
COMPARISON OF STANDARD AND Y-BELT AIRCRAFT PASSENGER RESTRAINTS IN FRONTAL IMPACTS WITH PMHS AND ATD

JOHN HUMM^{1,2}, JOHN DEROSIA¹, FRANK PINTAR¹, NARAYAN YOGANANDAN¹, AMANDA TAYLOR³, DAVID MOORCROFT³, RICHARD DEWEESE³, BRIAN PETERSON⁴

1 DEPARTMENT OF NEUROSURGERY, MEDICAL COLLEGE OF WISCONSIN,

2 DEPARTMENT OF BIOMEDICAL ENGINEERING, MARQUETTE UNIVERSITY

3 CIVIL AEROSPACE MEDICAL INSTITUTE

4 MILWAUKEE COUNTY MEDICAL EXAMINER'S OFFICE

FRONT ROW OCCUPANTS

- ❖ Motivation: Severe injury in oblique tests with PMHS → Flailing
- ❖ “Front Row” Occupants → Increased seat pitch → Flail
- ❖ Will similar injuries be produced in frontal impacts?
- ❖ Standard belt/Y-Belt



WHAT IS A Y-BELT?

Upper
Anchor

Top Segment

Reduce dummy head excursion →
Alter pelvis kinematics

Bottom
Segment

Lower
Anchor

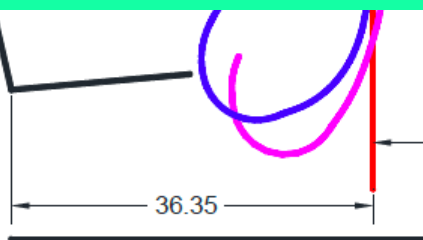
CAMI SLED TESTS



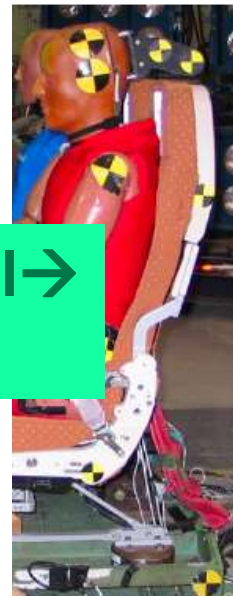
All Dimensions
in Inches

H-II with Y-belt
top of head path
(no wall)

**Move occupant close to wall →
increase seating density**



Wall located just beyond
projected path of head



INJURY CRITERIA

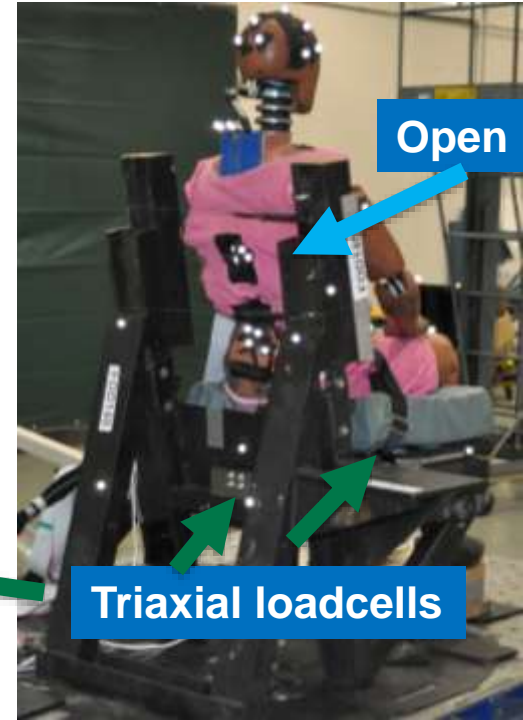
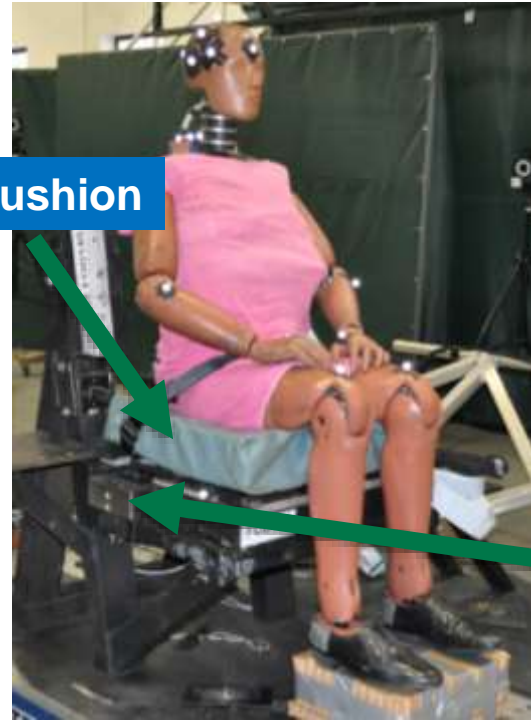
- ❖ Post Mortem Human Surrogate (PMHS) to define human response
- ❖ Same environment/loading conditions
- ❖ “Matched-paired” test w/ATD
- ❖ Injury Assessment Reference Values (IARV)



