


Thoracic Injury Assessment for Improved Vehicle Safety

- Introduction and Status per August 2010 -

Meeting: GA Telecall

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CHALMERS

Continental

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Partnership for Dummy Technology and Biomechanics (pdb)

1 First Technology
Innovative Solutions

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HUMAN BEHAVIOR

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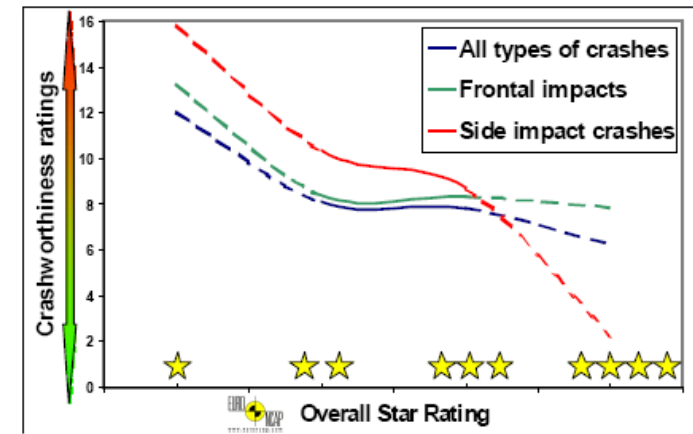
INRETS



UNIVERSITY OF VIRGINIA
ENGINEERING

SEVENTH FRAMEWORK PROGRAMME

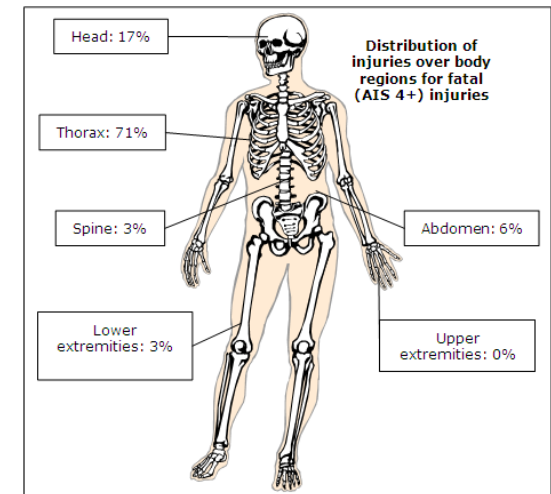
- The trend of increasing performance of vehicles in consumer rating programs is in contradiction with observations from accident data
- This is due to several reasons among which the usage of Hybrid III dummies that were developed in the late 70ties
- HIII thorax was designed to assess injury risk related to localized hub type loading of an adult male
- State of the art restraints use load limiter belts in combination with multi stage bags which result in a different load case and sensitivity range
- This is also true for combined active / passive systems



UK Safety Rating vs. Overall Star Rating (all crash types)

The aim of the THORAX project is to develop numerical and experimental tools for the optimisation and assessment of frontal restraints for a wide variety of car occupants (age, gender, size)

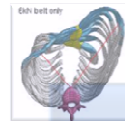
- Identification of the two most relevant thoracic injury types from real world accident data
- Characterization of injury mechanisms and governing parameters for these injury types, quantifying effects of user diversities like age
 - Using PMHS test data and HBM simulations
- Development of hardware demonstrator consisting of a new thorax / shoulder design implemented in a THOR NT dummy
- Development of injury risk functions for the hardware demonstrator and HBM's
- Assessment of the sensitivity of the hardware demonstrator to modern vehicle safety systems and usability in safety system optimization





WP1: Accident Analysis

- Prioritisation of thoracic injuries
- Real world accident outcome versus crash test results
- Benefit estimation



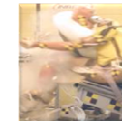
WP2: Biomechanics

- Biomechanical requirements
- Volunteer testing
- Injury mechanisms & assessment crit.
- PMHS testing
- Injury risk curves



