Developments in LS-DYNA Dummy Models

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HUMANETICS INNOVATIVE SOLUTIONS

Humanetics Innovative Solutions

- First Technology Safety Systems (FTSS) and Denton ATD are now subsidiaries of Humanetics Innovative Solutions

- Rebirth of the original Humanetics combining expertise, experience, and knowledge from both companies to provide a stronger platform for the next generation of innovative dummy products.

VARIABILITY IN CRASH TESTING

Variability in Crash Testing

Vehicle product development
- Meet targets at shortest time and lowest costs
- Need for over-engineering due to **un-quantified sources of variability** to avoid surprises

Variability in crash testing comes from all components in the entire chain
- Vehicle, restraint systems, test tools, instrumentation
- Procedures and human factors involved

Dimensions Weight Material Friction	Manufacturing Temperature Humidity Aging	Speed Acceleration Dynamics	Lab-to-Lab Calibration Operator Procedural

Tolerances and human factors must be minimized and procedures improved !!

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Variability in Crash Testing

Crash dummies are sophisticated products with relatively large variation due to:

- Design complexity: Improved Bio-fidelity results in increased variability
    - Many components to represent complicated structures
    - Hard and soft materials resistant to impact
    - Soft material properties changing over time
    - Broad spectrum of loading conditions

- Low volume business limiting investment possibilities
    - Manual operations in manufacturing

- Positioning and lack of robust procedures

- (Historically) different materials, geometries, and design used by different manufacturers
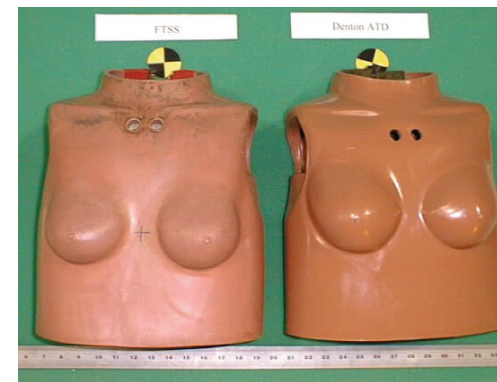
CRASH DUMMY VARIABILITY MINIMIZATION

Crash-Dummy Variability Minimization

How?

HARMONIZATION

One brand where possible

Driven by

Customer and government agencies

Examples

- BioRID
-FLEX-PLI-GTR
-WorldSID
see
www.humaneticsatd.com/harmonizatio
n-commonization/harmonization

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Crash-Dummy Variability Minimization

	HARMONIZATION One brand where possible	COMMONIZATION Use common components, materials, etc.
How?		
Driven by	Customer and government agencies	Humanetics with customer approval
Examples	- BioRID -FLEX-PLI-GTR -WorldSID see www.humaneticsatd.com/harmonization-commonization/harmonization	- One steel skeleton -One Foam to fill vinyl components -Non-tested Rubber parts molded the same (bumpers, stops, etc.) Machining Parts/Weldments Surface Finish

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Crash-Dummy Variability Minimization

	HARMONIZATION	COMMONIZATION	CORRELATION
How?	One brand where possible	Use common components, materials, etc.	Use common test equipment to certify
Driven by	Customer and government agencies	Humanetics with customer approval	Humanetics with customer approval
Examples	- BioRID -FLEX-PLI-GTR -WorldSID see www.humaneticsatd.com/harmonization-commonization/harmonization	- One steel skeleton -One Foam to fill vinyl components -Non-tested Rubber parts molded the same (bumpers, stops, etc.) Machining Parts/Weldments Surface Finish	- FTSS parts test on Denton cal fixture - Denton parts test on FTSS fixture - Harmonizing fixtures

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Crash-Dummy Variability Minimization

	HARMONIZATION One brand where possible	COMMONIZATION Use common components, materials, etc.	CORRELATION Use common test equipment to certify	OPTIMIZATION Further reduce tolerances
How?	One brand where possible	Use common components, materials, etc.	Use common test equipment to certify	Further reduce tolerances
Driven by	Customer and government agencies	Humanetics with customer approval	Humanetics with customer approval	Humanetics with customer approval and government agencies
Examples	- BioRID -FLEX-PLI-GTR -WorldSID see www.humaneticsatd.com/harmonization-commonization/harmonization	- One steel skeleton -One Foam to fill vinyl components -Non-tested Rubber parts molded the same (bumpers, stops, etc.) Machining Parts/Weldments Surface Finish	- FTSS parts test on Denton cal fixture - Denton parts test on FTSS fixture - Harmonizing fixtures	- Additional certification - Tighter corridors - Control of material and geometry - Manufacturing process - Support to improve positioning procedure

