



# THE NEED TO CONTROL BELT ROUTING FOR SILVER NCAP RATINGS

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Kennerly Digges, *Automotive Safety Research Institute, USA*

Dainius Dalmotas, *D.J. Dalmotas Consulting, Inc., Canada*

Priya Prasad, *Prasad Engineering, Inc., USA*

Becky Mueller, *Insurance Institute for Highway Safety, USA*

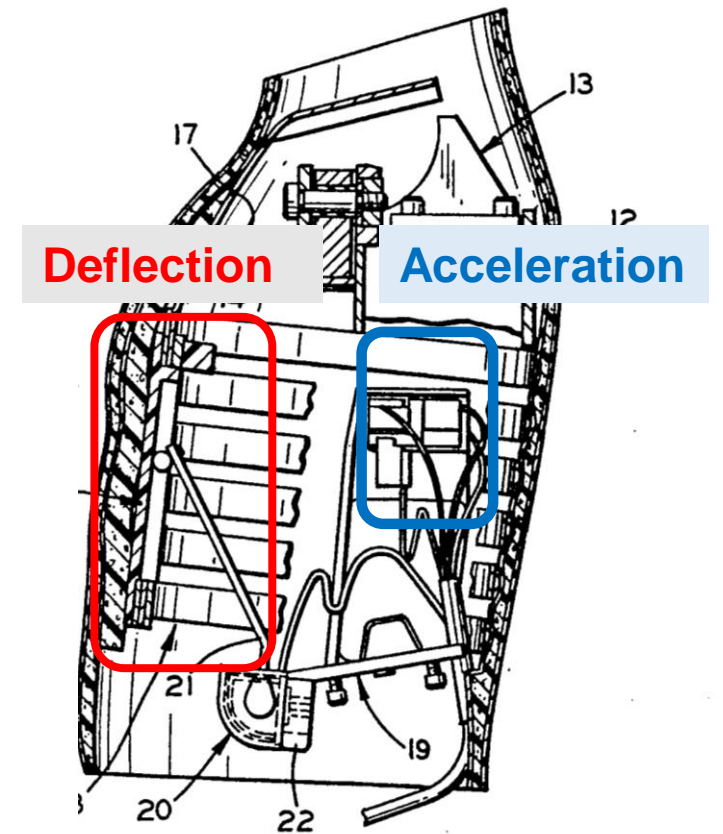
# Presentation Outline

- Relevant changes in NCAP 2011 upgrade
- Research purpose
- Main study results
- Conclusion/Recommendations



# Relevant 2011 NCAP changes

1. Used chest **deflection** rather than **acceleration** to measure injury risk

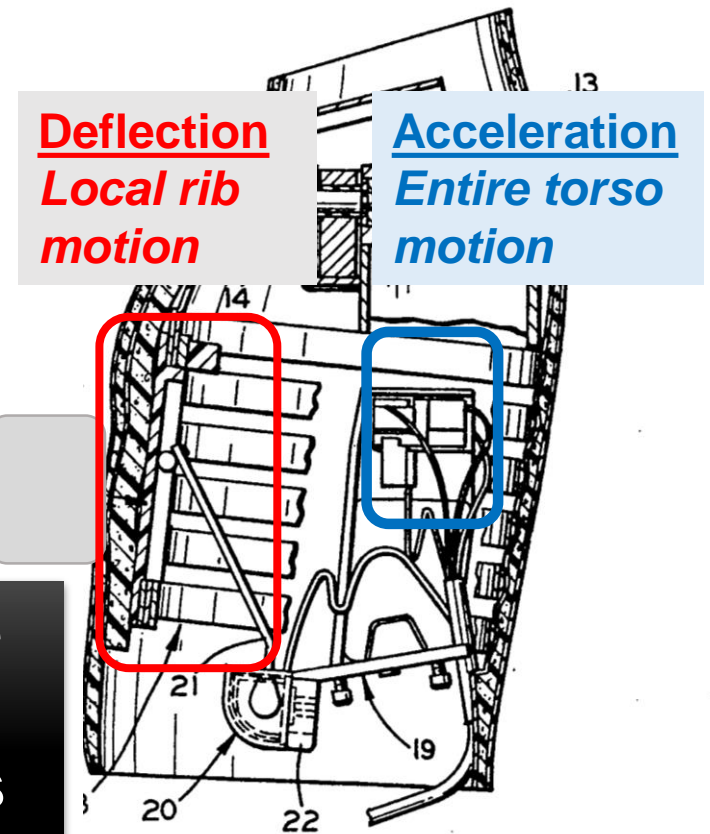


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Dummy should be used in a way consistent with its calibration