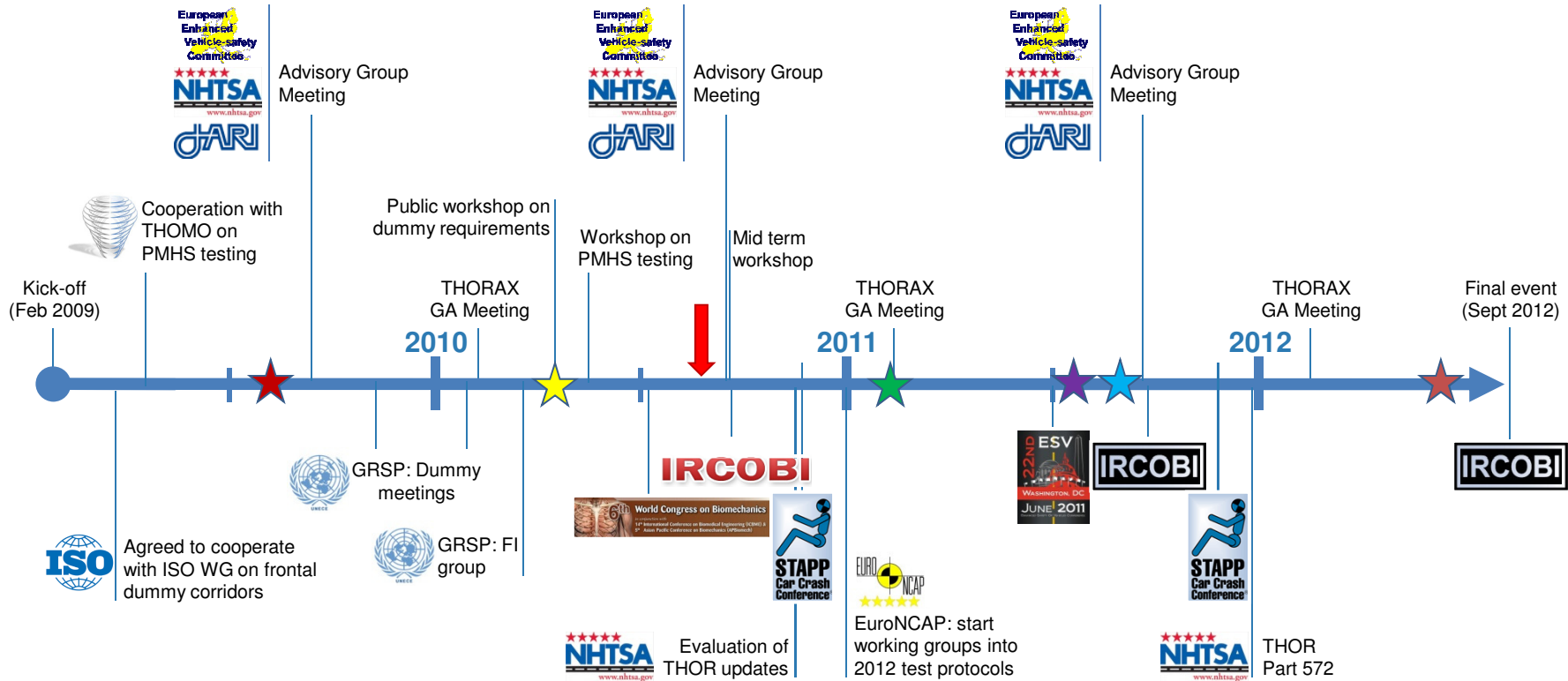
WP3: Demonstrator design

- Requirements
- Dummy concepts
- Design and prototype development
- Validation of biomechanical performance



