

Crash Safety Tools 1001

John H Bolte IV, PhD

*Regional Transportation Safety Forum @ MORPC
September 21, 2023*



INJURY BIOMECHANICS
RESEARCH CENTER



THE OHIO STATE UNIVERSITY

What is the IBRC?

- Mission –

- The Injury Biomechanics Research Center (IBRC) pioneers human injury research using an interdisciplinary and uniquely holistic approach to **save and improve lives**. With a commitment to cutting-edge research, **training** future experts through **experiential learning** opportunities, innovation in **technological development**, pursuing **safety equity** inclusive of all demographics, and providing **continuing education** for professionals, the Injury Biomechanics Research Center is a global leader in injury and fatality prevention efforts.

Injury

- Vision –

- Advance transformational initiatives to decrease global injuries and fatalities through injury biomechanics research



We are the IBRC

Who We Are:

- ~50 Personnel
 - 6 Faculty & 5 Staff
 - 6 PhD / 4 Masters
 - 30 Undergraduates
- Engineers
- Anthropologists
- Anatomists



What We Do:

- Investigate relationships between human injury and physical properties

Why We Do It:

- Protect lives!



NHTSA Tools, Publications & Data

Crash Data Publications (CrashStats)



[Find More →](#)

Fatality and Injury Reporting System Tool (FIRST)



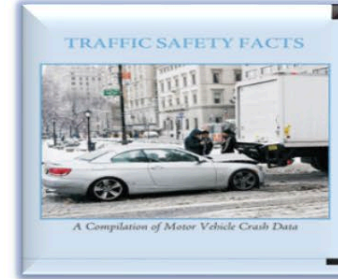
[Find More →](#)

State Traffic Safety Information (STSI)



[Find More →](#)

Traffic Safety Facts Annual Report Tables



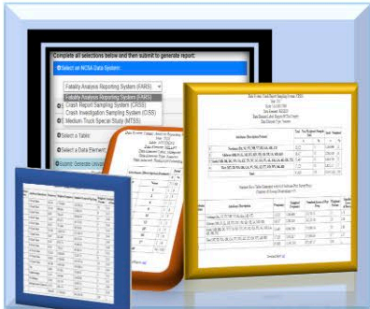
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Fatal Motor Vehicle Crash Data Visualization



[Find More →](#)

Motor Vehicle Crash Databook



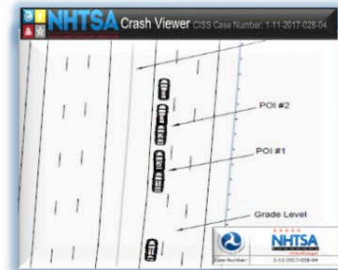
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FARS Data Tables



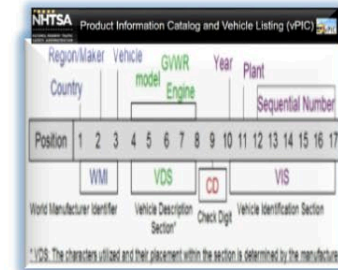
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Crash Viewer



[Find More →](#)

Product Information Catalog and Vehicle Listing (vPIC)



[Find More →](#)

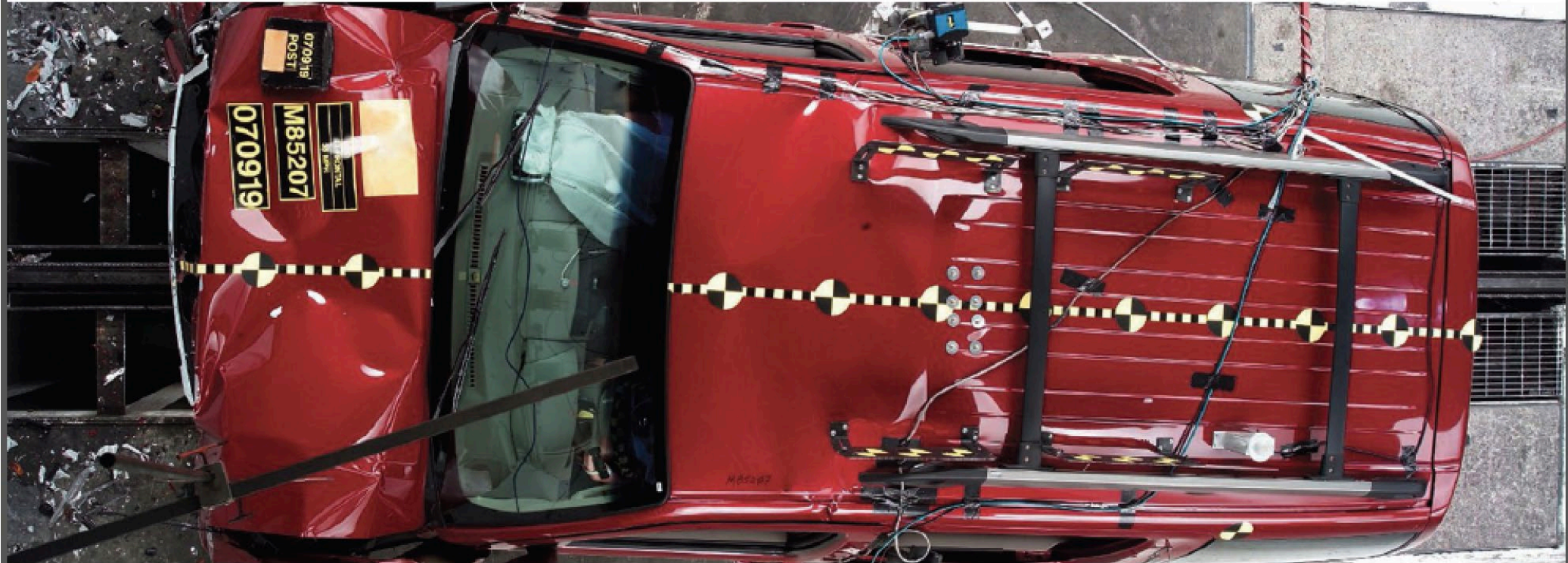
Data Download

- [Fatality Analysis Reporting System \(FARS\)](#)
- [Crash Report Sampling System \(CRSS\)](#)
- [Crash Investigation Sampling System \(CISS\)](#)
- [NCSA and Other Data Sources](#)



