Compatibility of Child Restraint Systems (CRS) with Commercial Aircraft Seats

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FUNDING ACKNOWLEDGEMENT

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BACKGROUND

- **The FAA recommends child restraint system (CRS) use on aircraft.**
- Safer than riding as a lap baby, especially during turbulence.
- CRS must pass safety regulations set by the federal government:
  - Vehicle: Frontal crash test
    - Coming soon: side crash test
  - Aircraft: Additional inversion test

Source: https://www.faa.gov/travelers/fly_children
Image: tampabayparenting.com

BACKGROUND

- CRS usage rate on aircraft is low (Palumbo, CChIPS 2018-2019)
  - Children under age 2: 26% in CRS
  - Children over age 2: 37% in CRS
  - *Rates may be overestimated due to response bias*
- Barriers to CRS use include:
  - Cost of extra seat vs. riding as lap baby
  - Carrying CRS through airport
  - Consider air travel to be very safe
  - Difficulty of installation on aircraft

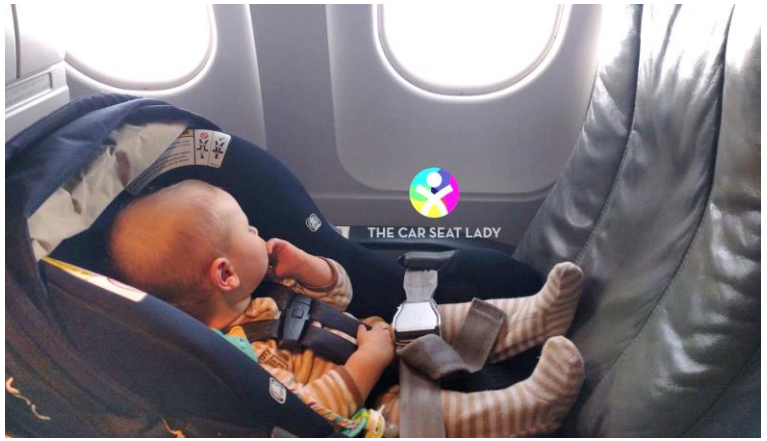

Image:thecarseatlady.com

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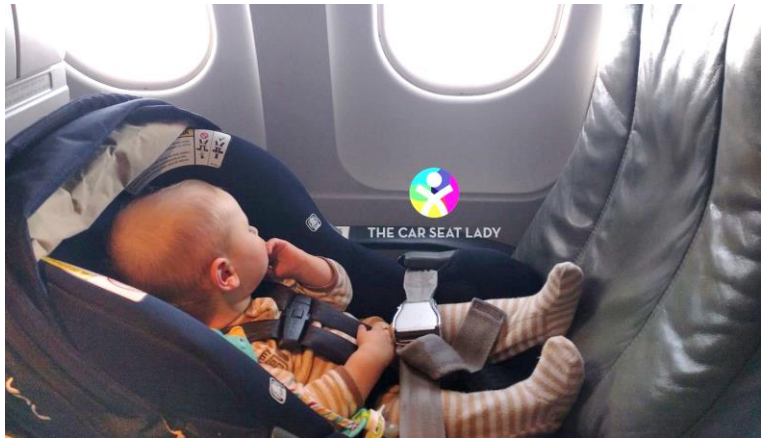


Which specific geometric factors might make CRS installation difficult or impossible on aircraft seats?

Image:thecarseatlady.com

OBJECTIVE AND SPECIFIC AIMS

Long term objective: Facilitate higher rates of CRS use on airplanes by alleviating compatibility concerns between CRS and aircraft seats and belts.

Specific aims:

1. Survey the physical dimensions and lap belt characteristics of modern commercial aircraft (Goal: 8-10 aircraft environments)
2. Compare the aircraft seating characteristics to the physical geometry of modern CRS to identify issues with compatibility.
   - Also compare aircraft seat dimensions to modern vehicle seat dimensions
3. Inform guidelines for families who are preparing to fly with a CRS

APPROACH

- Research team presented project outline to the SAE Aircraft Seat Committee
  - Committee leader: Kevin Walsh (Boeing)
  - Seat OEMs, aircraft OEMs, airline reps, researchers, regulators
- Scope decisions:
  - Each respondent provided data on their company's:
    - Regional jet
    - Narrow body aircraft
    - Wide body aircraft
  - Economy and premium seats
  - Focus on US domestic aircraft specifications
- Sent each aircraft seat OEM a blank spreadsheet with instructions to collect ~13 measurements.

APPROACH

- Spreadsheet returned by two major seat manufacturers
  - Collins Aerospace
  - Recaro Aircraft Seating
- Full data for 8 seats total, plus some extra miscellaneous dimensions

Seat #	Manufacturer	Aircraft type	Seat class	Seat identifiers
1	Collins	Regional Jet	Economy	Meridian
2	Recaro	Narrowbody	Economy	BL3530, STD
3	Recaro	Narrowbody	Premium	CL4710, STD
4	Collins	Narrowbody	Economy	Meridian
5	Recaro	Widebody	Economy	CL3710, IAT
6	Recaro	Widebody	Economy	CL3710, STD
7	Recaro	Widebody	Premium	PL3530, IAT
8	Collins	Widebody	Economy	Aspire

METHODS: AIRCRAFT SEAT MEASUREMENTS

1. Width between arm rests at narrowest point
2. Can arm rests be raised?
3. Height from seat cushion to top of arm rest:

