MCW-CIREN Research Project
Updated T and L Injury Mechanism Study
16 December 2015

Hans Hauschild, Frank Pintar, Dale Halloway

Medical College of Wisconsin

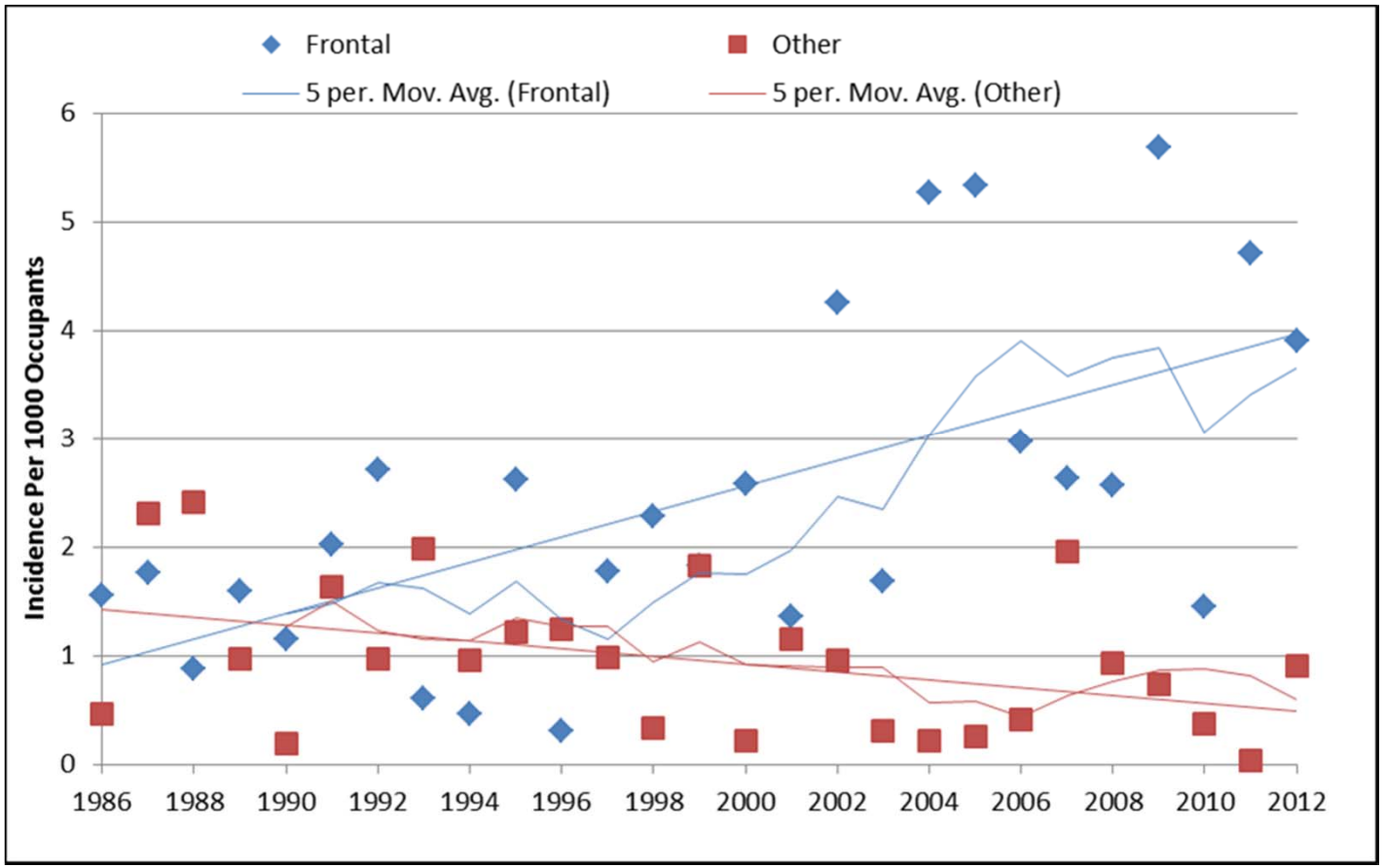
MEDICAL COLLEGE OF WISCONSIN

Updated T and L Injury Mechanism Study

- Background / Introduction
- Purpose
- Methods
- Results
- Discussion

Background / Introduction

- **CIREN Study found increased risk of T-L Spinal fx in newer model vehicles**



Background / Introduction

- Other research –
  - Doud (2014)
    - Found an approximate 8% - 9% increase of injury with MY increase
  - del Fueyo (2015)
- Studies found more likely with fixed object collisions
  - Belted occupants
  - Frontal Impacts
- Limited studies have been done examining injury source or cause
  - MCW Studies
- FEM modeling

Background / Introduction

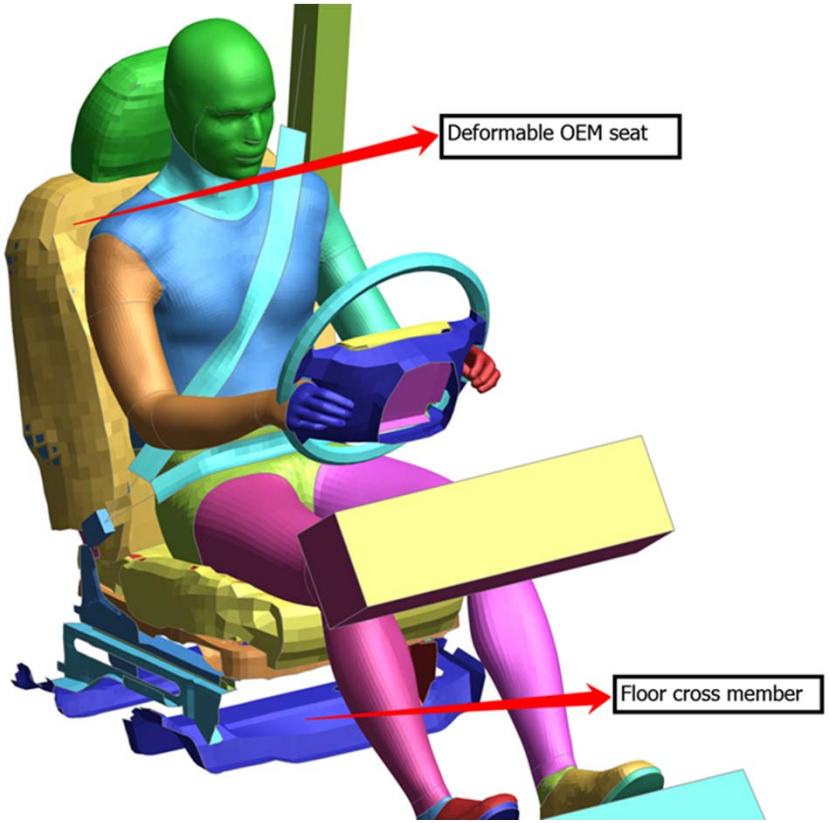
- **MCW Studies**
  - **Quasi-static – Seat design**
  - **Dynamic Sled – Seat design**
  - **Dynamic Sled- Pulse influence**
  - **Full Scale Crash – Systems input**
  - **Dynamic Sled – Current Study**
    - **Based on modeling studies**

Background / Introduction

- **Full Scale Crash Tests**

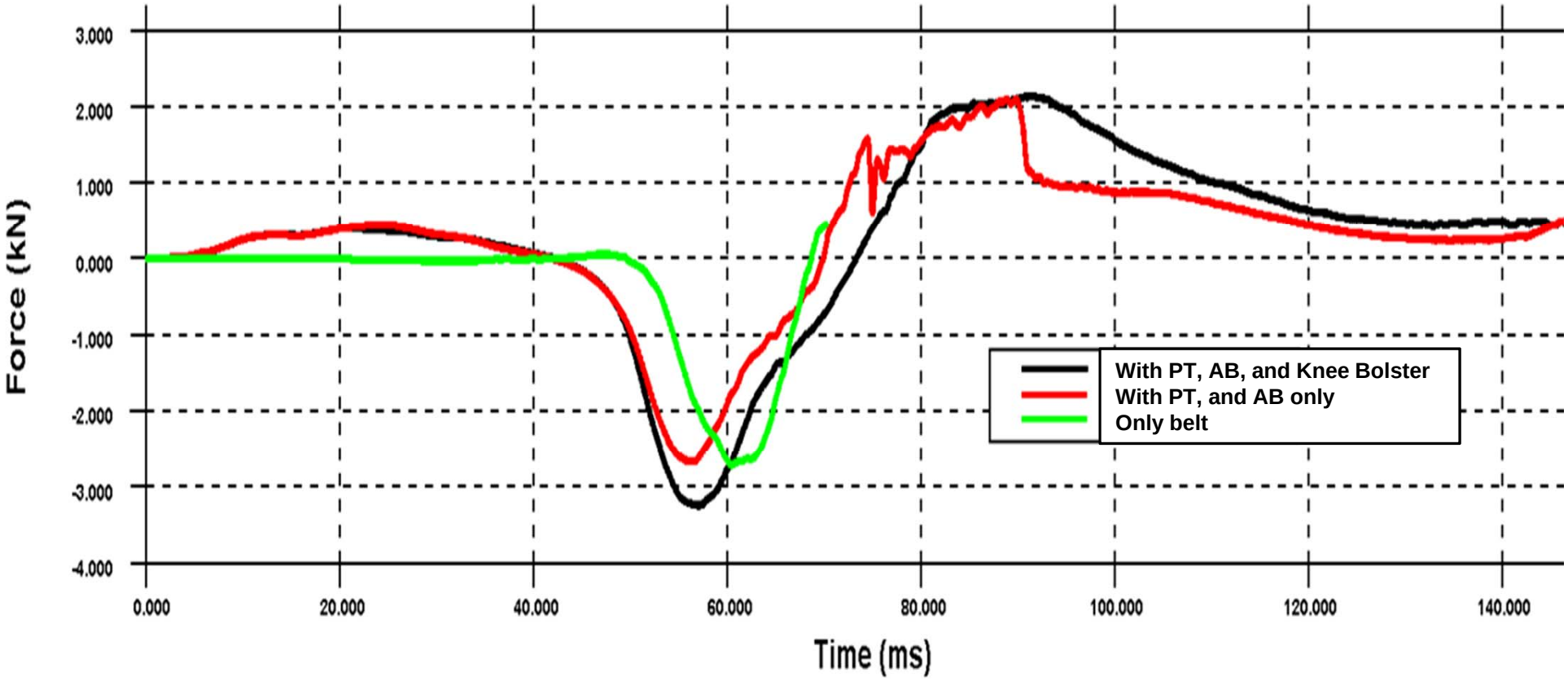
Background / Introduction

- **Computational Modeling**
  - **FEM GHBMC results guided test matrix**
    - **Seating position/knee bolster influence**
    - **Belt pretensioner influence**
    - **Pulse influence**



