People Saving People

FINAL ECONOMIC ASSESSMENT

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

FMVSS No. 213
FMVSS No. 225
Child Restraint Systems,
Child Restraint Anchorage Systems

Office of Regulatory Analysis
Plans and Policy

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SUMMARY

Child restraint systems are the most effective way to protect young children involved in motor vehicle crashes. NHTSA estimates that these systems, when properly used, reduce the chance of death in a motor vehicle crash by 71 percent. However, in order for these benefits to be achieved, child restraints must be installed and used properly. A four state study sponsored by the agency found that nearly 80 percent of child restraints were improperly installed or used. Every year an average of 230 children aged 0-6 are killed, and nearly 66,000 are injured in motor vehicle crashes while sitting in child restraints. An estimated 68 deaths and 874 nonfatal injuries could have been prevented if misuse of child restraints were eliminated.

To address this problem, NHTSA is establishing a uniform child restraint attachment system. Vehicles will be equipped with independent child restraint anchorage systems consisting of three anchorage points: two lower anchorages and one upper anchorage. Each lower anchorage consists of a 6 mm bar located at the intersection of the vehicle seat cushion and seat back, in a location where it will not be felt by passengers. The upper anchorage is a top tether anchorage. These anchorage systems will be required at two rear seating positions. In addition, if a vehicle has three designated seating positions in the rear seat or second or third row of seats, another seating position, other than an outboard position must be equipped with a user-ready tether anchorage. Child restraints will be required to be equipped with a means of attaching to these anchorage systems.

The agency considered several different types of uniform attachment systems. Both the vehicle anchorages and the child restraint attachments could be designed to be rigid or nonrigid (i.e., flexible). Both systems provide comparable safety benefits. However the agency selected the vehicle rigid anchorage system because it allows for more flexibility in child restraint designs. In addition, it will harmonize U.S. standards with anticipated European and Canadian standards. To further provide for design flexibility, the rule allows either rigid or non-rigid attachments on child restraints.

Safety Benefits:

The uniform systems will increase safety both by decreasing misuse, and by providing better protection than current systems do even when used properly. Of the estimated 68 lives lost annually due to misuse, this final rule is expected to prevent 30 to 33 fatalities. In the event of a crash, the tether will prevent head excursion and reduce the chance of serious head injury. An estimated 6 to 17 additional lives will be saved by tether anchorages. The safety benefits of both rigid and non-rigid connectors are summarized in Table S-1. It is estimated that these systems will prevent from 36 to 50 fatalities, and from 1,231 to 2,929 nonfatal injuries annually.

Table S-1
Benefits

CRS /Vehicle	Fatality Benefits	Injury Benefits
Rigid/Rigid	36 to 47	1,231 to 2,893
Nonrigid/Nonrigid	36 to 50	1,235 to 2,929
Nonrigid /Rigid	36 to 50	1,235 to 2,929

Estimated Average Costs

Table S-2 presents an estimate of what the agency believes will be the most likely total cost of the final rule. NHTSA believes that sales of child restraints with rigid connectors (shown in Table S-3 to cost from $33.87 to $43.87) and the nonrigid connector system that uses a single strap through the opening on the back of the seat (shown in Table S-3 to cost as low as $9.62) may be limited because few manufacturers indicated they would produce these types of systems. The estimate of most likely costs ($17.19) is thus based on an average of nonrigid connector systems with dual straps. The average vehicle costs ($5.67) are weighted by the number of seating positions required to be equipped with rigid anchorages.

Table S-2
Estimated Average Costs
($1996)

Restraint Type	Per Child Restraint	Per Vehicle	Total Annual Cost	Cost Per Equivalent Fatality (Millions)
CRS Nonrigid/ Vehicle Rigid	$17.19	$5.67	$152 Million	$2.1 to $3.7

Range of Costs:

The range of costs for providing anchorages and tethers, and modifying child safety seat designs are summarized in Table S-3. Anchorages and tethers are expected to increase vehicle costs by from $2.82 to $6.62. Child restraint costs will increase by $9.62 to $43.87.

Table S-3
Consumer Cost of Various Types of Systems
($1996)

System	Per Child Restraint	Per Vehicle*
CRS Rigid	$33.87 - $43.87	
CRS Nonrigid	$9.62 - $21.09	
Vehicle Rigid		$2.82 to $6.62

* The range represents vehicles with no rear seat (meaning anchorage required for one front seat) to vehicles with three rear seating positions (meaning two seating positions with lower anchorages and tether plus one seating position with just a tether).

Cost Effectiveness:

For the estimated average total annual cost of $152 million, the cost per equivalent life saved is estimated to be $2.1 to $3.7 million (see Table S-2).

INTRODUCTION

The National Highway Traffic Safety Administration (NHTSA) is publishing a Final Rule to introduce a new safety standard; Federal Motor Vehicle Safety Standard (FMVSS) 225, Child Restraints Systems, to improve the securement of add-on child restraints to vehicle seats. This Final Rule requires the use of a universal attachment system for child restraints, at two seating positions, and also requires child restraints be fitted with some means of attaching to those systems.

The number and types of seat belts in today's vehicles vary greatly. The vehicle belt design may make proper attachment of the child restraint difficult, because the correct way to route the vehicle seat belt through the child restraint varies from seat model to seat model. Also, many lap/shoulder belts of cars on the road need locking clips to hold the child restraint securely. The nonuse/misuse of locking clips appears to be a big contributor towards the misuse of child restraints. In addition, the interior designs of most vehicles have changed tremendously; many vehicles have been redesigned to improve adult comfort and safety, moving the seat belt anchorage away from the seat bight (i.e., the intersection of the vehicle seat back and its seat cushion), resulting in belt systems that are more difficult to attach to child restraints.

Injury to children in passenger vehicles can result from misuse, the compatibility problems between the child restraint and vehicle belt systems, or both. There are many ways that the child restraint can be misused:

1) The type of child restraint used is inappropriate fur the age/size of the child, or faced in the wrong direction.

2) The child restraint is nut restrained by the vehicle belt or nut properly installed in the vehicle, e.g., incorrectly routing vehicle belts about or through the child restraint device, failure to use a locking clip, or other such items.

3) The child is nut properly restrained within the child restraint, or failure to restrain the child at all.

4) The restraint is in the wrong seating position in the vehicle, i.e., installation of a rear-facing infant or convertible seat in the front passenger seat when the vehicle is equipped with a passenger-side air bag (unless the vehicle has an air bag cut-off switch and this switch is used properly).

Other examples of the need to improve the compatibility of child restraint systems and vehicles include:

I) The seat belt anchorages are positioned too far forward of the vehicle seat. Thus, the child restraint cannot be secured tightly against the seat back.

2) The seat cushions and seat backs are too deeply contoured. This prevents the child restraint from being put in a stable position on the seat. This final rule will make child restraints more stable, regardless of the contour of the seat and the seat back.

3) The seat belt length and accompanying hardware attachments are nut suitable fur use with child restraints, or with special child restraints. In some seat positions the distance between the anchorages fur the lap belt and buckle is nut as wide as a child restraint. In

these cases the seat belt may not tightly hold the child restraint and it can easily move from side to side. By providing a means for attaching child restraints that is independent of the vehicle belts, this final rule will improve the lateral stability of child restraints on the vehicle seats.

4) The vehicle seat is not wide enough or long enough to accommodate the child restraint properly. This final rule will accommodate child restraints on these seats by providing an independent means of stability.

As a result of the misuse and compatibility problems, the International Standards Organization Working Group for child restraint systems is working on a draft industry standard that would standardize the interface for attaching child restraints by means of an independent child restraint anchorage system.

NHTSA has determined that child restraints should be anchored to the vehicle using attachments independent from the safety belts currently provided with the vehicle. Having two different attachment systems, one that is designed for older children and adults and a second system designed specifically for child restraints, would allow designers to create the best design for child restraints, and the best design for adults without having to make compromises.

This final rule standardizes the motor vehicle child restraint interface to reduce the misuse and or compatibility problems of child restraints with the restraint systems of most passenger vehicles. With the child restraint anchorage system in the passenger vehicles standardized, the child restraint manufacturers are free to design child restraints that connect to the standardized vehicle anchorage system. Tether anchorages are also required. User-ready tether anchorages must be provided with each vehicle fur the owner's convenience. The user-ready anchorage must be designed to accept the tether strap hook directly, without requiring the installation of any other device. The purpose of the tether anchorage and tether strap is to secure the top part of the child restraint and limit head excursion.

Vehicle seats and seat belts have evolved over the years. At one time, the standard means of attaching a child restraint was the vehicle lap belt. Now all outboard seating positions are required to be equipped with lap/shoulder belts. This change has resulted in seat belt anchorages sometimes being positioned several inches forward of the seat back to better position the lap portion of the seat belt low on the pelvic area of older children, teenagers and adults. Vehicle manufacturers have given top priority to designing vehicle seat belts fur older children and adults. Because of the difficulty of designing vehicle seat belts to perform the dual function of restraining child restraint systems and of restraining the torsos of older individuals, the vehicle belts are nut as effective as they could be fur the purpose of restraining child restraints..

A forward mounted anchorage, fur example, is designed to allow comfort to the adult passenger, but allows a child restraint to slide too far forward in a frontal collision to safely limit the child's head excursion. Efforts to make vehicle belts systems more effective fur older children and adult passengers have also resulted in the belt systems becoming more complex and more difficult to use to attach child restraints correctly. Due to these complexities people often misuse child restraints in vehicles.

By having an independent child restraint anchorage system, compatibility between vehicle seat belts and child restraints would be greatly increased. This will result in more child restraints being correctly installed. The standardized anchorages required by this rule are intuitive and easy-to-use and eliminate the need to route the vehicle belt through or around the child restraint. By making child restraints easier to install, misuse is reduced, and some parents who otherwise might get frustrated trying to secure a child restraint, might use a child restraint to restrain their child on every trip.

NPRM/SUMMARY OF DOCKET COMMENTS

The NPRM

On February 20, 1997, (62 FR 7858) (See Docket No. 97-4084) the agency published a Notice of Proposed Rulemaking on Child Restraint Systems; Tether Anchorages for Child Restraint Systems; and Child Restraint Anchorage Systems. The NPRM proposed to require that two seating positions of all passenger cars, and all multipurpose vehicles (MPVs) and trucks with a gross vehicle weight rating (GVWR) of 10,000 pounds (lb) or less be equipped with a means independent of vehicle safety belts for securing child restraints to vehicle seats, and would further require that vehicles have up to three factory-installed, user-ready anchor points for attaching the tether. If an air bag cutoff switch were provided that deactivates the air bag for the front passenger position, one anchorage system would have to be provided in that position, and another in a rear seating position. If there were no rear seat and no air bag cutoff switch, an anchorage system would be disallowed in the front passenger seat, but a tether must be provided fur child restraints that use the vehicle belt system. A built-in child restraint may be substituted fur one of the anchorage systems, but nut both, since rear-facing built-in systems are not currently available.

The NPRM proposed requirements to specify the construction of the child restraint anchorage system, the location of the anchorages, and the geometry of related components, such as the hardware that attaches to a child restraint. To prevent vehicle anchorages from failing in a crash, the anchorages, including structural components of the assembly, would have had to withstand specific loads in a static pull test. The proposal would also have required child restraints to be equipped with an upper tether strap. The child restraints would have to be equipped with the means of attaching to the specialized lower anchorage system in the vehicle. Child restraint systems would be dynamically tested under Standard 2 13. A head excursion limit of 8 13 mm (32 inches) would have to be met without attaching the top tether. A head excursion requirement of 720 mm (28 inches) would also have to be met; a tap tether can be attached for this test.

The NPRM proposed to mandate nonrigid anchorages and nonrigid connectors (the flexible latchplate anchorage system or UCRA system) fur vehicles and child restraints. The NPRM would have permitted vehicles to have rigid anchorages (the ISO rigid bar anchorage system) instead of the nonrigid anchorages (UCRA latch plate anchors) if the vehicle manufacturers also provided an adaptor that enabled a child restraint with the nonrigid UCRA buckles to attach to the ISO bar.

Svstems Considered

Three types of child restraint attachment systems were discussed in the NPRM

A) Rigid Connectors:

1) 4-point Rigid Connectors (no tether)

2) CANFIX (2-point with tether)

B) Nonrigid Connectors: UCRA (Uniform Child Restraint Anchorage)

1) Dual Strap Manual with and without tether

2) Dual Strap Retractor with and without tether

C) A combination of rigid and nonrigid connectors i.e., a hybrid system

Summary of Docket Comments

There were close to 70 docket submissions to the NPRM. The commenters, in general, agreed with the proposal to require top tethers on child restraints. Although virtually all of the commenters agreed with the need for an independent standardized attachment system, about half opposed the proposed option in the NPRM of the nonrigid anchorage system over the rigid anchorage system for the lower anchorage points. Supporters of the nonrigid anchorage system include Advocates fur Highway and Auto Safety (Advocates), the Automotive Occupant Restraints Council, Drivers' Appeal for National Awareness (DANA), General Motors (GM), Gerry Baby Products, Evenflo Company, and Indiana Mills and Manufacturing Inc. (IMMI). Many of the commenters that supported the nonrigid anchorage system based their support on the cost factor.

Commenters that supported the rigid bar anchorage system include Chrysler, Ford Motor Company, BMW of North America, Mercedes-Benz of North America, the Economic Commission of Europe Group of Rapporteurs fur Passive Safety (GRSP), the UK Parliamentary Advisory Council fur Transportation Safety, Transport Canada, and the New South Wales Roads and Traffic Authority (Australia). These commenters disagreed with the agency's tentative determinations in the NPRM that the rigid anchorage system would be cost prohibitive, would add excessive weight and bulk to child restraints, and would need a longer leadtime to implement. The commenters recommended other ways to connect the child restraint to the rigid bars and stated that the rigid anchorage system is superior because it allows design flexibility to child restraint manufacturers. Commenters further stated that the rigid anchorage system has potential safety benefits by reducing head excursion in side impacts and by eliminating the need for the parent to tighten belts; and enhances international harmonization of safety standards.