   3a. Near seat bight

   3b. Near edge of seat

METHODS: AIRCRAFT SEAT MEASUREMENTS

4. Height from seat cushion to bottom of head rest, along the recline of seat back

5. Height from seat cushion to top of seat, along the recline of seat back

METHODS: AIRCRAFT SEAT MEASUREMENTS

6. Length of seat cushion, along centerline

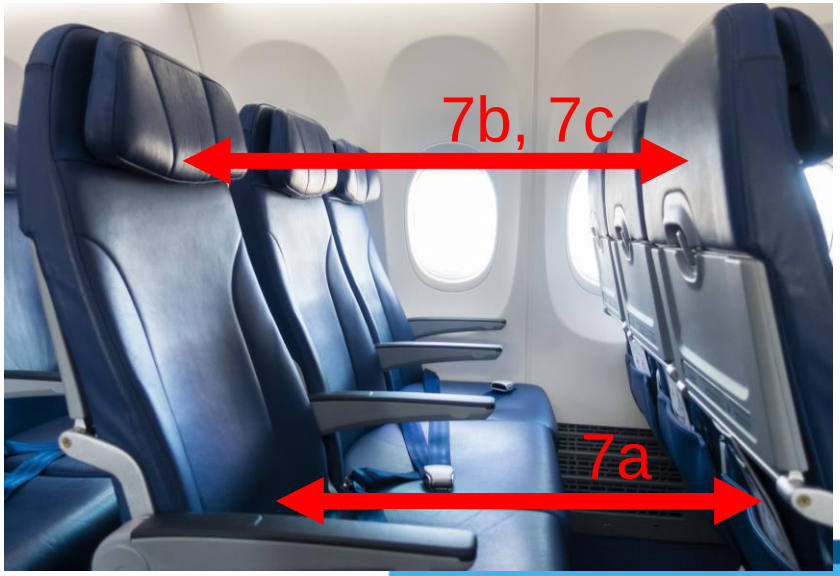
METHODS: AIRCRAFT SEAT MEASUREMENTS

7. Pitch (fore/aft clearance)

   7a. Along bottom of seat cushion

   7b. Approximately halfway up the seat

   7c. Repeat 7b with front seat fully reclined



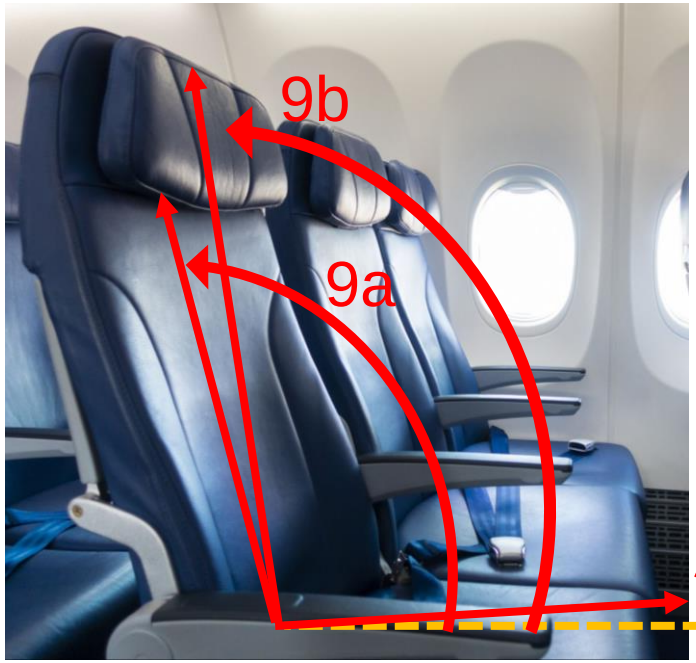
METHODS: AIRCRAFT SEAT MEASUREMENTS

8. Angle of seat cushion from horizontal

9. Angle of seat back from horizontal:

    9a. Underneath head rest

    9b. Over top of head rest



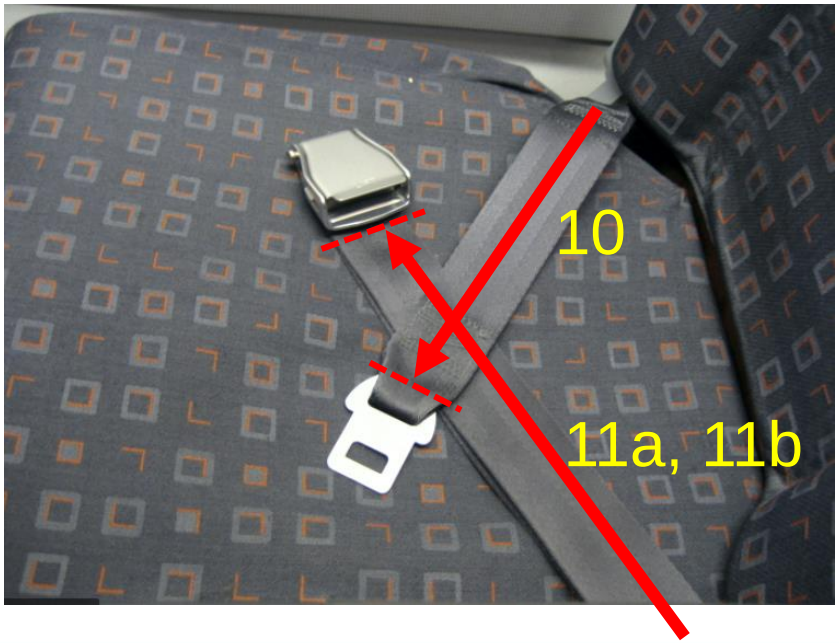
METHODS: AIRCRAFT BELT MEASUREMENTS

10. Length from seat cushion to bottom part of latch plate (include webbing only)

11. Length from seat cushion to bottom part of buckle (include webbing only)

11a. Fully shortened

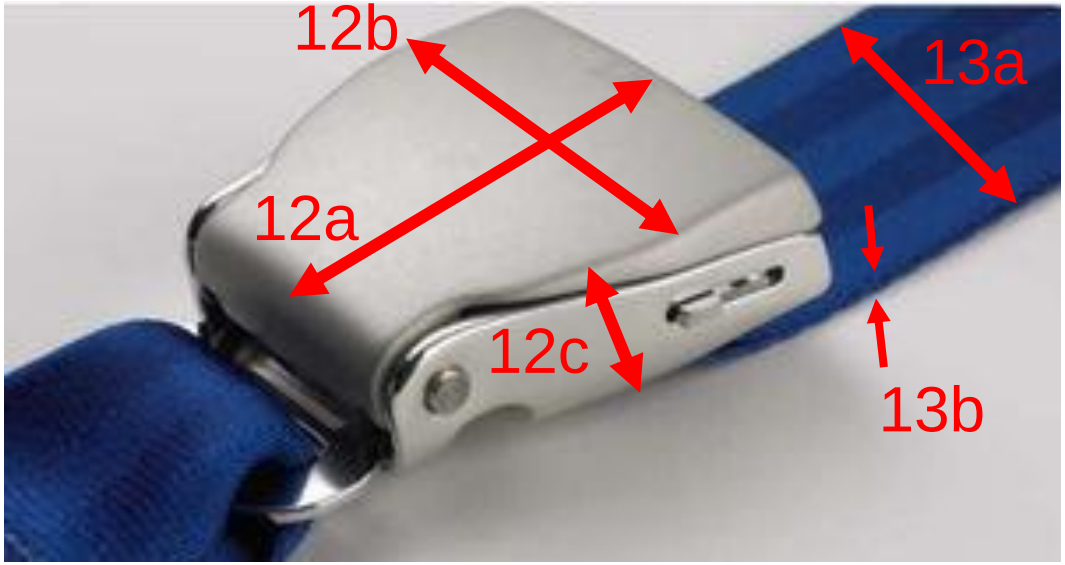
11b. Fully lengthened



METHODS: AIRCRAFT BELT MEASUREMENTS

12. Size of buckle (measure all at thickest point)
    - 12a. Length
    - 12b. Width
    - 12c. Height

13. Size of webbing
    - 13a. Width
    - 13b. Thickness (measure with calipers, if possible)



DATA ANALYSIS

- Similar methodology completed in:

TRAFFIC INJURY PREVENTION
2018, VOL. 19, NO. 4, 385–390
https://doi.org/10.1080/15389588.2017.1417594

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Check for updates

Compatibility of booster seats and vehicles in the U.S. market

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Injury Biomechanics Research Center, School of Health and Rehabilitation Sciences, The Ohio State University, Columbus, Ohio

40 CRS
95 vehicle seats

Traffic Injury Prevention (2015) **16**, S1–S8
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DOI: 10.1080/15389588.2015.1061663

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Investigation of Child Restraint System (CRS) Compatibility in the Vehicle Seat Environment

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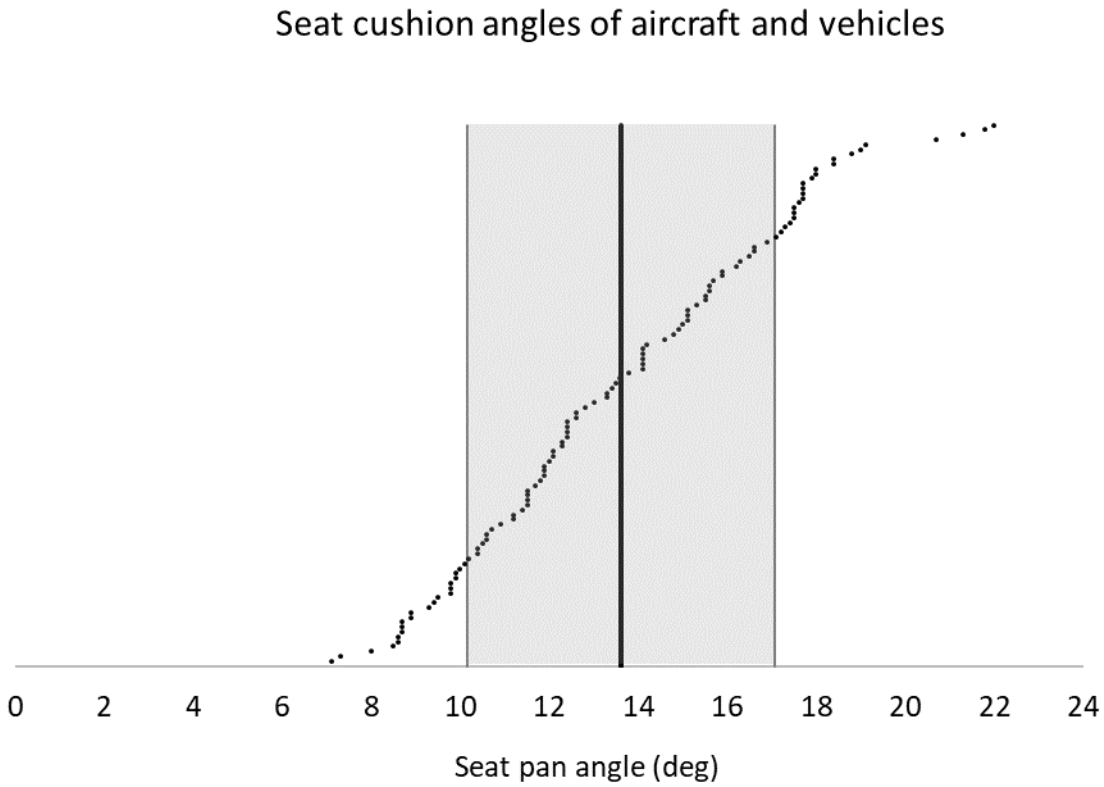
Injury Biomechanics Research Center, Division of Anatomy, The Ohio State University, Columbus, Ohio

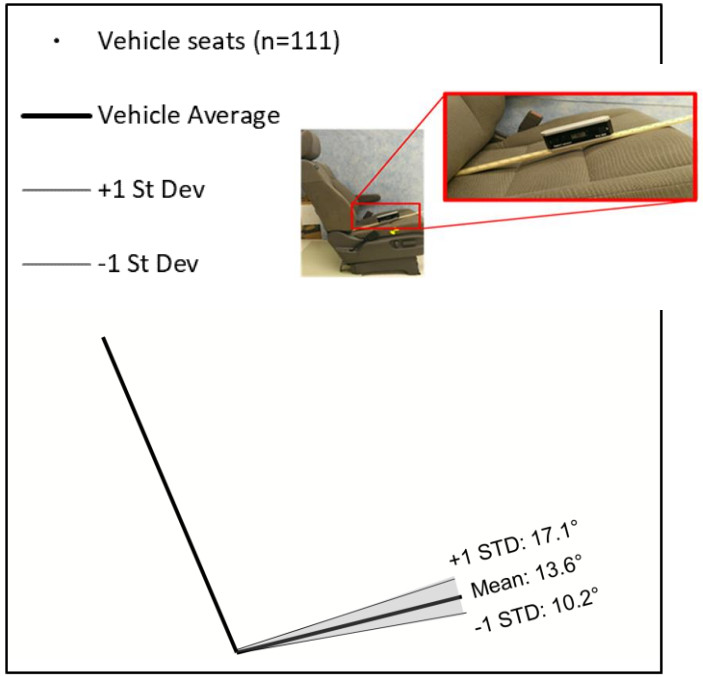
59 CRS
61 vehicle seats

DATA ANALYSIS

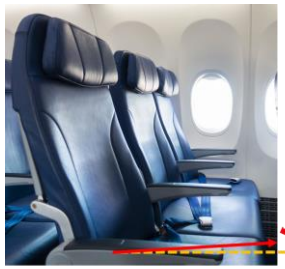
- Two approaches:
  1. **Compare aircraft seats to CRS**
     - Direct research question
  2. **Compare aircraft seats to vehicle seats**
     - Valuable to understand differences in seat types

