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FINAL REGULATORY IMPACT ANALYSIS

Child Restraint Systems--Side Impact Protection

FMVSS No. 213a

Office of Regulatory Analysis and Evaluation
NCSA
June 2022

Contents

Executive Summary

The National Highway Traffic Safety Administration (NHTSA) is issuing a final rule to amend Federal Motor Vehicle Safety Standard (FMVSS) No. 213, "Child Restraint Systems," and to establish FMVSS No. 213a, "Child restraint systems—side impact protection," which specifies side impact protection requirements for child restraint systems (CRSs) recommended for children in a weight range that includes weights up to 18 kilograms (40 pounds (lbs.)) or by children in a height range that includes heights up to 1100 millimeters (43 inches). The side impact performance requirements are established in a new FMVSS No. 213a, which the final rule incorporates into Standard No. 213. This final rule fulfills a statutory mandate set forth in the "Moving Ahead for Progress in the 21st Century Act" (MAP-21) that directed the Secretary of Transportation (NHTSA by delegation) to issue a final rule to improve the protection of children seated in child restraint systems during side impacts.

Frontal and side crashes account for most child occupant fatalities. FMVSS No. 213 currently requires CRSs to meet a dynamic test simulating a 48.3 kilometers per hour (30 miles per hour) frontal impact. This final rule requires an additional test in which applicable CRSs must meet the specified performance requirements in a dynamic sled test simulating the intrusions and accelerations observed at outboard seating position during a full-scale vehicle-to-vehicle side impact. The dynamic sled test simulates the FMVSS No. 214, "Side impact protection" crash test in which a moving deformable barrier (MDB) impacts the side of a test vehicle. The MDB test is a representation a striking vehicle traveling at 48.3 km/h (30 mph) perpendicularly impacting the side of a struck vehicle traveling at 24 km/h (15 mph).[1]

The final rule applies to CRSs designed for children weighing up to 18 kg (40 lb.) or for children up to 1100 millimeters (mm) (43.3 inches, or 3 feet 7 inches) in standing height, which include seats commonly referred to as rear-facing infant carriers, forward-facing child seats with internal harnesses, convertible child seats, combination child seats, and booster seats (to the extent those seats are designed for children up to 40 pounds). However, car beds, harnesses, and built-in/add-on child restraints are excluded from the requirements.

As specified in the final rule, CRSs are tested with an instrumented side impact test dummy representing a 3-year-old child, called the Q3s dummy[2], and a 12-month-old child test dummy[3] (i.e., the Child Restraint Air Bag Interaction (CRABI) dummy). The specified injury criteria (expressed in terms of chest deflection and a head injury criterion (HIC15)) for the Q3s allow a quantitative evaluation of the effectiveness of a CRS to prevent or mitigate head and chest injuries resulting from an impact with the intruding door. The 12-month old CRABI dummy would be used to measure the containment capability of the CRS (the ability to prevent the dummy's head from contacting the intruding door of the sled assembly).[4, 5]

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[1]The purpose of this dynamic sled test for FMVSS 213a is to evaluate child restraint systems in a sled system which simulates the intruding door of a small passenger car in a side impact (e.g., a vehicle-to-vehicle intersection crash). We do not have sufficient data to determine what share of covered crashes involve an intruding door. However, the door intrusion into the occupant compartment of a vehicle is a causative factor for moderate and serious injuries to children in side impacts.

[2] 49 CFR Part 572, Subpart W, "Q3s Three-Year-Old Child Test Dummy"

[3] 49 CRP Part 571, Subpart R, "CRABI 12-Month-Old Infant Crash Test Dummy, Alpha Version"

[4] Source: 2014-2018 Fatality Analysis Reporting System (FARS), age 0 to 3, all crashes. In addition, CRSs are required to meet other structural integrity requirements contained in FMVSS No. 213a.

[5] We note that the seating height of older children restrained in CRSs typically positions the head high enough to benefit from side curtain air bags installed pursuant to FMVSS No. 214, "Side impact protection," and FMVSS No.

A. Target Population

Approximately 28 percent of the children who died in a motor vehicle crash while restrained in a CRS were involved in a side impact crash.[6] For the period 2014 to 2018, there were 42 average annual fatalities to children ages zero to three restrained in child seats in passenger vehicles and 2,113 annual non-fatal injuries in non-rollover and non-ejection side impacts.

B. Countermeasure

NHTSA research has shown that some of the CRSs available on the market and tested by NHTSA met the side impact performance criteria that NHTSA is adopting in this final rule, and thus we believe some child restraint manufacturers have displayed the capability to design CRSs to address side impacts. Furthermore, we believe design changes for some of the forward-facing CRSs and rear-facing CRSs would enable applicable CRSs to meet the performance specified in the final rule, based on the test data we have. The test results during the Notice of Proposed Rulemaking (NPRM) testing showed that energy-absorbing padding added to a CRS around the head area and the side structures (CRS side "wings") would enable forward- and rear-facing CRSs to meet the side impact requirements without adding any additional structures to the CRS.[7]

C. Requirements

The final rule requires CRSs (CRSs) designed to seat children in a weight range that includes weights up to 18 kg (40 lb) or children in a standing height range that includes 1100 millimeters

226, "Ejection mitigation." Thus, the need for a side impact requirement in FMVSS No. 213 may be lessened for these older children.

[6] Some of these injuries and fatalities involved children in seats that were incorrectly used. However, we do not have complete data on the number of incidents that involved misuse because crash databases do not generally collect data on how child restraints were used.

[7] The test data showed a CRS would not need to add side structures (in addition to padding) to comply with the rule. Accordingly, the agency estimated the costs and the benefits of adding such padding to CRSs since padding appears to be the most feasible and reasonable countermeasure to meet the performance requirements. Thus, the agency has not estimated costs and benefits for other potential countermeasures.

(mm) (43.3 inches, or 3 feet 7 inches) to meet specific performance criteria in a dynamic sled test that simulates the side-impact MDB test. The most significant amendments by the final rule are described below.

1. A dynamic (sled) test would be used to evaluate the performance of the CRS in a side impact. The sled test was based on an acceleration sled system developed by Takata. The test procedure simulates the two-vehicle side crash replicated in the MDB test of FMVSS No. 214. The sled test simulates a near-side side impact of a small passenger car. It simulates the velocity of the striking vehicle, the struck vehicle, and an intruding door.

2. The test buck consists of a sliding vehicle seat (representative of a rear seat designated seating position) mounted to a rail system along with a side door structure rigidly mounted to the sled buck structure. The sliding vehicle seat and side door are representative of today's passenger vehicles. The sliding vehicle seat is positioned sufficiently away from the side door to allow the sled to reach a desired velocity (31.3 km/h) prior to the time the sliding vehicle seat starts to accelerate to a specific acceleration profile.

3. Most CRSs would be attached to the sliding vehicle seat of the side impact seat assembly (SISA) using two configurations: (1) with the Lower Anchors of the child restraint anchorage system and tether if available and (2) with a Type 2 seat belt and tether if available. The center of the CRS is positioned 300 mm from the edge of the sliding seat next to the intruding door (simulating a near-side position). At the time of contact, the front-face of the armrest on the door is located 38 mm inward from the edge of the seat closest to the child restraint system.

4. CRSs recommended for children with weights that include 13.6 kg to 18 kg (30 to 40 lb) or heights that include 870 mm to 1100 mm (34.3 to 43.3 inches) would be tested on the SISA

with an Anthropomorphic Test Device (ATD) representing a 3-year-old (or 3YO) child, referred to as the Q3s.[8]

5. Injury criteria (expressed in terms of HIC15 and chest deflection) are used for the Q3s. These criteria allow a quantitative evaluation of the effectiveness of the CRS, and the ability of the CRS to prevent or attenuate head and chest impact with the intruding door. The Child Restraint/Air Bag Interaction 12-month old ATD (CRABI) would be used to measure the containment capability (i.e., the ability to prevent the ATD's head from contacting the intruding door of the SISA) of CRSs recommended for children weighing more than 5 kg (11 lb) and up to 13.6 kg (30 lb).

D. Benefits

The countermeasure, i.e., adding padding to the head and wing portions of a CRS, would reduce the likelihood of injuries, with 4 (3.7) fatalities saved and 41 (40.9) serious injuries (i.e., the Maximum Abbreviated Injury Scale, MAIS 4 and 5) prevented when all applicable CRSs meet the performance requirements. The economic benefits of reducing these fatalities and injuries are estimated to be $168.97 million at a 3 percent discount rate and $152.16 million at a 7 percent discount rate in 2020 dollars.[9]

E. Costs

The cost of the final rule (in 2020 dollars) is estimated as follows.

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[8] The Q3s (49 CFR Part 572; Subpart W) is a side impact version of the 3 YO child Q-series dummy (Q3), a crash dummy developed in Europe. CRSs recommended to seat children with weights up to 10 kg (22 lb) would be tested with the 12 MO CRABI dummy (49 CFR Part 572, Subpart R).

[9] We note that in general the countermeasure would not completely eliminate the risk of injuries; rather, it would reduce the severity of an injury. In other words, the countermeasure would convert a particular injury level to a lower injury level. Since the countermeasure converts a particular injury level to a lower injury level, the number of minor or injuries with a lower severity can increase. The conversion or trickled-down effect is further discussed in a later section.

1) The incremental cost of adding padding to the head and/or wing area of a child restraint is estimated to a sales-weighted average of $0.91 per child restraint system that does not meet the required performance requirements. Distributing this total cost to all child restraints marketed for children weighing up to 40 lb., the average cost for additional padding is $0.58 per child restraint.[10] The total installation cost for the 11.3 million child restraints produced a year[11], after considering current compliance, is estimated to be about $6.5 million.

2) The total annual cost of testing applicable child restraint models was estimated to be $830,123.

Overall, the economic benefits of the final rule outweigh the costs. See Table 3 below.

Table 1 Estimated Annual Benefits

Category	No. of
Fatalities	4 (3.7)
Non-fatal injuries (i.e., MAIS 4-5)	41 (40.9)

Table 2 Estimated Annual Costs (2020 dollars, in millions)

Hardware cost	$6.54
Testing cost	$0.83
Total Annual Cost	$7.37

Table 3 Annual Costs and Benefits (2020 dollars, in millions)

	Costs	Benefits	Net Benefits
3% Discount Rate	$7.37	$168.97	$161.60
7% Discount Rate	$7.37	$152.16	$144.79

[10] NHTSA's test data indicated that 58.3 percent of convertible and combination child restraints and 80 percent of infant restraints would need additional padding to meet the new side-impact performance requirements.
[11] Source: Confidential industry data

I. Introduction

Impacts to the side of a vehicle rank almost equal to frontal crashes as a source of occupant fatalities and serious injuries to children ages 0-12. Side impacts are especially dangerous when the impact is on the passenger compartment because the designed energy absorbing structures between the occupant and the impacting vehicle or object, is less substantial than that designed for frontal crashes. The door collapses into the passenger seating area and the occupants contact the door relatively quickly after the crash at a high relative velocity.[12]

Passenger vehicles provide occupant protection in vehicle-to-vehicle crashes by meeting FMVSS No. 214, "Side impact protection." FMVSS No. 214 requires passenger vehicles to provide side impact protection in a full-scale crash test representing a severe intersection collision between two passenger vehicles.[13] The FMVSS No. 214 MDB crash test involves an MDB weighing 1,360 kilograms (kg) (3,000 lb.), to represent a vehicle which is traveling at 48.3 kilometers per hour (km/h) (30 mph) striking the side of another vehicle which is traveling at 24 km/h (15 mph).[14] The struck vehicle must limit the potential for injuries to an occupant's head, thorax, and pelvis, as measured by test dummies seated in the front outboard seat and rear outboard seat on the struck side of the vehicle ("near side" positions).

[12] Kahane, November 1982, NHTSA Report No. DOT HS 806 314.

[13] FMVSS No. 214 also specifies a static laboratory test that has greatly improved side door strength and protection against side impacts with fixed objects. The static test has resulted in manufacturers reinforcing side doors with a horizontal beam. In addition, FMVSS No. 214 specifies a full-scale crash test of a vehicle into a pole, which has resulted in the installation of side air bags to protect against head and chest injuries.

[14] In the FMVSS No. 214 test, only the striking vehicle, represented by the MDB, is moving. Using vector analysis, the agency combined the impact speed and impact angle data in crash files to determine that the dynamics and forces of a crash in which a vehicle traveling at 48.3 km/h (30 mph) perpendicularly striking the side of a vehicle traveling at 24 km/h (15 mph) could be represented by a test configuration in which: the test vehicle is stationary; the longitudinal centerline of the MDB is perpendicular to the longitudinal centerline of the test vehicle at impact; the front and rear wheels of the MDB are crabbed at an angle of 27 degrees to the right of its longitudinal centerline in a left side impact and to the left of that centerline in a right side impact; and the MDB moves, relative to its centerline at that angle and at a speed of 54 km/h (33.5 mph) into the side of the struck vehicle.