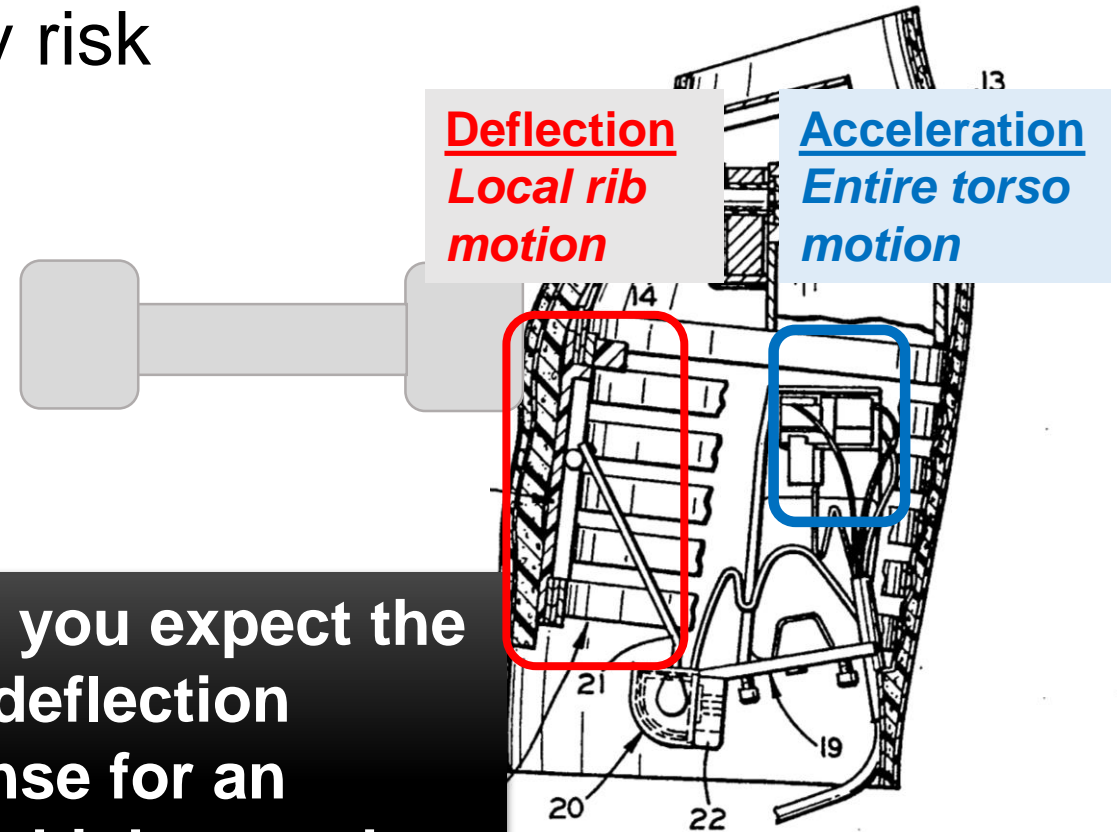


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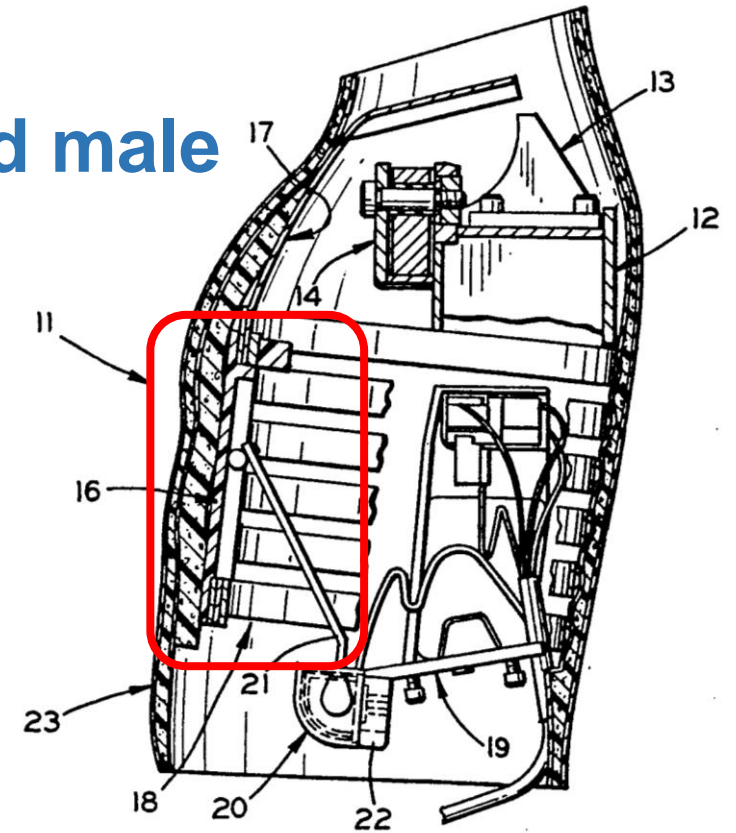
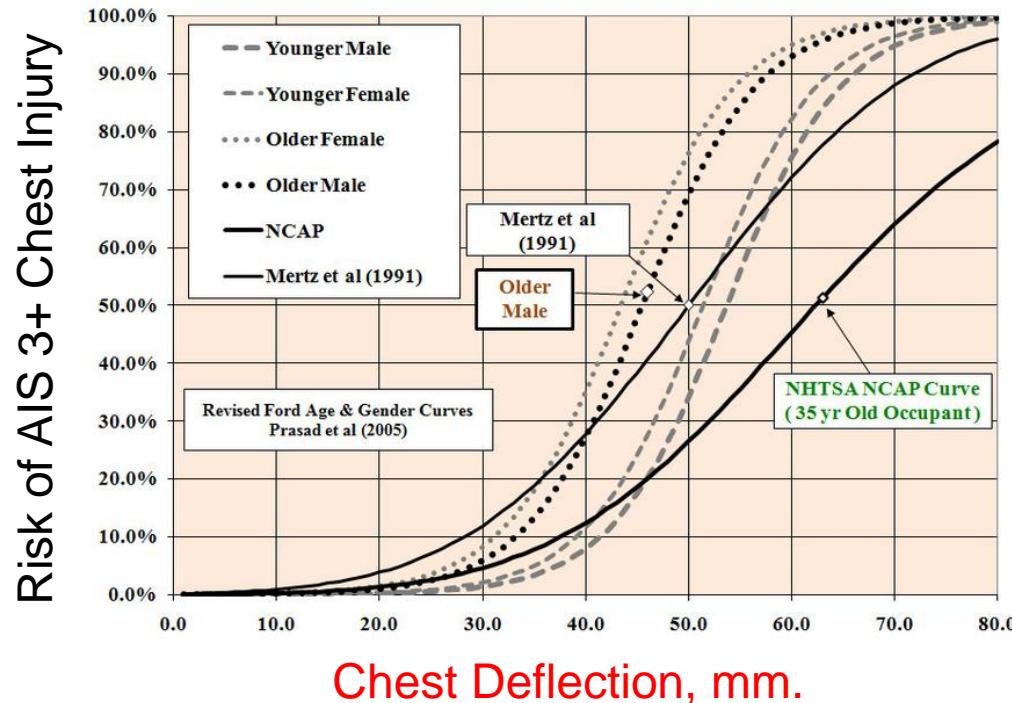


Would you expect the same deflection response for an impact higher on the chest?



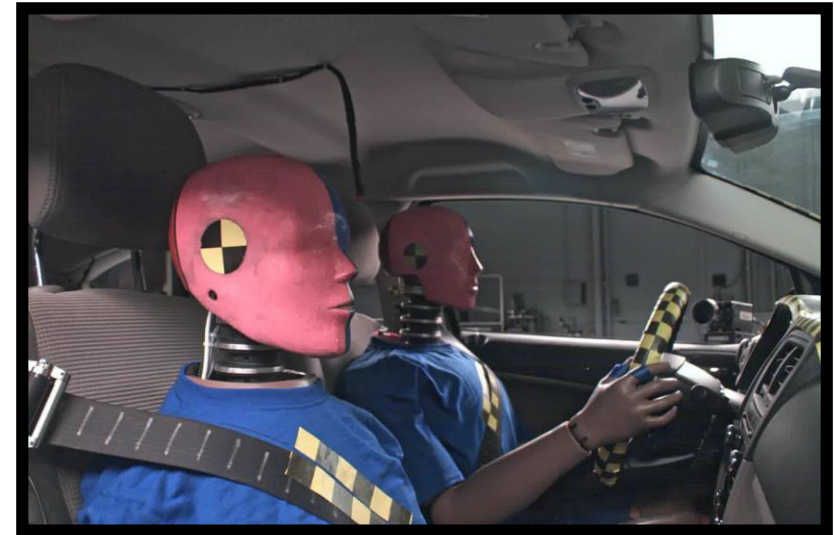
# Relevant 2011 NCAP changes

1. Used chest **deflection** rather than **acceleration** to measure injury risk
2. Used **deflection** injury risk for **35 year old male**



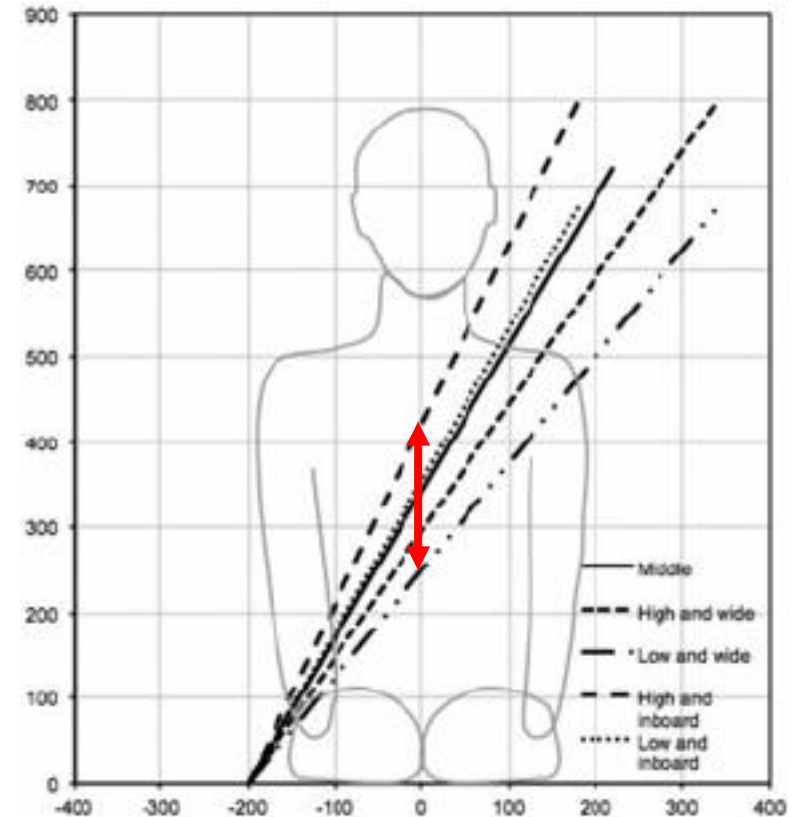
# Relevant 2011 NCAP changes

1. Used chest **compression** rather than **acceleration** to measure injury risk
2. Used deflection injury risk for **35 year old male**
3. For the right front passenger – Replaced **50% Male** (mid position) with **5% Female** (full forward)



# Relevant 2011 NCAP changes

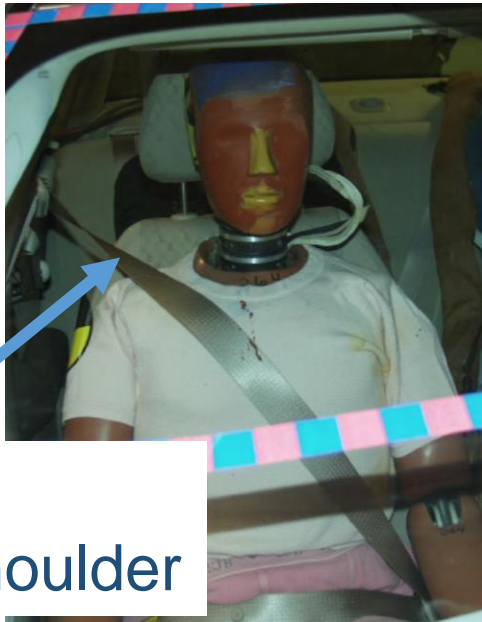
1. Used chest **compression** rather than **acceleration** to measure injury risk
2. Used chest injury risk for **35 year old male**
3. For the right front passenger – Replaced **50% Male** (mid position) with **5% Female** (full forward)
4. Test procedure has **no specification** on control of belt routing or D-ring location!!