WP4: Assessment for restraint optimization

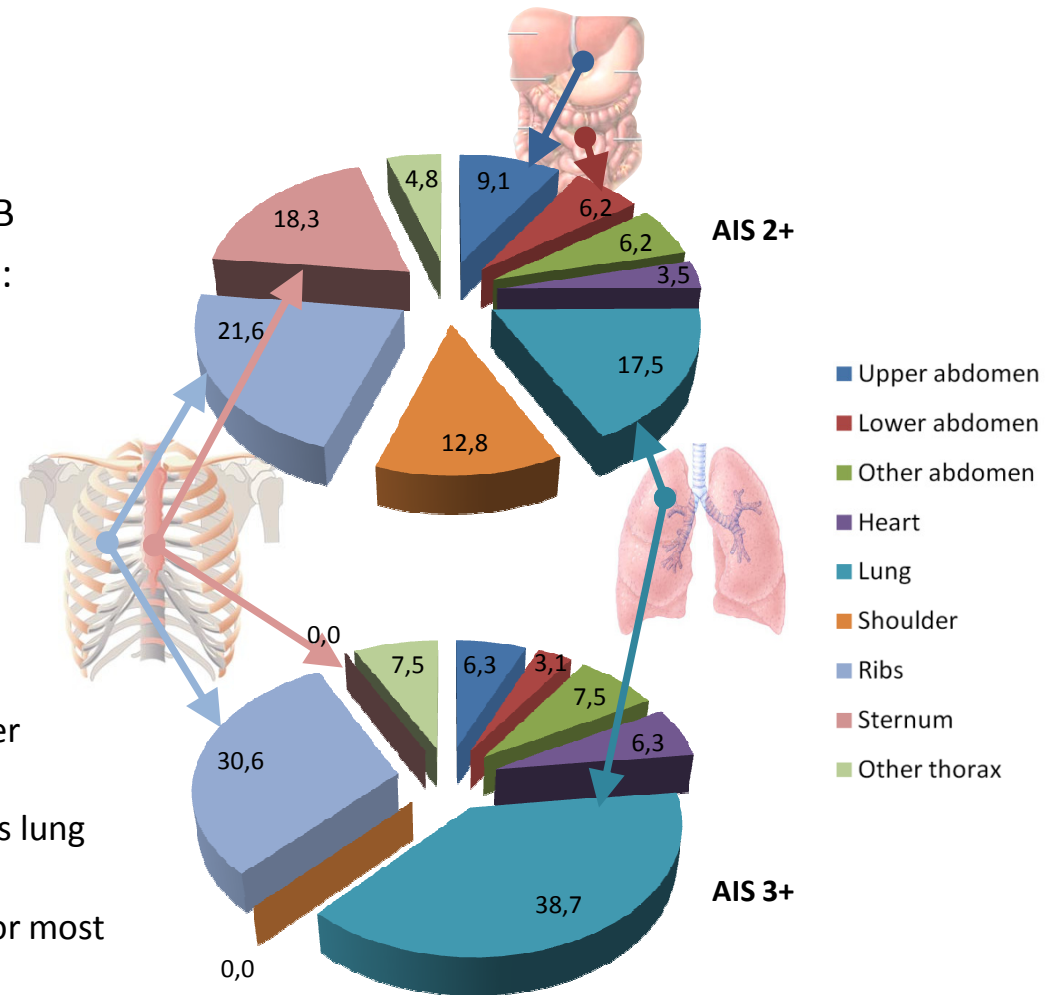
- Load cases and evaluation criteria
- Testing
- Data analysis



- ★ M1: Two most relevant thoracic injury types identified
- ★ M2: Design specification thorax / shoulder complex
- ★ M3: Prototype thorax / shoulder complex available for testing
- ★ M4: Prototypes validated against biomechanical requirements
- ★ M5: Dummy and HBM injury risk curves available
- ★ M6: Dummy sled tests completed and data analysed

Accident survey in GIDAS, CCIS, OTS and LAB

- Two most frequent thoracic injuries are:
 - Rib fractures
 - Lung injuries
- Of secondary importance are:
 - Shoulder injuries
 - Sternum fractures
- Also
 - Risk of thoracic injury is greater for older occupants than younger occupants
 - Younger occupants can sustain a serious lung injury without serious rib fractures
 - Load limiters reduce the risk of injury for most AIS3+ injuries
 - 4kN load limiters are much more efficient than 6kN load limiters
 - Accidents with widely distributed loading to the car front are most likely to cause torso injuries



Distribution of thoracic injuries AIS 2+ (top) and AIS 3+ (bottom)

34 cases from GIDAS & CCIS selected based on their similarity with EuroNCAP test



Collision / Accident Data			
Make:	Audi	Model:	A3
E.T.S (kph):	34	dv (kph):	31
Object hit:	Car	Seating / Restraint data	EES (kph): 39
		Overlap:	37
		Compartment	none
		Intrusion:	none

Loading: O/S longitudinal was loaded, both crumpling and bending. The N/S longitudinal was not directly loaded but was crumpled. The engine was directly loaded.