The final rule that accompanies this document incorporates a side impact test that simulates the two- vehicle side crash replicated by the FMVSS No. 214 MDB test of a small passenger car.

FMVSS No. 213 currently requires CRSs to meet a dynamic test simulating a 48.3 km/h (30 mph) frontal impact. The final rule requires an additional sled test in which CRSs designed for children in the weight range that includes weights up to 18 kg (40 lbs.) or for children up to 1100 mm (43.3 inches) (i.e., CRSs for infants and toddlers) must protect the occupant in a dynamic sled test that simulates the FMVSS No. 214 MDB test.

In the required side impact sled test, depending on the size of the child for whom the CRS is recommended, child restraints would be tested with the Q3s side impact test dummy representing the size and weight of a 3-year-old child, and with the CRABI dummy representing a 12-month-old infant.

NHTSA is issuing the final rule to ensure that child restraints designed to seat children in a weight range that includes weights up to 40 lb. or a height range that includes heights up to 1,100 mm provide at least a minimum level of protection in side impacts by effectively restraining the child, thus preventing more harmful head contact with an intruding vehicle door, side impact air bag, or child restraint structure. Chest deflection measurements and a head injury criterion (HIC15) are used as injury criteria for the Q3s. These criteria allow a quantitative evaluation of the effectiveness of the CRS to prevent or attenuate head and chest impact with the intruding door. In addition, the 12-month-old CRABI is used to measure the containment capability of the CRS (i.e., the ability to prevent the dummy's head from making contact with the intruding door of the sled assembly). Furthermore, CRSs are required to meet other structural requirements in the sled test ensuring a sound level of performance in side impacts.

Crash data indicate that CRSs for infants and toddlers are generally already remarkably effective in reducing the risk of fatal and serious injuries in side impacts. We have observed in recent years that increasing numbers of CRSs seems to have more side structure coverage (i.e., CRS side "wings") and side padding than before.[15] Because the stiffness of the padding and side wings are factors that affect the containment of the child dummy and the injury measures, we consider the side wing coverage and increased padding overall positive developments. Yet, because FMVSS No. 213 currently does not have a side impact test, a quantifiable assessment of the protective qualities of the features was not possible. The rulemaking establishes performance requirements to ensure that the wings, padding, padding-like features, or other countermeasures achieve a level of performance that will help reduce the risk of injury or fatality to young children in side impacts.

The purpose of this Final Regulatory Impact Analysis (FRIA) is to examine the costs and benefits of the side impact protection rule. The Fatality Analysis Reporting System (FARS) data files for the period 2014 to 2018 showed that approximately 28 percent of the children who died in a motor vehicle crash while in child restraints were involved in a side impact crash.

[15] SafetyBeltSafe U.S.A https://web.archive.org/web/20131012130527/http://www.carseat.org/Pictorial/InfantPict,1-11.pdf and https://web.archive.org/web/20120915194832/http://www.carseat.org/Pictorial/3-Five-%20Point-np.pdf . Last accessed December 16, 2011.

II. Background

The FRIA has three different sections for the background data, Side Impact Test Procedure, CRS Testing, and Annual Cost of Equipment Analysis.

A. Side Impact Test Procedure

The side impact test in the final rule simulates the FMVSS No. 214 MDB impact test of a small passenger car with the child dummy restrained in a CRS positioned in the rear seat near-side of the impact:

1. The test buck consists of a sliding seat mounted to a rail system along with a "side door" structure rigidly mounted to the sled buck structure. The sliding seat and side door are representative of modern passenger vehicles. The sliding seat of this side impact seat assembly (SISA) is positioned sufficiently away from the side door to allow the sled to reach a desired velocity (31.3 km/h) prior to the time the sliding seat starts to accelerate, from interaction with the SISA, to a specific acceleration profile.
2. The center of the CRS is positioned 300 mm from the edge of the sliding seat closest to the intruding door (simulating a near-side position). At the time the sliding seat starts to accelerate, the armrest on the door is located 38 mm past the edge of the seat closest to the CRS.
3. Rear-facing CRSs would be installed on the sliding seat using the lower anchorages of the child restraint anchorage system or lap and shoulder belt, and forward-facing CRSs would be installed using the lower anchorages of the child restraint anchorage system or lap and shoulder belt, both with tether attached, if available.
4. The final rule specifies HIC15 and chest deflection as the injury criteria for the Q3s, and head containment of the 12-month-old CRABI to assess the ability of the CRS to prevent the CRABI ATD's head from contacting the intruding door of the SISA. In addition, the

final rule requires CRSs to meet structural integrity requirements when tested with the respective ATDs, and other assorted performance criteria for belts and buckles.

B. Fleet Testing

We do not have crash data to compare the relative effectiveness of different models of car seats in the on-the-road settings. Because there are so few injuries and fatalities involving children in child restraints, and because child restraint models are updated frequently, it is difficult to get sufficient sample size of specific models. Therefore, dummies simulating child bodies are used to test how the carseats perform.

1. Q3s Dummy

A series of tests using forward-facing and rear-facing CRSs was conducted to assess performance of the selected CRSs.

The CRS tests were conducted with the Q3s dummy using injury criteria for the test dummy (i.e., HIC15 ≤ 570 and Chest Compression ≤ 23 mm). The results of the fleet test are shown below:

Forward-Facing CRS:

- Seven out of twelve (7/12) exceeded HIC15 of 570
- Three out of twelve (3/12) exceeded Chest Deflection of 23 mm (please note they also exceeded HIC15 of 570)

Rear-Facing CRS:

- 3/5 exceeded HIC15 of 570
- 2/5 exceeded Chest Deflection of 23 mm
- 1/5 exceeded both HIC15 and Chest Deflection limits (i.e., HIC15 of 570 and Chest Defection of 23 mm, respectively)

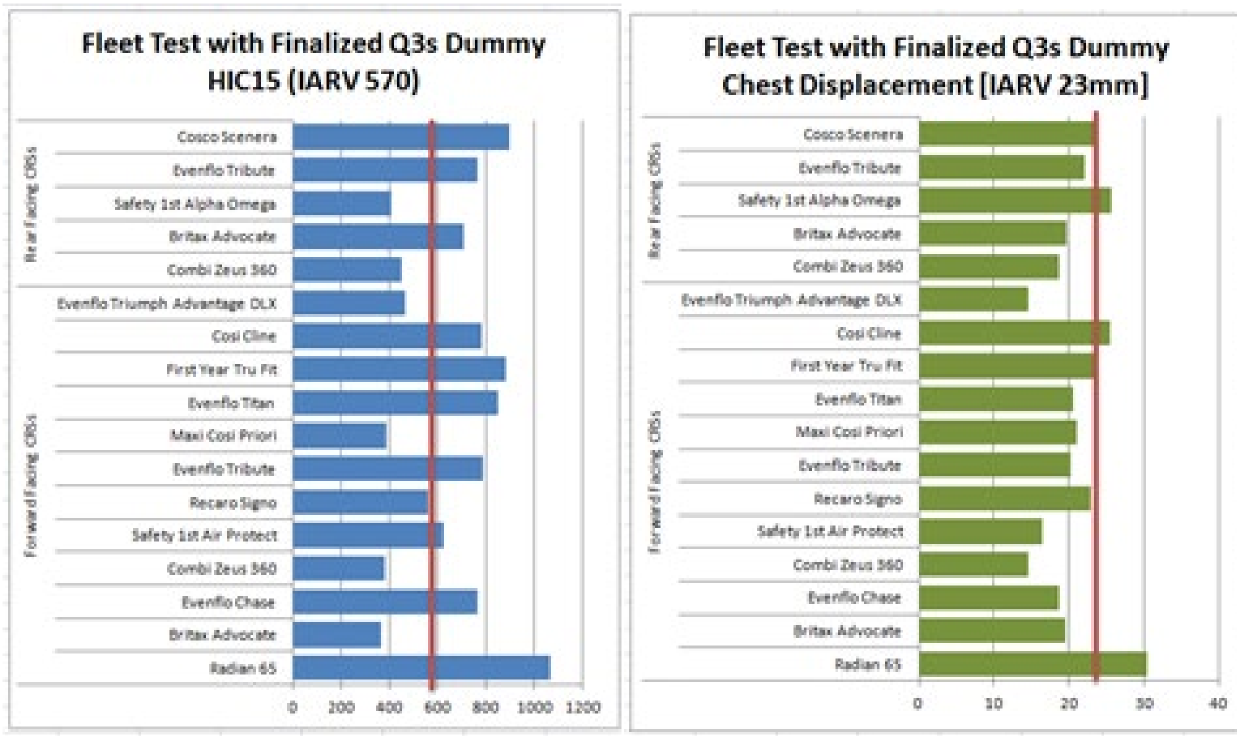

Figure 1 Fleet Test Results HIC15 (left) and Chest Displacement (right)

2. CRABI Test Dummy

A series of tests of rear-facing CRSs was conducted with the CRABI dummy to assess the performance of the fleet. All tests were performed with CRSs attached to the seat bench using the lower LATCH anchors. A 64 mm (2.5 in) thick armrest of stiff foam was added to the 57.15 mm (2.25 in) door panel foam. Twelve tests were performed with a windowsill height at 479 mm and 3 additional tests were performed with a windowsill at 500 mm with the ECE R44 foam. As discussed in the preamble of the final rule accompanying this FRIA, the increase in windowsill height did not affect the performance of the rear-facing CRS (using CRABI) because most models for younger children positioned the head below or completely below the window sill (at 479 mm).

Using head-to-door contact as the performance criterion for the fleet tests, the results showed that only the Combi Shuttle model (i.e., 1 out of 12 CRABI tested) failed this criterion. See Table 4, below.

Table 4 Fleet Test Results

CRABI	Windowsill @ 500mm	Windowsill @ 479 mm
Rear-Facing	**Contact**	**Contact**
Combi Shuttle	Contact	Contact
	Contact	
Britax Advocate	no contact	no contact
Combi Zeus 360		no contact
Safety 1st Air Protect		no contact
Graco My Ride		no contact
Evenflo Discovery 5		no contact
Chicco Key Fit 30		no contact
Safety 1st Designer		no contact
Britax Chaperone		no contact
Maxi Cosi Mico		no contact
Safety 1st OnBoard		no contact
Peg Pereggo		no contact

*Blank cells indicate test was not performed for that CRABI level for the given CRS.

C. Annual Cost of Equipment Analysis

In their comments to the proposed rule, UMTRI stated that costs involving the purchase of the Q3s ATD, new instrumentation (IR-TRACC) and buck manufacturing should be included in cost estimates as this adds to the yearly cost of testing. We believe the yearly testing costs would be relatively small when the costs, i.e., initial and maintenance costs, are spread over the expected lifetime of these test devices, based on an analysis of the annual cost of equipment or investment over its lifetime.

The two most common approaches to estimate the annual cost of equipment or investment over its lifetime are the Net Present Value (NPV) and Equivalent Annual Cost (EAC) methods. The NPV is calculated using the total cash inflow (benefits) and comparing it with the total cash outflow (cost) at different time intervals. The cash flows accrue through a capital investment and at future time intervals. The future cash flows are discounted to bring them to their present values. This methodology is useful when making decisions on the profitability of an investment.

The EAC captures the cost per year of owning, operating, and maintaining an asset over its lifetime and is used to assess the optimal economic life of an equipment, lease versus owning decision and comparing annual cost savings. But most importantly, EAC can be used to compare equipment costs having unequal lives as it avoids a built-in bias which would favor a longer termed investment.

EAC is calculated using the following formula,

$$\text{EAC} = \frac{Asset\ Price * Discount\ Rate}{(1 - (1 + Discount\ Rate)^{-n})} + Annual\ Maintenance$$

Where,

$$n = Expected\ Lifetime$$

The following assumptions are made to derive the EAC, and these assumptions are based on anecdotal evidence collected and literature reviewed. For Expected lifetime, using anecdotal evidence, we assume that the equipment (i.e., the Q3s ATD, new instrumentation (IR-TRACC) and test buck) would last at least 20 years as they are sturdily built fixtures. For Annual Maintenance, the maintenance cost is derived using the Replacement Asset Value (RAV). RAV is the monetized value which would be required to replace the present asset and its production function, including process equipment and supporting peripherals but excludes depreciation and its insured value. The cost of replacing the present asset is assumed to be the original investment cost as the evaluation is being done at the current time and no substantial technological changes have been made to drive down cost or render the technology outdated and not substitutable. Moreover, similar types of test dummies have been used for decades with minimal technological overhaul. Maintenance cost as a percent of RAV is the universal benchmark measure of operating asset performance success. The industry accepted standard of a healthy maintenance cost is 2% to 5% of RAV.