NHTSA Crash Tests

/// UPDATING THE 5-STAR SAFETY RATINGS ///



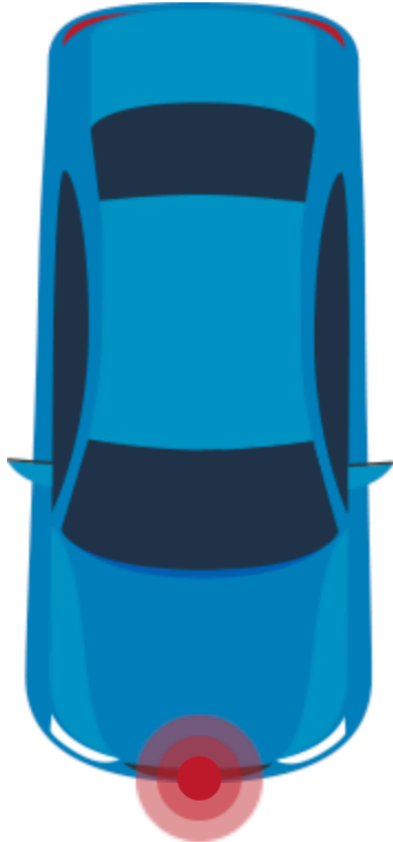
NHTSA continues to look to the future and drive the development of safer vehicles by updating the 5-Star Safety Ratings to keep pace with the newest safety technologies. Enhancements such as tougher and more stringent ratings criteria and recommended crash avoidance technologies encourage manufacturers to continuously improve driver and passenger safety and make cars on our roads safer.



Frontal Crash Test

Frontal Crash Test Scenario:

You are heading south on a two-lane road, while another vehicle is driving north on that street. The driver in the other vehicle starts to fall asleep at the wheel and veers into your lane. Suddenly, you collide head-on with the northbound vehicle.



Test Details



- An average-size adult male in driver seat
- A small-size adult female in front passenger seat
- All dummies are secured with a seat belt



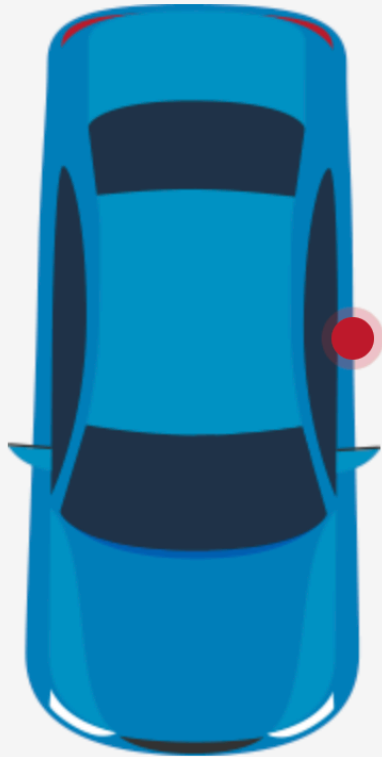
- Represents crashes between two similar vehicles with same weight
- A vehicle crashes into a fixed barrier at 35 mph



- Evaluation of injury to the head, neck, chest, and femur (leg)
- Frontal crash ratings must only be compared between vehicles from the same weight class (+/- 250lbs)



Side Crash Test



Side Barrier Crash Test Scenario:

You pull up to a four-way intersection and make a complete stop, look to your left and right and begin to accelerate into the intersection. Another vehicle approaches the same intersection, but doesn't yield at the stop sign and hits your vehicle on the driver's side.

Test Details



- An average-size adult male in driver seat
- A small-size adult female in rear passenger seat (driver's side)
- All dummies are secured with a seat belt



- Represents an intersection type collision
- A 3,015 lb moving barrier crashes at 38.5 mph into a standing vehicle



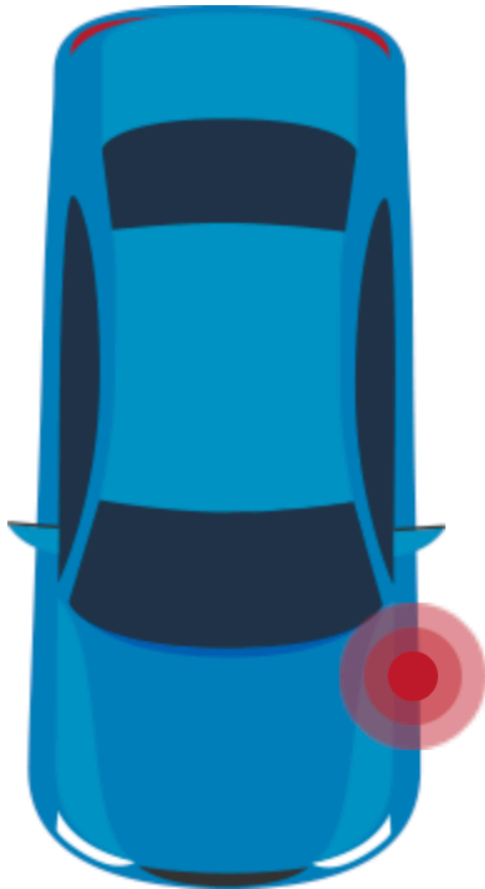
- Evaluation of injury to the head, chest, abdomen, and pelvis
- For side barrier ratings, it is possible to compare all vehicles with each other



Side Pole Crash Test

Side Pole Crash Test Scenario:

On a rainy afternoon, you're driving down a curved street in your neighborhood. All of a sudden, you lose control of the vehicle. You start sliding on the road sideways and crash into a telephone pole on the driver's side.