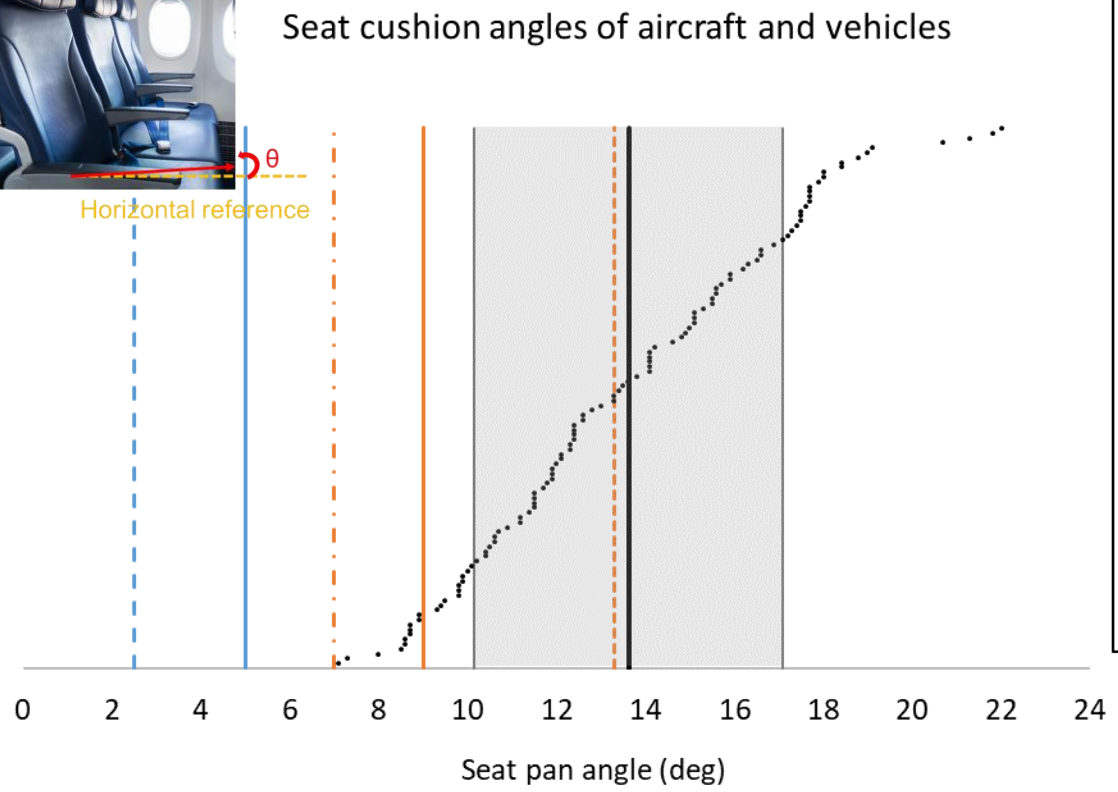
RESULTS: SEAT CUSHION ANGLE

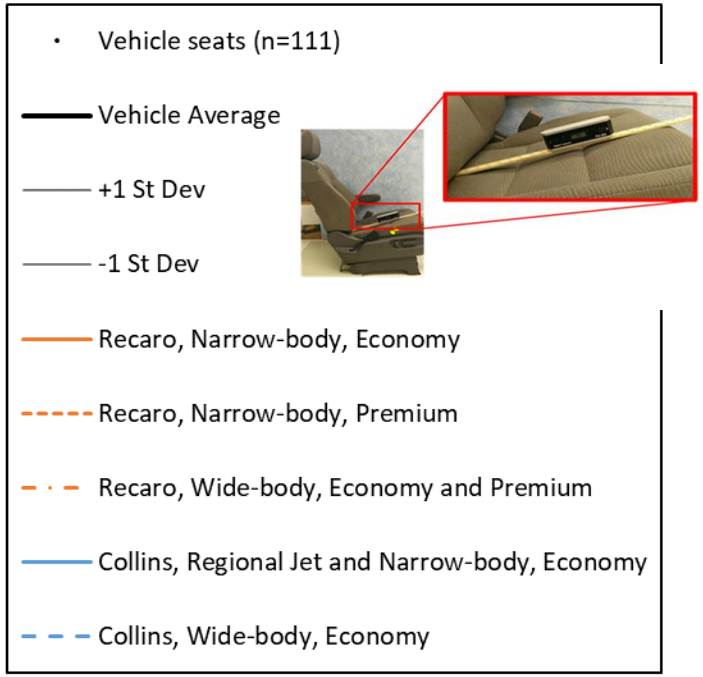




RESULTS: SEAT CUSHION ANGLE







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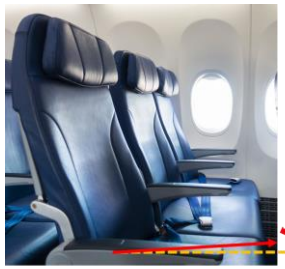
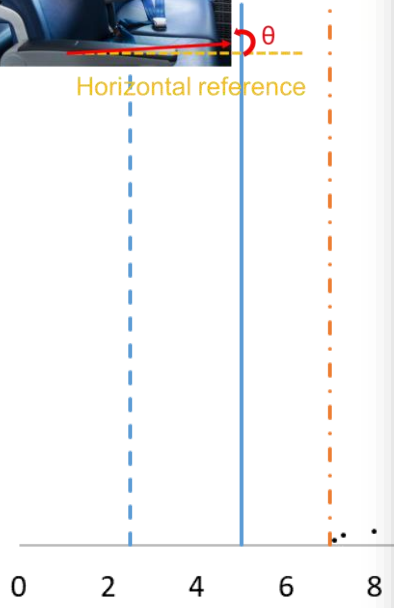




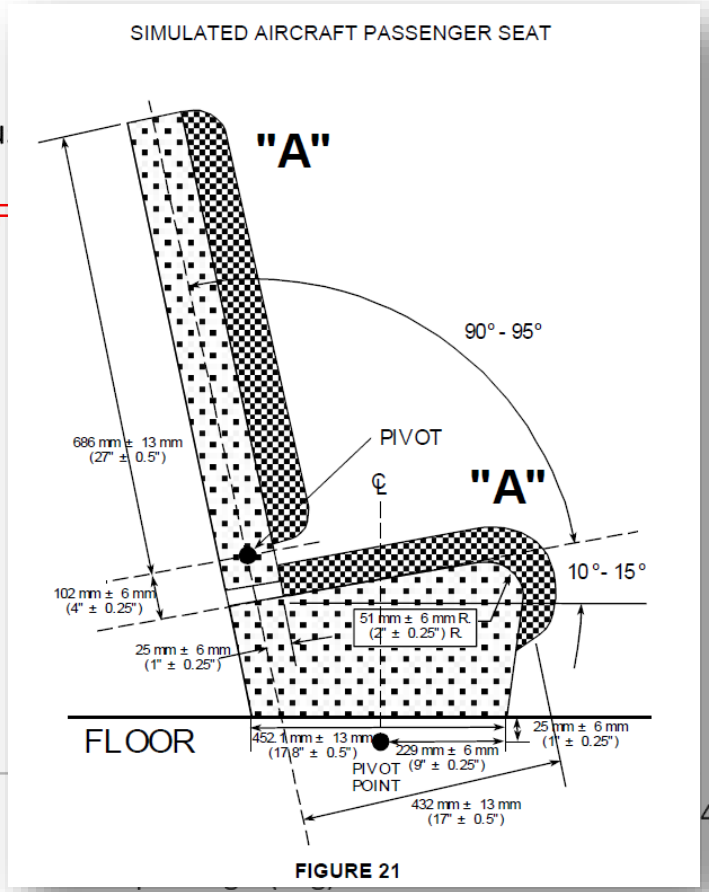
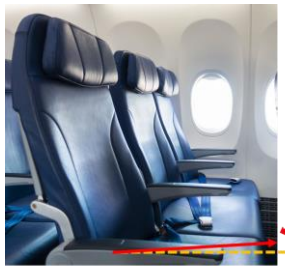
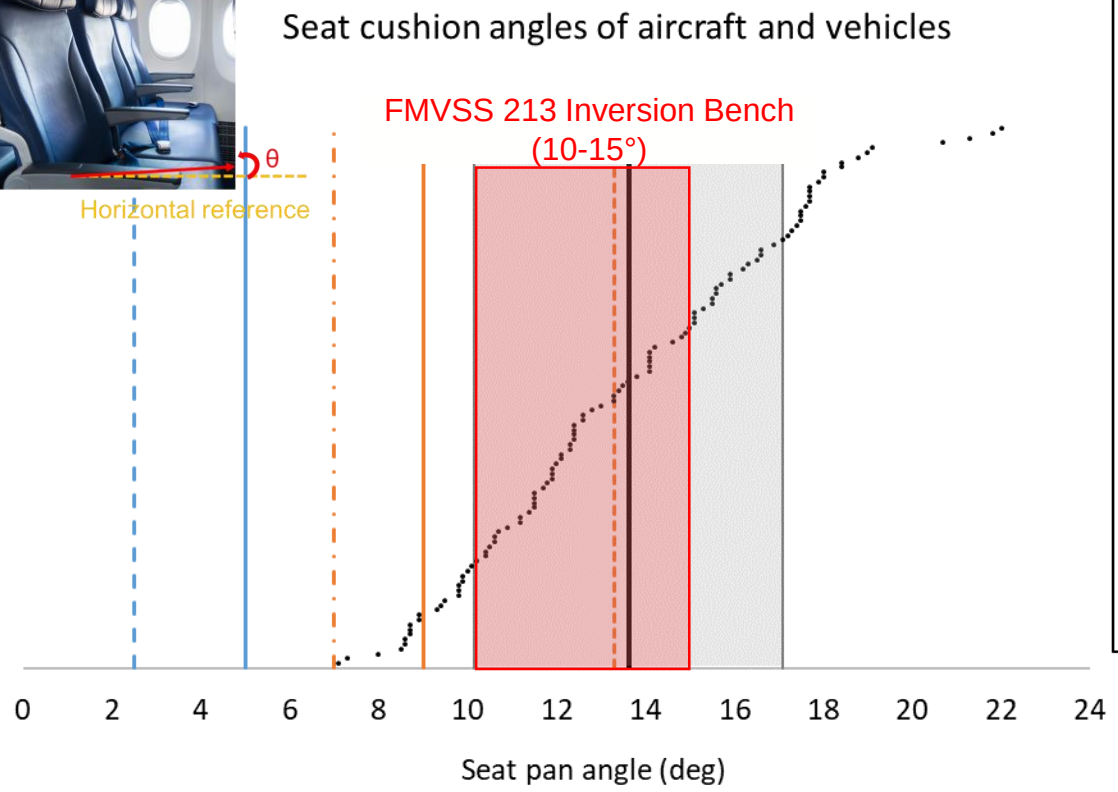


FIGURE 21

- Vehicle seats (n=111)
- Vehicle Average
- +1 St Dev
- -1 St Dev
- Recaro, Narrow-body, Economy
- Recaro, Narrow-body, Premium
- Recaro, Wide-body, Economy and Premium
- Collins, Regional Jet and Narrow-body, Economy
- Collins, Wide-body, Economy