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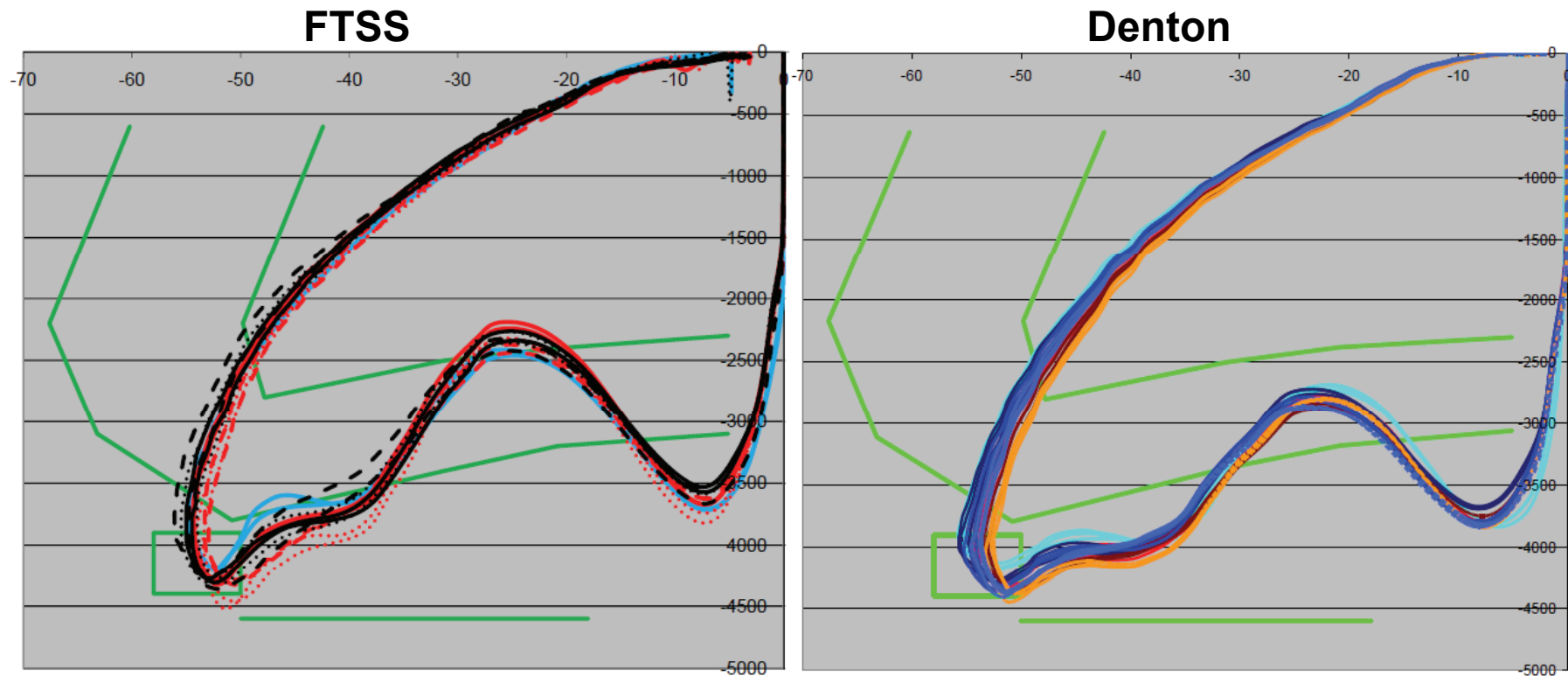
CAE NEEDS AND SOLUTIONS

The Role of CAE

Variability can be reduced but not removed!