Test Details



- A small-size adult female in driver seat
- The dummy is secured with a seat belt



- Vehicle, angled at 75 degrees, is pulled sideways at 20 mph into a 25cm diameter pole at the driver's seating location



- Evaluation of injury to the head, chest, lower spine, abdomen, pelvis
- For side pole ratings, it is possible to compare all vehicles with each other



ATD Summary

SAFETY TESTS

The 5-Star Safety Ratings evaluate how well vehicles perform in crash tests to help consumers make smart decisions about safety when purchasing a vehicle. NHTSA conducts frontal, side and rollover tests because they account for the majority of crashes on America's roadways.

In each of the crash tests described, data from crash test dummies indicate the seriousness of the injuries that could occur in the type of crash involved.

The Frontal Crash Test

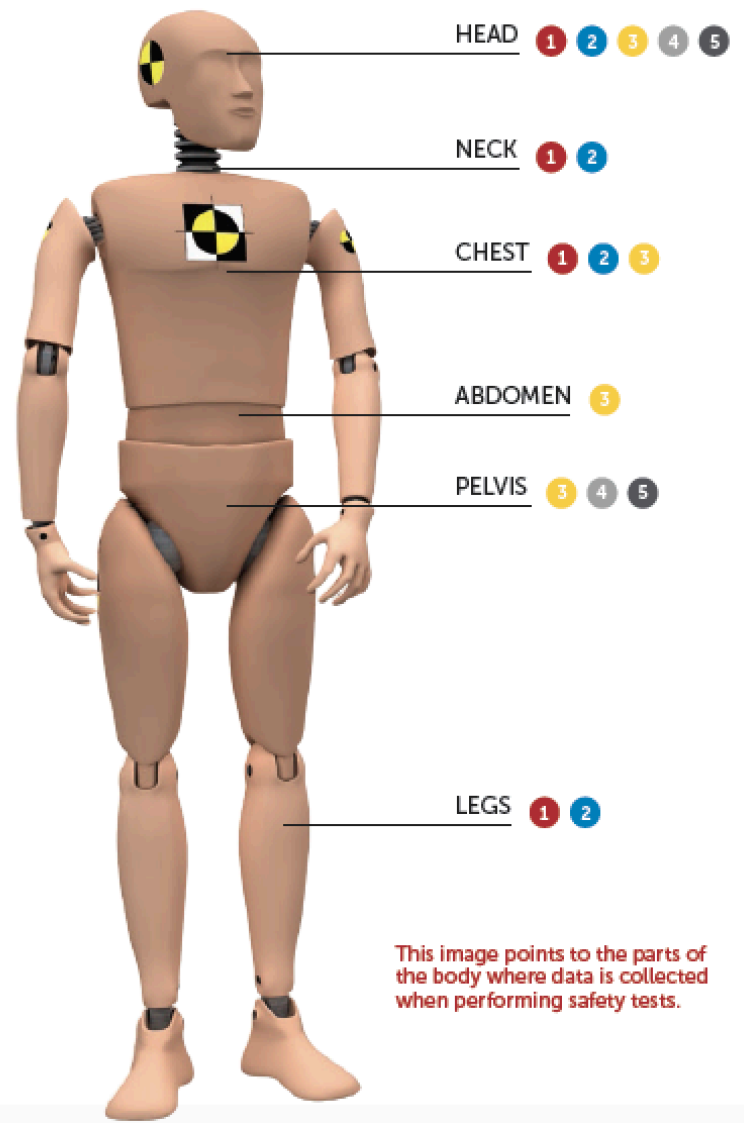
- 1 Average-size adult male dummy (Driver)
- 2 Small-size adult female dummy (Front passenger)

The Side Barrier Crash Test

- 3 Average-size adult male dummy (Driver)
- 4 Small-size adult female dummy (Rear passenger)

The Side Pole Crash Test

- 5 Small-size adult female dummy (Driver)



This image points to the parts of the body where data is collected when performing safety tests.

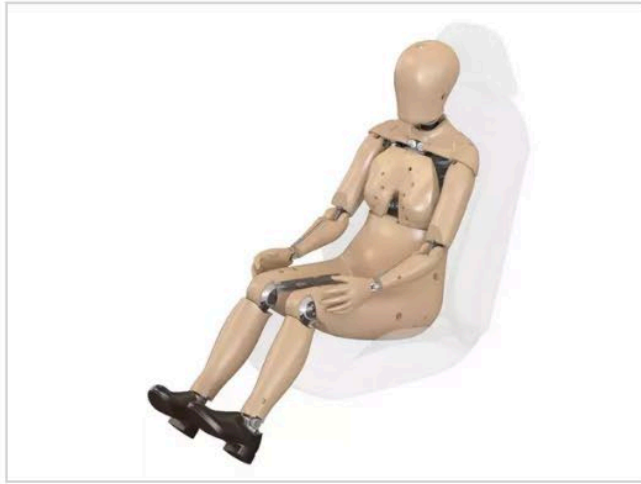


Crash Safety Tools

- “Crash Test Dummy” or “Anthropomorphic Test Device” (ATD)
 - instrument that measures the effect of an impact on a “human”
- 1. Dummy must respond like a human
 - “Biofidelity”
- 2. Dummy must provide measurements that correlate with human injury
 - “Injury Criteria”