AIRCRAFT V. MOTOR VEHICLE



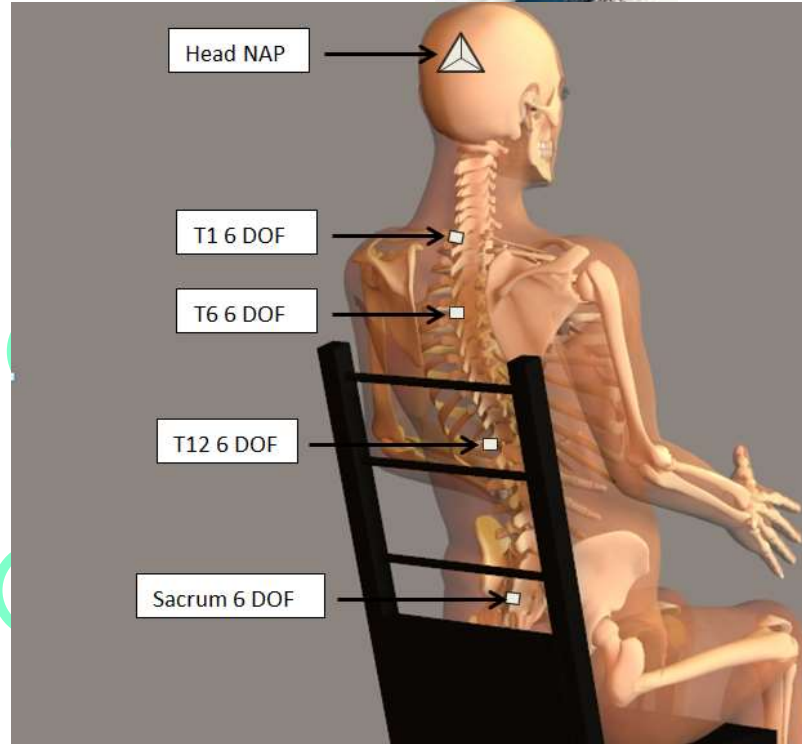
SLED BUCK – AIRCRAFT INTERIOR



PMHS INSTRUMENTATION

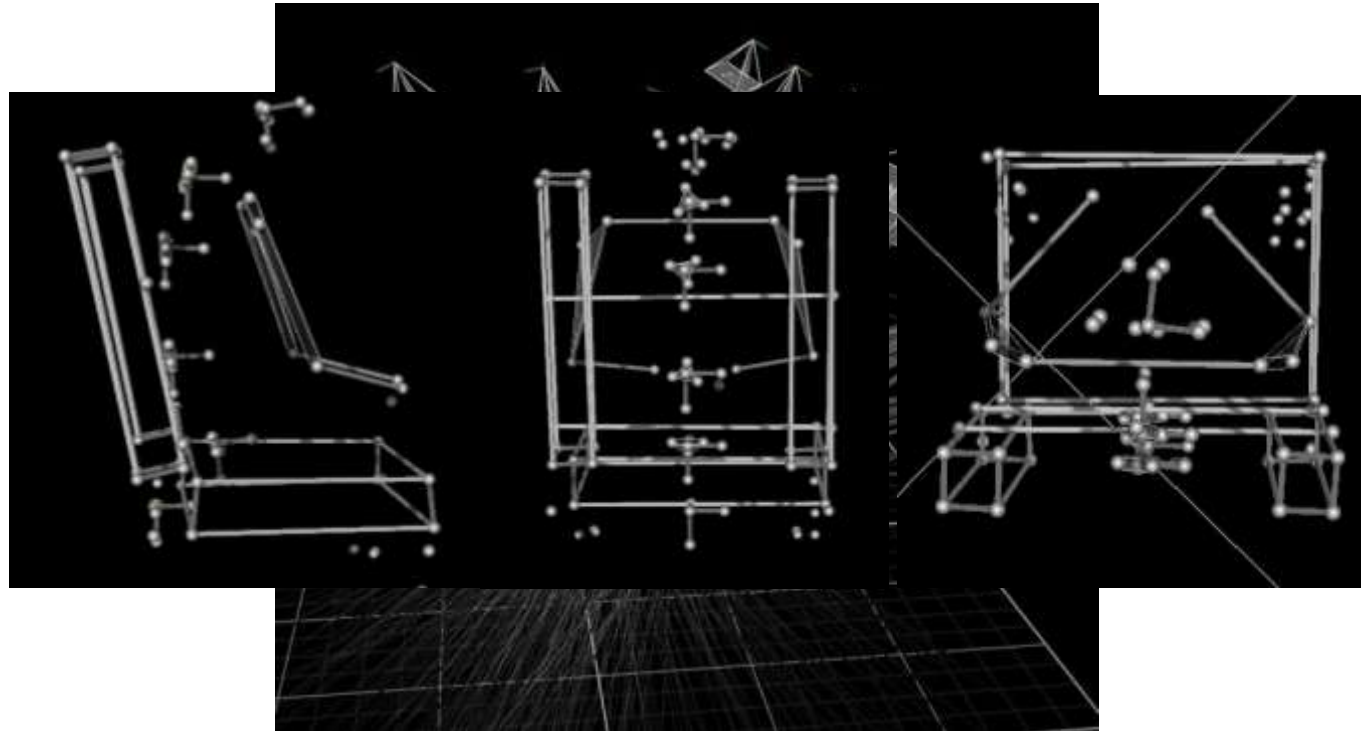


Spine



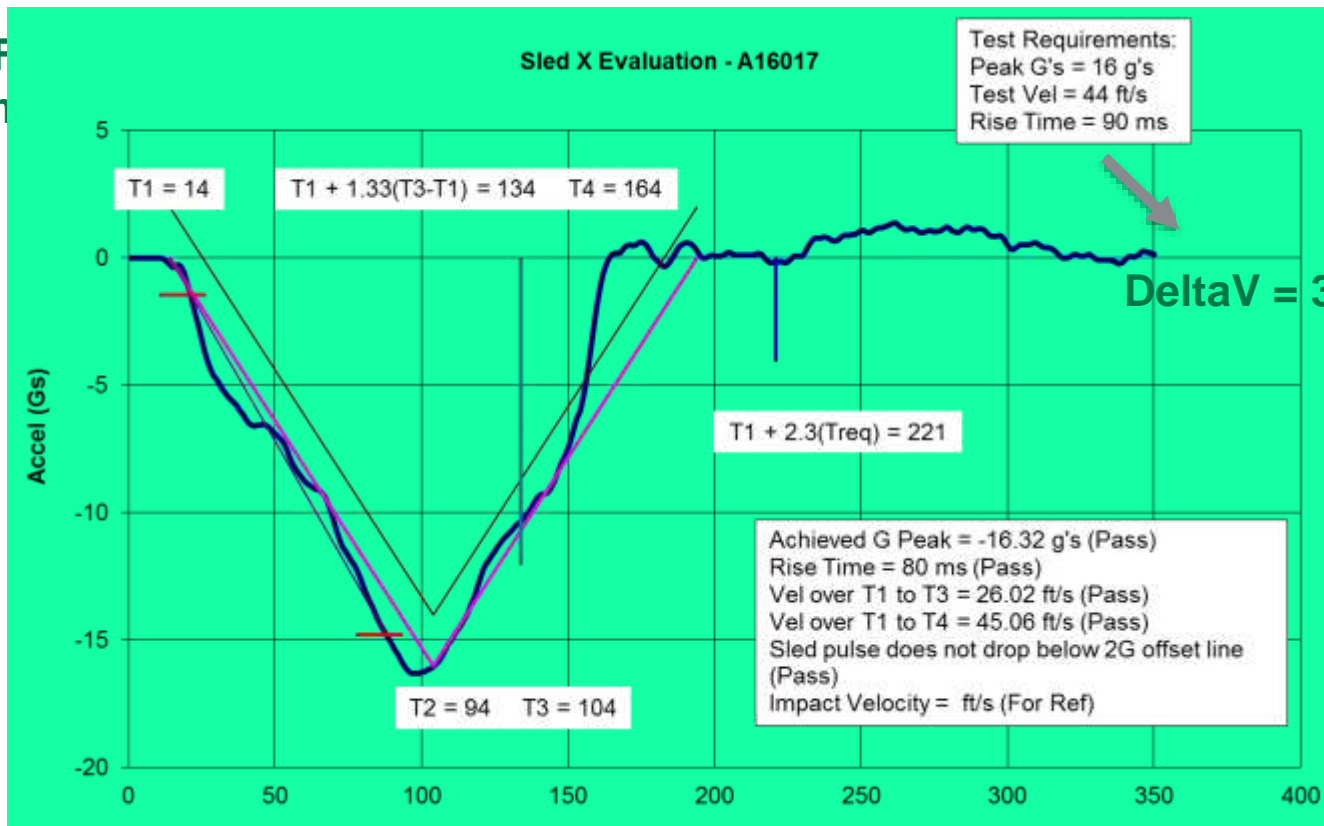
Left

PMHS INSTRUMENTATION

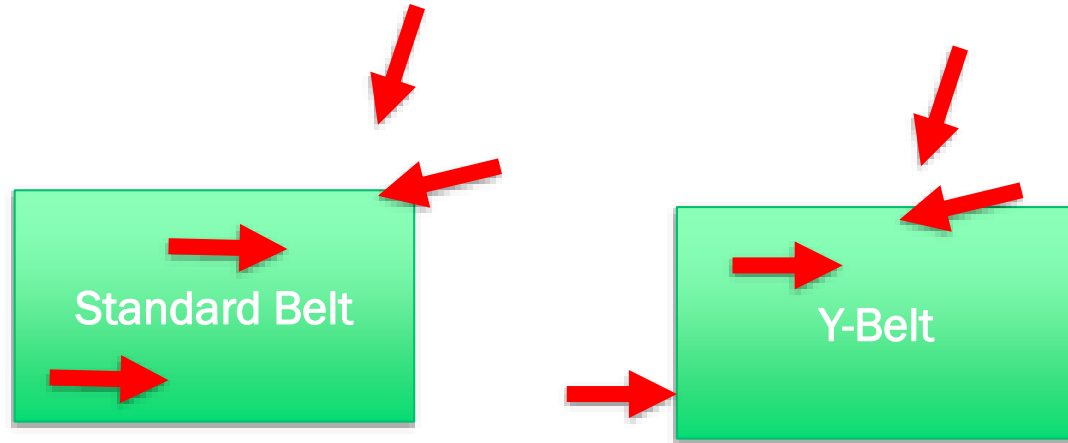