- A robust design process is needed to comprehend variability

Humanetics goals:
1. Models predicting average dummy response
2. Quantification and understanding of variability
3. Models predicting the full spectrum of dummies in the field
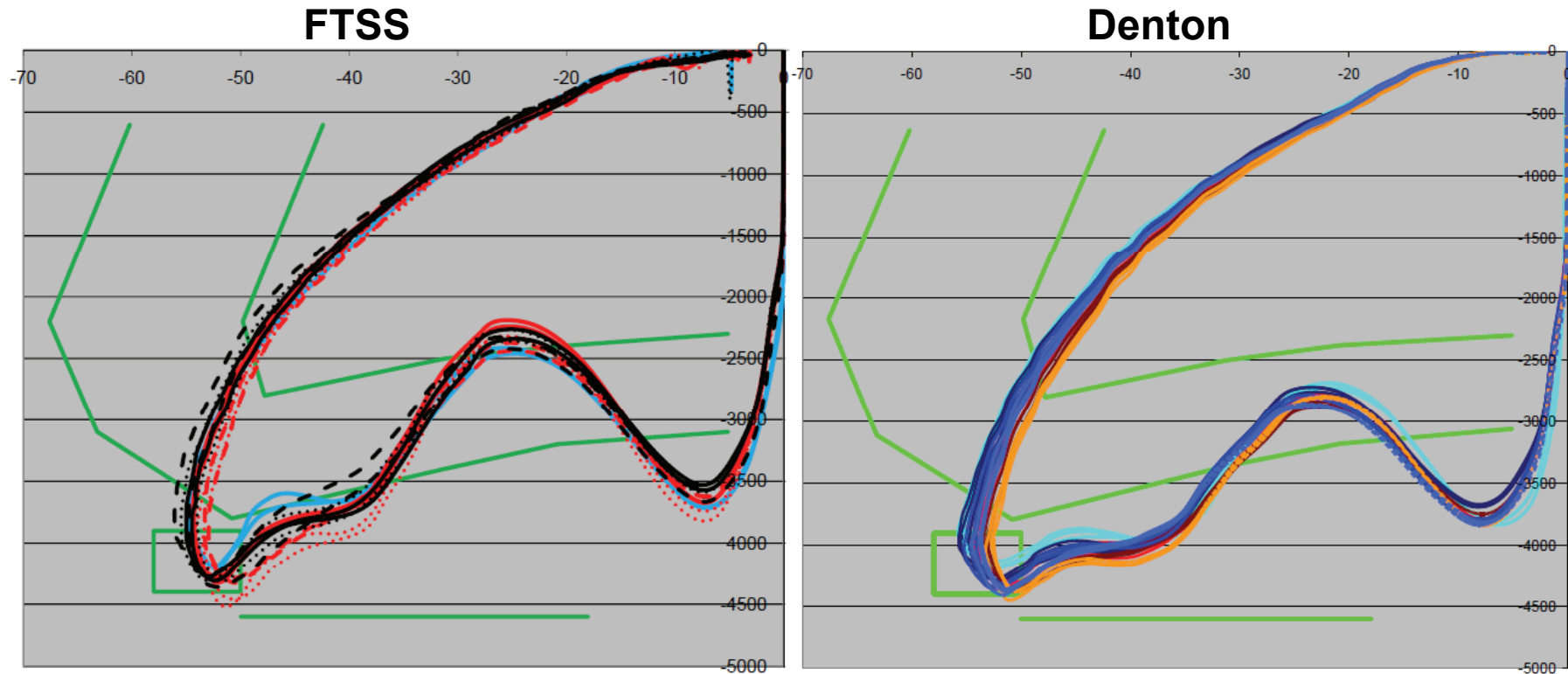
H3 5th Thorax from different brands

FTSS

Denton

Results of 35 thorax certification tests with "harmonized" jackets

- FTSS significantly softer than Denton @25 mm
- Difference is dominated by ribs.

H3 5th Thorax from different brands

FTSS   Denton
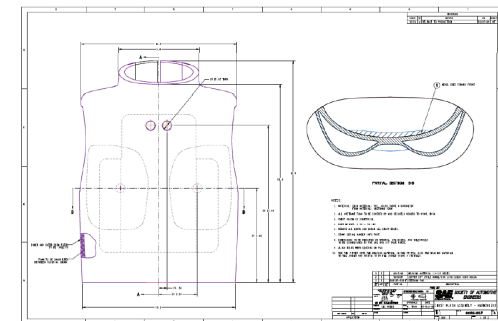
- Dummy Hardware Commonization progress is essential but depends on customer approval