RESULTS: SEAT CUSHION ANGLE





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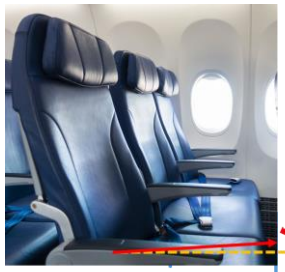
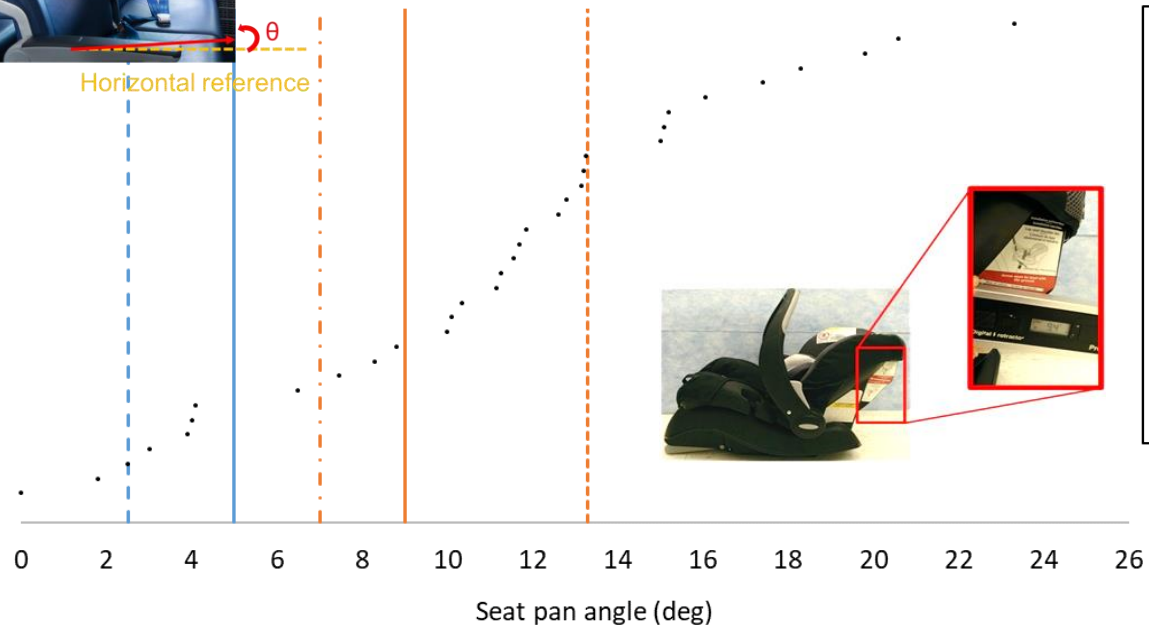
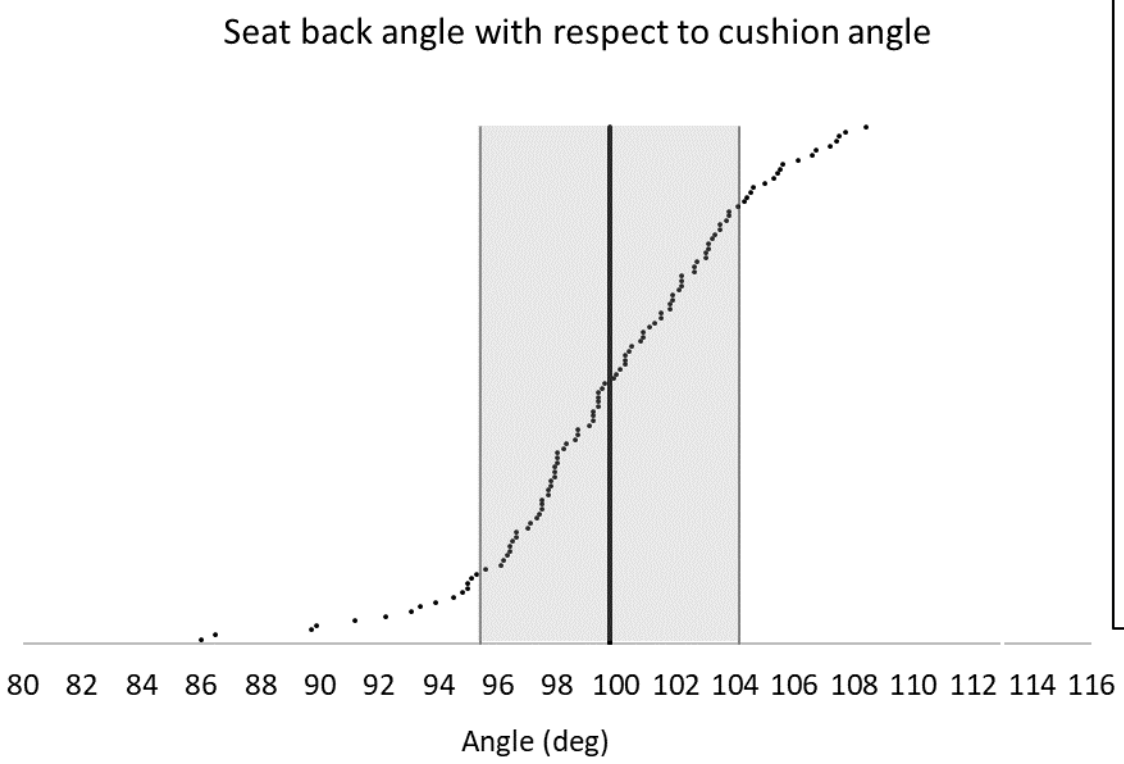
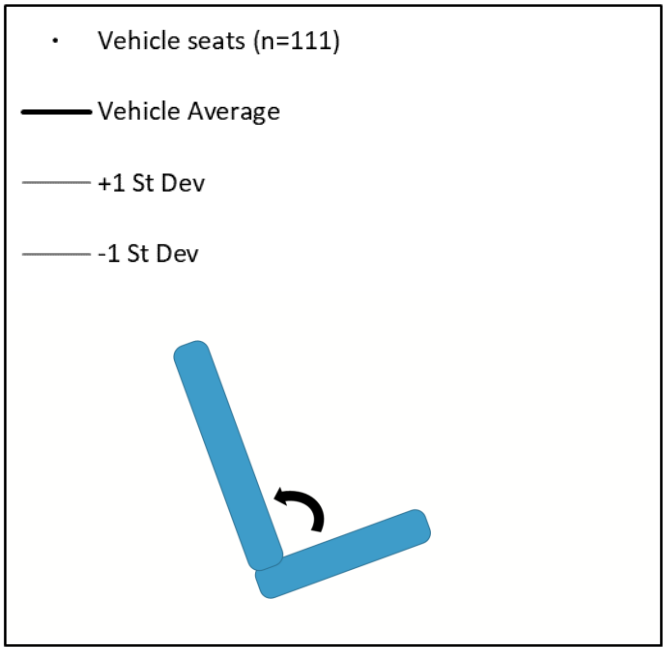


Seat cushion angles of aircraft and RF CRS



RESULTS: SEAT BACK ANGLE





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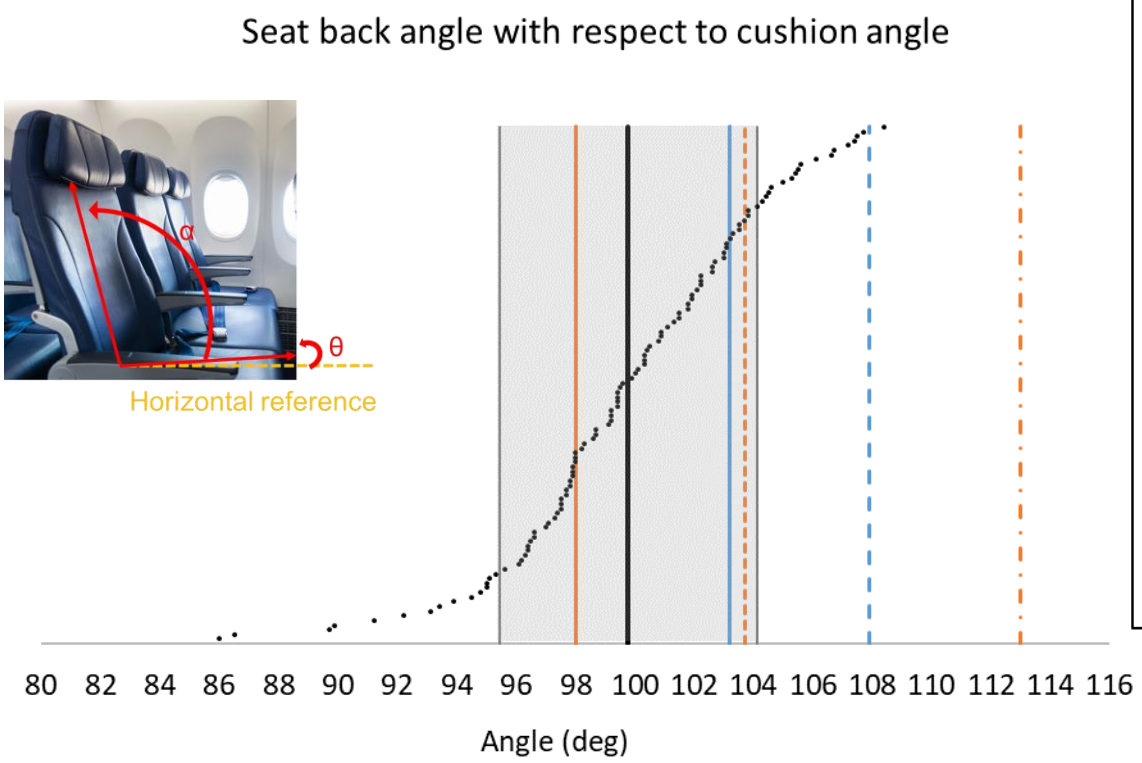