Background / Introduction

- **Computational Modeling**
  - **Modeling results indicate**
    - **Knee bolster increase peak force by about 20 %**
    - **Seat belt showed highest sensitivity**



Purpose

- **Evaluation of spine loads in different seating positions and restraint system interactions in a reproducible vehicle setting**
  - **Belted occupant seating system interaction influence**
  - **Knee bolster system distance influence**
  - **Pretensioner and airbag system influence**

Methods

- **Dynamic Sled Test**
  - **Body in white – Yaris**
  - **LF seating position**
  - **HIII 50% with curved spine and lumbar load cell**
  - **Seat with pan and anti-submarine bar**
  - **Full dash with knee bolsters (no knee bags)**
  - **Pole Pulse**
  - **8 tests**
  - **Seat position**
  - **Belt with and w/o pretensioner**
  - **Airbag timing**

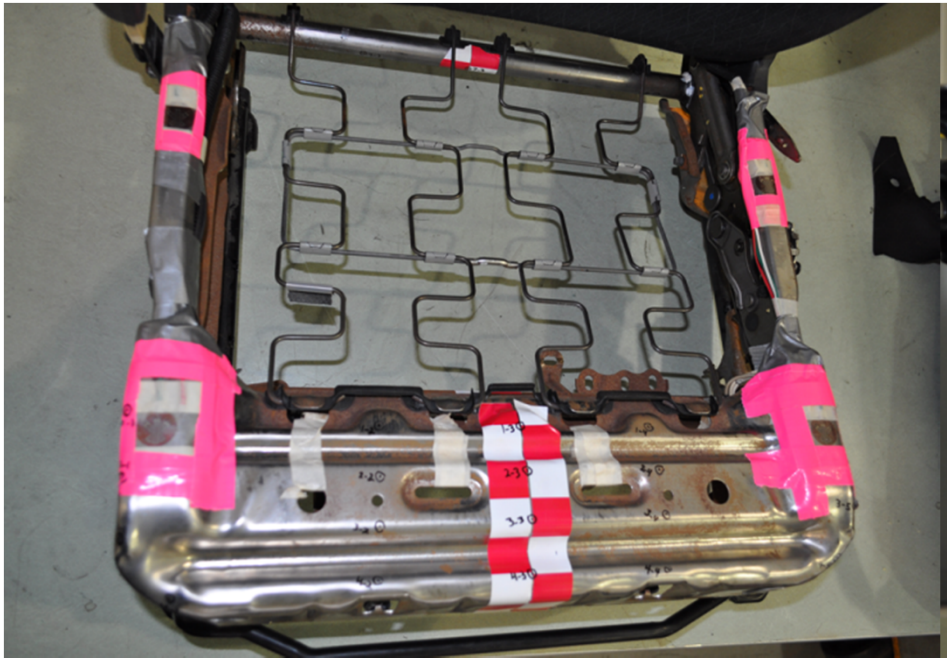
Methods

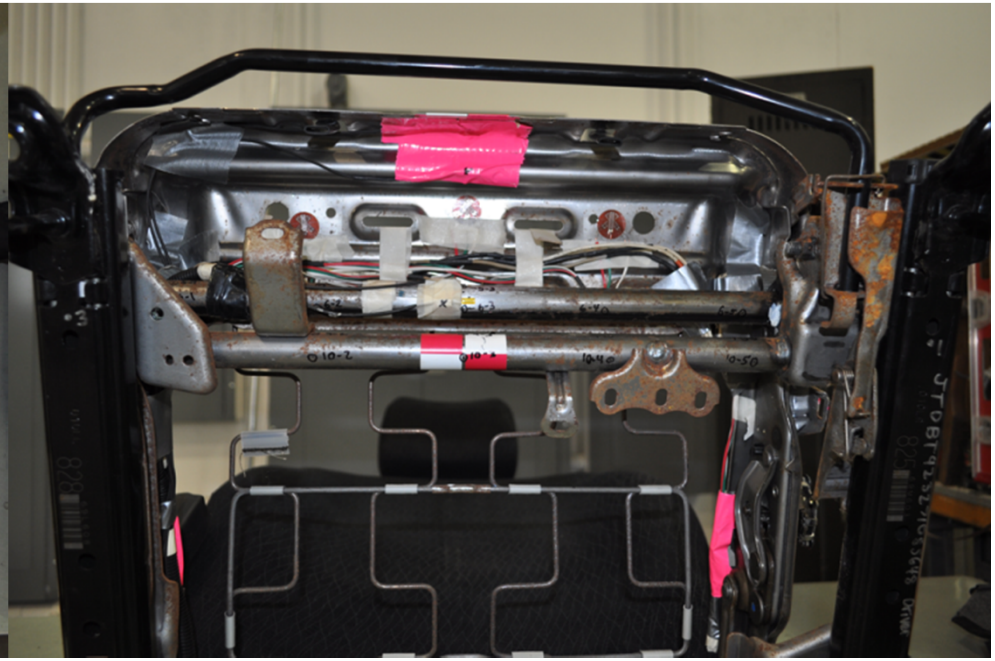
- **Dynamic Sled Test**
  - **Body in white – Yaris**
  - **LF seating position**
  - **Fore/aft seat positions used - 3**

MEDICAL COLLEGE OF WISCONSIN

Methods

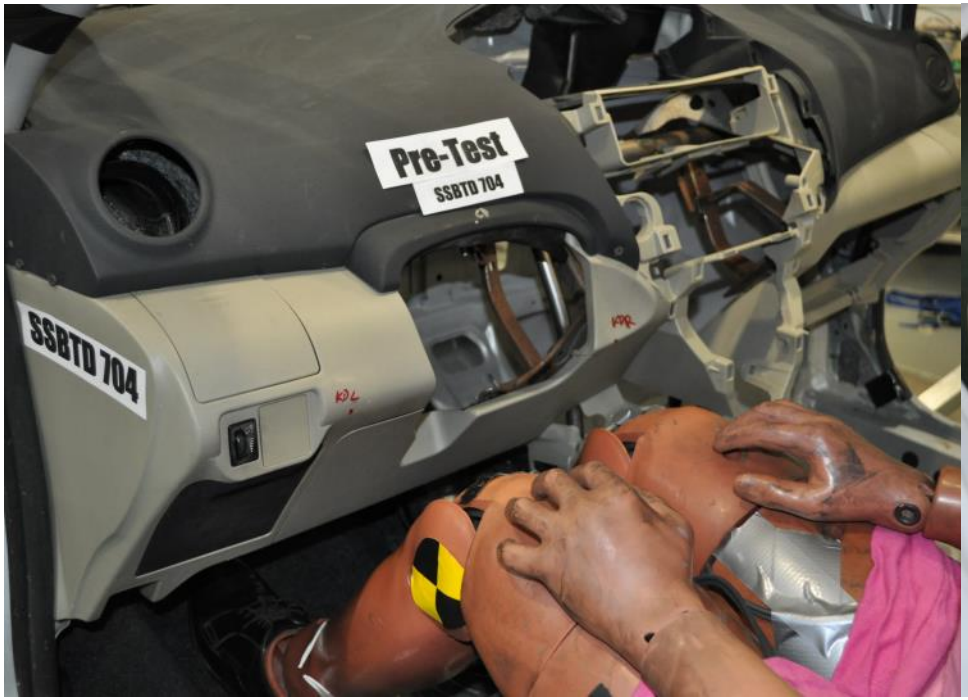
- **Dynamic Sled Test**
  - **Factory seat**
  - **Seat with pan and thigh-bar**
  - **Pan set at highest angle - 15 degrees ±**