# Consequence of no D-ring Specification

- 2001-2005 NCAP (50% Dummy RFP) **18% D-ring in Highest Location**  
82% in Mid or Lowest Location

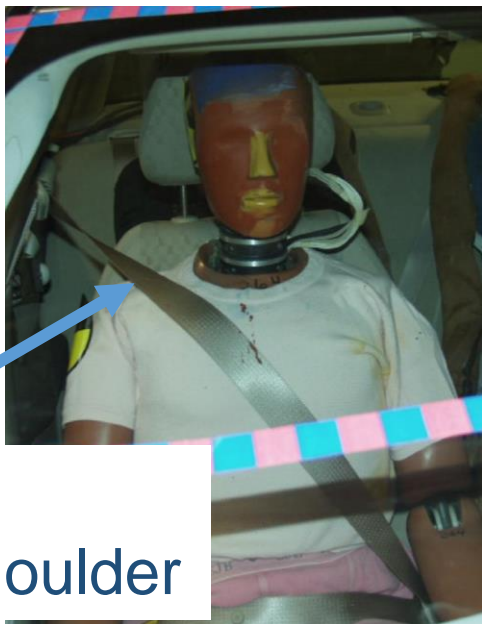


Belt  
mid-shoulder

2001-05 NCAP D-ring in Mid Location – 80+%

# Consequence of no D-ring Specification

- 2001-2005 NCAP (50% Dummy RFP) **18% D-ring in Highest Location**  
82% in Mid or Lowest Location
- 2013-2017 NCAP (5% Dummy RFP) **92% in Highest Location**



Belt  
mid-shoulder

2001-05 NCAP D-ring in Mid Location – 80+%

Belt on Neck



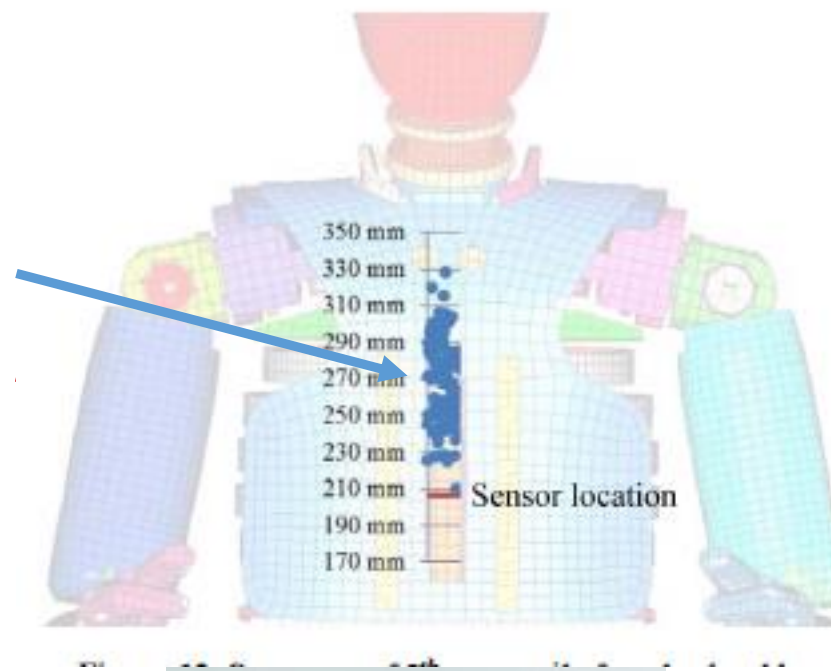
2013-17 NCAP D-ring in Highest Location – 90+%

# Consequence of no D-ring Specification

- 2001-2005 NCAP (50% Dummy RFP) **18% D-ring in Highest Location**  
82% in Mid or Lowest Location



Belt Crossover  
Locations  
Yr. 2011 NCAP  
Tests



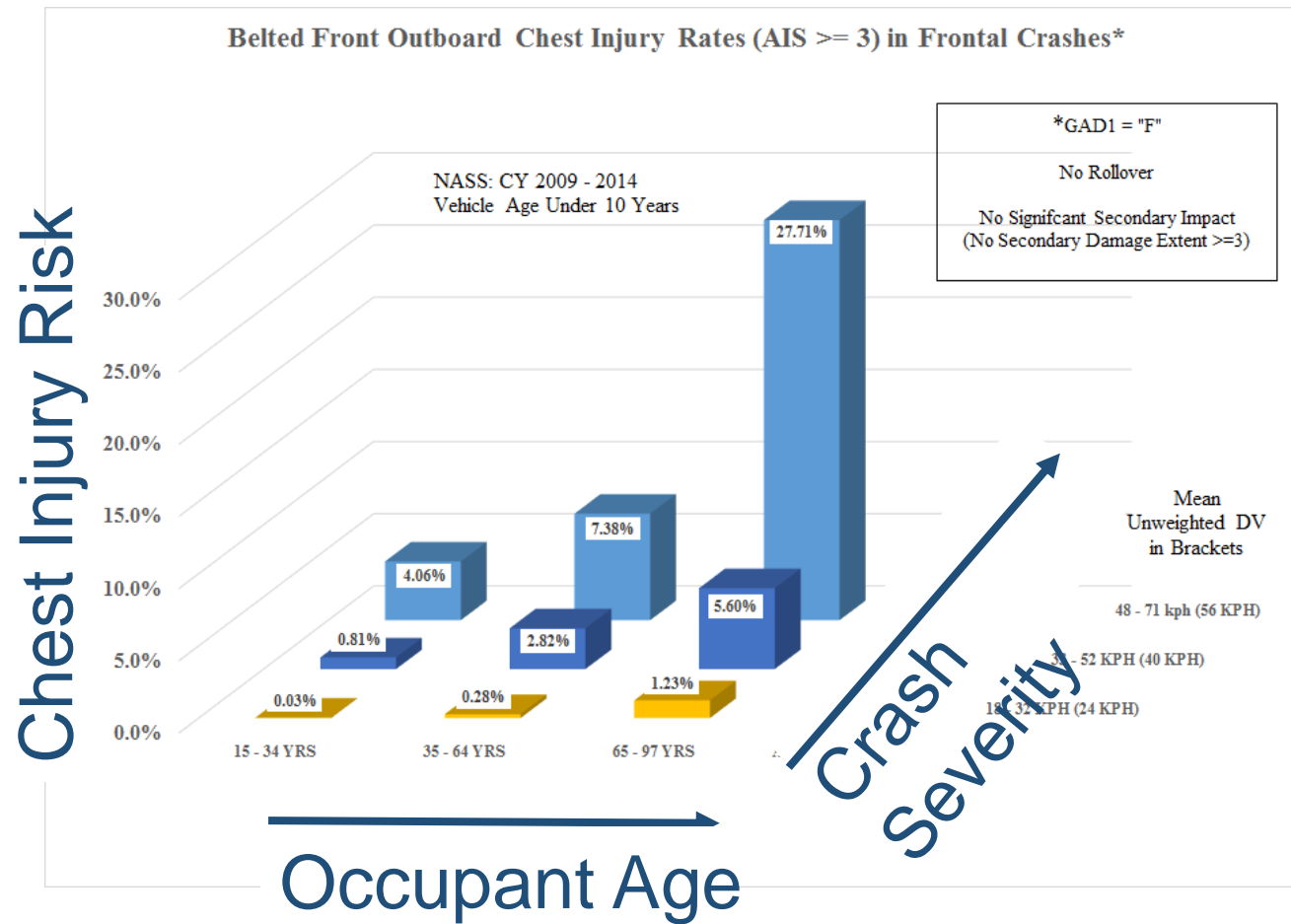
2001-05 NCAP D-ring in Mid Location – 80+%

# Research Objectives

- In an earlier paper, (ESV 13-0064) the authors proposed a “Silver Rating”.
- The “Silver Rating” *increased the weight of the chest injury measurement*
  - based on the higher frequency and risk of death for seniors with chest injuries.



# Vulnerability of seniors to chest injury



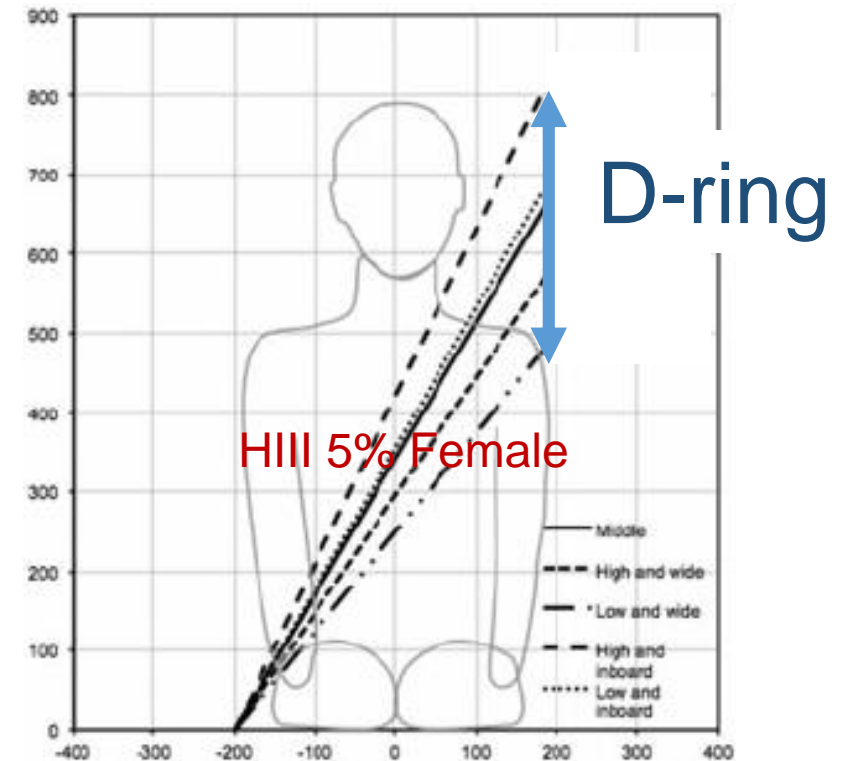
# Research Objectives

- In an earlier paper, ( ESV 13-0064) the authors proposed a “Silver Rating”.
- The “Silver Rating” *increased the weight of the chest injury measurement*
  - based on the higher frequency and risk of death for seniors with chest injuries
- **Therefore, the accuracy of the chest injury measurement became more important!!!**



# Research Question

In the NCAP frontal test  
how do variations in belt positioning  
across the chest  
from different D-ring positions  
influence the Hybrid III 5<sup>th</sup> female  
chest injury measurements?