EuroNCap Test:			
Tested model	Audi A3 1.6		Score: 29
Hand of drive	RHD		
Body type	small family car		
Year of publication	2003		

Frontal Impact Test: The restraint system used single stage tethered airbags teamed with belts fitted with pretensioners and load limiters. These worked well although loads on the occupants' chests were a little high. Unfortunately the driver risked knee injuries from hand points behind the fascia. The body proved very strong after the impact showing minimal distortion around the sill and screen pillar areas, while the footwell suffered only minor deformation.

	Frontal impact driver	Frontal impact passenger	Rating:	Score:
Legend			ADULT OCCUPANT	Front: 12 Side: 16
Legend			ADULT OCCUPANT	29

Driver (right side): Personal data			
Gender:	Male	Age:	25
Height (m):	Unknown	Mass (kg):	unknown
Seating / Restraint data			
Pretensioner:	Fitted and activated	Load limiter:	Fitted and activated
Airbags:	Steering wheel - activated	Seat back angle:	102°
Seat Position:	Mid position		

CCIS severity: slight

Injury data			
Injury:	None	Body Region:	
	unknown	AIS:	
		Injury mechanism:	
		Influenced by intrusion?	

Passenger (left side): Personal data			
Gender:	Female	Age:	25
Height (m):	Unknown	Weight (kg):	unknown
Seating / Restraint data			
Pretensioner:	Fitted and activated	Load limiter:	Not activated, not activated
Airbags:	Not activated	Seat back angle:	102°
Seat Position:	Far back		

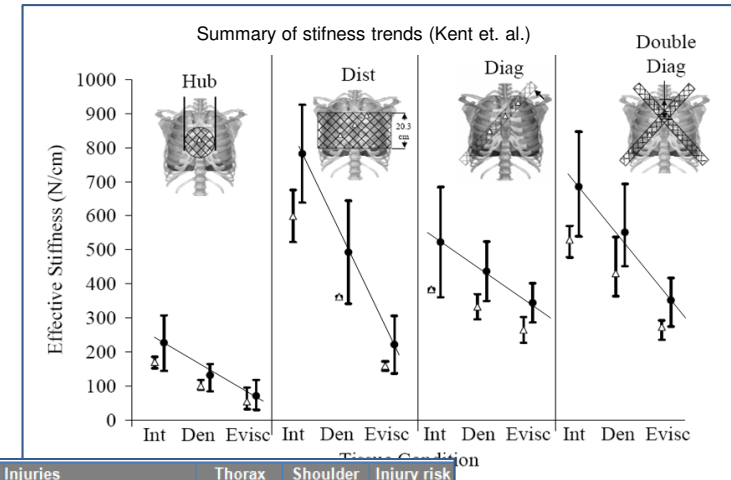
CCIS Severity: Serious

Injury data			
Injury:		Body Region:	
	Displaced # L clavicle mid 1/3 rd	AIS:	2
		Injury mechanism:	Seat belt webbing
		Influenced by intrusion?	No
Abrasion R knee:		AIS:	1
		Injury mechanism:	Facia panel
		Influenced by intrusion?	No

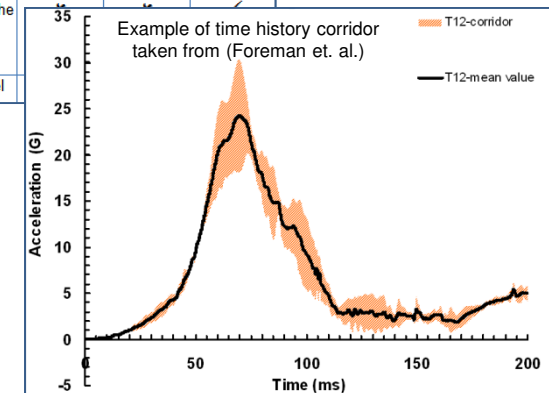
Summary: Euro NCAP predicted adequate protection for the thorax for the front seat passenger. This occupant sustained only one injury to this region; however, a clavicle fracture seems harsh given the age of the occupant and the low delta-v of the crash. The FSP load limiter was not activated and was possibly set too high for clavicle protection. The pretensioner activated. It is also noted from the photographs that the Audi A3 appears to have overridden the VW Golf, because the Golf's longitudinal is bent downwards.