In addition, we have anecdotal data that show the total cost of the Q3s ATD would be $70,000. Therefore, with the $70,000 total cost, the maintenance cost would fall in the range of ($70,000*2/100) and ($70,000*5/100), i.e. $1,400 to $3,500. For the estimate, an average annual maintenance cost of $2, 450 is chosen for these fixtures. For Cost of Capital, according to the 2019, KPMG analysis on determining the cost of capital parameters, the after-tax Weighted average cost of capital (WACC), is the most common discounting cashflow method to discount the future cashflows.[16]

We have data that show the WACC has remained consistently stable in the last 5 years, averaging at 7% for major industrial countries in Europe. More specifically the automotive industry averaged 8% and 8.2% WACC for the years 2017-2018 and 2018-2019, respectively. However, in the United states, as of January 2020, the after tax WACC for Auto and Truck and Auto Parts are 4.40% and 6.37%, respectively.[17] Thus, the combined average after tax WACC for the US automotive industry is 5.4%, approximately. Based on the 5.4% WACC, the EAC of the Q3 ATD was estimated to be $8,259. Furthermore, we assumed the total cost of the test buck would be $10,000 with an operational life of 20 years. Similar to the approach used for the ATD, we estimated an EAC of $1,180 for the test buck.

Table 5 Equivalent Annual Cost (EAC) for Q3s ATD and Test Buck

Data Elements	**Q3s ATD,**	**Test Buck**
Investment Cost	$70,000	$10,000
Expected Lifetime	20	20
Annual Maintenance	$2,000	$350
EAC	$8,259	$1,180

[16] KPMG Cost of Capital study, 2019. https://assets.kpmg/content/dam/kpmg/ch/pdf/cost-of-capital-study-2019.pdf
[17] Cost of capital by sector (US). https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/wacc.htm

Although the estimated EAC of the ATD and test buck is close to $10,000, the incremental unit cost would be relatively small since the cost is to be spread over the total number of CRS sold, with a total annual sale of 15 million CRSs[18] and a design cycle of about 4-5 years for each CRS. Likewise, we expect that the new instrumentation would result in a relatively small increase in CRS unit cost.

[18] According to confidential data, annual CRS sales are approximately 14.6M, but these include about 3.3M "Booster Only" seats to which the rule would not apply.

III. Benefits

A. Target Population

The target population for the FRIA consists of CRS-restrained children under age 4 involved in side impact crashes. Children in this age group have very high child restraint use. According to the 2019 National Survey of the Use of Booster Seats (NSUBS), children younger than one year have a CRS use rate of 97.4% and 1-year-old to 3-year-old children have a CRS rate of 91.2%.[19] [20] Therefore, improving side impact protection of child restraints for this age group would have a high potential for reducing injuries and fatalities in side impact crashes. (Note that in the survey data, a child who is 1 day younger than his or her 4th birthday is considered a 3-year-old. Thus, survey data representing 1-year-old to 3-year-old children include 3-year-old children who are nearly 4 years old and close to the 40 lb. weight limit of a CRS. The weight of the 50th percentile 4-year-old is approximately 35-36 lb., and the weight of the 90th percentile 4-year-old is approximately 42 lbs. [21]) Real world data showed that for children 0 to 12 years old, head injuries were the most common injuries in a side impact environment. According to McCray[22], head injuries in children 1-3 years old are slightly higher than for overall children 0-12 years of age. Likely countermeasures CRS manufacturers can use are: 1) the addition of padding to reduce the severity of the impact and 2) the addition of larger wings (which are padded) to keep

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[19] Enriquez, Jacob. Report Number DOT HS 813 033. May 2021. NSUBS is a probability-based nationwide child restraint use survey conducted by NHTSA's National Center for Statistics and Analysis (NCSA). https://crashstats.nhtsa.dot.gov/Api/Public/Publication/813033#:~:text=NHTSA's%20National%20Center%20for%20Statistics,not%20a%20statistically%20significant%20change.

[20] To reduce ambiguity, when this report talks about children X-year-old to Y-year-old, that means children between the Xth birthday and the day before their Y+1st birthday. (e.g., 3-4 year olds are "the set of children that are three years old and four year olds. Children after their fifth birthday and older are not included in that set. Children younger than their third birthday are not included in that set.)

[21] Growth Charts - Data Table of Weight-for-age Charts (cdc.gov) https://www.cdc.gov/growthcharts/html_charts/wtage.htm

[22] Injuries to children one to three years old in side impact crashes," 20th International Conference on the Enhanced Saved of Vehicles (ESV), 2007. Paper Number 07-0186, https://www-esv.nhtsa.dot.gov/Proceedings/20/07-0186-W.pdf.

the head contained within the child restraint. Although the test procedure simulates a near-side impact, it is reasonable to assume that children involved in far-side impacts will also benefit from CRS designs that protect children in near-side impact. As Table 9 shows, a large percentage of the child injuries are from striking the interior of the child restraint. The far-side effectiveness of the CRS should be equal or greater than the near-side effectiveness since the peak acceleration experienced by the child in a CRS would be lower than that of a child in near-side impact. Our data show an annual total of 223 children ages 0-3 years who were killed in motor vehicle crashes in all crash modes during the period 2014 to 2018 (See Table 6). Of this total, approximately 28 percent, or 63 per year, were in side impact crashes. During this 5-year period, there were an average annual total of 42 children 0-3 years killed in side impacts who were restrained in child restraints (i.e. 210 over the entire period with no discernible trend) (Table 7). Children seated on the side nearest to the crash accounted for 57 percent of these fatalities. Fatalities from the mid- and far-side seated individuals were 15 and 26 percent, respectively. Although FARS does not have a "properly restrained" code, there is a code which indicates that a child seat is used improperly in fatal crashes. Based on this coding, we understand that approximately 20 percent of the fatalities were in restraints that were improperly used. We do not expect the proposed requirements to increase child restraint usage rate further, therefore only children in child restraints in the crash data were considered for the target population.

The fatality data presented in Table 6 and Table 7 include children (ages 0-3 years) in front and rear seating positions. In addition, we included side impact fatalities cases in which the vehicle rolled over subsequent to being struck in the side because, for restrained occupants, the side impact is almost always the most injurious impact and the secondary rollover rarely adds a more severe injury. We note that the data in Table 6 and Table 7 could not be further categorized by whether the child was in rear-facing or forward-facing child restraints since FARS does not provide this information.

Table 6 2014-2018 Annual FARS Occupant Fatalities in Passenger Vehicles (Ages 0-3) All Crashes

Type of Crash	Frontal Impact	Side Impact	Rear Impact	Others	Total
Fatalities	98	63	41	22	223
Percent of Total	44%	28%	18%	10%	100%

Table 7 2014-2018 FARS Fatalities
Side Impact Crashes, Passenger Vehicle Occupant in Child Safety Seat (Ages 0-3)
Seating Position Relative to Impact Point

Seat Use	Far Side	Mid	Near Side	Unknown	Total
Proper Use	42	27	95	4	168
Improper Use	12	4	25	1	42
Total	54	31	120	5	210
Annual Total	**11**	**6**	**24**	**1**	**42**
Total Percentage	26%	15%	57%	2%	100%

Table 8 shows the breakdown of injuries by Maximum Abbreviated Injury Scale (MAIS) levels.[23] The data for the 2014 to 2018 period show that approximately 43 percent of the nonfatal injuries to children in side impact crashes were in forward-facing child seats, and 57 percent of the nonfatal injuries were in rear-facing child seats. Approximately 91 percent of the nonfatal injuries were recorded as MAIS 1 injuries. Of the MAIS 2-5 injuries 28 percent were in

[23] The Abbreviated Injury Scale (AIS) is a coding system for injuries intended to categorize any individual injury sustained in a crash, where an AIS 1 would be a minor cut with no chance of death and the maximum value of AIS 6 would be a 100% fatal injury. The MAIS is the maximum AIS value amongst all the injuries suffered to a person involved in a crash.

in rear-facing seats.[24] Additionally, when considering the target population for side-impact crashes, it is important to adjust our focus to not underestimate the possible benefits of this rule by considering rollover crashes after a side impact. Typically, if a vehicle suffers a side impact and subsequently rolls over, occupants suffer greater injuries from the initial side impact than from the ensuing rollover event. Thus, Table 9 eschews inclusion of rollover-first crashes but does include crashes that included a rollover following a side-impact event, to properly quantify the target population of side impact crashes that might see a benefit from the rule.

Table 8 Estimated Non-Fatal Injured Children (Ages 0-3)
in non-Rollover-first, non-Ejection, Side Impact Crashes in Passenger Vehicles
Maximum Injury Severity by Seat Design
Annual Average of 2011-2015 Crashworthiness Data System (CDS)

Seat Design	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Total	Percent
Forward-Facing	763	44	0	99	0	906	43
Rear-Facing	1,152	0	40	0	15	1,207	57
Total	1,915	44	40	99	15	2,113	100
% of total number of injuries	91%						

As shown in Table 9, for the rear-facing seats, injury to the children was caused by contact with the child seat. For the forward-facing child restraints, injuries were caused by a variety of elements, but most of those elements could be reduced by either padding the child restraint or better retaining the child's head within the child restraint system.

[24] Most child restraints in use for 0 to 3 years old children are new models. The large majority (over 70%) of child restraints in use for 0 to 3 years old are less than 3 years old. While some newer child restraint models have additional padding on the wings, they may not have been evaluated and optimized for the side impact crash environment. Therefore, we believe the protection level offered by newest models with additional padding may be the same or only slightly improved over the older models that were in this field data. Therefore, we expect the number of injuries presented in Table 7 to be similar or only slightly lower if the newest child restraint models were in use at the time of these accidents.

Table 9 All Non-Fatal Injured Children (Ages 0-3)
in Side Impacts In Child Safety Seats by Source
2004 to 2008 CDS Data

Seat Type	Point of Contact by Occupant	Percentage
Rear-Facing	Child Safety Seat	100
Forward-Facing	Child safety seat	30.44
	Left side interior surface	0.67
	Left side window glass/frame	2.59
	Right side interior surface	3.60
	Seat back support	1.79
	Belt restraint webbing/buckle	19.96
	Other occupants	0.18
	Interior loose objects	1.06
	Ground	0.36
	Unknown	26.98
	Flying glass	9.62
	Non-contact injury	2.76

NHTSA estimates that CRSs are already 42 percent effective in preventing death in side-impact crashes involving 0-3 YO children.[25] We believe that the effectiveness of CRSs in side impact crashes can be attributed to the CRS harness containing the child in the seating position, thereby

[25] NHTSA conducted an analysis of the Fatality Analysis Reporting System (FARS) data files of real world fatal non-rollover frontal and side crashes of passenger cars and light trucks and vans involving children for the years 1995 to 2009. From this analysis, the agency estimated the effectiveness of CRSs in preventing fatalities among 0-3 YO children to be 42 percent in side crashes and 52 percent in frontal crashes. The 42 percent effectiveness estimate in side impacts combined near side, middle seat, and far side child restraint occupants. The analysis method is similar to that reported in the NCSA Research Note, "Revised Estimates of Child Restraint Effectiveness," DOT HS 96855 and is also detailed in the technical report in the docket. In addition, CRSs are 71 percent effective in all crash modes combined in preventing fatalities and injuries to children 0-1 years old. Furthermore, the 42% estimated degree of effectiveness is high, and is only 11 percentage points lower than CRS effectiveness in frontal crashes (53 percent), notwithstanding that FMVSS No. 213 requires CRSs to meet specific performance requirements in a frontal impact sled test but has no such dynamic performance requirements in side impact.

mitigating harmful contact with interior vehicle components, and to the CRS structure shielding the child from direct impact and absorbing some of the crash forces.

