

**MORNSAN**  
Technologies

Pune, INDIA   
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**SIMBIO-M**

Injury Biomechanics Conference

18 & 19<sup>th</sup> June  
Stratford-Upon-Avon (UK)



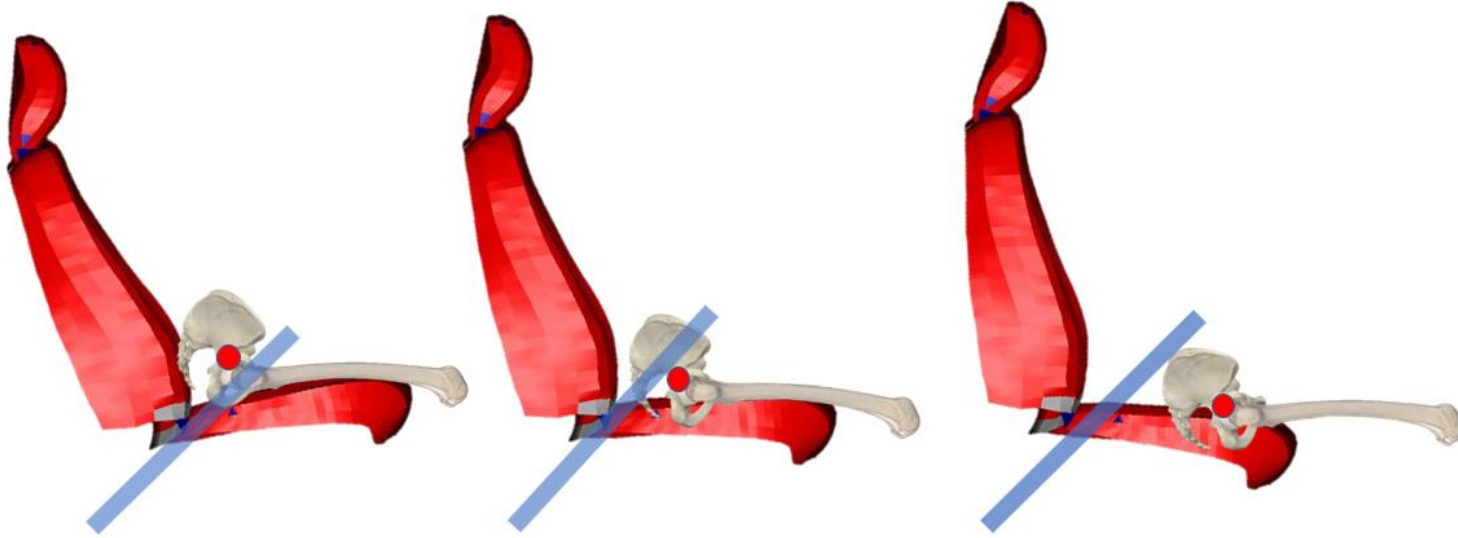
**Chandra K.  
Thorbole, Ph.D.**

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**How much is too much for a  
seatback recline to promote  
occupant submarining : A  
study using rigid seat sled  
model and 5<sup>th</sup> percentile  
female ATD.**



What is submarining?

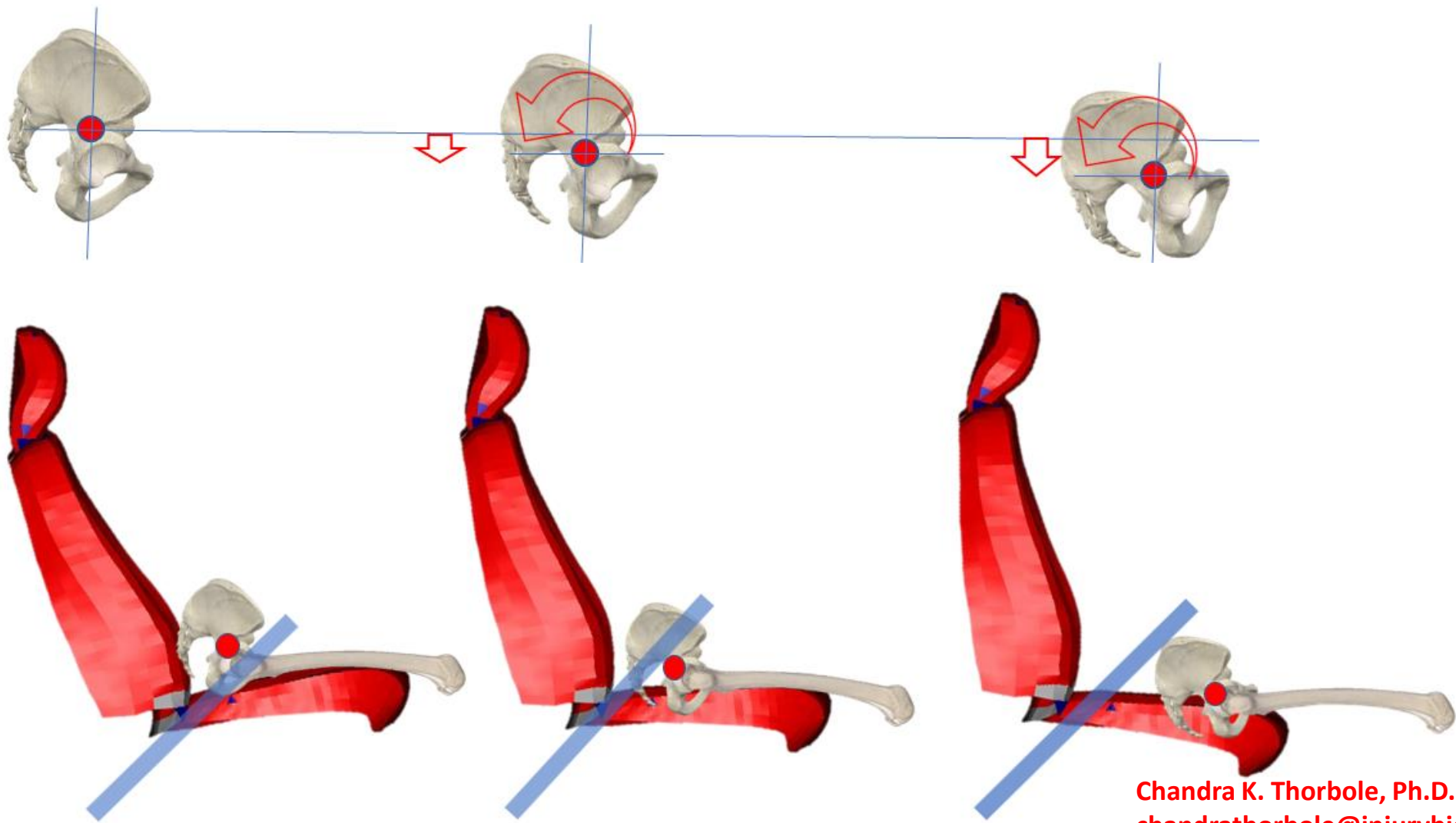


**“ the lap belt slides over iliac crest with lap belt forces effecting the internal abdominal organs During forward displacement of the lower torso”**

Dieter Adomeit & Alfred Heger  
SAE 751146

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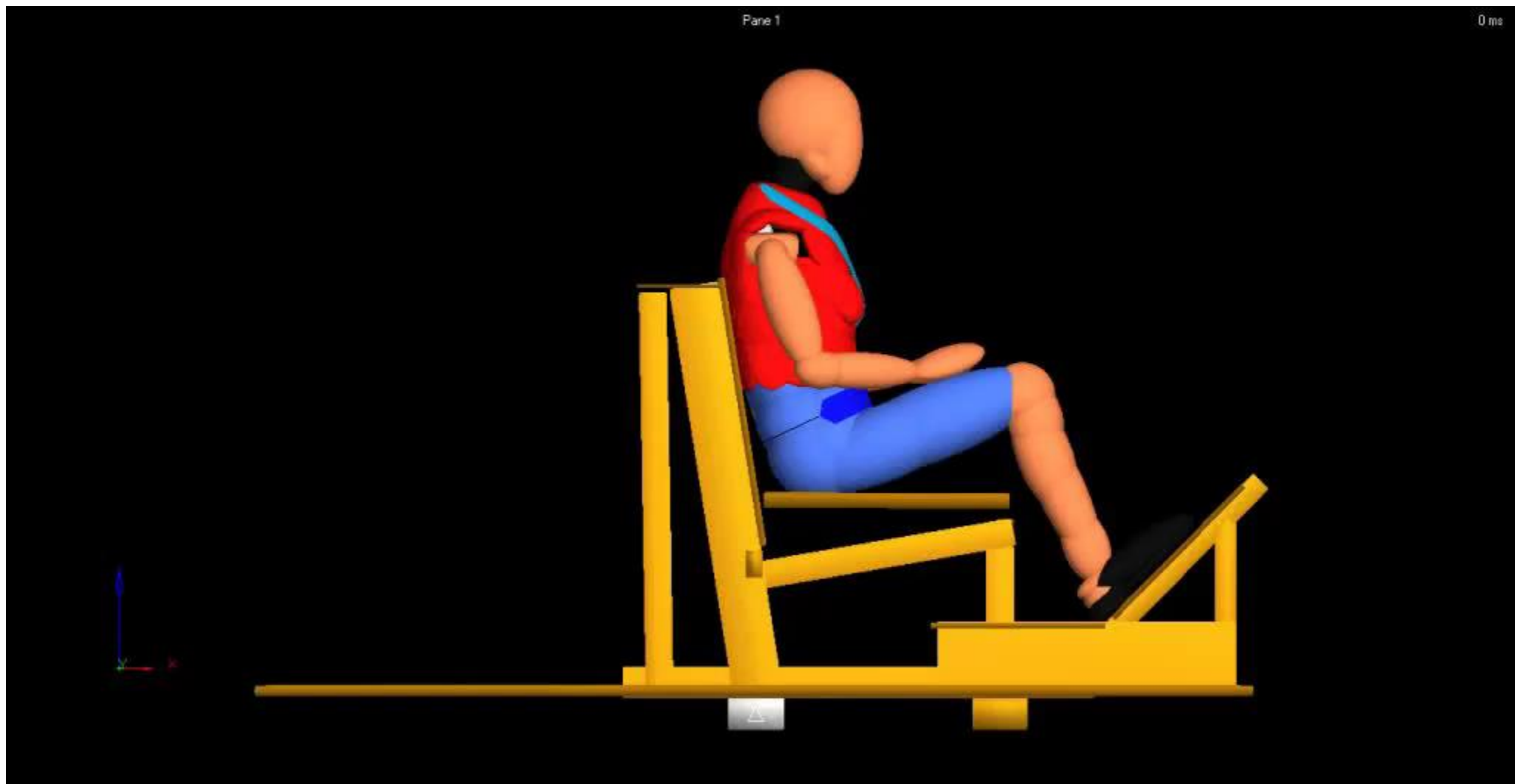
# Submarining