- Thoracic injuries mainly result from belt loading
- Front seat passengers are at higher risk than drivers
 - As front seat passengers are mostly female a “female” dummy should be used at the passenger position in combination with a “male” driver
- Protection of younger occupants in offset frontal crashes is generally good
 - Positive influence of Regulation 94 and Euro NCAP
 - There is an effect of age and injury risk curves for various ages should be developed

- Dependency of thoracic response to loading type
- Large number of datasets checked on their applicability
 - 13 sets found to be relevant → some provided with corridors
 - 11 sets potentially relevant
- Issue: scaling method to be applied
- Cooperation with ISO group on frontal dummy corridors

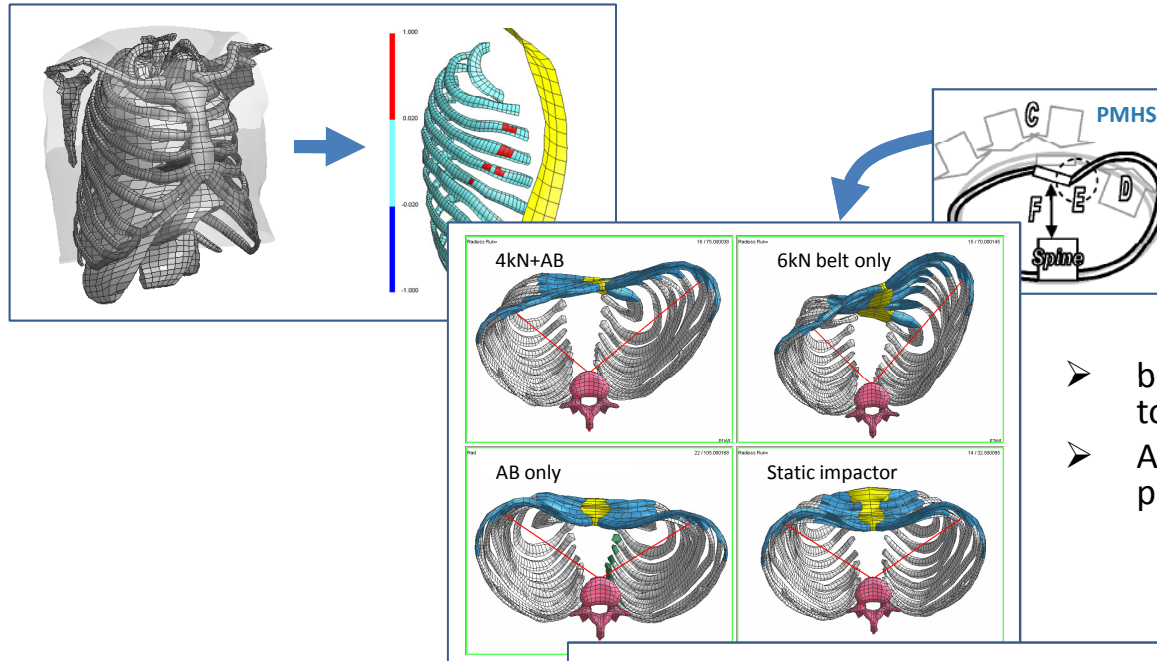


Author / Appendix	Description	Restraints	Chest compression measurement	Shoulder displacement measurements	Injuries	Thorax biofidelity requirements	Shoulder biofidelity requirements	Injury risk functions
Shaw <i>et al.</i> (2009) / App A	Sled tests. 8 PMHS, of which 6 meets the inclusion criterion, at 40 km/h in rigid/cable seat	3-point belt (separate lap and shoulder belt)	Multiple 3D-film targets on rib cage, sternum and along the spine and accelerometer arrays	Three-dimensional film targets on shoulder (left and right acromion)	5 rib fractures in average, clavicle fractures in 2 and 1-2 sternum fractures in all but one subject	✓	✓	✓
Petitjean <i>et al.</i> (2002)	Sled tests. 4 PMHS at 64 km/h using production seat and restraints	Force limited 3-point belt and airbag combinations	Not available	Not available	15 rib fractures on average	✗	✗	✓
Veziin <i>et al.</i> (2002)	Sled tests. 6 PMHS, of which 5 PMHS meets the inclusion criterion, at 30 km/h and 50 km/h using a and rigid seat and commercial restraint systems	Force limited 3-point belt (separate lap and shoulder belt) and force limited 3-point belt with an airbag	Spine accelerometer data only	Not available	6 rib fractures in average for the airbag test and 2 rib fractures in average for the belt only tests			✓
Cavanaugh <i>et al.</i> (1999)	Table top tests. Static. 9 PMHS	Chest loading plate; 4.5 mm x 40 mm	Chest deflection	None	Sub-injury and injury level			



