U.S. Head Restraint Measurement Variability Study

Head Restraint Informal Working Group GTR Meeting
Cologne, Germany
**January 23-26, 2006**

Draft

NHTSA

Goal of Study

- **To understand the expected variation in measurement ranges when using multiple compliance laboratories.**

  - Explicitly designed to exclude seat build variability by measuring the same set of seats at all laboratories.

  - Attempted to excluded seat setup variability

  - Explicitly included variability associated with using different SAE J826 manikins and ICBC devices.
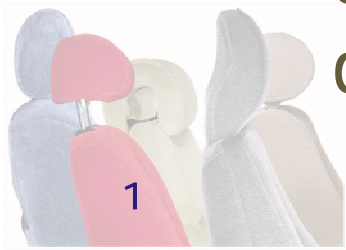
Summary

- **3 laboratories with different levels of experience**
  - Each Lab used a different J826 manikin
  - Lab 2 and 3 used the same ICBC device
- **10 2005 MY vehicles (20 seats) measured**
  - 8 vehicles (16 seats) for Lab to Lab comparison
    - Lab 1 and Lab 2 measured the same 4 seats
    - Lab 2 and Lab 3 measured the same 12 seats
- **2 additional vehicles for within Lab comparison**
  - Lab 1 and 2 each measured an additional vehicle
- **Driver and passenger seat measured in each vehicle, but not compared to each other**
- **Each seat measured at least 3 times**
- **Backset measured in every position of head restraint adjustment**
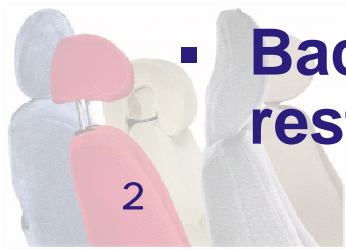
Measurement Procedure

- **NHTSA draft compliance test procedure was used to set up the seat, install the manikin, and take the measurement (TP-202aS-00, HR-3-9)**

  - Seat setup was the same for each vehicle in every lab

    – Seat back angle was not always 25 degrees due to a need to match existing test data.

  - Adjustable seat cushion angles were set so the front of the cushion was in the lowest position with respect to the rear

    – Not strictly positioned according to procedure, but it allowed for a quicker seat set up.