Frontal Adult ATD Family



THOR-5F



THOR-50M



Hybrid III 5th Female



Hybrid III 50th Male



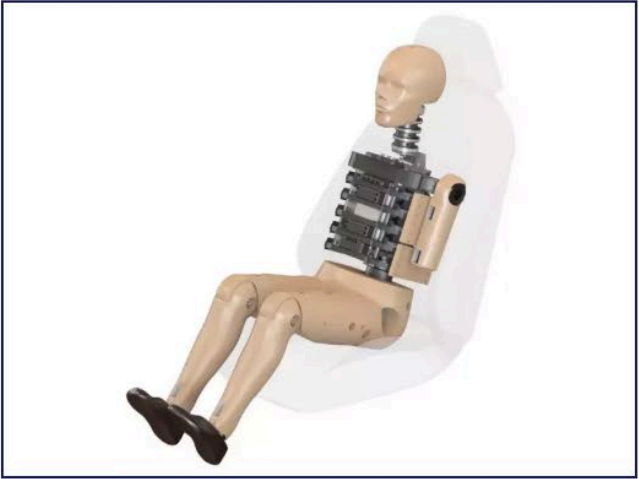
Hybrid III 95th Male



Hybrid II 50th Male



Side Adult ATD Family



SID-IIa



ES-2



ES-2re



WorldSID-5F



WorldSID-50M



Child ATDs



Q-Series



Hybrid III Children Series



CRABI Series



P-Series



CAMI Mark I & II



JASPER



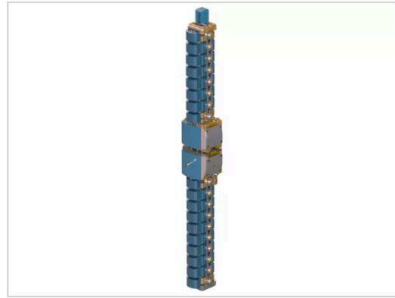
Other ATDs



Pedestrian Headforms



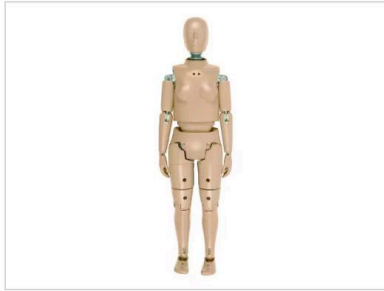
aPLI Legform



Flex-PLI Legform



TRL Pedestrian Legforms



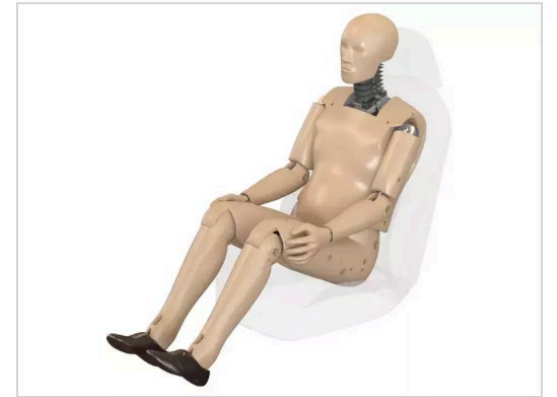
HIII-5F PED



HIII-50M PED



HIII-95M PED



BioRID-II



Elderly ATD



Obese ATD



POWERED TWO-WHEELER DUMMY (PTW)



