U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

Report to Congress

Anton's Law

Section 6 – Evaluation of Integrated Child Safety Systems

December 2003

EXECUTIVE SUMMARY

On December 4, 2002, President Bush signed Anton's Law, Public Law 107-318 (116 Stat. 2772), which, in part, calls for evaluation of integrated child safety systems. Section 6 of Anton's Law directs the Secretary of Transportation to evaluate built-in or integrated child restraints and booster seats in the following areas: (1) the safety of the child restraint and correctness of fit for the child; (2) the availability of testing data on the system and vehicle in which the child restraint will be used; (3) the compatibility of the child restraint with different makes and models of vehicles; (4) the cost-effectiveness of mass production of the child restraint for consumers; (5) the ease-of-use and relative availability of the child restraint to children riding in motor vehicles; and (6) the benefits of integrated seats for improving compliance with State child occupant restraint laws. Anton's Law also directs the Secretary to report to Congress on this evaluation no later than December 4, 2003 (12 months from the date of enactment of Anton's Law). This report fulfills the reporting requirement.

Section 8 of Anton's Law authorized appropriation of $5,000,000 to complete the evaluation required by Section 6, and to research the nature and causes of injury to children involved in motor vehicle crashes. However, appropriations for the Department of Transportation and the National Highway Traffic Safety Administration (NHTSA) provided no funding for these purposes. Consequently, NHTSA used existing information and hypothetical analysis to address as best as possible the evaluation specified in Section 6. The findings are:

(1) There are no existing integrated seats that can properly fit all heights and weights of children. For this report, the agency assumes integrated

child restraints would be designed for children age 1-7, with internal harnesses for 1 to 3 year olds. There are also no rear-facing integrated seats, meaning that infants still need rear-facing add-on child restraints.

(2) Analysis of Compliance and New Car Assessment Program (NCAP) data and a Children's Hospital of Philadelphia (CHOP) study indicate that integrated child restraints do not provide enhanced safety over add-on child restraint systems.

(3) The agency knows of no compatibility problems for integrated child restraints, although there are some concerns regarding proper fit. Taking into consideration the changing circumstances being brought about by LATCH (Lower Anchorages and Tethers for Children), the recent upgrade to Federal Motor Vehicle Safety Standard No. 213, "Child restraint systems," and proposed requirements for lap/shoulder belts for all vehicle rear designated seating positions, the agency would expect a small benefit from integrated child restraints for compatibility if all vehicles were equipped with integrated child restraints.

(4) The estimated incremental benefits of requiring one integrated child restraint per vehicle over the current situation would be up to 20 lives saved and 166 Abbreviated Injury Severity (AIS) 2-5 (Moderate – Critical) injuries reduced annually. [The basis for this is an assumption that there would be less misuse with built-in child restraints than with either add-on child safety seats or lap/shoulder belts, and that the effectiveness of a properly used add-on child restraint is the same as a

properly used integrated child restraint.] The incremental cost would be $302 million annually, resulting in an incremental cost of about $20 million per equivalent life saved (discounted at 7 percent). If two integrated child restraints were required, the estimated incremental benefits would be up to 21 lives saved and 181 AIS 2-5 injuries reduced annually. The incremental cost would be $707 million, resulting in an incremental cost of about $41 million per equivalent life saved (discounted at 7 percent). If there were more children in a vehicle than integrated child restraints, or if the integrated child restraints were not appropriately sized for the children riding in the vehicle, add-on child restraints would have to be used in addition to the integrated seats.

(5) It is assumed that because integrated child seats are permanently installed in vehicles, they are easy to use. However, NHTSA has not done a rating on integrated child restraints based on their ease of use to confirm this assumption. Therefore, in fiscal year 2004, the agency will examine the feasibility of developing criteria to rate integrated child seats and evaluate the criteria to determine if an ease of use rating program for integrated child seats would be beneficial to consumers.

(6) Integrated child restraints have not been designed for rear-facing infants (those less than 1 year old). Also, integrated child restraints are not designed for every seating position, and many families have three or more children in the 1-7 year old age group. Thus, all children

required by State laws to be in child restraints cannot use an integrated child restraint to meet the State law. Of those children required by State laws to be restrained by child restraints, 61 percent of them could be covered by one integrated child restraint per vehicle. With two integrated child restraints required per light passenger vehicle, 75 percent of the children required by State laws to be restrained could be restrained by integrated child restraints. The remaining children would need to be restrained by add-on child restraints.

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I. INTRODUCTION

On December 4, 2002, President Bush signed Anton's Law, Public Law 107-318 (116 Stat. 2772), which, in part, calls for evaluation of integrated child safety systems. Section 6 of Anton's Law directs the Secretary of Transportation to evaluate built-in or integrated child restraints and booster seats in the following areas: (1) the safety of the child restraint and correctness of fit for the child; (2) the availability of testing data on the system and vehicle in which the child restraint will be used; (3) the compatibility of the child restraint with different makes and models of vehicles; (4) the cost-effectiveness of mass production of the child restraint for consumers; (5) the ease-of-use and relative availability of the child restraint to children riding in motor vehicles; and (6) the benefits of integrated seats for improving compliance with State child occupant restraint laws. Anton's Law also directs the Secretary to report to Congress on this evaluation no later than December 4, 2003 (12 months from the date of enactment of Anton's Law). This report fulfills the reporting requirement.

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Section 6(b) of Anton's Law requires the Secretary of Transportation to report to the Committee on Energy and Commerce of the House of Representatives and the Senate

Committee on Commerce, Science, and Transportation on the evaluation of integrated child safety systems not later than 12 months after the date of the law's enactment (December 4, 2002). This report presents the results of those tests and analyses addressing each of the six aspects of integrated child restraints and booster seats.