Single Lab Range

- **The largest backset measurement range for a single lab was 21 mm ($\pm$ 10.5 mm)**
  - Lab 2, Chevrolet Equinox
  - Technician inexperience led to inconsistent manikin installation
    - Because of seat build technician could either maintain level manikin base or longitudinal orientation, not both.
- **The next largest was 7 mm ($\pm$3.5 mm)**
  - Lab 2, Nissan Altima
  - Lab 3, Chevrolet Equinox
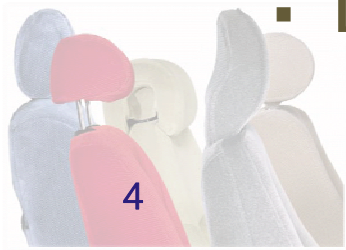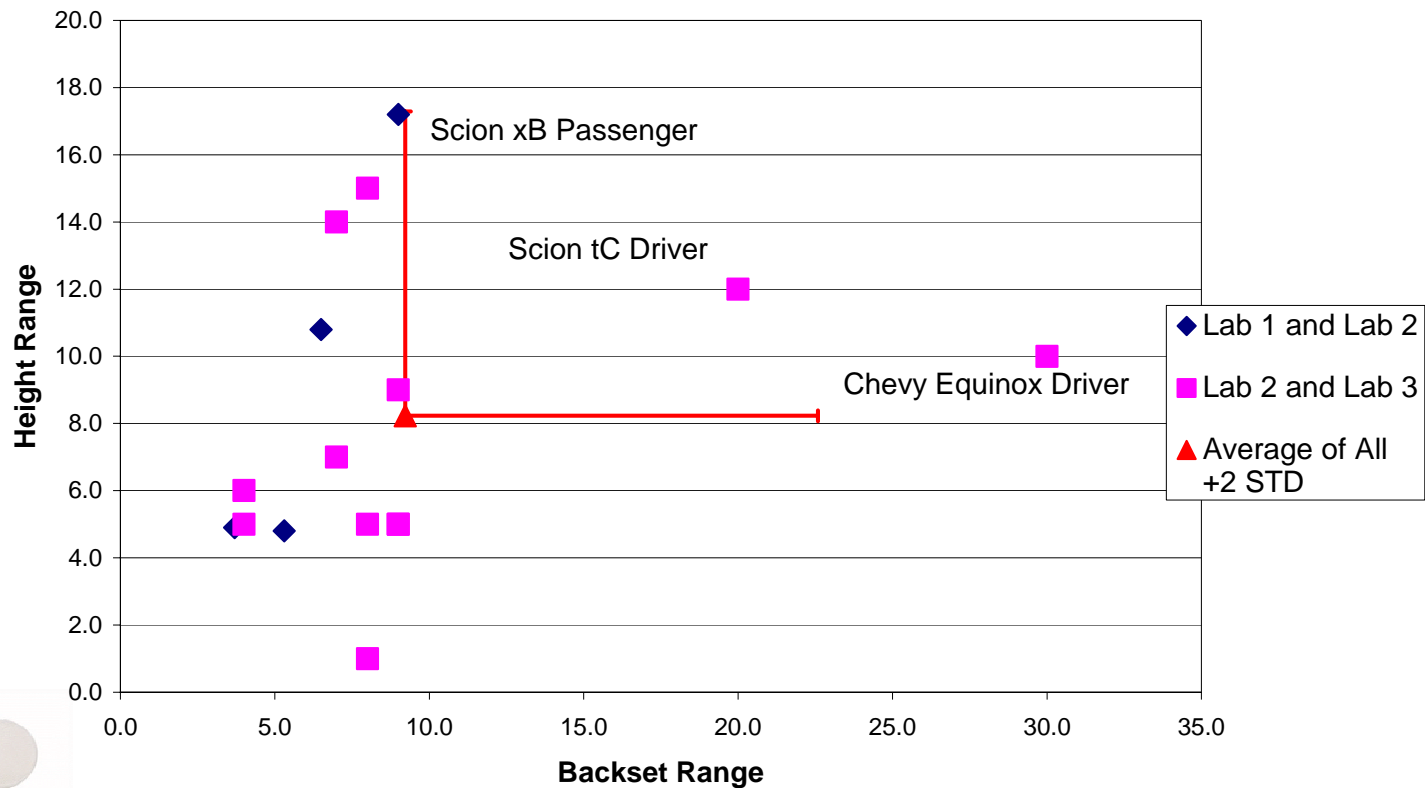
Lab to Lab Range

- **Largest Backset Range**
  - 30 mm (±15 mm) for Chevrolet Equinox driver seat
  - Next largest was 20 mm (±10 mm) for Scion tC driver seat

- **Largest Backset Range using average of 3 measurements**
  - 17.7 mm (±8.9 mm) for Scion tC driver seat
 - Next largest was 7.5 mm (±3.8 mm) for Chevrolet Equinox driver seat