Virtual ATD & Human FE Models



THOR-50M FE



THOR-5F FE



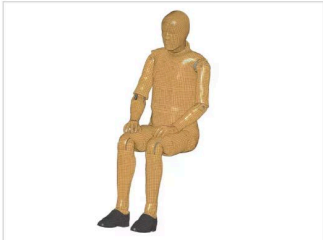
Hybrid III 5th Female FE



Hybrid III 50th Male FE



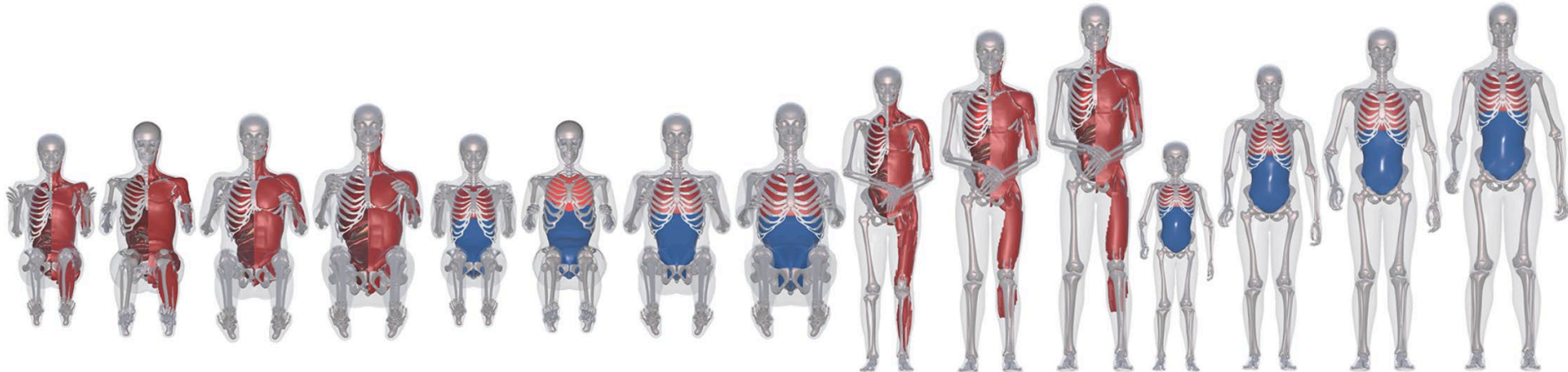
Hybrid III 95th Male FE



Hybrid II 50th Male FE



F05-O F50-O M50-O M95-O F05-OS F50-OS M50-OS M95-OS F05-P M50-P M95-P 6YO-PS F05-PS M50-PS M95-PS



Detailed Occupants

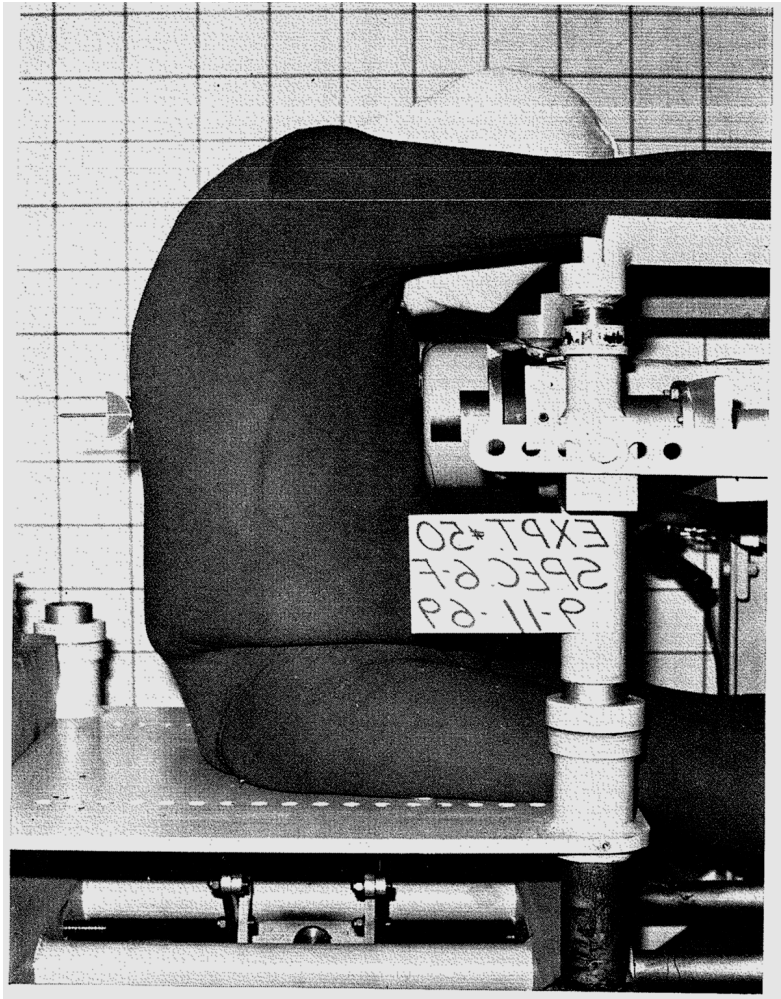