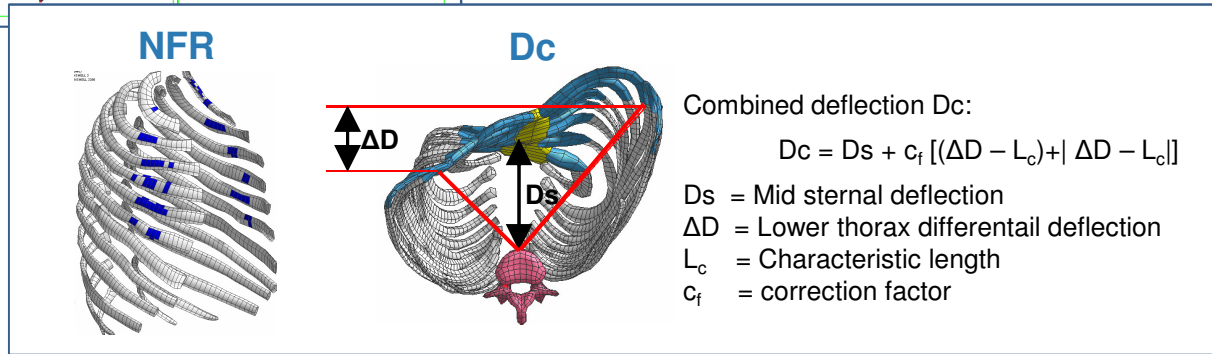
Full set of response corridors to be delivered February 2011

Studies into rib fractures using validated Human Body Models

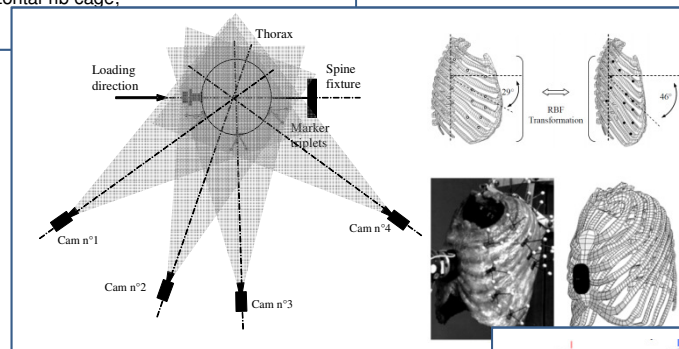
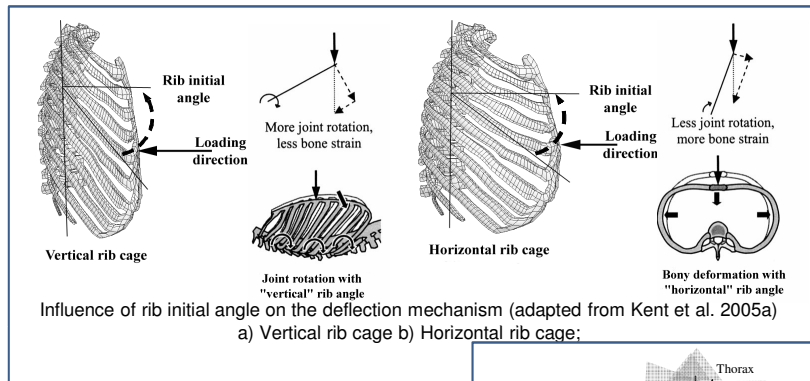


- bending is the main loading mode leading to rib fracture
- Analysis of various load cases resulted in proposals for two new criteria:
 - Combined Deflection D_c
 - Number of Fractured Ribs NFR

Will be analysed further in future THORAX activities with HBM's and hardware demo and included in risk curve development