While booster seats (e.g., belt-positioning seats) sold for children in a weight range that includes weights up to 40 pounds would be subject to the test requirements, we believe that manufacturers would likely re-label the booster seat as not recommended for children weighing less than 40 pounds rather than develop countermeasures to meet the requirements specified in the final rule. As discussed further below, we believe this approach improves child safety and is aligned with NHTSA's view that children under age 4 are better restrained in a CRS with internal harness than in a booster seat. Since the likely effect of the requirements would merely be relabeling of these booster seats as intended for children weighing more than 40 pounds, we have not further considered booster seats for estimating the cost and benefits of the requirements. We are encouraging children to remain in CRSs with internal harnesses for a longer time – up to 40 pounds (which is nearly the average weight of a 5-year-old). This is consistent with the current child passenger safety recommendations for children 4-7 years old to remain in child seats with internal harnesses until they outgrow them. We do not believe that the reduced availability of booster seats for children under 40 pounds will affect overall usage of child restraints but may change the type of restraint used by some children. We believe this rulemaking action could reduce premature use of booster seats and thereby enhance child passenger safety.[26] [27]

Using combined data from several states and NASS-CDS, NHTSA found that for KAB[28] (see below) injuries, child restraints reduced injuries for 3-year-old to 4-year-old children by 27% (statistically significant) compared to booster seats. No other injury grouping (KABC or K) was found to have statistically significant differences, although both showed harnessed child restraints safer than booster seats for 3-year-old and 4-year-old children.

When we compared any injury (KABC on the KABCO scale), it showed 3-year-old children have about a 15 percent lower injury rate in harnessed child restraints than in booster seats while the 4-year-olds showed almost no difference in injury rates between harnessed child restraints and booster seats. When the analysis was limited to the more severe injuries (KAB) there was no difference in injury rates between the 3-year-old and 4-year-olds by restraint type. There were not enough cases to determine whether a difference existed for only the killed (K) cases.

K = killed
A = incapacitating injury

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[26] A note on Booster Seats: NHTSA has evaluated the effectiveness of booster seats compared to internal harness child restraints.[26] The findings from this evaluation were that parents should keep children in harnessed child restraints at ages 3-4 and for as long as possible, rather than moving them into booster seats. In addition, further analysis of data for children ages 4-8 found that parents should keep children in booster seats rather than moving them to lap/shoulder belts. Harnessed child restraints are more effective than booster seats for 3-year-olds to 4-year-olds, while booster seats are more effective than adult lap/shoulder belts for 4-year-olds to 8-year-olds.

Booster Seat Effectiveness Estimates Based on CDS and State Data (NHTSA Report No. DOT HS 811 338, July 2010, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811338

[27] Harness seats have been shown to perform better than booster seats, see the report "Evaluation of Child Restraint System Effectiveness" (NHTSA Report No. DOT HS 813 047), https://crashstats.nhtsa.dot.gov/Api/Public/Publication/813047

[28] The KABCO Injury Scale is a police reported injury scale. Law enforcement officers use this to classify injuries into the following rough categories. Typically, a conversion factor is applied when aggregating injuries to convert KABCO to MAIS in order to compare and combine injuries in an "apples to apples" manner.
K – Fatal; A – Incapacitating injury;B – Nonincapacitating injury; C – Possible injury; and O – No injury.

B = non- incapacitating injury
C = possible injury
O = no injury

When analyzed collectively for children aged 4 to 8, the data also showed a 14 percent reduction in overall child injuries in booster seats compared to adult belts. The CRS effectiveness by its type, age and injury severity are provided below.

Table 10 CRS effectiveness of harnessed child restraints when compared to booster seats, by Age

Age of children	KAB	KABC	K
3 years	27%	Positive effectiveness, but **not** statistically significant differences (15%)	Not determined
4 years	27%	Positive effectiveness, but **not** statistically significant differences (almost no difference)	Not determined

B. Fatalities Prevented by Requirements

Due to the high effectiveness of CRSs with a high CRS use rate among 0-3 years old children, the fatalities of 0-3 YO CRS restrained children presented in Table 7 may be biased towards higher severity crashes, some of which may be non-survivable. To research this issue further, the agency analyzed all cases in the NASS/CDS and Special Crash Investigation (SCI) databases from 2002 to 2009 which met the following criteria:

1. The vehicle was impacted on its side
2. A child occupant restrained in a child restraint system was killed.

There were 30 side impact cases with 34 CRS-restrained fatally injured children. Of the 34 children, 17 children were in the struck-side of the vehicle (near-side), 11 were in the center seat (center) and 6 were in the opposite side of the impact (far-side). A group of NHTSA crash investigators, engineers and statisticians examined the details of each of these crashes and used their expertise to analyze the circumstances of each crash. The experts made informed judgments about: 1) the survivability of the crash, i.e., whether the circumstances of the crash were so severe that the child had no chance of survival; and 2) the source of the fatal head injury, i.e., whether the injury was in an area where padding could have reduced injury severity to the point that the crash may have been survivable.[29] A summary of the 34 fatalities is presented in Table 11. Based on this detailed evaluation, the selected cases were categorized into one or more of four categories, in terms of survivability factors:

Survivability Factor 0) - survivable-if CRS had more padding/bigger wings
Survivability Factor 1) - not survivable due to extensive vehicle damage
Survivability Factor 2) - not survivable due to gross restraint misuse
Survivability Factor 3) - no consensus - where no consensus was reached among the team analyzing the cases.

There were five children in three cases in which the group could not agree whether the severity of the crash was so severe that it would be considered not survivable. In Table 11, these cases are designated with 1 and 3 in the "Survivability Factors" column. Because the majority of participants of this group thought that these cases were not survivable, for this analysis, when no consensus was reached, these cases were considered not survivable.

Table 11 Summary of 34 CRS restrained child fatalities in side impact crashes from 2002-2010 NASS/CDS and SCI data files

Case No	Year	Make	Model	Total Delta V (mph)	Maximum Crush (inches)	Age (Months)	Seating Position*	CRS Orientation **	Survivability Factors	Side Impact Type***
2002-S03-024	1998	Honda	Accord	23	19	20	21	FF	1, 3	Near
2002-S03-024	1998	Honda	Accord	23	19	2	23	RF	1, 3	Far
2002-45-77	1994	Infiniti	G20	27	19	29	23	FF	**0**	**Near**
2003-S01-007	1993	Dodge	Caravan	32	32	21	23	FF	1	Near
2003-S01-021	2002	Chevrolet	Lumina MV	32	31	7	32	RF	1	Center
2003-S01-022	1991	Chevrolet	Lumina MV	37	39	36	22	FF	1	Center

[29] In our examination, we also found that later models of the child restraints in which these three fatalities occurred had been sled-tested and that the later-model child restraints did not meet the side impact requirements in the tests. We assumed that if these later models did not meet the standard, earlier models produced by the same manufacturer would have used similar padding strategies and would also not have passed the standard. Thus, it was the agency's judgment that these three crashes were potentially survivable and that more padding in the head area, added to meet the standard, would have been effective in preventing the three fatalities.

2003-74-110	1994	Chevrolet	Camaro	26	20	17	23	FF	1	Near
2004-S03-005	2001	Mazda	Protégé	10	11	22	22	FF	1	Center
2004-12-92	1998	Jeep	Cherokee	21	15	2	23	UNK	2	Far
2004-12-162	1996	Pontiac	Grand Am	25	31	24	22	UNK	1	Center
2005-S01-023	2001	Mitsubishi	Montero	UNK	10	24	21	FF	1	Near
2005-S01-023	2001	Mitsubishi	Montero	18	18	7	23	RF	2	Far
2005-S01-038	1998	Chevrolet	Cavalier	23	23	20	21	FF	**0**	**Near**
2005-S02-021	1997	Pontiac	Bonneville	UNK	UNK	17	22	FF	1	Center
2005-S03-020	1998	Mitsubishi	Eclipse	UNK	UNK	24	21	FF	1, 3	Far
2005-S03-020	1998	Mitsubishi	Eclipse	UNK	UNK	8	23	FF	1, 3	Near
2005-49-171	1994	Saturn	SL	30	25	12	23	UNK	1	Near
2006-S02-008	2001	Pontiac	Grand Am	25	22	12	23	RF	1, 2	Near
2006-S02-002	1996	Ford	Taurus	UNK	UNK	36	21	FF	2	Near
2006-S03-004	2000	Toyota	Camry	UNK	UNK	36	21	FF	1	Near
2006-43-002	2002	Chrysler	Town & Ctry	22	17	8	23	RF	1	Near
2007-S02-003	2000	Toyota	Camry	41	30	11	21	FF	1, 2	Near
2007-S03-044	2002	Ford	Expedition	47	45	21	22	FF	1, 3	Center
2007-S03-044	2002	Ford	Expedition	47	45	36	23	UNK	1	Near
2007-76-74	2007	Pontiac	G6	25	22	5	21	RF	1	Near
2008-S01-002	2000	Honda	Civic	14	16	24	23	FF	**0**	**Near**
2008-S03-004	1998	Mitsubishi	Montero	16	15	23	23	FF	1	Near
2008-81-43	1998	Mercury	Mystique	27	28	5	22	RF	1	Center
2009-S03-007	2001	Pontiac	Sunfire	41	48	13	22	FF	1	Center
2009-S03-027	1998	Ford	F-150	24	26	36	22	FF	2	Center
2009-74-69	2007	Chrysler	Town & Ctry	30	20	48	23	FF	1	Far
2009-79-18	2004	Chevrolet	Impala	39	47	11	22	RF	1	Center
2010-S01-001	2008	Toyota	Yaris	44	28	9	22	RF	1	Center
2010-75-38	2002	Pontiac	Firebird	37	44	24	23	FF	1	Far

*The three cases highlighted red and bold are the 3 cases designated as "survivable if CRS had more padding / bigger wings"

The fatality distribution for each type of side impact crash and their survivability is shown in

Table 12.

Table 12 Survivability (by informed judgement) for Thirty-Four Side Impact Cases from NASS and SCI Databases (2002-2009)

Children both CRS Restrained and Fatally Injured		Survivable (if more padding and bigger wings were available)		Not survivable (due to the following factors or combination of factors:)			
Number	Seating Position	Number	Effectiveness	1. Extensive	2. Restraint Gross	1. Extensive damage 2. Restraint Gross	1. Extensive damage 3. No

				Damage	Misuse	Misuse	Consensus
17	Near	3	.176	9	1	2	2
11	Center	0	0	9	1	0	1
6	Far side	0	0	2	2	0	2
34	Total	3	.0882	20	4	2	5

The evaluation indicated that among the 34 CRS restrained child passenger fatalities in side impact crashes in the NASS and SCI data-files for the years 2002 to 2009, 3 fatalities could have been prevented by additional padding. Seven of eight fatalities[30] to children in rear-facing CRSs were not survivable and one had no consensus and assumed to be not survivable. The three fatalities that could have been prevented by improved padding were to children 1-3 years old in forward-facing CRSs. Therefore, the finding indicates an overall estimated effectiveness for fatalities of 0.088 (3/34) for the rule. Due to small sample size, the average combined effectiveness of 0.088 for near, center and far side impacts for both forward-facing CRSs and rear-facing CRSs is used rather than the individual computed effectiveness in Table 12 for each impact mode.

The number of fatalities prevented annually by the rule is determined as follows:

1. The annual number of fatalities in side impact for children ages 0-3 years old in child restraints is 42 (Table 7).
2. The overall estimated effectiveness of countermeasures taking into consideration crash survivability is 0.0882 (Table 12).

[30] One of the fatalities to children in RF CRSs was because the CRS was too small for the child and so was coded as incorrect use of CRS

3. Using the above data, the number of lives saved by the rule = 42 x 0.088 (effectiveness) = 3.7 Lives.

In conclusion, the rule will save about 3.7 lives annually.

C. Injuries Prevented by the Requirements:

1. Fleet Data

NHTSA followed a different procedure when calculating injuries prevented by the rule. In some fatal cases, the crash is so severe that adding padding to a child restraint cannot help. However, for those cases in which a child survived the impact, padding could lessen the severity of the injury. The effectiveness numbers used in the injury calculations came from an examination of injury risk curves and test data from CRS fleet testing. As seen in Table 13 and Table 14, we compared the injury levels produced by the test dummy with child restraints to the injury levels at the required limit. The benefits are derived from reducing the risk of injury from a higher level (pre- standard tested level) to a lower level (meeting the required limit) for each of those child restraints that exceeded the required limit. The risk of injury at various criteria is further explored later in Table 17. For the rear-facing infants, the requirement was that there was no direct contact of the head of the CRABI dummy with the door surface. The result of fleet testing[31] with the Q3s dummy showed:

Forward-Facing CRS

- 7/12 exceeded HIC15 limit of 570
- 3/12 exceeded Chest Deflection limit of 23 mm

(each of these also exceeded HIC15 limit – that is to say 3 of 12 exceeded both limits)

[31] CRS models tested were a representative sample of seats available in the market.

- 5/12 passed –

  (they did not exceed either HIC15 limit of 570 or Chest Deflection limit of 23 mm)

Table 13 shows a breakdown of the test results for the forward-facing CRSs.