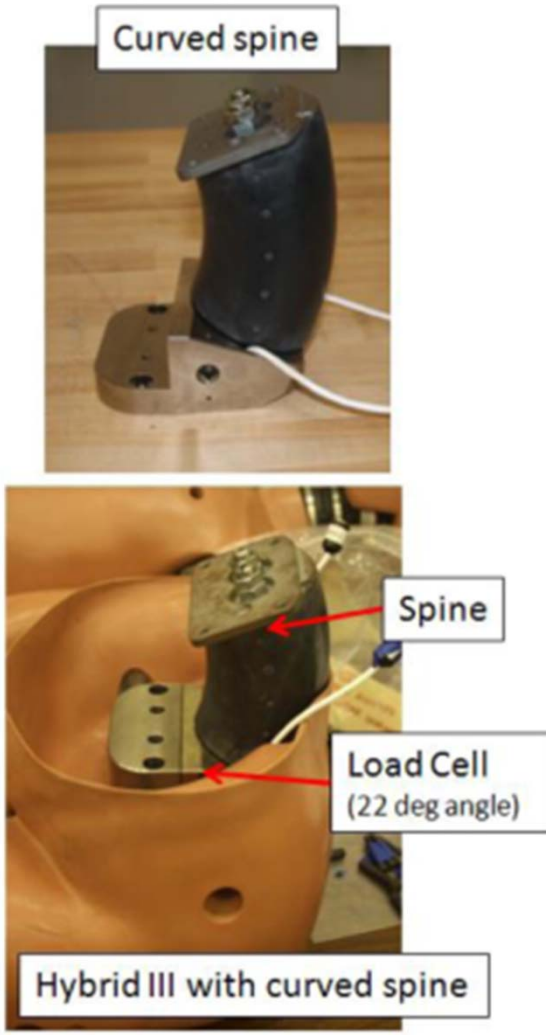
Methods

- **Dynamic Sled Test**
  - **Full dash with knee bolsters**
  - **Belts with pretensioners**
  - **Steering column – highest position**



Methods

- Dynamic Sled Test
  - HIII 50% with upper and lower lumbar load cells
  - Driver seating position (P1)
  - Positioning based on
    - Other NHTSA tests
      - NCAP
    - Other Yaris tests
      - SOI
      - Oblique angle



Methods

- Dynamic Sled Test
  - Seat position
    - Mid Position
    - Full rear
    - 1 Forward of full rear
  - Belt with and w/o pretensioner
  - Airbag / pretensioner timing
    - 10 ms – Baseline frontal
    - 35 ms
      - IIHS Pole test (30 & 34 ms)
      - EDR from NASS (FLEE/FREE)(34, 38, 46 ms)

MEDICAL COLLEGE OF WISCONSIN

Methods

- **Dynamic Sled Test**

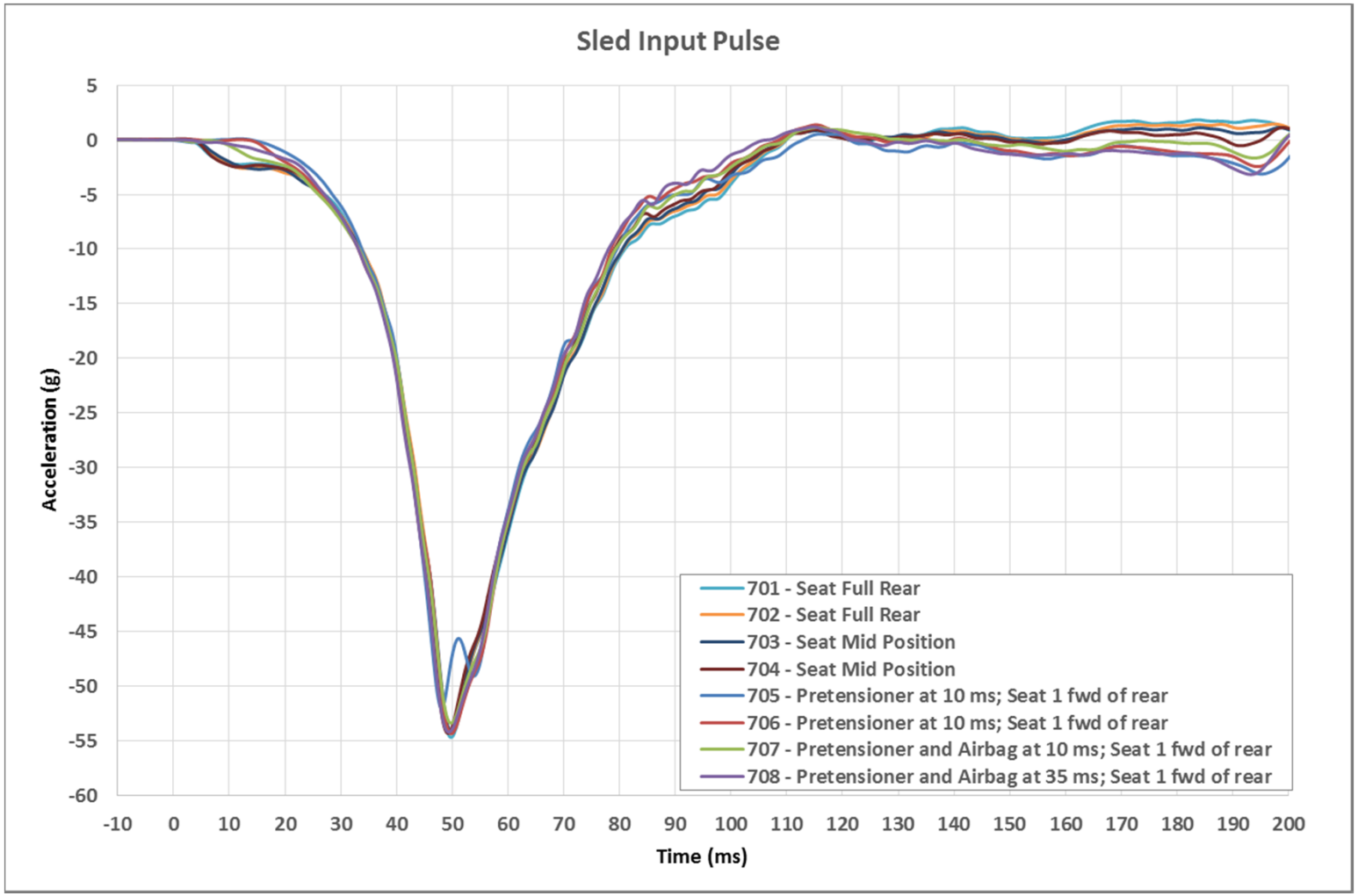
Tests 701 – 704
No airbag,
No pretensioner
Seat position varied
-mid & full rear

Tests 705 & 706
Pretensioner 10 ms
No airbag
Seat position 1 forward full rear

Tests 707 & 708
Airbag,& pretensioner timing varied
10 ms & 35 ms
Seat position 1 forward full rear

Methods

- **Dynamic Sled Test - Pole Pulse**



Methods

- **Dynamic Sled Test**
  - **8 tests**

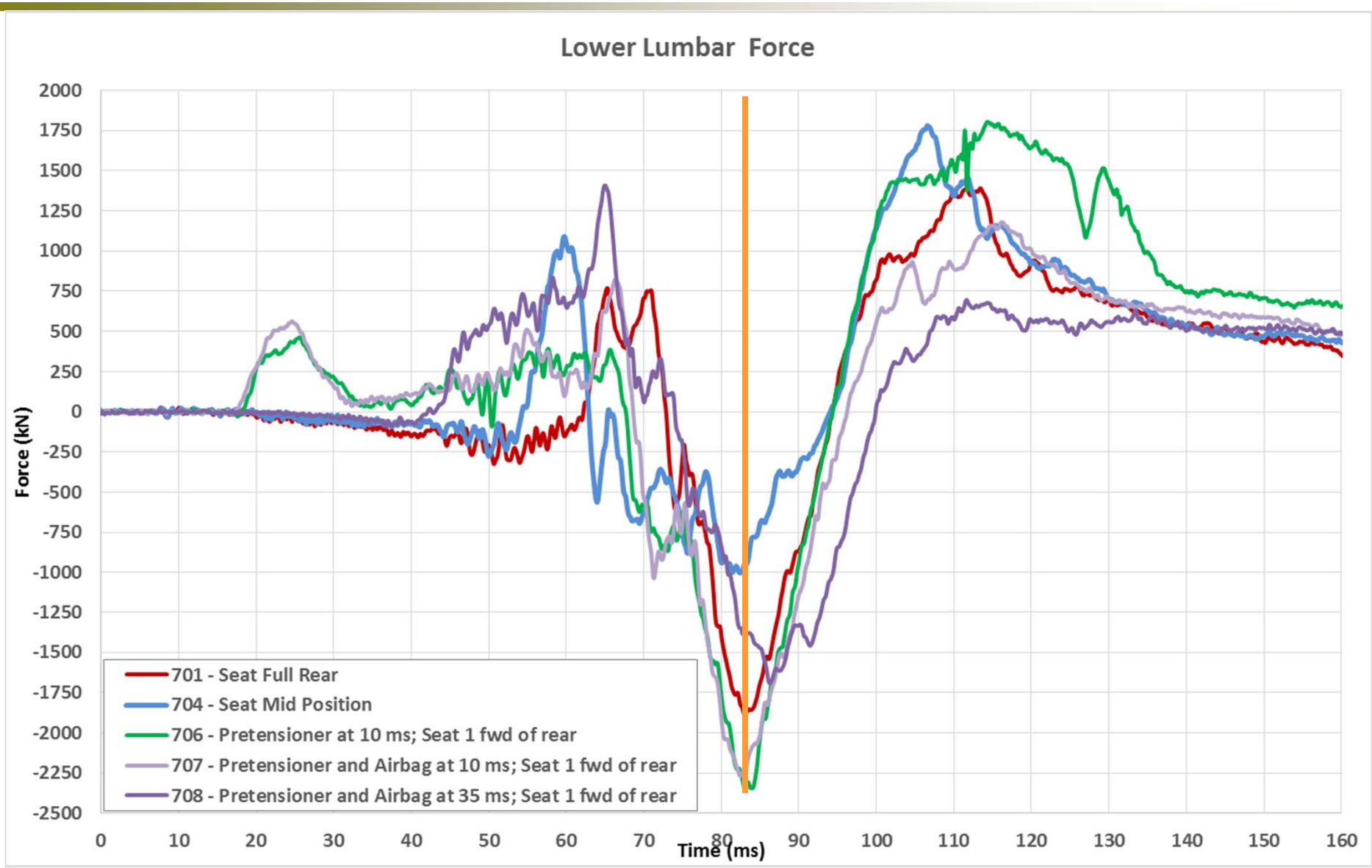
Test #	Seat	Position	ATD/Spine	Seat Position/ Distance to bolster	Belt Pretension	Belt Pretension Timing (ms)	Airbag	Airbag Timing (ms)	Steering Column	Column Position	Pulse	Target Delta -v (km/h)
701	Stock Yaris	D	HIII/curved	full rear	N	na	N	na	N	na	Pole	56
702	Stock Yaris	D	HIII/curved	full rear	N	na	N	na	N	na	Pole	56
703	Stock Yaris	D	HIII/curved	Mid per NHTSA	N	na	N	na	N	na	Pole	56
704	Stock Yaris	D	HIII/curved	Mid per NHTSA	N	na	N	na	N	na	Pole	56
705	Stock Yaris	D	HIII/curved	1 forward of full rear	Y	10	N	na	N	na	Pole	56
706	Stock Yaris	D	HIII/curved	1 forward of full rear	Y	10	N	na	N	na	Pole	56
707	Stock Yaris	D	HIII/curved	1 forward of full rear	Y	10	Y	10	Y	full up	Pole	56
708	Stock Yaris	D	HIII/curved	1 forward of full rear	Y	35	Y	35	Y	full up	Pole	56

