Update of Safety Benefits & Tradeoffs Related to Requiring the Use of Child Restraint Systems on Aircraft for Children Less Than Two Years of Age

Office of Accident Investigation and Prevention
Federal Aviation Administration,
December 2011

This paper updates and confirms the FAA's position that requiring the use of child restraint systems (CRS) in FAR Part 121 operations would result in a significant net increase in total transportation fatalities. This update concludes that requiring the use of CRS would increase total transportation deaths by 72 over 10 years and by 115 deaths over 15 years.

Part 1: Outline of the FAA Position

FAA has long agreed that an infant is safer in a properly secured safety seat and FAA continues to encourage adults traveling with young children to use such seats when traveling by air. The virtues of using proper child restraint systems are not at issue. Rather, the issue is the unintended consequence of requiring their use: a net increase in transportation deaths.

FAA's position is based on two fundamental premises plus the empirical evidence, which shows no preventable infant deaths in air carrier operations for more than 17 years. The first premise holds that price matters; it affects consumer decisions, including modal choice for family travel within competitive distances. Requiring CRS would significantly increase the price of family air travel for a small, targeted population, who would bear the entire cost of the requirement. The cost of a trip by air would double for one adult traveling with an infant. Cost would increase by half for a party of two plus an infant, and by one-third for a party of 3 plus an infant. Parties who travel by air with infants average 2.2 persons plus the infant.[1] That average party would have to purchase 3.2 tickets and would incur an average cost increase of 45 percent per trip by air.

Families' responses to such price increases would vary, depending on trip distance, the urgency of a trip, and household income. Many families would choose to continue their trips as planned and purchase an extra ticket, and some families would simply cancel their trips. However, many families would choose to drive to the same destinations or, for more discretionary trips such as vacations, they might choose different locations and travel by road.

The second fundamental premise holds that the Nation's highway system, which would capture virtually all of the family travel that price might divert from the air transport system, is less safe than the air carrier system. This remains true despite recent improvements in highway fatal accident rates. Consequently, the diverted travel would impose higher risks on the entire travel party and, to some degree, on other drivers. The net effect would be an increase in total transportation deaths.

---

[1] U.S. Department of Transportation, Federal Aviation Administration, Report to Congress, Child Restraint Systems, May 1995

To reach any other conclusion, FAA must argue that price is irrelevant in family travel decisions, and therefore would not divert any trips, or that highway travel and air travel impose equal risk of fatality to infants and to other family members. Neither argument would be credible.

Part 2: Preventable Infant Deaths in the Air Carrier Industry

Part 91.107 of the Federal Aviation Regulations requires that each person on board a U.S.-registered civil aircraft certified after November 1, 1987 "must occupy an approved seat or berth with a safety belt, and if installed, shoulder harness, properly secured about him or her during movement on the surface, takeoff, and landing." However, "a person may . . . be held by an adult who is occupying an approved seat or berth, provided that the person being held has not reached his or her second birthday." A child who has reached his or her second birthday must be in his or her own seat. Therefore the issue of requiring the use of a CRS is limited to infants (children less than 2 years of age). Benefits would accrue only when the CRS could prevent fatalities or injuries to infants.

A review of airline accidents from fiscal year (FY) 1980 (October 1979) through August 2011 shows that CRS would have prevented 3 fatal injuries to infants over 32 years. [2] The 3 fatalities that could have been averted occurred at Denver in November 1987, at Sioux City in July 1989, and at Charlotte in July 1994. No preventable fatalities have occurred since Charlotte, more than 17 years ago. In short, the empirical evidence is limited to 3 "saves" over 32 years and none in the past 17 years. The NTSB agrees that this is the extent of the empirical evidence.

The 3 preventable infant deaths occurred in an 8-year span, which constituted an unusual spike for this issue even in that era of much higher accident rates. In those 8 years (1987 through and including 1994), U.S. air carriers had a rate of 25 fatalities per every 100 million occupants. In the past 4 years the rate has fallen to 0.3 per 100 million occupants. As major accidents become increasingly rare, opportunities for additional saves also will become increasingly rare.

Yet FAA recognizes that the risk of incurring a preventable infant death is greater than zero, and therefore the possible benefit of requiring the use of CRS remains greater than zero. Nevertheless, given the experience of the past 17 years and the substantial and continuing reduction in fatality rates among passengers on air carrier aircraft, we can not assume more than 1 possible save every 10 to 15 years.

