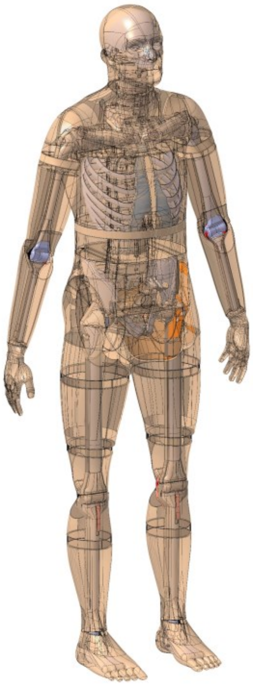


HOCHSCHULE FÜR TECHNIK UND WIRTSCHAFT DRESDEN UNIVERSITY OF APPLIED SCIENCES

DUMMY. CRASHTEST. KONFERENZ.

Development of a biofidelic dummy to indicate human injuries

Benjamin Härtel, Prof. Lars Hannawald, HTW Dresden

Overview

- Motivation
- Biofidel-Dummy (PRIMUS)
- Development status
- Validation (sled tests / full scale crash tests)
- Research focus and outlook

Motivation

How to evaluate future occupant protection?

Source: Volvo concept 360c

Motivation

Which tools are used to evaluate new restraint systems?

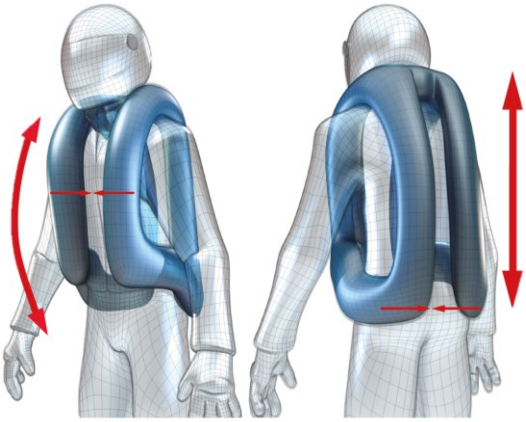
Source: Daimler / Beltbag

Source: Insafe

Motivation

How to protect vulnerable road users?

Source: Hövding 3



Source: Helite

Motivation

How to protect vulnerable road users?

Source: Screenshot Autoliv / Youtube

Motivation

Sources: msasafety, ffw-muenchen, BMW Sicherheitsfahrzeuge, rescue-tec, batex

Structure

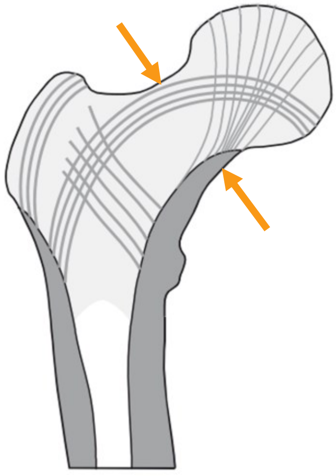
- Bone components
- Ligaments and tendons
- Soft tissue
- Anthropomorphic geometry
- Real range of motion
- Age, weight, height and mass distribution 50-percentile
- Inertial measuring unit in head, pelvis and thorax
- ISO 9001 certified