INPUT ACCELERATION

CF
En



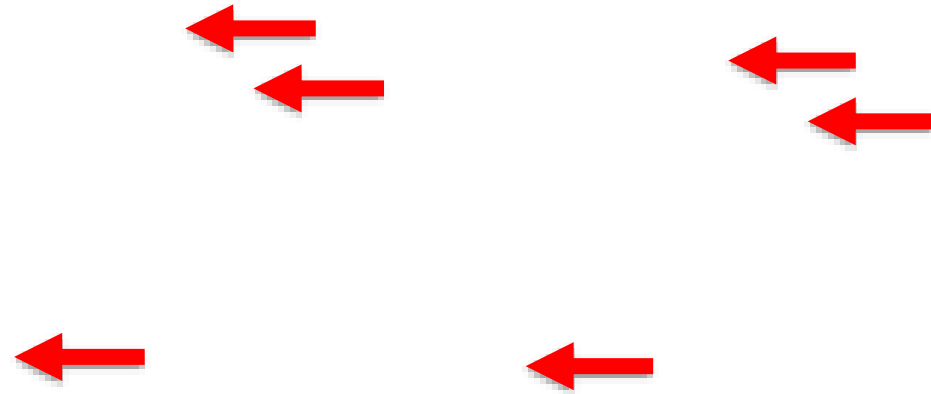
ONBOARD LATERAL: 0 MSEC



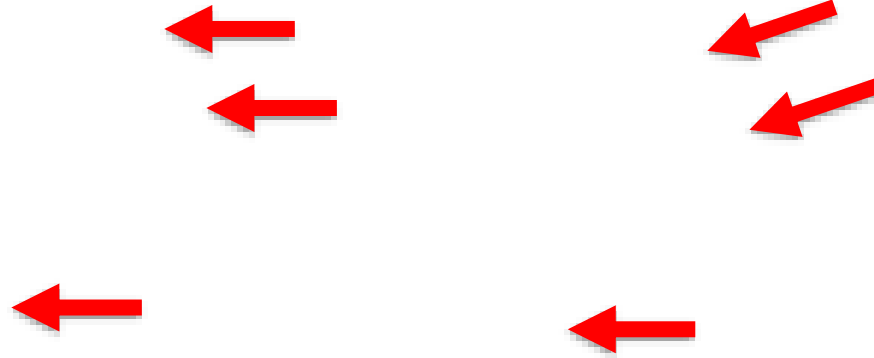
ONBOARD LATERAL: 50 MSEC



ONBOARD LATERAL: 100 MSEC



ONBOARD LATERAL: 125 MSEC



ONBOARD LATERAL: 150 MSEC