Results

- Lumbar Compression Force
- Belt Loads
- Femur Forces
- Pelvis vertical accelerations
- Seat anti-submarine bar vertical deformation

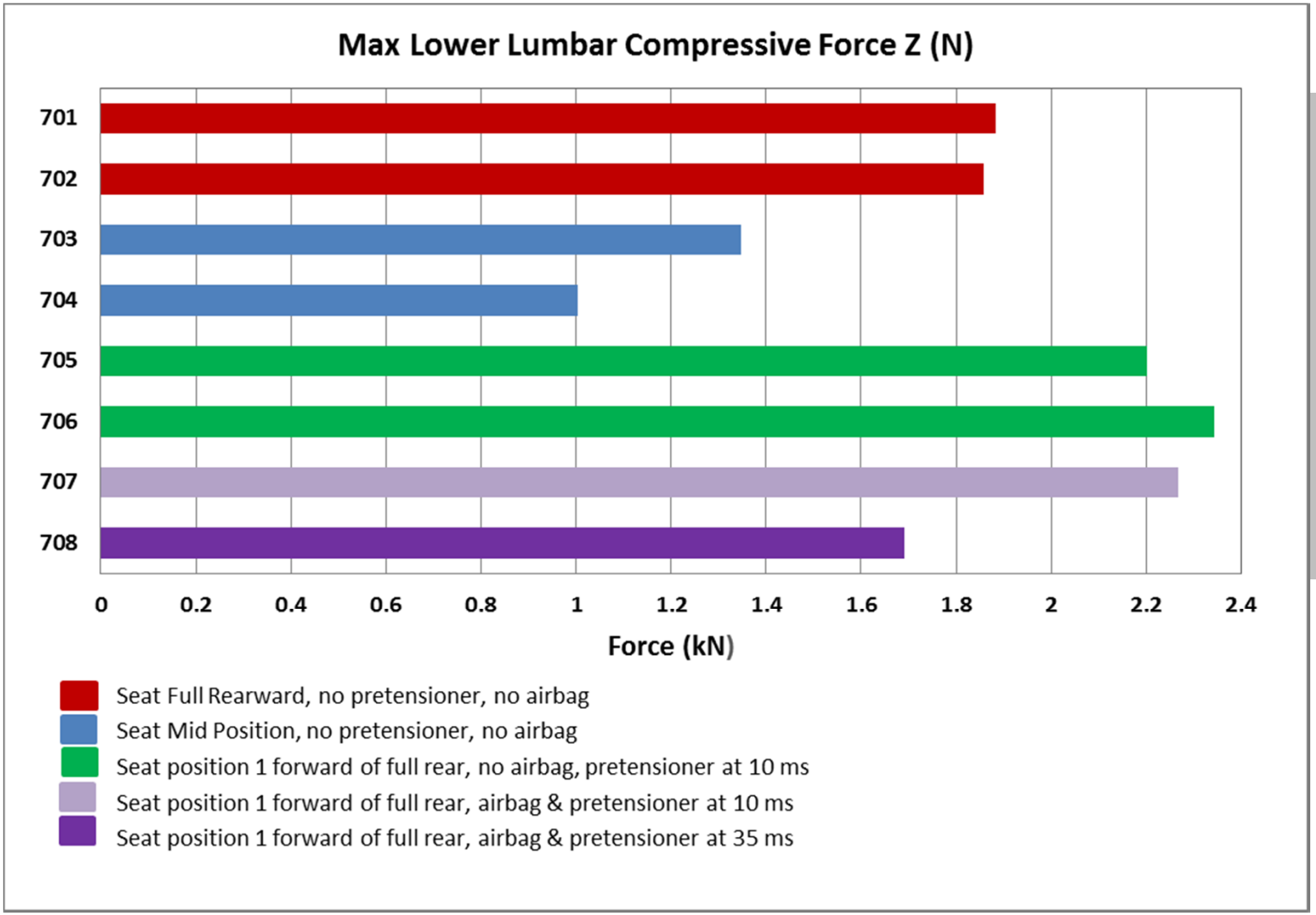
MEDICAL COLLEGE OF WISCONSIN

Results



MEDICAL COLLEGE OF WISCONSIN

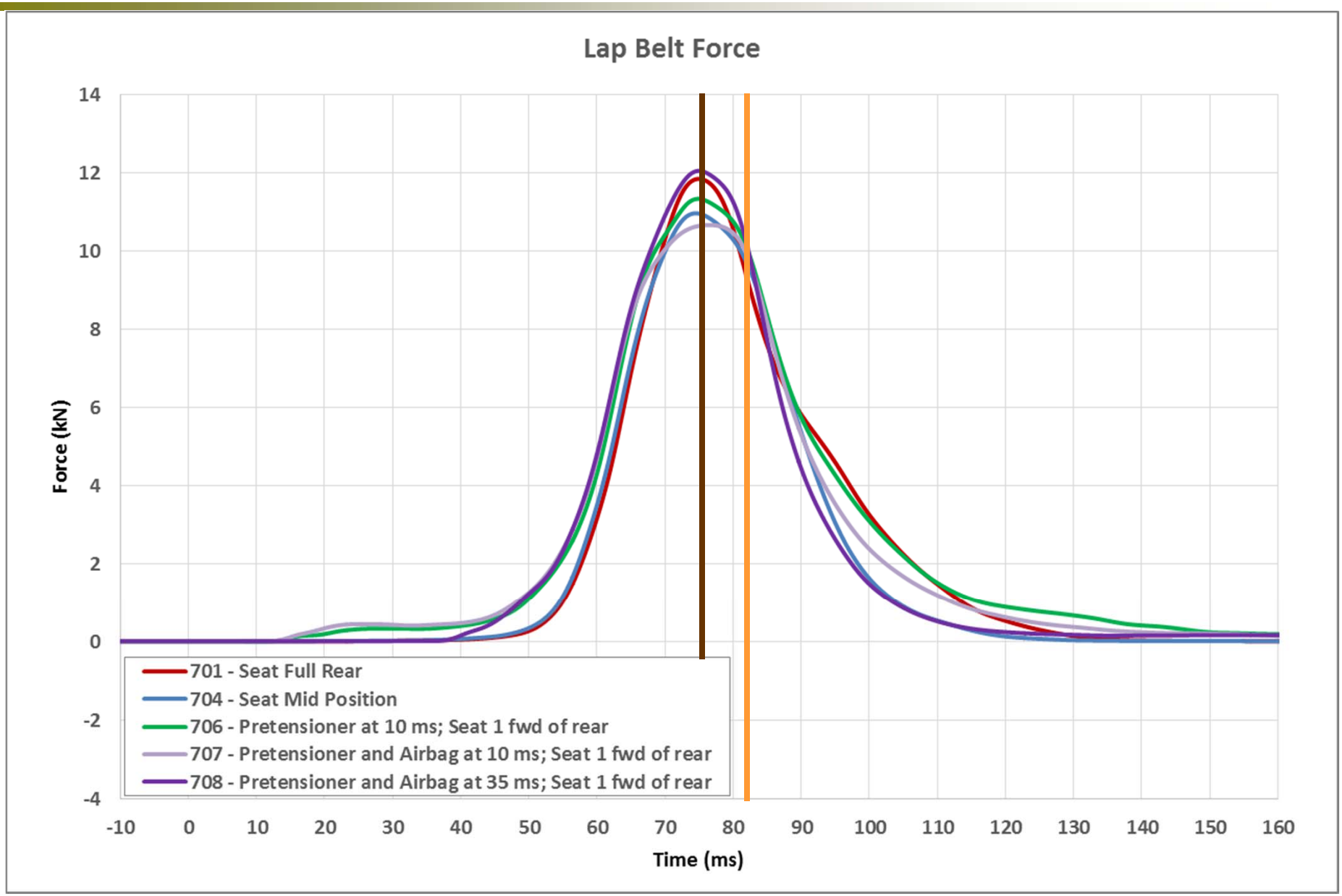
Results



1882
1858
1347
1003
2202
2343
2268
1692

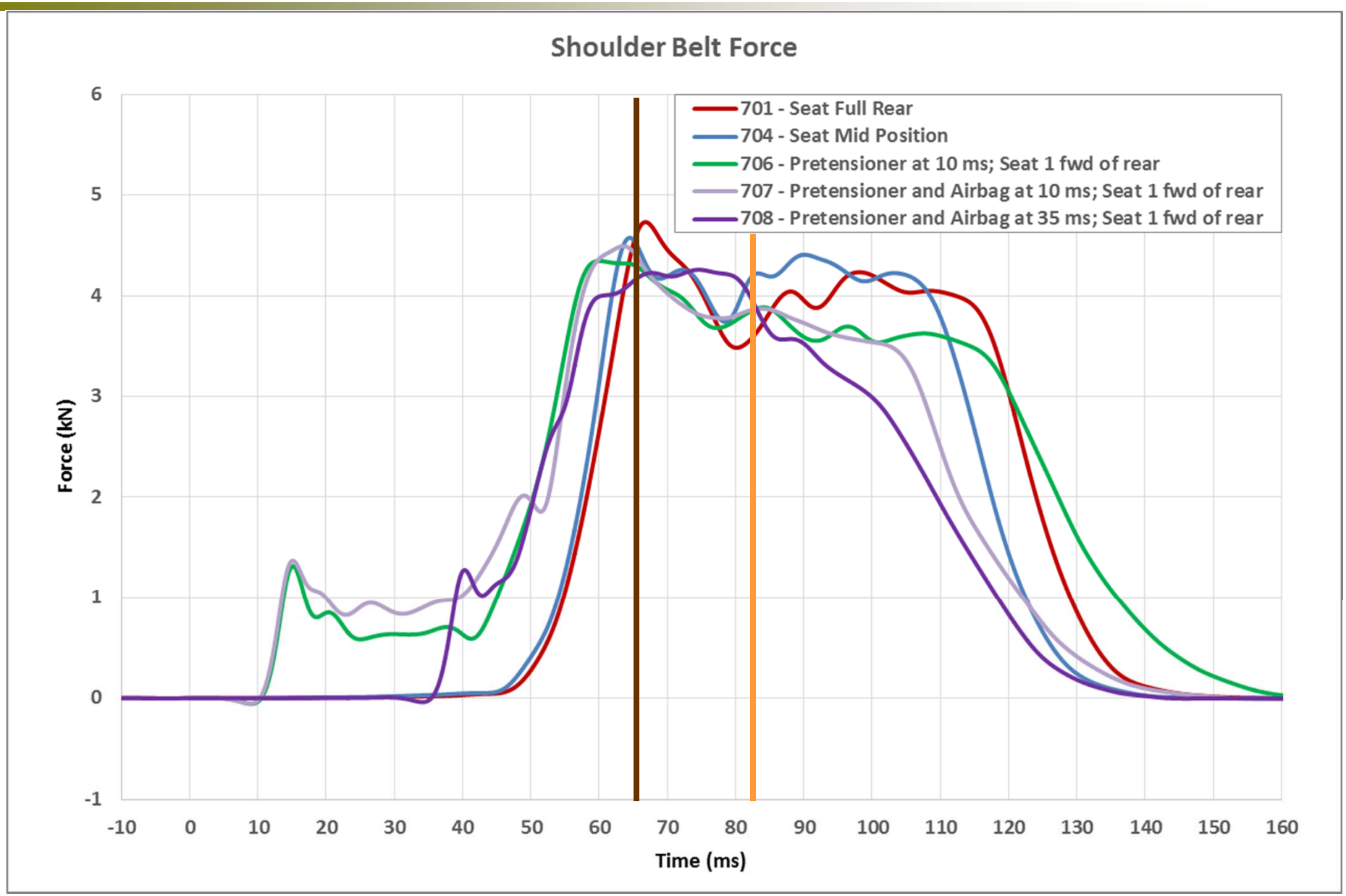
MEDICAL COLLEGE OF WISCONSIN

Results

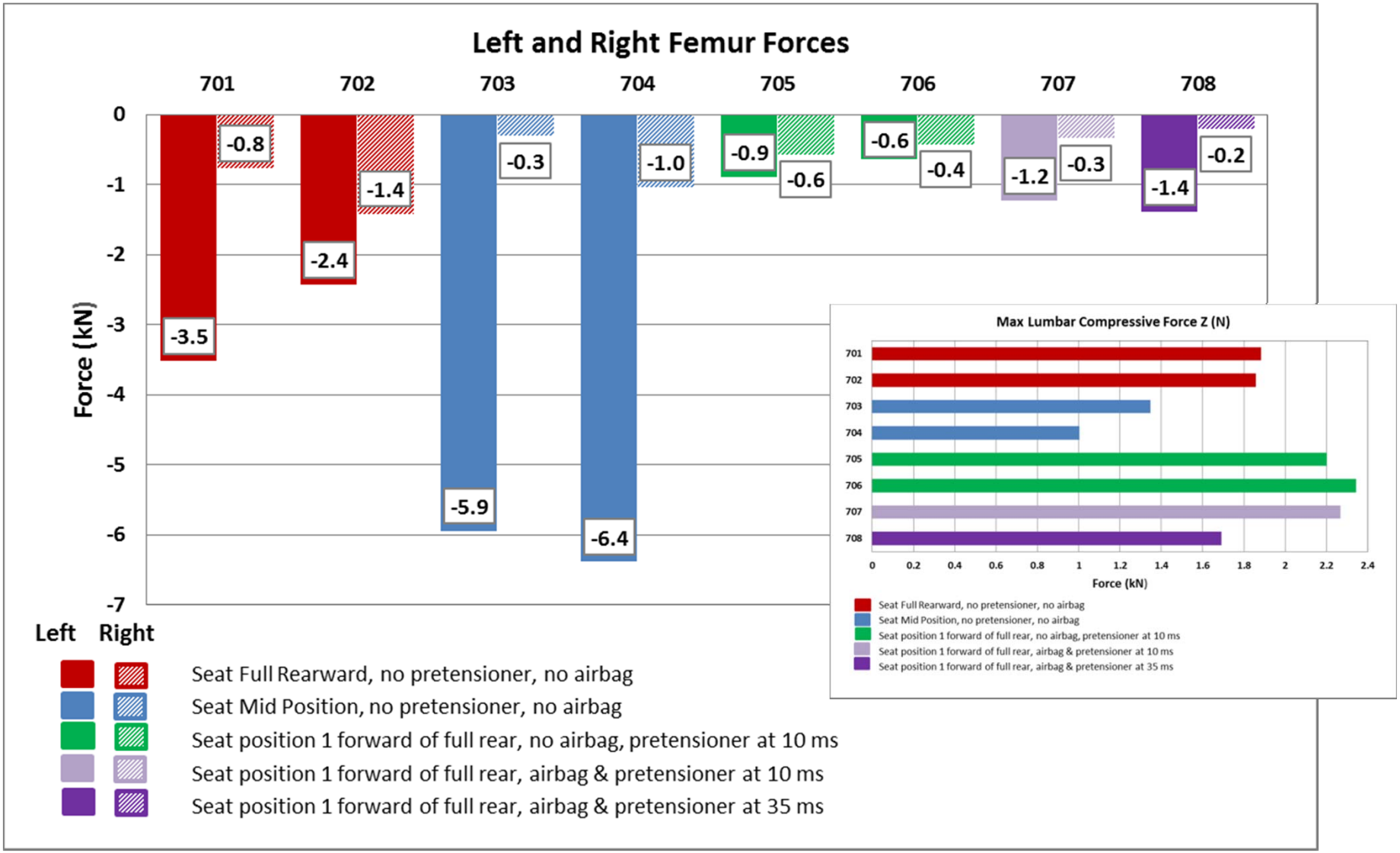


MEDICAL COLLEGE OF WISCONSIN

Results