Part 3: Size of the Affected Travel Population & Trip Distance

In 2010, airlines carried 675.5 million ticketed passengers on domestic routes. FAA forecasts call for an average annual growth rate of 3.7 percent in ticketed domestic passengers from 2011 through 2015, followed by an annual average growth rate of 2.5 percent for the following 15

[2] FAA implemented FAR Part 119 in spring 1997. Prior to that rule, scheduled passenger operations in aircraft from 10 to 30 seats were regulated under FAR Part 135 (commuter) rules. As of spring 1997, FAR 119 placed scheduled passenger operations in those aircraft under the more demanding FAR Part 121, which had regulated all passenger operations in larger aircraft. The review of accidents cited here includes pre-1997 operations addressed by FAR Part 119 to ensure a common definition over the study period.

years.[3] Those projected growth rates would produce an annual average of 787.3 million passengers over the next 10 years and an annual average of 845 million over 15 years.

Most observers assume that lap infants account for about 1 percent of occupants on air carrier aircraft.[4] If so, an annual average of 8 million infants will travel in the domestic air carrier system over the next decade, with an annual average of 8.53 million over 15 years. With 3.2 persons per travel party, including infants, a total population of about 25.6 million air travelers per year would be affected by a CRS requirement over 10 years and about 27.3 million per year over 15 years.

Highways already dominate inter-city family travel. The National Household Travel Survey (NHTS) reports 97 percent of trips of less than 250 miles use private vehicles. NHTS also finds that highways account for 95 percent of trips of less than 500 miles. From 500 to 749 miles, highways account for a more modest but still dominant 62 percent of trips and 42 percent of trips from 750 to 999 miles. Even at distances of 1,000 to 1,499 miles, private vehicles still account for 31 percent of all trips. In short, private vehicles remain the mode of choice past 1,000 miles and remain competitive through 1,500 miles.

Table 1 shows airline trips by distance (in statute miles) for the top 1,000 airline city pairs to begin identifying the share of families whose travel would be within distances where highways compete and even dominate. To avoid over-estimating the population that could be affected by a CRS rule, the table accounts for "barrier markets" in which physical barriers eliminate road alternatives, such as trips to Hawaii and Puerto Rico, intra-islands trips in Hawaii, travel to, from or within Alaska, or trips to the U.S. Virgin Islands. Barrier markets account for 5.8 percent of domestic air travelers. However, even after eliminating air travelers whose trips are to or from barrier markets, private vehicles remain competitive or dominant in city pairs that capture 74 percent of domestic air travel.

Many families, as well as other travelers, currently choose private vehicles for multiple reasons, including access to multiple or isolated destinations, flexibility, and total cost. Conversely, families who chose to travel by air within those distances may do so for reasons of convenience, urgency, or safety and risk assessment. Nevertheless, given that highways dominate trips up to 750 miles and remain very competitive through 1,000 miles, the extra cost of an additional ticket for air travel would divert a substantial share of families who now fly.

Proponents of a CRS rule assert that the airlines could manage those increased costs through a variety of strategies, including variable pricing, free seats on city pairs with low load factors, frequent-flyer benefits, spreading the costs across all tickets, etc. Some price competition for infant tickets could occur at the margins, but with load factors at 83 percent system-wide, and higher on densely traveled city pairs, most families would have to absorb the full cost of a ticket, or an average cost increase of 45 percent for an average party of 3.2 people, of whom one now travels free.

---

[3] FAA Aerospace Forecasts FY 2011-2031, Federal Aviation Administration, Table 5, and Table 8 for trans-border traffic to Canada.
[4] U.S. Department of Transportation, Federal Aviation Administration, Report to Congress, Child Restraint Systems, May 1995.

Though the precise level of inter-modal elasticity is not well established, empirical evidence shows that competition among air carriers is intensely price-sensitive. A review of the literature on price elasticity in aviation shows that elasticity is strongest in short-haul markets, at -1.74 for the first quartile of trip distance, which captures the competitive trip distances. [5] In fact elasticity among air carriers remains quite strong at any distance.

Since many parents of infants have yet to reach peak earning years, sensitivity to the cost of an extra air ticket will be substantial among these consumers. Diversion could easily reach one-third for trips up to 500 miles. Since 95 percent of all travelers currently choose private vehicles for such trips, one-third may err on the low side. For trips from 500 to 749 miles, highways' dominance drops from 95 to 62 percent. If we reduce the assumed diversion rate proportionately, we can assume 22-percent diversion from 500 to 749 miles. A similar pro-rata reduction in the assumed rate of diversion for long trips produces an assumed diversion rate of 15 percent from 750 to 999 miles. For trips of 1000 to 1,499 miles, where private vehicles still capture 31 percent of all inter-city trips, this analysis assumes a diversion rate of just 5 percent.

