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An Oral Presentation on
The Performance of Automobile Child Restraints Devices in Airplane Passenger Seats

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An oral presentation by Van Gowdy FAA Civil Aeromedical Institute

Introduction.

The use of child restraint devices in commercial transport airplanes is an issue of concern to the FAA, airlines, and the passengers who choose to provide automobile restraint devices for accompanying children. Although there are no published statistics on the number of children traveling in commercial airplanes, the Air Transport Association estimates six to eight thousand children under two years of age travel daily in U.S. airlines. As the number of passengers continues to increase, it is reasonable to assume the number of children traveling by airplane will increase.

Public acceptance of the benefits provided by child restraint devices for automobiles is recognized by the adoption of laws requiring their use in all 50 states. Although the risk of injury in commercial air transport operations is small, some parents desire to bring a child restraint device when traveling with their children. FMVSS-213 approved devices are allowed on airplanes; however, there is no requirement that children be supplied a restraint system other than the lap belts available on the passenger seat.

The subject to be addressed in this presentation is the performance of approved child restraint devices airplane seats. If a parent purchases a child restraint labeled as "certified for use in motor vehicles and airplanes", the implications are the device has passed the government requirements and will provide a significant level of protection to a child in the event of an accident, whether in an automobile or airplane. Since the U.S. requirements are based primarily on the automobile seat environment, it is important to understand the performance of child restraints in airplanes.

Current FAA Policy: (adopted 9/92, 14 CFR 121)

- Child restraints must be certified to meet FMVSS-213, United Nations Standard, or labeled to meet a foreign government approval.
- The restraint device must be installed in forward facing seat and per the instructions of the manufacturer.
- No airline can prohibit the use of an approved child restraint if a ticket is purchased for the child or a seat is made available by the airline.

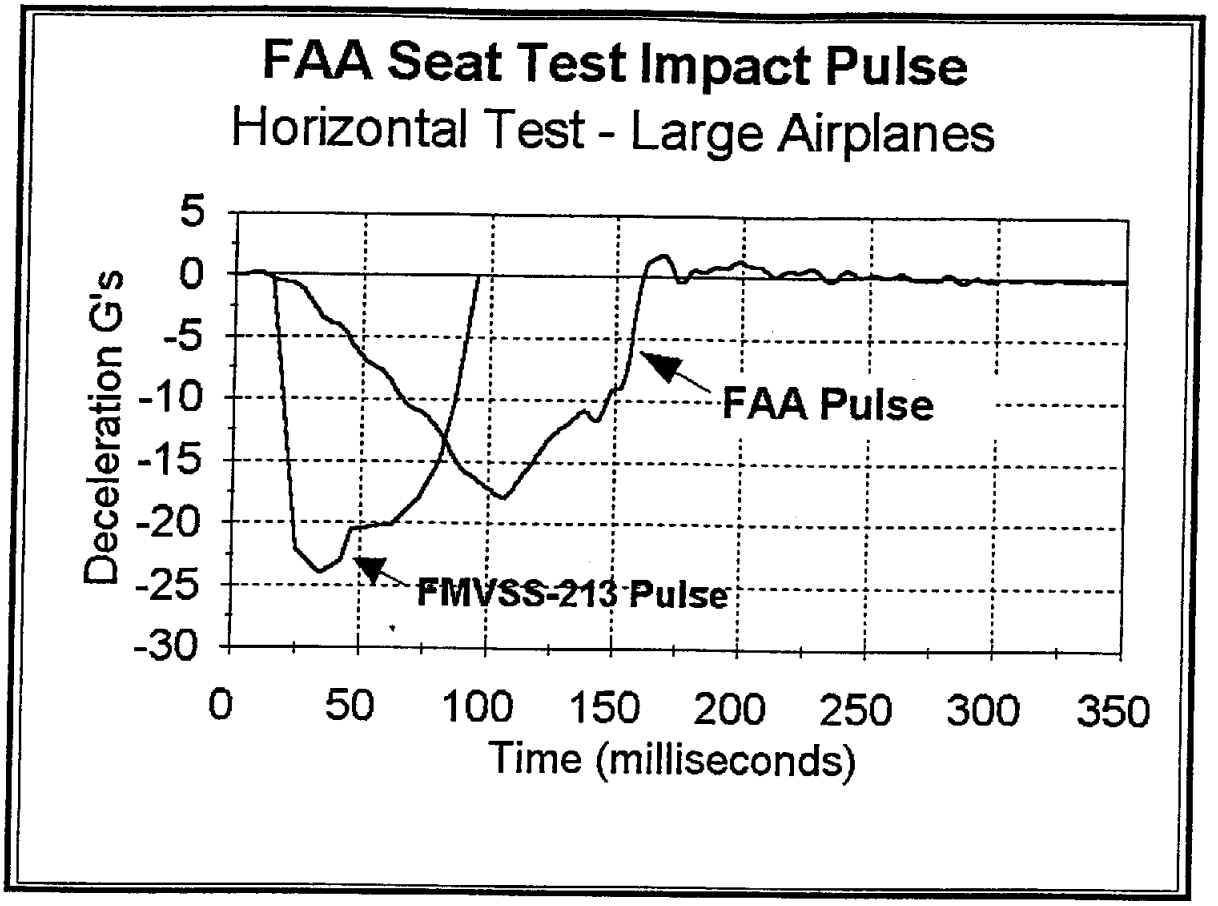
A CHILD RESTRAINT DEVICE INSTALLED IN AN AIRPLANE PASSENGER SEAT SHOULD MEET THREE IMPORTANT PERFORMANCE FACTORS:

- Fit, adaptability, and adjustment in the airplane seat and the lap belts provided on the seat.
- Dynamic structural performance
- Occupant protection during a crash.
  (flail envelope, load distribution, restraint function)

ACCEPTABLE PERFORMANCE SHOULD BE ACHIEVED WITHIN THE SURVIVABLE CRASH CONDITIONS MANDATED FOR MODERN PASSENGER SEATS IN TRANSPORT AIRCRAFT

- Large Airplanes : (14 CFR 25 Section 562)
  a. Horizontal impact, 16 Gpk, 44 ft/sec
  b. Vertical impact, 14 Gpk, 35 ft/sec

NOTE: For new airplanes, certificate date after May, 1988


FAA Seat Test Impact Pulse
Horizontal Test - Large Airplanes
Deceleration G's
5
0
-5
-10
-15
-20
-25
-30
0
50
100
150
200
250
300
350
Time (milliseconds)
FAA Pulse
FMVSS-213 Pulse

FAA Civil Aeromedical Institute (CAMI)
Research Project:

"Performance of Automobile Child Restraint Devices in Airplane Passenger Seats"

Protocol :

Dynamically test a variety of approved child restraints installed in airplane passenger seats, at the 16 G severity (14 CFR 25)

Configure test setup to represent a typical multi-row seat installation, include effects of aft row occupant impact.

Investigate airplane seat compatibility with child restraint, observe and measure three performance factors.

"Performance of Automobile Child Restraint Devices in Airplane Passenger Seats"

FMVSS Certified Devices Tested:

Booster Seats (child weight 30-60 lbs) ..... 4 models

Aft Facing Carriers (< 20 lbs) 4

Aft/Fwd Convertibles (<20 >lbs) 7

Add on Harness (> 30 lbs) 1

"Performance of Automobile Child Restraint Devices in Airplane Passenger Seats"

Test Configurations Conducted*:

Front Row Seat (no forward structure) .....5 tests

Normal Row Seat (with forward row seat) 20

All tests were conducted in a forward facing orientation.

Double row tests were configured with 32 inch seat pitch.

The impact severity was 16 Gpk, 44 ft/sec, (FAA 16 G test)

Anthropomorphic Test Dummies

6 months old ..... standard dummy (49 CFR 572)

6 months old..... CRABI (articulated)

27 months ..... CAMI-X experimental ATD, with instrumented abdominal bladder insert to measure pressure.