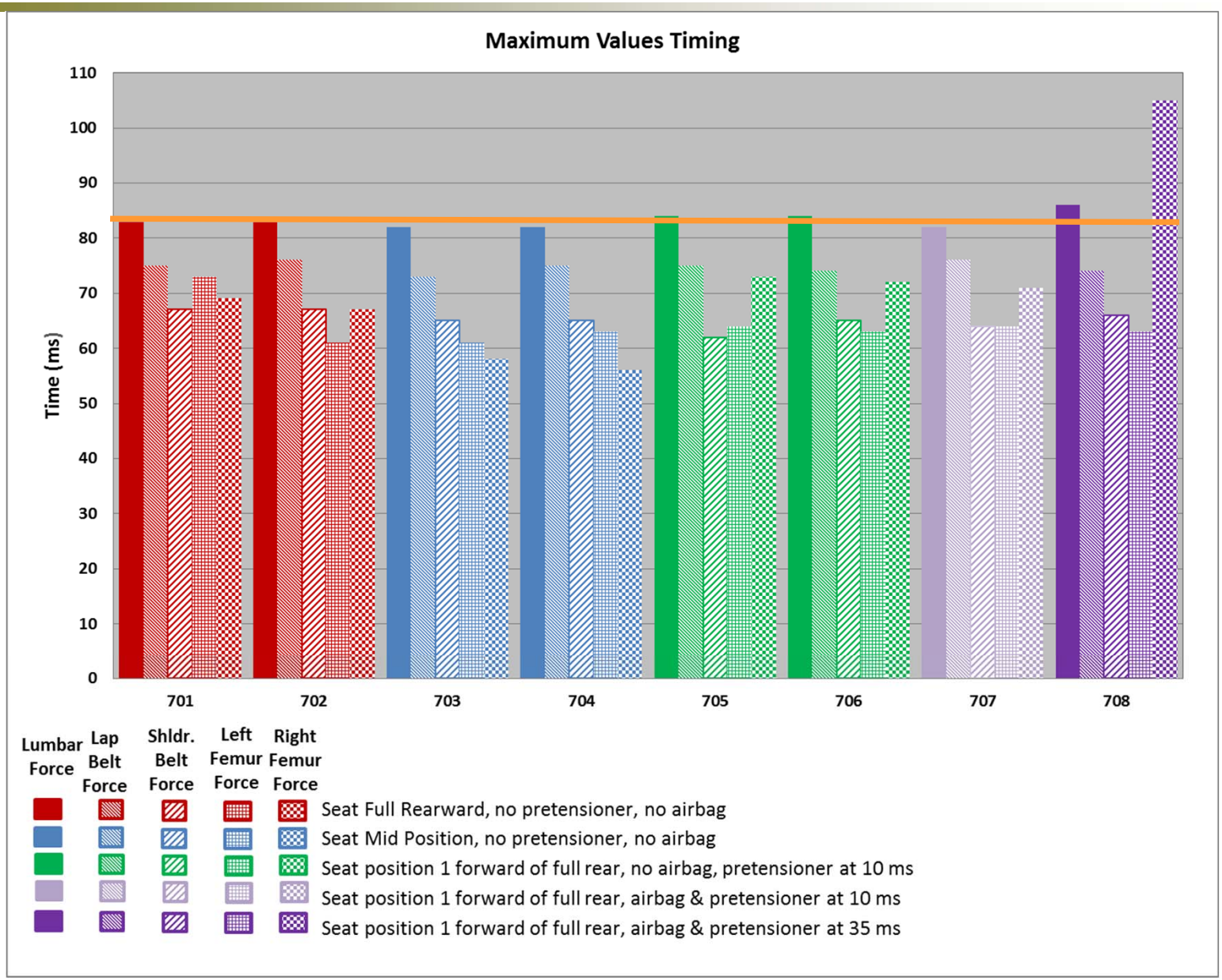


Results

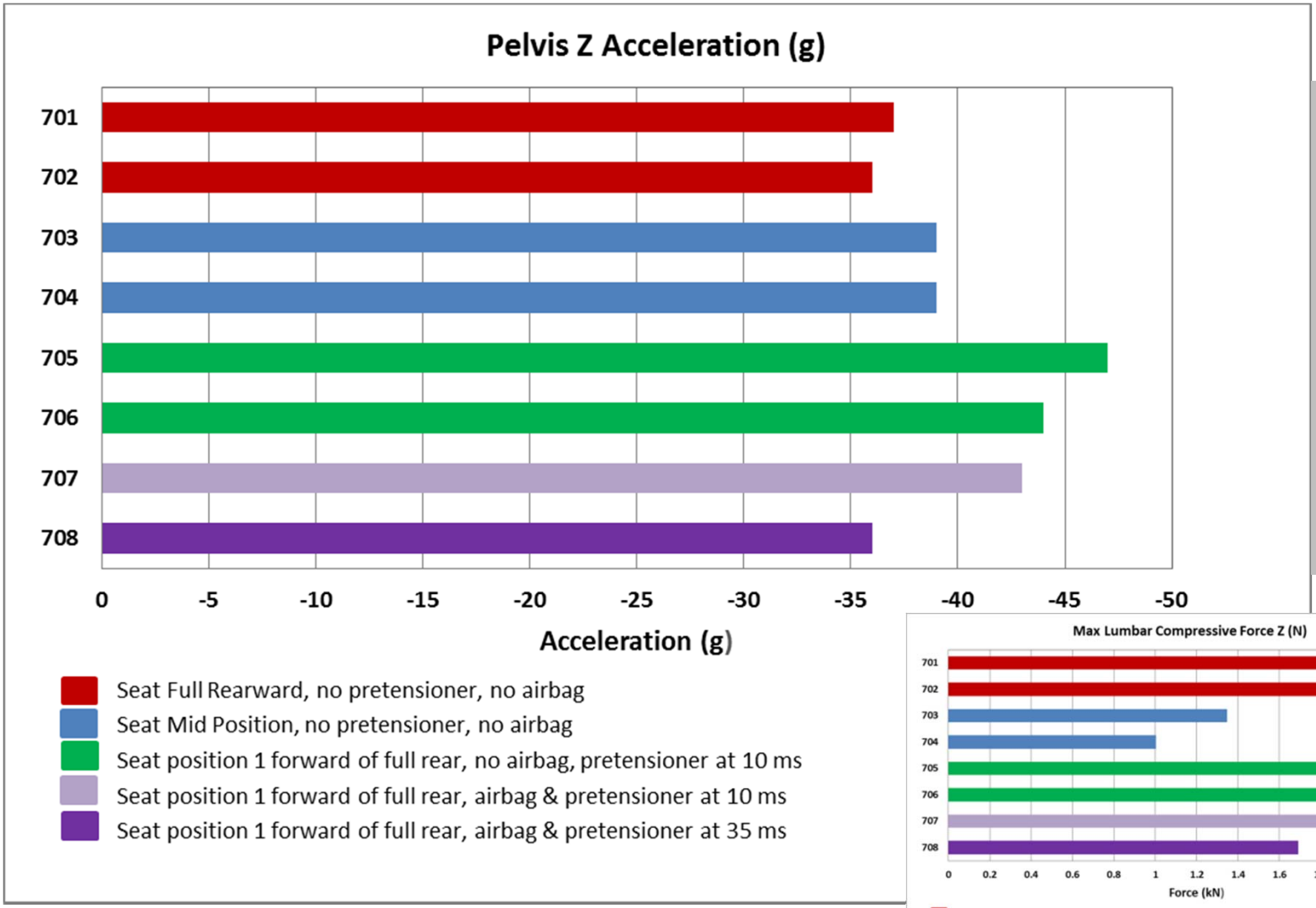

Left and Right Femur Forces
701
702
703
704
705
706
707
708
0
-1
-2
-3
-4
-5
-6
-7
Force (kN)
-3.5
-0.8
-2.4
-1.4
-5.9
-0.3
-6.4
-1.0
-0.9
-0.6
-0.6
-0.4
-1.2
-0.3
-1.4
-0.2
Left
Right
Seat Full Rearward, no pretensioner, no airbag
Seat Mid Position, no pretensioner, no airbag
Seat position 1 forward of full rear, no airbag, pretensioner at 10 ms
Seat position 1 forward of full rear, airbag & pretensioner at 10 ms
Seat position 1 forward of full rear, airbag & pretensioner at 35 ms
Max Lumbar Compressive Force Z (N)
701
702
703
704
705
706
707
708
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
Force (kN)
Seat Full Rearward, no pretensioner, no airbag
Seat Mid Position, no pretensioner, no airbag
Seat position 1 forward of full rear, no airbag, pretensioner at 10 ms
Seat position 1 forward of full rear, airbag & pretensioner at 10 ms
Seat position 1 forward of full rear, airbag & pretensioner at 35 ms