II. SAFETY OF THE INTEGRATED CHILD RESTRAINT AND CORRECTNESS OF FIT.

Within the 2001 – 2004 model year vehicles, only Saab (9-3, 9-5 models), Subaru (Legacy), Volvo (S40, S60, V40, V70, S80, XC90), Chevrolet (Venture), Chrysler (Town & Country, Voyager), Dodge (Caravan, Grand Caravan), Pontiac (Montana), and Nissan (Quest) offered integrated child seats. From these, only Chevrolet Venture and Pontiac Montana offered integrated child seats as standard equipment for their 2003 model year vehicles. To address this section of Anton's Law, the agency selected three of the above vehicles with integrated seats that cover weight limits for toddlers and young children in forward-facing positions: 2004 Volvo XC90 with integrated booster seat and a child weight range of 15 to 36 kilograms (kg) (33 to 80 pounds), 2001 Chrysler Town and Country with integrated 5-point harness child seat and a child weight range of 10 to 23 kg (22 to 50 pounds), and 2003 Chevrolet Venture with standard integrated 5-point harness child seat and a child weight range from 10 to 18 kg (22 to 40 pounds).

A Hybrid III 6-year-old dummy was used to evaluate the correctness of fit for toddlers and young children restrained in booster and child seats. A Hybrid III 10-year-old dummy was also used to evaluate the correctness of fit for young children in booster

seats. Belt contact comfort zones established in 1993[1] were used to evaluate the correctness of fit with these dummies. The contact comfort zones correlated with reduced injury assessment measurements.

The evaluation showed that for the Volvo XC90 integrated booster seat, the lap portion of the lap/shoulder belt fit well on both the 6-year-old and 10-year-old dummies. Also the shoulder belt fit well on the 10-year-old dummy. However, the shoulder belt placement was closer to the neck and higher on the chest on the 6-year-old dummy, failing to meet the recommended placement zone. The evaluation also showed that the integrated 5-point harness restraints in the Chrysler Town and Country and the Chevy Venture exhibited good fit for the 6-year-old dummy; the lower portion fit well within the pelvic zone and the upper harnesses fit within the shoulder zone.

The results from these three vehicles indicate that there is currently no single integrated seat that can properly fit all height and weight ranges of children. It should also be noted that there are no rear-facing integrated seats, meaning that infants still need a rear-facing add-on child restraint.

III. AVAILABILITY OF TESTING DATA ON THE SYSTEM AND VEHICLE IN WHICH THE CHILD RESTRAINT WILL BE USED.

To address this section, the agency analyzed the National Automotive Sampling System – Crashworthiness Data System (NASS - CDS) data for 1992 to 2001, the agency's compliance data, the 2003 New Car Assessment Program (NCAP) data for

[1] "Improved Design for Safety Belts", Chambers, Fletcher K., et al, NHTSA Final Report DOT HS 808-082, June 1993. The lap belt part of the comfort zone was taken from recent unpublished static belt fit study.

integrated child seats, and Children's Hospital of Philadelphia (CHOP) for use patterns and performance of integrated child restraints.

In the NASS-CDS data, from 1992 to 2001, there were 18 children coded as riding in an integrated child seat when involved in a crash. The children were 1 to 7 years old. Twelve of the 18 children had no injury (AIS = 0)[2], one child whose injury level was unknown (AIS = 7), four children had minor injury (AIS = 1), and one child had a broken femur with serious injury (AIS = 3). That child was the only child hospitalized. The vehicles were involved in frontal, side, and rear impact crashes at speeds up to 40 kilometer per hour (km/h). All vehicles were also towed from the crash site.

Federal Motor Vehicle Safety Standard (FMVSS) No. 213, "Child restraint systems," allows integrated child restraints to comply by one of two requirements: a sled test placing a vehicle's shell on the sled buck using FMVSS No. 213 pulse at 48 km/h (30 mile-per-hour (mph)) velocity frontal test, or a FMVSS No. 208, "Occupant crash protection," full frontal barrier test. To date the agency has conducted four vehicle integrated seat compliance tests using FMVSS No. 208 full frontal barrier test. The test results show that all four vehicles met the HIC, chest acceleration, and knee excursion requirements, thereby ensuring performance consistent with integrated child restraint systems (CRS) tested under FMVSS No. 213.[3]

The agency conducted an NCAP (56 km/h or 35 mph fixed barrier) test on a 2003 Volvo XC90 vehicle with an integrated booster seat. A Hybrid III 6-year-old dummy

[2] Abbreviated Injury Scale, Association for the Advancement of Automotive Medicine, 1990, AIS 1 – minor; AIS – 2, moderate; AIS 3 – serious; AIS 4 – severe; AIS 5 – critical; AIS 6 – maximum; AIS 7 – injury level unknown.
[3] Section 5.1.3.1(b) of FMVSS No. 213 does not require head excursion limits for integrated child restraint systems.

was seated in the integrated booster seat in the center rear seating position, and another Hybrid III 6-year-old dummy was seated on an add-on booster seat in the left rear seating position. Both dummies were restrained by the vehicle's lap and shoulder belts. Also a Hybrid III 3-year-old dummy was seated in an add-on child restraint system with a 5-point harness in the right rear seating position. The head and chest responses exceeded the FMVSS No. 213 requirements for all three dummies, with the exception of the 6-year-old dummy chest response in the add-on booster seat. Analysis of the above data sources indicates that integrated child restraints have comparable safety performance to add-on child restraints.

CHOP, under NHTSA contract for Anton's Law, conducted analyses of use patterns and performance of integrated child restraint systems. The CHOP study utilizes crash data from a major insurance company that covers over 38 million vehicles in the United States. Therefore, the study is likely representative of the insured public in this country. The surveillance system is limited to children occupying model year 1990 and newer vehicles insured in 15 states and the District of Columbia. The study obtained nearly all of its data via telephone interviews with the driver/parent of the child and is, therefore, subject to potential misclassification. Ongoing comparisons of driver-reported child restraint use and seating position to evidence from crash investigations have demonstrated a high degree of agreement.

The study sample for these analyses was children under 9 years of age restrained in the rear rows in forward-facing child restraint systems (both integrated and add-on devices). All children in integrated CRS were grouped together as the primary group of interest (target group) (unweighted sample = 100). Children in add-on forward-facing

child safety seats (FFCRS) (unweighted sample = 2,350), belt-positioning booster seats (BPB) (unweighted sample =340), and shield booster (unweighted sample = 278) functioned as comparison groups. Use of an integrated CRS was determined by survey responses. Survey responses were compared to a list of vehicles equipped with integrated CRS obtained from the Insurance Institute for Highway Safety. Only those respondents who answered that their child was in an integrated system and who were in a vehicle equipped with such a device were included in the target group.