Table 2 summarizes these assumptions and the vehicle miles of travel (VMT) that would be generated by diverted trips. Over 10 years, these assumptions would divert 11.3 million family trips to highways and 18.1 million family trips over 15 years.

The above assumptions may err on the low side. Nevertheless, they produce a total of 6.4 billion VMT over 10 years and 10.2 billion VMT over 15 years. The remaining issues for this analysis are: (1) the level of risk to which travelers would be exposed if they diverted to highways; and (2) the number of fatalities that risk would produce.

Part 4: Highway Volume and Accident Rates

This analysis uses a consciously conservative fatal accident rate for highways, based on the reasoning outlined below. The highway data supporting this reasoning is shown in Table 3.

1. Diverted family travel would be limited to passenger vehicles on the Interstate System. This excludes accidents that involve only motorcycles or trucks and captures only automobiles, SUV's and some other 4-tired, light vehicles.

2. All diverted travel is assumed to use inter-city highways, where design characteristics reduce the fatal accident rate. Rural Interstate mileage typically is used to represent rates for inter-city travel. Rural Interstates in 2008 and 2009, the 2 most recent years for which highway data is available by functional system, produced a fatality rate for family vehicles, as defined above, of 14.2 fatalities per billion VMT. However, a more balanced assessment must recognize that inter-city trips in fact also use urban Interstate mileage, where fatal accident rates are much lower than on the Rural Interstate, at 5.5 fatalities per billion VMT.

[5] "Air Travel Demand Elasticities: Concepts, Issues and Measurement;" David W. Gillen, William G Morrison and Christopher Stewart, Wilfred Laurier University, Waterloo, Canada.

3. Assume that inter-city trips on the Interstate use rural and urban mileage in proportion to the rural/urban split of all Interstate mileage: 32.6 percent urban and 67.4 percent rural as of 2009.[6] Weighting fatality rates by this rural/urban split of Interstate mileage yields a fatality rate of 11.4 fatalities per billion VMT for family vehicles.

4. Unlike aviation, risk in highway travel is essentially linear. Generally, a 500-mile trip on an Interstate is about 10 times more likely to produce an accident than is a 50-mile trip on the Interstate.

5. Vehicle occupancy is assumed to average 3.2 for affected families versus a mean occupancy of 1.6 for all passenger vehicles on the Interstate. In a serious accident, this would increase the average fatality rate proportionately from the above 11.4 per billion VMT to 22.8 per billion VMT for inter-city family trips.

6. However, passengers, especially those in rear seats, are at less risk than are drivers. This would lower the effective fatality rate to about 21 persons per billion VMT.[7]

7. The demographics of the affected drivers would reduce that rate even further, due to driver age, lower rates of alcohol involvement when driving with families onboard, lower rates of excessive speed with families onboard, etc. Newman, Johnson and Grossman estimate a fatal accident coefficient of 0.53 for this group during family travel. This reduces the above fatality rate for this analysis, from 21 to 11.13 per billion VMT for diverted travelers.

8. Fatalities involving passenger vehicles are not limited to people in vehicles. Highway data identifies fatalities to cyclists and pedestrians on rural and urban Interstates, but does not distribute them by vehicle class. Consequently, those fatalities are distributed here in rural and urban areas according to the respective number of passenger vehicles involved in fatal crashes as a share of all vehicles involved, adjusted for the 0.53 coefficient noted above. This raises the Interstate fatality rate from 11.13 to 11.3 fatalities per billion VMT for diverted family trips. This is the rate assumed for the calculations that follow.

The 45-percent increase in costs for air travel from a CRS rule would generate 6.4 billion VMT over 10 years and 10.2 billion VMT over 15 years, as noted in Table 2, with an occupancy rate of 3.2 persons and a fatality rate of 11.3 per billion VMT. At these rates, diversion would produce 72 new fatalities over 10 years and 115 new fatalities over 15 years.