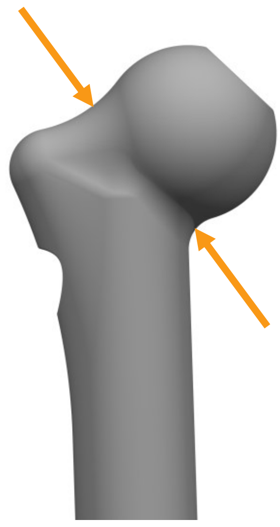
Source: Crashtest-Service

Correlation between **dummy damage**

and **human injury**

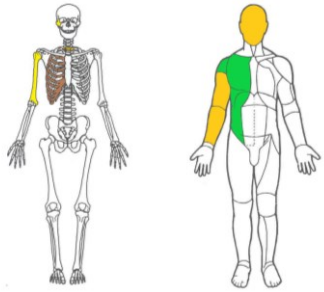
Example - Femoral neck





Technical autopsy

Quelle: Crashtest-Service

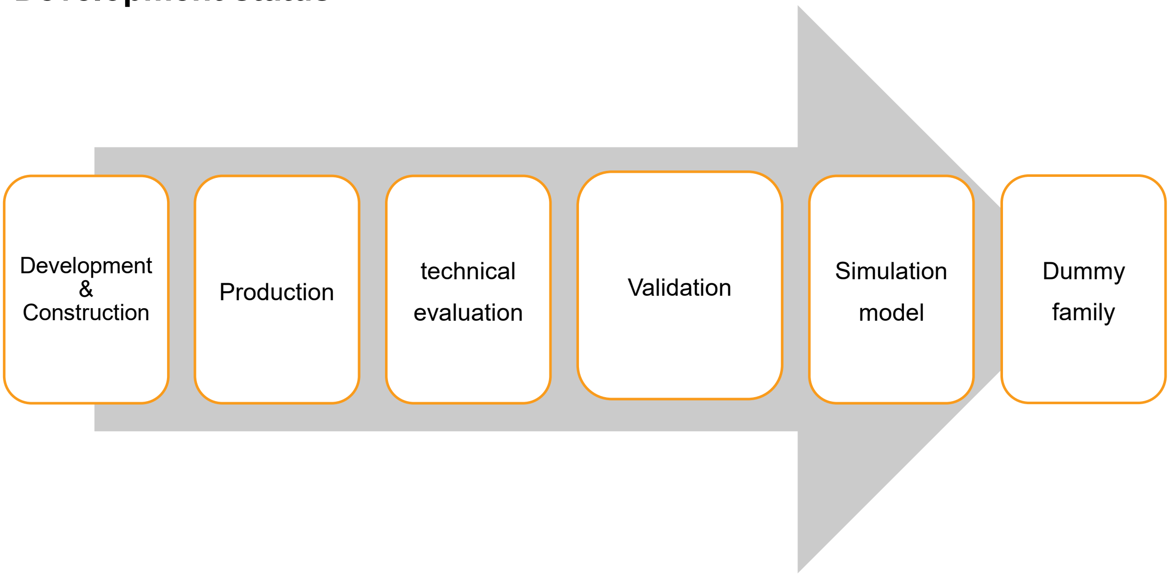


AIS-Code	Farbe	AIS-Verletzungsschwere	NTDB [%]	GIDAS AIS [%]	GIDAS MAIS [%]
0		unverletzt	100	100	100
1		gering	99,3	99,8	99,9
2		ernsthaft	99,2	99,4	99,6
3		schwer	96,5	98,3	95,8
4		sehr schwer	85,4	74,6	74,9
5		kritisch	60,4	61,5	42
6		maximal (nicht behandelbar)	21	0	0
9		Nicht genauer angegeben			

NTDB National Trauma Database, GIDAS German In Depth Accident Study, AIS Abbreviated Injury Scale, MAIS maximaler AIS-Wert.

Quellen: Thomas A. Gennarelli, Elaine Wodzin (Hrsg.): The Abbreviated Injury Scale 2005. American Association for Automotive Medicine (AAAM), Barrington IL 2006. Sean O'Brien: Measurement and Assessment of Passenger Vehicle Compatibility in Front and Side Collisions. 2010 (Dissertation, RMIT University).