The CHOP study shows that few children (less than 5 percent) use integrated CRS as compared to add-on systems (either FFCRS, shield booster, or BPB). The data indicate that the typical child using an integrated device is less than three years of age and less than 18 kg (40 pounds), which suggests that those using integrated restraints more closely represent those in add-on FFCRS and shield boosters than those in add-on BPB. For the few children in integrated child restraints who sustained a serious injury (six children), those injuries were to the head for four children and to the lower extremity for the remaining two children. This injury pattern was like that for add-on restraint types. The injury rates among the 3 restraint types were extremely low and not statistically different from one another. It is possible that statistically significant differences were unable to be detected due to small sample sizes. A review of the body regions of serious injury indicated similar patterns of injury. The analyses show that efforts to reduce injuries in all four restraints types should focus on the head, and for harness-based systems the lower extremities as well. Four of the six children with serious injuries in integrated CRS were in frontal crashes, suggesting that management of head excursion that is important for add-on systems is also important for integrated systems. Also, the

study found that there was no difference in crash severity among the restraint types. The CHOP analyses concluded that integrated child restraint systems do not provide enhanced performance over add-on CRS (either FFCRS, shield booster, or BPB).

IV. COMPATIBILITY OF CHILD RESTRAINTS WITH DIFFERENT VEHICLE MAKES AND MODELS.

In spring 1996, NHTSA initiated the development of a database on compatibility between child-seats and passenger vehicles. Pertinent information regarding the compatibility between the child restraints (rear-facing infant seats (24), convertible seats (74), and booster/toddler seats (24)) and late model vehicles was acquired by installing child restraints in different vehicle makes/models at acceptable seating locations (excluding those in front of an air bag), and documenting the fit.

After two years, information for 280 vehicles (passenger cars, minivans, sport utilities and pick-up trucks), spanning model years 1992 to 1999, was collected with most of the information for 1994-97 model years. A total of 53 child restraints (15 rear-facing infant seats, 25 convertible seats, and 13 booster seats) were tested in 122 configurations.

In total, booster seats were installed in 13,176 seating positions, and they fit in 10,106 (76.7 percent of the seating positions). The primary reasons that all of the different styles of boosters didn't fit were: (1) the vehicle seat was too narrow, too contoured (fore/aft and/or laterally asymmetric) or too deep to have either enough room or provide a stable platform for the booster to rest on, (2) the position of the lap belt anchors were not ideal - if they were too far forward of the seat bight, they often prevented proper tightening of the booster (particularly ones with small shields), and (3)

at the time of the study, many vehicles came with only a lap belt in the rear center seat. Thus, a booster seat without a small shield could not be installed at that position, since a belt-positioning booster seat needs a lap/shoulder belt for proper restraint.

NHTSA discontinued the CRS/vehicle seat compatibility effort in 1998. Each year, there are about 330 vehicle makes and models sold in the U.S., and about 100 different CRS make/model/child size configurations. This means that there are about 33,000 CRS/vehicle compatibility configurations that would need to be assessed annually. Since multiple model year CRSs are used for each vehicle model year, the number of possible combinations is increased several-fold. Providing timely information to consumers for all combinations was not feasible, and both time and cost prohibitive.

NHTSA promulgated requirements for both CRS and vehicles intended to standardize installation of CRS in vehicles, reduce misuse of CRS, and improve CRS safety performance. In 1999, NHTSA established a new Federal motor vehicle safety standard that requires motor vehicle manufacturers to provide motorists with a new way of installing child restraints. FMVSS No. 225, "Child restraint anchorage systems," requires vehicles to be equipped with child restraint anchorage systems that are standardized and independent of the vehicle's seat belt system. The new independent system has two lower anchorages, and one upper tether anchorage (Lower Anchors and Tethers for Children or LATCH). Each lower anchorage includes a rigid round rod or "bar" onto which a hook, a jaw-like buckle, or other connector that can be snapped. The bars are located at the intersection of the vehicle seat cushion and seat back (seat bight). The upper anchorage is a ring-like object to which the upper tether of a child restraint system is attached. NHTSA also amended FMVSS No. 213, "Child restraint systems," to

require child restraints to be equipped with means for attaching to the new independent anchorage system. The purpose of FMVSS No. 225 is to have a simple and standard system that would be easy to understand, reduce incompatibility, and easy to attach and detach a child restraint to a vehicle. Nearly all passenger vehicles manufactured on or after September 1, 2002, are equipped with the standardized anchorages, and all child restraints manufactured on or after the same date have hardware designed to attach to these anchorages.[4]

Finally, as part of the Transportation, Recall Enhancement, Accountability, and Documentation (TREAD) Act, NHTSA issued a final rule on June 24, 2003 (68 FR 37620) to upgrade FMVSS No. 213. Among other things, the seat geometry of the test fixture was modified to more closely represent that of vehicles in the U.S. fleet. These changes will facilitate development of CRS that are more compatible with vehicle seat configurations.

V. COST-EFFECTIVENESS OF MASS PRODUCTION OF THE CHILD RESTRAINT FOR CONSUMERS.

This analysis examines two alternatives – 1 or 2 integrated child seats for the rear designated seating positions of any light vehicle under 3,857 kg (8,500 pounds) gross vehicle weight rating (GVWR).

[4] LATCH requirements do not apply to booster seats since children in booster seats use vehicles' lap/shoulder belt systems.

Vehicles:

The projected number of light vehicle sales in the future is about 16 million, eight million passenger cars and eight million light trucks. Of the eight million passenger cars, about two percent will be two-seaters and have no rear seat. This leaves 7.84 million passenger cars to potentially be equipped with integrated child restraints. Of the eight million light trucks, the number of vehicles under 3,857 kg (8,500 pounds) GVWR is estimated to be about 7.6 million. About 51 percent of these will have no rear seat (being mostly pickup trucks without a rear seat or cargo vans). This leaves 3.72 million light trucks with a rear seat to potentially be equipped with integrated child restraints. In total, the agency estimates 11.56 million light vehicles having the potential to be equipped with integrated child restraints.