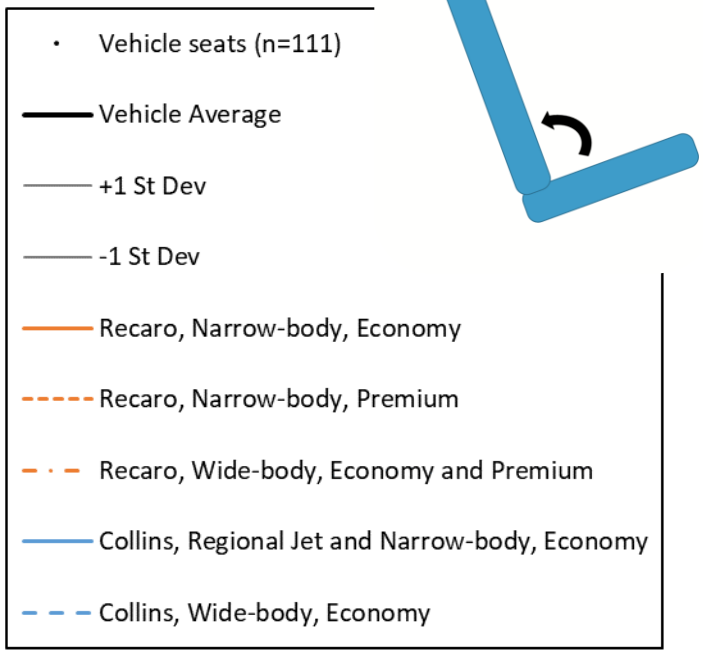

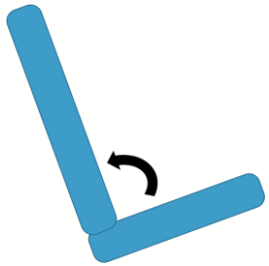

RESULTS: SEAT BACK ANGLE

Horizon

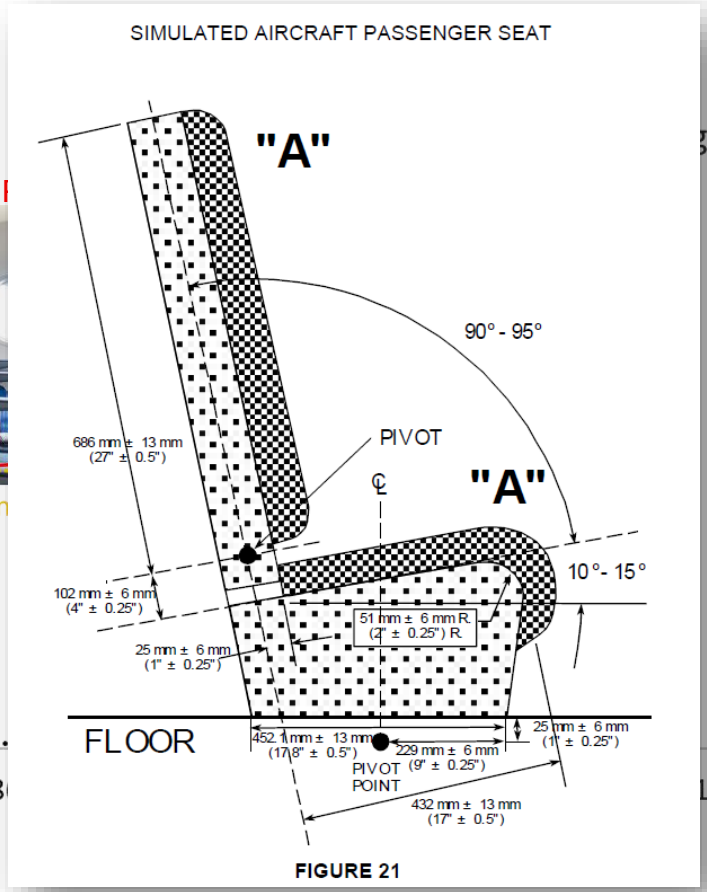

FIGURE 21

gle

80 82 84 8

110 112 114 116

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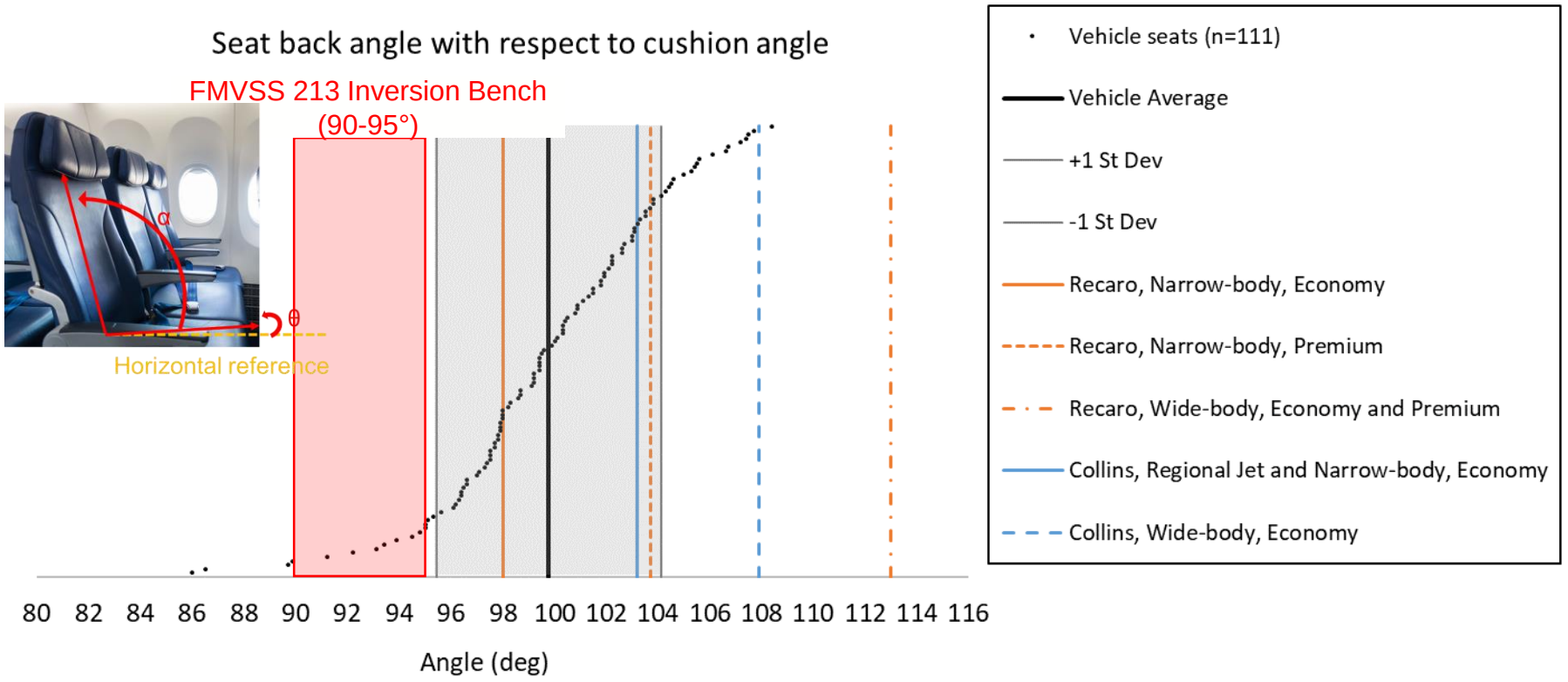

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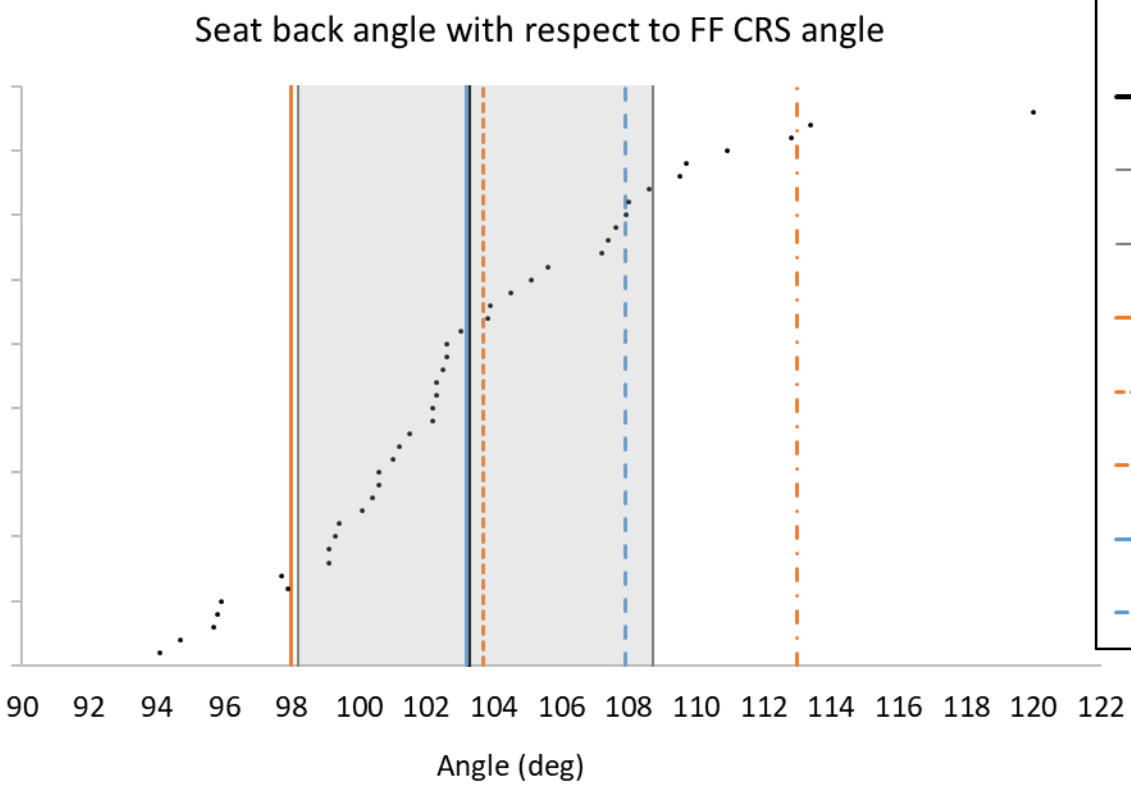
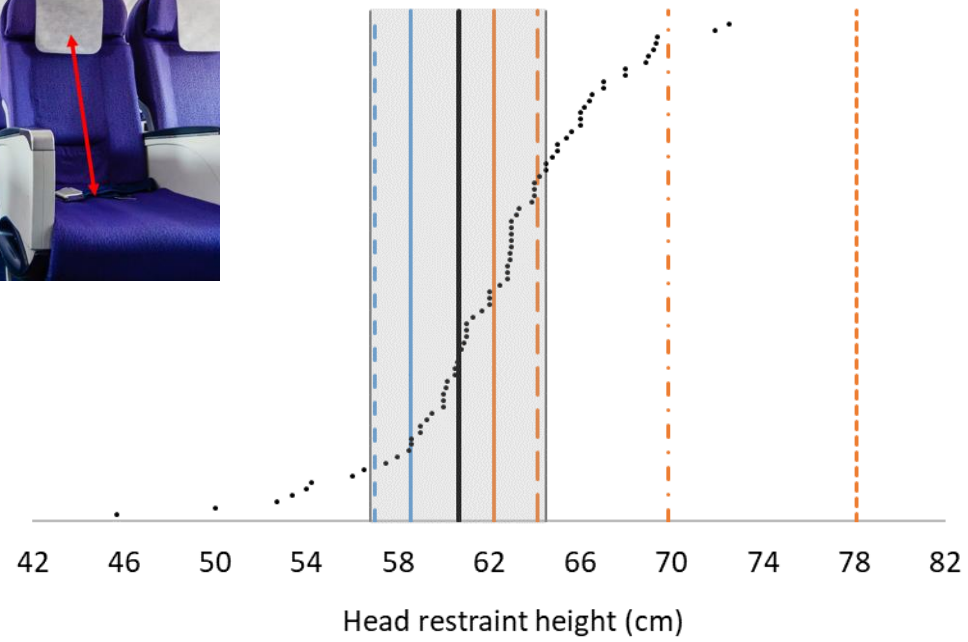