3 year old ..... standard dummy (49-CFR-572)

50th percentile male, Hybrid II, as adult occupant in aft row seat

Standard ATD instrumentation, including head and chest accel.s

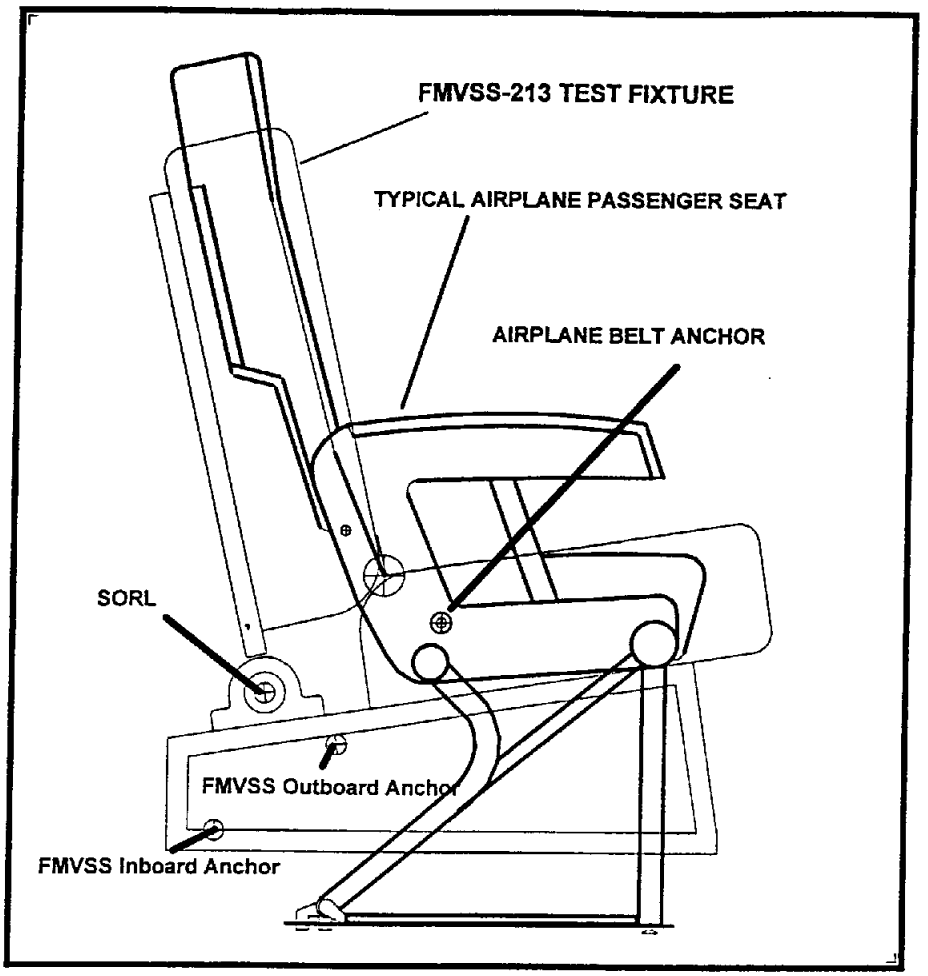
A SERIES OF 35mm SLIDES WILL
NEXT BE PRESENTED, SHOWING THE
LABORATORY TEST SETUP AND SPECIMENS

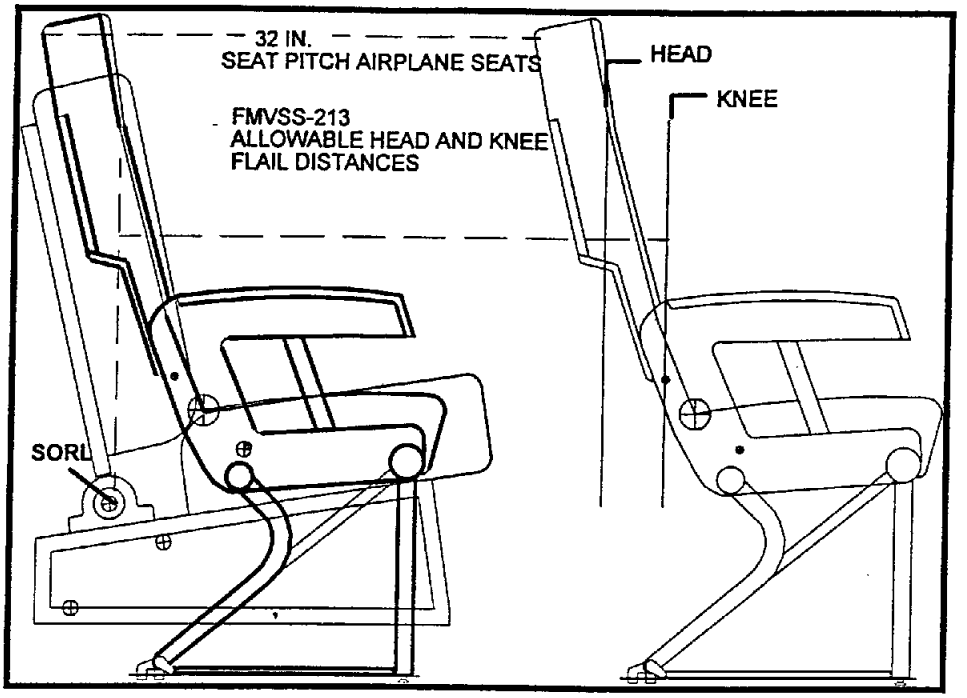
Results and Observations:

1. Differences between the typical airplane passenger seat and the automobile child restraint test fixture defined in FMVSS-213 result in poor performance of some child restraints when tested in an airplane seat.

The most significant differences are:

a. Restraint geometry and anchor points.
b. Restraint buckle location and size
c. Seat back breakover on airplane seats
d. Close proximity to forward row structures.


FMVSS-213 TEST FIXTURE
TYPICAL AIRPLANE PASSENGER SEAT
AIRPLANE BELT ANCHOR
SORL
FMVSS Outboard Anchor
FMVSS Inboard Anchor


32 IN.
SEAT PITCH AIRPLANE SEATS
FMVSS-213
ALLOWABLE HEAD AND KNEE
FLAIL DISTANCES
HEAD
KNEE
SORL

EFFECTS RESULTING FROM DIFFERENCES IN FMVSS-213 AND AIRPLANE PASSENGER SEATS:

1. Booster Seats. (no back shell)

   Location of lap belt buckle did not fit in path provided over the front shield of all four booster seats

   1 would not fit in available space between arm rests, could not be used in a seat with fixed arm rests

   1 failed structurally during 16 G forward test

   Measured abdominal pressure force of
   20 psi with no interaction of seat back breakover
   60 psi with aft row occupant forcing seat back breakover

   (Abdominal pressure measured by experimental system, 500ml IV bag, water filled, instrumented)

EFFECTS RESULTING FROM DIFFERENCES IN FMVSS-213 AND AIRPLANE PASSENGER SEATS:

2. Aft Facing Carriers (child weight < 20 lbs)

   No significant performance problems were observed.

   When installed and adjusted, the lap belt buckle is centered on top of the carrier, easily accessible to a child. This could be a problem with the child releasing the buckle.

EFFECTS RESULTING FROM DIFFERENCES IN FMVSS-213 AND AIRPLANE PASSENGER SEATS:

3. Fwd/Aft facing convertible carriers

Most had installation problems

Difficult to route large buckle through required path.

Buckle size often prohibited proper tightening of belts due to interference with shell of device

Belts could not be tightened due to limited adjustment range of airplane seat belts

In forward facing mode, head excursions resulted in contact with back of forward row seat. Six of eight tests resulted in HICs above 1000. (Range of HIC 682 - 2256)

EFFECTS RESULTING FROM DIFFERENCES IN FMVSS-213 AND AIRPLANE PASSENGER SEATS:

3. Add on Harness System (FMVSS-213 Certified)

   Would not install properly in lap belts on airplane seat, lap belts were slack when adjusted to shortest possible length. Could not test in the device per the instructions provided with the device that is on the market.

   Airplane seat was modified, lap belts were wrapped around armrest structure to obtain tighter tension on belts.

   Excessive translation and flail was observed from test films, 3 year-old ATD torso moved off front edge of seat cushion.

VIDEOS OF EXAMPLES OF
SLED TESTS CONDUCTED
AS PART OF THIS SERIES WILL
BE SHOWN NEXT

CONCLUSION:

The results from these tests indicate the differences between FMVSS-213 test methods and the typical airplane seat installation can adversely affect the performance of a child restraint installed in an airplane seat, even when tested at a reduced severity from the automobile requirement.

RECOMMENDATION:

The selection and approval methods for child restraint devices allowed to be used on airplanes should include assessment of the following:

1. Space limitations for installation of child restraints, includding distance beween arm rests, cross aisle space, single side access.

2. Restraint geometry and hardware, including range of adjustment and method of adjustment on passenger seats.

3. The effects of seat back breakover combined with aft row occupant impact forces.

4. The close proximity of forward structures and potential for head injury during a forward impact.