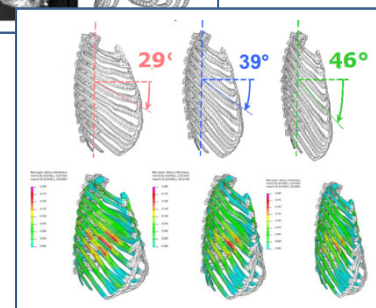


Combined experimental – numerical approach to study influence of internal thorax (rib cage geometry and joints) parameters on the injury mechanism

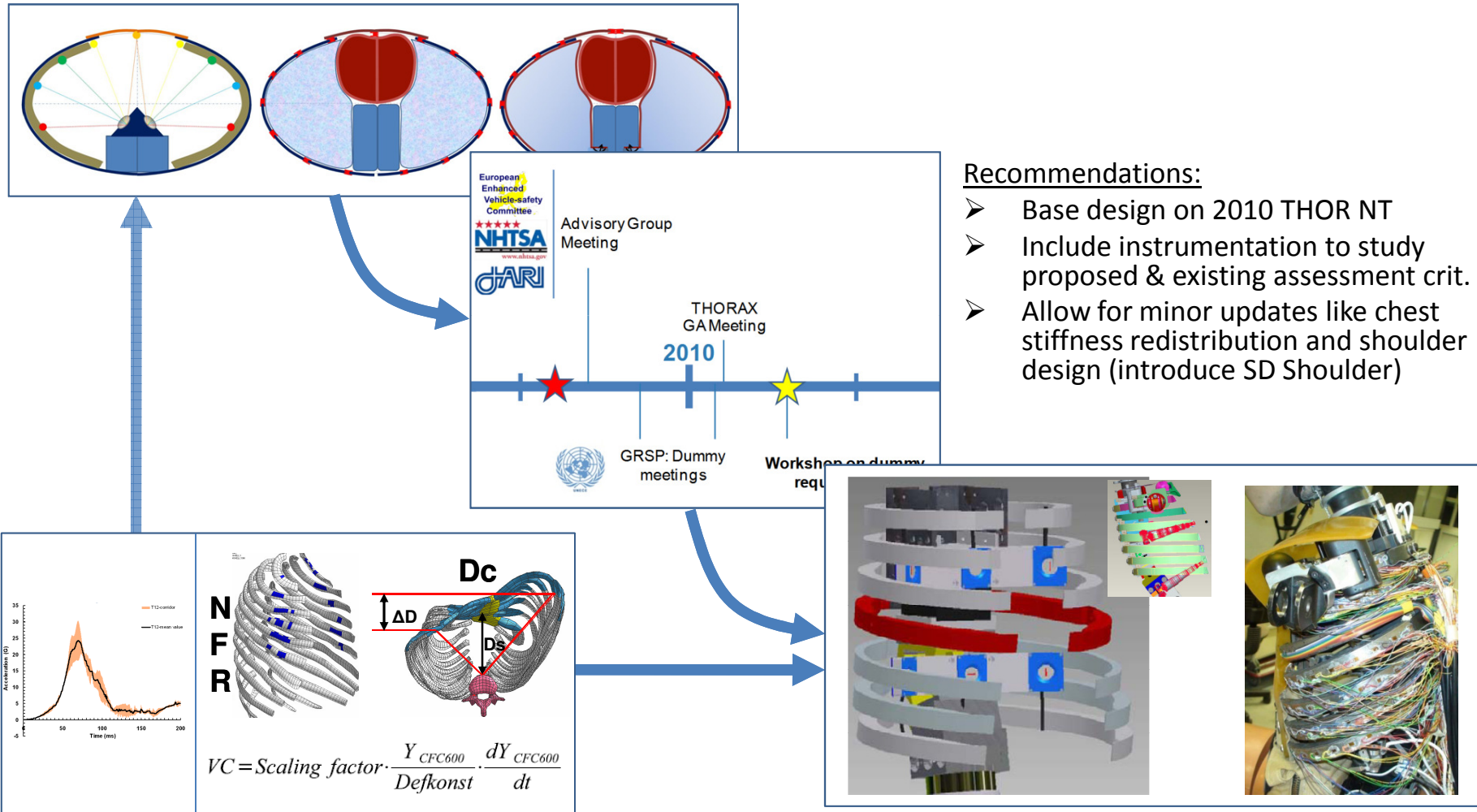


- PMHS testing with advanced tracking system for 3-D deformation measurements
- Personalised FE models for each subject
- Allow to isolate geometry from other parameters like material properties and cross section thickness
- Initial studies on isolated rib cages show that the rib cage morphologie (e.g. orientation, curvature spine, curva rib and their distribution) is influencing the response
- Influence of internal organs investigated by future PHMS tests in THORAX