Simplified Occupants

Detailed Pedestrians

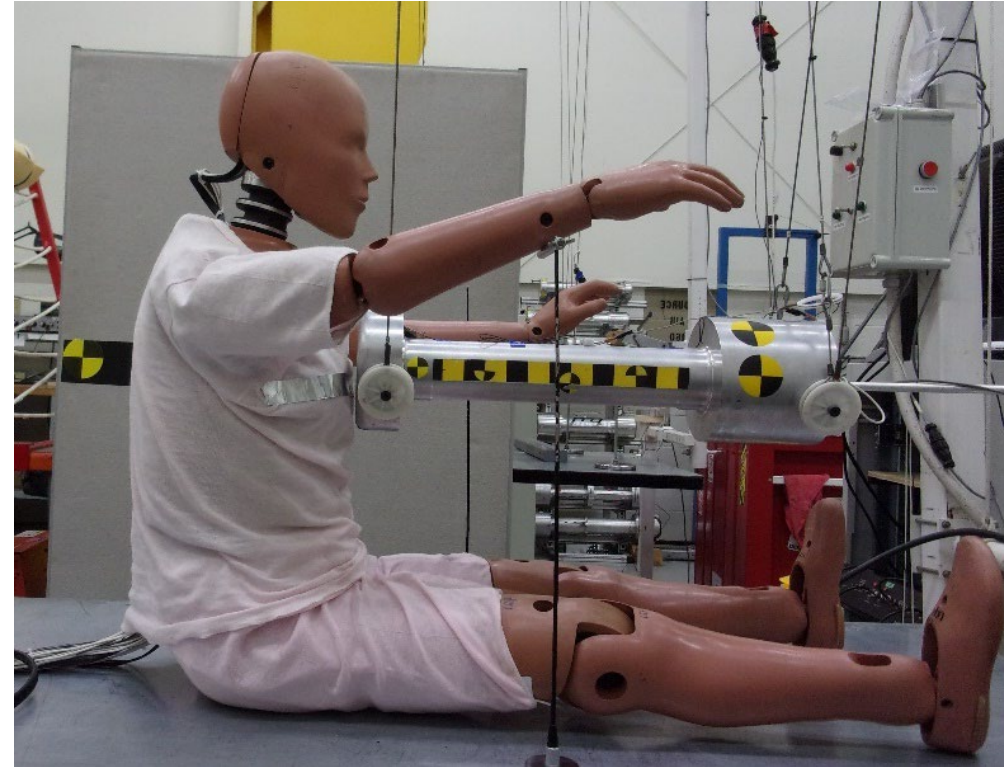
Simplified Pedestrians



Traditional Experimental Set-up



Nahum et al., 1970; Kroell et al., 1971 & 1974

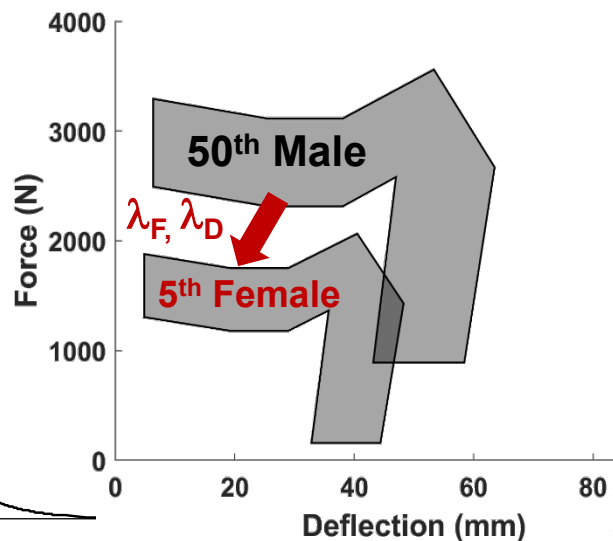
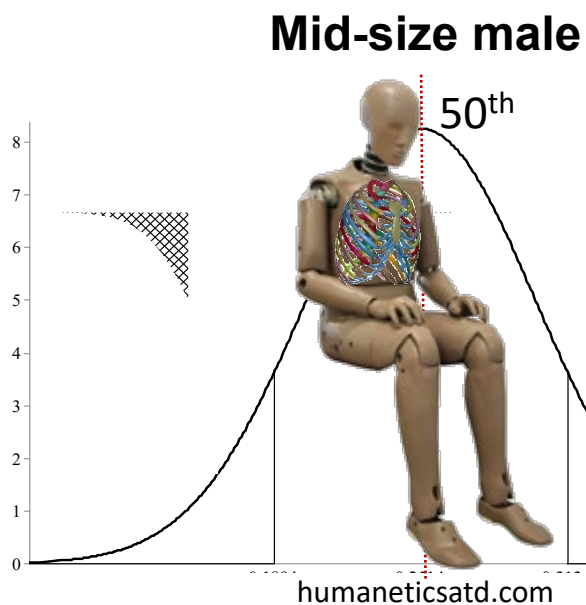


Part 572 condition



Traditional Scaling

- Due to limited availability of biomechanical data for the thorax
 - Small female: scaling approach