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## Undesired Kinematics

- H-point downward travel (Pelvis Dive)
- Pelvis backward rotation
- Torso angle > 90°



# Submarining Kinematics

MADYMO Simulations

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# Submarining Detection Methods

Film Analysis



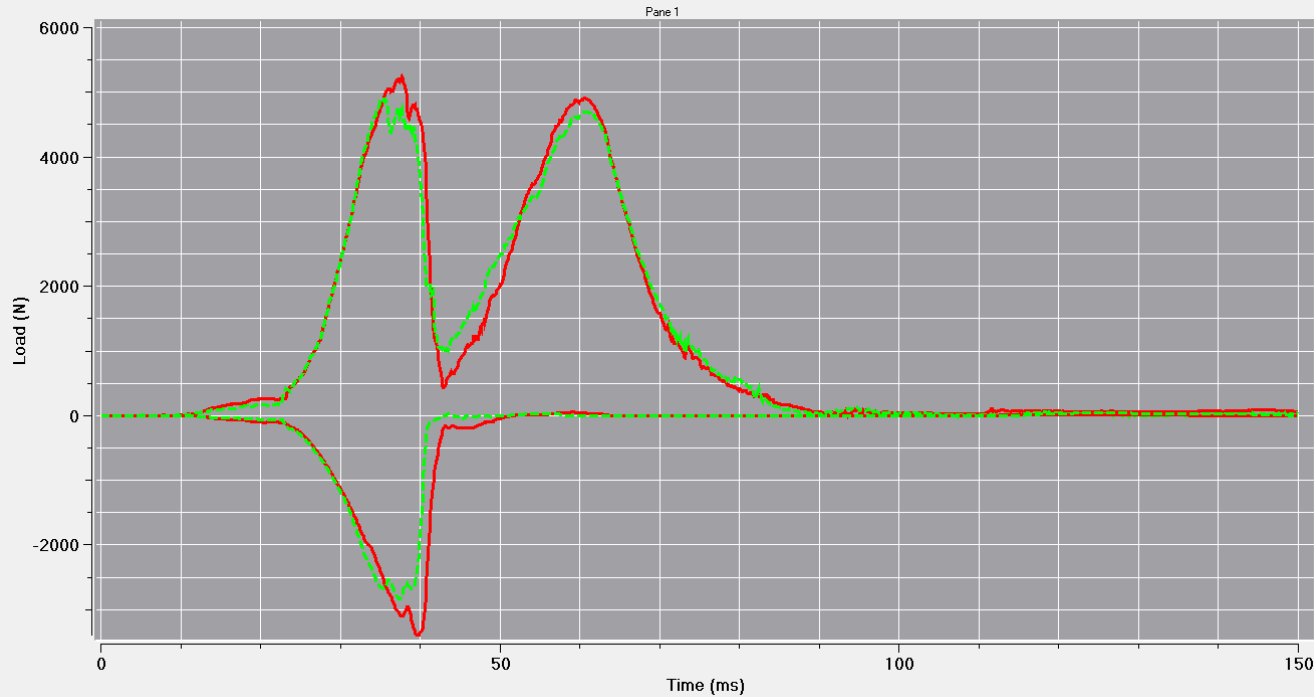
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graph TD; A[Film Analysis] --> B[Seatbelt load profile study]; B --> C[A.S.I.S Load profile study];
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Seatbelt load profile study

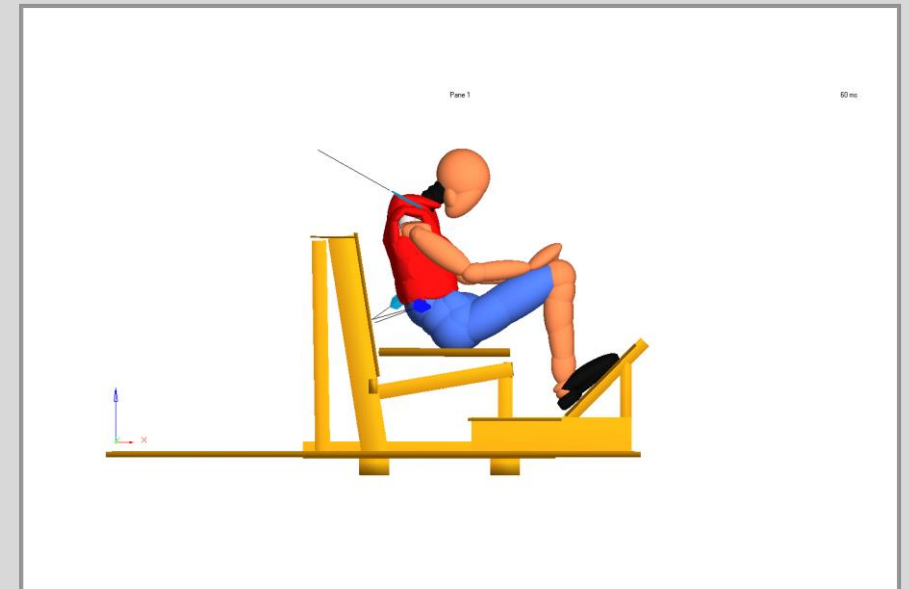
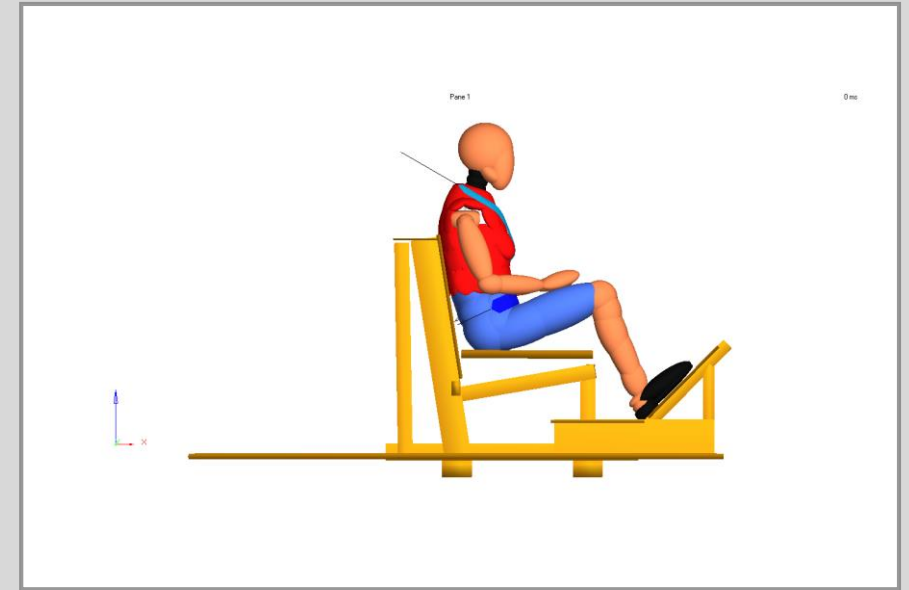
A.S.I.S Load profile study