Approach will be used to support further studies into the injury assessment criteria and development of risk curves

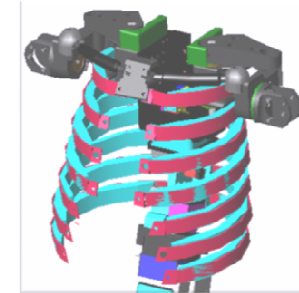


Concepts of different level of complexity developed and discussed with Stakeholders from Governments & Industry



Key work items for next period

- Completion of the biomechanical requirements by Jan 2010
- WP3 to deliver 2 prototype dummies to partners for testing of biomechanical performance in Jan 2011
- Development of Injury Risk curves by Dec 2011
 - Risk functions of humans (considering diversities)
 - Risk functions HBM's
 - Risk functions of hardware demonstrator
- Sled testing to assess dummy performance for restraint optimisation Aug 2011 – June 2012



Please visit www.thorax-project.eu for more information

The screenshot shows the THORAX project website homepage. At the top left is the THORAX logo, a stylized 'T' and 'R' inside a circle. To its right is the tagline "Thoracic injury assessment for improved vehicle safety". On the far right of the header is the European Union flag. Below the header is a navigation menu with links: HOME, SEARCH, SITEMAP, LOGIN. A secondary menu contains: About THORAX, Consortium, News, Events, Downloads, Contact, Links. The main content area is divided into several sections: 1. Project summary: A large image of a car interior with a crash test dummy and a 3D anatomical diagram of the thorax. Text describes thoracic injuries as a major cause of fatalities and lists project goals: understanding injury mechanisms, implementing numerical models, and updating crash test dummies. 2. Facts & Figures: A text block stating that 41,600 people were killed and 1.7 million injured in European road accidents in 2005, and that fatalities have declined by 17% since 2001. 3. Co-funded under 7th FP (Seventh Framework Programme): Includes the logo for the Seventh Framework Programme and the European Union flag. 4. Events: Lists two events: "ISN & COVER Workshop on Biomechanical Experiments with Human Subjects" (September 14, 2010, Hanover, Germany) and "17th Congress of the European Society of Biomechanics 2010" (July 5-8, 2010, University of Edinburgh, UK). 5. News: Lists two news items: "Presentation during the 6th World Congress of Biomechanics available" and "Second COVER Newsletter". 6. Images: Three smaller images showing a crash test dummy, a 3D model of a human torso, and a 3D model of a car seat and dashboard.

THORAX Thoracic injury assessment for improved vehicle safety

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Project summary

Thoracic injuries are one of the dominant causes for fatalities and injuries in car crashes today. The tools available today for studying these injuries are not up to par with the latest implementation of restraint systems and airbags.

The THORAX Project will focus on reduction and prevention of thoracic injuries through:

- Understanding the thoracic injury mechanisms
- Implement this understanding in numerical computer models and
- Implementation of an updated THORAX design in a crash test dummy

The models and dummy will enable the design and evaluation of advanced restraint systems for a wide variety (gender, age and size) of car occupants.

[Learn more about THORAX project »](#)

Co-funded under 7th FP (Seventh Framework Programme)

SEVENTH FRAMEWORK PROGRAMME

Events

ISN & COVER Workshop on Biomechanical Experiments with Human Subjects
September 14, 2010
Hanover, Germany
information and call for papers: [PDF](#)

17th Congress of the European Society of Biomechanics 2010
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[View all events »](#)

News

- [Presentation during the 6th World Congress of Biomechanics available](#)
- [Second COVER Newsletter](#)
- [THORAX Stakeholder Workshop on Dummy Demonstrator Requirements](#)
- [ISN & COVER Workshop on Biomechanical Experiments on Human Subjects, Call for Papers](#)

Facts & Figures

About 41,600 people were killed and more than 1.7 million injured in European road accidents in 2005. Although the number of road fatalities has declined by more than 17% since 2001, more efforts will have to be made to meet the EC's target of halving the number of deaths in the period between 2001 and 2010.

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