# Differences in shoulder belt routing

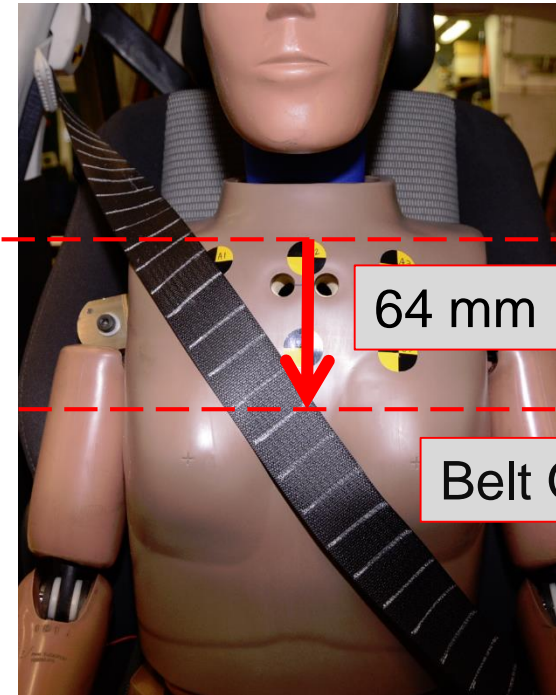
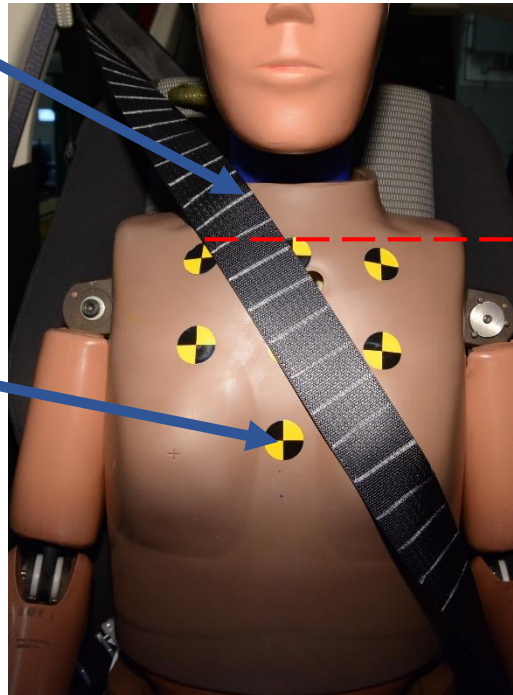
Right front passenger Hybrid III 5<sup>th</sup> female dummy in forwardmost seat position

**D-ring full up**

**D-ring full down**

Belt on Neck

Center  
chest  
sensor





# Differences in shoulder belt routing

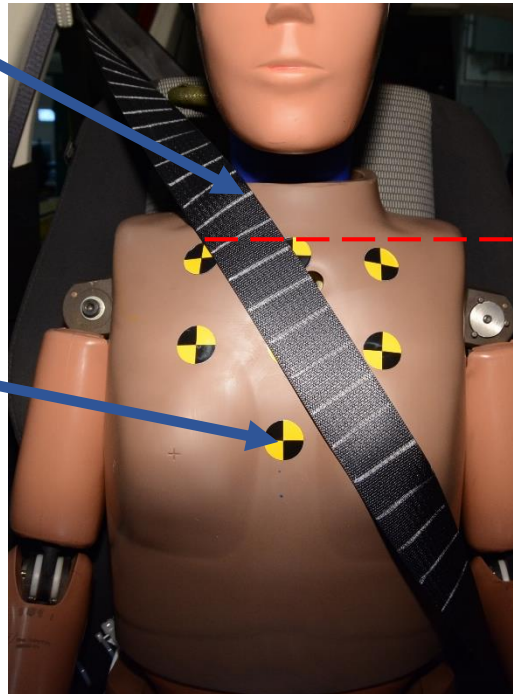
Right front passenger Hybrid III 5<sup>th</sup> female dummy in forwardmost seat position

**D-ring full up**

**NCAP Test**

Belt on Neck

Center chest sensor

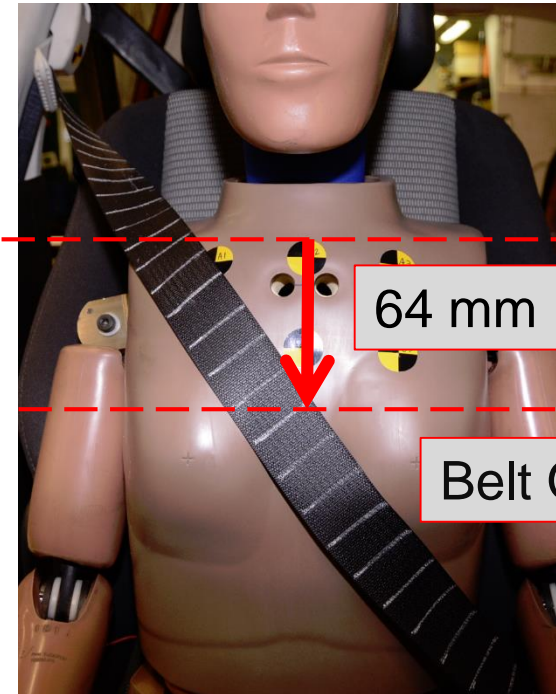


**D-ring full down**

**Our Retest to NCAP**

64 mm

Belt Overlays Sensor



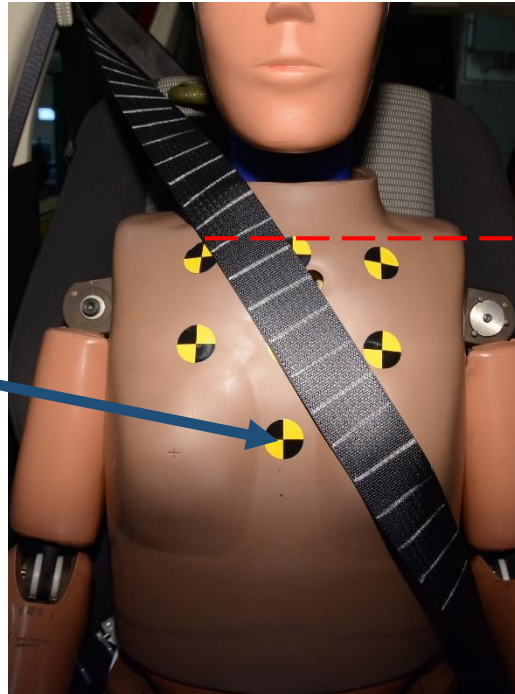
# Differences in shoulder belt routing

Right front passenger Hybrid III 5<sup>th</sup> female dummy in forwardmost seat position

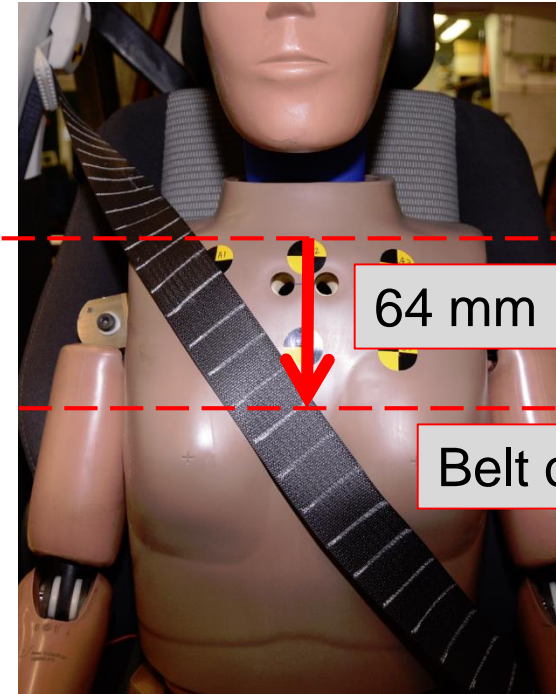
## D-ring full up

Crash test  
chest deflection: **11.8 mm** (from NCAP test)