ONBOARD LATERAL: 175 MSEC



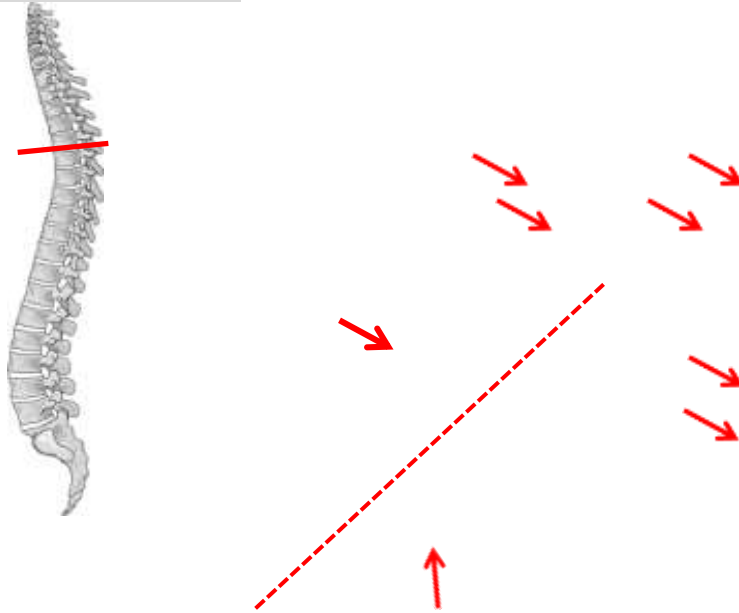
ONBOARD LATERAL: 275 MSEC

INJURIES – STANDARD BELT



Transection of vertebral column and Spinal Cord at T4-T5. Also demonstrated are multiple bilateral rib fractures resulting in Flail Chest condition.