Child restraint manufacturers Kolcraft, Cosco and Century supported the rigid bar anchorage system after they realized that the rigid bracket connector would nut be required fur the child restraint system. These manufacturers stated that they now prefered the rigid bar anchorage system over the flexible latchplate system, provided that the access and location of the anchors allowed design flexibility fur either a frame mounted (bracket-based) or a nonrigid (strap) mounted connector on the child restraint. Factors cited fur the change in preference were performance, future child restraint system design flexibility and international harmonization. Century stated, however, that the bars had to be accessible and visible. Cosco believed that the cost effectiveness of the rigid bar anchorage system and flexible latchplate system would be approximately equal, and that “any difference in the using public concerning ease of use and/or desirability of one with respect to the other would soon disappear if such a real difference exists at all today.” Cosco added that the rigid bar anchorage system would help to eliminate certain types of force vectors which may occur within the system of flat latchplates that could be detrimental. Cosco continued that it also clearly distinguished the car seat attachment system from any of the hardware that may be near by.

In this analysis, the agency compares the vehicle and child restraint design option combinations shown below:

Vehicle Anchorages	Child Restraint Connectors
Rigid - Bar	Rigid - Jaw; Nonrigid - Jaw; Nonrigid - Hook
Nonrigid - Bar	Nonrigid - Hook
Nonrigid -Latchplate	Nonrigid- Buckle; Nonrigid - Hook

The Final Rule

The agency has carefully considered the advantages and disadvantages of the various child restraint attachment systems, and has decided that the rigid anchorage system (IS0 6 mm bars) will be mandated on the vehicle. This system will provide more design flexibility for child restraint manufacturers because it is believed that both rigid and non-rigid child restraint systems can be more easily designed for a rigid anchorage than for a non-rigid anchorage. The agency feels that it is important to allow manufacturers the ability to develop rigid systems for both the vehicle anchorage and the child restraint system because theoretically a rigid to rigid system could perform better in side impact crashes. However, the agency dues nut have enough information available yet to quantify any potential difference in safety. To provide design flexibility, the CRS manufacturers will have the option of deciding what type of child restraint connectors they will produce fur sale to the public, but they must be attachable to the rigid bar system.

Equipment Requirements

FMVSS 225 requires manufacturers of motor vehicles and child restraint systems to provide consumers with the equipment that will lead to improved child safety. The new standard requires all passenger cars, trucks and multipurpose vehicles of 8,500 pounds gross vehicle weight rating (GVWR) or less and all buses (including school buses) of 10,000 pounds GVWR or less, to be equipped with:

I) Two child restraint anchorage systems (rigid 6 mm bars) in rear seating positions with tether anchorages, plus a tether anchorage in a third seating position (if there are three or more rear seating positions),

2) If an air bag cutoff switch is provided that deactivates the air bag fur the front passenger position, one child restraint anchorage system must be provided in that position, and anuther anchorage system in a rear seating position. If there is no rear seat and no air bag cutoff switch, a full child seat anchorage system would be disallowed in the front passenger seat but a tether anchor would be required at each front passenger seat.

3) A built-in child restraint may be substituted at one of the three required positions, but not all. Rear-facing built-in systems are currently unavailable, and it is desirable to maintain this seating option, which would be precluded if all positions had built-in forward-facing systems.

The system consists of two rigid 6 mm bar lower anchorages at the vehicle seat bight (the intersection of the seat cushion and the seat back) and a top tether anchorage. For the upper tether, the specifications and test requirements are the same as the ones that have been adopted by Transport Canada to harmonize with Canada and Australia on this fixture. Most vehicles that are sold in the US and Canada currently have the tether anchor structure, but not the hardware. The tether anchor has a proven record and results in improving the safety of children restrained in car seats. To achieve the success of tether use of other countries, this final rule requires that the anchor points and hardware be factory installed and easily accessible to consumers.

The child restraint system standard (Standard No. 213) is amended, in effect, to require child restraints to be equipped with a top tether, and with connectors (e.g., rigid bars or nonrigid hooks) that are compatible with the rigid anchorages on the vehicle.

All child restraints that use the universal child restraint systems must also be capable of being restrained with the current method using the vehicle lap belt, so that they can be used in older vehicles not equipped with the Rigid Anchorages.

Testing Requirements

Fur the dynamic sled testing of the child restraint, the dynamic test specified in Standard 2 13 will be used to evaluate the performance of the child restraint when attached to the universal vehicle anchorage. The standard seat assembly specified in the standard to test add-on child restraints is revised to incorporate a child restraint anchorage system with the 6 mm bars meeting the specifications. A child restraint is to be attached to the lower anchorages (at the seat bight), both with and without the tether strap attached.

Each child restraint is required to meet the following requirements:

Child restraint lap belt testing

i) The current FMVS S 2 13 requirements (including a head excursion limit of 8 13 mm, 32 inches) when tested in a 30 mph sled test using a lap belt only (no tether);

ii) A head excursion limit of 720 mm (28 inches) when tested using a lap belt plus tether:

Child restraint universal anchorage system testing

iii) A head excursion limit of 8 13 mm (32 inches) when tested using the universal anchorage system without a tether;

iv) A head excursion limit of 720 mm (28 inches) when tested using the universal anchorage system with a tether.

In the vehicle, the 6 mm bar and the tether anchors must meet a pull test to assure strength. (See the final rule fur the specifics of the anchorage tests.)

BENEFITS

Benefits are examined using an analysis of crash data to determine target populations and effectiveness, an analysis of a four-state survey that looked into how widespread misuse of child restraints is, and sled testing by the agency to determine how injurious the various misuse modes can be. These pieces of information were combined to estimate what fatalities and injuries could have been prevented with proper use of child restraints. For the remainder of the analysis, the term "misuse" is used in the broader context to mean either misuse or compatibility problems.

Analysis of Crash Data

Tables I(a) and I(b) show the restraint use of children ages zero to six who were involved in fatal crashes for the period 1994 to 1996. For all age groups, the not restrained category accounted for the highest number of fatalities. For the 3 year period, there were 2,539 fatalities of which 52.4 percent were children who were not restrained. An additional 20.2 percent of the fatalities were incorrectly restrained i.e., they were in lap and lap/shoulder belts. Age group five to six had the highest percentage of non-use (60.1 percent). As the children get older the percentage of fatalities that were not using restraints increases. Similarly, as children get older child restraint use decreases. On average for 1994 to 1996, 232 children were killed annually in child restraints,

Table 1(a)
1994 - 1996* Fatalities By Restraint System Used
(Zero To Six Year-Old Children)

Restraint Type	Age <1	Age 1 to 4	Age 5 to 6	Total
None	222	756	353	1,331
L/S Belt	2	117	84	203
Lap Belt	13	159	138	310
Child Restraint	255	428	12	695
Total	492	1,450	587	2,539

* three years of data, not the annual average.

Table 1(b)
1994 - 1996 Percentage of Fatalities By Restraint System Used
(Zero To Six Year-Old Children)

Restraint Type	Age <1	Age 1 to 4	Age 5 to 6	Total
None	45.12%	51.78%	60.14%	52.42%
L/S Belt	.41%	8.01%	14.31%	8.00%
Lap Belt	2.64%	10.89%	23.51%	12.21%
Child Restraint	51.83%	29.32~	2.04%	27.37~
Total	100%	100%	100%	100%

Table l(c) provides the estimated number of non-fatal injuries by injury severity and type of restraint use for the 3 year period of 1994 to 1996. On average there were about 1,867,000 children age 6 or less in police reported crashes per year. Of these, about 730,000 were in child restraints and about 66,000 were reported by the police to be injured or possibly injured.

Table l(c)
1994 - 1996' Injuries By Restraint System Used
(Zero To Six Year-Old Children)

Restraint Type	Injury Severity				
	No Injury	Possible	Non-Incapacitating.	Incapacitating	Total
None	620,792	100,638	75,572	36,051	833,053
L/S Belt	997,856	98,355	40,829	11,921	1,148,961
Lap Belt	1,239,973	127,443	49,175	13,431	1,430,022
Child Restraint	1,990,303	119,279	56,477	22,366	2,188,425
Total	4,848,924	445,715	222,053	83,769	5,600,461

* three years of data, not the annual average.

Target Population

Child restraints are the most effective means of protecting children against injury or death in the event of a crash. Unfortunately, many children are transported in motor vehicles in child restraints that are not properly secured. In an attempt to determine the types and levels of child restraint misuse/compatibility problems that can distinguish misuse from correct use, the agency had Ketron Division of the Bionetics Corporation of Pennsylvania conduct a survey (Ketron Study) "Patterns of Misuse of Child Safety Seats," in January 1996. This survey was conducted in cities in four states, Mississippi, Missouri, Pennsylvania and Washington.

In the survey, there were 4,019 vehicles and 5,869 children that were under 60 pounds in the target population, and 2,223 other vehicle occupants. The surveyed group included: Infants (559) - children under 20 pounds; Toddlers (3,419) - children 20 to 40 pounds; and Pre-schoolers (1,871) - children 40 to 60 pounds. Fur all surveyed children under 40 pounds, 71.6 percent were restrained in a Child Safety Seat (CSS), 18.5 percent were restrained in a safety belt, and 9.9 percent were nut restrained, Fur children 40 to 60 pounds, 6.2 percent were restrained in a CSS, 76. I percent were restrained in a safety belt, and 17.7 percent were nut restrained.

Observed misuse rates fur all types of CSS elements

CSS Element	Misuse Rate
Locking clip use	72.0%
Harness retainer chest clip use	58.8%
Harness strap use	45.5%
Vehicle safety belt use	16.9%
Seat Direction	9.6%
Harness connection (buckle use)	3.3%
One or more CSS elements	79.5~

Tables 2 and 3 shuw the various types of misuse that were recorded during the Ketrun study. Of those children in child restraints only 20.5 (100 - 79.5 =20.5) percent of the children in the survey were found to be correctly restrained. Some of these misuses would be prevented with the use of a universal attachment system, either flexible or rigid. The misuses that could be prevented are seat direction fur rear-facing only infant restraints, vehicle seat belt use, locking clip use, safety belt latchplate being away from the bight, and possibly some of the seat contour problems (no benefit was assumed fur vehicle manufacturers potentially redesigning their vehicle seats).

Table 2
Correct and Incorrect Use by Misuse Element

	Infant seats	Convertible seats	Booster seats	Totals
Seat Direction:				
Correct	75.9%	94.6%	....	90.4%
Incorrect	24.1%	5.4%	....	9.6%
Total	100.0%	100.0%	....	100.0%
Seat Belt Use:				
Correct	80.3%	82.2%	88.3%	83.1%
Unbuckled/Disconnected	2.0%	1.9%	2.0%	
Misrouted	3.3%	2.4%	1.0%	
Improper Use/Fit	14.4%	13.5%	8.7%	16.9%
Total	100.0%	100.0%	100.0%	100.0%
Locking Clip Used:				
Correct	27.6%	27.0%		28.0%
Not used	62.8%	64.6%		
Improper Use /Fit	9.6%	8.4%		72.0%
Total	100.0%	100.0%		100.0%
Harness Connection (Buckle Use):				
Correct	94.5%	97.3%	....	96.7%
Unbuckled/Disconnected	5.4%	2.7%		3.3%
Total	100.0	100.0%		100.0%
Harness Strap Used:				
Correct	48.2%	55.9%	.	54.5%
Misrouted	13.5%	4.0%		
Not Used	3.7%	2.9%	....	
Improper Use/Fit	34.6%	37.2%	....	45.5%
Total	100.0%	100.0%	....	100.0%
Harness Retainer (Chest)	Clip Use:			
Correct	51.1%	37.8%	....	41.2%
Not Used	15.3%	22.1%	....	
Improper Use/fit	33.6%	40.1%		58.8%
Total	100.0%	100.0%		100.0%

Table 3
Child Safety Seat Misuse by Vehicle Restraint Type, Latchplate Position, and Non-Standard Vehicle Seat Type

	Correct Use	Incorrect Use (Misuse)	Total
Vehicle Safety Belt Type	Child Restrained		
L/S Belts (To Door)	4 (14.3%)	24 (85.7%)	28
L/S Belts (3-point)	212 (16.2%)	1,093 (85.7%)	1,305
Auto with L/S Belts	10 (20.4%)	39 (79.6%)	49
Auto with Seat Belts	4 (14.3%)	24 (85.7%)	28
Lap Belt (2-point)	257 (25.2%)	761 (74.8%)	1,018
Total	487 (20.1%)	1,941 (79.9)	2,428
Safety Belt Latchplate	Position		
At Bight	489 (21.3%)	1,804 (78.7%)	2,293
Away from Bight	---	107 (100%)	107
Total	489 (20.4%)	1,911 (79.6%)	2,400
Non-Standard Vehicle Seat	Type		
Deeply Contoured Seats	13 (22.4%)	45 (77.6%)	58
Very slanted Seats	28 (24.1%)	88 (75.9%)	116
Center Curved	13 (34.2%)	25 (65.8%)	38
Pull-down Jump Seat	---	2 (100%)	2
Narrow Rear Seat	1 (11.1%)	8 (88.9%)	9
Built-in CSS	23 (56.1%)	18 (43.9%)	41
Total	78 (29.5%)	186 (70.5%)	264

Sled Testing of Misuse Modes

The agency has run 30 mph sled tests on some of the misuse modes to determine the potential effects of injury from misuse. The following five tables show the estimated increase in the probability of injuries (AIS 4+ severe to fatal injuries) that a child might experience given the type of misuse that occurred in some cases in the Ketrun study. AIS 4+ had the best correlation of HIC to head injury, indicative of potential change in the probability of injury. The baseline numbers were obtained from tests done at VRTC for proper use of the child restraint and are compared to the given misuse mode.