Development status



Validation

Sled tests

compared to:
- Cadaver tests PMHS
- Human test persons

Full scale crash tests

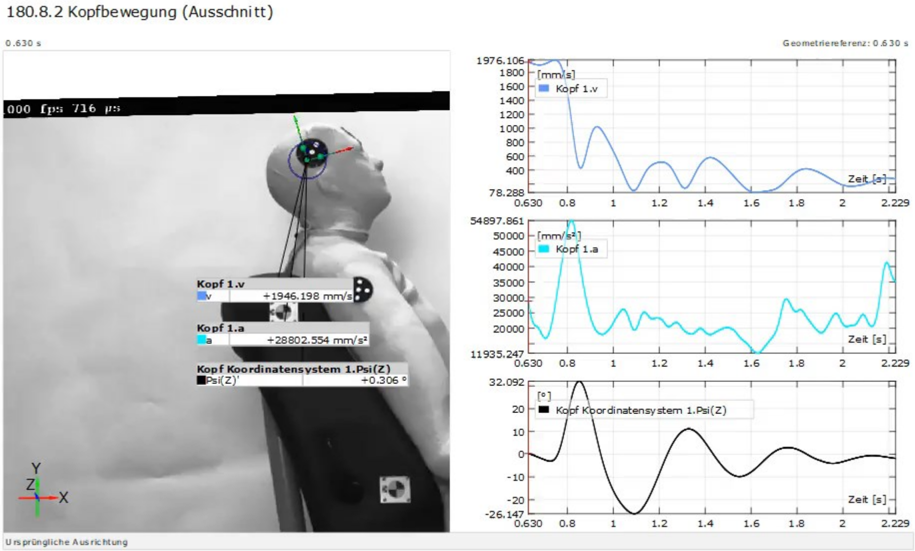
Source: Crashtest-Service

compared to:
- Cadaver tests PMHS
- Real accidents of high documentation quality

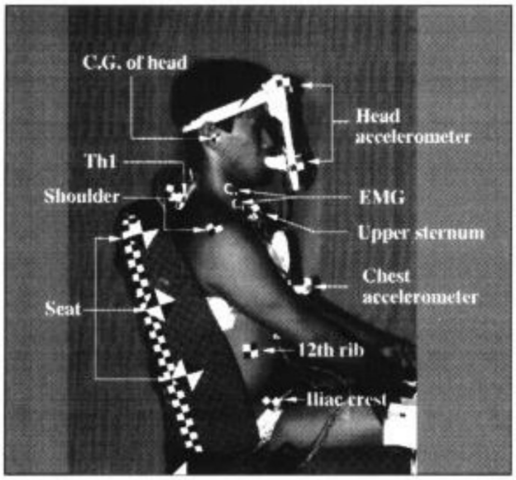
Sled example - head load rear impact

180.8.2 Schlittenbewegung

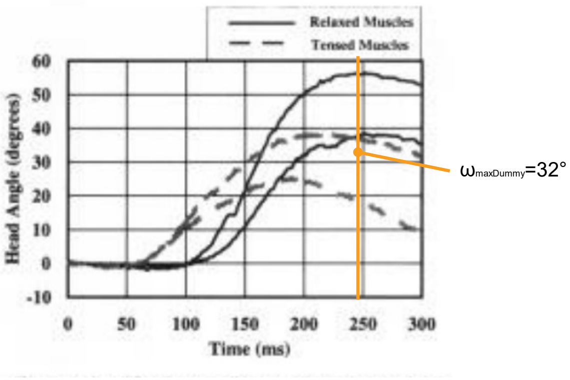
Sled example - head load rear impact



Sled example - head load rear impact



Source: [1] Koshiro et. al.



Source: [1] Koshiro et. al.

Test results - Rear impact

Data					Test results (percentage match)					
	Reference	Scenarios	No.	ID No.	Test No.	Head acc.	Head rotation	thoracic acc.	Pelvic acc.	Description
Human volunteer tests	Ono. et. al. [1]	rear impact 4 km/h	1-13	N/A	180.4.1 180.4.2 180.4.3	●				The deviation of the resulting head acceleration of the sled test in relation to the human volunteer test is on average 3.4 %. The deviation of the resulting head rotation rates of the test in relation to the human volunteer test is 20.4% on average.
		rear impact max. 6km/h	14-20	N/A	180.6.1 180.6.2 180.6.3					
		rear impact max. 8km/h	21-23	N/A	180.8.1 180.8.2 180.8.3 180.8.4 180.8.5 180.8.6			-		

-	There is no data in the literature for a comparison
◆	Different measuring systems
■	Differences of the test objects in age, weight and size
●	No identical test conditions possible

100%-80%		79%-50%		49%-25%		24%-10%		9%-0%	
	Good		Adequate		Marginal		Weak		Poor