Submarining Detection

# Seatbelt load profile study

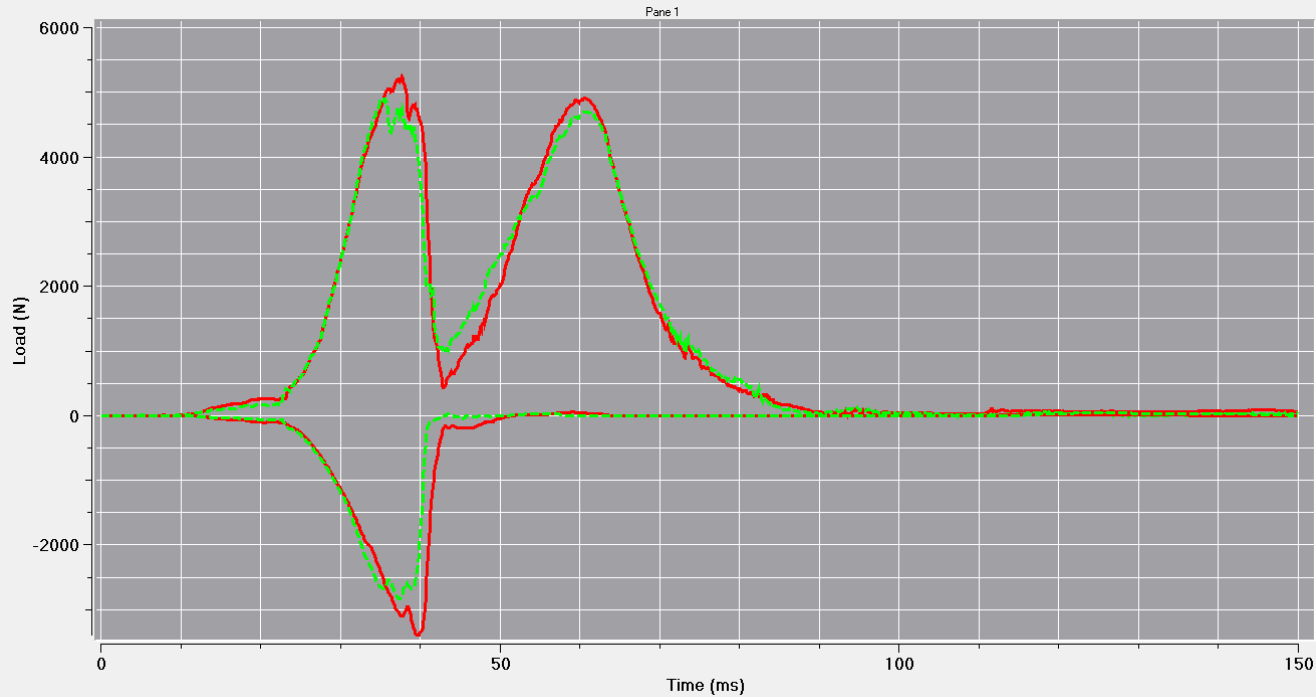


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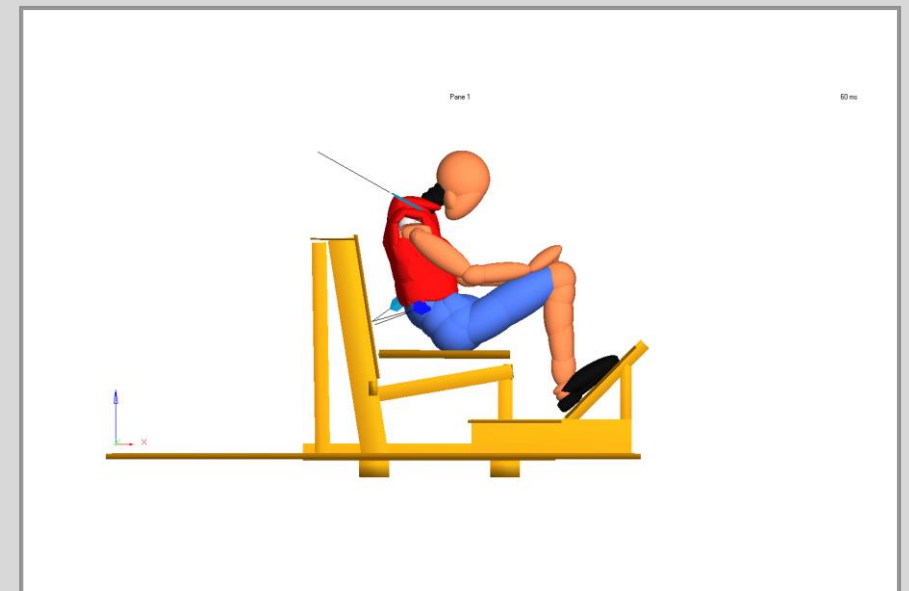
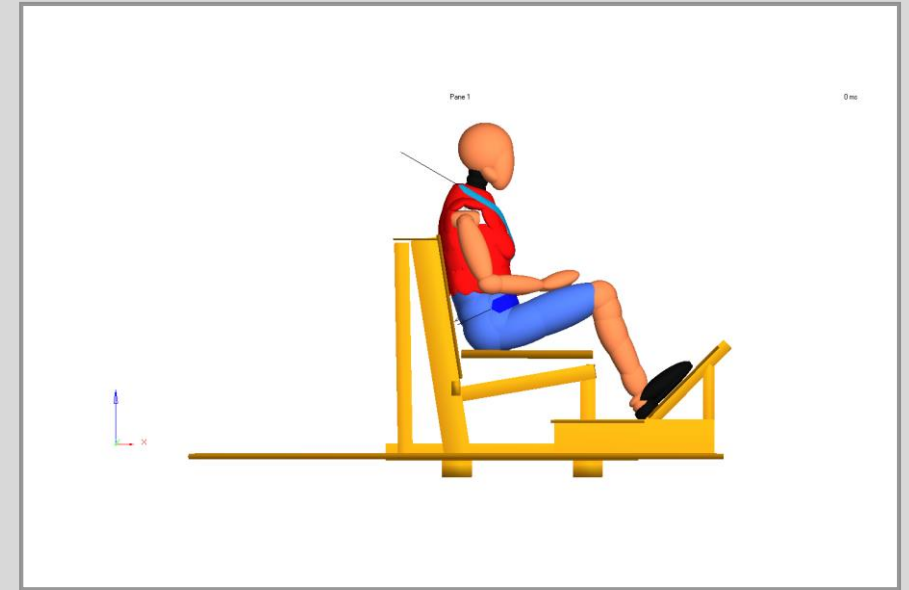