Maximum lab-to-lab measurement range for backset and height

**Combined Lab Data Comparison -
Max Measured Range for Each Seat
and All Head Restraint Position**

Maximum range of lab average measurements for each seat

Lab to Lab Comparison -
Range of Average Measurments from Each Lab for
Each Seat and Head Restraint Position
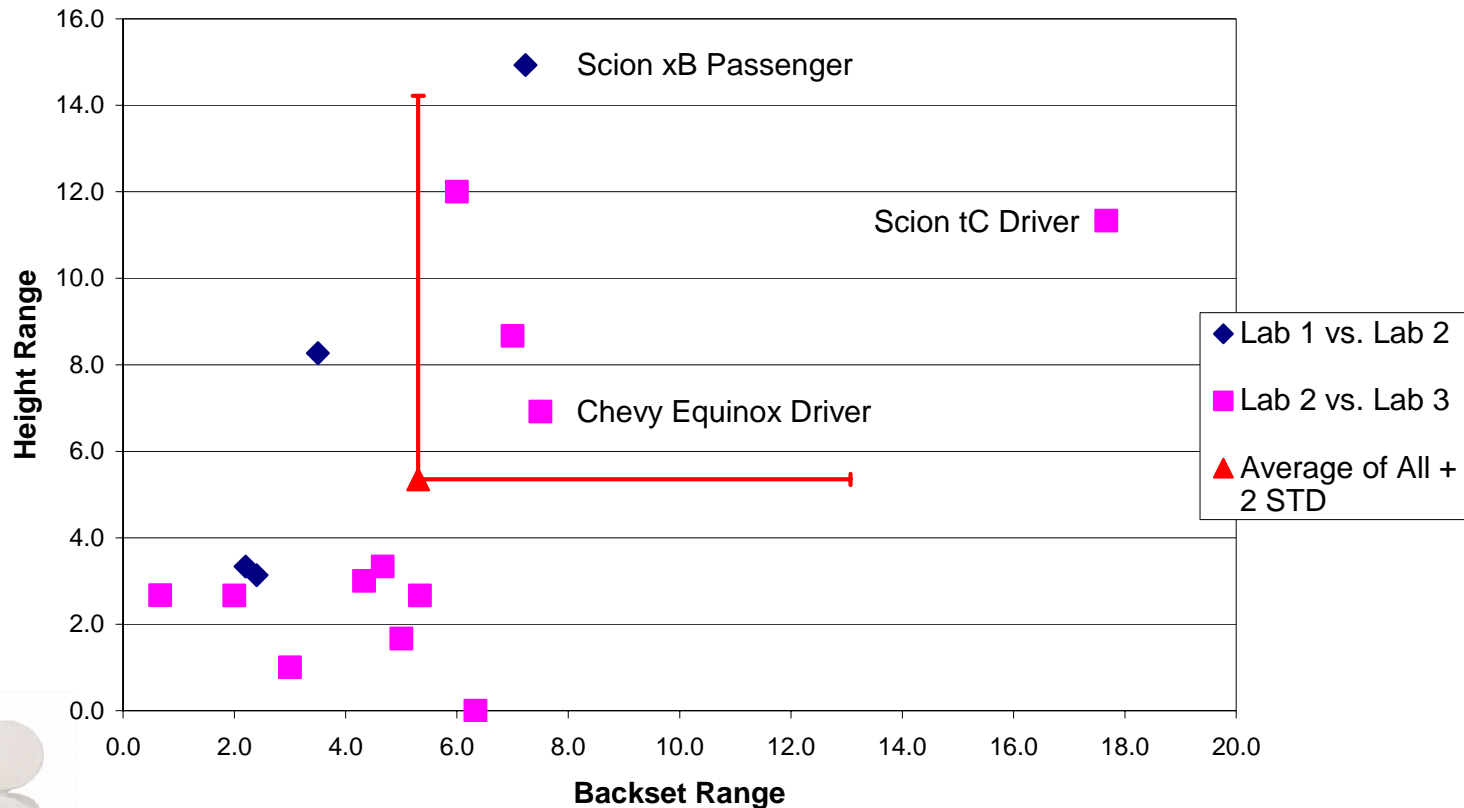
Backset Measurement Maximum Seat Range

	Max Range	Min Range	Average Range	s.d.	Avg. +2s.d.	Avg. +3s.d.
Lab 1 All Seats	3.0	0.8	2.1	0.7	3.5	4.3
Lab 2 All Seats	21.0	1.0	4.8	4.4	13.6	17.9
Lab 3 All Seats	7.0	1.0	3.3	1.6	6.6	8.2
Max Range All Seats	30.0	3.7	9.2	6.7	22.6	29.3
Range of Lab Avg. All Seats	17.7	0.7	5.3	3.9	13.1	17.0

NHTSA

Backset Measurement Variability

Measurement Iterations	Level of Certainty	
	2s.d.	3s.d.
1	±11.3 mm	±14.7 mm
3	±6.5 mm	±8.5 mm

- **2s.d = 97.7%, 3s.d = 99.9% of measurement variability**

Backset Limit Adding Measurement Variability to 50 mm Base

Measurement Iterations	Range (mm)
1	61 – 65
3	57 – 59

Conclusions

- **Taking the average of three backset measurements reduces measurement variability**

- **Based on the NHTSA study, backset limit would need to be increased to 57-59 mm to account for measurement variability**

- **Procedural**

  - Emphasis on manikin pan leveling over longitudinal alignment when conflict exists

  - Emphasis on preventing manikin seat pan sliding during installation procedure.