- A CAE Solution is required to capture differences between dummies in general
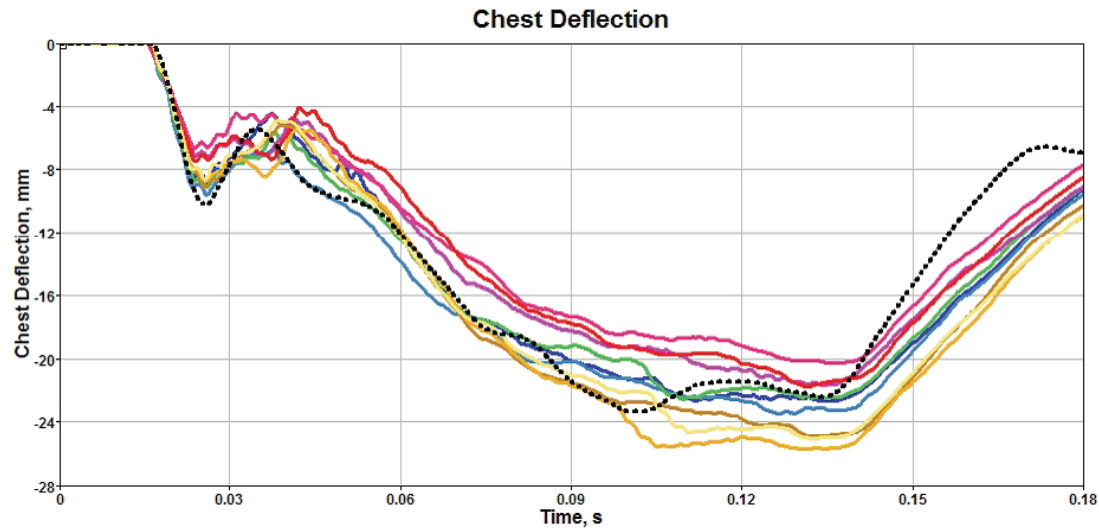
Positioning variability

Point of interest

- Variability due to dummy positioning
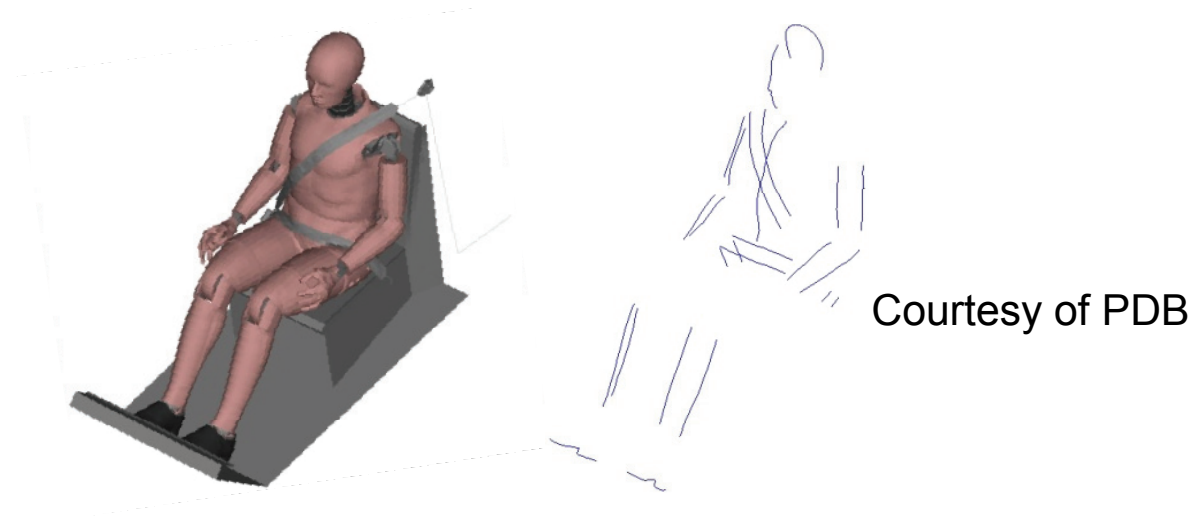
Courtesy of PDB

Data set

- H350, simplified sled test
- Rigid seat, belted, retractor, and pre-tensioner
- Scaled-down EuroNCAP pulse
- 3 dummies from one Brand (3 repeats)

Positioning variability

Belt and torso positions recorded precisely

Courtesy of PDB

- 3-7% chest peak variation is observed when the same dummy is used in a well controlled environment

- Influence of positioning is likely much bigger in standard environment

- Potential to reduce variability due to improved positioning

- The CAE process should take positioning variability into account!