Center  
chest  
sensor



## D-ring full down

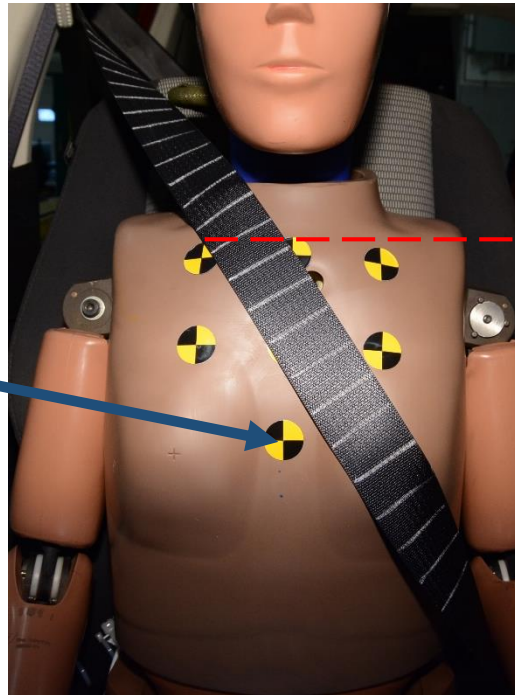


# Differences in shoulder belt routing

Right front passenger Hybrid III 5<sup>th</sup> female dummy in forwardmost seat position

## D-ring full up

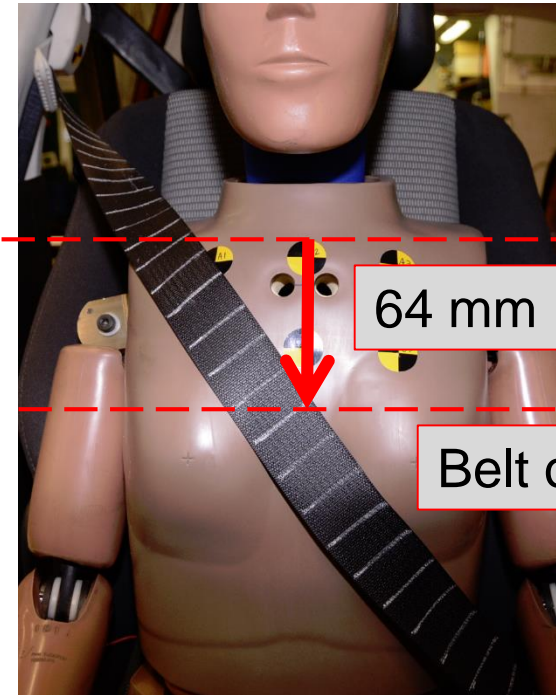
Crash test chest deflection: **11.8 mm** (from NCAP test)