HIII5th



humaneticsatd.com

THOR5th



THUMS AF05



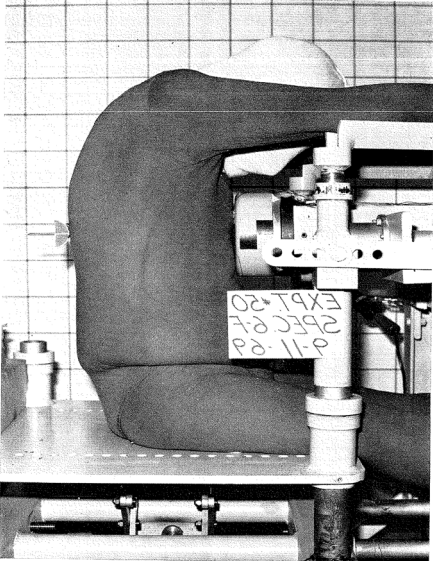
<https://global.toyota/>

GHBM5th

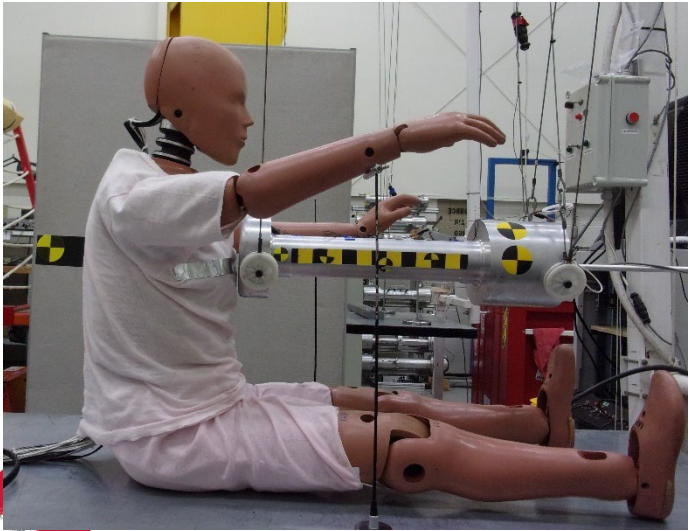


Davis et al., 2016

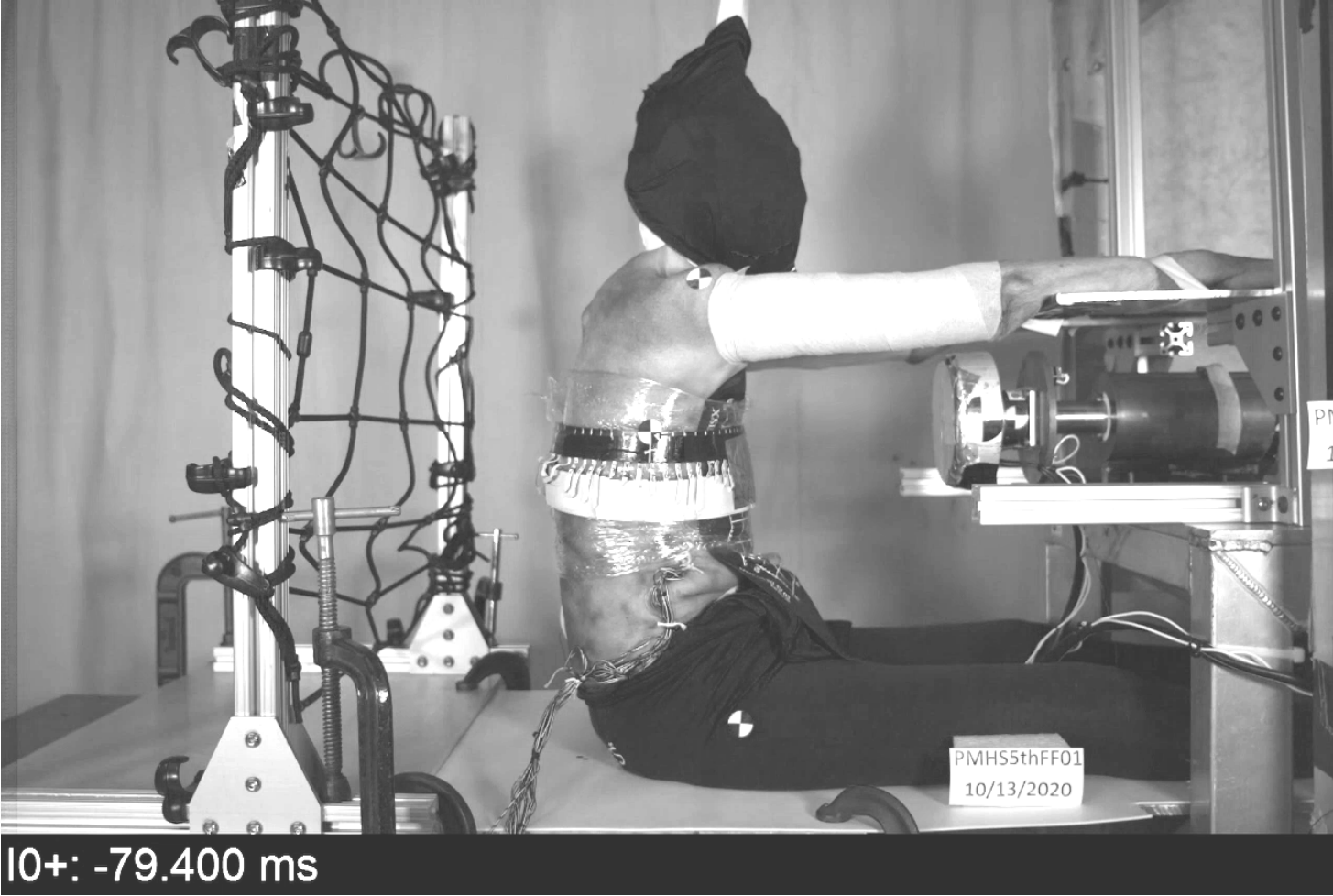
Traditional Experimental Set-up



Nahum et al., 1970; Kroell et al., 1971 & 1974



Part 572 condition



Evaluation of 5th Percentile ATDs in Near-Side Impact Scenarios Compared to Elderly PMHS

*A. Tesny¹, C. Fibbi¹, Y.S. Kang¹, A. Agnew¹, G. Baker, Y. Zaragoza-Rivera¹, B. Shurtz², B. Pipkorn³,
H. Rhule⁴, K. Moorhouse⁴, C. Markusic⁵, S. Malcolm⁵, J. Bolte¹*

*¹Injury Biomechanics Research Center, OSU,
²Autoliv Americas, USA, ³Autoliv Research, Sweden,
⁴NHTSA VRTC, ⁵Honda Development and Manufacturing*

*IRCOBI Conference
13 September 2023*



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R E S E A R C H C E N T E R



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Previous Work

Hub impacts

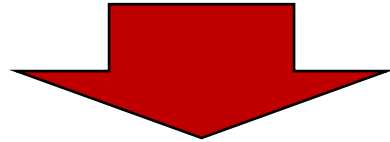
+

Sled tests with simplified boundary conditions

=

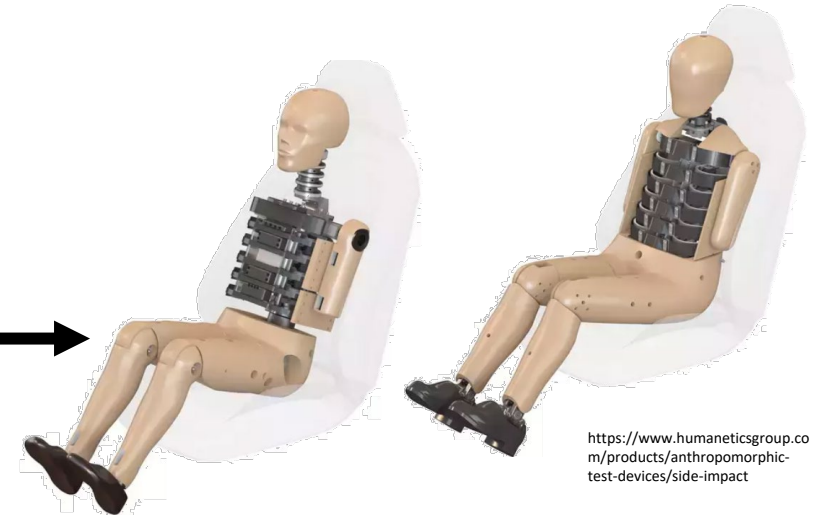
Biofidelity Corridors & Thoracic Injury Criteria