Table 4
Child Restraint Misuse: 4" Forward of Bieht (6-yr-old)

	HIC	AIS 4+ *	Chest G's	AIS 4+ **
Baseline	642	4.9%	42	20.3%
Misuse	6 9 7	6.1%	53.1	30.7%
Increased probability of injury		1.1%		10.4%
Increased Probability of combined head/chest AIS 4+ injury	11.4%***			

* Probability of injury for AIS 4+ HIC determined by $(1+@EXP((4.9+200/HIC)-0.00351*HIC))^{-1}$
The injury probabilities are based on adults, not on children'
** Probability of injury for AIS 4+ chest G's[2] determined by using $(1+@EXP((5.55-0.0693*CHESTG's))^{-1}$
*** This number is calculated thus: (.011+.104) - (.011 x. 104) = ,115 - .0011 = ,114

Table 5
Child Restraint Misuse: 2" forward of bight (3-yr-old)

	HIC	AIS 4+	Chest G's	AIS 4+
Baseline	642	4.9%	42	20.3%
Misuse	599	4.2%	46.6	24.3%
Increased probability of injury		-0.75%		4.0%
Increased Probability of combined head/chest 4+ injury	3.2%			

[1]FMVSS No. 201, Upper Interior Head Protection. Final Economic Assessment, Page 4-50. Office of Regulatory Analysis, Plans and Policy June 1995.

[2]Viano, David and Arepally, Sudhakar (1990) Assessing the Safety of Occupants Restraint Systems 1990 Stapp SAE Paper No. 902328

Table 6(a)
Child Restraint Misuse: 2" forward of bight (baseline)
with and without (misuse) locking clip (6-yr-old)

	HIC	AIS 4+	Chest G's	AIS 4+
Baseline	599	4.2%	46.6	24.3%
Misuse	1109	23.4%	50.9	28.3%
Increased probability of injury		19.2%		4.0%
Increased Probability of combined head/chest AIS 4+ injury	22.4%			

Table 6(b)
Child Restraint Misuse: 4" forward of bight
with and without tether (3-yr-old)**

	HIC	AIS 4+	Chest G's	AIS 4+
Baseline	503	2.8%	42.3	20.6%
Misuse	631	4.7%	59.6	38.0%
Increased probability of injury		1.9%		17.4%
Increased Probability of combined head/chest AIS 4+ injury	19.0%			

** Test data showed head excursion was 29.1 inches without tether and 25.2 inches with tether.

Table 7
Child Restraint Misuse: Chest clip unhooked
(forward facing, 9-month-old dummy)

	HIC	AIS 4+	Chest G's	AIS 4+
Baseline	483	2.6%	42.1	20.4%
Misuse	947	14.3%	57.7	35.8%
Increased probability of injury		11.7%		15.4%
Increased Probability of combined head/chest AIS 4+ injury	25.3%			

The types of misuse examined by the agency to date would individually increase the probability of head and chest injuries by 3.2 to 25.3 percent. These do not include the gross misuse categories of having the seat belt unbuckled or not using the interior harness, both of which probably result in the child restraint providing no benefit. From the above tables, misuse of the chest clip increases the probability of head and chest AIS 4+ injury by the greatest percentage: 25.3 percent. However, this Rulemaking will not address this problem. In the Ketron study the greatest misuse of child safety seats occurred when the locking clip was misused: 72.0 percent. This increased the probability of head and chest AIS 4+ injury by 22.4 percent. Many of the children observed in the Ketron study had more than one misuse mode. Multiple misuses will increase the overall probability of injury to some unknown extent.

Effectiveness

A child restraint system must be properly secured in the motor vehicle to provide optimum protection to the child in the event of a crash. The current safety performance of correctly used child restraints is not in dispute, but the non-use and the misuse of the current systems are of great concern. Kahane found that correctly used child safety seats are highly effective, reducing fatality risk by an estimated 71 percent and serious injury risk by 67 percent. But misuse of the current child restraints can partially or completely nullify this effect.[3] To determine the impact of reducing misuse of child restraints, the potential effectiveness of these systems must be compared to the actual effectiveness of systems as are currently used.

Data from National Highway Traffic Safety Administration's Research Note, "Revised Estimates of Child Restraint Effectiveness", authored by Ellen Hertz (I 996), showed the following effectiveness numbers:

Estimated Fatality Reducing As Used Effectiveness of Child Restraints

	Age Group	
Vehicle Type	Less than 1	1 -4
Passenger Cars	71%	5 4 %
Light Trucks and Vans	58%	59%

[3]Kahane, Charles 3. (I 986). An Evaluation of the Effectiveness and Benefits of Safety Seats. U.S. Department of Transportation, National Highway Traffic Safety Administration. DOT HS 806 889. P. 305

The combined fatality effectiveness for child restraints for children less than one and one to four is 59 percent. This was derived by weighting the above effectiveness estimates by the number of fatalities in each age group and vehicle type group. Since only four of the 232 annual fatalities in child restraints were five to six year olds, it is assumed that the combined effectiveness of all children up to six years old is 59 percent. These estimates of current and potential child restraint effectiveness will provide the basis for estimating the potential benefits of this rulemaking.

Benefits of Misuse Reduction

A first step in calculating benefits from uniform child restraint anchorages is to estimate the maximum potential benefit if all misuse were eliminated. This is done by estimating the potential fatalities that would occur without child restraints and then comparing the benefits that occur under current systems to those that would occur without misuse.

The formula for lives saved is:

$$\text{Lives Saved} = \text{Restrained Fatalities} \quad X \quad \frac{\text{Restraint Effectiveness}}{\text{1-Restraint Effectiveness}}$$

The annual number of fatalities from Table l(a) would be 695/3 = 232.

Using the "as used" fatality effectiveness of 59 percent: 232 x .59/.41 =334, then

334 lives were saved by child restraints annually.

Potential fatalities = actual fatalities plus lives saved = 232 + 334 = 566.

Using the potential child restraint effectiveness of 71 percent: 566 x .71 = 402.

Therefore, if all misuse had been eliminated, 402 - 334 = 68 lives of children 0 to 6 year old could have been saved.

Using the following formula:

$$\text{Injuries prevented} = \text{Restrained Injuries} \times \frac{\text{Restraint Effectiveness}}{\text{1-Restraint Effectiveness}}$$

The same procedure was applied for nonfatal injuries. The number of children injured in child restraints was taken from appendix-7, Tables 23 to 25. Using the effectiveness numbers calculated for each age group, the number of injuries that could have been prevented with proper use of child restraints are calculated below. For children less than one year old, the as used effectiveness of children one to four is used in the calculations.

Injuries for children less than one year old to four years old.

192,727 x .66/.34 = 374,117 injuries prevented, then

potential injuries = 192,727 + 374,117 = 566,844.

Assuming a 67% effectiveness for correctly used child restraints,

injuries prevented = 566,844 x .67 = 379,786.

Difference in injuries prevented = 379,786 - 374,117 = 5,669

Therefore if misuse could have been eliminated, then the number of injuries to children in the less than one year old to four years old age group in child restraints that could have been prevented with correct child restraint usage, would total approximately 5,669 injuries (1990 through 1996) over the seven years, or an annual average of 810 injuries on an annual basis.

Injuries for children ages five to six years of age:

5,395 x .64/.36 = 9,591 injuries prevented, then

potential injuries = 5,395 + 9,591 = 14,986, now

assuming a 67% effectiveness fur correctly used child restraints, injuries that would have been prevented = 14,986 x .67 = 10,041

difference in injuries prevented =10,041 - 9,591 = 450

Therefore, if misuse could have been eliminated, then the number of injuries to children in the five to six year old age group that could have been prevented with correct child restraint usage, would total approximately 450 injuries over the seven years or an annual average of 64 injuries on an annual basis.

In summary, with the elimination of all misuse in child restraints, injuries to children ages zero to six who were restrained in child restraints could have been reduced by 874 injuries annually.

The analysis will now focus on the expected benefits of a new anchorage system fur child restraints in reducing misuse. Sled testing at 30 mph showed an increase chance of injury of 5. I to 18.3 percent fur sume misuse modes. The Ketrun study[4] showed 79.5 percent misuse of current restraints. The largest element of misuse in the Ketrun study that might be eliminated, if a new connector system were employed, would be the use of the locking clip. In the Ketrun study,

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[4] Decina, E. Lawrence and Knoebel, Y. Kathleen (1996). Patterns Of Misuse Of Child Safety Seats. U.S. Department of Transportation, National Highway Traffic Safety Administration. DOT HS 808 440

misuse due to locking clip was: infant child safety seat 72.4 percent; convertible child safety seat 73.0 percent; and booster child safety seat 67.6 percent.

Other misuse elements of the Ketron study that could have been reduced with use of a new anchorage system are: seat direction and vehicle safety belt use for rear-facing only infant restraints; and vehicle seat belt use for convertible child safety seats and booster seats.

Table 8 takes what is known about types of misuse and their impact on injury and estimates the number of fatalities that could be reduced for each misuse mode, if that misuse mode were eliminated. Among the misuse modes, locking clips, seat direction, seat belt use, and proximity to bight would potentially be impacted by a universal attachment for child safety seats. Contour seats are not included in this group because there is no requirement to redesign contour seats. About 50 percent of the effectiveness loss is due to misuse from not correctly securing the child to the child restraint (not affected by a universal system) and about 50 percent of the effectiveness loss is due to misuse from not correctly attaching the child restraint to the vehicle seat (which could be affected by a universal attachment point system). Based on this data, it is estimated that any universal attachment point system could potentially eliminate approximately 50 percent of the misuse recorded.

In Table 8 a change was made to the percent of the fleet in which the anchorage was more than four inches away from the seat bight. The Ketron study found only 4.5 percent (see Table 3) of the vehicles had their anchorages away from the seat bight. However, these were older models.

A sample of 1993 to 1998 model year vehicles found a much higher percentage of vehicles with anchorages greater than four inches away from the seat bight (42.9 percent)

Table 8
Summary of Benefits Associated With Various Misuse Modes[5]

Misuse Mode	Percent of misuse (A)	Increased Probability of injury (B)	Product of A and B (C)	Column C Normalized (D)	Fatals (E)	Fatals related to misuse mode (F)
Locking clip	72	.224	16.13	31.79	68	22
Seat direction	9.6	.16	1.54	3.04	68	2
Seat belt used	16.9	.224	3.79	7.47	68	5
Harness Clip	58.8	.253	14.88	29.33	68	20
Harness strap	45.5	.114	5.19	10.23	68	7
Harness buckle	3.3	1	3.30	6.50	68	4
Bight	42.9	.114	3.7	9.66	68	7
Contour seat	8.8	.114	1.003	1.98	68	1
Total			50.733	100.0		68

children in child restraints by seating positions, is 42.94 percent i.e.,(.256x.703) + (.563x.349) + (.062x.491) + (. 119x. 189) = 42.94. This number (42.94%) is used in Table 8, column A, instead of the 4.5 percent taken from the Ketron study used in the PRE, because it is based on more recent data.

Table 9 (a)
1993 to 1998 Model Year Vehicles With Their Seat Belt Buckle Distance From The Bight

	cars		Light Trucks	
Distance From Bight	Right Front	Rear Seat	Right Front	Second Seat
0 to 2 inches	1.4%	36.8%	13.0%	47.6%
2.5 to 3 inches	28.3%	28.3%	37.9%	33.5%
4+ inches	70.3%	34.9%	49.1%	18.9%

Table 9 (b)
Distribution Of Fatals In Child Restraints By Seating Position (FARS 1996)

	Cars	Light Trucks
Right Front Seat	25.6%	6.2%
Rear Seat	56.3%	11.9%

Table 10 summarizes the potential impact of universal attachments on the affected misuse modes. Note that seat direction only affects infants in rear facing seats. Convertible seats will have attachments that allow installation in both directions and thus could still be misused. After adjusting for the portion of cases that occur in rear facing child restraints (estimated at 22.5% of cases), less than one life is saved.

Table 10
Effects of Target Population Breakdown

Component	Fatalities Prevented
Locking Clip	22
Seat Direction	.5 (2x.225)only affects infants in rear-facing only seats might not affect convertible seats
Vehicle Belt Use (incorrect routing of belt)	5
Bight (greater than 4 inches forward of the bight)	7
Total	34 of 68

The same calculations done for injuries, with a slightly different distribution of injuries by seating position and vehicle type resulted in 454 out of 874 injuries being affected by a universal anchorage system that was used correctly (about 52 percent).

Nut all systems will be used correctly. Based on the clinic discussion (see Appendix 3) it was found that the Rigid Connector was used properly 88 percent of the time, and the Nonrigid Connector was used properly X9 to 96 percent of the time. The misuse modes are not always extreme enough to reduce the total benefit of the system, but assuming they were, the benefits are shown in Table I 1.

Table 11
Estimated Misuse Target Population and Benefits

	Target Population		Estimated Benefits	
	Fatalities	Injuries	Fatalities*	Injuries
Rigid Connector	34	454	30	400
Nonrigid Connector	34 I	454	30 to 33	404 to 436

* 34x .88= 30; 34 x .89 = 30; and 34 x .96 = 33
454x.88= 400; 454x .89= 404; and 454x .96= 436

Some commenters to the NPRM noted that the rigid attachment system would provide greater protection to child occupants than the nonrigid attachment system in side impact crashes. Michael Griffiths and Paul Kelly of the Roads and Traffic Authority (RTA), New South Wales, Australia, (See Docket No. 96-095N3-62A) submitted data on side impact tests RTA conducted comparing the performance in side impacts of the rigid to rigid system, nonrigid latchplate system, and a lap belt with tether system. RTA found that only the rigid to rigid system was able to prevent contact between either the dummy's head or the child restraint and the door structure in the 90 degree test. The nonrigid latchplate system rotated at the end of its sideways movement allowing the dummy's head to deflect the side wing and roll around its front edge and contact the side door as the CRS rebounded from the door.