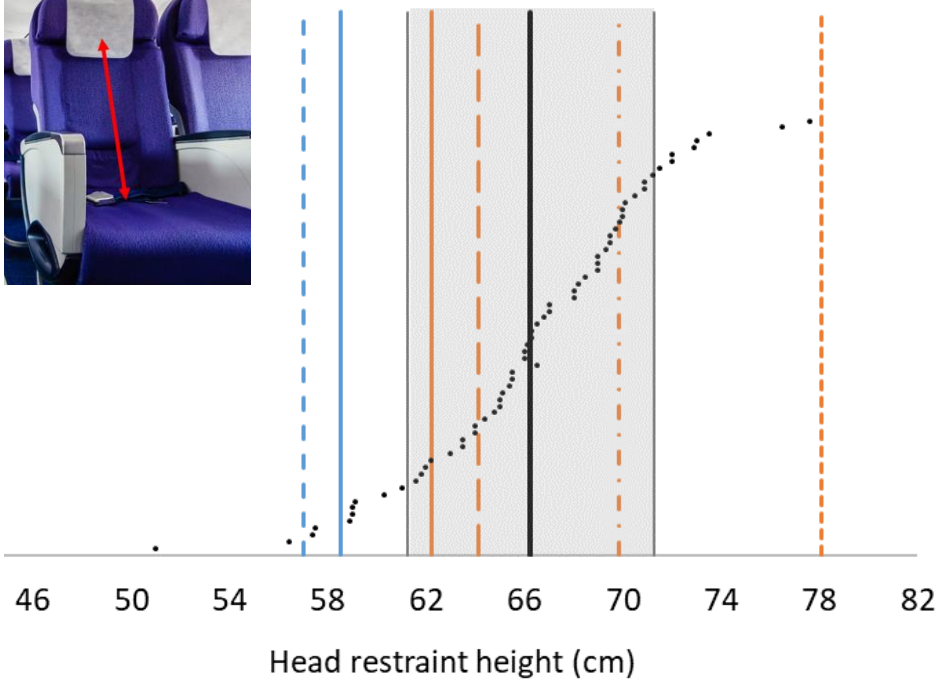
RESULTS: HEAD RESTRAINT HEIGHT



n=204 vehicles total
n=78 non-removable HRs

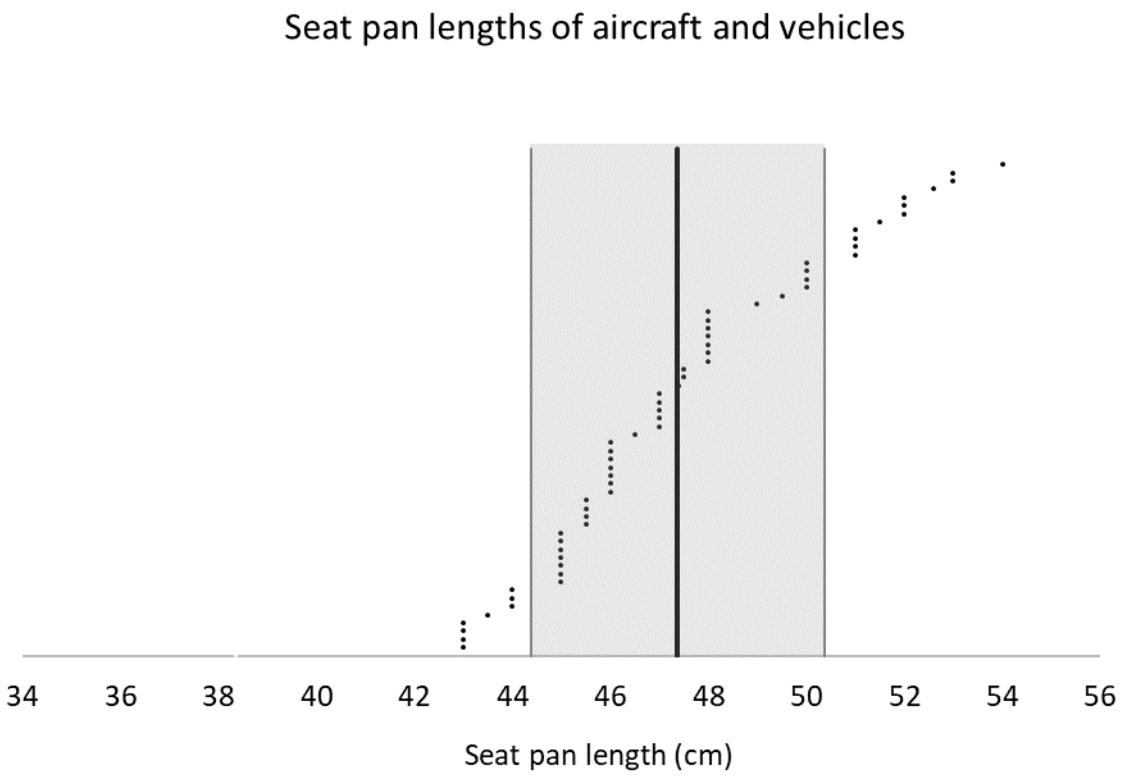
RESULTS: HEAD RESTRAINT HEIGHT

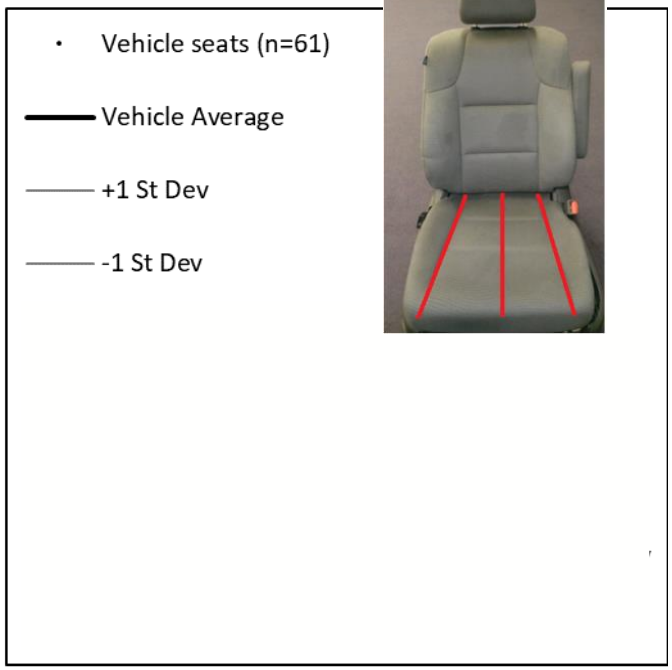
Head restraint heights of aircraft and FF CRS



- FF CRS heights (n=64)
- FF CRS Average
- +1 St Dev
- -1 St Dev
- Recaro, Narrow-body, Economy (raised)
- Recaro, Narrow-body, Premium (raised)
- Recaro, Wide-body, Economy (raised)
- Recaro, Wide-body, Premium (raised)
- Collins, Regional Jet and Narrow-body, Economy (not raised?)
- Collins, Wide-body, Economy (not raised?)

RESULTS: SEAT CUSHION LENGTH





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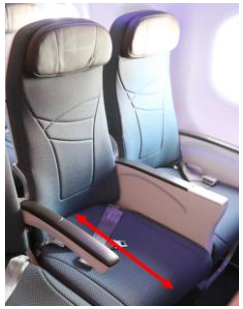