Table 2 estimated a total of 11.33 million diverted family trips in 10 years among the 80 million families who would be traveling by air with infants, or 14.2 percent of all such families. In short, with a total diversion of just 14 percent in response to a 45-percent average price increase in net

[6] Table HM-220, Highway Statistics (annual), Federal Highway Administration. Three-digit Interstate Spur mileage into central cities is excluded (from FHWA Interstate Route Finder).
[7] Newman, Thomas B., MD, MPH, Brian D. Johnson, MD, MPH and David C. Grossman, MD, MPH, "Effects and Costs of Requiring Child-Restraint Systems for Young Children Traveling on Commercial Airplanes," *Archives of Pediatrics & Adolescent Medicine* 157 (October 2003) 969-974 .

costs for air travel, requiring the use of CRS would lead to 72 additional transportation fatalities over 10 years and 115 fatalities over 15 years in the hope of achieving one “save.”

The disparity of serious injuries is much greater than the disparity in fatalities. Data from NTSB shows that, from 1980 through and including 2001, Part 121 passenger operations incurred 3.6 fatalities for every serious injury. With the sharp improvement in Part 121 fatality rates, that ratio has changed to 1 fatality per serious injury over the past decade. In highways, the number of serious injuries has always and greatly exceeded the number of fatalities. Data from the Bureau of Transportation Statistics shows that highway passenger vehicles produced 85 serious injuries for every fatality from 2004 through 2009.[8]

If we apply those ratios (1-to-1 versus 85-to-1) to the fatality ratio of 72-to-1 over 10 years, the 10-year experience produces a fantastic comparison of 6,120 serious injuries in passenger vehicles per serious injury in Part 121 passenger operations. Even after accounting for the relative safety of the Interstate and the added safety of family drivers, family travel on the Interstate would produce a still fantastic 1,400 additional serious injuries over 10 years and about 2,200 additional serious injuries over 15 years.

Conclusion

The use of child restraint systems could have prevented 3 infant deaths during US air carrier operations in the past 32 years, but none in the past 17 years. As major airline accidents become increasingly rare, opportunities for additional “saves” also will become increasingly rare. Consequently, though the risk of a preventable infant fatality is greater than zero, benefits are limited to the possibility of 1 infant “save” over 10 to 15 years.

However, a CRS rule will impose very substantial cost increases on a targeted population of adults traveling with small children. Based on the simple premise that price matters, those cost increases will change travel decisions among some traveling families, at least within competitive trip distances. Those new consumer decisions will include diversion of trips from air to highways. After accounting for recent and impressive improvements in highway fatality rates, and after adjusting those rates downward to account for several important factors that make inter-city family travel relatively safe, the net effect will be an increase of about 72 additional transportation fatalities over 10 years and 115 additional deaths over 15 years. The disparity in serious injuries is even greater, on the order of about 1,400-to-1. FAA believes these results are conservative. However, even if these estimates were deemed to be overstated by 3-fold or 5-fold, the benefit-cost ratios would remain prohibitive.

[8] See Bureau of Transportation Statistics, Table 2-21: Passenger Car Occupancy Safety Data.

Table 1: Distribution of Airline Passenger Trips By One-Way Trip Distances, Top 1,000 Markets, CY 2009

Trip Distance (Statute Miles)	% All Air Pax	% of All Air Pax in Barrier City Pairs	Net % of All Air Pax
0 - 99	0.161	0.161	0.000
100-149	1.002	0.9	0.121
150-199	1.426	0.348	1.078
200-249	2.864	0.398	2.466
250-299	2.976	0.078	2.898
300-349	4.628	0.2	4.405
350-399	3.477	0.0	3.477
400-449	4.168	0.0	4.168
450-499	3.260	0.000	3.260
500-549	2.658	0.0	2.658
550-599	3.412	0.1	3.276
600-649	3.089	0.0	3.089
650-699	2.881	0.0	2.881
700-749	2.777	0.0	2.777
750-999	17.690	0.000	17.690
1000-1499	20.432	0.672	19.760
1500-1999	10.304	0.949	9.355
2000-2499	8.885	0.677	8.208
2500 >	3.910	1.460	2.450
Total	100.000	5.983	94.017

Source: FAA (APO)