Table 13 Forward-Facing Child Restraints Data

Forward-Facing Child Restraints	**HIC15 (>570)**	**Chest Deflection [mm] (>23 mm)**
Radian 65	1066.0	30.51
Evenflo Chase	766.0	18.76
Safety 1st Air Protect	624.5	16.46
Evenflo Tribute	787.5	20.19
Evenflo Titan	846.5	20.56
First Year Tru Fit	882.7	23.52
Cosi Cline	782.5	25.48
Britax Advocate	364.7	19.47
Combi Zeus 360	380.3	14.54
Recaro Signo	560.4	22.88
Maxi Cosi Priori	388.2	21.08
Evenflo Triumph Advantage Deluxe	463.8	14.64

Rear-Facing CRS with the Q3s dummy:

- 3/5 exceeded HIC15 limit of 570
- 2/5 exceeded Chest Deflection limit of 23 mm
- 1/5 exceeded both HIC15 and Chest Deflection limits

Table 14 shows a breakdown of the test results for the rear-facing seats

Table 14 Rear-Facing Child Restraints data

Rear-Facing Child Restraints	**HIC 15 (>570)**	**Chest Deflection[mm] (>23 mm)**
Combi Zeus 360	451.8	18.73
Britax Advocate	706.0	19.75
Safety 1st Alpha Omega	407.0	25.61
Evenflo Tribute	763.0	22.04
Cosco Scenera	897.0	23.34

The results show one (1) out of 12 CRSs tested did not meet the head containment criteria when tested with the CRABI dummy. The low failure rate is consistent with the high effectiveness of rear-facing CRSs for children 0-1 YO.

2. New CRS Test Data

After the NPRM was published, more side impact sled testing was performed on a new set of child restraint models. For this testing, NHTSA selected CRS models that had advertised side impact protection features; this set of CRS models were not selected to represent the CRS fleet. These new CRS models generally performed worse than the CRS models in the NPRM fleet testing (the CRS models in the tests presented in the NPRM were selected to be representative of the CRS market at that time). There is no data to suggest that the newer CRS model designs are a result of recent requirements or other obligations that would result in worse performance in the side impact test than the CRS models tested in support of the NPRM. Thus, NHTSA assumes that the previous NPRM data are more reflective of a proper baseline for the industry than their most recent performance. Thus, the risk analysis and risk reduction calculations in the FRIA depend upon values from the original NPRM data rather than the new CRS test data presented in the final rule

The new CRS test data is provided below, for context and completeness, but keep in mind these values are not reflective of what the industry has shown they were capable of producing in the past, and are therefore not a proper baseline for our calculations for future costs and benefits.

New Forward-Facing CRS

- 8/10 exceeded HIC15 limit of 570
- 3/10 exceeded Chest Deflection limit of 23 mm (each of these also exceeded both limits)

- 2/10 within both limits

Table 15 New CRS Test data for Final Rule
Front-Facing Convertible or Combination Restraints

Front Facing Child Restraints	**HIC15 (>570)**	**Chest Deflection[mm] (>23 mm)**
Chicco NextFit	**582.0**	18.7
Evenflo Tribute	**760.3**	20.8
Cosco Scenera Next	**979.8**	**26.8**
Maxi-Cosi Pria 70	512.9	17.6
Evenflo Chase	**937.5**	**24.3**
Britax Boulevard	521.7	7.08
Britax Advocate	**665.3**	18.3
Safety 1st Advance SE Air+	**616.3**	**27.7**
Graco Nautilus 65	**609.0**	13.6
Graco Nautilus Safety Surround	**838.5**	17.9

New Rear-Facing CRS with the Q3s dummy:

- 3/4 exceeded HIC15 limit of 570
- 3/4 exceeded Chest Deflection limit of 23 mm
- 3/4 exceeded both HIC15 and Chest Deflection limit

Table 16 New CRS Test data for Final Rule
Rear-Facing Convertible Child Restraints

Rear-Facing Child Restraints	**HIC15 (>570)**	**Chest Deflection[mm] (>23 mm)**
Cosco Scenera Next	**677.7**	**26.2**
Graco Size4Me 65	**778.5**	**23.5**
Evenflo Triumph	487.8	12.2
Baby Trend PROtect	**963.7**	**25.8**

3. Injury Risk Calculation

Currently, the target population of children represented by the 3 YO in rear-facing CRSs is very small but is expected to grow in the future. This increase in CRS usage is due in part to the expected positive influence of updated CRS-usage recommendations from NHTSA[32] and the American Academy of Pediatrics (AAP).[33] As it is difficult to estimate the percent of children in rear-facing CRSs represented by the 12 MO CRABI as opposed to the Q3s and we do not obtain HIC15 numbers from the 12 MO CRABI,[34] we evaluated benefits assuming the injury reduction obtained from the Q3s are also representative of the injury reduction obtained from the 12 MO CRABI. In addition, since most of the CRSs that exceeded the chest deflection limit also exceeded the HIC15 limit on the Q3s dummy, the benefits are computed using only the HIC15 injury risk curves developed for the Q3s dummy. In short, the 12 MO CRABI has limitations that have led to the use of the Q3s dummy as a much better representative for injury risk distribution.

Table 17 shows the data used to calculate the effectiveness (risk reduction) from the injury curves for both the rear-facing and forward-facing seats we tested, as listed in Table 13 and Table 14. The injury risk curves are the same scaled HIC15 injury risk curves used in the "Final Economic Assessment of FMVSS No. 208 Advanced Air Bag Rule" published in May 2000.[35]

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[32] NHTSA recommends that children 1-3 YO remain in rear-facing child restraints as long as possible until they reach the top height or weight limit allowed by the car seat's manufacturer. https://www.nhtsa.gov/equipment/car-seats-and-booster-seats#age-size-rec

[33] AAP recommends children remain in rear-facing child restraints as long as possible, dropping the age criterion. https://publications.aap.org/aapnews/news/12188

[34] The CRABI 12 month old is not a side impact dummy. Because we have concerns about the relevance of HIC values measured on the CRABI in side impact tests, we propose to use head-to-door contact as the injury measure

[35] Docket No. NHTSA-2000-7013-0002. Cadaver head drop tests from different heights were conducted and autopsy done to determine injury severity. Head accelerations were measured in the tests from which the HIC value was computed. Regression analysis correlating the HIC values to head injury outcome was conducted. The resulting regression parameters were used to construct the risk curves. The dummy head was designed to be biofidelic to the average human head so that the developed injury risk curves could be applied to the dummy head. The risk curves were then scaled to the different size heads of dummies, including the child dummies.

Table 17 Injury Risk and Risk Reduction from the
Baseline Risk at HIC15=570 for the CRSs where HIC15 value exceeded 570

HIC	MAIS1	MAIS 2	MAIS 3	MAIS 4	MAIS 5
Baseline Injury Risk (Pb)					
570	**0.097**	**0.362**	**0.363**	**0.146**	**0.023**
Forward-Facing CRS Injury Risk (Pa)					
1066	0.002	0.029	0.143	0.301	0.525
766	0.020	0.167	0.394	0.319	0.100
624.5	0.064	0.308	0.399	0.190	0.036
787.5	0.017	0.150	0.381	0.336	0.116
846.5	0.010	0.108	0.336	0.374	0.171
882.7	0.007	0.088	0.304	0.387	0.214
782.5	0.017	0.154	0.384	0.332	0.112
AVERAGE 822.2	0.012	0.124	0.356	0.361	0.146
Average Percent reduction in risk for Forward-Facing CRSs					
	N/A	N/A	N/A	59.50%	N/A
Average Percent reduction in risk for Rear-Facing CRSs					
	N/A	N/A	N/A	N/A	83.91%

Table 17 shows the risk of injury at the different MAIS levels for the CRSs where HIC15 exceeded the injury limit of 570 (See Table 13 and Table 14). The HIC15=570 baseline injury risk at each MAIS level is also presented in Table 17. The average HIC15 for the representative forward-facing CRSs with HIC15 values exceeding 570 is 822.2. The corresponding injury risk at each MAIS level for HIC15=822.2 is shown in Table 17.

To determine risk reduction from the side impact test requirements, we assumed that these CRSs with HIC15 exceeding 570 would be redesigned to produce a HIC value of 570 (i.e., HIC15 = 570) when tested for compliance. For HIC15 values above the baseline (HIC15 = 570), the MAIS4 and MAIS5 injury risk exceeds the corresponding baseline MAIS4 and MAIS5 injury risk; in contrast, the MAIS1, MAIS2 and MAIS3 injury risks for HIC15 greater than 570 are less than the corresponding baseline injury risks at HIC15=570. Therefore, the focus of this analysis was to determine reduction in MAIS4 and MAIS5 injuries.

The target population only has data representing MAIS 1,2 and 4 for forward-facing CRSs, and MAIS 1,3, and 5 for rear-facing CRSs. For forward-facing CRSs with HIC15 greater than 570, the average risk of MAIS4 injury is 0.361; in contrast, the baseline MAIS4 injury risk for HIC15=570 is 0.146. Therefore the risk reduction of MAIS4 injuries for forward-facing CRSs resulting from the rule is (0.361-0.146)/(0.361) = 0.595. This represents a 59.5% reduction in the number of MAIS 4 injuries. A similar calculation results in an 83.91% reduction for MAIS 5 injuries. Because of limited data with the Q3s dummy in rear-facing CRSs, the MAIS 5 injury risk reduction of 83.91% computed for forward-facing CRSs was applied to rear-facing CRSs. Additionally, the proportion of rear-facing CRSs exceeding the baseline HIC of 570 was also assumed to be the same as that from forward-facing CRSs. Since 7 of the 12 forward-facing CRSs tested exceeded the head injury limit of 570, we estimated that the injury risk reduction applies to 58.3 percent (7/12) of injuries at each MAIS severity levels for both forward-facing and rear-facing CRSs.

The target population of MAIS 1, 2, 3, 4, 5 injuries annually was obtained from Table 8 and is presented in the first three rows of Table 18. The average reduction in risk in Table 17 is used with the corresponding injuries numbers in Table 18 to calculate the MAIS injuries prevented. (Example: There were a total of 906 injuries in the target population. The 99 MAIS 4 injuries in forward-facing CRSs are reduced by 58.91 = 59.5% x 99. However, we must also consider the

CRS failure rate of 58%, further reducing the benefits of the rule to 34.36. Similarly the 15 MAIS5 injuries in rear-facing CRSs are reduced by 7.34 = 15 x 83.91% x 58%.)

In addition to the incremental injury benefits, we considered effects of mitigated injury severity or trickled-down effects resulting from the performance requirement specified in the final rule.[36] The same injury curves are used to proportionally distribute the reduction of injuries (from MAIS 4 and 5) down to all levels lower than their point of origin. This "trickle down" effect preserves the fact that the crashes are still occuring, but due to the improved head protection, these extant injuries are of a lesser severity than they had previously been. This estimate is a conservative one as no injuries are eliminated altogether, so the total number of injuries should still be 2,155 as shown in Table 19, but as seen in that table, the number of MAIS 4 and 5 injuries decrease while the MAIS 1, 2, and 3 injuries increase in equal measure.

Table 18 Calculation of Injuries Prevented Annually
HIC15 level of 570

Category		**MAIS1**	**MAIS 2**	**MAIS 3**	**MAIS 4**	**MAIS 5**
Injuries (from Table 8)	FF CRS	763	44	0	99	0
	RF CRS	1,152	0	40	0	15
	Total	1,915	44	40	99	15
Un-Adjusted Reduction of Injuries		MAIS1	MAIS 2	MAIS 3	MAIS 4	MAIS 5
	FF CRS	0.00	0.00	0.00	**34.36**	0
	RFCRS	0.00	0.00	0.00	0	**7.34**
Weighted		MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5

[36] These injury totals include children in seats that were improperly used. The injuries prevented by the final rule were determined using the risk reduction obtained from sled test data. Since the child restraints in the sled tests were correctly used, the risk reduction is for correctly used child restraints. This risk reduction is applied to the target population (which includes some misused child restraints) to estimate the benefits of the final rule. We believe that the final rule would provide benefit to children who may have been restrained with minor misuses. Since the children were not fatally injured, we believe it is likely that the target population does not contain cases of gross misuse of the child restraint (such as child restraint not attached to the vehicle or the harnesses not used to restrain the child).