Tables 12 (a) and 12 (b) show a breakout of fatalities and injuries, to children ages zero to twelve, suffered in side impact crashes. There were 238 fatalities in side impact in 1996 for children ages zero to five years old, an estimated 2,377 suffered an incapacitating injury and 12,455 incurred nonincapacitating injuries. These numbers include both restrained and unrestrained children, and thus represent the maximum population that could be impacted if all children were in child restraints. Some of these fatalities and injuries might be prevented if the children were restrained by the rigid anchorage system. However, the agency does not know how effective a rigid anchorage system would be in reducing fatalities or injuries or how much more effective a rigid anchorage system could be compared to a nonrigid anchorage system.

Table 12 (a)
1996 Fatalities Due to Side Impacts

Ages	Passenger Cars	Light Trucks	Other	Total
0 - 5	189	48	1	238
6 - 12	157	55	5	217
Total	346	103	6	455

Table 12 (b)
1996 Injuries Due to Side Impact Crashes

Ages	No Injury	Possible Injury	Nonincapacitating	Incapacitating	Total
0 - 5	221,002	19,610	12,455	2,377	255,444
6 - 12	189,152	24,703	12,492	6,528	232,875
Total	410,154	44,313	24,947	8,905	488,319

Based on the test data of Rigid Anchorages, Nonrigid Anchorages, Nonrigid Latch plate, and current child restraints it appears that the systems proposed in this final rule would be safer than current restraint systems (as used in the real world) in both frontal and side impacts. It is believed these systems when used properly will have higher effectiveness than current child restraints when used properly, due to the presence of the tether and better compatibility between the restraint and the vehicle. There are no data available to indicate the exact increase in as-used effectiveness that will occur due to improved compatibility and the addition of the tether. However, NHTSA feels an increase of one to three percentage points is a reasonable expectation, and may be conservative. For this analysis, a range of benefits reflecting an increase of one to three percentage point will be examined. For every one percentage point increase in effectiveness, 6 children's lives could be saved (566 children in child restraints (see page 23)in potentially fatal crashes x .01 = 6), and 831 injuries could be reduced [83,118 = (566,844 + 14,986)/7 years of data (see pages 24 and 25) in potentially injurious crashes x .01 = 831]. For this analysis it will be assumed that these new child restraint systems will increase effectiveness by 1 to 3 percentage points -- a savings of 6 to17 lives and 831 to 2,493 injuries.

Table 13
Summary of Benefit Estimates

	Misuse Savings		Increased Effectiveness		Total Savings	
	Fatals	Injuries	Fatals	Injuries	Fatals	Injuries
Rigid Connector	30	400	6 to 17	831 to 2,493	36 to 47	1,231 to 2,893
Nonrigid Connector	30 to 33	404 to 436	6 to 17	831 to 2,493	36 to 50	1,235 to 2,929

Other factors that could influence the benefits estimates include the current "lockability' requirement for new vehicles and the potential that these systems could increase child restraint usage.

FMVSS Standard No. 208 Occupant Crash Protection S7.1.1.5 states that passenger cars and trucks, buses, and multipurpose passenger vehicles with a GVWR of 10,000 pounds or less manufactured on or after September 1, 1995 shall meet the "lockability" criteria. That is, each designated position, except the driver's position, and except any right front seating position that is equipped with an automatic belt, shall have a seat belt assembly whose lap belt portion is 'lockable' so that the seat belt assembly can be used to secure a child restraint system tightly. However, automatic belts must be phased out by the 1998 model year for cars and the 1999 model year for light trucks, so all new vehicles will be subject to the "lockability" requirements. The lockability requirements should help reduce the misuse or non-use of locking clips and may decrease death and injuries for this age group. The lockability requirement still depends upon the user knowing enough and making the effort to manipulate the belt system. To the extent that consumers using the lockability requirement correctly, the estimated benefits in this analysis would be reduced. The agency does not know whether these belts with the lockability features in newer vehicles are being used correctly a higher percent of the time than locking clips in older vehicles. The main analysis assumes the same correct usage as in the Ketron study. Sensitivity analysis are presented later in the analysis assuming higher correct usage rates.

Some commenters to the NPRM stated that vehicle seats with a child restraint anchorage system should still be subjected to the "lockability" requirement to meet the needs of parents using a child restraint that is nut equipped with the new attachment devices. Ford and General Motors suggested that the lockability feature could be deleted some time after all child restraints were equipped fur the child restraint anchorage system.

The agency believes that the "lockability" requirement should be retained until virtually all child restraint systems in use have the attachments that connect the restraint to the child restraint anchorage system. The agency believes that on average, child restraints are used not more than ten years. Since all new child restraints will be required to have attachments that connect to the child restraint anchorage beginning in 2002, then by 2012, most child restraints in use will be able to use the child restraint anchorage system and will not need lockable belts. Therefore, this rule rescinds the lockability requirement beginning September 1, 2012. This recession applies only to seats with a child restraint anchorage system, not all seats.

It is possible that easier to use and more secure child restraints could result in an increase in child restraint use. There could be some people that get so frustrated with using child restraints that they don't use them at all or don't want to take the time to move the child restraint from one vehicle to the other. With about 35 percent of the rear seats of new passenger cars having seat belt anchorages 4 inches or more away from the seat bight, consumer confidence in the safety of their child restraint system is probably eroding. The consumer clinic showed that the number one consumer safety concern was with how tight (secure) participants could get the child restraint,. With an anchorage point 4 inches from the seat bight, it is impossible to secure the child restraint tightly, and testing shows that a seat with the anchorage point 4 inches away from the seat bight increases the probability of severe or greater injury by over 11 percent. The agency fears that the more forward seat belt anchorages will erode consumer confidence in the child restraint systems and could result in less use of child restraints. Use of a child restraint is the most important factor for safety. Being able to tightly secure a child restraint provides consumers with confidence in their safety and has the most potential for the highest use of child restraints. The agency could not estimate these potential impacts.

The agency would also expect that with a new child restraint system becoming available, public interest in child restraints will rise and there may be an increase in overall child restraint use. Again, no estimate could be made of the potential magnitude of the increase in child restraint use.

Costs

This Final Economic Assessment relies in part on the cast, weight and lead time analysis performed by Ludtke and Associates, in conjunction with RFH and Associates, under contract to NHTSA. The contractors reviewed existing child restraint configurations, considering the full range of usage, features and sizes. The contractors also reviewed vehicle configuration; seat operating mechanisms, vehicle seat support structure, and a range of vehicle sizes and types. Evaluation of both the child restraint and the vehicle configuration were considered in respect to the various types of child restraints; that is, convertible seats (forward and rear facing), infant seats (rear facing), shield type booster seats, toddler seats and car beds. Vehicle seating positions examined were: right front, center rear, and rear outboard (two positions). Cost and weight estimates were made fur rigid and nonrigid anchorage systems. Some of those cost and weight estimates are used in this Find Economic Assessment.

Fur the rigid connector child restraint system, the contractor designed a frame base that held two side rails which contained front and rear latch assemblies. Prototype designs shown by the child restraint manufacturers indicated that they would design the rigid system into the base of the child restraint at a much lower cost than the cost fur a frame base. Costs estimates used in this FRE are a combination of cost estimates from Ludtke and Associates, information provided by child restraint and vehicle manufacturers to NHTSA at meetings, and judgment by NHTSA when other data were nut available.

Cost figures used in the FRE are different from those prices provided to the Child Restraint System Clinic. The largest price difference was $22. The agency estimated the incremental cost of the rigid child restraint system to be $43, while the clinic's incremental cost was $65. For the nonrigid child restraint system with buckles, the agency's incremental cost was $15.60 compared to the clinic's incremental cost of $10. The agency estimated the tether strap to be $3.87 while the clinic's cost for the tether strap was $5. Clinic costs were estimates and were nut based on specific tear down studies.

Child Restraint and Vehicle Costs

Table 14(a) shows the nonrigid variable costs for child restraints. Table 14(b) shows the estimated consumer costs for rigid connectors for child restraints. The estimated consumer cost in Table 14(c) is derived by multiplying the incremental variable cost by 2.60 for child restraints to account for manufacturer and retail markup. The 2.6 factor was derived from information provided by child restraint manufacturers.

In Tables 15(a) through 15(e) and in Tables 18(a) and 18 (b), total costs are shown under the assumption that all child restraints and/or all vehicles are produced with the same system. Based upon discussions with child restraint manufacturers, this is not likely to be the case. However, total costs are shown for analytical purposes and just in case the market eventually demands the lowest priced system or the high end of the market system.

Table 14 (a)
Nonrigid Connector Child Restraint Additions
Incremental Variable Costs (1996)

SYSTEM	COMPONENT	COMMENT
Nonrigid Connector	Jaw-type Connectors	(2) Req'd at $2.00 ea. + $0.33 Ass'y/Installation = $4.33
	Belts	(2) Req'd at $0.30/yard x 1/2 yards. = $0.30
	Tighteners	(2) Req'd at $0.25 ea. + $0.33 Ass'y/Installation = $0.83
	Adaptor brackets	(2) Req'd at $0.20 ea. + $0.33 Ass'y/Installation = $0.73
	Added Plastic	(2) Req'd at $0.215 ea. = $0.43
		Subtotal = $6.62
Tether	Hook	(1) Req'd at $0.20 = $0.20+ $0.17 Ass'y/Installation = $0.37
	Belt	5 feet = $0.50
	Tightener	(1) Req'd at $0.25 = $0.25 + $0.17 Ass'y/Installation = $0.42
	Heavy Duty Plastic	Designed into frame = $0.20
		Subtotal = $1.49
Total	Seat Plus Tether	$1.49 + $6.62 = $8.11
Nonrigid Connector Belt Using Opening on Back of Seat*	Jaw-type Connectors Belts Tighteners	(2) Req'd at $2.00 ea. + $0.33 Ass'y/Installation = $4.33 (1) Req'd at $0.30/yard x 1 yards. = $0.30 (1) Req'd at $0.25 ea. + $0.33 Ass'y/Installation = $0.58
Tether	Hook, Belt, Tightener, Plastic	$0.37+$0.42+$0.50+$0.20 = $1.49
Total	Connector and Tether	$5.21+$1.49 = $6.70

* System has two jaws at the end of one belt and one tightener. The belt goes through the opening in the back of the child restraint. Each jaw is connected and the belt at one end is pulled tight. The same system could be used with other connectors saving $1.41 in variable costs per seat. $1.41 = $0.43 + $0.25 + $0.73 i.e., the added plastic, adaptor brackets, plus one tightener.

Table 14(a) continue

Nonrigid Connector	Buckles	(2)Req'd at$0.95 + $0.33 Ass'y/Installation = $2.23
	Belts	(2)Req'd at $0.30/yard x 1/2yards = $0.30
	Tighteners	(2)Req'd at$0.25ea. +$0.33 Ass'y/Installation = $0.83
	Adaptor Brackets	(2)Req'd at$0.20ea. +$0.33 Ass'y/Installation = $0.73
	Added Plastic	(2)Req'd at$0.215 ea.= $0.43
		Subtotal = $4.52
Total	Connector plus Tether	$1.49 + $4.52 = $6.01
Nonrigid Connector	Hook-type Connectors*	(2)Req'd at$0.50ea. +$0.33 Ass'y/Installation = $1.33
	Belts	(2)Req'd at $0.30/yard x 1/2yards = $0.30
	Tighteners	(2)Req'd at$0.25ea. +$0.33 Ass'y/Installation = $0.83
	Adaptor Brackets	(2)Req'd at$0.20ea. +$0.33 Ass'y/Installation = $0.73
	Added Plastic	(2)Req'd at$0.215 ea.= $0.43
Total	Connector plus Tether	$1.49 + $3.62 = $5.11

'A hook like the currently used tether hook except it must be longer and have a way to disconnect it without reaching into the seat bight.

The least expensive nonrigid connector system considered would have two hooks for connectors, one on both ends of a belt that pass through the back of the child restraint. The variable costs for this system are estimated to be $3.70 ($5.11 - $1.41).

Table 14(b)
Rigid Connector Child Restraint Additions
Incremental Consumer Costs ($1996)

Rigid Connector	One Way	$30.00
	Convertible	$40.00
	Tether	$3.87'
Total		$33.87 to $43.87

*Tether variable cost of $1.49 x 2.6 markup = $3.87 in consumer costs.

Table 14(c)
Incremental Child Restraint Costs (in $1996)

	Estimated Consumer Cost	Weight (lbs)
Rigid Connector	$33.87 - $43.87	3.0
Nonrigid Connector	$9.62 to $21.09*	1

* The variable costs range of systems considered are $3.70 to $8.11. This range times the 2.6 markup to consumer costs is $9.62 to $21.09.

Table 14(d) shuws the cost estimates of the various vehicle modifications to accommodate the different child restraint systems.

Table 14(d)
Rigid Anchorages/Nonrigid Anchorages, Vehicle Additions
Incremental Variable Costs – Per Seating Position

Rigid Anchorages	Lower Seat Anchors	(2) Req'd at $0.23 ea. + $0.76 Ass'y/Installation = $1.22
	Tether Anchor	(1) Req'd at $0.65 ea. = $0.65
Total		$1.22 + $0.65 = $1.87
Nonrigid Anchorages*	Lower Seat Anchors	(2) Req'd ***at $0.96 ea.* =** $1.92
	Tether Anchor	(1) Req'd at $0.65 ea. = $0.65
Total		$1.92 + $0.65 = $2.57

@Variable vehicle costs times 1.5 1 = consumer cost used in following tables.
* The agency is not allowing Nonrigid anchorages.

The agency is requiring vehicle manufacturers to equip two rear seating positions with a child restraint anchorage system, plus a tether anchorage at a third seating position. Tables 15(a) to 15(e) is a summary of the cost to the purchasers of child restraints and vehicles.