Table 2: Assumed Diversion Rates, Trips Diverted & VMT Generated

	Trip Length in Statute Miles				
	0-499	500-749	750-999	1,000-1,499	Sub-Tot
% of Air Travel (Minus Barrier markets)	21.87	14.68	17.69	19.76	74.00
Current Highway % of All Intercity Travel (NHTS)	95	62	44	31	59
Assumed Diversion, Family Travel, with 45-% price Increase (in %)	33.3	22	15	5	15.1
Million Family Trips Diverted in 10 Years	5.83	2.58	2.12	0.79	11.33
Million Family Trips Diverted in 15 Years	9.33	4.13	3.40	1.26	18.12
Median Trip Length, Statute Miles (Table 2)	347	618	883	1134	753
Highway VMT (Billions) Over 10 Years	2.02	1.60	1.87	0.90	6.39
Highway VMT (Billions) Over 15 Years	3.24	2.55	3.00	1.43	10.22

Table 3: Highway Vehicle Miles of Travel (VMT) and Fatalities For Passenger Vehicles

	2008			2009			Two-Year Total		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Interstate Crashes									
Single Pax Vehicle Only	1,079	922	2,001	954	829	1,783	2,033	1,751	3,784
Multi-Vehicle, Pax Vehicles Only	268	354	622	226	327	553	494	681	1,175
Multi-vehicle, Pax & Other Vehicle	421	469	890	367	385	752	788	854	1,642
All Crashes Involving Pax Vehicles	1,768	1,745	3,513	1,547	1,541	3,088	3,315	3,286	6,601
Interstate Fatalities									
Single Pax Vehicle Only	1,219	1,006	2,225	1,068	909	1,977	2,287	1,915	4,202
Multi-Vehicle, Pax Vehicles Only	348	407	755	276	395	671	624	802	1,426
Multi-Vehicle, Pax & Other Vehicle	518	531	1,049	469	431	900	987	962	1,949
Interstate Total Involving Pax Veh.	2,085	1,944	4,029	1,813	1,735	3,548	3,898	3,679	7,577
Million VMT, All Pax Vehicles	135,091	335,612	470,703	139,621	334,765	474,386	274,712	670,377	945,089
Fatalities per Billion VMT, Pax Vehicles Interstate	15.43	5.79	8.56	12.99	5.18	7.48	14.19	5.49	8.02

Appendix

Air Carrier Accidents Since 1980 in Which Child Restraint Systems Could Have Prevented Infant Fatalities

November 15, 1987 Continental DC-9 At Denver
28 fatalities, 28 serious injuries, 25 minor injuries; 1 no injury
The aircraft remained on the runway for 27 minutes after de-icing in heavy snow. The takeoff roll appeared normal, but the crew over-rotated, rolled right and crashed. The failure to de-ice again, plus the rapid rotation with ice-contaminated wings led to the loss of control. No passengers in left-side window seats from rows 2 through 9 survived and occupants in the center of the aircraft died from severe compression. However, the 28 fatalities included a lap baby in seat 5C (right side). The baby's mother survived, but the baby struck the bulkhead and died of multiple blunt trauma injuries. Yet, the only passenger to have no injuries was a 6-week-old lap baby in row 24.

July 19, 1989 United Airlines DC-10 A At Sioux City, IO
111 fatalities and 47 serious injuries; 138 minor or no injuries.
During an uncontained engine failure, the fan disk penetrated the aircraft and severed all hydraulics systems. Thrust and asymmetric thrust were the only controls available to the crew. During an emergency landing at Sioux City, the aircraft banked right just before touchdown, cart wheeled and burned. Of 296 occupants, 4 were lap babies, from 7 to 26 months. Two of the 4 remained secure in the crash sequence and had only minor injuries but parents lost control of the other 2 children. Another passenger, who re-entered the burning aircraft, rescued one of those 2 children. The other lost child died after impact from toxic smoke inhalation (not from blunt trauma on impact). The NTSB found that a proper child restraint system would have prevented this fatal injury.

July 2, 1994 USAir DC-9-31 at Charlotte, NC
37 fatalities, 16 serious injuries and 4 minor injuries.
On descent in heavy daytime rain, with thunderstorms and strong gusts, the crew descended through 200 AGL 0.6 miles out, then tried to initiate a go-around but flew into severe windshear and crashed half-mile out, a quarter-mile right of the extended runway. Of 57 occupants, 2 were lap-babies. Most fatally injured passengers were seated forward (all passengers in rows 3 through 10 sustained nonsurvivable blunt trauma on impact) and near or over the wing section (where fatalities were caused by thermal injury or carbon monoxide). All persons from rows 17 through 21 survived, except for a lap baby. That part of the aircraft sustained relatively minor deformation with survivable impact forces. However, the baby's parent lost control of the infant upon impact and the child died of blunt trauma. A proper child restraint system would have prevented this fatal injury.