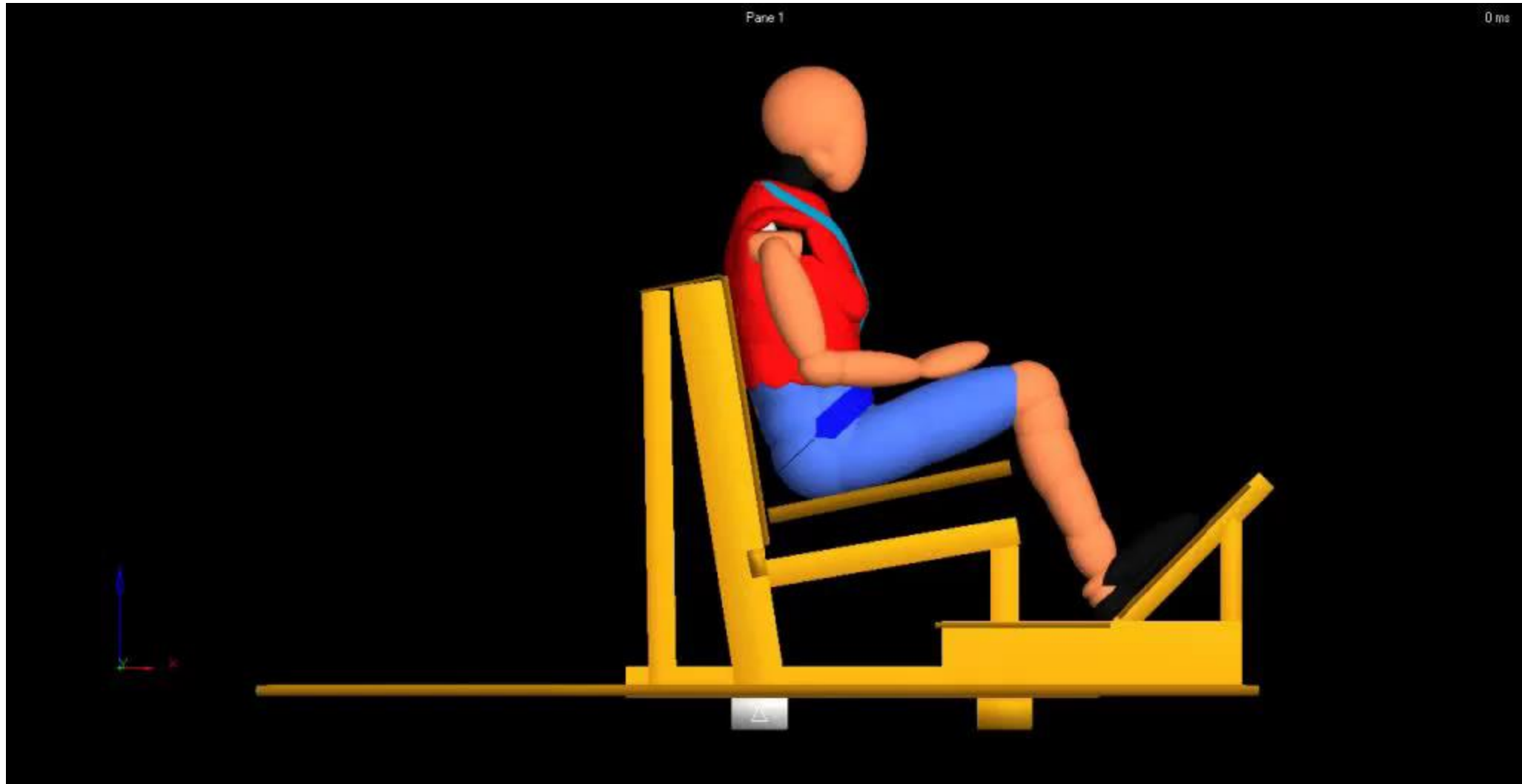
# A.S.I.S load profile study



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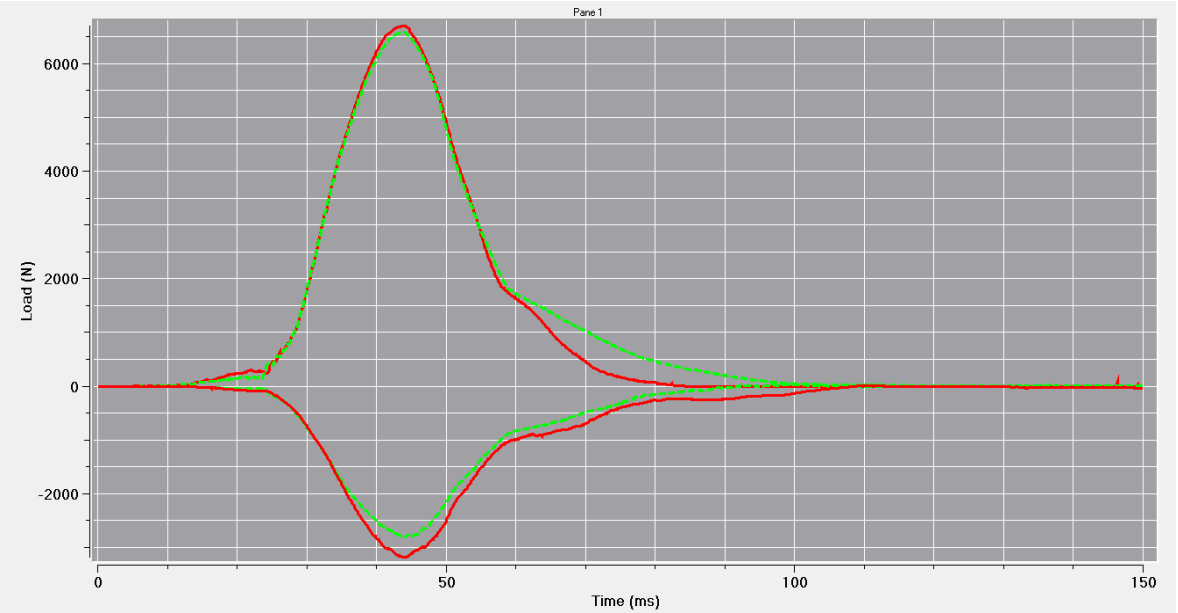
Desired Kinematics, belt  
load & A.S.I.S load  
profile



Pane 1



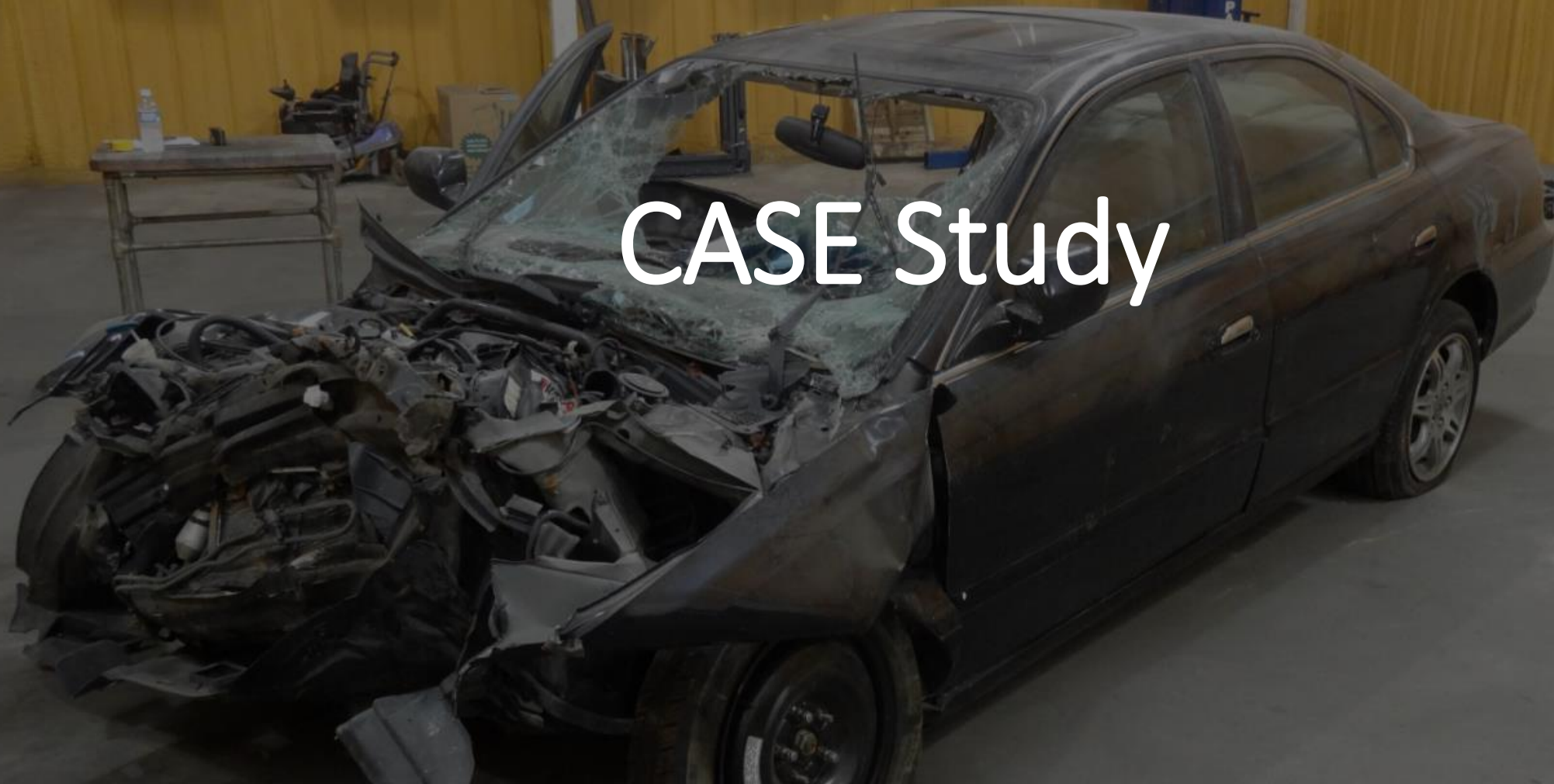
## Seatbelt & A.S.I.S load profile study



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How reclined seatback  
promotes submarining  
and changes injury  
pattern & severity

# CASE Study

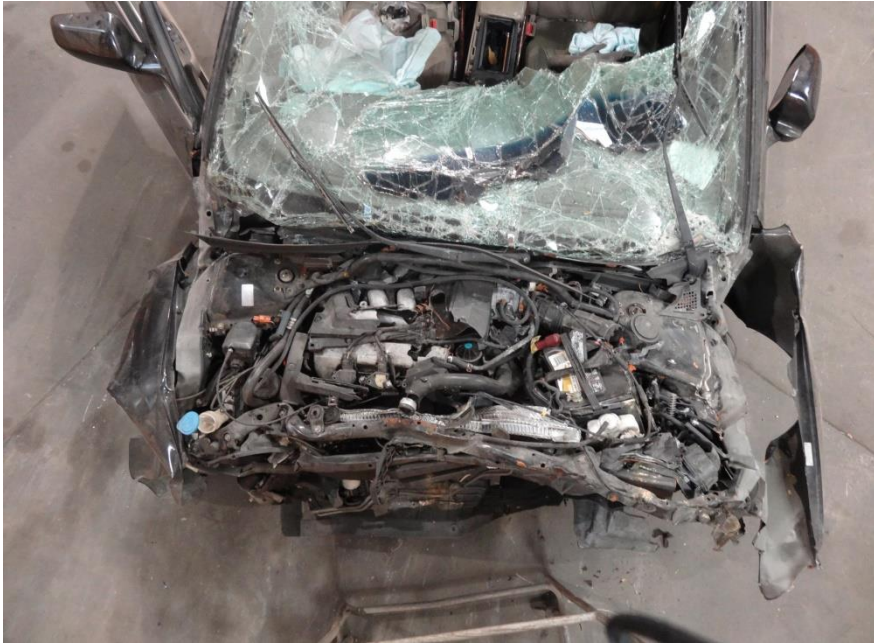




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Vehicle Type : 1999, 4-door sedan  
Occupant Type : Belted Front  
Passenger  
Seatback : Reclined 60 deg with  
vertical  
Compartment : No intrusion





# Front end damage pattern

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Driver and Passenger  
Airbag Deployed  
PDOF 12 O'CLOCK  
Delta V OF 35 TO 40 mph