Table 15(a)
Consumer Cost of Various Types of Child Restraint Systems

Restraint Type	Per Child Restraint	Total Annual Cost -- CRS *
Rigid Connector	$33.87 - $43.87	$132 - $171 Million
Nonrigid Connector	$9.62 to $2 1.09	$38 to $82 Million

*Assumes 3.9 million child restraint sales (excludes booster seats)

Table 15(b)
Consumer Cost of Various Types of Svstems for Vehicles with Rear Seats

Restraint Type	Per Vehicle*	Total Annual Cost -- VEH. **
Rigid Anchorages	$6.62	$60 Million
Nonrigid Anchorages	$8.74	$79 Million

*Assumes 2 rear seating positions with lower anchorages and a third seating position with a tether anchorage. Times 1.5 1 markup to consumer costs
** Assumes 9 million light vehicles (passenger cars and light trucks) with adequate rear seats

Table 15(c)
Consumer Cost of Vehicles with No or Limited Rear Seats #

Restraint Type	Per Vehicle No Rear Seat	Per Vehicle Limited Rear Seat	Total Annual Cost -- VEH.
Rigid Anchorage	$2.82'	$5.62"	$25 Million
Nonrigid Anchorage	$3.88'	$7.76"	$35 Million

Assumes 6 million light vehicles (passenger cars and light trucks)
*Assumes 1 front seating position (3.0 million light vehicles with no rear seat)
**Assumes one front and one rear seating position (3 million vehicles with inadequate rear seats)

Table 15(d)
Total Consumer Cost of Child Restraints and Vehicles *

Restraint Type CRS -- Vehicle	Total Annual Cost --- CRS (millions)	Total Annual Cost -- VEH. (Millions)	Total Annual Cost (millions)
Rigid – Rigid	$132 to $171	$85	$217 - $256
Nonrigid – Nonrigid	$35 to $82	$114	$149 to $196
Nonrigid -- Rigid	$35 to $82	$85	$123 to $167

* Assuming all vehicles and child restraints are produced to meet the given assumptions. These totals are not additive.

Table 15(e)
Summary of Costs Per Vehicle by Number of Seating Positions

Restraint type	Two rear seats	Two rear seats plus tether	One front seat	One front seat and one rear seat
Rigid Anchorage	$5.64	$6.62	$2.82	$5.62
Nonrigid Anchorage	$7.76	$8.74	$3.88	$7.76
Nonrigid-Latch Plate	$7.76	$8.74	$3.88	$7.76

Estimated Average Costs

Table 15(f) presents an estimate of what the agency believes will be the must likely total cost of the final rule. NHTSA believes that sales of child restraints with rigid connectors (shown in Table 14(b) to cost from $33.87 to $43.87) and the nonrigid connector system that uses a single strap through the opening on the back of the seat (shown in Table 14(c) to cost as low as $9.62) may be limited because few manufacturers indicated they would produce these types of systems. The estimate of must likely costs ($17.19) is thus based on an average of nonrigid connector systems with dual straps [calculated from Table 14(a) as ($5.11 + $8.1 1)/2 = $6.61 variable costs x 2.6 markup to consumer costs = $17.19]. The average vehicle costs ($5.67) are weighted by the number of seating positions required to be equipped with rigid anchorages. Total annual casts are estimated to be $152 million [$17.19 x 3.9 million child restraints + $5.67 x 15 million vehicles].

Table 15 (f)
Estimated Average Costs
($1996)

Restraint Type	*Per* Child Restraint	Per Vehicle	Total Annual Cost
CRS Nonrigid/ Vehicle Rigid	$17.19	$5.67	$152 Million

<u>Cosco Petition</u>

Cosco petitioned the agency to require a separate lap belt for child restraints. This alternative would cause no increase in child restraint costs. Cosco (050) said that the nonrigid connector system was too expensive and price increases imposed by the nonrigid connector system would cause lower usage of child restraints and result in additional deaths and injuries, not prevent them.

Response to Cosco's Comment

The agency agrees that for a competitive market an increase in prices will result, depending on the price elasticity of demand, in a decrease in quantity demanded. The classical way of estimating price elasticity of demand is to examine the change in sales volume when there is a price increase or decrease, but the product remains the same. Demand for child restraints appears to be highly inelastic. This conclusion is supported by the fact the child restraints can be considered a necessity since their use is required in every State. Also, examining the information provided by Cosco to the Docket (Docket number 96-095-N03-050, see Cosco's Infant Car Seat by Price Segment, Table 2), price is not the only criteria affecting sales. The lowest priced child restraints do not have the highest sales volume. In addition, some of the higher priced child restraints have the higher sales volumes. Thus, consumers recognize different qualities in different models of child restraints and some consumers are willing to pay more for these perceived better qualities.

The new anchorage system will be a safety improvement over the conventional safety belt anchorage system. When the safety aspects of the system are advertised, consumers will know that they are getting a better product. Based on clinical trials, consumers that tried these new child restraints indicated that they were willing to pay a higher price for these systems than the incremental cost estimates (the average annual family income of participants in the survey was over $50,000). In their response to the NPRM, Ford (035), Gerry Baby Products Company (039), Indiana Mills and Manufacturing Inc. (040), and Volvo (053), all noted that child restraints were not price sensitive.

Finally, if there would be an adverse effect on the child restraint market, the low end of that market would be disproportionately affected, according to Cosco. The agency believes that the hospitals and loaner prugrams will be able to satisfy that demand if it should arise. From talks with some of these entities (hospitals and loaner programs), the agency has found that they were eager tu have the new seats because of the safety aspect and also because of the ease of installation of the seats. Many of them believed that they would be able to accumulate enough funds to purchase the new seats without any major disruption in the flow of the number of seats they are able to provide to the public.

The agency is aware that there will be a group of the population, for a ten or fifteen year time span, that will be driving older vehicles without rigid anchorages in the seats. This section of the population, which will tend to include those in the lower income brackets, will experience a price increase fur child restraints without benefitting from this final rule. They will not get the full benefit of the universal child seat because their vehicles are nut equipped with the required anchorages. Although owners of older cars would nut get the benefits of newer seats, the owners will have to buy the newer more expensive seats. NHTSA did nut want to give the public a choice between the older seats and the newer seats because individuals not recognizing the added value of the newer seat, might buy the older seats. In vehicles equipped with the anchorages, the older seats will not provide the protection to the children that the agency estimates the newer seats will give. Over time, vehicles equipped with universal child restraint anchorages will filter into the used vehicle fleet and the entire driving population will have access to the full benefits of these systems.

Fuel Economy Impacts

The impact of increased weight on vehicle fuel economy and secondary weight effects and the cost implications thereof, has to be considered in any cost analysis. Secondary vehicle weight refers to weight increases in other parts of the vehicle to compensate for the additional "primary" weight (i.e., the anchorages and the tether hardware). These secondary weight increases would only occur with a new vehicle design. The attachment bars for the rigid anchorages are approximately 6 mm in diameter, 50 mm long and made of steel of yield stress 600 N/mm*. Similar attachment bars plus a tether are used to secure the rigid anchorages. The incremental vehicle weight increases are less than one pound and are too small to require redesign of other subsystems. The effects on fuel economy also will be negligible.

The incremental weight of the child restraint system depends on the make and model of the child restraint. These incremental weights range from less then one pounds to three pounds. These do not affect secondary weight considerations, since most child restraints are aftermarket designs and vehicles are designed to carry adults, who are heavier than children in child restraints. As a result of these minor weight adjustments, fuel economy will not be affected.

Test Costs

The agency estimates the average cost to run a sled test at $1,300. The child restraints will each be tested with and without a top tether, which will essentially double the number of compliance tests run. The agency estimates that the number of runs per seat will range from two to six depending of the type of seat (i.e., infant seat two runs, or convertible seat six runs>. Therefore, the incremental test costs per seat will range from ~2,600 to $7,800. Whatever the attachment system (i.e., rigid connector, nonrigid connector, or nonrigid hook) is on the child restraint, it will be tested with the rigid bar. The agency is requiring that two dots be placed at each seating position to indicate where that rigid bars are located. Manufacturers could have the upholstery marked when the seat covers are made. This will result in negligible additional costs.

LEAD TIME

In order to provide consumers with the standardized anchorages as quickly as possible, the agency is establishing a three-year phase-in of the requirements fur the 6 mm bars beginning in the year 2000 (model year 2001).

Ford commented that a phase-in was necessary because the standard would require substantial redesign of vehicle seats and supporting structure, and there were no attachment points suitably located in the vehicle. Ford explained that manufacturers will typically need Boor pan stamping modifications and changes to floor pan welding tools, which are long leadtime changes.

Volkswagen commented that the IS0 system is already provided as standard equipment in Europe on all 1998 model Golf vehicles, and would likely be in practically all other Volkswagen and Audi models by the 1999 model year.

The agency has concluded that because vehicles will require modifications to floor pan stamping and to floor pan welding tools, a phase-in will introduce the child restraint anchorage systems as soon as possible while providing manufacturers needed time to redesign and produce vehicles in a cost efficient manner. This Final Rule adopts a three year phase-in period for the lower vehicle anchorages, which will begin September 1, 2000. The phase-in schedule for providing child estraint anchorages systems is as follows:

Period of Manufacturer	Percentage of Fleet that Needs to Provide Child Restraint Anchorage Systems
From September 1, 2000 to August 31, 2001	20 percent
From September 1, 2001 to August 31, 2002	50 percent
On or after September 1, 2002	100 percent

NHTSA has decided to allow manufacturers of vehicles manufactured in two or more stages (e.g. van conversions) to delay compliance until the final year of the phase-in for which a particular vehicle will be certified as complying with the new requirements.

Some commenters argued against a phase-in for the requirement that child restraint systems be equipped with means of attaching to the child restraint system on vehicles. The commenters stated that the requirement for the attachments on child restraints should nut become effective before the requirement fur the lower anchorage system is phased into 100 percent of the new vehicle fleet, otherwise, consumers will be faced with a new set of attachment hardware and probably no vehicle in which to use the system, which is likely to cause widespread confusion and increased potential for misuse. Child restraint manufacturers also did not want a phase-in of requirements fur child restraints because many consumers would buy the cheaper old system and not the more expensive new system if given a chance. The agency agrees that there should nut be a phase-in fur child restraints, and the requirement should nut become mandatory until 100 percent of new vehicles are required to have the new anchorage system, which will be September 1, 2002. It should be noted however that the new system can be used in vehicles with the existing seat belt system.

The top tether anchorage will be required in 80 percent of all passenger cars in the year beginning September 1, 1999 and in all passenger cars and LTV's starting September 1, 2000.

COST EFFECTIVENESS

This section combines costs and benefits to provide a comparison of the estimated injuries and Eves saved per dollar spent. It should be noted that costs occur when the vehicle is purchased, but the benefits accrue over the lifetime of the vehicle. Benefits must therefore be discounted to express their present value and put them on a common basis with costs.

In some instances, costs may exceed economic benefits, and in these cases, it is necessary to derive a net cost per equivalent fatality prevented. An equivalent fatality is defined as the sum of fatalities and nonfatal injuries prevented converted into fatality equivalents. This conversion is

Appendix V of the "Regulatory Program of the United States Government", April 1, 1990 - March 31, 1991, sets out guidance for regulatory impact analyses. One of the guidelines deals with discounting the monetary values of benefits and costs occurring in different years to their present value so that they are comparable. Historically, the agency has discounted future benefits and costs when they were monetary in nature. For example, the agency has discounted future increases in fuel consumption due to the increased weight caused by safety countermeasures, or decreases in property damage crash costs when a crash avoidance standard reduced the incidence of crashes, such as with center high-mounted stop lamps. The agency has not assigned dollar values to the reduction in fatalities and injuries, thus those benefits have not been discounted. The agency performs a cost-effectiveness analysis resulting in an estimate of the cost per equivalent life saved, as shown on the previous pages. The guidelines state, "An attempt should be made to quantify all potential real incremental benefits to society in monetary terms of the maximum extent possible." For the purposes of the cost-effectiveness analysis, the Office of Management and Budget (OMB) has requested that the agency compound costs or discount the benefits to account for the different points in time that they occur.

There is general agreement within the economic community that the appropriate basis for determining discount rates is the marginal opportunity costs of lost or displaced funds. When these funds involve capital investment, the marginal, real rate of return on capital must be considered. However, when these funds represent lust consumption, the appropriate measure is the rate at which society is willing to trade-off future for current consumption. This is referred to as the "social rate of time preference," and it is generally assumed that the consumption rate of interest, i.e. the real, after-tax rate of return on widely available savings instruments or investment opportunities, is the appropriate measure of its value.

Estimates of the social rate of time preference have been made by a number of authors. Robert Lind[6] estimated that the social rate of time preference is between zero and 6 percent, reflecting the rates of return on Treasury bills and stock market portfolios. More recently, Kolb and Sheraga[7] put the rate at between one and five percent, based on returns to stocks and three month Treasury bills. Moore and Viscusi[8] calculated a two percent real time rate of time preference fur health, which they characterize as being consistent with financial market rates fur tbe period covered by their study. Moore and Viscusi's estimate was derived by estimating the implicit discount rate for deferred health benefits exhibited by workers in their choice of job risk.

Four different discount values are shown as a sensitivity analysis. The 2 and 4 percent rates represent different estimates of the social rate of time preference fur health and consumption. The 10 percent figure was required by OMB Circular A-94, until October 29, 1992. Tbe 7 percent figure is the current OMB requirement, which represents the marginal pretax rate of return on an average investment in the private sector in recent years.

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[6]Lind, R.C., "A Primer on the Major Issues Relating to the Discount Rate for Evaluating National Energy Options," in Discounting fur Time and Risks in Energy Policy, 1982, (Washington, D.C., Resources fur the Future, Inc.).

[7]J. Kolb and J.D. Sheraga, "A Suggested Approach fur Discounting the Benefits and Costs of Environmental Regulations,: unpublished working papers.

[8]Moore, M.J. and Viscusi, WK., "Discounting Environmental Health Risks: New Evidence and Policy Implications," Journal of Environmental Economics and Management, V. 18, No. 2, March 1990, part 2 of 2.

percent figure is the current OMB requirement, which represents the marginal pretax rate of return on an average investment in the private sector in recent years.