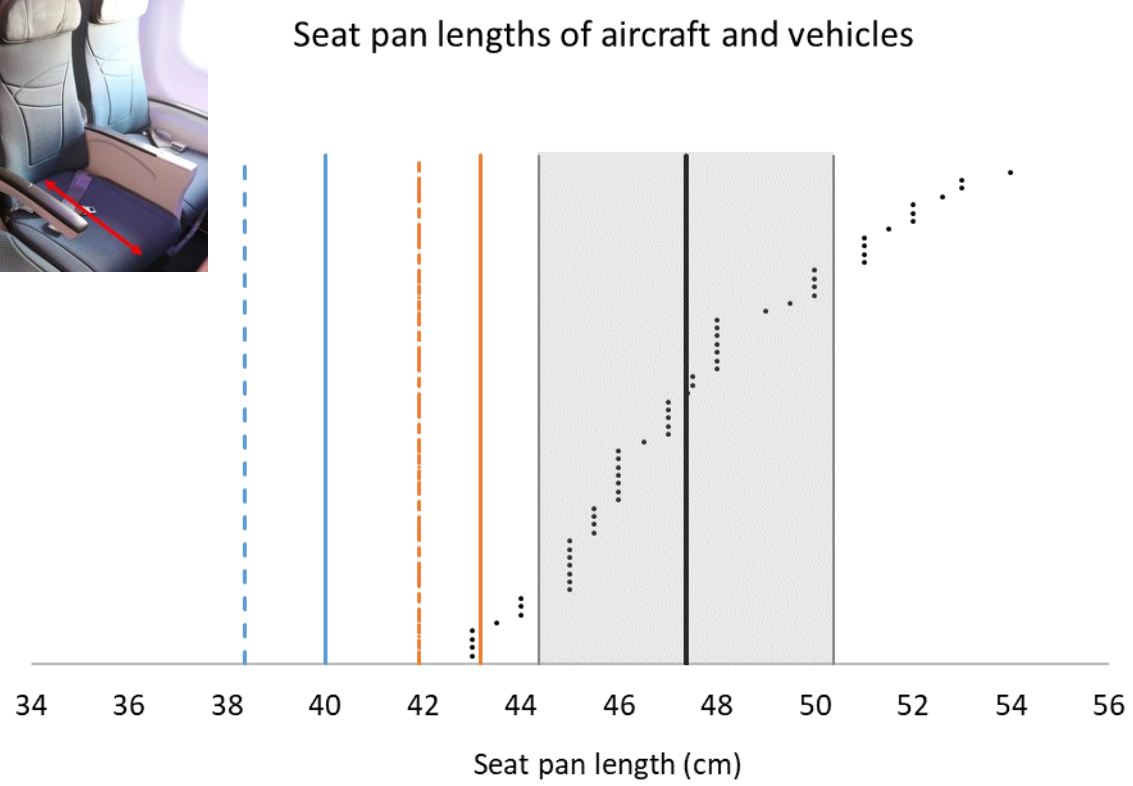

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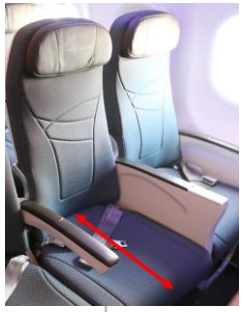
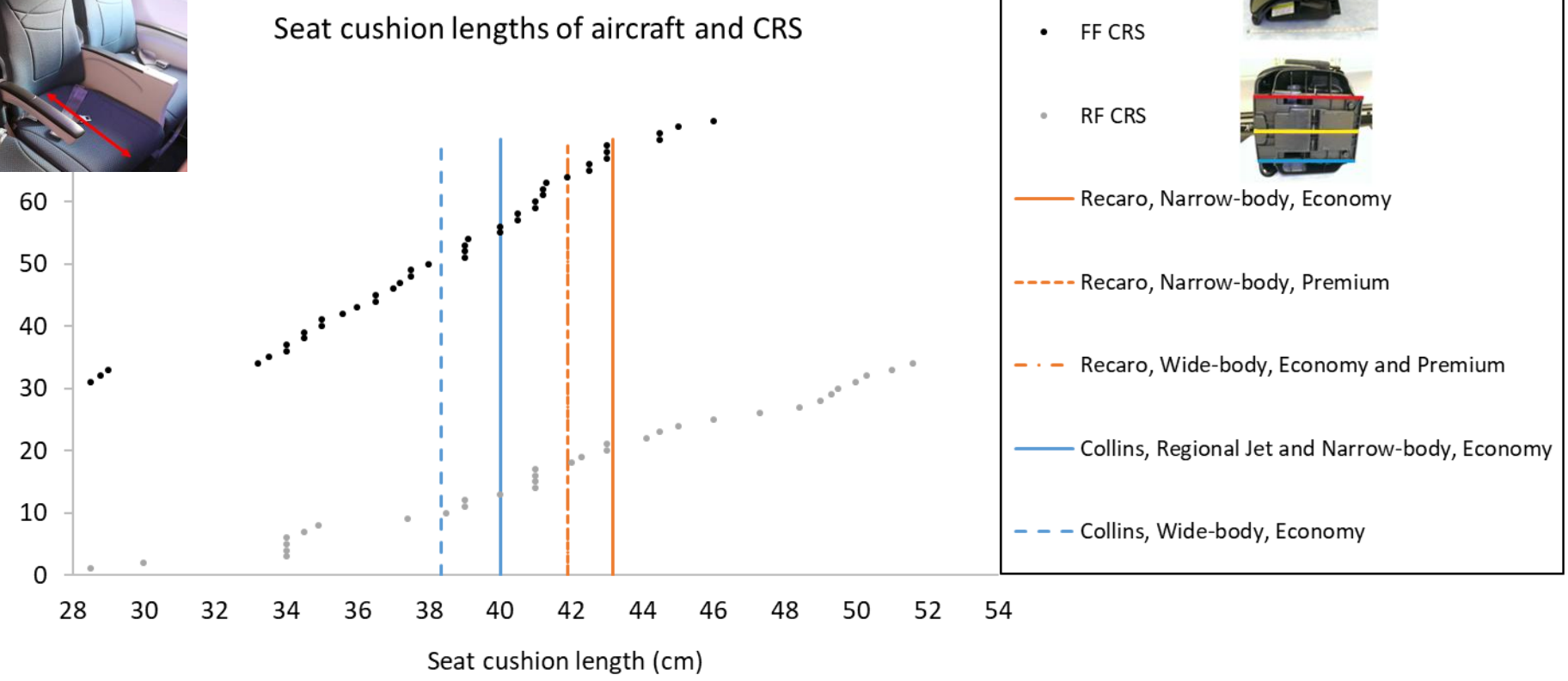