**Case Occupant-2**

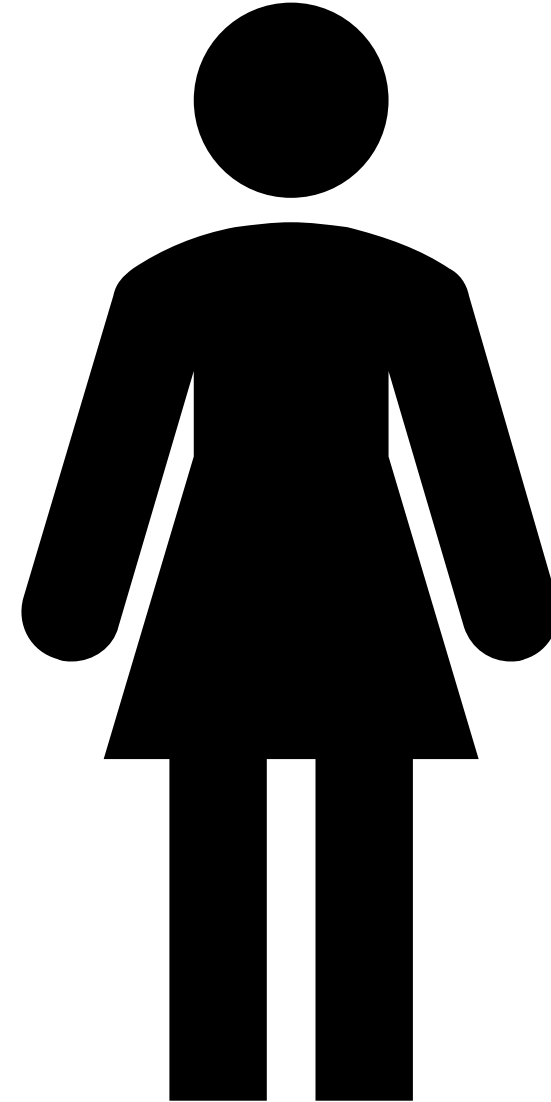
**Position : Belted Front Passenger**

**Age : 26-Year-old**

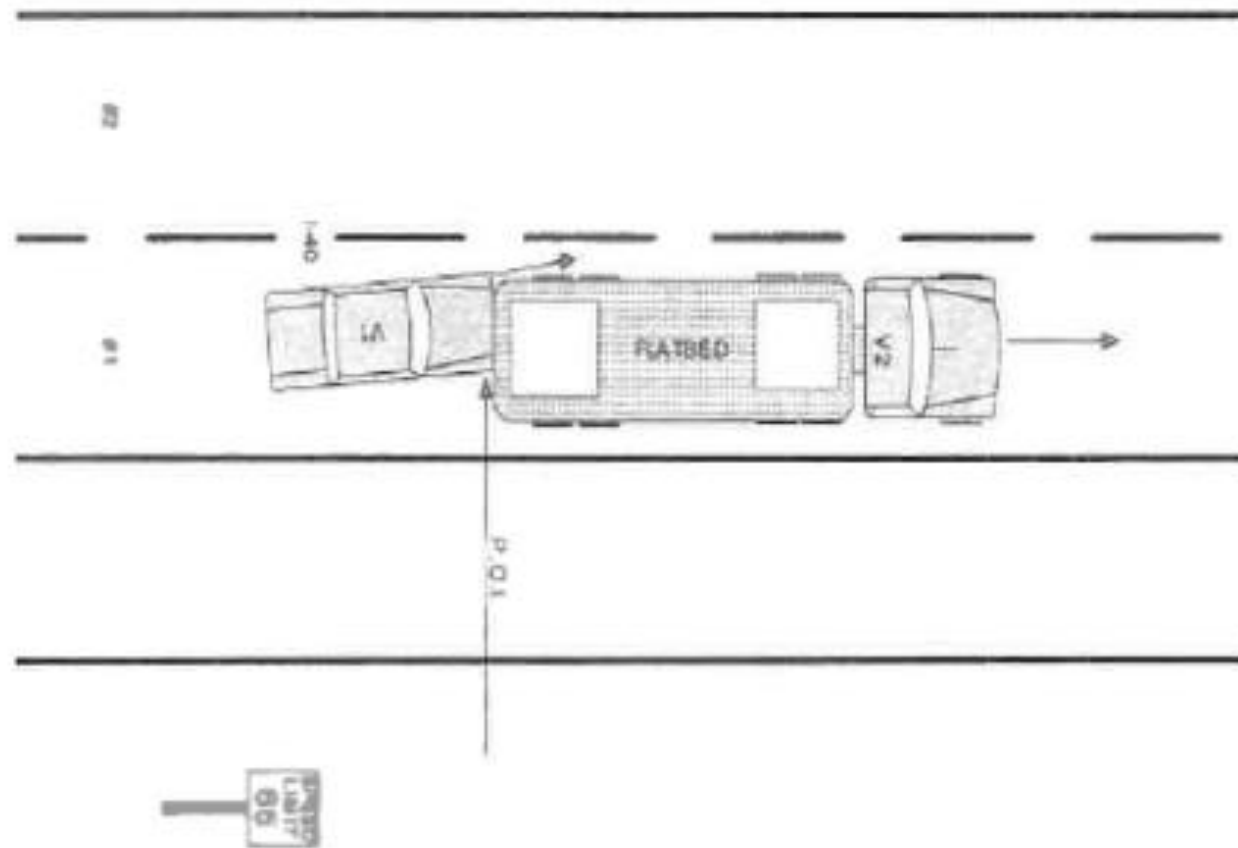
**Sex : Female**

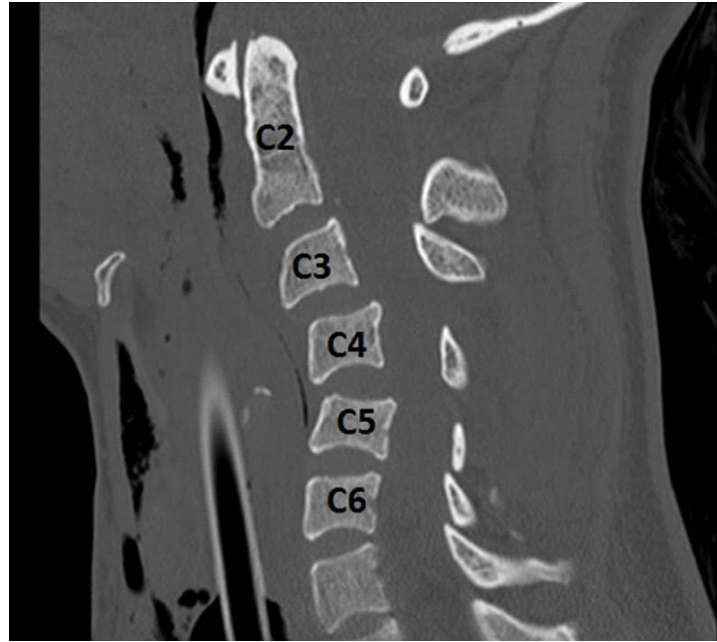
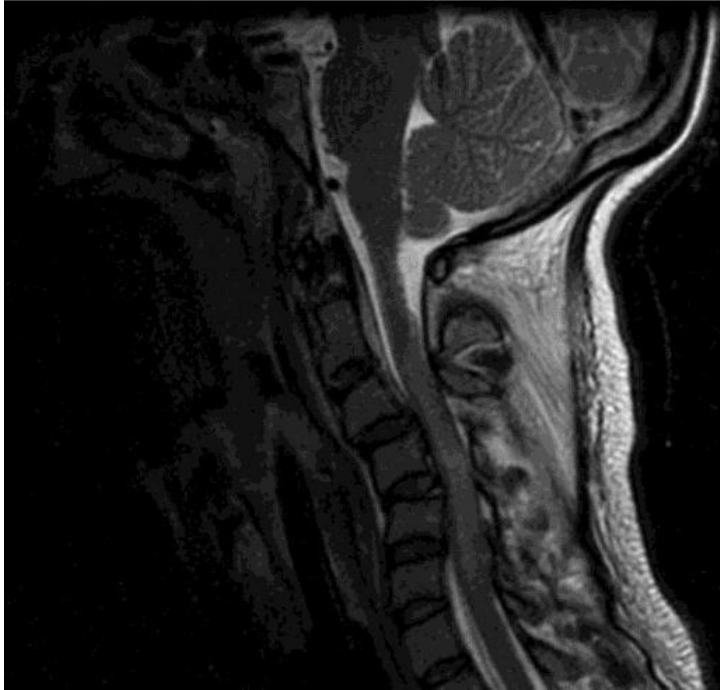
**Height : 5' 8" (~177 cm)**

**Weight : 130 lbs. (59 Kg.)**



# Police Crash Report





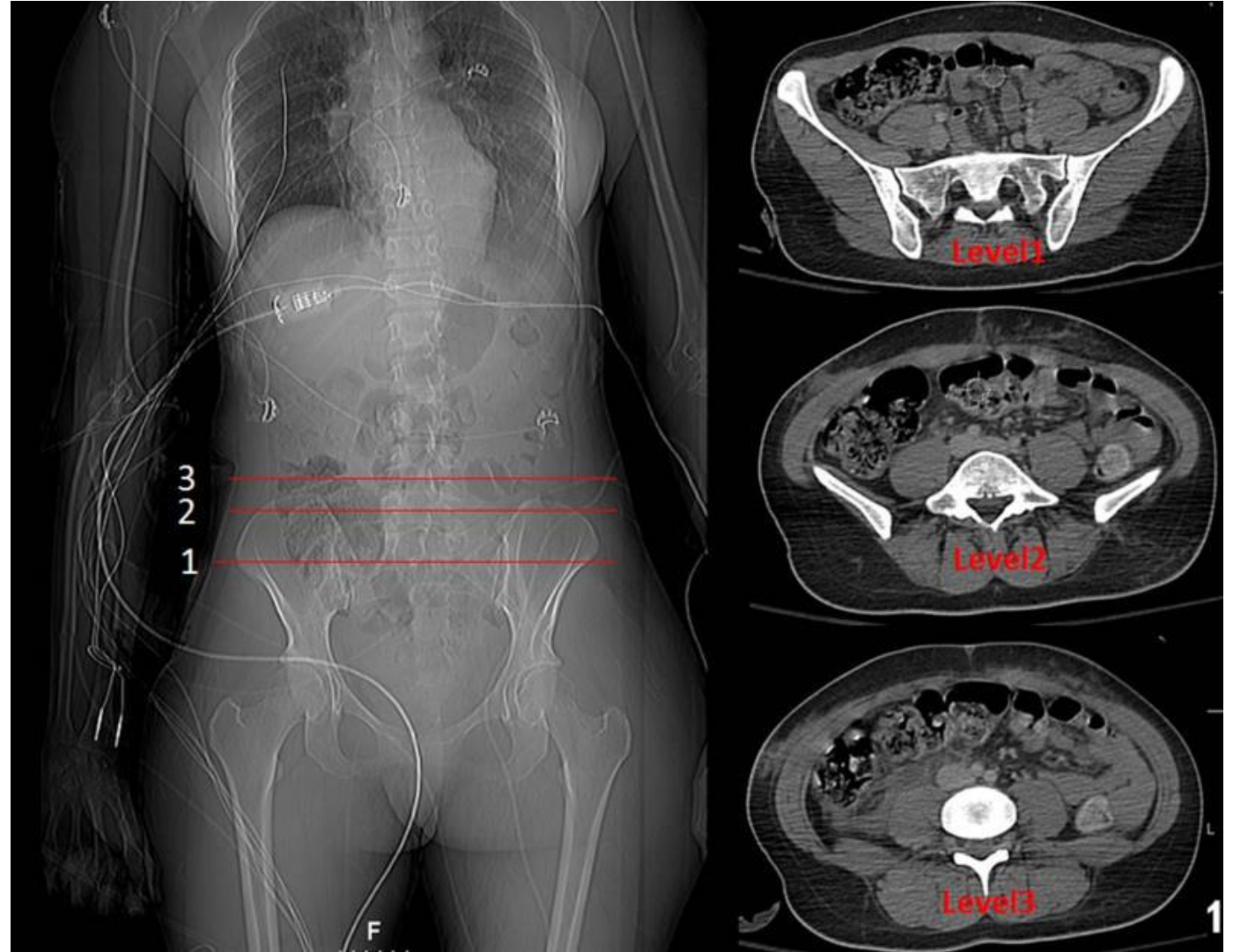
- Increase in the C3-C4 and C4-C5 disc space.
- Anterolisthesis of C3 over C4 (Grade 1).
- Anterolisthesis with anterior and inferior tilt of C4 on C5.
- Subluxation involving the bilateral facet joints of C3-C4 and C4-C5.
- Locking of left facet joint at C4-C5.
- Perching of the left facet at C3-C4.
- Fracture involving the left transverse process of C4 Vertebrae.
- Significant kyphosis at C3,C4 and C5 level.
- Increased posterior disc space at C3/C4 and C4/C5.
- ALL intact at this level.
- PLL focal disruption at C3/C4 and C4/C5.
- Increased interlaminar distance at C3/C4 and C4/C5 level.
- Extensive posterior subcutaneous tissue injury.