Probability of Injury Reduction	Weighted probability, Lives saved	0.3796	0.3425	0.2040	0.0649	0.0090
	Weighted probability, MAIS 5	0.3830	0.3456	0.2059	0.0655	N/A
	Weighted probability. MAIS 4	0.4099	0.3698	0.2203	N/A	N/A
	Weighted probability, MAIS 3	0.5257	0.4743	N/A	N/A	N/A
	Weighted probability, MAIS 2	1.000	N/A	N/A	N/A	N/A
	Weighted probability, MAIS 1					
Trickle-Down Benefits Calculation		MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5
	Lives saved (3.7 total)					
	Forward-Facing (1.59 lives)	0.6032	0.5442	0.3242	0.1031	0.0143
	Rear-Facing (2.11 lives)	0.8035	0.7250	0.4319	0.1374	0.0190
	MAIS 5 (7.34, all RF CRS)					
	Forward-Facing	0.0000	0.0000	0.0000	0.0000	N/A
	Rear-Facing	2.8122	2.5372	1.5117	0.4809	N/A
	MAIS 4 (34.36, all FF CRS)					
	Forward-Facing	14.0844	12.7071	7.5711	N/A	N/A
	Rear-Facing	0.0000	0.0000	0.0000	N/A	N/A
	MAIS 3					
	Forward-Facing	0	0	N/A	N/A	N/A
	Rear-Facing	0	0	N/A	N/A	N/A
	MAIS 2					
	Forward-Facing	0	N/A	N/A	N/A	N/A
	Rear-Facing	0	N/A	N/A	N/A	N/A
	MAIS 1					
	Forward-Facing	N/A	N/A	N/A	N/A	N/A
	Rear-Facing	N/A	N/A	N/A	N/A	N/A
Trickle-Down Benefits Summary		MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5
	Increase in number of lower-severity injuries					
	Forward-Facing	14.688	13.2512	7.8953	0.1031	0.0143
	Rear-Facing	3.616	3.2621	1.9436	0.6183	0.0190
Overall Impact (Benefits minus Trickle Down effect)		MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5
	Forward-Facing	(14.69)	(13.25)	(7.90)	34.26	(0.01)
	Rear-Facing	(3.62)	(3.26)	(1.94)	(0.62)	7.32
	Total	**(18.30)**	**(16.51)**	**(9.84)**	**33.64**	**7.31**

Total Injuries Prevented	FF CRS	-14.7	-13.3	-7.9	34.3	0.0
	RF CRS	-3.6	-3.3	-1.9	-0.6	7.3
	Total	-18.3	-16.5	-9.8	33.6	7.3

Table 19 Change in Injury Distribution (Benefits) due to the Rule

	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal	Total
Before	1,915	44	40	99	15	42	**2,155**
Overall benefits	**(18.30)**	**(16.51)**	**(9.84)**	**33.64**	**7.31**	**3.71**	**0**
After	1,933	61	50	65	8	38	**2,155**

Table 19 summarizes the final results of the analysis in Table 18. The target population, before the final rule becomes effective is estimated to be 2,113 MAIS1 to MAIS5 injuries and 42 fatalities annually. This final rule is estimated to reduce 3.71 fatalities, 33.64 MAIS 4 injuries and 7.3 MAIS 5 injuries annually.

IV. Costs

The agency tested both forward- and rear-facing child restraints to determine the appropriate amount of padding that could be used as a countermeasure so that the complete head of the child is protected, i.e., padding area and padding thickness and/or change their shape. The additional padding material can be added to the wings of a CRS to increase its thickness. The agency believes that the minimum amount of padding needed to cover the head area is 32 square inches per wing or a total area of 64 square inches for each CRS; for the side structure or chest area, the agency believes a minimum of 60 square inches of coverage for each side is needed, resulting in 120 square inches.[37] Therefore, the total amount of padding needed to comply with the final rule would be 184 square inches. The estimate was based on the measurements obtained in testing. The amount of padding needed for each child restraint that did not pass the required test was determined, and the measurements and estimated costs of padding are shown in Table 21 and Table 22. Padding costs were calculated using the Universal Foam Products Expanded Polystyrene pricing calculator[38], which provides the standard manufacturer costs per square inch of padding given the area and thickness required. The padding costs include the costs of any additional fabric required to cover the padding.

There were 12 forward-facing seats tested with the Q3s dummy. Seven of 12 forward-facing child seats needed padding to meet the proposed HIC15 limit of 570 or chest compression limit of 23 mm - see Table 21. This represents 58.3 percent of the seats tested. We are assuming that

[37] Costs are based on estimates of what it would take to bring currently available child restraints into compliance with the proposed standards. Benefits are based on the number of injuries and fatalities that occurred with seats that were in use during the 2006 to 2010 period. We believe that the use of different time periods for costs and benefits will not affect the analysis because there is little safety difference between CRTs that were in use during the 2006 to 2010 time period and those that are marketed currently.

[38] Data was taken from Univfoam.com/pricing-calculators/, a resource which has since been rendered private by the company responsible for the page.

the 58.3 percent is a representation of the total population of forward-facing child seats since NHTSA selected the CRS models to get a representation of the market at the time with a variety of CRS manufacturers and models. This means that 58.3 percent of the forward-facing seats need to have added padding. In addition, there were 5 rear-facing seats tested and 4 of 5 needed padding (80 percent).

There are approximately 11.3 million CRSs sold annually for children weighing up to 40 pounds, which includes rear-facing seats, toddler seats (forward-facing only), convertible seats (can be used rear-facing and forward-facing) and combination seats (seat that goes from forward-facing to booster). Of this total, it is estimated that there are approximately 3.27 million infant seats, 2.00 million convertible/toddler seats, 2.09 million combination seats, and 3.95 million all-in-one seats marketed for children weighing up to 40 lb. These sales estimates are based on sales in calendar year 2021.

The retail cost of padding (2010 dollars) for forward-facing seats is obtained by multiplying the area to be padded by the number of seats to be padded and by the consumer cost per square inch of padding[39]. The average cost per child restraint (for those child restraints that need padding) is a simple average of those seats tested.

All cost estimates above are in 2010 economics, so we must adjus these costs to their more appropriate values in 2020 economics. This is done using the BLS Consumer Price Index Inflation adjustments. For this analysis, the "All Urban Consumers – (CPI-U) 1913-2021" will

[39] The cost per square inch of padding did not change in the range of thickness that was considered in this analysis

be used.[40] The ratio of the average CPI for both years is obtained to yield an overall adjustment factor to adjust the cost of something provided in 2010 to reflect a more appropriate value in the present day. See Table 20 for details, and note the final value of 1.187, the adjustment factor to move from 2010 economics to 2020 economics.

Table 20 Consumer Price Index (CPI) Inflation Adjustment
2010 Economics to 2020 Economics

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg
2010	216.687	216.741	217.631	218.009	218.178	217.965	218.011	218.312	218.439	218.711	218.803	219.179	218.056
2020	257.971	258.678	258.115	256.389	256.394	257.797	259.101	259.918	260.28	260.388	260.229	260.474	258.811
2020/2010	**1.191**	**1.193**	**1.186**	**1.176**	**1.175**	**1.183**	**1.188**	**1.191**	**1.192**	**1.191**	**1.189**	**1.188**	**1.187**

With all the parts in place, we can begin constructing the final cost estimates in 2020 economics. For Table 21, we added the total area cost in the right-hand column and divided by the 7 child seats that needed padding to get an average variable cost of $0.537.

[40] https://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/

Table 21 Variable Cost of Padding for Forward-Facing Seats*

Forward - Facing CRS models	Padding Thickness (inches)	Area (sq. ins)	Cost per Square Inch	Total Area Cost ($)	Padding Thickness (inches)	Area (sq. ins)	Cost per Square Inch	Total Area Cost ($)	Total Cost
Body Region	Head				Chest				
Radian 65	1.125	64	0.004	0.256	0.625	98	0.004	0.39	0.648
Cosi Cline	1.125	64	0.004	0.256	1.375	120	0.004	0.48	0.736
Evenflo Tribute	1.125	64	0.004	0.256	0.625	68	0.004	0.27	0.526
Evenflo Chase	0.625	38	0.004	0.152					0.152
Evenflo Titan	1.375	120	0.004	0.48					0.48
First Year Tru Fit	1.125	64	0.004	0.256	1.375	120	0.004	0.48	0.736
Safety 1st Air Project	1.375	120	0.004	0.48					0.48
Average total area Cost per child restraint that did not meet the Proposed requirement									0.537

* Some seats need both head area padding and side structure padding.
This is incremental padding thickness and areas that need to be covered in order to pass the test.

To estimate the total incremental cost of the rule, NHTSA received confidential projected sales volumes by seat type. We estimate on an annual basis, there are 3,270,734 infant seats, 1,997,253 convertible/toddler seats, 2,090,613 combination seats, and 3,949,328 all-in-one seats. These values are presented in Table 23, along with the total incremental cost numbers for each seat type, which we will calculate next.

This variable cost is marked-up (that is, increased the cost from a variable cost to a consumer cost) by multiplying by 1.51.[41] Finally, that product is multiplied by the 2010 to 2020 economic adjustment factor. Hence, $0.537*1.51*1.186902 = $0.96 is the cost per CRS for convertible/toddler seats in 2020 economics. Using the number of 1,997,253 convertible/toddler seats (listed in Table 24), the 58.3% that require padding, and the $0.96 per seat for padding, we see 1,997,253 * 0.583 * $0.96 = $1,121,588, or approximately $1.12M.

The sales of combination seats that were marketed for children up to 40 lb. were approximately 2,090,613. The chosen countermeasures are extended to the sides of combination seats, since combination seats were tested as forward-facing and 58.3 percent of the forward-facing needed padding, then the annual consumer cost is approximately $1,174,016 (2,090,613 x 0.583 x $0.96).

The sales of all-in-one seats that were marketed for children up to 40 lb. were approximately 3,949,328. The chosen countermeasures are extended to the sides of all-in-one seats, since combination seats were tested as forward-facing and 58.3 percent of the forward-facing needed padding. Then the total annual consumer cost is approximately $2,217,805 (3,949,328 x 0.583 x $0.96).

Of the 5 rear-facing seats, four seats exceeded a limit specified in this final rule, either of HIC15=570 or chest compression=23 mm (or both) when tested with the Q3s as shown in Table 14. Assume that this represented 80 percent of the total population of rear-facing child seats to be padded at a variable cost of $0.432 per seat – see Table 22. The retail price in 2020 economics is

[41] Spinney, B., Faigin, B., Bowie, N., Kratzke, S., Advanced Air Bag Systems Cost, Weight, and Lead Time Analysis Summary Report Contract No. DTNH22-96-0-12003, Task Orders – 001, 003, and 005

approximately \$0.77 (\$0.432 x 1.51 x 1.187) per seat. Since the HIC15 injury criterion is not used with the CRABI dummy to evaluate infant carriers, the same failure rate and retail price estimated for rear-facing seats (convertibles) using HIC15 and chest deflection were applied to estimate the incremental costs for infant carriers to comply with the requirements. This incremental cost likely overestimates the actual cost since failure rates of infant carriers tested using the CRABI dummy is lower than the failure rate of rear-facing convertible seats tested using the Q3s dummy. There are about 3,270,734 infant seats sold annually. It is estimated that the total cost of padding for these seats is approximately \$2,025,875 (3,270,734 x 0.80 x \$0.77).

Table 22 Variable Cost of Padding for Rearward-Facing Seats*

Rearward-Facing CRS models	Padding Thickness (inches)	Area (sq. ins)	Cost per Square Inch	Total Area Cost	Padding Thickness (inches)	Area (sq. ins)	Cost per Square Inch	Total Area Cost	Total Cost
Body Region	**Head**				**Chest**				
Britax Advocate	1.125	64	0.004	0.256					0.256
Safety 1st Alpha Omega					1.375	120	0.004	0.48	0.48
Evenflo Tribute	1.125	64	0.004	0.256					0.256
Cosco Scenera	1.5	64	0.004	0.256	1.375	120	0.004	0.48	0.736
Average total area cost per child restraint that did not meet the proposed test requirements.									0.432

* Some seats need both head area padding and side structure padding.

The fact that many of the child restraints can meet the reference value for HIC15 and chest deflection results indicate that design changes could be made that would allow the child restraints to pass the test. These changes would not amount to significant changes to the design of the child restraints. Total cost of padding for child seats, including convertible and toddler seats, rear-facing seats, and infant seats is $6,539,284 ($2,025,875+ $1,121,588+$1,174,016 + $2,217,805).