Dummy variability

"Simplified EuroNCAP"
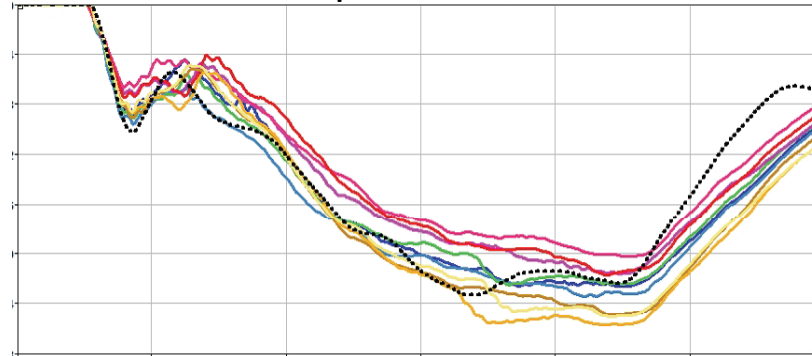
- ~ 25% chest peak variation is observed when comparing different dummies in well controlled environments

- Complex belt-shoulder interactions can play a dominant role rather than the ribs

- Potential to reduce variability and the CAE process should represent the performance of the dummy population

Extremity joint variability

Point of interest

- Variability due to ligament joint friction setting (human factor)

Test1
Test2
Test3
Model 1 g
Model 4 g
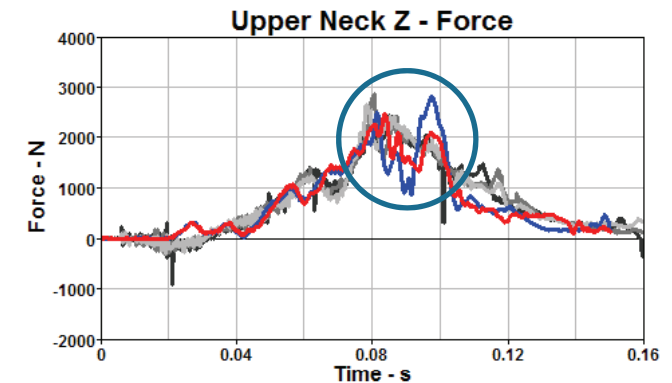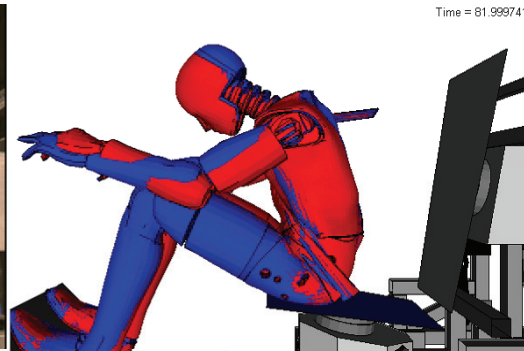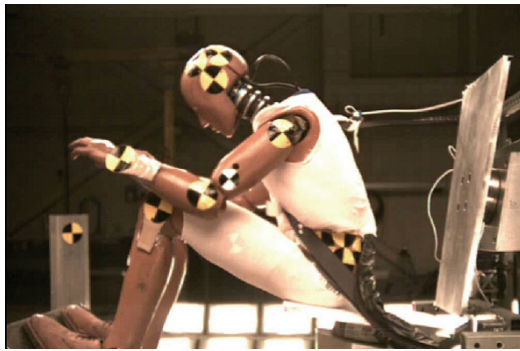
- A large variation can be observed due to dummy joint frictions settings
- Properly capturing the joint friction moments in the CAE process is required

Data set
- Rigid seat
- Pulse: generic small car, 35 mph, into rigid barrier
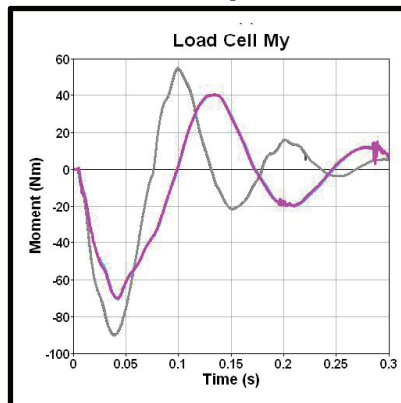- Belted, load limiter, retractor, pre-tensioner
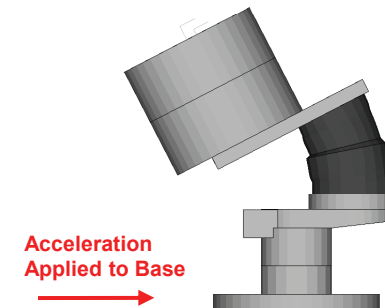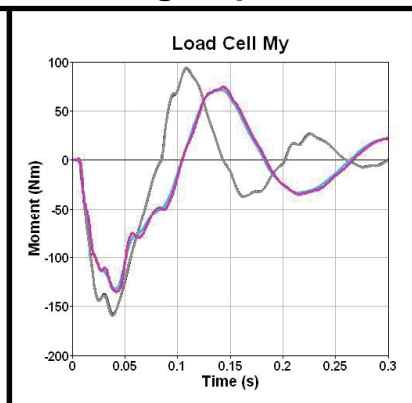- 1 dummy (3 repeats)