Limitations: mid-size males, not representative



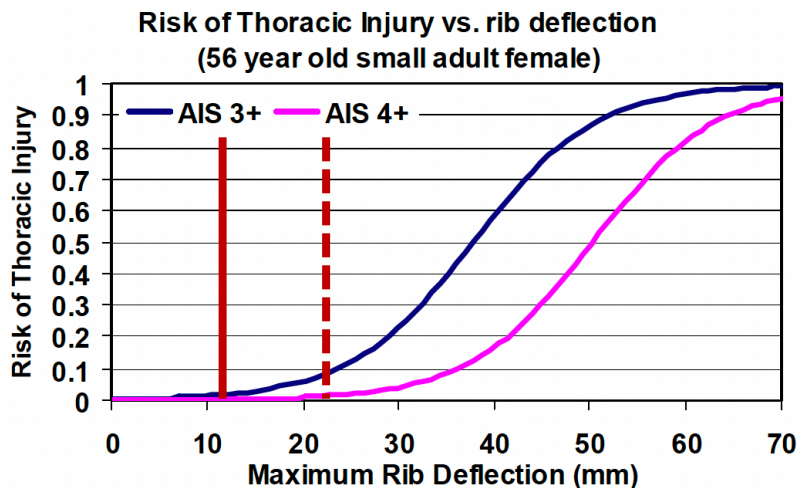
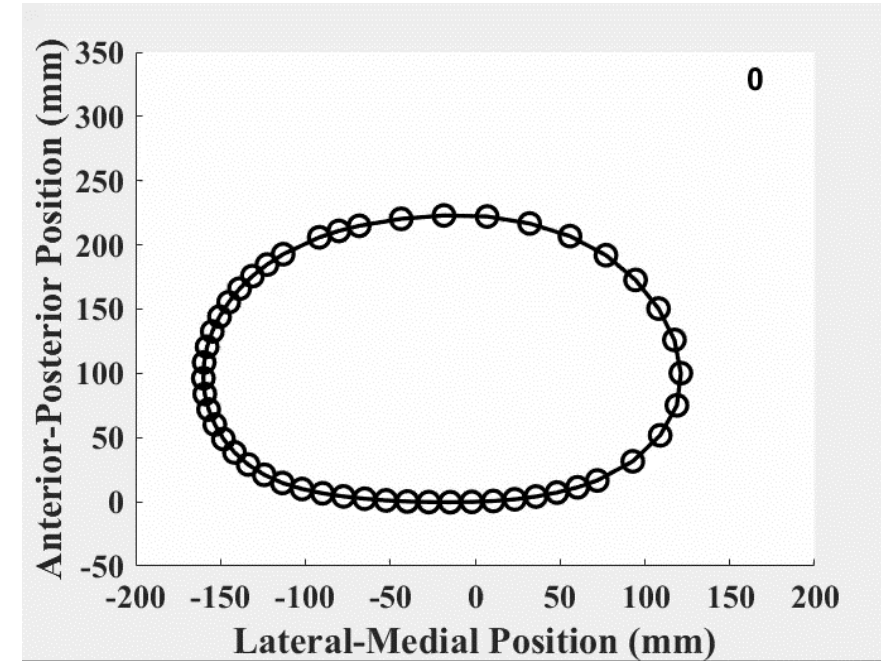
?

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Bolte et al 2023

	TARGET (female)	ESI 01	ESI 02	ESI 03	ESI 04	ESI 05
Age (yrs)	60+	61	83	81	67	69
Height (cm)	136-167	167	155	160	155	165
Weight (kg)	42-56	56.0	44.0	51.7	54.9	54.9
aBMD (t-score)	-2.5 < x < -1	-2.4	-1.6	-1.4	-1.5	-2.2
Test Injuries	-	5 rib fx	15 rib fx L clavicle fx spleen lac	5 rib fx	20 rib fx sternum fx	5 rib fx L clavicle fx
MAIS	-	3	3	3	3	3



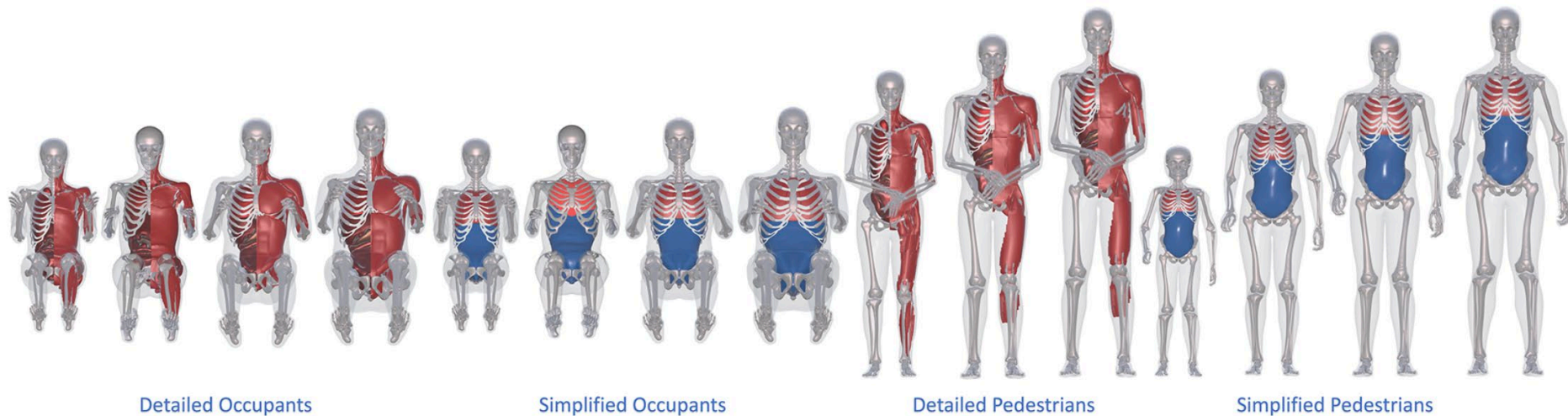
- - - - Axilla Peak Compression
- Axilla @ AIS = 3

Kuppa (2006 - NHTSA)



Conclusions

- ATDs & HBMs
 - Are safety tools that measures the effect of an impact on a “human”
- Do current ATDs & HBMs respond like a human?
- Do current ATDs & HBMs provide measurements that correlate with human injury?



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