coronal CT



T4-5 TRANSECTION OF VERTEBRAL COLUMN/SC

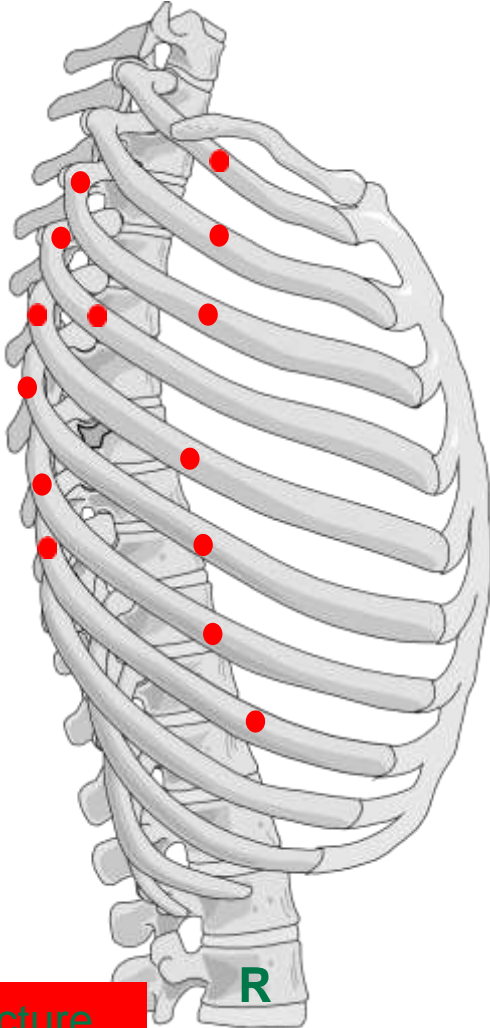
PROXIMAL FEMUR FRACTURES



PROXIMAL FEMUR FRACTURES

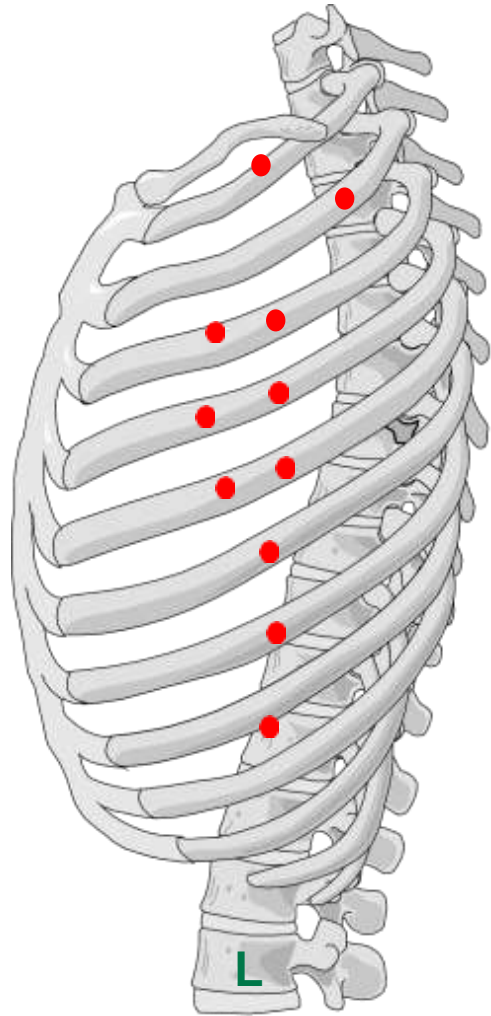
Left

Right



fracture

R



L

LEFT RIB FRACTURES

RIGHT RIB FRACTURES

POSTERIOR RIB FRACTURES

INJURIES – Y-BELT

Summary

Transection of vertebral column L5-S1

Multiple Left Rib Fractures

Flail Chest

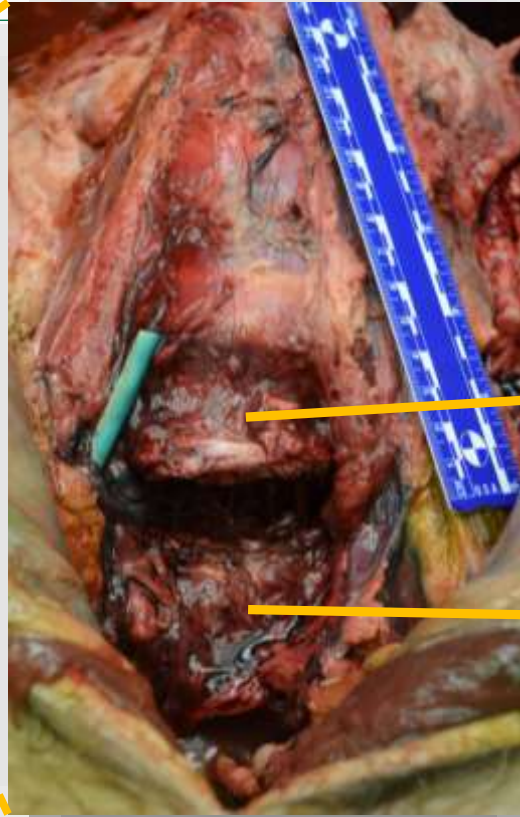
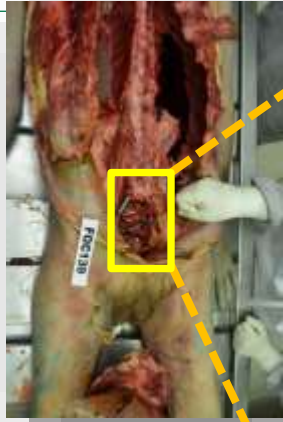
L5-S1 Transection of Vertebral Column

T10	T10
T11	T11
T12	T12
L1	L1
L2	L2
L3	L3
L4	L4
L5	L5

PRE

POST

L5-S1 Transection of Vertebral Column



L5 Vertebral Body

Sacrum

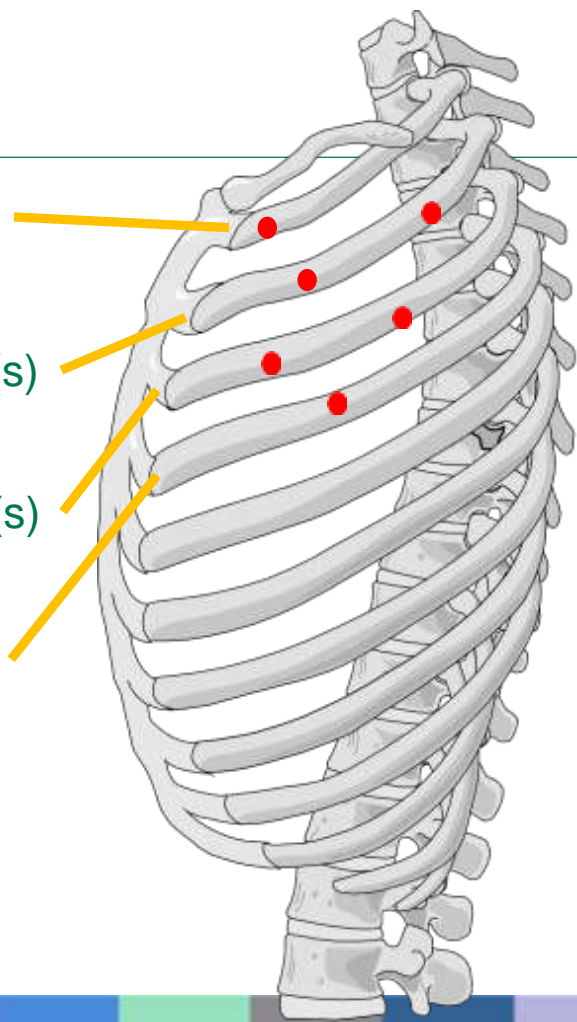


Left Rib 2 Fx

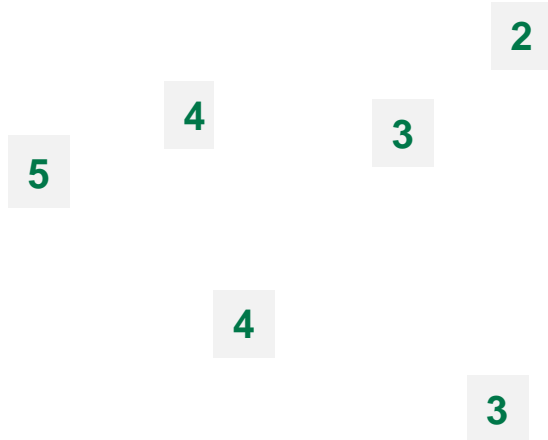
Left Rib 3 Fx(s)