Table 23 Total cost of padding for child seats, including convertible and toddler seats, rear-facing seats, and infant seats

Type of CRS		Number of CRS		Total incremental cost	
		actual	rounded	in 2010 $'s	in 2020 $'s
Rear-Facing	Infant seats	3,270,734	3,270,000	$1,706,852	$2,025,875
Forward-facing	Convertible / toddler seats	1,997,253	2,000,000	$944,967	$1,121,588
Forward-facing	Combination seats	2,090,613	2,090,000	$989,139	$1,174,016
Forward-facing	All-in-One seats	3,949,328	3,950,000	$1,868,559	$2,217,805
	Total			$5,509,517	$6,539,284

A. Summary of Costs for HIC15=570

1. Hardware Costs

Table 24 presents a summary of potential total costs for the considered countermeasure (padding). The consumer cost per seat for those not meeting the proposal is the average total area cost per child restraint that did not meet the proposed test requirements in Table 21 and Table 22 multiplied by 1.51 retail price markup factor, then further multiplied by the factor to adjust from 2010$ economics to 2020$ economics. Thus, the incremental cost to improve rear-facing seats that need the countermeasure to meet the rule is $0.432 *1.51*1.187 = $0.77. The average incremental cost to improve rear-facing seats in general is the cost to improve one seat multiplied by the percentage of CRS that need improvements, $0.77 * 80% = $0.62

Similarly, the average cost per forward-facing seat when the incremental cost is distributed among all forward-facing child restraints sold annually is $0.56 (= $0.96 x 0.583).

The average cost for both forward-facing CRSs and rear-facing CRSs not meeting the proposal is $0.91 and the average cost for all forward-facing CRSs and rear-facing CRSs in $0.58. The total incremental cost is $6.54 million.

Table 24 Consumer Cost Summary
(2020 economics)

	Infant Seats	Convertible Seats	Combination Seats	All-in-one seats	Weighted Average*/ Total
Cost per seat for those not meeting the proposal	$0.77	$0.96	$0.96	$0.96	$0.91
Average cost per seat for all child restraints	$0.62	$0.56	$0.56	$0.56	$0.58
Total incremental cost	$2,025,875	$1,121,588	$1,174,016	$2,217,805	$6,539,284

*Weighted average cost is determined by sales.

2. Testing Costs

Currently there are 127 child restraint models on the market for children that are 40 lb. or below. Table 25 is a breakdown of the number of the sled tests per child restraint system type. Since each sled test can accommodate one child restraint, there would be a total of 538 sled tests, each at a cost of $1,300 per test (in 2010$).[42] Adjusting for 2020 economics with an adjustment factor of 1.1867, the total cost of testing all the child restraint models is $830,123 (= 538 x $1,300 x 1.1867). However, several models may be in production for several years without substantive changes, meaning that manufacturers may not test all 127 restraints every single year. Therefore this cost estimate for testing may be an overestimation.

[42] This testing cost comes from our test lab at VRTC in East Liberty, Ohio.

Table 25 Sled Tests by Restraint System

Child Restraint Systems	Number of Models	Required Sled Tests for Each Models	Total Number of Sled Tests
Infant Seat	41	2	82
Convertible Seat	39	6	234
Combination/Toddler	15	2	30
All in one	32	6	192
Total	127		538

3. Total Costs

The total cost for the rule is the combination of the hardware costs and testing costs and is presented below in Table 26. They total approximately $7.37 million dollars.

Table 26 Total Combined Costs
(in 2020$ dollars)

Hardware cost	$6,539,284
Testing cost	$830,123
Total	**$7,369,407**

V. BENEFIT COST and COST EFFECTIVENESS

This chapter provides benefit-cost and cost-effectiveness analyses for the final rule. The Office of Management and Budget (OMB) recommends all agencies to perform both analyses in support of rules, effective January 1, 2004.[43]

A. Benefits Cost Analysis

1. Costs

Total Costs from Table 26 are $7.4 million for the final rule (to meet the injury criteria, injury limits of HIC15 = 570 and chest deflection = 23 mm). While foam component purchasing, foam installation, and research/development costs are made by the manufacturer early on, we presume that both installation and testing costs occur at the time that the child restraint is purchased since these costs are passed on to the consumer (and marked up).

2. Monetized Safety Benefits

Effective in February 2021 the Office of the Secretary for the U.S. DOT issued revised guidance regarding the treatment of value of a statistical life (VSL) in regulatory analyses. The new guidance establishes a VSL of $11.9 million in 2020 economics. The underlying assumptions for the VSL are presented in Table 27 and Table 28 below.

[43] See OMB Circular A-4. Available at: https://www.reginfo.gov/public/jsp/Utilities/circular-a-4_regulatory-impact-analysis-a-primer.pdf

Table 27 Economic Costs by Injury Severity
2020$, MAIS

	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$3,739	$15,299	$64,947	$182,093	$513,315	$15,117
EMS	$129	$264	$496	$999	$1,020	$1,076
Market Prod	$3,424	$24,318	$80,820	$176,891	$424,096	$1,172,349
Household Prod	$1,083	$8,926	$28,500	$47,158	$119,849	$364,180
Ins. Adm.	$3,933	$5,557	$18,332	$33,666	$86,497	$33,778
Workplace	$428	$3,321	$7,256	$7,991	$13,932	$14,802
Legal	$1,410	$3,997	$14,791	$31,806	$98,644	$127,003
Crashworthiness Subtotal	**$14,146**	**$61,682**	**$215,142**	**$480,604**	**$1,257,353**	**$1,728,305**
Travel Delay	$1,791	$1,822	$1,872	$1,899	$1,921	$7,186
Property Damage	$9,492	$10,149	$19,114	$19,474	$18,000	$13,372
Crash Avoidance Total	**$11,283**	**$11,971**	**$20,986**	**$21,373**	**$19,921**	**$20,558**

*Modified from 2010$ data, see Appendix A for details

Table 28 Comprehensive Unit Costs

Components	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	FATAL
Medical	$0	$0	$3,739	$15,299	$64,947	$182,093	$513,315	$15,117
EMS	$71	$45	$129	$264	$496	$999	$1,020	$1,076
Market Prod	$0	$0	$3,424	$24,318	$80,820	$176,891	$424,096	$1,172,349
Household Prod	$75	$57	$1,083	$8,926	$28,500	$47,158	$119,849	$364,180
Ins. Adm.	$228	$171	$3,933	$5,557	$18,332	$33,666	$86,497	$33,778
Workplace	$78	$58	$428	$3,321	$7,256	$7,991	$13,932	$14,802
Legal	$0	$0	$1,410	$3,997	$14,791	$31,806	$98,644	$127,003
Congestion	$2,470	$1,662	$1,674	$1,702	$1,749	$1,774	$1,795	$6,715
Property Damage	$4,045	$3,026	$8,946	$9,565	$18,014	$18,353	$16,963	$12,602
QALYs	$0	$0	$30,606	$479,493	$1,071,207	$2,713,724	$6,049,769	$10,201,971
Total comprehensive crashworthiness cost*	**$452**	**$331**	**$44,752**	**$541,175**	**$1,286,349**	**$3,194,328**	**$7,307,122**	**$11,930,276**

* Excludes Congestion (i.e., Travel Delay) and Property Damage when crashworthiness FMVSSs are considered, including FMVSS No 213.

**Modified from 2010$ data, see Appendix A for details

Benefits are realized throughout a CRS's life. According to OMB Circular A-4, the analytically preferred method of handling temporal differences between benefits and costs is to adjust all the

benefits and costs to reflect their value in equivalent units of consumption and to discount them at the rate consumers would normally use in discounting future consumption benefits.
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, estimated here at 7 percent based on analysis of the average before-tax rate of return to private capital in the U.S. economy conducted by OMB.

However, when these funds represent lost 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. If we take the rate that the average saver uses to discount future consumption as our measure of the social rate of time preference, then the real rate of return on long-term government debt may provide a fair approximation. Over the last thirty years, this rate has averaged around 3 percent in real terms on a pre-tax basis.

Thus, fatal equivalents are required to be discounted to present value at 3 and 7 percent per OMB Circular A-4 where 3 percent represents the social rate of time preference, and 7 percent represents the average rate of return to capital.

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 safety seat's lifetime. Data on 15,785 child safety seats were collected at the SAFE KIDS BUCKLE UP events from February 2001 to

September 2001. As seen in Table 29 the majority of the child seats in use were manufactured within the most recent period. One characteristic of the data is child safety seat by year of manufacture. For this analysis, the agency assumes that the distribution of child safety seats for the period pre-1981 to 2001 is an appropriate proxy measures for the distribution of such crashes over the child safety seat's lifetime (see Table 29 and Table 30).

Table 29 Age Distribution of Child Safety Seats Child safety seats by year of manufacture*

Year	Frequency	Percent
Pre-1981	47	0.30%
1982	1	0.01%
1983	3	0.02%
1984	5	0.03%
1985	10	0.06%
1986	15	0.10%
1987	7	0.04%
1988	24	0.15%
1989	23	0.15%
1990	52	0.33%
1991	67	0.42%
1992	95	0.60%
1993	193	1.22%
1994	263	1.67%
1995	417	2.64%
1996	615	3.90%
1997	1,144	7.25%
1998	1,673	10.60%
1999	3,080	19.51%
2000	6,097	38.63%
2001	1,954	12.38%

*Data from 15,785 seats seen at SAFE KIDS BUCKLE UP Events from February 2001 to September 2001

Table 30 Child Safety Seats Age and Discount Factor
(7% Discount Rate Shown as an Example)

Seat age in years	Frequency	Percent of Frequency	7%		3%	
			Discount Factor	Value Factor	Discount Factor	Value Factor

1	1954	0.124	0.9667	0.120	0.9853	0.122
2	6097	0.386	0.9035	0.530	0.9566	0.370
3	3080	0.195	0.8444	0.126	0.9288	0.181
4	1673	0.106	0.7891	0.035	0.9017	0.096
5	1144	0.072	0.7375	0.015	0.8755	0.063
6	615	0.039	0.6893	0.004	0.8500	0.033
7	417	0.026	0.6442	0.002	0.8252	0.022
8	263	0.017	0.602	0.001	0.8012	0.013
9	193	0.012	0.5626	0.000	0.7778	0.010
10	95	0.006	0.5258	0.000	0.7552	0.005
11	67	0.004	0.4914	0.000	0.7332	0.003
12	52	0.003	0.4593	0.000	0.7118	0.002
13	23	0.001	0.4292	0.000	0.6911	0.001
14	24	0.002	0.4012	0.000	0.6710	0.001
15	7	0.000	0.3749	0.000	0.6514	0.000
16	15	0.001	0.3504	0.000	0.6324	0.001
17	10	0.001	0.3275	0.000	0.6140	0.000
18	5	0.000	0.306	0.000	0.5961	0.000
19	3	0.000	0.286	0.000	0.5788	0.000
20	1	0.000	0.2673	0.000	0.5619	0.000
Pre 1981	47	0.003	0.2498	0.000	0.5456	0.002
	15785	1.000		0.833		0.925

The 7% discount rate results in a multiplier of 0.833 and the 3% discount rate results in a multiplier of 0.925. In Table 19 the number of fatalities reduced (3.7 lives) and the injuries reduced ("Total Injuries Prevented, Total of FF CRS and RF CRS" from Table 18) are multiplied by these factors (0.833 for 7%, and 0.925 for 3%) to account for the fact that benefits from the rule will happen over the lifetime of the CRS. Table 31 presents the nonfatal injuries and fatalities prevented and Table 33 presents the cost per equivalent lives saved using the proposed injury criteria limits of HIC1 5= 570 and chest deflection = 23 mm.

Table 31 Value of Benefits at the Proposed Injury Criteria Limits of HIC15=570 and chest deflection=23 mm From Reduced Economic Costs (2020 $)

3% Discount	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal	Total
Injuries Reduced	**-18.3**	**-16.5**	**-9.8**	**33.6**	**7.3**	**3.7**	
Discounted 3%	-16.9	-15.3	-9.1	31.1	6.8	3.4	
Economic Value	$0.04	$0.54	$1.29	$3.19	$7.31	$11.93	
Monetized Benefits @3% (Millions)	($0.76)	($8.27)	($11.71)	$99.40	$49.40	$40.90	$168.97
7% Discount							
Injuries Reduced	**-18.3**	**-16.5**	**-9.8**	**33.6**	**7.3**	**3.7**	
Discounted 7%	-15.2	-13.8	-8.2	28.0	6.1	3.1	
Economic Value	$0.04	$0.54	$1.29	$3.19	$7.31	$11.93	
Monetized Benefits @7% (Millions)	($0.68)	($7.44)	($10.54)	$89.51	$44.49	$36.83	$152.16

Table 32 Equivalent Lives Saved at the Proposed Injury Criteria Limits of HIC15=570 and chest compression=23 mm

	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal	Total
Injuries Reduced Undiscounted	-18.3	-16.5	-9.8	33.6	7.3	3.7	
Relative Injury Factors	0.003	0.047	0.105	0.266	0.593	1	
Equivalent Lives Saved	-0.055	-0.776	-1.033	8.949	4.334	3.706	**15.12**

Table 33 Cost per Equivalent Lives Saved at HIC15 Injury Limit of 570

	Undiscounted	3% Discount Rate	7% Discount Rate
Present Value Discount Factor		0.925	0.833
Equivalent Lives Saved	15.12	13.99	12.60
Total Cost (refer to Cost section)	**$7,369,407**		
Cost per Equivalent Lives Saved	$487,257	$526,765	$584,943

Table 31 takes the injuries reduced, discounts them, and then applies the associated economic value of injuries with a given MAIS to produce the sum economic value of the injuries and fatalities prevented by the rule. In Table 33, the injuries reduced are multiplied by relative injury factors to express each injury as a fractional portion of a fatality, and the results are called Equivalent Lives Saved (ELS). Table 33 presents these equivalent lives saved and presents the cost per equivalent lives saved using the proposed injury criteria limits of HIC15=570 and chest compression=23 mm. These numbers compare favorably to the comprehensive VSL of $11.9M (in 2020 dollars).