- **Height and backset variability based on lab averages were very similar**

Backset Measurement Range for Each Seat

	Suzuki Forenza		Scion xB		Buick LaCrosse		Scion tC		Chrysler 300		Nissan Altima		Dodge Grand Caravan		Chevrolet Equinox		Volvo S40		Kia Rio	
	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas
Lab 1	2.0	2.2	2.5	1.8	3.0	0.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lab 2	2.0	5.0	4.0	3.0	TBD	TBD	2.0	6.0	5.0	4.0	2.0	7.0	5.0	4.0	21.0	5.0	1.0	1.0	5.0	4.0
Lab 3	NA	NA	NA	NA	NA	NA	3.0	2.0	4.7	1.0	2.0	3.0	3.0	3.0	7.0	5.0	2.0	4.0	NA	NA
Max Seat Range	3.7	5.3	6.5	9.0	TBD	TBD	20.0	8.0	9.0	8.0	7.0	9.0	7.0	4.0	30.0	9.0	8.0	4.0	NA	NA
Range of Average	2.2	2.4	3.5	7.2	TBD	TBD	17.7	5.0	4.7	7.0	6.0	4.3	3.0	0.7	7.5	5.3	6.3	2.0	NA	NA

Height Measurement Range for Each Seat

	Suzuki Forenza		Scion xB		Buick LaCrosse		Scion tC		Chrysler 300		Nissan Altima		Dodge Grand Caravan		Chevrolet Equinox		Volvo S40		Kia Rio	
	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas	Drv	Pas
Lab 1	1.9	1.2	1.8	1.8	4.5	1.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lab 2	2.0	4.0	4.0	5.0	TBD	TBD	3.0	5.0	2.0	8.0	5.0	8.0	7.0	6.0	5.0	2.0	1.0	3.0	3.0	4.0
Lab 3	NA	NA	NA	NA	NA	NA	2.0	2.0	3.3	7.0	2.0	4.0	6.0	3.0	4.0	4.0	1.0	2.0	NA	NA
Max Seat Range	4.9	4.8	10.8	17.2	TBD	TBD	12.0	5.0	5.0	15.0	14.0	9.0	7.0	6.0	10.0	5.0	1.0	5.0	NA	NA
Range of Average	3.3	3.1	8.3	14.9	TBD	TBD	11.3	1.7	3.3	8.7	12.0	3.0	1.0	2.7	6.9	2.7	0.0	2.7	NA	NA

Single Lab Range Equation

$$Max_{p=0}^{n}\left[Max_{i=1}^{3}\left[m1_{ip}\right] - Min_{i=1}^{3}\left[m1_{ip}\right]\right]$$

- **p = counter for head restraint position**
- **i = counter for measurement iteration**
- **m1, m2, and m3 = Measurements from Lab 1 through Lab 3.**