Costs:

The costs of integrated child restraints are currently about $100 per seating position when provided as an option. The agency has no data providing an estimate of the costs of an integrated child restraint as standard equipment. For purposes of this analysis, the agency assumes that the cost of an integrated child restraint depends upon the features of the system. The agency estimates a fold down seat with an internal harness will cost $40 per seating position. Thus, the annual cost of providing one integrated child restraint per new light vehicle with a rear seat as standard equipment is estimated to be: $462.4 million (11.56 million x $40 per vehicle). The annual cost of providing two integrated child restraints per new light vehicle with a rear seat as standard equipment is estimated to be $924.8 million ($462.4 million x 2).[5]

[5] Section 5(b) of FMVSS No. 225 states that a vehicle may be equipped with a built-in child restraint system conforming to the requirements of Standard No. 213 (49 CFR 571.213) instead of one of the

Current car seat prices:

While there is a wide range in prices for add-on CRSs, we assumed an average price near the lower end of the range. For this analysis the agency assumes the following average prices: infant restraints $50, convertibles $60, booster seats - high back $60, and booster seats - no back $30.

NHTSA does not have an estimate of the number of child restraints sold by type. The agency estimates that roughly seven million child restraints were sold in 1999. Based on the recent increase in booster seat sales, the agency estimates that the total is probably closer to 7.5 million now. We used the following rationale to distribute the seat sales types. In the U.S., there are roughly four million children born each year. With 98 percent of them in a child restraint there is a need for 3.92 million child restraints for infants. Not all of these will be new sales; there are hand-me-downs and some seats are sold used. In addition, there is a distribution in the types of child restraints used by infants, some are infant restraints and some are convertible seats. The agency estimates about 1.5 million new infant restraints sold per year.

When the children reach age one, most of them are restrained in a convertible seat, so in any one year there should be close to 4 million convertibles sold (some for infants and some for 1 year olds). Now there are some families that buy two seats for two vehicles, or grandparents, or other caregivers that buy seats. On the other hand, there are some families without vehicles (living in big cities, etc.) that never buy a child seat, or that have hand-me-downs or buy used seats. NHTSA suspects that most of these

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required tether anchorages or child restraint anchorage systems. If a manufacturer decided to not supply one set of LATCH hardware when they installed one built-in child restraint, this would minimally decrease (about $3 per vehicle) the annual estimated cost.

additional sales would be in convertible seats, and not infant seats or booster seats. So, we estimate 4.5 million convertibles sold a year.

When the child is aged 3 to 5, over one third of households buy a booster seat, so about 1.5 million booster seats are sold. Based on the availability in the market, NHTSA assumes 90 percent of these are high back and 10 percent are no back booster seats. Thus, the agency assumes a grand total of about 7.5 million child restraints sold per year. In year 2002 values, the total cost is estimated to be $430.5 million (Table 1).

Table 1. Estimated Consumer Spending on Child Restraints in 2002

Child restraint type	Assumed sales	Average price	Total costs
Infant restraint	1,500,000	$50	$75,000,000
Convertible	4,500,000	$60	$270,000,000
High back booster	1,350,000	$60	$81,000,000
No back booster	150,000	$30	$4,500,000
Total	7,500,000		**$430.5 million**

Population distribution and the need for more than one integrated child restraint:

Integrated child restraints do not protect rear-facing infants, so if all passenger vehicles had an integrated child restraint, all families with an infant under one year old would still need to purchase an infant restraint - 3.92 million child restraints for infants. If only one integrated seat is required per vehicle, all families with more than one child in the age group of 1 to 7 years old would need to buy a convertible child restraint. To get an estimate of how often a convertible seat would be needed, the agency examined NASS data to determine, given that one 1-7 year old child was in a passenger vehicle, how often were there two 1-7 year old children, three 1-7 year old children, etc., in the same vehicle. However, even though there might be one or two integrated child restraints in a vehicle, there may be more children of the same age traveling in that vehicle. As an

example, if a parent or a caregiver has three infants, the parent or the caregiver still needs to buy a convertible seat for the third child. Table 2 shows NASS crash data with at least one child in the 1 to 7 year old group in a passenger vehicle that was towed from the crash. Based on this data, if only one integrated seat is required, 22.8 percent of the children would not be able to use an integrated restraint because there is more than one child in the 1 to 7 year old group in a vehicle. If two restraints were supplied in every vehicle, 5.2 percent of the children would not be able to use an integrated child restraint because there are more than 2 children in the 1 to 7 year old group in a vehicle.

Table 2. Number of Towed Passenger Vehicles with 1 to 7 Year Old Children (Total Children 294,441) (Annual Average for 1998-2001 NASS)

Number of children in each vehicle	Vehicles with 1-7 year olds	Percent of children not covered by one integrated seat	Percent of children not covered by two integrated seats
1	175,338		
2	38,610	13.1	0.0
3	11,399	7.7	3.9
4	1,549	1.6	1.0
5	298	0.4	0.3
6	0		
Total	227,194	**22.8**	**5.2**

Below, NHTSA estimates the total future costs to consumers for restraint systems where one or two integrated restraint system per vehicle is required. This total cost to consumers assumes that an age appropriate child will use one integrated child restraint system, and the add-on child restraints will be purchased for children of an age not appropriate for the integrated child restraint, or for other children in the household.

The Table 2 calculations are based on the number of children in each vehicle and not on child age distribution. For 1 to 7 year old children, 22.8 percent of the child seats (convertibles and boosters) will still be made for households with a second or third child if only one integrated child restraint with integral harnesses were required. Since 1 to 3 year old children will use a convertible CRS, the agency assumes that 22.8 percent of the sales of convertible seats per year will still be made for households with a second or third child if only one integrated child restraint with internal harnesses were required for this age group. Since 4 to 7 year old children do not use convertible CRS, 22.8 percent of this age children will not have access to integrated child seats with internal harnesses. From the 4 to 7 year old children, the agency assumes that 66 percent will buy booster seats and 34 percent will just use vehicle lap/shoulder belts. So, of the 22.8 percent with more than one child, 15 percent (0.66*22.8) will buy booster seats and 7.8 percent (0.34*22.8) will just use vehicle-provided lap/shoulder belts. If two integrated child restraints are required, 5.2 percent of convertible CRS sales will still be made for 1 to 3 year old children. From the 4 to 7 year old children for two integrated seats, the agency assumes that the consumer will buy more booster seats for a vehicle with one integrated seat than for a vehicle with two integrated seats. Therefore, the agency assumes that 60 percent will buy booster seats and 40 percent will just use vehicle lap/shoulder belts. So, 3.1 percent (0.60*5.2) will buy booster seats and 2.1 percent (0.4*5.2) will just use vehicle lap/shoulder belts. The agency also assumes, for this analysis, that parents and caregivers will buy booster seats for an additional 20 percent of the previously estimated 3.92 million restraints needed yearly (3,920,000*0.2 ≈ 800,000 sales per year) as child safety advocates spread the information that booster seats are improving belt fit and belt

effectiveness for children older than three years old. The total future consumer costs for integrated and other type of child seats are estimated in Table 3a and Table 3b. Table 3a and Table 3b assume that, in the future, all of the infants (3.92 million infants) will need new infant seats, the use of convertible seats will decrease by about 500,000 due to availability of integrated seats, and an additional 20 percent (800,000) of 4 to 7 year old children will need booster seats.