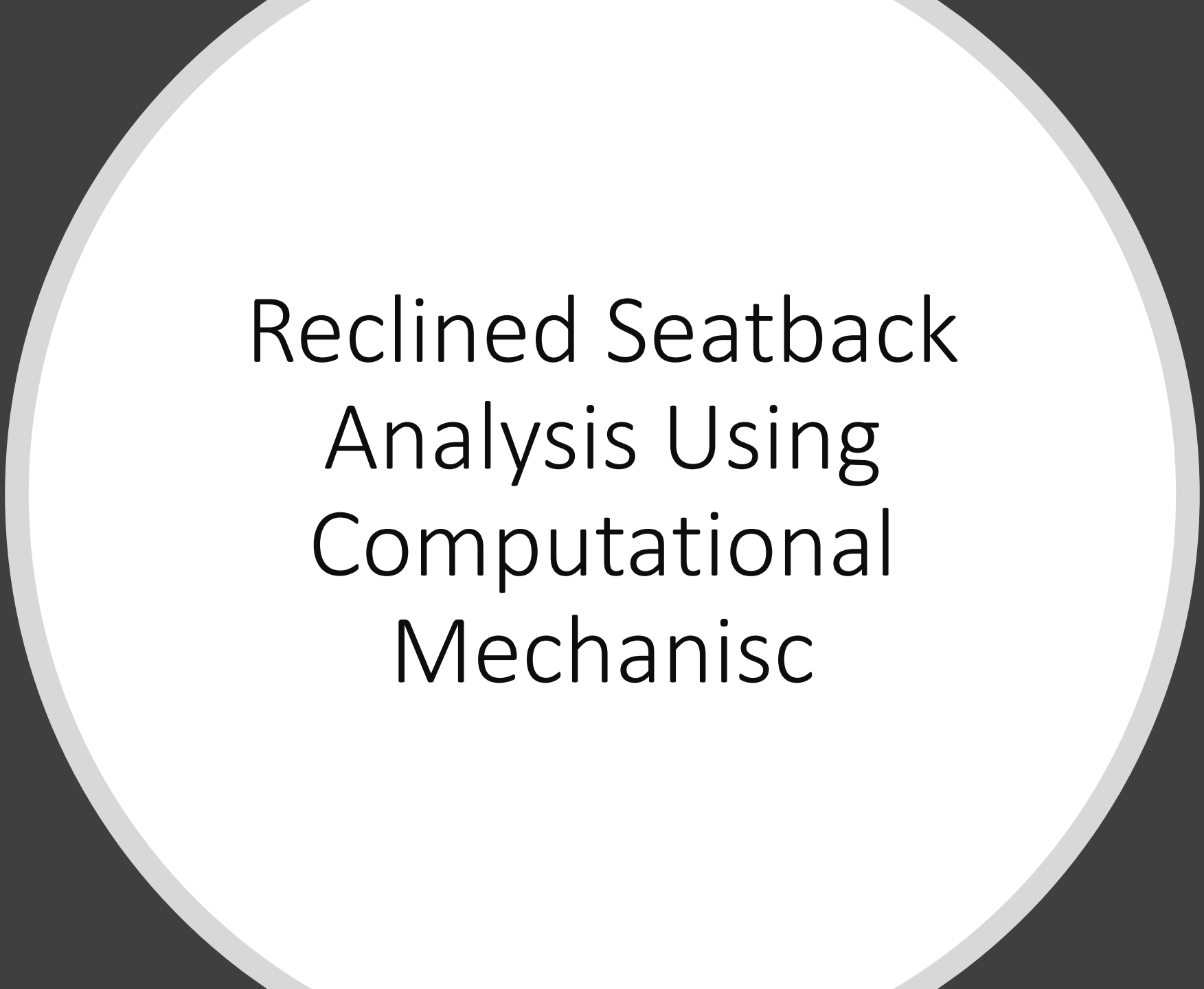
# Injury Pattern

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# Fat Stranding Analysis

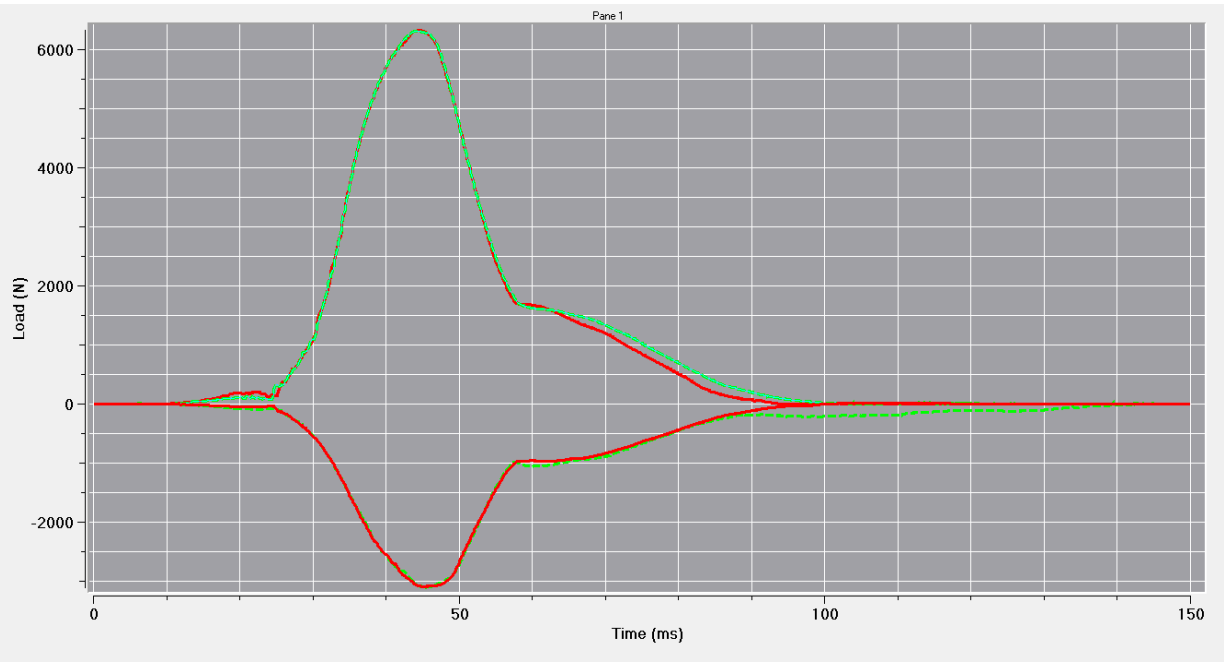
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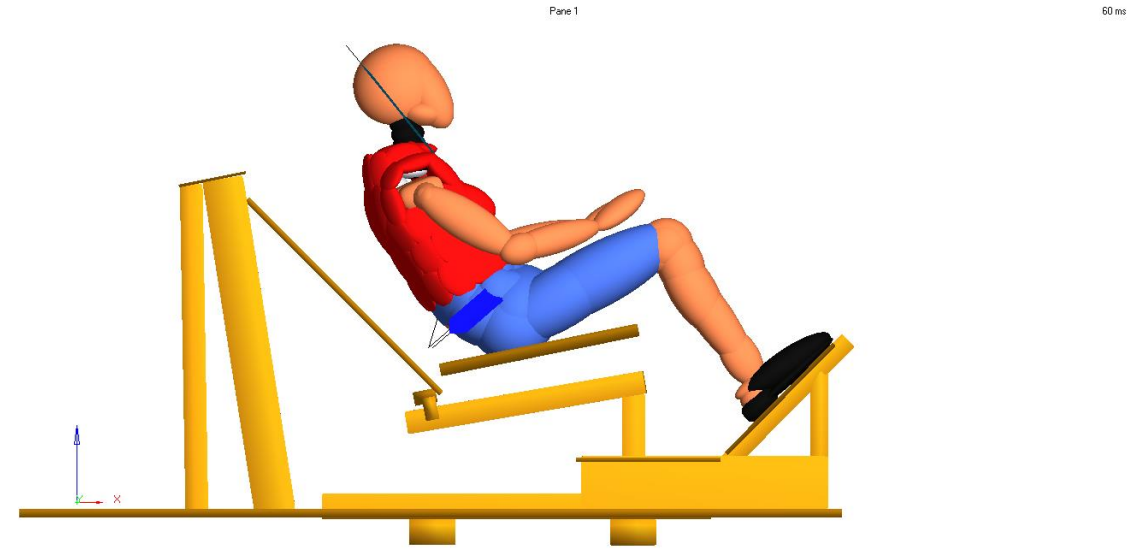
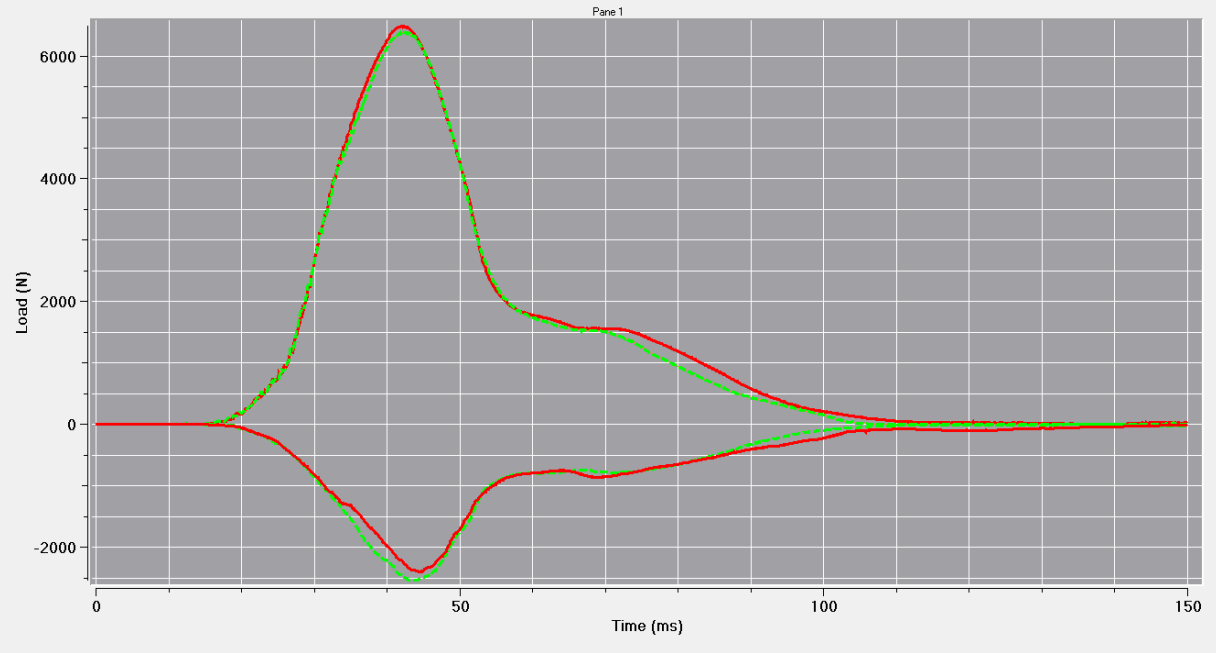
# Reclined Seatback Analysis Using Computational Mechanisc