Safety benefits occur when there is a crash severe enough to potentially result in occupant death and injury, which could be at any time during the vehicle's lifetime. For this analysis, the agency assumes that the distribution of weighted yearly vehicle miles traveled are appropriate proxy measures for the distribution of such crashes over the vehicle's lifetime. Multiplying the percent of a vehicle's total lifetime mileage that occurs in each year by the discount factor and summing these percentages over the 20 or 25 years of the vehicle's operating life, results in the following multipliers for the average of passenger cars and light trucks: 0.9014 at a 2 percent discount rate, 0.8193 at a 4 percent discount rate, 0.7195 at a 7 percent discount rate, and 0.6408 at a 10 percent discount rate. These values are multiplied by the equivalent lives saved to determine their present value (e.g., Table 18(a) 57 x .9014=51.4 and 101 x .9014=91.0). The costs per equivalent life saved for passenger cars and light trucks are then recomputed and shown in Table 18(b) i.e., using the cost figures in Table 15(d) and the computed numbers in Table 18(a) e.g., ($149/91=$1.6 million and $196/51.4=$3.8 million).

Table 18(a)
Equivalent Lives Saved

CRS / Vehicle	Base Equivalent	2 Percent	4 Percent	7 Percent	10 Percent
Nonrigid/Nonrigid	57 to 101	51.4 to 91.0	46.7 to 82.7	41.0 to 72.7	36.5 to 64.7
Rigid/Rigid	57 to 97	51.4 to 87.4	46.7 to 79.5	41.0 to 69.8	36.5 to 62.2
Nonrigid/ Rigid	57 to 101	51.4 to 91.0	46.7 to 82.7	41.0 to 72.7	36.5 to 64.7
		x .9014	x .8193	x .7195	x .6408

Table 18(b)
Discounted Costs per Equivalent Life Save
($millions)

CRS / Vehicle	2 Percent	4 Percent	7 Percent	10 Percent
Nonrigid/NonRigid	1.64 to 3.81	1.80 to 4.20	2.05 to 4.78	2.30 to 5.37
Rigid/Rigid	2.48 to 4.98	2.73 to 5.48	3.11 to 6.24	3.49 to 7.01
Nonrigid/Rigid	1.35 to 3.25	1.49 to 3.58	1.69 to 4.07	1.90 to 4.58
Estimated Average Cost Nonrigid/Rigid	1.67 to 2.96	1.84 to 3.25	2.09 to 3.71	2.35 to 4.16

Sensitivity Analysis on Lockability

A sensitivity analysis was conducted to explore the probability that correct usage rates of new vehicles will be higher due to the lockability feature than measured in the "Ketron" study, which examined many older vehicles that did not contain lockability features. NHTSA does not have data to indicate what the rate will be, so two rates will be examined here.

Assuming that in those cases where the non-use or incorrect use of a locking clip was estimated to have led to a fatality or injury, there is a 50 percent increase in correct usage due to the use of the lockability feature of the seat belts, this will result in 11 fewer fatalities in the target population in Table 10. Misuse of the locking clip accounted for an estimated 22 fatalities in the target population. Similarly if there was a 25 percent increase in correct usage due to the correct use of the lockability feature of the seat belt, there will be 17 fatalities in the target population instead of the 22 fatalities that were attributed to the incorrect use of the locking clip.

Under these assumptions "Total Savings" in Table 13, which were 36 to 47 lives saved and 1,231 to 2,893 injuries reduced for the Rigid Connector, would change as follows:

at the 25 percent correct use level 32 to 43 lives saved and 1,166 to 2,828 injuries reduced

at the 50 percent correct use level 26 to 37 lives saved and 1,103 to 2,765 injuries reduced

And for

Nonrigid connectors "Total Savings" were 36 to 50 lives saved and 1,235 to 2,929 injuries reduced, would change as follows:

for the 25 percent correct use level 32 to 45 lives saved and 1,170 to 2,859 injuries reduced.

for the 50 percent correct use level 26 to 39 lives saved and 1,106 to 2,790 injuries reduced.

The impact of these assumptions on fatalities is greater than on nonfatal injuries because only the misuse savings (shown in Table 13) are impacted. Benefits from increased effectiveness of the tether and tether anchorages are not impacted and they are a much larger portion of the total nonfatal injury benefits than of the fatal injury benefits.

Without the above assumptions, the cost per equivalent fatality (in millions) is $2.09 to $3.71 at the seven percent discount rate.

Using the above assumptions, the cost per equivalent fatality (in millions) is:

for the 25 percent assumption is $2.25 to $4.06.

For the 50 percent assumption is $2.41 to $4.75.

FINAL REGULATORY FLEXIBILITY ANALYSIS

The Regulatory Flexibility Act of 1980 (Public Law 96-354) requires agencies to evaluate the potential effects of their proposed and final rules on small businesses, small organizations and small governmental jurisdictions.

Section 603 of the Act requires agencies to prepare and make available for public comment a final regulatory flexibility analysis (FRFA) describing the impact of final rules on small entities. Section 603(b) of the Act specifies the content of a FRFA. Each FRFA must contain:

- A description of the reasons why action by the agency is being considered;
- A succinct statement of the objectives of, and legal basis for, the final rule;
- A description of and, where feasible, an estimate of the number of small entities to which the final rule will apply;
- A description of the projected reporting, record keeping and other compliance requirements of the final rule including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;

- An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap or conflict with the final rule.

- Each final regulatory flexibility analysis shall also contain a description of any significant alternatives to the final rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the final rule on small entities.

I. Description of the reasons why action by the agency is being considered

NHTSA is considering this action to improve compatibility between child restraints and vehicle safety belts and increase the correct installation of child restraints.

The correct use of child restraints is important because of the number of children killed and injured in vehicle accidents. Annually, about 600 children less than five years of age are killed and over 70,000 are injured as occupants in motor vehicle crashes.

While child restraints are highly effective in reducing the likelihood of death or serious injury in motor vehicle crashes, the degree of their effectiveness depends on how they are installed. NHTSA estimates that the potential effectiveness of child restraints, when correctly used, is 71 percent. However, it is estimated that imperfect securing of children in the child restraints and/or the child restraints in vehicles reduce that effectiveness from the potential 73 percent to an actual 59 percent.

Child restraint effectiveness is affected by limitations imposed by vehicle belt design, and by belt anchorage locations. Some belt systems can be used to secure a child restraint only when used with an accessory item that impedes movement of the belt or child restraint in a crash, such as a locking clip or supplemental strap. Some belt systems, such as an automatic seat belt, may not be compatible with a child restraint at all.

The agency recognizes the difficulty of designing vehicle seat belts to restrain both child restraint systems and a wide range of weights and sizes of individuals. Some vehicle seats have the seat belt anchorage positioned far forward of the vehicle "seat bight" (the intersection of the seat cushion and the seat back). Forward-mounted anchor points may better protect an adult using the vehicle seat belt system by drawing the vehicle belt low across the pelvis where the body can best tolerate the forces in a crash. However, when used with a child restraint, the belt anchor is too far forward of the seat bight to adequately resist the initial forward motion of the child restraint, which can result in a greater likelihood of a head impact.

Child restraint effectiveness is also reduced by incorrect securing of children and child restraints due to the complexities of adapting vehicle belts to those purposes and due to failure to follow instructions. A four-state study done fur NHTSA in 1996 examined people who use child restraint systems and found that approximately 80 percent of the persons made at least one significant error in using the systems. Observed misuse due to a locking clip being incorrectly used or not used when necessary was 72 percent, and misuse due to the vehicle safety belt incorrectly used with a child restraint (unbuckled, disconnected, misruuted, or untightened) or used with a child too small to fit the belts was 17 percent.

2. Objectives of. and legal basis for, the final rule

This document requires that motor vehicles and add-on child restraints be equipped with a means independent of vehicle safety belts for securing child restraints to vehicle seats.

The difficulty with using vehicle safety belts to attach child restraints arises from the fact that those belts are primarily designed to restrain and protect larger and older vehicle occupants. Given the inability to change vehicle belt design and anchorage location because of this purpose, the agency is seeking a means of securing a child restraint that is independent of the safety belt.

This final rule reduces allowable head excursion to effectively require child restraints to be equipped with an upper tether strap, and requires vehicles to have two factory-installed, user-ready anchor points for attaching the tether. It also requires vehicles to have two rear vehicle seating positions equipped with a specialized lower anchorage system, and requires child restraints to be equipped with means of attaching to that system.

NHTSA has issued this final rule under the authority of 49 U.S.C. 322, 30111, 30115, 30117 and 30166; delegation of authority at 49 CFR 1.50. The agency is authorized to issue Federal motor vehicle safety standards that meet the need for motor vehicle safety.

3. Description and estimate of the number of small entities to which the final rule will apply

The final rule affects motor vehicle manufacturers, almost all of which would nut qualify as small businesses, and aftermarket child restraint manufacturers. NHTSA estimates there to be about 10 manufacturers of aftermarket child restraints, four of which could be small businesses.

Business entities are generally defined as small businesses by Standard Industrial Classification (SIC) code, fur the purposes of receiving Small Business Administration assistance. One of the criteria fur determining size, as stated in 13 CFR 121.601, is the number of employees in the firm. There is no separate SIC code fur child restraints, or even a category that they fit into well. However, in order to qualify as a small business in all ufthe SIC codes that the child restraint manufacturers currently are listed under, including those business ventures other than child restraints, in the Standard and Pour's Register of Corporations, Directors and Executives, 1.995, the firm must have fewer than 500 employees. In addition, to qualify as a small business in the Motor Vehicle Parts and Accessories category (SIC 3714), the firm must have fewer than 500 employees. Thus, it is assumed that any child restraint manufacturer with fewer than 500 employees would be considered a small business. Several of the child restraint manufacturers (Table 19) are subsidiaries of larger corporations. In this case, the total number of employees of the corporation are considered in relation to the 500 employee limit to qualify as a small business.

Table 19
Employment of Child Restraint Manufacturers*
(less than 500 employees qualifies as a small business)

Manufacturer	Number of Employees
Babyhood Manufacturing Co.	10
Century	1,000
COSCO (Dorel Company)	1.000
Early Development Co. has less than 10 employees, However, it is partly owned and a joint venture with Takata of Japan	large company
Evenflo itself has 250 employees, but Evenflo is a division of Spalding & Evenflo Co. Inc.	2,600
Femo-Washington, Inc.	515
Gerry is a product of Evenflo, which has 250 employees, But Evenflo is a subdivision of Spalding & Evenflo Co. Inc.	2,600
Kolcraft	500
Safeline Children's Products Co.	< 10
Little Cargo, Inc.	<10

* Source: Standard and Poor's Register of Corporations. Directors, and Executives, 1995.

4. Description of the projected reporting, record keeping and other compliance requirements fur small entities

The final rule sets new performance requirements that would enhance the safety of child restraints. Child restraint manufacturers must certify that their products comply with the final rule. Manufacturers could use any means to determine that their products comply, so lung as they exercise due care in making their certification. Manufacturers of 'child restraints should be familiar with the final test responsibilities because the test is almost identical to current test requirements.

The final rule will result in new designs for child restraints and an increase in the price of child restraints, which may have a significant economic impact on a substantial number of small businesses. If the price elasticity of demand fur child restraints were somewhat elastic, an increase in the price of a child restraint could lead to a decrease in demand for the product, notwithstanding the restraint use laws. NHTSA dues nut know the specific elasticity of demand fur child restraints, but believes it is highly inelastic. Based on comments submitted to the NPRM, it would appear that the elasticity of demand fur child restraints might be inelastic. NHTSA believes that an increase in the price ($9.62) of a child restraint will not lead to any significant decrease in demand fur the product.

An increase in child restraint prices may also affect loaner and giveaway programs. While such a program could have fewer seats available, comments submitted to the NPRM indicate that if the new seats perform as projected, there would be minor effect on the loaner programs.

There are no additional reporting or record keeping requirements in this final rule for child restraint manufacturers or small businesses.

5. Duplication with other Federal rules

There are no relevant Federal rules which may duplicate, overlap or conflict with the final rule.

6. Description of any significant alternatives to the Final rule

NHTSA tentatively believes that there are no alternatives to the final rule which would accomplish the stated objectives of 49 U.S.C. $30101 et seq. and which would minimize any significant economic impact of the final rule on small entities. As discussed in the preamble to this final rule, NHTSA considered a number of other approaches to minimize or eliminate compatibility problems between child restraints and vehicle seats.

SAE Recommended Practice J18 19, "Securing Child Restraint Systems in Motor Vehicle Rear Seats," provides voluntary design guidelines that designers of both the vehicle and child restraint can evaluate each product for compatibility. However, J1819 alone has not solved the compatibility problems. It is a tool fur evaluating compatibility problems, not a requirement that vehicle seats and child restraints must be compatible. NHTSA believes it is very difficult for a single system to optimize the safety protection for adults of all ranges and child restraints of different types.

Another alternative is the current "lockability" requirement, which requires vehicle lap belts or the lap belt portion of lap/shoulder belts to be capable of being used to tightly secure child restraints, without the need to attach a locking dip or any other device to the vehicle's seat belt webbing. NHTSA tentatively believes that the lockability requirement is insufficient alone in addressing compatibility problems. While the requirement ostensibly makes a locking clip obsolete, it still depends on the user knowing enough and making the effort to manipulate the belt system. Also, the vehicle belt must be routed correctly through the child restraint, which may not be an easy task in all cases. Further, the lockability requirement does nut address compatibility problems arising from forward-mounted seat belt anchors. Thus, excessive forward movement of a child restraint can still occur, even if the feature is engaged and the belt is "lucked."

Another alternative discussed in the preamble is the "Car Seat Only (CSO)" system suggested by Cosco. The CSO system consists of a simple lap belt installed fur a vehicle seating position. No changes are needed to child restraint systems.

NHTSA is concerned that the CSO system might nut make attaching a child restraint significantly easier than it is today. The CSO belt would have to be correctly routed through the child restraint, which is a problem occurring with present seats. In some cases, it appears that it might be difficult to cinch up the belt with the CSO system. Another concern relates to the potential that the CSO belt would be inadvertently used by an adult occupant as a restraint, particularly in a seating position equipped with a lap belt, even if the CSO belt were labeled.