MEDICAL COLLEGE OF WISCONSIN

Results



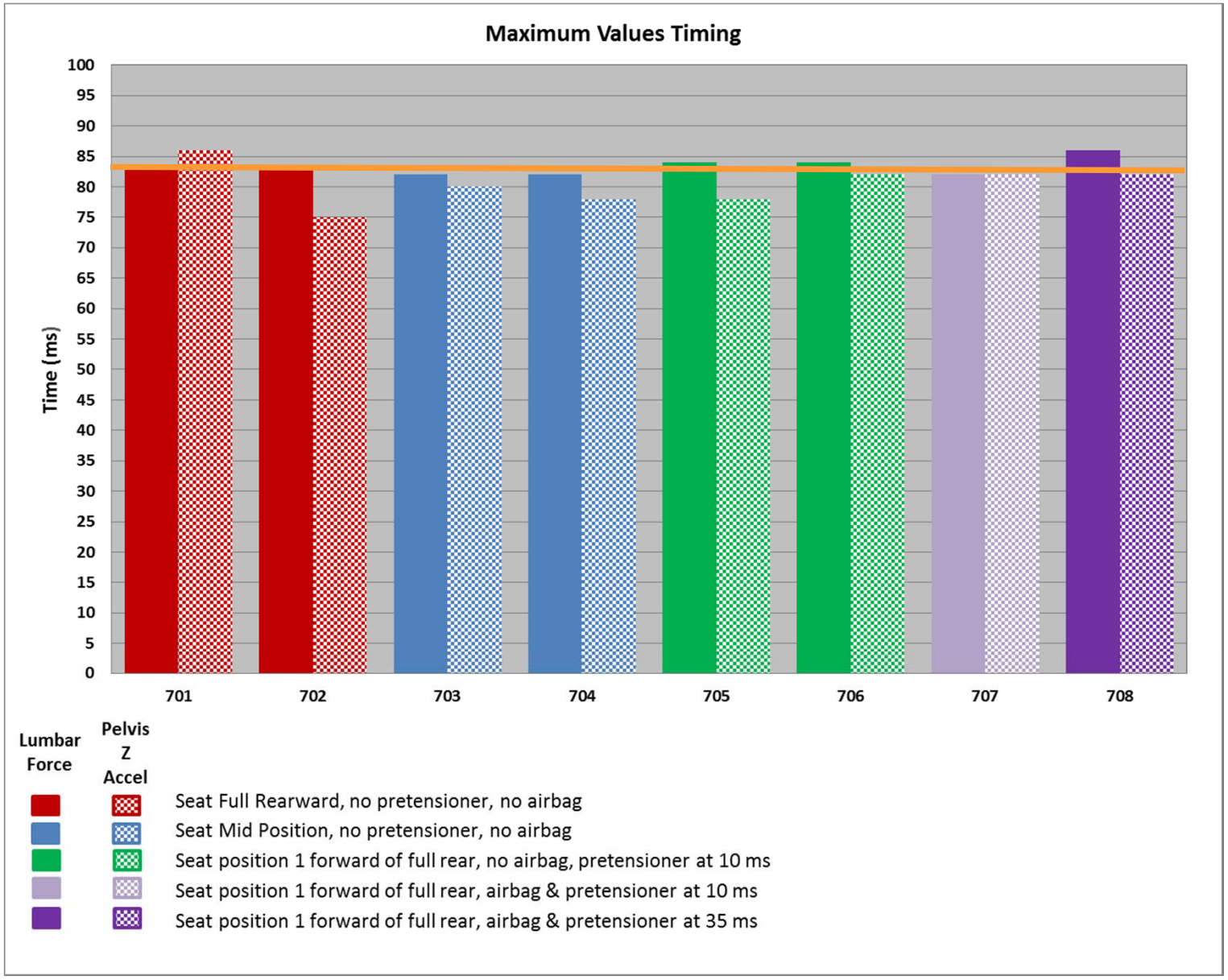
Results



701	-37
702	-36
703	-39
704	-39
705	-47
706	-44
707	-43
708	-36

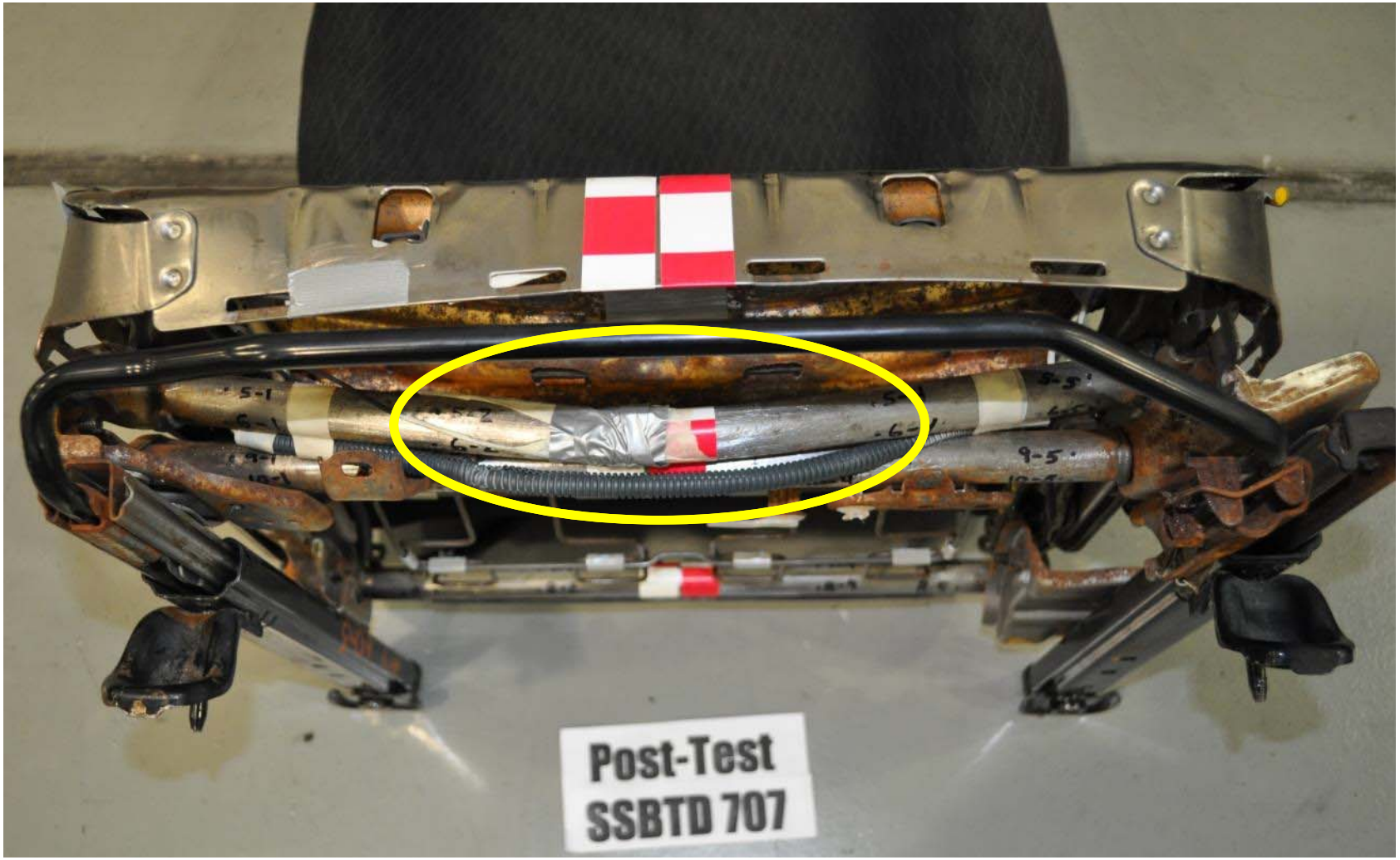
MEDICAL COLLEGE OF WISCONSIN

Results



Results

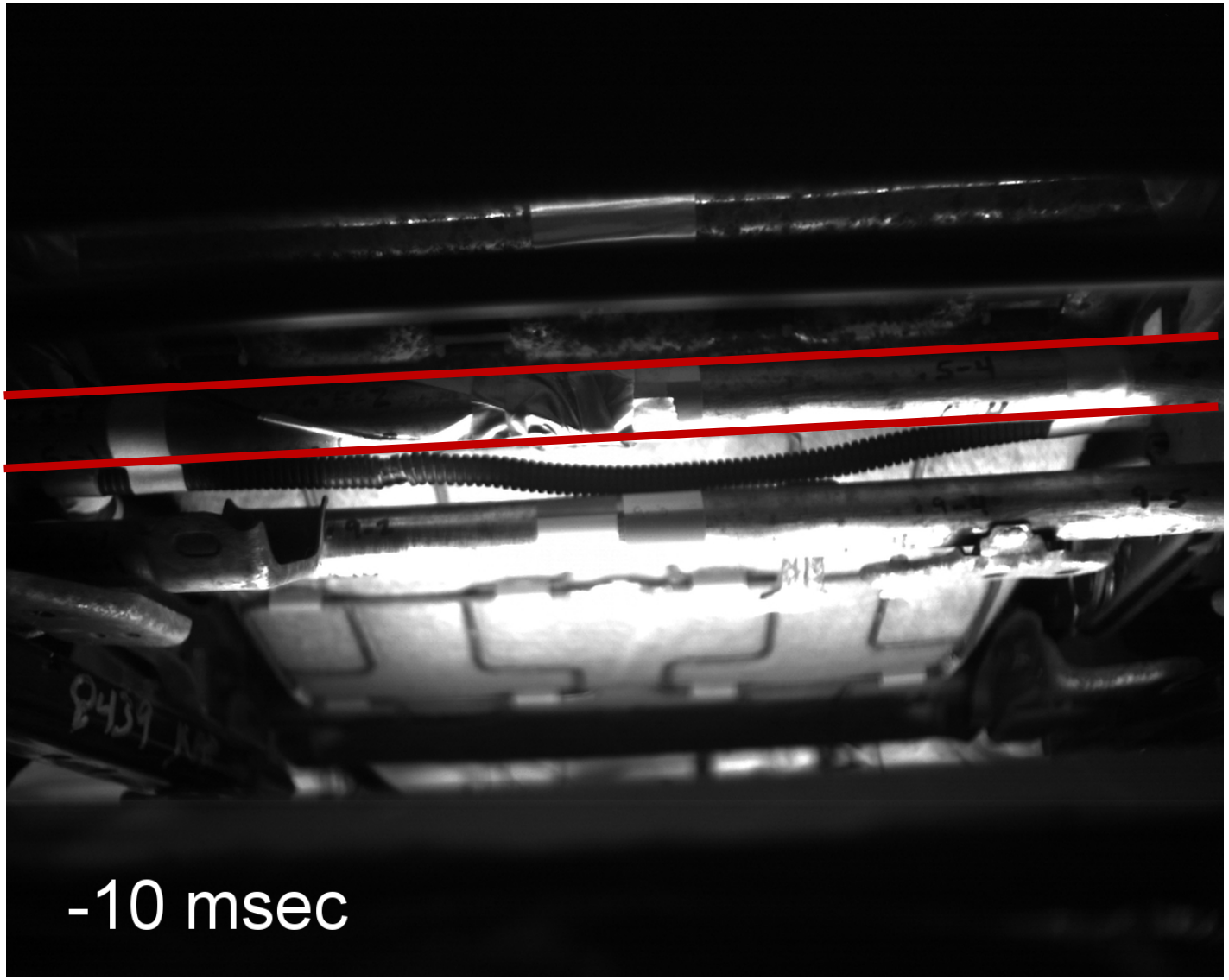
- **Seat Thigh-bar Z Static Deformation**