# 30 deg Recline

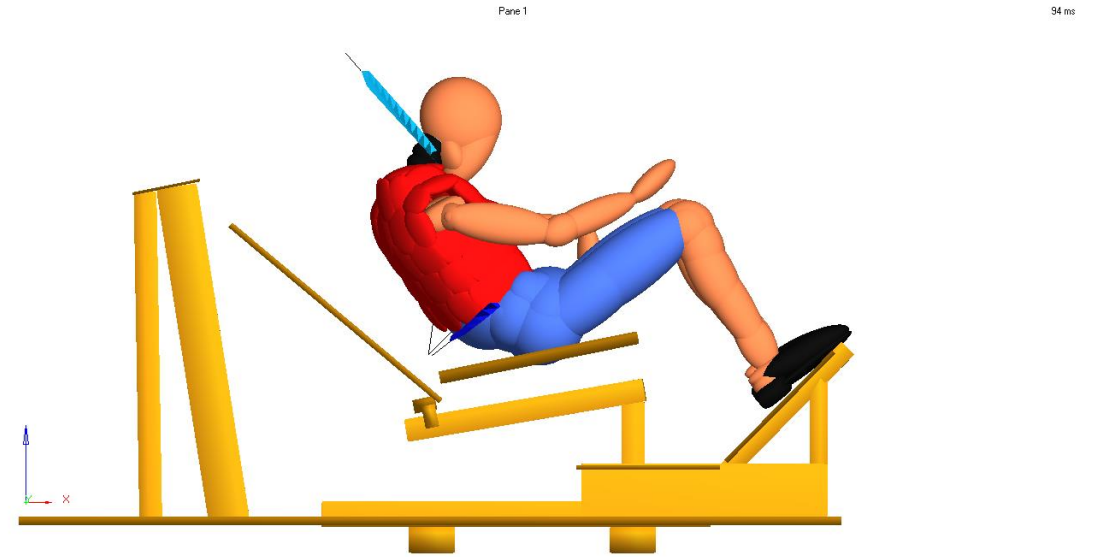
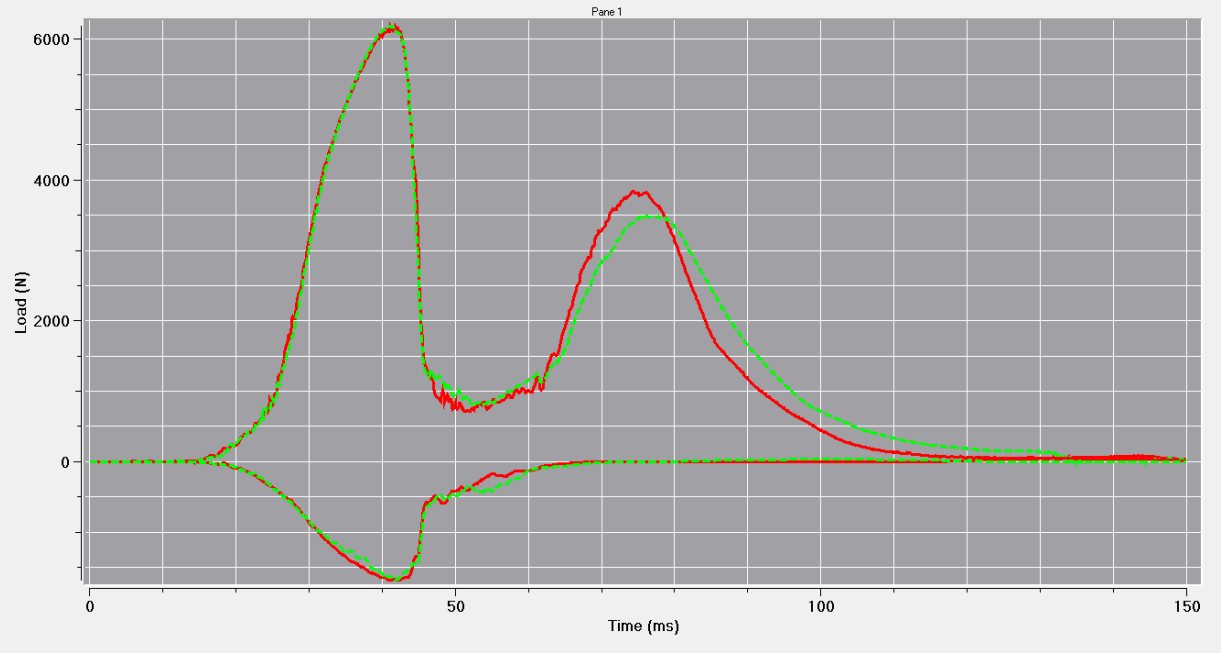
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# 45 deg Recline