As discussed and analyzed throughout this assessment, the agency considered requiring a rigid to rigid system or a nonrigid to nonrigid system. The agency finally decided to require a rigid 6 mm bar anchorage system in the vehicle, but allow the child restraint manufacturers to use any type of connector they wanted to connect to the rigid bars. Certainly for the small business child restraint manufacturers, the final rule provides the most flexibility possible of the alternatives considered.

UNFUNDED MANDATES REFORM ACT ANALYSIS

The Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires agencies to prepare a written assessment of the costs, benefits and other effects of proposed or find rules that include a Federal mandate likely to result in the expenditure by State, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually.

These effects have been discussed in detail in previous sections of this Final Economic Assessment, see e.g., sections on "Costs," "Benefits," and "Final Regulatory Flexibility Analysis." To summarize, NHTSA is issuing this final rule to require a universal child restraint anchorage system under the authority of 49 U.S.C. 322,301 1 I, 30115, 30117 and 30166; delegation of authority at 49 CFR 1.50.

The final rule would improve the safety of children restrained in child restraints by remedying compatibility problems between child restraints and vehicle safety belts and increasing the correct installation of child restraints. The potential effectiveness of child restraints, when correctly used, is 71 percent. However, it is estimated that imperfect securing of children in the child restraints and/or the child restraints in vehicles reduce that effectiveness from the potential 7 I percent to an actual 59 percent.

Child restraint effectiveness is reduced by limitations imposed by vehicle belt design, and by belt anchorage locations. Some vehicle seats have the seat belt anchorages positioned to protect an adult, but too far forward to adequately restrain a child restraint. Child restraint effectiveness is also reduced by incorrect securing of children and child restraints due to the complexities of adapting vehicle belts to those purposes and due to failure to follow instructions.

This final rule for an independent means for securing child restraints to vehicle seats is estimated to save 36 to 50 lives per year, and prevent 6,218 to 17,891 injuries. An independent means of attaching child restraints would also enable vehicle manufacturers to optimize the design of vehicle belt systems for adult occupants.

The cost of the final rule, considering both child restraint and vehicle improvements, is estimated to be $152 million annually. A sensitivity range on total costs, assuming that every child restraint manufacturer produced the cheapest connector system considered to the must expensive connector system considered, is from $123 to $256 million. The cost of the rule related to vehicles is estimated to be about $85 million, ranging, per vehicle, from $2.82 (one set of rigid anchorages in front seat only) to $6.62 (two sets of rigid anchorages plus a third tether anchorage), fur approximately 15 million vehicles. The cost of the connectors on the child restraint are estimated to average $17.19 per child restraint for a total annual cost of $67 million. The sensitivity range of total costs are from $38 to 171 million, at $9.62 for nonrigid connectors to $43.87 for rigid connectors per child restraint.

It should be noted that the rigid bar anchorage system selected by this rule is the most cost effective of the alternative independent child restraint anchorage systems that the agency evaluated in this regulatory action. This anchorage system could result in lower child restraint costs (as low as $9.62 per restraint) than the flexible latchplate system ($11.96 per restraint), and lower vehicle costs ($6.62 fur two full anchorage plus a third tether anchorage, compared to $8.74 fur two full flexible latchplate systems with a third tether anchorage). The vehicle cost of the rigid bar is lower than the vehicle cost of the CSO system (The retractor alone would cost $2.50 to $3.00 per system, or $5 to $6 fur two systems. Adding the cost of the belt and anchorage would increase this cost well above the $6.62 fur two full rigid anchorages).

NHTSA held a public meeting at the Lifesavers 1995 National Conference on Highway Safety Priorities (March 1995) to obtain comments on improving the proper installation and use of child restraints. The agency scheduled the meeting to coincide with the Lifesavers conference so that persons participating in the Lifesavers conference could attend the meeting. Those participants typically work in State highway traffic safety agencies, community traffic safety programs, State or local EMS or injury prevention offices and State or local law enforcement agencies. Persons attending the meeting expressed strung support fur a requirement fur a universal child restraint anchorage system, such as in this final rule. Support fur a universal child restraint anchorage system was also expressed at NHTSA's October 1996 public workshop on the various anchorage systems under consideration. Participants at this workshop included representatives of the child restraint and motor vehicle industry, and consumer advocacy groups. All were unanimous that the means of attaching child restraints to the vehicle interior should be easier, more efficient and without compatibility problems. All agree that there should be a universal and independent means of attaching child restraints.

An increase in child restraint prices may affect loaner and giveaway programs. A cost increase could result in fewer seats being purchased by the program for loan or giveaway. On the other hand, persons responsible for some State loaner/giveaway programs informed the agency that if the new seats cost more, they could be able to find the funding to keep up with demand. They also said that the time saved installing child restraints in each vehicle and making adjustments would be worth the difference in price.

NHTSA believes that there are no feasible alternatives to the final rule. As discussed in the preamble, SAE Recommended Practice J 18 19, “Securing Child Restraint Systems in Motor Vehicle Rear Seats,” is not a feasible alternative, because it is a tool for evaluating compatibility problems, and is not a requirement that vehicle seats and child restraints must be compatible. NHTSA believes it is very difficult for a single system to optimize the safety protection for adults of all ranges and child restraints of different types. The current “luckability” requirement is insufficient alone in addressing compatibility problems. While the requirement ostensibly makes a locking clip obsolete, it still depends on the user knowing enough and making the effort to manipulate the belt system. Also, the vehicle belt must be routed correctly through the child restraint, which may not be an easy task in all cases. Further, the lockability requirement does not address compatibility problems arising from forward-mounted seat belt anchors. Excessive forward movement of a child restraint can still occur, even if the feature is engaged and the belt is “locked.” Cosco’s “Car Seat Only (CSO)” system dues not make attaching a child restraint significantly easier than it is today. The CSO belt would have to be correctly routed through the child restraint, which is a problem occurring with present seats. From photographs of the CSO system, it appears difficult to cinch up the belt. In addition, the CSO belt could be inadvertently used by an adult occupant as a restraint, particularly in a seating position equipped with a lap belt.

CUMULATIVE IMPACTS OF RECENT RULEMAKINGS

Section 1(b)1 1 of Executive Order 12866 Regulator-v Planning and Review requires agencies to take into account to the extent practicable "the costs of cumulative regulations". To adhere to this requirement, the agency has decided to examine both the costs and benefits of all final rules with a cost or benefit impact on child restraints effective from MY 1990 on.

Costs will be presented in two ways, the cost per affected child restraint and the average cost uver all child restraints. The cost per affected child restraint includes the range of costs that any child restraint might incur. For example, if two different child restraints need different countermeasures to meet the standard, a range will show the cost for both. The average cost over all child restraints takes into account voluntary compliance before the rule was promulgated or planned voluntary compliance before the rule was effective and the percent of the child restraints for which the rule is applicable. Costs are provided in 1994 dollars.

Benefits are provided on an annual basis for the fleet once all child restraints in the fleet meet the rule. Benefit estimates take into account voluntary compliance.

Table 20
COSTS OF RECENT CHILD RESTRAINT RULEMAKINGS
(1994 Dollars)

Description	Effective Date	Cost Per Affected Restraint $	Cost Per Average Restraint $	Estimated Total Annual Cost
FMVSS 213, Warning Labels on Rear Facing Child Restraints for Vehicles with Air Bags	May 27, 1997	$0.30 - $0.60	$0.30 - $0.60	$1,170,000 - $2,340,000
FMVSS 213, Registration of Child Restraints	July 1994	$0.22 - $0.57	$0.22 - $0.57	$1,020,000 - $2,703,000
FMVSS 213, Booster Seats	July 1994	None	None	None
FMVSS 213, Test Dummies and Requirement for Testing Child Restraint Systems	1/3/96 for add-ons and 9/1/96 for built-in	Testing Cost $1,337	Testing Cost $1,337	$247,345

BENEFITS OF RECENT CHILD RESTRAINT RULEMAKINGS
(Annual benefits when the standard is met)

Description	Fatalities Prevented	Injuries Reduced	Property Damage Savings $
FMVSS 213, Registration of Child Restraints	not estimated	not estimated	None
FMVSS 213, Warning Labels on Rear Facing Child Restraints for Vehicles with Air Bags	2 to 4	445	None
FMVSS 213, Booster Seats	not estimated	not estimated	None
FMVSS 213, Test Dummies and Requirement for Testing Child Restraint Systems	not estimated	not estimated	None

APPENDIX

1 -Definition of Terms

Anchorages – the fixtures on the vehicle used to attach a child restraint to the vehicle. Fur purposes of this analysis, anchorages can either be rigid or nonrigid. However, the final rule requires the anchorages to be rigid 6 mm bars. The analysis also examined a nonrigid anchorage, a latchplate on webbing designed for the UCRA system, proposed in the NPRM as a flexible latchplate anchorage system.

Connector – the fixture on the child restraint used to attach a child restraint to the vehicle anchorages, Connectors can either be rigidly or nonrigidly attached to the child restraint.. The final rule allows child restraints to use any type of connector, rigid or nonrigid. A rigid connector sold in Europe by Britax is a bracket-type system with a jaw at the end to connect to the 6 mm bar. Nonrigid connectors are attached to the child restraint by webbing. The nonrigid connectors can take many forms, including a jaw, snap-hook, or buckles.

This final rule specifies that each of the lower attachments be a 6 mm straight, round rod, or bar. The ends of each bar point to the sides of the vehicle, with the bars being about two inches (50.8 mm) in length and 11 inches (280 mm) apart. The attachment bars would be approached through holes in the backrest cushion or through gaps in between the backrest cushion and the bottom cushion of the seat at the seat bight. The bars would be far enough back so that they would nut be felt by an adult passenger. There could be a funnel aperture to guide the child restraint connector onto the attachment bar.

2-Component Ratings

A study done by Britax (1 996) compared bath the nonrigid connectors and the rigid connectors. For the rigid connectors, the seat structure used was the 4-point rigid base. In the study, the configuration used was: Britax sled, ECE R44 pulse, TNO P3 (3-year-old) test dummy and no top tether attached to the child restraints. The results obtained are shown in Table 2 1.

Table ?1

	Symm. Setup	Slack (mm)	MC	Head Excur.	Head Accel.	Chest Accel.
Rigid Anchors, fixed	yes	0	581	530	62.7	40.4
Rigid Anchors, loose *	yes	50	718	570	76.6	40.7
Nonrigid Anchor, 170 mm **	yes	0	505	515	55.3	36.8
Nonrigid Anchor, 245 mm	yes	0	559	570	62.5	34.9
Nonrigid Anchor, 245 mm	yes	20	672	610	71.1	40.6
Nonrigid Anchor, 245 mm	yes	50	1000	625	79.5	62.5
Nonrigid Anchor non symetr.	no	0	858	630	79.8	46.7

* Seat buckled up but not ratcheted towards the back seat cushion

** tethers mounted to the lowest and rearmost possible attachment point of the child restraint

As slack was applied to the test seats, HIC, Head Excursion and Head Acceleration numbers all increased. These data are provided to show the significance of tightening belts or anchorages on child restraints.

From a safety point of view, the rigid to rigid system may be safer in side impact crashes, and the rigid to rigid system dues nut need to be tightened, thus eliminating a misuse made. By choosing the rigid anchorages system on the vehicle, the agency is allowing the market to decide what type of connector is used on the child restraint. If people want to buy a slightly safer, more convenient, more costly child restraint, they should have that option. That option is not available with the latch plate connector in the vehicle. Only one anchorage system on the vehicle could be chosen, the agency picked the one that allowed the widest option for the child restraint manufacturers from which to choose. An additional reason for choosing the rigid anchorage system is harmonization with the rest of the world.

3-Research

Since the first prototype of the rigid connector system was developed by Sweden in 1990, there have been many other types of rigid connector systems presented for review. From the inception of the IS0 program most of the research was done on the 4-point rigid connector system, which had two connectors at the seat bight and two connectors below the seat cushion. Later, research was conducted on the newer systems such as, the 3-POINT rigid connector, CANFIX, and the nonrigid (Dual Strap) systems, which had two connectors at the seat bight and one tether anchor.

A review of the PRE will show the various research projects that were completed. A synopsis of a research done on the 4-point rigid connector showed that a comparison of the 4-point rigid connector and the child restraint that is sold today for use in motor vehicles revealed that the 4-point rigid connector had better results for head excursion and chest acceleration in both front impact and side impact configurations.

A Canadian study,[9] to develop standardized procedures fur measuring the ease with which an infant or child restraint system could be correctly installed, employed two rigid connector restraint system prototypes: a rearward-facing infant restraint and a forward-facing child restraint. The rigid connector design comprises twu rear attachments on the child restraint to be secured to two anchorage points located behind the vehicle seat bight and includes the tether anchorage feature.

In testing of the rigid connectors to measure the ease of installation of child restraints by consumers, three conventional child restraints that used the vehicle seat belts fur anchorage served as experimental controls. All forward-facing child restraint systems used a tether strap attached to the parcel shelf.

Thirty-six parents and child-care providers, consisting of nine men and 27 women, were recruited at random. Of the 36 participants, eight were selected cm the basis of size to ensure that the sample included the extremes of the population. The study found that the rigid connector child restraint, one infant restraint (rear-facing) and one child restraint (forward-facing) configuration were correctly installed greater than 85 percent of the time, which was the study's established criterion of acceptability.

A number of problems related to the prototype rigid connector attachment systems were identified. The anchorages were hard to find, and it was difficult to align the latches and lock mechanism. It

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[9] Noy, Ian Y. (1995). Installing Child Restraint Systems in Vehicles: towards Usability Criteria. Ergonomics Division Transport Canada

was difficult to know whether the restraint was properly engaged because the sound of the latch touching the attachment anchorage was the same as when it locked. Greater physical force than that used with the conventional seats had to be applied to install the infant restraint, and the latches sometimes released by accident after locking. It was recommended that design improvements to the rigid connector infant and child restraint systems would greatly improve their safety and ease of correct installation.