Table 3a. Total Future Consumer Costs Assuming One Integrated Child Restraint per Vehicle for Children 1 to 7 Years Old

Type of child seat	Total cost for restraints purchased for one integrated seat
Infant	3,920,000 @ $50 = $196,000,000
Convertible	22.8%* 4,000,000 @ $60 = $55,000,000
Booster	(15%*(1,500,000 + 800,000)) @ $57[6] = $20,000,000
Integrated	11,560,000 @ $40 = $462,000,000
Total	**$733,000,000**

Table 3b. Total Future Consumer Costs Assuming Two Integrated Child Restraints per Vehicle for Children 1 to 7 Years Old

Type of child seat	Total cost for restraints purchased for two integrated seats
Infant	3,920,000 @ $50 = $196,000,000
Convertible	5.2%* 4,000,000 @ $60 = $13,000,000
Booster	(3.1%*(1,500,000 + 800,000)) @ $57 = $4,000,000
Integrated	11,560,000 @ $40*2 = $925,000,000
Total	**$1,138,000,000**

Benefits – Target Population:

To start the analysis the agency estimated the number of injuries and fatalities that occur in the current fleet of passenger cars and light trucks (pickup trucks, vans, and sport utility vehicles). The estimates were derived from the Fatal Analysis Reporting System (FARS) for fatalities and from the National Automotive Sampling System (NASS) for

[6] The $57 is weighted average for high back and no back booster seats as given in Table 1.

injuries. The agency limited the analysis to the rear seats of passenger cars and light trucks with rear seats, since the agency assumed that integrated child restraints would only be incorporated into rear seats (Table 4a and Table 4b from FARS data).

Table 4a. Child Occupant Fatal Injuries by Age and Restraint Use for Passenger Car Rear Seating Positions (2001 FARS)

Age (years)	Child restraints	Improperly* used CRS	Belted	Unbelted	Total
Under 1	26	9	1	14	50
1	35	3	2	8	48
2	26	2	6	7	41
3	18	0	9	18	45
4	12	1	13	11	37
5	5	0	13	10	28
6	2	0	16	13	31
7	0	1	21	14	36
Total	124	16	81	95	**316**

* The 2002 FARS users manual was used for definition of improperly used CRS.

Table 4b. Child Occupant Fatal Injuries by Age and Restraint Use for Light Truck Rear Seating Positions (2001 FARS)

Age (years)	Child restraints	Improperly used CRS	Belted	Unbelted	Total
Under 1	9	1	1	10	21
1	11	3	0	2	16
2	14	1	2	5	22
3	9	0	3	12	24
4	2	1	17	8	28
5	3	0	8	10	21
6	0	0	4	12	16
7	0	0	6	10	16
Total	48	6	41	69	**164**

Table 5a and Table 5b (from FARS and NASS data) show the distribution of injuries for AIS 1 (minor injuries), AIS 2-5 (moderate to critical injuries) and fatalities by age for the rear seats of passenger cars and light trucks.

Table 5a. Injury Levels and Fatality by Age - Passenger Car Rear Seating Positions

Age (Years)	(MAIS* 1)	MAIS 2 –5	Fatal
Under 1	2735	131	50
1	4875	148	48
2	6218	263	41
3	5007	459	45
4	5922	305	37
5	4920	185	28
6	6780	164	31
7	3329	421	36
Total	39,786	2,076	**316**

*Maximum Abbreviated Injury Scale

Table 5b. Injury Levels and Fatality by Age - Light Truck Rear Seating Positions

Ages (Years)	MAIS* 1	MAIS 2-5	Fatal
Under 1	867	11	21
1	1472	32	16
2	1422	208	22
3	1424	76	24
4	1726	48	28
5	2133	193	21
6	2943	267	16
7	1986	85	16
Total	13,973	920	**164**

*Maximum Abbreviated Injury Scale

Usage:

Table 6a shows the current usage of child restraints by age groupings that were observed in the 2002 National Occupant Passenger Usage Survey (NOPUS).

Table 6a. Observed Child Restraint Usage by Age (percent)
National Occupant Protection Use Survey (NOPUS) 2002

Age (years)	Car seat restraint	High-back booster	Belt, or backless booster	No restraint	Total
Less Than One	97	1	1	1	100
1-3	65	16	13	6	100
4-7	10	6	67	17	100
Total 0 to 7	88			12	100

In order to perform this analysis the agency had to assume how children would use the integrated child restraints, strictly on judgment, since the agency has no data on how children actually use the small number of integrated child restraints in the current vehicle fleet. Table 6b assumes there will be one integrated child restraint available for every vehicle, and Table 6c assumes there will be two integrated child restraints available in every rear seat. The agency makes adjustments for cases where there are more children of the appropriate age traveling in the vehicle than the potentially required number of integrated child restraints in the vehicle.