Left Rib 4 Fx(s)

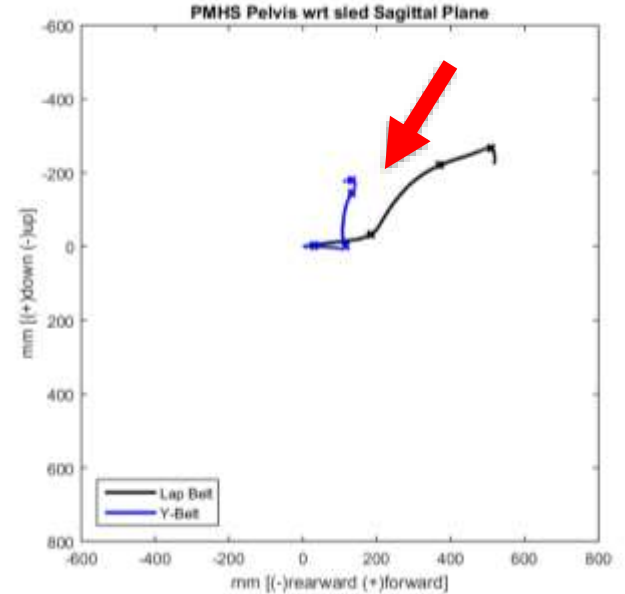
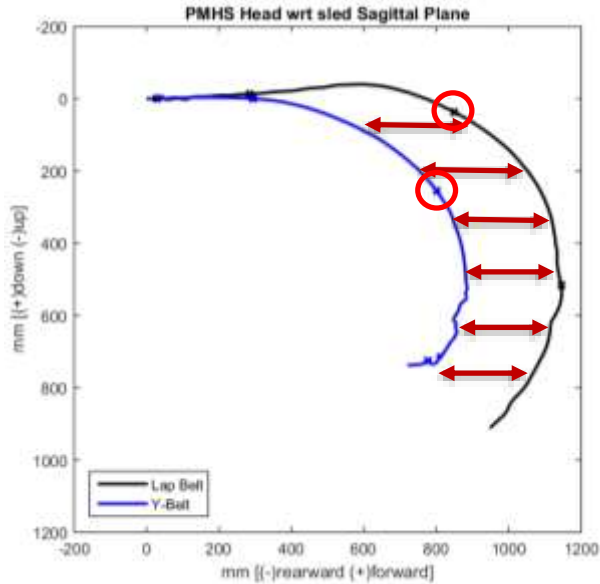
Left Rib 5 Fx



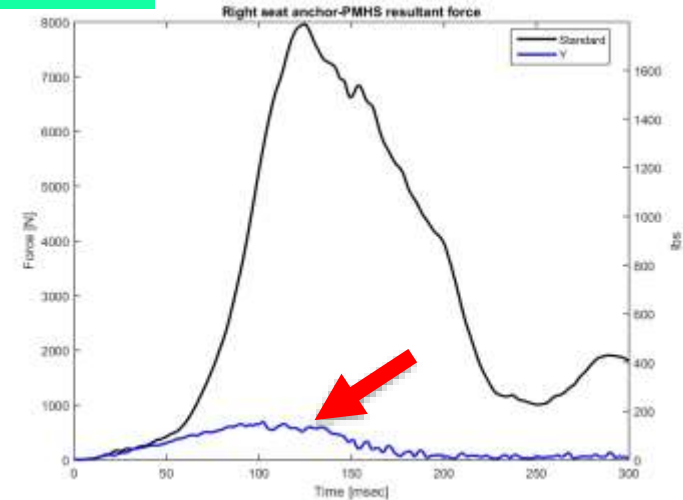
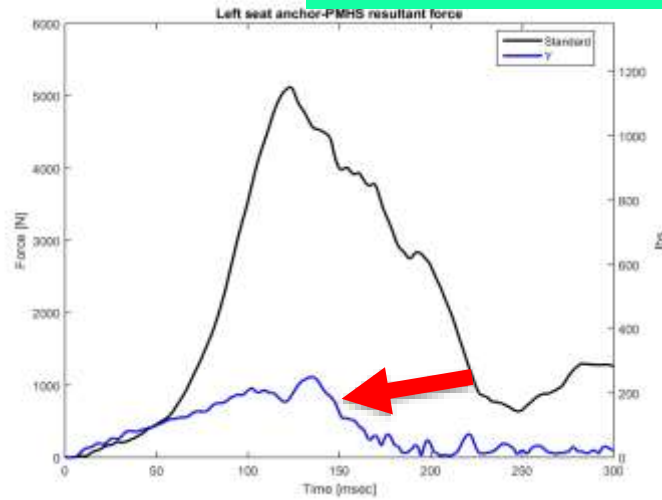
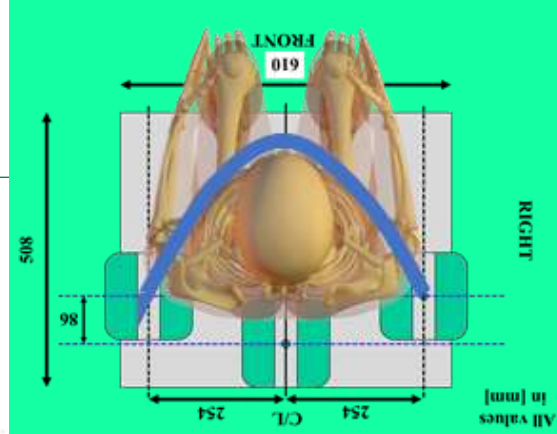
left lateral thorax Rib
Fx's