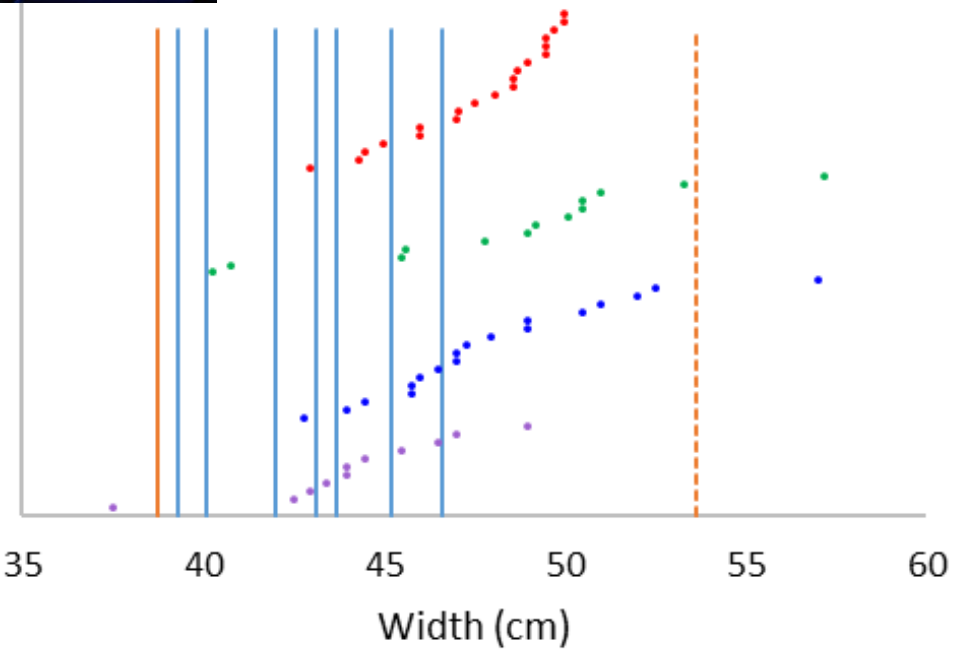
RESULTS: SEAT WIDTH

Aircraft: Width at narrowest point between arm rests

CRS: Width at widest point of base, back, or arm rests

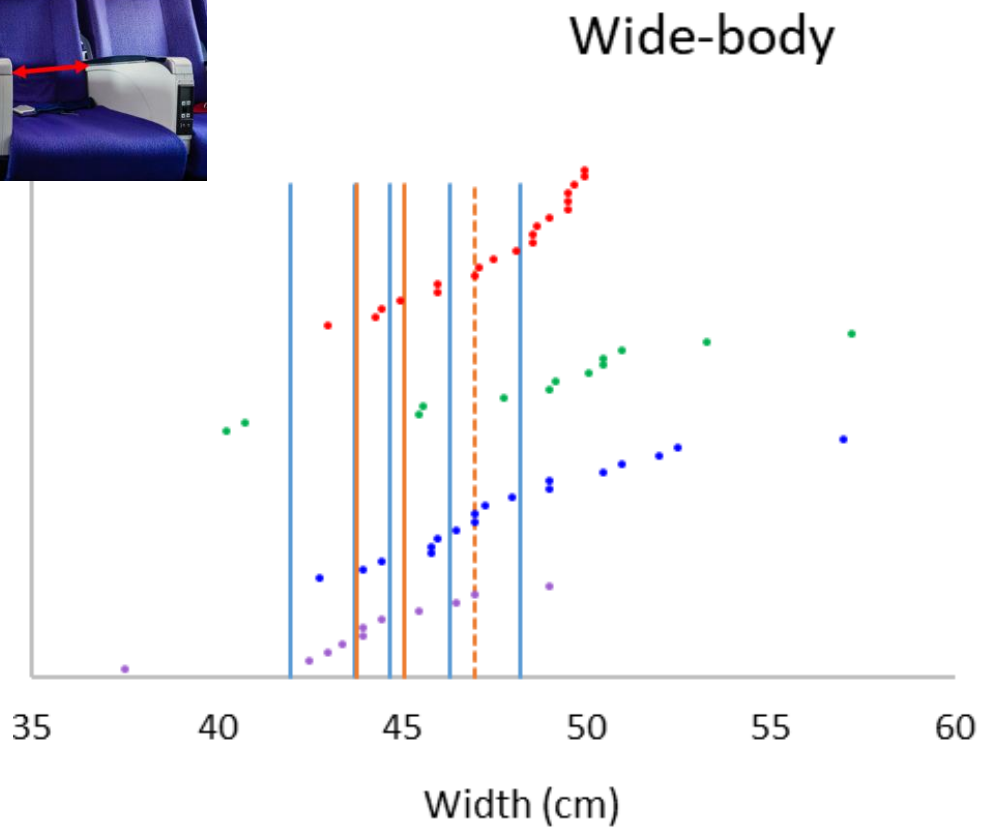
n=62 CRS

RESULTS: SEAT WIDTH



n=62 CRS

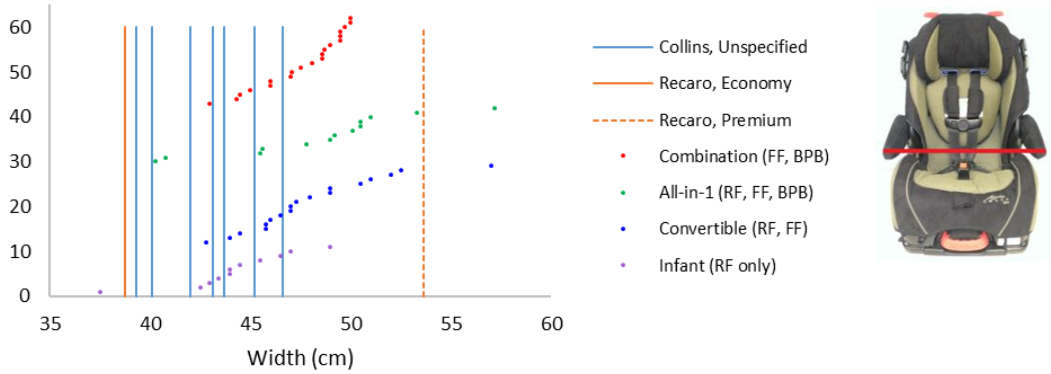
RESULTS: SEAT WIDTH



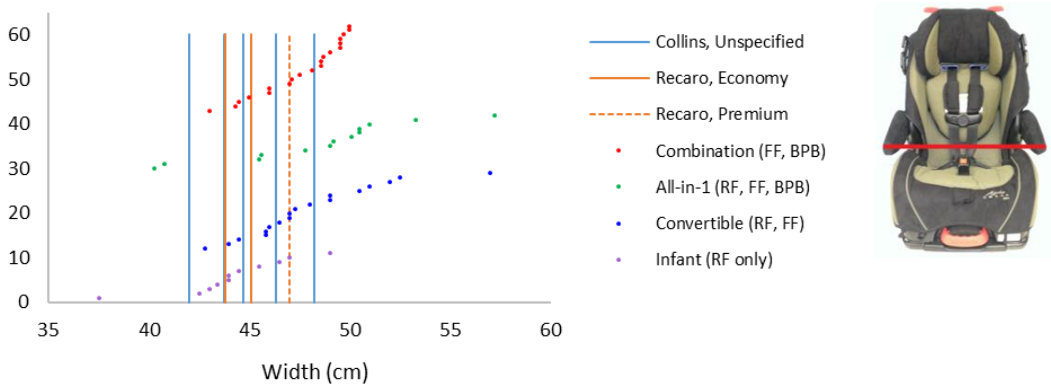
n=62 CRS

RESULTS: SEAT WIDTH

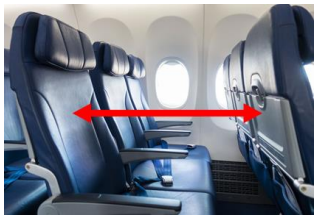
Regional Jet and Narrow-body

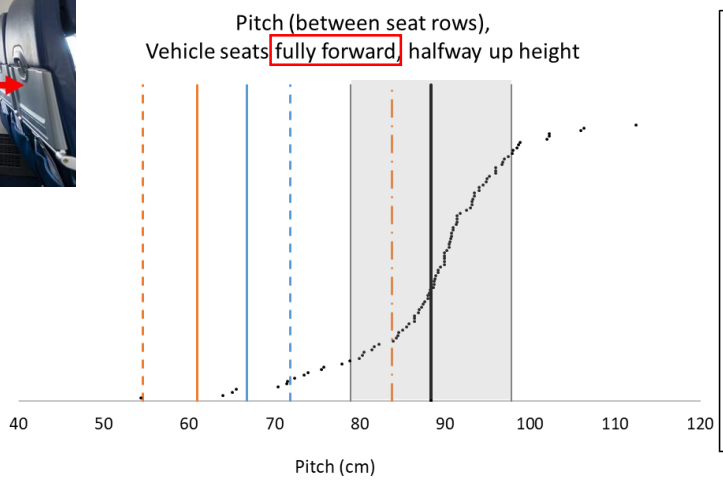


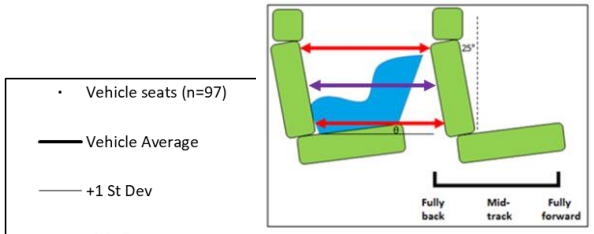
Wide-body

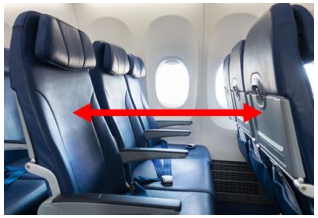


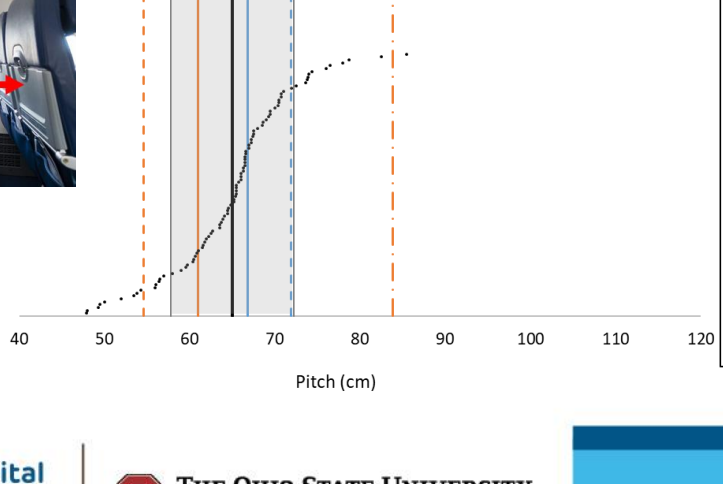
RESULTS: PITCH

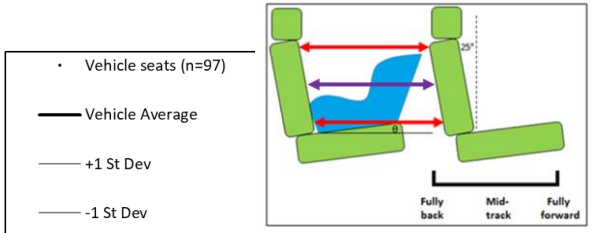




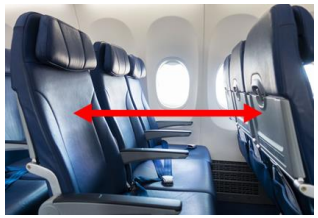


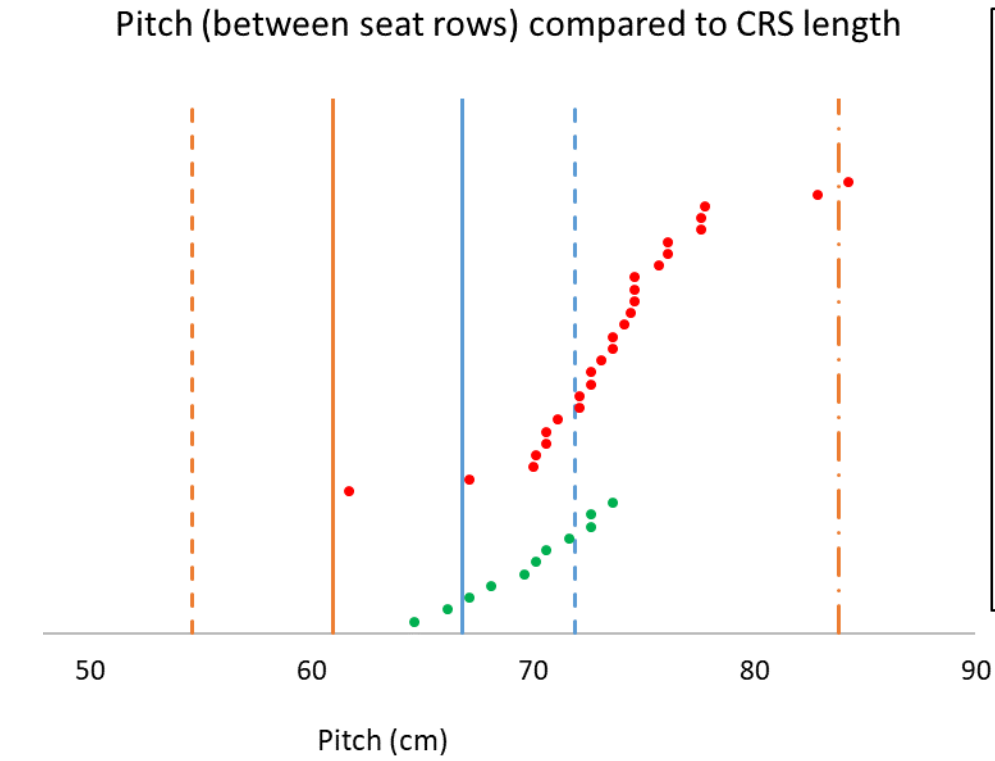




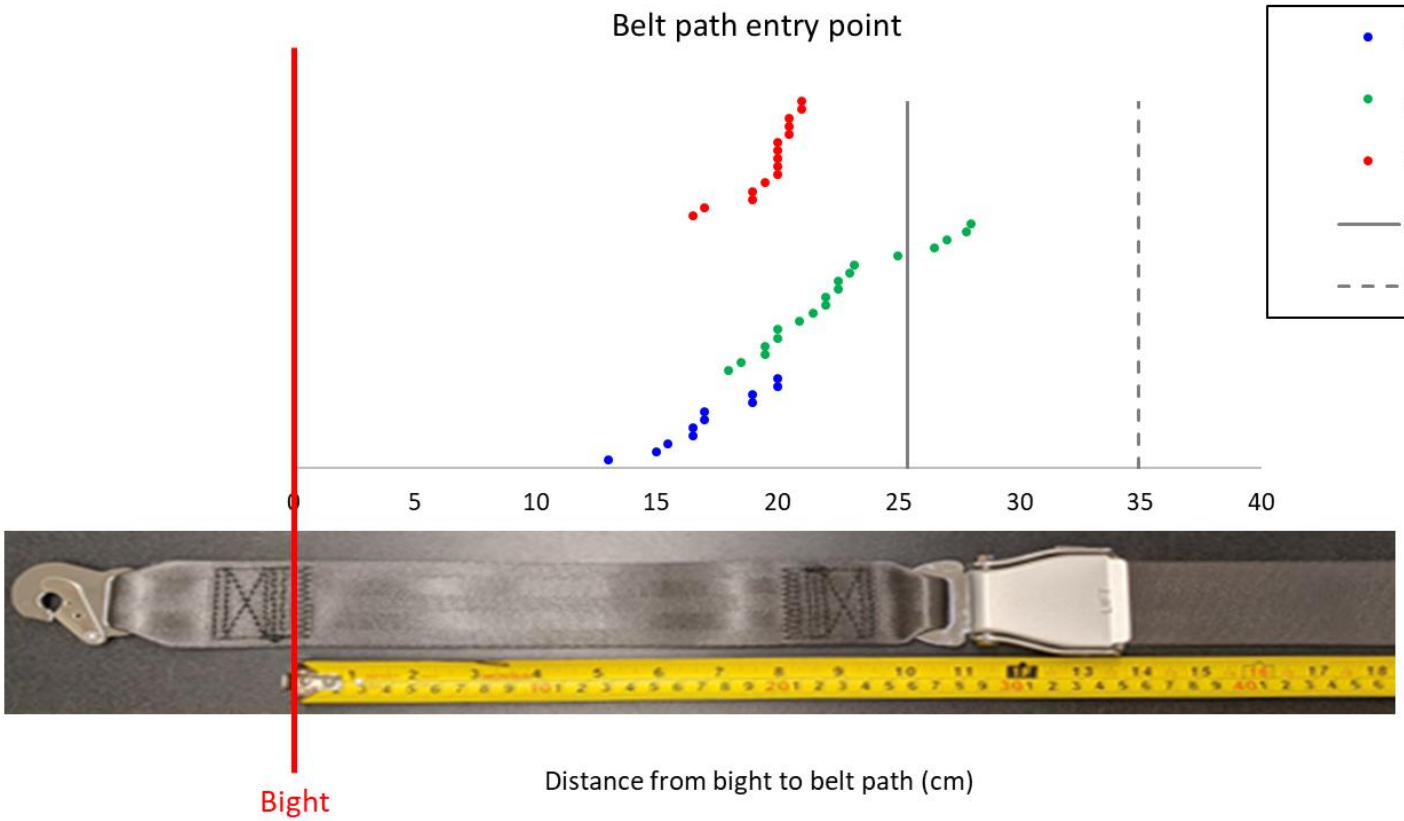


RESULTS: PITCH





RESULTS: SEAT BELT



CONCLUSIONS

- Main areas of potential issues:
  - Pitch (fore/aft clearance) for RF CRS
    - Aircraft smaller than vehicles
  - Seat cushion length
    - Aircraft shorter than vehicles
  - Width between arm rests
    - Different arrangement than vehicles
  - Seat cushion (pan) angle
    - Aircraft more horizontal than vehicles

CONCLUSIONS

- The data presented here can be used as a reference or benchmark for industry, CRS manufacturers, and/or families.
  - Full report submitted to FAA through CChIPS.
  - Publication or other public availability forthcoming.

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Compatibility of Child Restraint Systems (CRS) with Commercial Aircraft Seats

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