Center chest sensor

## D-ring full down

**34.5 mm** (Our repeat NCAP Test)

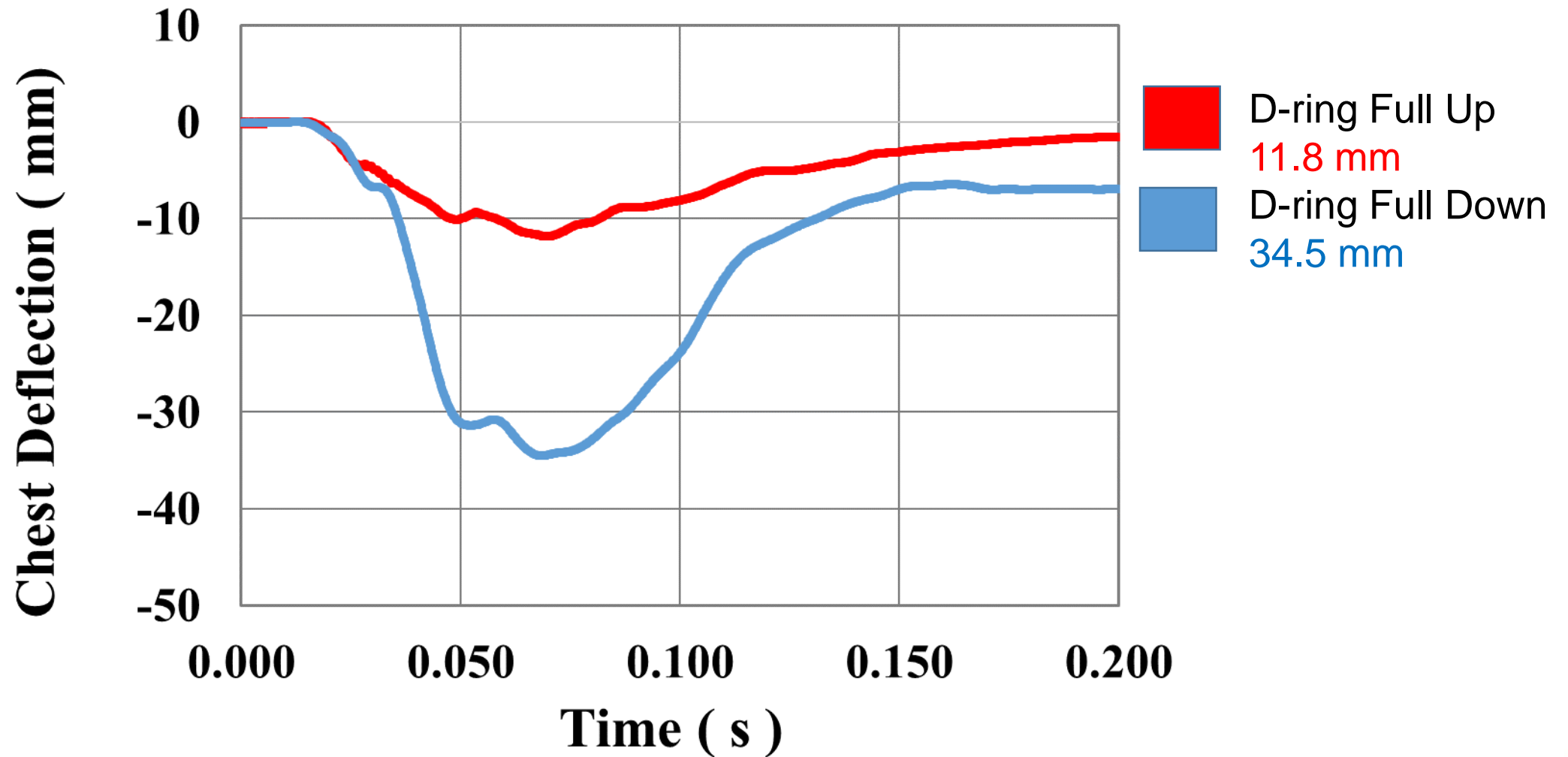


64 mm

Belt overlays sensor

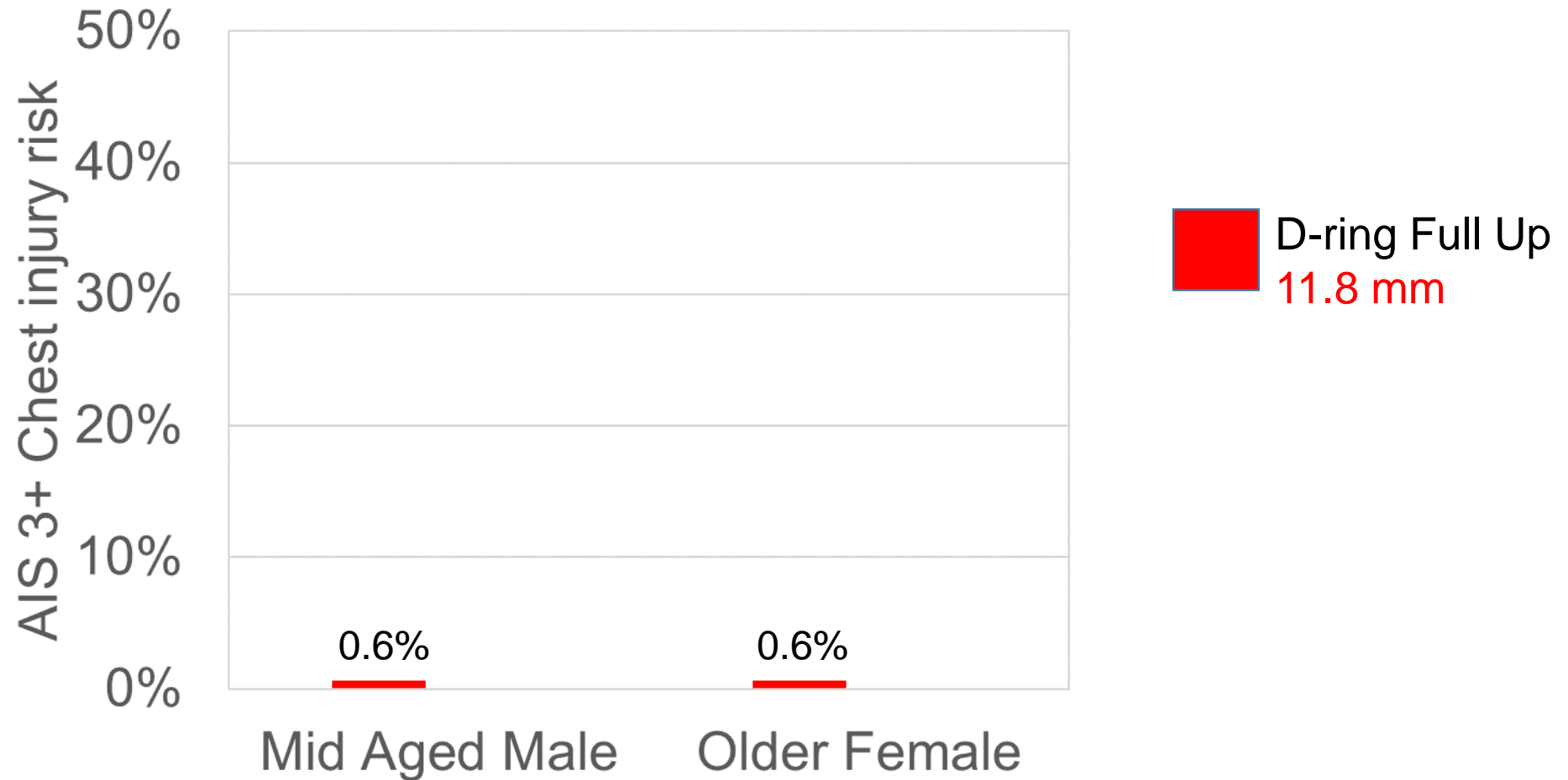
# Full vehicle test chest deflection comparison

Right front passenger Hybrid III 5<sup>th</sup> female dummy in forwardmost seat position