Table 6b. Assumed Child Restraint Usage by Age With One Integrated Seat (percent)

Age (years)	Child seat restraint	Booster seat	Lap/shoulder belt	Integrated child restraint	No restraint	Total
Under 1	98	0	0	1	1	100
1-3	23	0	0	71	6	100
4-7	0	15	8	60	17	100

Table 6c. Assumed Child Restraint Usage by Age With Two Integrated Seats (percent)

Age (years)	Child seat restraint	Booster seat	Lap/shoulder belt	Integrated child restraint	No restraint	Total
Under 1	98	0	0	1	1	100
1-3	5	0	0	89	6	100
4-7	0	3	2	78	17	100

Effectiveness:

The effectiveness of child restraints was taken from a number of studies[7,8,9]. For AIS 1 injuries, the agency has typically assumed that any type of restraint reduces AIS 1

[7] DOT HS 808 945, NHTSA Technical Report "Effectiveness of Lap/shoulder Belt in the Back Outboard Seating Positions" June 1999.
[8] NHTSA Research Note "Revised Estimates of Child Restraint Effectiveness" December 1996.

injuries by 5.5 percent for the rear seating position. The most important effectiveness estimates for this analysis are the estimates for lap/shoulder belts versus integrated child restraints. Results are shown in Table 7.[10] The agency has no data on integrated child restraint effectiveness. Based on limited test data, the agency assumes the same effectiveness for integrated seats, booster seats, and the new child restraints with LATCH.

Table 7. Effectiveness of Restraints by Type for Children in Reducing Injuries and Fatalities (percent)

Restraint type	MAIS 2 TO 5	Fatalities
Integrated seats	58	61
Booster seats	58	61
Lap/shoulder belts (as used)*	53	56
Child safety seats (CSS), properly used (0-4 years)	67	71
Old CSS as used (0-4 years)	52	55
Estimated new CSS (LATCH) as used (0-4 years)	58	61

*This effectiveness applies to 3 to 7 year olds. No effectiveness, or negative effectiveness, for 0 to 2 year olds. As used indicates actual use including belted and unbelted child occupants.

Estimated Benefits:

From Tables 5a and 5b, there were 480 (316 + 164) fatalities annually, which is the target population for this analysis. Based on current usage estimates for CRS, current fatalities given the CRS used, and the effectiveness of the CRS, the number of fatalities that would have occurred if no restraint of any type were used is 1,049. Depending on whether one or two integrated child restraints would be provided in the rear seats of

[9] NHTSA Report to Congress "Improving the Safety of Child Restraints, Booster Seat Study" October 2002.

[10] A study by Durbin, et. al., JAMA, Vol. 289, No. 21: 2835 – 2840, reported that belt-positioning booster seats reduce the risk of injuries among children in vehicle crashes. The agency has examined this paper and agrees that booster seats provide better protection than lap/shoulder belts for children 4-7 years old. However, the agency believes that the number of seriously injured children in belt positioning booster seats in the study was not large enough for the agency to be confident in the findings of very large differences in effectiveness between vehicle's lap/shoulder belt and belt positioning booster seats.

vehicles, two benefit estimates would result as shown in Table 8. These estimates assume that all vehicles will have integrated seats and the integrated seats will be filled first by age appropriate children. However, for cases when there are more children than integrated seats, there is no additional benefit for the extra children. For example, under the assumption that one integrated child restraint would be installed per vehicle, 22.8 percent of the children could not be in an integrated child restraint and would not share the benefits of an integrated seat.

Table 8. Estimated Benefits Versus Unrestrained Children for Injuries Prevented and Lives Saved, One and Two Integrated Seats Per Vehicle[11]

	AIS 1	AIS 2 TO 5	Fatalities
Current usage	2,567	4,102	543
With one integrated seat	2,567	4,268	563
With two integrated seats	2,567	4,283	564

Cost per Equivalent Life Saved:

This analysis combines costs and benefits to provide a comparison of costs to the estimated injuries and lives saved. Vehicle costs and child restraint costs occur when the vehicle or child restraint is purchased, but benefits accrue over the lifetime of the vehicle or child restraint.

An equivalent fatality is defined as the sum of fatalities and nonfatal injuries prevented converted into fatality equivalents. This conversion is accomplished using the relative values of fatalities and injuries measured using a "willingness to pay" approach. This approach measures individual's willingness to pay to avoid the risk of death or

[11] Values in Table 8 were derived from FARS (2001) and CDS (1993 to 2001) for children from birth to 7 years old. These data along with the usage rate and the effectiveness of integrated child restraints were used to calculate the values of injuries prevented and lives saved.

injury based on societal behavioral measures, such as pay differentials for more risky jobs.

The estimated incremental benefits of requiring one integrated child restraint per vehicle over the current situation, from Table 8, is up to 20 (563 – 543) lives saved and 166 (4,268 – 4,102) AIS 2-5 injuries reduced annually at an incremental cost of $302 million ($733 million - $431 million) annually for an incremental cost of $19.8 million per equivalent life saved (discounted at 7 percent). If two integrated child restraints were required, the estimated incremental benefits would be up to 21 (564 – 543) lives saved and 181 (4,283 – 4,102) AIS 2-5 injuries reduced annually at an incremental cost of $707 million ($1,138 million - $431 million) for an incremental cost of $41 million per equivalent life saved (discounted at 7 percent). Table 9 presents the undiscounted and discounted cost per equivalent fatality saved for one or two integrated seats cases based on discounting future benefits with a 4 percent and 7 percent discount factor.

Table 9. Estimated Cost per Equivalent Life Saved (in millions of dollars)[12]

	Undiscounted	Discounted @4%	Discounted @7%[13]
One integrated seat	13.1	16.9	19.8
Two integrated seats	27.2	35.0	41.1

[12] Since NHTSA does not believe in assigning a value to a life, the agency derives a cost per equivalent life saved. The agency says equivalent life, because the agency uses a "willingness to pay" approach to equate injuries to lives. So, for example an MAIS 1 injury (Maximum Abbreviated Injury Scale of 1 - a simple cut or bruise) is estimated by the agency's methodology to be valued at .0031 of the value of a life. This means that 323 AIS 1 injuries equate to one life. This cost per equivalent life methodology allows the agency to compare the cost/effectiveness of various standards that affect different injury levels.

[13] Costs occur when the vehicle is purchased. Benefits occur over the lifetime of the vehicle (whenever a crash occurs). The benefits are discounted back to present value to bring them into the same economics. The agency uses a discount rate of 7 percent (as required by OMB) in its analysis.

VI. EASE-OF-USE AND RELATIVE AVAILABILITY OF THE CHILD RESTRAINT TO CHILDREN RIDING IN MOTOR VEHICLES.

In November of 2000, Congress enacted the TREAD Act. Section 14 (g) required NHTSA to establish a child restraint safety rating consumer information program to provide practicable, readily understandable, and timely information to consumers for use in making informed decisions in the purchase of child restraint systems. On November 6, 2001, NHTSA published a Notice of Proposed Rulemaking (NPRM) and sought comments on a rating system based on the ease of use and dynamic performance of add-on child restraints (66 FR 56048).