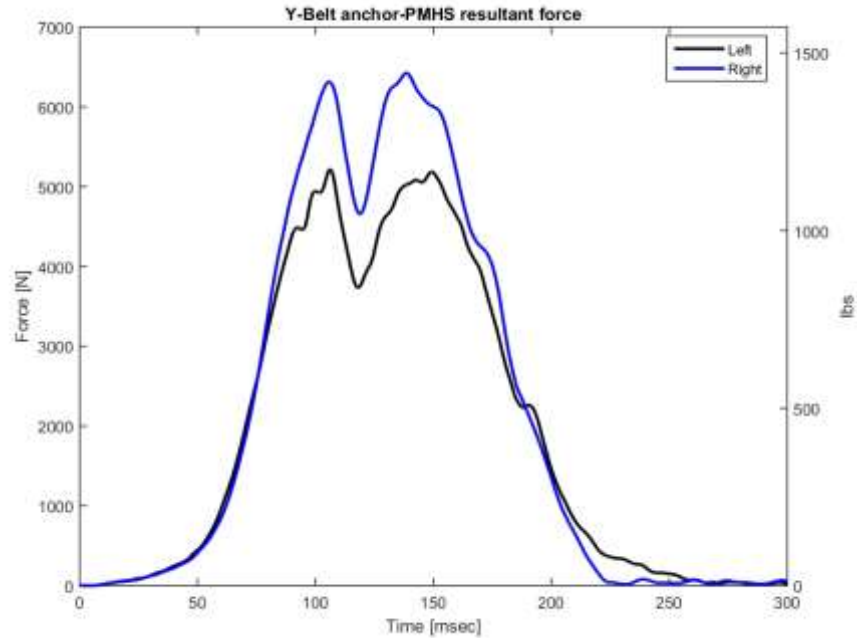
KINEMATICS



BELT LOADS



Y-BELT LOAD



MATCHED-PAIRED TESTS



FAA-Hybrid III

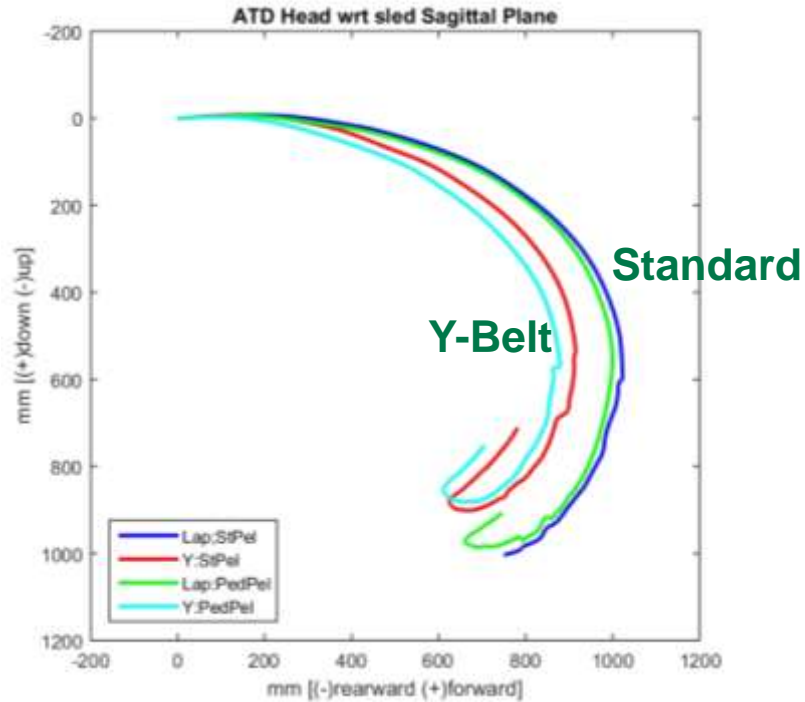
Fixed (standard) Pelvis

Pedestrian Pelvis

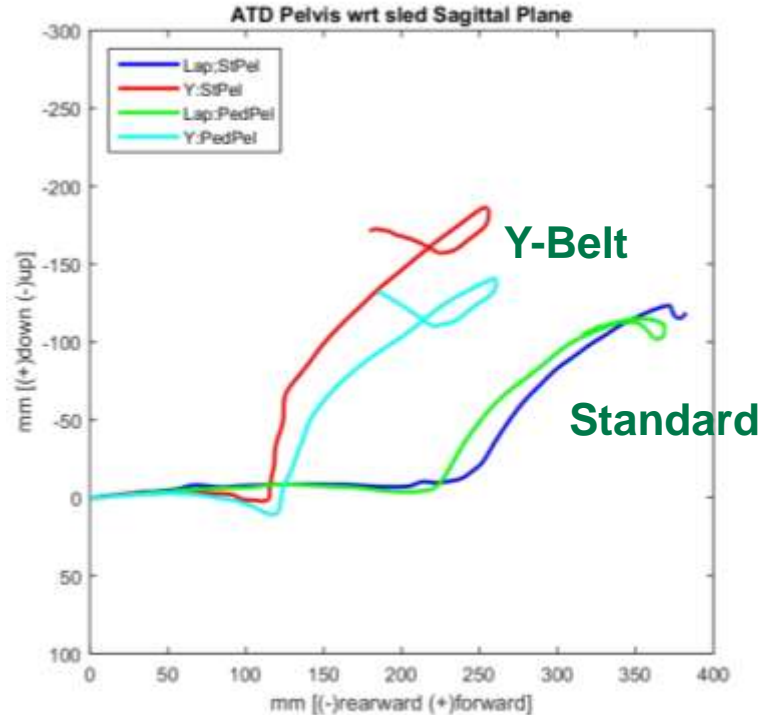
Lumbar Load cell

Thoracic Load cell

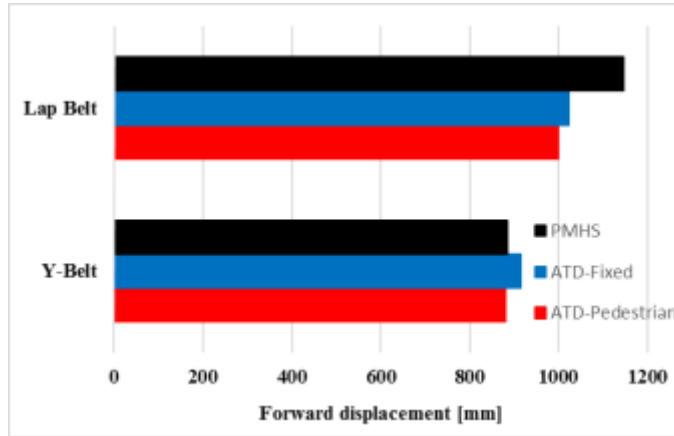
HEAD KINEMATICS - ATD



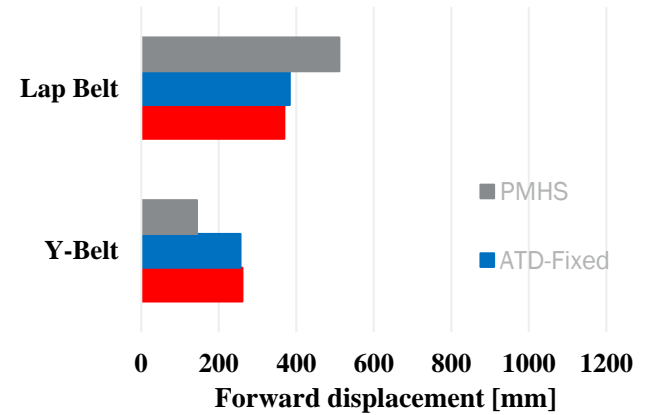
PELVIS KINEMATICS- ATD



PEAK FORWARD TRANSLATION

