 1987 report from NTSB (*7*) suggests that even this low estimate of effectiveness is optimistic. In the NTSB study, 43 poststandard school-type bus accidents were investigated immediately after their occurrence. The study concluded that lap belts would have resulted in no overall net benefit to the passengers of the buses involved in the accidents. This conclusion should not be generalized and cannot be transferred to intercity buses.

In the original work (*1*) on which this paper is based, some thought was given to the greater need for seat belts at certain seating locations on the bus. The passenger seating charts for the accidents were studied, and the frequency of occurrence of deaths and injuries in the various seating locations are presented in Figure 2. Front seats and back bench seats are frequently mentioned as being more dangerous than other locations. This was not borne out by the available data. Most buses did not have back bench seats, and as can be seen from Figure 2 deaths and serious injuries were scattered throughout the vehicles. Fatalities and serious injuries occurred more frequently on the left side of the bus. As seen from Figure 2 the second row on the left of the bus incurred the highest number of serious injuries.

The location of fatalities and serious injuries on the bus is influenced by the location and direction of impact of the collision. Intrusion of the other vehicle or object into the bus has been found to be the most frequent cause of death or serious injury. This is one of the reasons why the effectiveness of lap belt use in buses is estimated to be low. Seat belts are not effective when death or injury results from intrusion of another vehicle or object into the bus.

CONCLUSIONS

Intercity bus accidents in California resulted in approximately 11 deaths and 160 severe injuries during the 1975 through 1984 period. Six deaths and 51 severe injuries are documented in MAIT reports. The total numbers of deaths and severe injuries are approximate (probably an overestimation) because the data sources (CHP SWITRS and BMCS) do not classify intercity bus as a specific category.

For the purpose of analysis of lap belt effectiveness, buses must be classified by body type. The intercity bus or coach has a body type that is different from the transit bus or the minibus. Fleets of motor carriers may include minibuses; hence, BMCS data may include minibuses as well as intercity buses (motor coaches). The California SWITRS classifies all non-school buses as "other bus," which includes transit buses, minibuses, and farm labor buses, as well as intercity buses. (In CHP-reported accidents, commercial buses are separated from farm laborer buses, but this is not a statewide classification.)

The effectiveness of lap belts in reducing the number of deaths and severe injuries was subjectively estimated at about 15 to 25 percent with full use of the belts. In light of more recent studies by the NTSB, this is now considered to be overly optimistic. Furthermore, the potential for lap-belt-induced injuries to passengers who otherwise would be uninjured (or have minor injuries) exists. This has been documented for small vehicles but not for large buses.

The California data base for 1975 through 1984 did not include any serious accidents. In 1986 such an accident occurred and the bus rolled over, down an embankment, and into a river. Passengers were ejected and swept away in the river. Seat belts may have been effective in preventing some of the deaths in this case, and serious accidents such as this one draw attention to the fact that buses do not have seat belts.

During the conduct of this work, safety problems related to minibuses and transit buses have become evident. Minibuses (Type II buses) used to transport school children are equipped with lap belts. The potential for lap-belt-induced injuries in head-on collisions of small vehicles has been documented and is a matter for serious concern. Transit buses, designed for operation at low speeds on city streets, are now traveling at higher speeds on urban and interurban freeways. Seats in many of these buses are low backed with exposed metal bars similar to the prestandard school bus seats. Transit buses operating on freeways should be equipped with padded seats and high seat backs.

Future study of passenger safety on buses would be facilitated if accident data bases would classify buses by body type, namely, school-type buses, intercity buses (motor coaches), transit buses, minibuses, and van-type buses. It would also be helpful if statistical records would include data on direction of impact and depth of penetration for the "hit object" class of accidents.

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