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Dummy material variability

Point of interest

- Variability of aging of certified lumbar spine

Acceleration Applied to Base

Test results

Low Speed

Load Cell My

Moment (Nm)

Time (s)

High Speed

Load Cell My

Moment (Nm)

Time (s)

21 months old spine
Brand new spine
Brand new spine

- Variability due to aging can be significant and should be quantified and understood

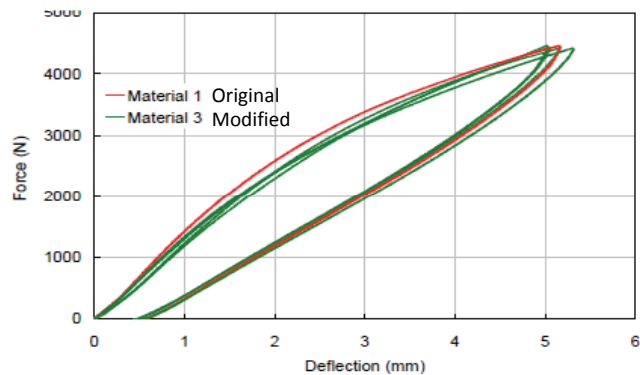- Hardware may be improved and the models should represent aging effect

Dummy material variability

Point of interest

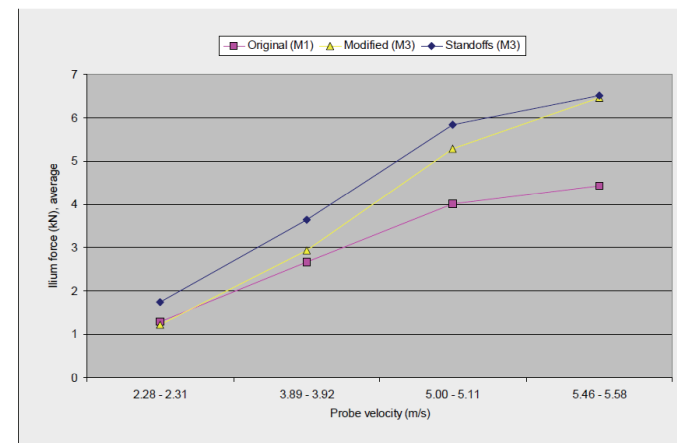- Variability of SID-IIs Iliac Wing due to urethane material replacement