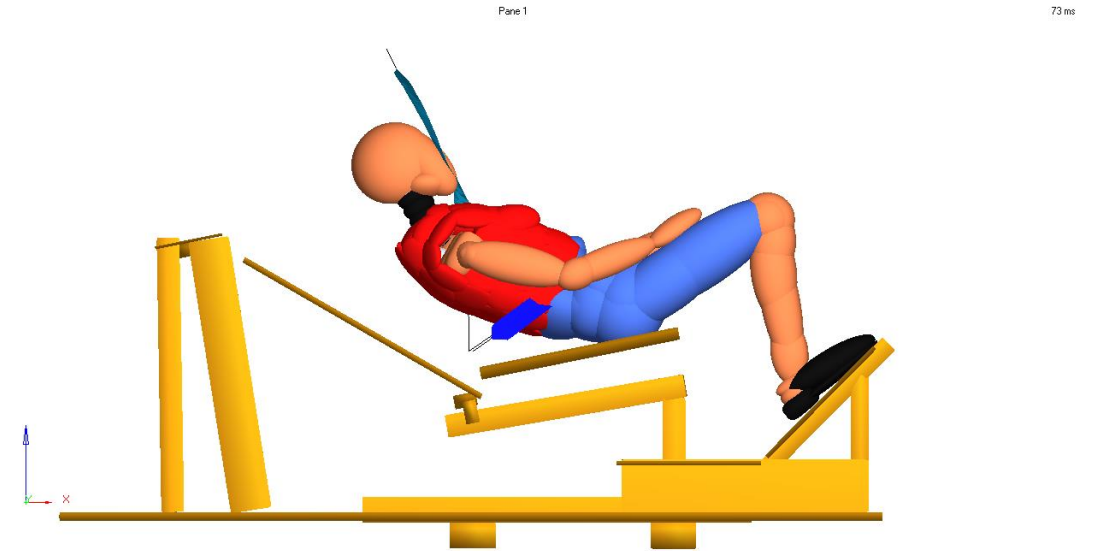
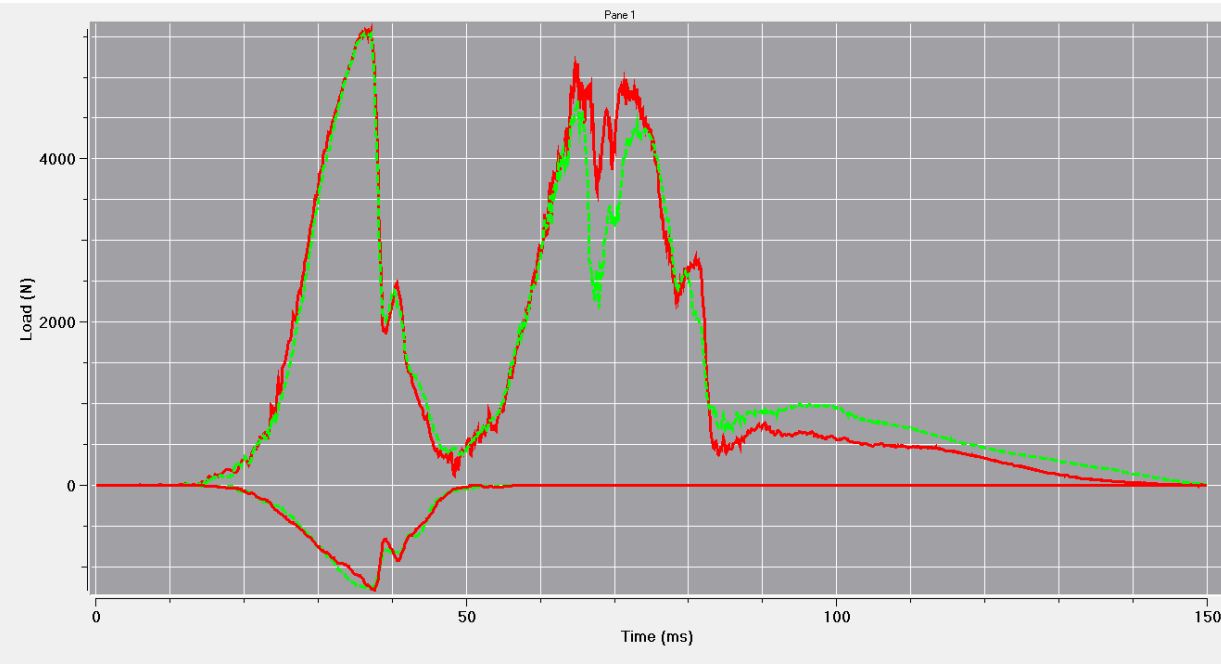
Chandra K. Thorbole, Ph.D.  
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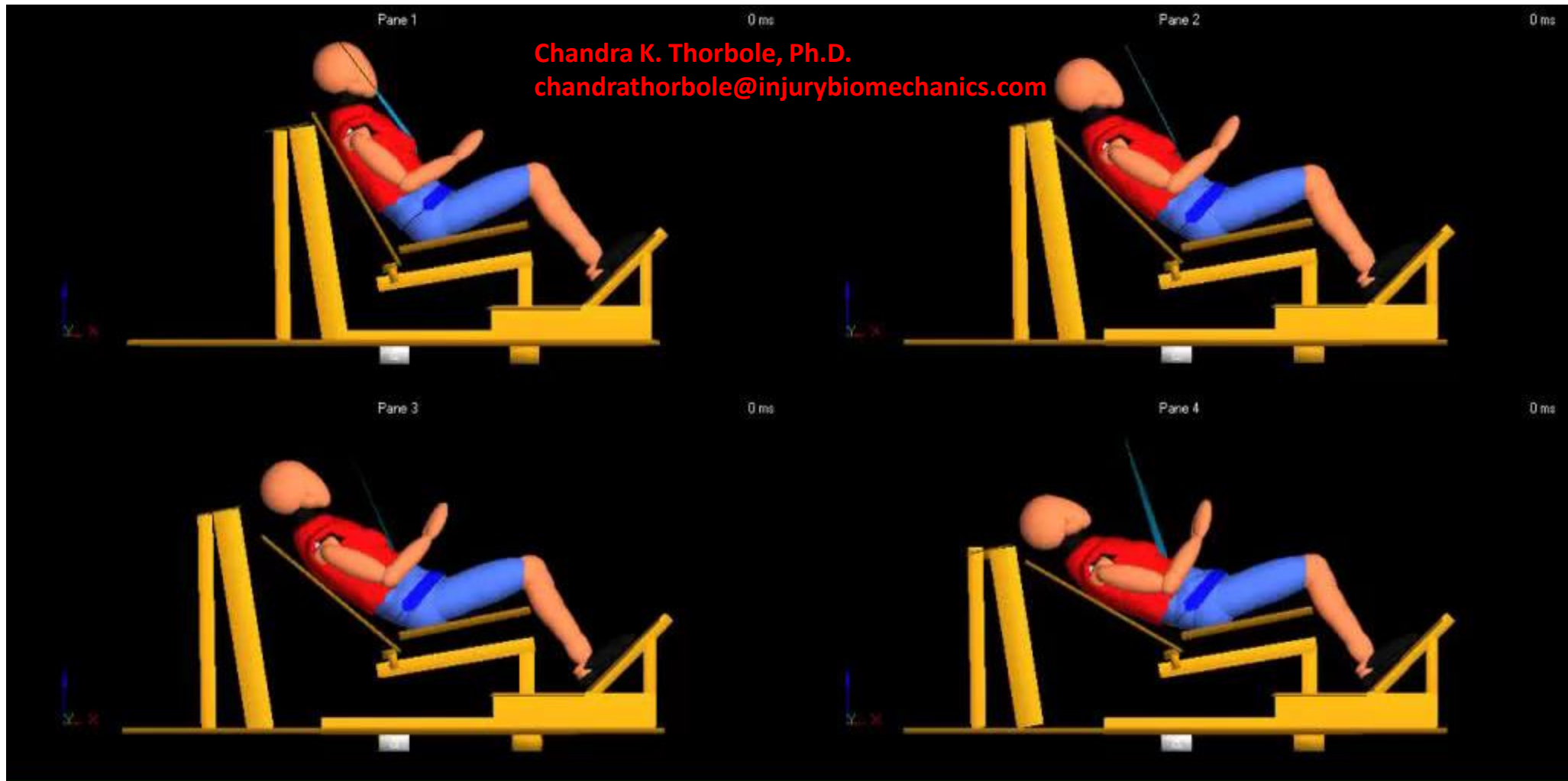
# 50 deg Recline

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# 60 deg Recline

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30,45,50 &60 deg Recline

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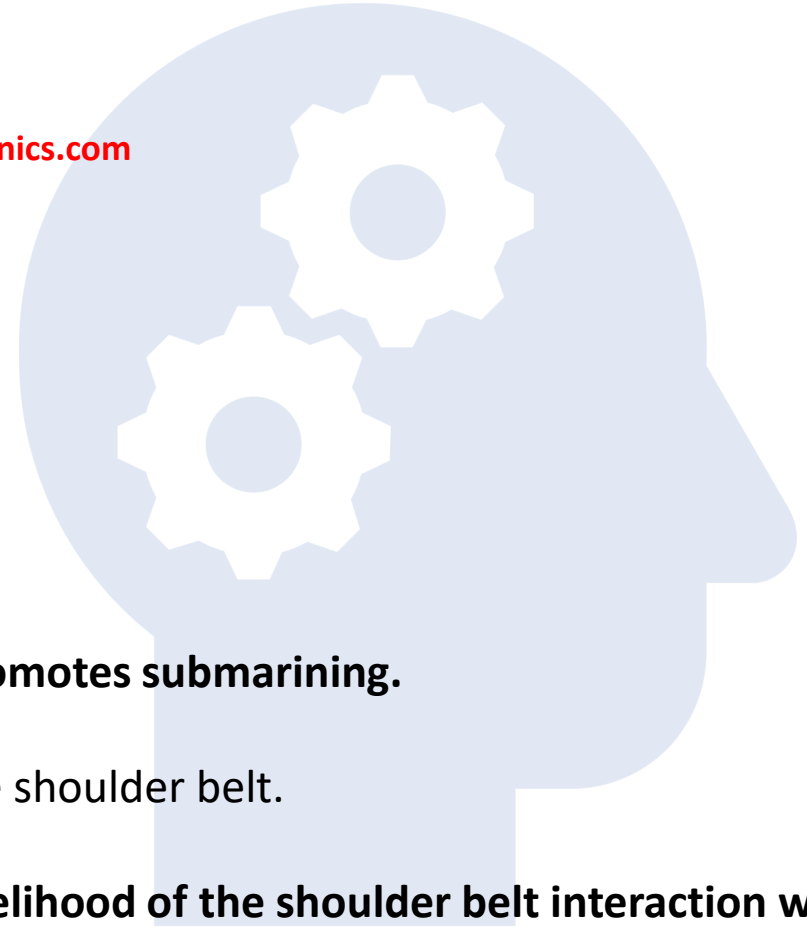
# Conclusion

**Seatback recline greater than 45° with the vertical promotes submarining.**

Occupant kinematics involves neck interaction with the shoulder belt.

**All-Belts-To-Seat (ABTS) belt system eliminates the likelihood of the shoulder belt interaction with the occupants' neck.**

Similar study with production seat model and human body model is warranted.



A special thanks to  
Dummy developers at  
TASS/Siemens  
(MADYMO) for sharing  
the dummy validation  
file for this study



# MORNSAN Technologies Pvt. Ltd.

## Automotive Passive Safety Solutions



Passive Safety  
Innovative Solutions



Restraint System  
Analysis & Design



Crashworthiness  
Analysis & Design



Accident Injury  
Biomechanics



Accident  
Reconstruction

# Thank You !!!!