Child Restraint System Clinic

The AAMA, AIAM, and several manufacturers of child restraints set up a clinic to determine consumer acceptance of seven child restraint types. Consumers evaluated one current production and six prototype child restraints. There were 254 principal drivers from a cross section of cars and trucks. Included were 194 primary care givers of children 4 years of age or less (97 women / 97 men) and 60 "empty nesters" who transport a child 4 years of age or younger at least twice a month.

The tested child restraint systems, letter designations, and prices provided during the clinic were:

Baseline (K): Current U.S. type forward facing CRS secured using existing vehicle restraint system. Estimated Retail Price: $63

TOD Tether(N): Current Canadian type forward facing CRS secured using existing vehicle restraint system and top tether anchorage. Estimated Retail Price: $68

Nonrigid Buckle Connector to Nonrigid Latchplate (UCRA) (M): Forward facing CRS with top tether and two manually adjusted side straps with a buckle type connector that connect to nonrigid lower anchorages incorporating "latch plates". Estimated Retail Price: $78

Nonrigid Snap Hook Connector to Rigid 6 mm Bar (L): Forward facing CRS with top tether and two manually adjusted flexible side straps that connect a snap hook to rigid 6 mm bar anchorages. Estimated Retail Price: $73

Rigid Jaw Connector to Rigid 6 mm Bar (L): Forward facing CRS with top tether and two rigid jaw brackets that connect to rigid 6 mm bar lower anchorages. Estimated Retail Price: $128

Rigid Jaw Connector to Adaptor, Adaptor Connected by Buckles to Latchplate (Opelfix)(P): Forward facing CRS with top tether and two brackets incorporating buckles that connect with latchplate type lower anchorages held in an adapter. Estimated Retail Price: $78

Nonrigid Jaw Connector Rigid 6 mm Bar(S): Forward facing CRS with top tether and two manually adjusted side straps incorporating jaws that connect to rigid 6 mm bar lower anchorage. Estimated Retail Price: $80

Conclusions from child restraint systems clinic

The Nonrigid Buckle Connector to Nonrigid Latchplate restraint system was the most preferred.

The Rigid Jaw Connector to Rigid 6 mm Bar was the second must preferred.

The Nonrigid Snap Hook Connector to Rigid 6 mm Bar was the third must preferred.

The Nonrigid Jaw Connector to Rigid 6 mm Bar was the fourth must preferred.

Consumers apparently are looking for simplicity; they want systems with minimal operating steps and parts. Consumers are sensitive to price, if offered two equally rated alternatives; they would purchase the least expensive of the twu. The must preferred of all the seat alternatives was the nonrigid buckle connector to nonrigid latchplate. From the focus group discussions, the nonrigid buckle connector system met consumers' criteria for convenience, safety/security, and values. The second most preferred system is the rigid jaw connector to rigid 6 mm bar. From the focus group discussions the rigid-based CRS with rigid connectors met consumers' criteria for safety/security and convenience due to the rigid lower anchorage points. The group raised concerns about being too heavy, too expensive, and being at an uncomfortable angle for the child.

4-Anchorage Designs

Since the rigid anchorage system is intended to be a universal attachment system, the expectation is that the attachments should be able to fit any passenger seating position (or multiple seating positions within the same vehicle), and attachments to the vehicle should be as simple and inexpensive as possible.

The guidelines others have considered for the design included the following factors:

- be simple and inexpensive
- be accommodated within a relatively small space
- not interfere with the comfort of adult passengers
- use relatively small attachments and latches on the child restraints so that entry apertures in the seat trim would be small or negligible in size.
- be relatively insensitive to the most likely type of misalignment of the child restraint during installation.
- provide some self aligning guidance for the user when installing the child restraint.

The attachment bars need to be sufficiently strong to support the impact forces from the restraint while being as small as possible to permit a low profile latch. Stress analysis indicated that a 6 millimeter (mm) diameter bar, 25 mm long, supported firmly at each end, made from steel of yield stress 600 N/mm^2, would support a force of X.2 kN applied at the center without breaking. This would provide a safety margin of 50 percent more than is believed necessary[10].

5-Tether Anchorages

The universal system selected uses three attachment points fur anchoring the child restraint. Two of the points are at or near the vehicle seat bight. The third attachment point is a top tether anchorage used to anchor the back of the child restraint.

Australia and Canada require all vehicles to be equipped with tether anchorage locations (holes). Until recent requirements for ready to use anchorages become effective, most vehicle users must install the tether anchorage hardware themselves[11]. Canada does not require a tether fur rear-facing child restraints, but Australia does. The agency believes that the benefits of an upper tether would mostly be accrued in forward-facing child restraints and so is specifying the tether provision only for those systems‘

[10] Lowne, R.W. and Turbell, L. The Development of a Unified Child Restraint to Car Attachment System: A Contribution to the Rigid anchorages Discussion p 1601. The Fourteenth International Technical Conference on the Enhanced Safety of Vehicles, Munich, 1994

[11] Noy, Ian Y., and Arnold, A. K (1995). Installing Child Restraint Systems in Vehicles: Towards Usability Criteria. Ergonomics Division, Road Safety and Motor Vehicle Regulation, Transport Canada.

The Final Rule specifies that consumer-ready to use tether anchorages consisting of a threaded or unthreaded hole capable of accepting an M8 bolt 30 mm long be installed in the vehicles. The rule also requires that manufacturers provide an equivalent device that combines the function of a tether anchorage and tether anchorage hardware. To provide more flexibility to parents in determining where to place their children, and enable them to better use the center rear seating position in a passenger car, the rule requires tether anchorages at three rear seating positions. (The lower anchorages are required in only two rear seating positions.)

Figure 1 shows the Rigid Connector design which has the two rear attachment anchorages plus the tether strap that serves as a third attachment point. The middle figure also shows the rigid anchorage, the 6 mm bar in the vehicle seat.

RIGID JAW

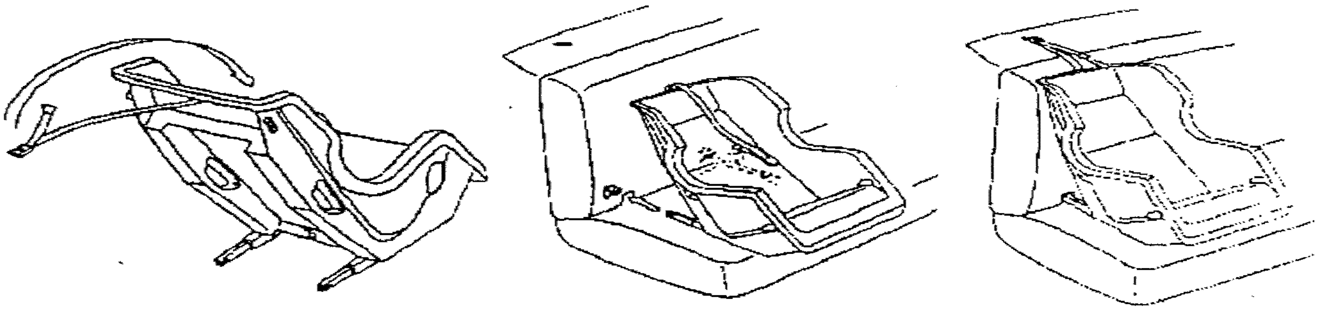

Figure 1

6-Misuse in Fatal Crashes

Table 22 shows the restraint use and injury severity of 0 to 6-year-old occupants of passenger vehicles in fatal crashes in child restraints for 1996 by reported correct/improper use.

Table 22

1996 FARS - In Fatal Crashes

Child Restraint Use	Injury Severity						
	No	Possible	Non-Incap.	Incapacit	Fatal	Unknown	Total
Correct Use	467	192	286	222	219	4	1,390
Improper Use	6	8	10	15	32	1	72
% Misuse	1.28	4.17	3.50	6.76	14.61	0.25	5.18

In the above table, although this is a small sample, one notices that as the percent of misuse increases, the severity of the injuries also increases. Given that these misuse percentages are based on police accident reports, they probably are showing only clearly obvious misuse modes (child not buckled into child restraint, child restraint not buckled to vehicle, etc.)

7-Non-fatal Injury Effectiveness Calculations

Effectiveness for restraint systems used by children are calculated as follows:

$e = 1 - r/n$

where: e = effectiveness of restraint system against injury r = rate of injury fur restrained occupants

n = rate of injury fur unrestrained occupants

Both r and n are calculated as:

r or n = i / t

where i = injured occupants restrained (r) or not restrained (n)

T = total occupants restrained (r) or not restrained (n)

Tables 23, 24 and 25 are weighted GES data. The data illustrate the restraint system used and the imputed injury severity of zero to six year old occupants involved in crashes. Each table is a combination of data fur the period 1990 to 1996. Effectiveness estimates for each system include misuse, i.e., they represent the range of both proper and improper usage that actually occurred when children are restrained.

Table 23
1990 - 1996' GES - Total Crashes
(Less Than One Year-Old Children)

Restraint use	Injury Severity				
	No Injuries	Possible	Non-Incap.	Incapacit	Total
None	88,282	7,907	3,394	2,352	101,935
L/S Belt	49,628	5,118	719	29	55,494
Lap Belt	35,049	1,420	499	98	37,066
Child Restraint	494,934	31,952	11,756	5,347	543,989
Total	667,893	46,397	16,368	7,826	738,484

*Seven years of data, not an annual average.

For children less than one year, the injury rates are:

None = 13,653/101,935 = ,134
CRS = 49,055/543,989 = .0902
L/S Belt = 5,866/55,494 = .106
Lap Belt = 2,017/37,066 = .054

The effectiveness calculations are:
effectiveness of child restraint systems = 1 - .0902/. 134 = 33%,
effectiveness of lap/shoulder belts = 1 - .106/. 134 = 21%,
effectiveness of lap belts = 1 - .054/. 134 = 60%

For children less than one year old, the effectiveness estimates are not what the agency would expect. Based on previous studies, the agency would expect to find child restraint effectiveness for infants to be very high (in the 60 to 70 percent range, not 33 percent), Similarly, one would not expect lap belt effectiveness to be as high as 60 percent for infants and there to be such a divergence of effectiveness between lap belt and lap/shoulder belts (60 percent versus 21 percent). Much higher injury effectiveness for child restraints for 1 to 4 year olds and fatality effectiveness estimates for infants, lead us to believe that their estimates are not reasonable. Injury calculations in this analysis for infants will use effectiveness estimates from the 1 - 4 year olds

Table 24
1990 - 1996' GES - Total Crashes
(One To Four Year-Old Children)

Restraint Use	Injury Severity				
	No Injuries	Possible	Non-Incap.	Incapacit	Total
None	333,703	54,711	42,558	21,592	452,564
L/S Belt	557,974	47,824	20,050	6,261	632,109
Lap Belt	692,182	65,288	25,525	7,225	790,220
Child Restraint	1,448,402	84,299	42,966	16,407	1,592,074
Total	3,032,261	252,122	13 1,099	51,485	3,466,,967

* Seven years of data, not an annual average.

For children between the ages of one and four years old, the injury rates are:
None = 118,861/452,564 = .263
CRS = 143,672/1,592,074 = .09
L/S Belt = 74,135/632,109 = .117
Lap Belt = 98,038/790,220 = .124

The effectiveness calculations are:
effectiveness of child restraint systems = 1 - .09/.263 = 66%,
effectiveness of lap/shoulder belts = 1 - .117/.263 = 56%,
effectiveness of lap belts = 1 - .124/.263 = 53%

Table 25
1994 - 1996* GES - Total Crashes
Five To Six Year-Old

Restraint Use	Injury Severity				
	No Injury	Possible	Non-Incap.	Incapacit	Total
None	198,807	38,020	29,620	12,107	278,536
L/S Belt	390,254	45,413	20,060	5,631	461,358
Lap Belt	512,742	60,735	23,151	6,108	602,736
Child Restraint	46,967	3,028	1,755	612	52,362
Total	1,148,770	147,196	74,568	24,458	1,394,992

*Seven years of data, not an annual average.

For children between the ages of five and six years old, the injury rates are:
None = 79,747/278,536 = .286
CRS = 5,395/52362 = .103
L/S Belt = 71,104/461,358 = .154
Lap Belt = 89,994/602,736 = .149

The effectiveness calculations are:
the effectiveness of child restraint systems = 1 - .103/.286 = 64%,
the effectiveness of lap/shoulder belts = 1 - .154/.286 = 46%,
the effectiveness of lap belts = 1- .149/.286 = 48%

Note: A sensitivity analysis was done by converting the KABCO data to MAIS data. The effectiveness percentages for AIS 2 and greater were calculated. These effectiveness percentages, when compared to those calculated for the above three age groups for all injuries, showed similar results.

REFERENCES

Decina, L. E. and Knoebel, K. Y. (1996). Patterns of Misuse of Child Safetv Seats Final Report, U.S. Department of Transportation, National Highway Traffic Safety Administration. DOT HS 808 440.

Kahane, Charles J. (1986). An Evaluation of the Effectiveness and Benefits of Safetv Seats. U.S. Department of Transportation, NHTSA. DOT HS 806 889.

Lowne, R.W. and Turbell, L. The Development of a Unified Child Restraint to Car Attachment System: A Contribution to the Rigid Anchorages Discussions, The Fourteenth International Technical Conference on the Enhanced Safety of Vehicles, Munich, 1994.

Turbell, T., Lowne, R., Lundell, B. and Tingvall, C. Rigid Anchorages-A New Concept of Installing Child Restraints in Cars, SAE Paper 933085, Child Occupant Protection, SAE Publication SP-986, 1993.

Pedder, J., Legaut, F., Salcudean, G.,and Hillebrandt, D., and Gardner W., and Labrecque. M. Development of the CANFIX Infant and Child Restraint/Vehicle Interface System, SAE Paper 942221, 38th Stapp Car Crash Conference, Florida 1994.