On November 5, 2002, NHTSA published a response to comments and a notice of final decision (67 FR 67448). In response to the mandate and comments from the proposed notice, NHTSA decided to establish a consumer information program for add-on child restraints based on ease of use. NHTSA also decided to perform two pilot programs, one to perform dynamic sled testing of child restraints and the other to include child restraints in the vehicles tested under the New Car Assessment Program (NCAP). The child restraints ease of use rating program evaluates child seats in five categories: (1) assembly (i.e., ready to use out of the box), (2) evaluation of the labels, (3) evaluation of the instructions, (4) securing the child features, and (5) installation features. Two of the five categories (assembly and installation features) are not required for integrated child restraints, and several of the criteria for evaluating labels and instructions also do not apply. In the notice of final decision, NHTSA stated:

> "…This ease of use rating program will apply to add on child restraints only. In developing an ease of use ratings program, NHTSA did not consider built-in child

> restraints, thus the features and rating criteria are designed to evaluate only add on child restraints. In order for NHTSA to evaluate built-in child restraints, a modified set of criteria would need to be developed. Based on the time frame for implementing the child restraint ratings program, developing and testing criteria to rate built-in child restraints is not possible. However, rating built-in child restraints may be explored by the agency in the future."

Therefore, in order for NHTSA to evaluate integrated child restraints, a modified set of criteria needs to be developed. Based on the time frame given in Section 6 of Anton's Law, developing an ease of use rating program for integrated child seats was not possible.

On June 11, 2003, NHTSA announced the first set of ease of use ratings for 68 add-on child restraints, representing approximately 95 percent of the child restraint models available to consumers. These ratings are published on the NHTSA website (http://www.nhtsa.dot.gov/CPS/CSSRating). The main reason the ease of use program was developed was to address the issue of child safety seat misuse. Studies have been published showing that 80 percent of child safety seats are misused (new agency misuse study is under internal review). The goal of the ease of use program is to encourage child restraint manufacturers to design child safety seats that are easier for consumers to use. A child safety seat that is easier to use is more likely to be used properly.

In 2003, Chevrolet Venture and Pontiac Montana provided integrated child restraints as standard equipment. Chrysler Voyager, Town & Country; Dodge Caravan, Grand Caravan; and Volvo S40, S60, V40, V70, XC70, S80, XC90 also offered integrated child restraints as optional equipment. The assumption is that because integrated child seats are permanently installed in vehicles, they are easy to use. However, NHTSA has not done a rating on integrated child restraints based on their ease

of use to confirm this assumption. In fiscal year 2004, the agency will examine the feasibility of developing criteria to rate integrated seats and evaluate the criteria to determine if an ease of use rating program for integrated child seats would be beneficial to consumers.

As stated before, for model year 2003, Chevrolet Venture and Pontiac Montana are the only vehicles that provided integrated child restraints as standard equipment. A total of 85,598 front wheel drive (FWD) and 3,576 all wheel drive (AWD) Chevrolet Venture, and 43,569 FWD and 2,370 AWD Pontiac Montana were produced in model year 2003. The total production for the two vehicle models is only about 5.5 percent of the total General Motors (GM) light truck production for that year. Compared to all vehicles sold in the U.S., this number is negligible.

VII. BENEFITS OF INTEGRATED SEATS FOR IMPROVING COMPLIANCE WITH STATE CHILD OCCUPANT RESTRAINT LAWS.

Integrated child seats are labeled for various child weight ranges. They range from up to 40 pounds for the GM vehicles; up to 50 pounds for the Chrysler vehicles; up to 66 pounds for the Nissan Quest van (no longer offered); and from 33 to 85 pounds for the Volvo vehicles. Integrated child seats only accommodate forward facing children (20 pounds or more). To analyze the potential for integrated child seats to improve compliance with State child occupant restraint laws, the agency assumed they would be designed for children ages 1-7 (with internal harnesses for 1 to 3 year olds). Table 10 shows the age and average weight of children.

Table10. Age and Average Weight Distribution of Children

Age (years)	1	2	3	4	5	6	7	8
Weight (pounds)	Up to 34			Up to 47			Up to 62	

State laws on the maximum age under which a child must be restrained vary from birth to eight years of age, with the majority of laws clustered around less than four years of age. So, when a State law is effective up to age 4, the agency assumes it affects children ages 3 and under. Table 11 shows the distribution of States according to the age under which children must be restrained, and percent of the U.S. population for that age group.

Table 11. State Laws for Child Restraints Requirements by Age of Children

Age group required to be restrained	**Number of States (including D.C.)**	**Percent of United States population in those States**
<2	2	2.3
<3	5	5.1
<4	20	45.9
<5	11	13.4
<6	8	26.8
<7	3	3.3
<8	2	3.2
Total	51	100.0%

Table 12 shows the distribution of the population of the United States by age up to 7 years.

Table 12. Distribution of Child Population of the United States by Age

Age (years)	< 1	1	2	3	4	5	6	7
Percentage of total population	1.35	1.36	1.35	1.36	1.41	1.41	1.43	1.46

This analysis compares the percent of the United States child population that integrated restraints could cover, after considering State laws, to the total percent of the

United States population that are required to be in a child restraint by State law. Currently 6.56 percent[14] of the United States population is required by State law to be restrained in a child restraint. Currently, integrated child restraints are designed to restrain children forward facing. Therefore, infants (less than 1 year old) (1.35 percent of the United States population) that are transported rear facing would not be covered by any of the current integrated child restraints.

Since there are many families with two or more children in these age groups, one integrated child restraint alone per vehicle would provide coverage for 4.02 percent (6.56-1.35)*(1-.228) of the U.S. population or 61 percent of those required to be in child restraints by State law. Two integrated child restraints per vehicle would provide coverage for 4.94 percent (65.6-1.35)*(1-.052) of the U.S. population or 75 percent of those required to be in child restraints by State law.