Test results - Frontal impact

Data					Test results (percentage match)					
	Reference	Scenarios	No.	ID No.	Test No.	Head acc.	Head rotation	thoracic acc.	Pelvic acc.	Description
Human volunteer tests	Smith et. al. [2]	frontal impact 21km/h	24	508	0.21.1 0.21.2 0.21.3	■	-	■	-	The deviation of the resulting head acceleration of the sled test in relation to the human volunteer test is on average 13 %. The deviation of the resulting thoracic acceleration of the sled test in relation to the human volunteer test is on average 7 %.
			25	509	0.21.1 0.21.2 0.21.3					
			26	511	0.21.1 0.21.2 0.21.3					
			27	512	0.21.1 0.21.2 0.21.3	-		■		
			28	513	0.21.1 0.21.2 0.21.3					

-	There is no data in the literature for a comparison
◆	Different measuring systems
■	Differences of the test objects in age, weight and size
●	No identical test conditions possible

100%-80%		79%-50%		49%-25%		24%-10%		9%-0%	
	Good		Adequate		Marginal		Weak		Poor

Test results - Side impact

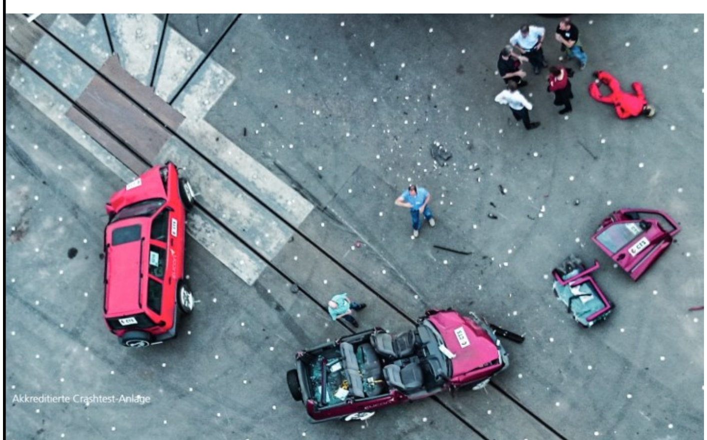
Data					Test results (percentage match)					
	Reference	Scenarios	No.	ID No.	Test No.	Head acc.	Head rotation	thoracic acc.	Pelvic acc.	Description
PMHS[1]	Shaw et. al. [3]	side impact 15km/h	29	1569	90.15.1 90.15.2 90.15.3 90.15.4 90.15.5	-	-	◆	◆	The deviation of the resulting thoracic acceleration of the sled test in relation to the human volunteer test is on average 20 %. The collection of reference pelvic acceleration data is poorly documented and has limited comparability.
			30	1570	90.15.1 90.15.2 90.15.3 90.15.4 90.15.5			◆	◆	
			31	1571	90.15.1 90.15.2 90.15.3 90.15.4 90.15.5			◆	◆	

-	There is no data in the literature for a comparison
◆	Different measuring systems
■	Differences of the test objects in age, weight and size
●	No identical test conditions possible

100%-80%		79%-50%		49%-25%		24%-10%		9%-0%	
	Good		Adequate		Marginal		Weak		Poor

[1] Post Mortem Human Subjects

Full scale crash tests



Source: Crashtest-Service

- 3 Crash tracks
- DAkkS accredited testing laboratory
- 7 Tests
- v_k = 35 km/h - 75 km/h
- technical and medical documentation of real accidents
- car-car / car-pedestrian / car-tree / car-bicycle