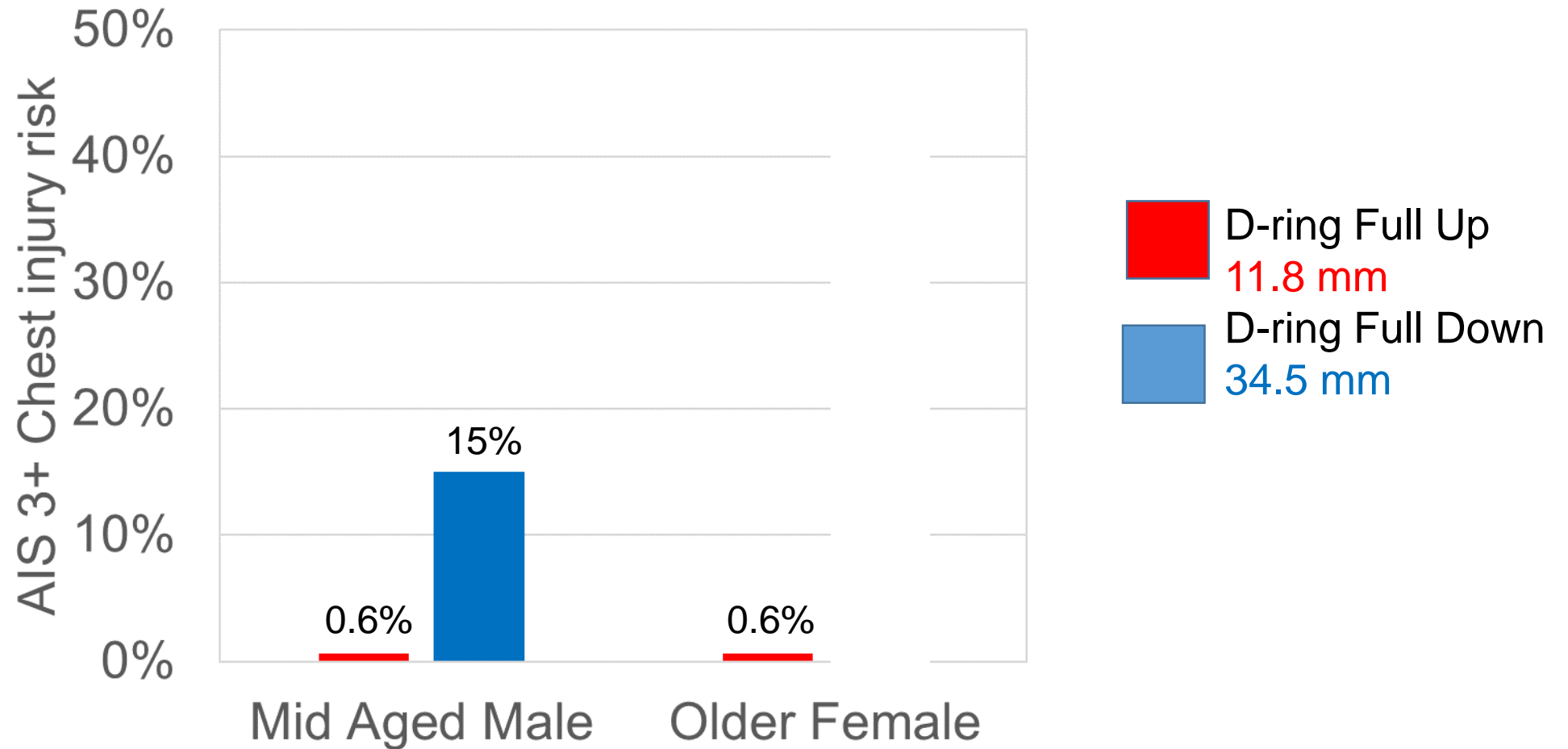
# Age related chest injury risks

NCAP tests with D-ring full up and full down



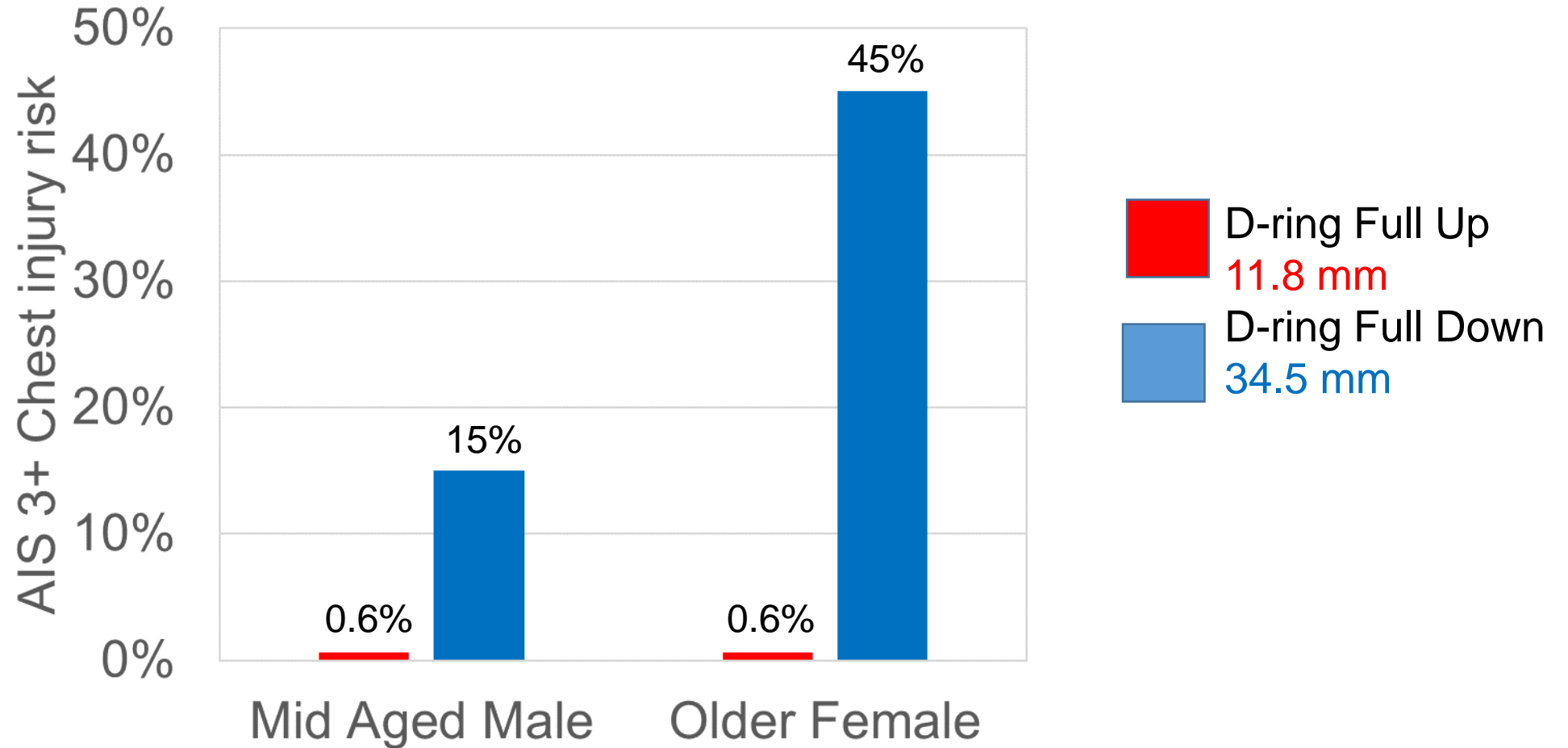
# Age related chest injury risks

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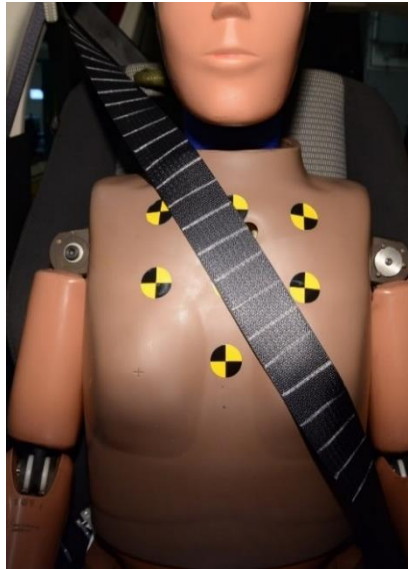
# Age related chest injury risks

NCAP tests with D-ring full up and full down



# Observations

- NCAP 2011+ ratings use chest deflection measurements
  - Protocol does not control of shoulder belt routing
  - HIII-5F dummy chest deflection measures are highly sensitive to routing
- In ~90% of NCAP tests, the belt is high above the HIII-5F center chest sensor





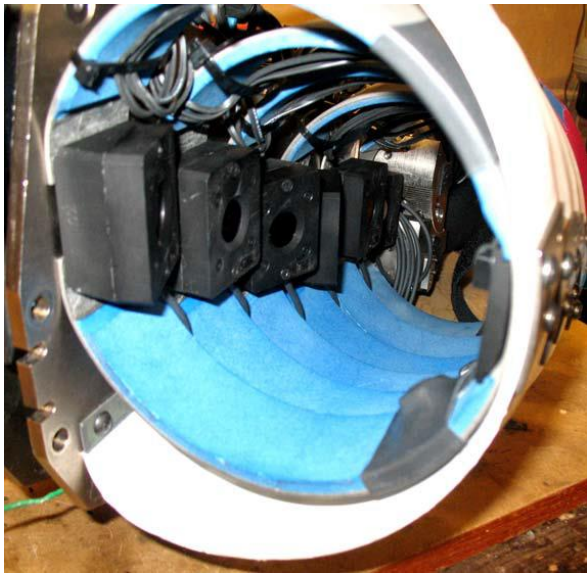
# Observations

This study's test results with D-ring full down

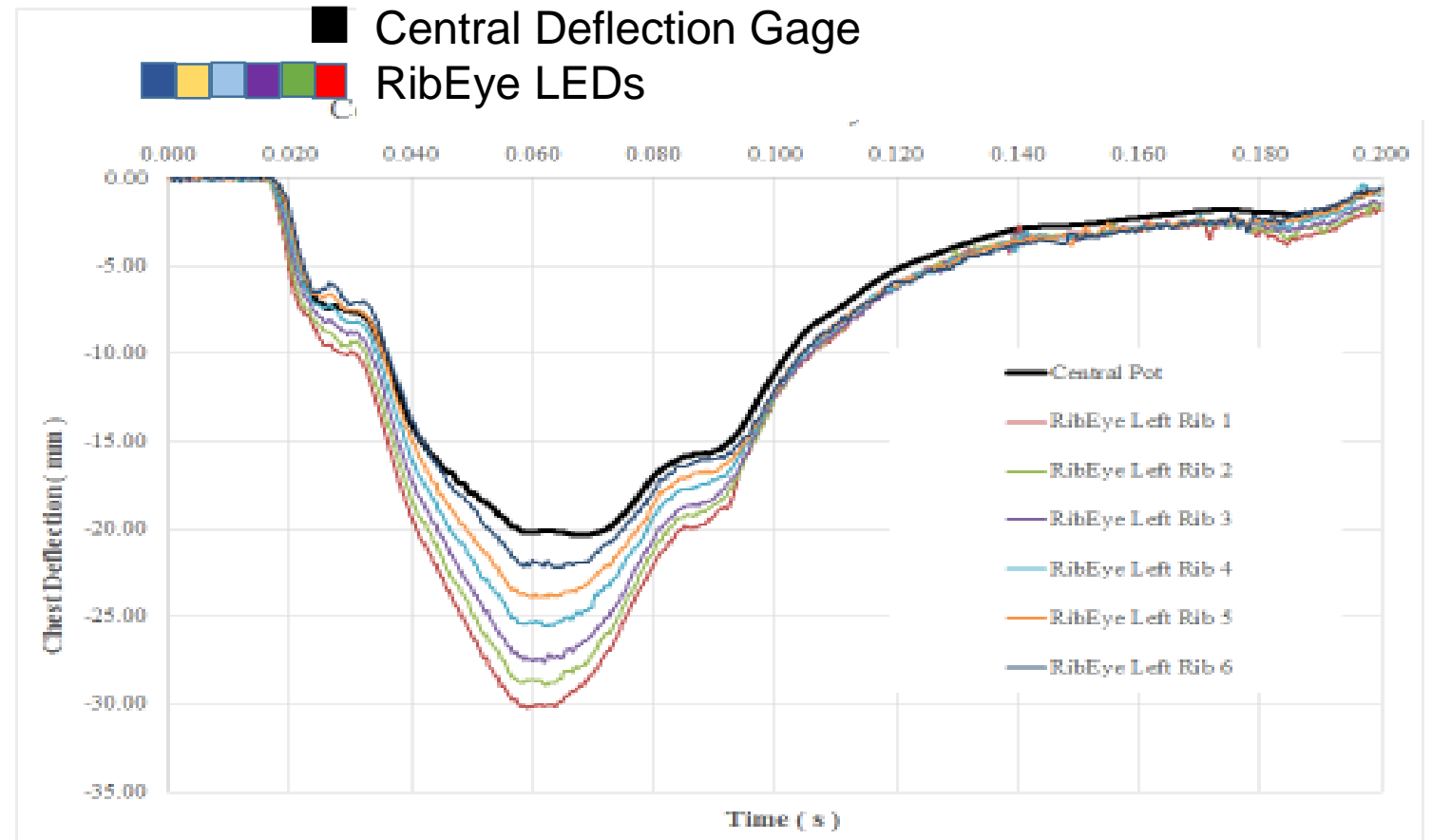
- The belt is 62 mm lower - across the center chest sensor
- Measured 22.7 mm additional deflection
- Measured a **25 times** increase in chest injury risk (NHTSA Risk)
- **Older female** chest injury risk increased **75 times** (Prasad Risk)