While the above analysis provides a theoretical coverage of how integrated child restraints line up with the State laws, the question asked is how could integrated seats improve compliance with State child occupant restraint laws? To answer this question the agency needs to look at current compliance with State laws by age of occupants. The latest occupant usage survey results by age were shown in Table 6a. Almost all of the infants observed in 2002 were in child restraints (97% in car seats, 1% in high back booster seats, about 1% in belts or backless boosters and 1% unrestrained). About 94 percent of toddlers (1-3 year olds) were restrained and 83 percent of the 4-7 year old children were restrained. For all children (0-7 years old), 88 percent of the children were

[14] The 6.56 percent value was derived using the latest official data (February 2003) from each State population and percentage of children that are required to be restrained in child seats in each State. With the high degree of recent changes in state legislative requirements for child restraint, the 6.56 percent value is expected to change significantly in the near future.

restrained. Not all of the restraint modes are age appropriate. The potential range of improvement for overall child restraint use is 12 to 14.3 percent (to reach 100% use).

The next question is: "Why would restraint use increase just by having an integrated child restraint installed in the vehicle?" Safety belts are already installed at each seating position. The majority of children in the 4 to 7 age group currently use safety belts as a restraint (although booster seats and integrated child restraints are safer than safety belts for these ages). So, the convenience of having an integrated child restraint in the vehicle, as opposed to the convenience of having safety belts, may not motivate children in this age group to restrain themselves. This is in addition to a parental responsibility to ensure that children are transported in vehicles restrained in an age appropriate CRS at all times. However, an integrated child restraint would fit and restrain the children better than the vehicle seat belt system alone, and restraint use might increase because of better comfort. This could result in vehicles equipped with integrated child restraints leading to a portion of the children that use safety belts today to use the integrated child restraints.

There has been a significant shift toward booster seats in observed usage. In 2000, there were almost no high-back booster seats observed in our survey (NOPUS 2002). In 2002, 16 percent of the 1-3 year olds and 6 percent of the 4-7 year olds were observed in high-back booster seats. This increase is expected to continue as child safety advocates spread the information that booster seats are improving belt fit and belt effectiveness for those 4 years old and older. However, in 2002, 16 percent of the 1 to 3 year old children were inappropriately restrained in high-back booster seats. The agency recommends that children over one year old and weighing 20 to 40 pounds should be

restrained in convertible/forward-facing child seats, and children 4 to 8 years old and weighing over 40 pounds should be restrained in booster seats unless they reach 4 feet, 9 inches in height. Children restrained in inappropriate (misused) child seats have greater injury severity in a crash than children in appropriate child seats.[15]

In summary, integrated child restraints have not been designed for rear-facing infants (those less than 1 year old), thus all children required by State laws to be in child restraints cannot use an integrated child restraint (even with two integrated child restraints required per passenger vehicles and pick ups) to meet the State law compared to 100 percent compliance for add-on child restraints.

VIII. CONCLUSIONS

Based upon the studies and analyses presented in this report, the agency makes the following observations and conclusions:

(1) There are no existing integrated seats that can properly fit all heights and weights of children. For this report, the agency assumes integrated child restraints, would be designed for children age 1-7, with internal harnesses for 1 to 3 year olds. There are also no rear-facing integrated seats, meaning that infants still need rear-facing add-on child restraints.

(2) Analysis of Compliance and NCAP data, and a CHOP study indicate that integrated child restraints do not provide enhanced safety over add-on child restraint systems.

[15] Kids In Crashes: The Real World Consequences of Child Restraint Misuse, Elizabeth Edgerton, MD, MPH, et al, CIREN 2002.

(3) The agency knows of no compatibility problems for integrated child restraints, although there are some concerns regarding proper fit. Taking into consideration the changing circumstances being brought about by LATCH, recent upgrade to Federal motor vehicle safety standard No. 213, "Child restraint systems," and proposed requirements for lap/shoulder belts for all vehicle rear designated seating positions, the agency would expect a small benefit from integrated child restraints for compatibility if all vehicles were equipped with integrated child restraints.

(4) The estimated incremental benefits of requiring one integrated child restraint per vehicle over the current situation would be up to 20 lives saved and 166 AIS 2-5 injuries reduced annually. [The basis for the 20 lives saved estimate is the assumption that there would be less misuse with built-in child restraints than with child safety seats and lap/shoulder belts. This assumes that integrated child restraints will not have the misuse associated with the installation of forward-facing add-on child seats (loose or unattached seats), the misuse associated with moving children out of child restraints into vehicle lap/shoulder belts before the children can fit the belt system, or the misuse of putting a shoulder belt behind their back. It should be noted that the agency estimates the effectiveness of a properly used add-on child restraint is the same as a properly used integrated child restraint.] The incremental cost would be $302 million annually, resulting in an incremental cost of about $20 million per equivalent life saved (discounted at 7 percent). If two integrated child restraints were required,

the estimated incremental benefits would be up to 21 lives saved and 181 AIS 2-5 injuries reduced annually. The incremental cost would be $707 million, resulting in an incremental cost of about $41 million per equivalent life saved (discounted at 7 percent). If there were more children in a vehicle than integrated child restraints, or if the integrated child restraints were not appropriately sized for the children riding in the vehicle, add-on child restraints would have to be used in addition to the integrated seats.

(5) It is assumed that because integrated child seats are permanently installed in vehicles, they are easy to use. However, NHTSA has not done a rating on integrated child restraints based on their ease of use to confirm this assumption. Therefore, in fiscal year 2004, the agency will examine the feasibility of developing criteria to rate integrated child seats and evaluate the criteria to determine if an ease of use rating program for integrated child seats would be beneficial to consumers.

(6) Integrated child restraints have not been designed for rear-facing infants (those less than 1 year old). Also, integrated child restraints are not designed for every seating position, and many families have three or more children in the 1-7 year old age group. Thus, all children required by State laws to be in child restraints cannot use an integrated child restraint to meet the State law. Of those children required by State laws to be restrained by child restraints, 61 percent of them could be covered by one integrated child restraint per vehicle. With two integrated child restraints

required per light passenger vehicle, 75 percent of the children required by State laws to be restrained could be restrained by integrated child restraints. The remaining children would need to be restrained by add-on child restraints.

Therefore, from the above observations, the agency believes that both integrated and add-on child restraint systems work well in protecting children and, therefore, both should coexist to provide the best safety protection in transporting children in motor vehicles.