MEDICAL COLLEGE OF WISCONSIN

Results

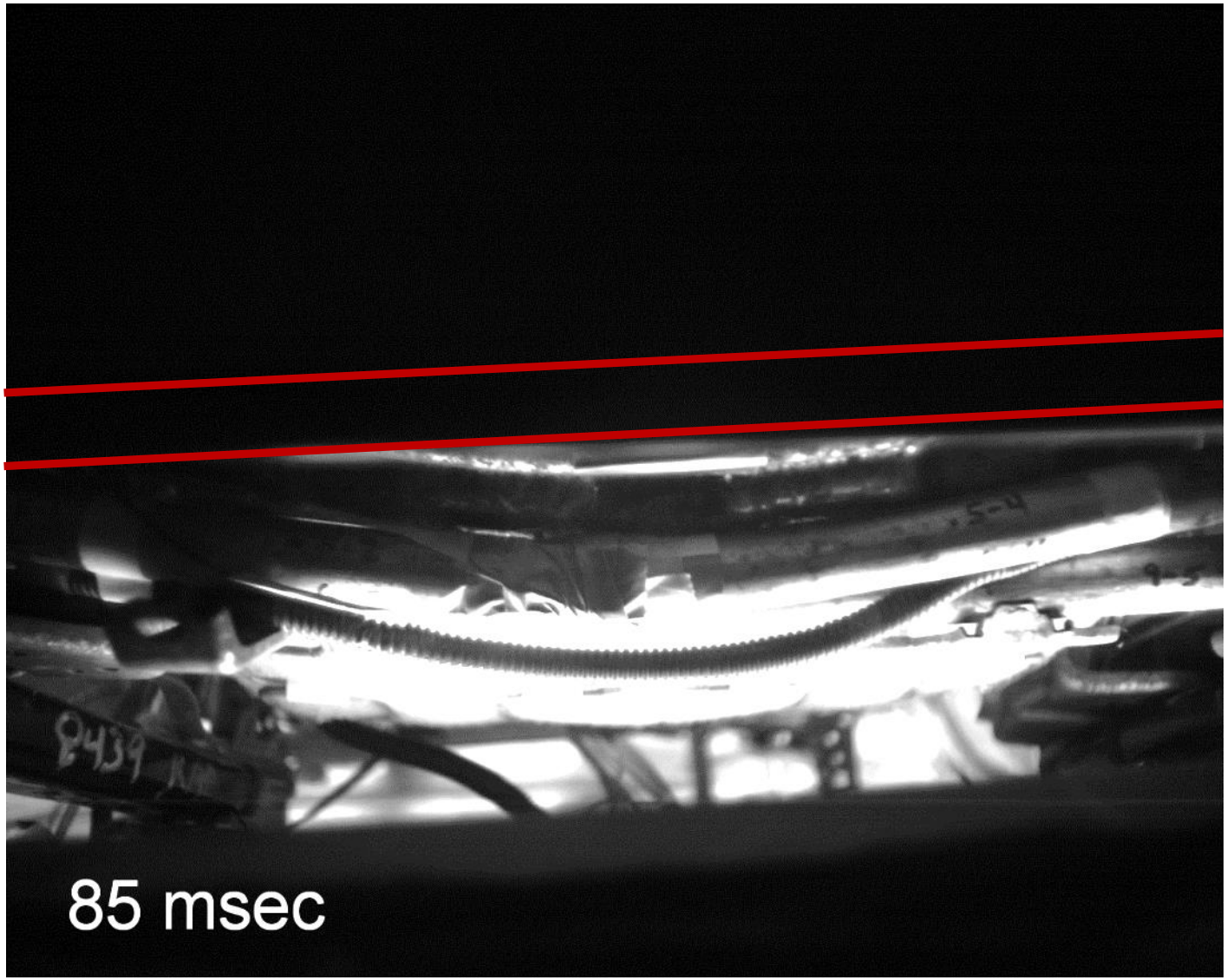
- **Seat Thigh-bar Deformation**



MEDICAL COLLEGE OF WISCONSIN

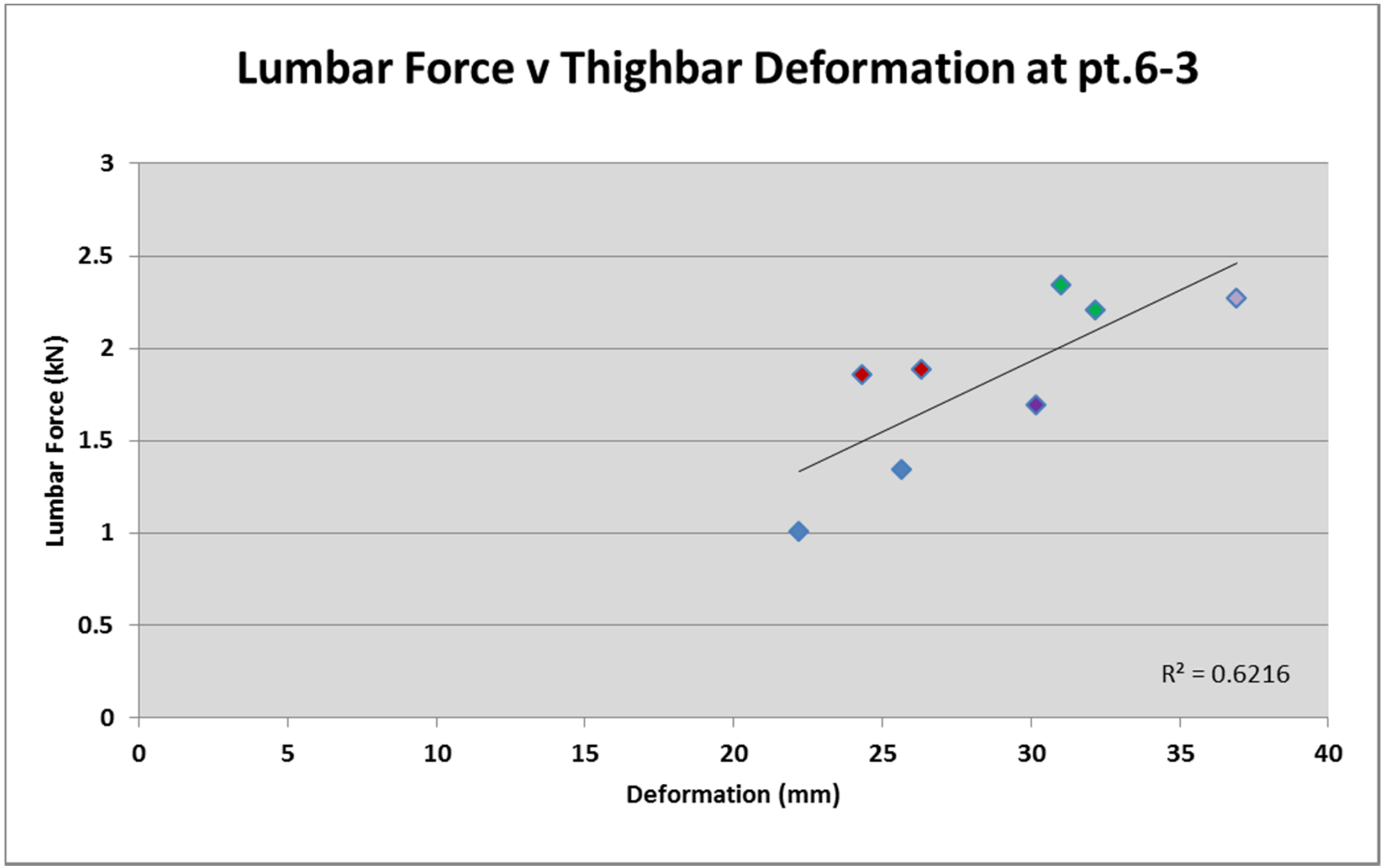
Results

- **Seat Thigh-bar Deformation**



MEDICAL COLLEGE OF WISCONSIN

Results



MEDICAL COLLEGE OF WISCONSIN

Discussion

- Seat position influence
  - Knee to Knee Bolster Distance
- Belt pretention influence - timing
- Airbag influence
  - Airbag timing
- Lumbar load timing
  - With respect to kinematics
- Other factors

MEDICAL COLLEGE OF WISCONSIN

Discussion

- Future testing – short term
  - Seat position
    - UMTRI – Reed et al (2001)
    - 45.5 mm rearward of mid position (avg.)
  - Airbag Belt Timing
  - Crash test validation
    - Yaris to Pole/ Centered Frontal
- Computational Modeling
  - Validate inputs
  - Improve OEM seat characteristics
  - Future GHBMC
    - Role of pelvis motion influence to spine kinetics
  - Determine future testing

Summary

- 8 Dynamic sled tests
- 1 model stock vehicle seat with thigh-bar design
- 50th HIII ATD w/ curved spine and load cells
- 4 Configurations
- 2 Different belt and airbag fire times
- 1.0 – 2.3 kN load on lower lumbar
- 22 – 37 mm of seat structure deformation downward

Conclusion

- Belt pretensioner influences lumbar loading
  - Results similar to modeling
- Airbag and pretensioner timing influence lumbar loading
- Seat position influences lumbar loading
- Knee to bolster interaction may influence lumbar loads
  - More investigation needed
  - Model indicated potential knee bolster influence
- Seat deformation is related to lumbar loads

Questions

MEDICAL COLLEGE OF WISCONSIN

Updated T and L Injury Mechanism Study

16 December 2015

Hans Hauschild, Frank Pintar, Dale Halloway

Medical College of Wisconsin