New Iliac Wing Design P/N 180-4322-1; -2
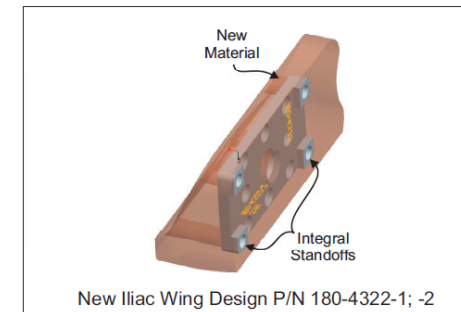
Quasi static test – no difference
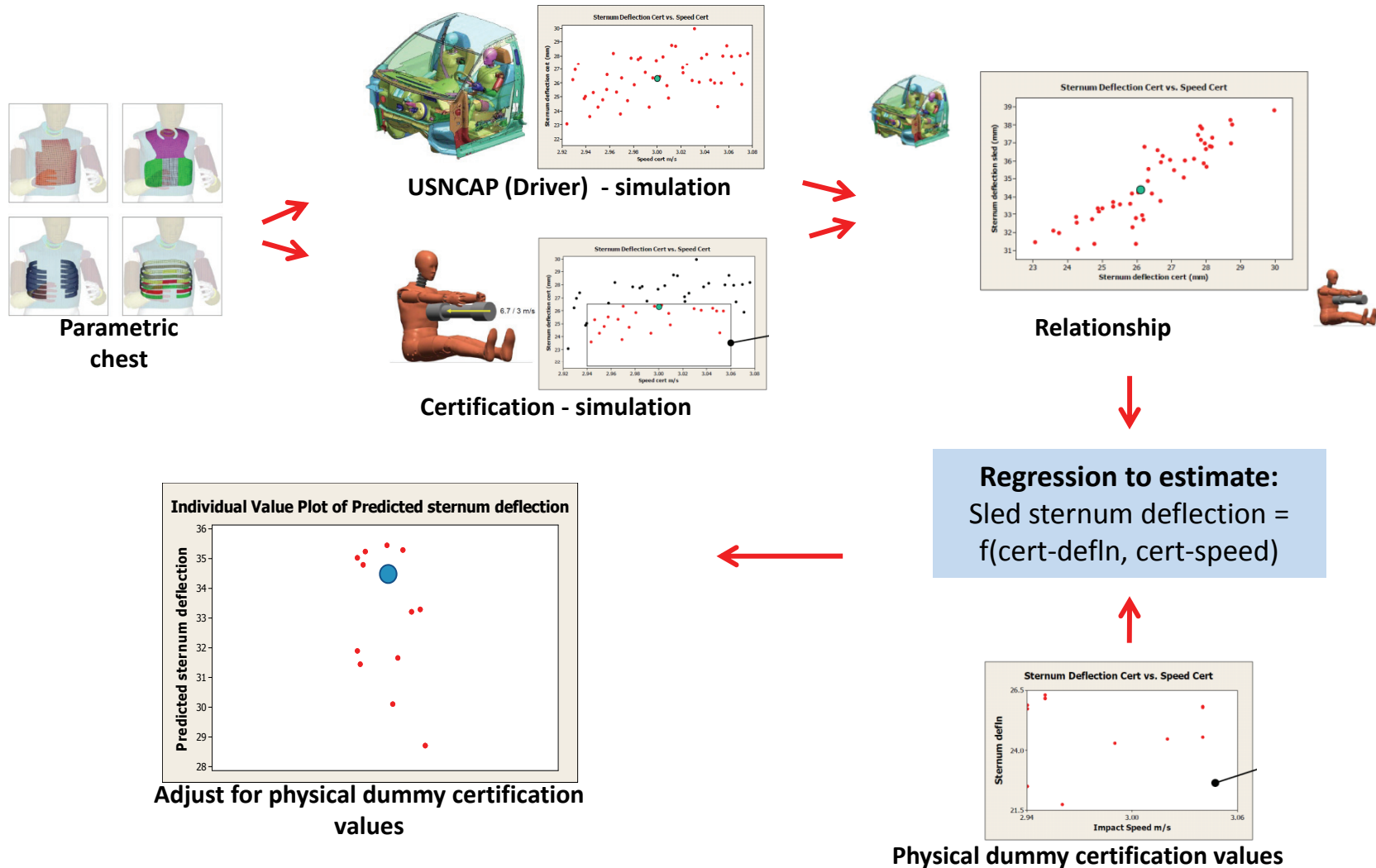

Dynamic tests – ~ 30% difference at 5 m/s

- Material changes can have affect on dummy performance

Example: Parametric dummy model

Parametric chest

USNCAP (Driver) - simulation

Certification - simulation

Relationship

Regression to estimate:
Sled sternum deflection =
f(cert-defln, cert-speed)

Physical dummy certification values

Adjust for physical dummy certification values

Courtesy: Jaguar Land Rover

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SUMMARY

Summary

► **Variability in passive safety testing comes from all components in the entire chain and must be minimized and controlled**

► **Part of variability is caused by the crash test dummy**

► **Humanetics minimizes variability of dummies through:**

Harmonization   - One brand where possible

Commonization   - Material, geometry and manufacturing alignment of regulated
dummies from different brands

Correlation   - Common equipment to certify

Optimization   - Reduce tolerances

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Summary

VIRTUAL

► **CAE can account for the remaining variability in vehicle design:**

- Hardware variability can be reduced but not removed
- Addressing sources of variability is required

► **Humanetics goals:**

1. Models predicting average dummy response
2. Quantification and understanding of performance variability
3. Models predicting the full spectrum of dummies in the field

THANKS!