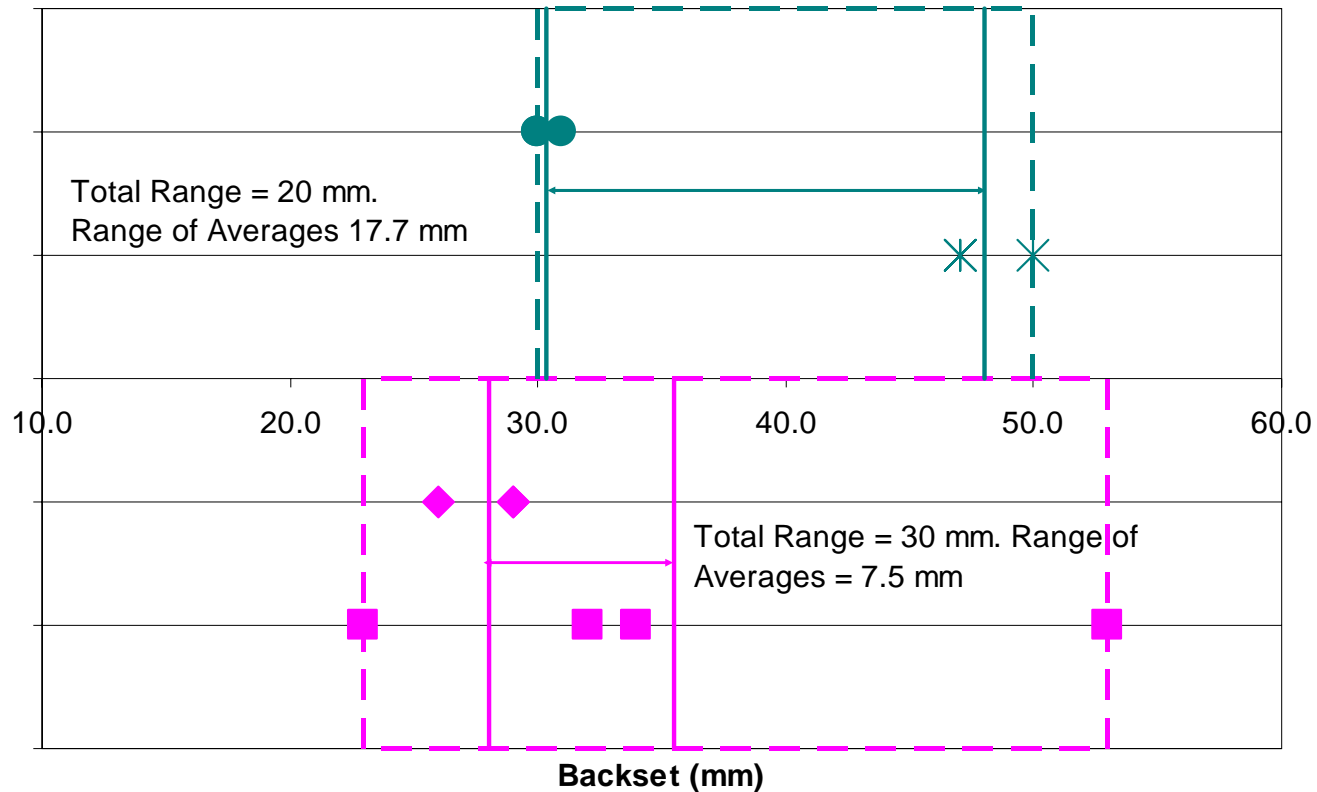# *Lab to Lab Range Equations*

- **Across Lab maximum range**

$$Max_{p=0}^{n}\left[Max_{i=1}^{3}\left[_{j=1}^{2}\left[m_{jip}\right]\right] - Min_{i=1}^{3}\left[_{j=1}^{2}\left[m_{jip}\right]\right]\right]$$

- **Across Lab maximum range or averages**

$$Max_{p=0}^{n}\left[ABS\left[\sum_{i=1}^{3}\left[\frac{m_{1ip}}{3}\right] - \sum_{i=1}^{3}\left[\frac{m_{2ip}}{3}\right]\right]\right]$$

- **Calculations repeated for Lab 2 and 3 comparison**

Seats with Largest Backset Range

Total Range = 20 mm.
Range of Averages 17.7 mm

Total Range = 30 mm. Range of Averages = 7.5 mm

Backset (mm)

■ Equinox Driver - Lab 2 ◆ Equinox Driver - Lab 3
✳ Scion tC Driver - Lab 2 ● Sciion tC Driver - Lab 3

Height Measurement Maximum Seat Range

	Max Range	Min Range	Average Range	s.d.	Avg. + 2s.d.	Avg. + 3s.d.
Lab 1 - All Seats	4.5	1.2	2.2	1.2	4.5	5.7
Lab 2 - All Seats	8.0	1.0	4.3	2.1	8.4	10.4
Lab 3 - All Seats	7.0	1.0	3.4	1.8	6.9	8.7
All Seats Max Range	17.2	1.0	8.2	4.5	17.3	21.8
All Seats Range of Lab Avg.	14.9	0.0	5.3	4.4	14.2	18.7