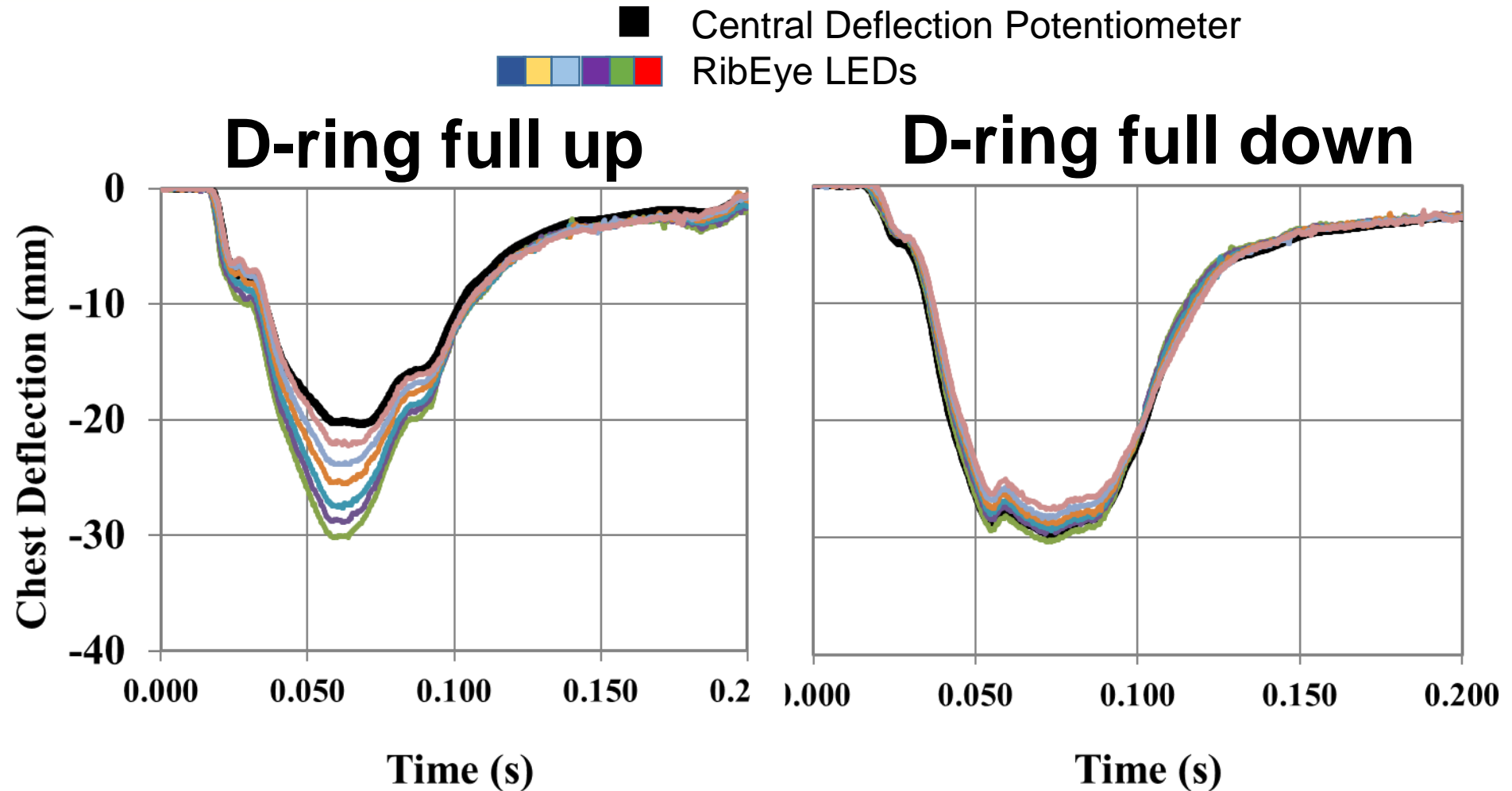
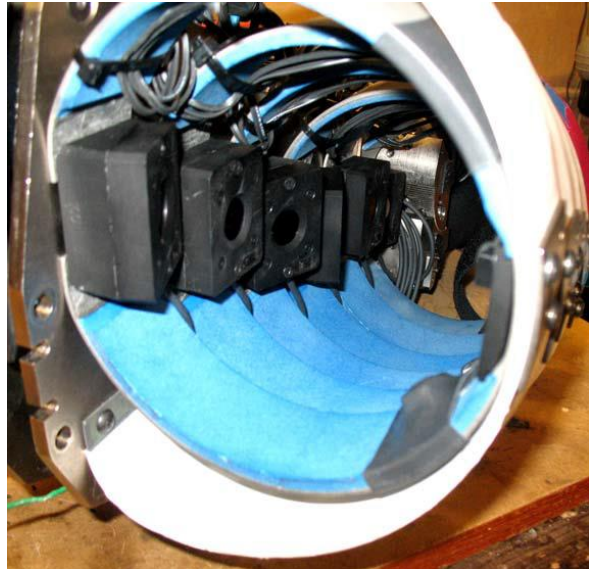
# Sled Test Results for 5% Female with RibEye



NHTSA NCAP Sled Test (**D-ring Full-up**)



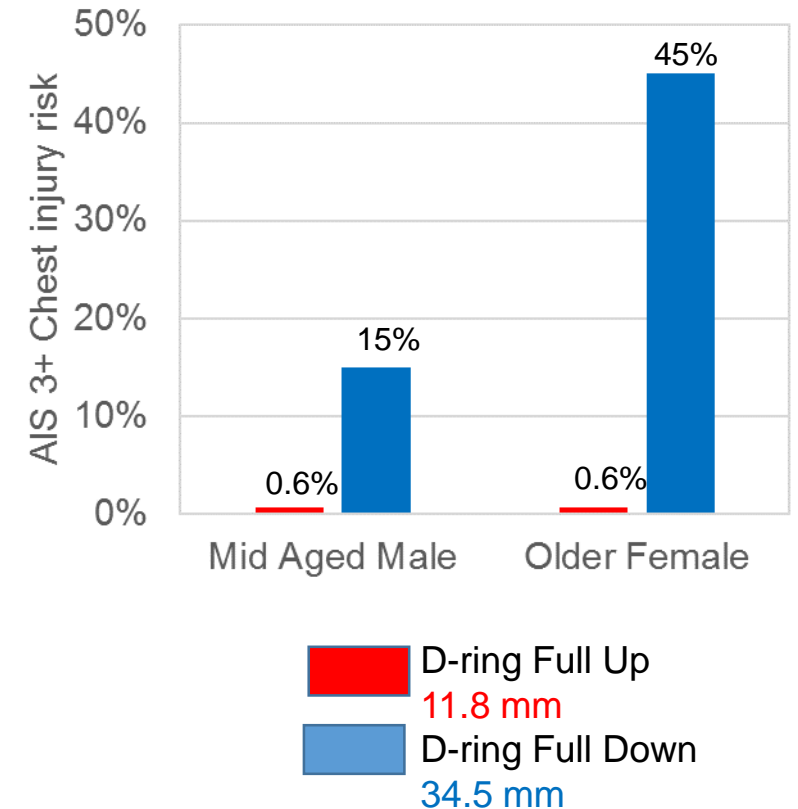
# Ribeye useful for assessing asymmetry of belt routing on chest



RibEye may be Useful in Controlling Belt Position – See Paper for Other Tests

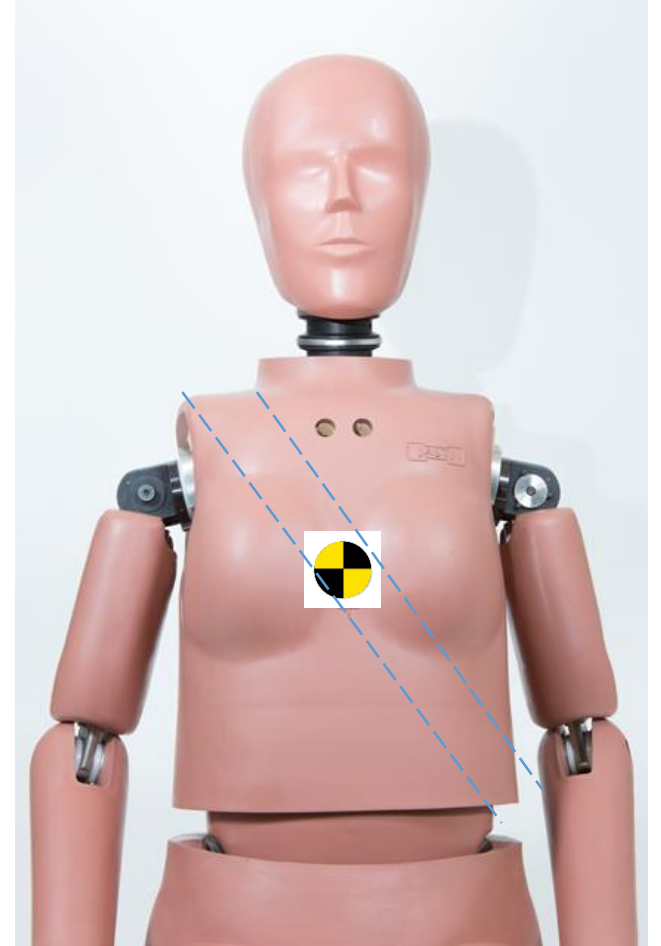
# Conclusions/Recommendations

- NCAP chest ratings are highly dependent on shoulder belt routing relative to the chest sensor
- Better control of belt routing is necessary for NCAP comparative evaluations to be meaningful
- Especially important when considering **Silver NCAP** (chest injury risks are 4-5 times greater than for younger occupants)
- See paper for other test results!



# Conclusions/Recommendations

- NCAP chest ratings are highly dependent on shoulder belt routing relative to the chest sensor
- Better control of belt routing is necessary for NCAP comparative evaluations to be meaningful
- Especially important when considering **Silver NCAP** (chest injury risks are 4-5 times greater than for younger occupants)
- A dummy landmark-based belt positioning procedure should be developed
  - Provide better control of belt routing relative to the dummy's chest sensor



# Acknowledgement

Funding for this research has been provided, in part, by private parties, who have selected Dr. Kennerly Digges to be an independent solicitor of and funder for research in motor vehicle safety, and to be one of the peer reviewers for the research projects and reports. Neither of the private parties have determined the allocation of funds or had any influence on the content.

The authors would also like to acknowledge IIHS for taking time out of their vehicle crashworthiness test and rating schedule to conduct a full-vehicle NCAP test to validate the results of this study's sled test series. IIHS remains interested in pursuing research projects that further improve the real-world relevance of crash test procedures.