B. Net Benefit

In order to compare safety benefits to costs, benefits (i.e., injuries prevented and lives saved are combined and expressed as equivalent lives saved) must be monetized. Table 31 shows examples of the calculations that produce the projected benefits to be realized by the rule (with injury limits HIC15 = 570 and chest compression = 23 mm) as a result of the value of the lives saved and injuries prevented. Also, Table 31 shows that the rule would result in a savings of $168.97 million at the 3 percent discount rate and $152.16 million at 7 percent discount rate.

The benefit-cost analysis measures the net benefit which is the difference between benefits and costs in monetary values. After determining the number of equivalent fatalities prevented and the total amount of the monetizable benefits that will result from the final rule, the agency is able to project the expected net economic impact on society. The combined monetized benefits from Economic Costs and Value of a Statistical Life of the final rule are shown in Table 34. Table 34 also presents the benefit-cost analysis that compares the costs of the final rule to the combined monetized benefits. The monetized benefits of the final rule outweigh the costs irrespective of the discount rate. The final rule is expected to produce a net benefit ranging from $145 million to $162 million in 2020 dollars.

Table 34 Combined Monetized Benefits and Net Benefits
Proposed Injury Limits (HIC15 = 570, Chest Compression = 23 mm)
in 2020 Dollars

	3% Discount Rate	7% Discount Rate
Benefits from Economic Costs Avoided	$142.7 million	$128.5 million
Benefits from VSL of Injuries Prevented	$26.2 million	$23.6 million
Combined Monetized Benefits	$169.0 million	$152.2 million
Costs	$7.4 million	$7.4 million
Net Benefits	$161.6 million	$144.8 million

VI. Small Business Act

The Regulatory Flexibility Act of 1980, as amended, 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 regulatory flexibility analysis describing the impact of proposed or final rules on small entities, unless the head of the agency certifies that the final rule will not have a significant impact on a substantial number of small entities (§605). The head of the agency has so certified.

The factual basis for the certification (5 U.S.C. 605(b)) is set forth below. Although NHTSA is not required to issue a final regulatory flexibility analysis (FRFA), in the interest of presenting the issues we discuss below many of the issues that a FRFA would address (§604).

Section 603(b) of the Act specifies the content of an RFA. Each RFA 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 rule;

· A description of and, where feasible, an estimate of the number of small entities to which the 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 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.

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

NHTSA is taking this action to protect children involved in side impact crashes.

Better protection for children involved in side impact crashes is important because of the number of children killed and injured in vehicle crashes. Impacts to the side of a vehicle rank almost equal to frontal crashes as a source of occupant fatalities and serious injuries to children ages 0-12. This rulemaking is statutorily-mandated by "Moving Ahead for Progress in the 21st Century Act" (MAP-21), which directed the Secretary of Transportation (NHTSA by delegation) to issue a final rule to improve the protection of children seated in CRSs during side impacts.

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

This document requires that portable child restraints be manufactured so as to reduce the severity of the impact on the children during a near-side side impact crash.

Side impacts are especially dangerous when the impact is directly against the passenger compartment because, unlike a frontal or rear-end crash, there are no substantial, crushable structures between the occupant and the impacting vehicle or object. The door collapses into the passenger compartment and contacts the occupants relatively quickly after a high velocity crash at. It is an added technical challenge to design countermeasures for child restraints in near-side side impacts. Children seated in the center and far-side seats are better protected than in near-side seats because there is greater distance between the child and harmful intruding surfaces.

NHTSA has issued this Final Rule under the authority of 49 U.S.C. 322, 30111, 30115, 30117 and 30166 (the National Traffic and Motor Vehicle Safety Act; "Safety Act"); delegation of authority at 49 CFR 1.95. The agency is authorized under the Safety Act to issue Federal motor vehicle safety standards that meet the need for motor vehicle safety. This final rule is also issued under the "Moving Ahead for Progress in the 21st Century Act" (MAP-21), P.L. 112-141; July 6, 2012. Subtitle E of MAP-21, entitled "Child Safety Standards," includes §31501(a) which states that, not later than 2 years after the date of enactment of the Act, the Secretary shall issue a final rule amending Federal Motor Vehicle Safety Standard Number 213 to improve the protection of children seated in CRSs during side impact crashes.

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

The final rule would affect manufacturers of portable child restraints. NHTSA estimates there to be about 38 manufacturers of portable child restraints, none of which are small businesses.

Business entities were generally defined as small businesses by Standard Industrial Classification (SIC) code, for the purposes of receiving Small Business Administration assistance. The SIC codes have changed. In the small business section of our analyses we have used 500 employees as the cut-off for small businesses for many years. Business entities are now defined as small businesses using the North American Industry Classification System (NAICS) code, for the purposes of receiving Small Business Administration assistance.

One of the criteria for determining size, as stated in 13 CFR 121.201, is the number of employees in the firm. There is no separate NAICS code for child restraints. That said, there are other possible categories that could be appropriate, including: a) To qualify as a small business in the Motor Vehicle Seating and Interior Trim Category (NAICS 336360), the firm must have fewer than 500 employees, b) In the "All Other Motor Vehicle Parts Manufacturing" category (NAICS

336399), the firm must have 750 employees, c) In the “All Other Transportation Equipment Manufacturing” category (NAICS 336999), the firm must have 500 employees. We believe that child restraints fit better into category a) or c) since the components are manufactured similarly to vehicle seats (use of similar materials, such as plastic and metal parts, padding, webbing, buckles, seat covers, flame retardant material). Thus, we will continue to use 500 employees as the limit.

NHTSA believes there are 31 manufacturers of CRSs. Of these manufacturers, one makes restraints for school buses, one makes car beds, one makes CRSs for ambulances, and four make only harnesses or booster seats. None of the 38 manufacturers, we believe, would be classified as small businesses with fewer than 500 employees. Table 35 gives a listing of the child seat manufacturers.

Table 35 List of Child Restraint Seat (CRS) Manufacturers

Graco Children's Products, Inc.
Evenflo Company, Inc.
Dorel Juvenile Group
Team-Tex America, Inc.
Mercedes-Benz USA, LLC
Volvo Cars of N.A., LLC
Porsche Cars North America, Inc.
Angel Guard Products, Inc.
Britax Child Safety, Inc.
Peg Perego Usa, Inc.
Snug Seat, Inc.
Safe Traffic System, Inc.
Baby Trend, Inc.
Learning Curve Brands, Inc.
Recaro Gmbh & Co. Kg
E-Z On Products Inc. of Florida
Chicco Usa, Inc.
Combi Usa, Inc.
Immi
Orbit Baby, Inc.

Ferno-Washington, Inc.
Q Straint
Sunshine Kids Juvenile Products (aka Diono)
Teutonia Usa, LLC
Regal Lager
Aprica USA LLC
Clek Inc.
Harmony Juvenile Products
Summer Infant Inc.
Baby Jogger
Cosco
Nuna
Phil&teds
Uppababy
Kids Embrace
WayPico
Bubble Bum
Hiccapop

D. Description of the projected reporting, record keeping and other compliance requirements for small entities

The final rule adopts new performance requirements that would enhance the safety of child restraints. Under the Safety Act, child restraint manufacturers are required to ensure and certify that their products meet all applicable safety standards, which would include the new side impact requirements. Manufacturers are not required to conduct the exact test specified in the FMVSSs, but they must ensure that their child restraints will meet the requirements specified in the final rule when tested by NHTSA using the test procedure specified in FMVSS No. 213a.

E. Duplication with other Federal rules

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

VII. UNFUNDED MANDATES REFORM ACT

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 final rules that include a Federal mandate likely to result in the expenditures by State, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted annually for inflation with base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for the year 2020 results in $170 million (258.811/152.4 = 1.70). The final rule is not estimated to result in expenditures by State, local or tribal governments, in the aggregate, or by the private sector, of more than $170 million annually.

Appendix A. COMPREHENSIVE UNIT COSTS

The comprehensive value of societal impacts from fatalities and injuries includes a variety of cost components. Table A-1 summarizes the cost components and corresponding unit costs in 2019 dollars. As shown, the cost components included medical, EMS, market productivity, household productivity, insurance administration, workplace, legal, congestion, travel delay, and the nontangible value of physical pain and loss of quality of life (i.e., quality adjusted life years, QALYs). The unit costs were revised from those published in the agency's 2015 report (Blincoe, 2015 et al).[44] Blincoe et al reported unit costs in 2010 dollars.

The current established DOT VSL is $11.9 million (in 2020 dollars) which was based on the most current 2020 DOT Guidance on VSL (DOT, 2020).

Table A - 1
Comprehensive Unit Costs (2020 $)

Components	PDO	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	FATAL
Medical	$0	$0	$3,739	$15,299	$64,947	$182,093	$513,315	$15,117
EMS	$71	$45	$129	$264	$496	$999	$1,020	$1,076
Market Prod	$0	$0	$3,424	$24,318	$80,820	$176,891	$424,096	$1,172,349
Household Prod	$75	$57	$1,083	$8,926	$28,500	$47,158	$119,849	$364,180
Ins. Adm.	$228	$171	$3,933	$5,557	$18,332	$33,666	$86,497	$33,778
Workplace	$78	$58	$428	$3,321	$7,256	$7,991	$13,932	$14,802
Legal	$0	$0	$1,410	$3,997	$14,791	$31,806	$98,644	$127,003
Congestion	$2,643	$1,779	$1,791	$1,822	$1,872	$1,899	$1,921	$7,186
Property Damage	$4,293	$3,211	$9,492	$10,149	$19,114	$19,474	$18,000	$13,372
QALYs	$0	$0	$30,606	$479,493	$1,071,207	$2,713,724	$6,049,769	$10,201,971
Total Avoidance comprehensive cost*	$7,388	$5,321	$25,429	$73,653	$236,128	$501,977	$1,277,274	$1,748,863

[44] Blincoe, L., Miller, T., Zalloshnja, E., Lawrence, B., The economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised), DOT HS 812 013 National Center for Statistics and Analysis, Washington, D.C., May 2015.
These economic and societal impact numbers were further adjusted internally before use in this analysis, to provide the most up-to-date expression on comprehensive cost.

*Note: Exclude Congestion and Property Damage when crashworthiness FMVSSs are considered.
Baseline used:

Unit Costs in 2010 $ for Police-Reported Crashes

Cost Components	**PDO**	**MAIS0**	**MAIS1**	**MAIS2**	**MAIS3**	**MAIS4**	**MAIS5**	**FATAL**
Medical	$0	$0	$2,799	$11,453	$48,620	$136,317	$384,273	$11,317
EMS	$59	$38	$109	$221	$416	$838	$855	$902
Market Prod	$0	$0	$2,726	$19,359	$64,338	$140,816	$337,607	$933,262
Household Prod	$60	$45	$862	$7,106	$22,688	$37,541	$95,407	$289,910
Ins. Adm.	$191	$143	$3,298	$4,659	$15,371	$28,228	$72,525	$28,322
Workplace	$62	$46	$341	$2,644	$5,776	$6,361	$11,091	$11,783
Legal	$0	$0	$1,182	$3,351	$12,402	$26,668	$82,710	$106,488
Congestion	$2,104	$1,416	$1,426	$1,450	$1,490	$1,511	$1,529	$5,720
Property Damage	$3,599	$2,692	$7,959	$8,510	$16,027	$16,328	$15,092	$11,212
QALYs	$0	$0	$23,241	$364,113	$813,444	$2,060,724	$4,594,020	$7,747,082
Total	$6,075	$4,380	$43,943	$422,866	$1,000,572	$2,455,332	$5,595,109	$9,145,998
Relative QALYS	0.0000	0.0000	0.0030	0.0470	0.1050	0.2660	0.5930	1.0000

Source: Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. (2014, May), The economic and societal impact of motor vehicle crashes, 2010
(Report No. DOT HS 812 013), Washington, DC: National Highway Traffic Safety Administration, Revised 2015