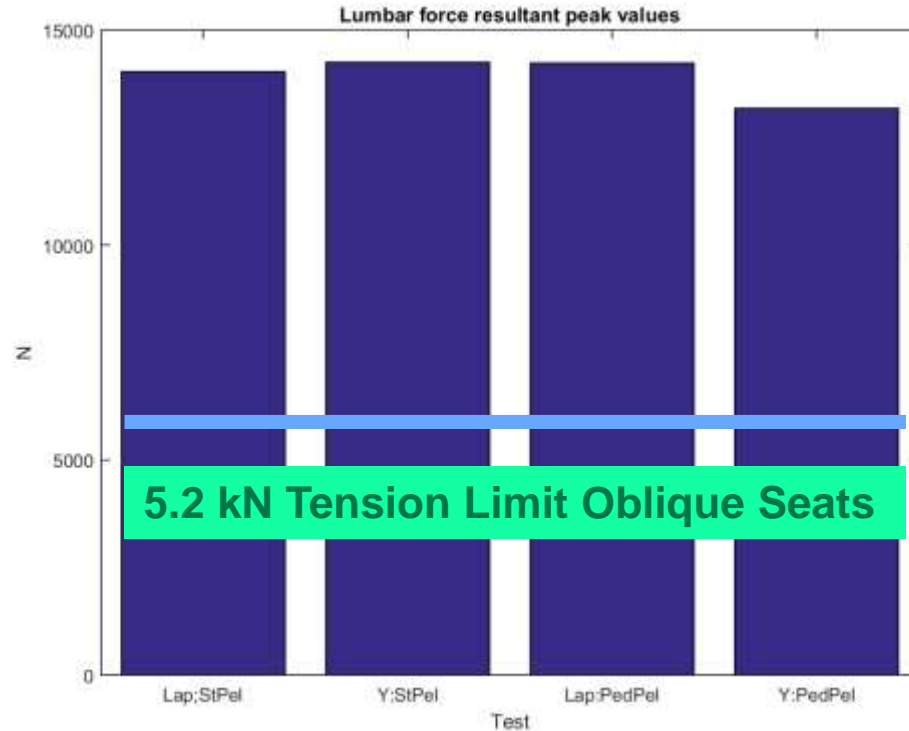


Head



Pelvis

ATD LUMBAR FORCE



SUMMARY

2 PMHS Tests → Standard and Y-Belt

Severe spine injuries

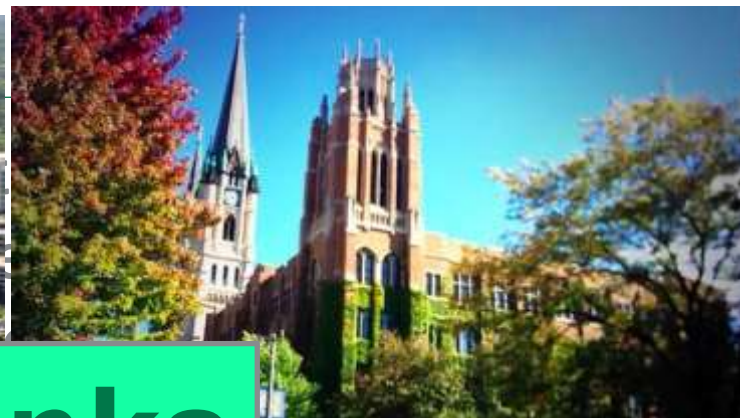
Matched ATD Tests → Fixed/Pedestrian Pelvis

Head kinematics

- Standard Belt PMHS > ATD : Pedestrian & Fixed similar
- Y-Belt PMHS and ATD similar : Pedestrian < Fixed

ATD lumbar tension forces similar

Results may require updates to future certification projects



Thanks

FAA Grant 150