Crash example – car-tree

Real accident

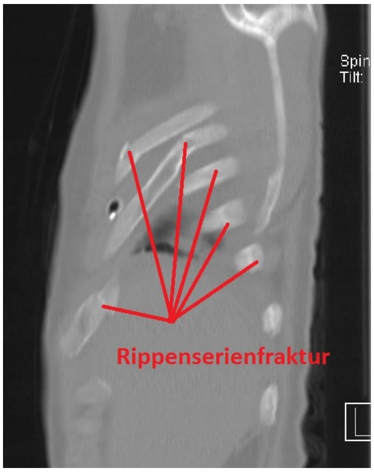
Source: GIDAS

Crash test

Source: Crashtest-Service

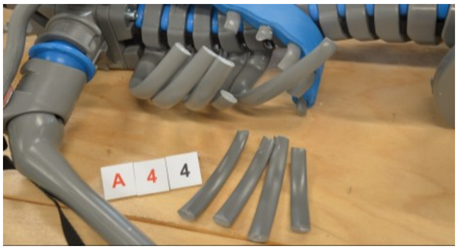
Crash example – car-tree

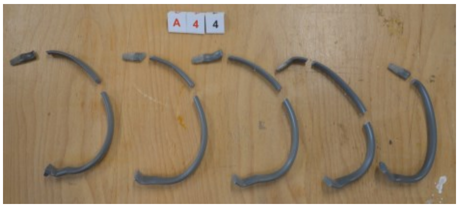
Real accident



Source: GIDAS

Crash test





Source: Crashtest-Service

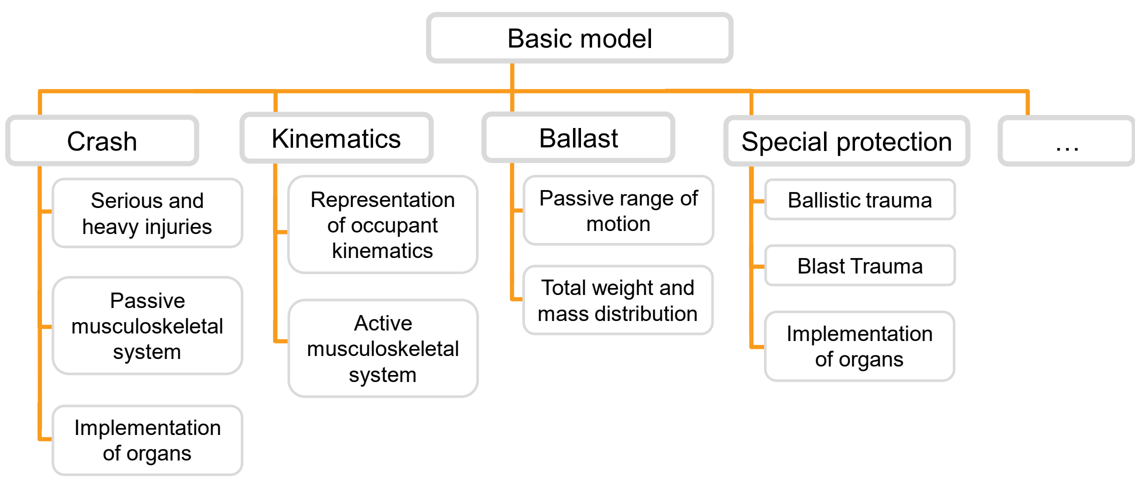
Test results - Full scale crash tests

Data Real Accident						Test results (percentage match with real data)				
Reference	Scenarios	No.	ID No.	Speed [km/h]	Max. AIS	Test No.	AIS injuries [%]	MAIS [%]	Dummy SN	Description
GIDAS	pedestrian-car	32	1081001	35	2	200514			12067	
	car-tree	33	1180018	65	4	200528				
	car-tree	34	1070341	52	2	200724	●	●		Movement behavior is realistic, due to differences in the seat belt, injuries were indicated differently.
						200903			12087	AIS 1 excluded
	car-car	35	1060896	75	2	200818			12088	
	car-car	36	1070050	30	2	200811				AIS 1 excluded
	car-bicycle	37	1060768	45	2	201020			12087	

●
No identical test conditions possible

100%-80%	79%-50%	49%-25%	24%-10%	9%-0%
Good	Adequate	Marginal	Weak	Poor

Research priorities



References

[1] Koshiro Ono, Koji Kaneoka, Adam Wittek and Janusz Kajzer (1997): **Cervical Injury Mechanism Based on the Analysis of Human Cervical Vertebral Motion and Head-Neck-Torso Kinematics During Low Speed Rear Impacts**. In: *SAE Transactions* (106).

[2] George R. Smith, Emery C. Gulash and Roy G. Baker (1974): **Human Volunteer and Anthropomorphic Dummy Tests of General Motors Driver Air Cushion System.** In: SAE Transactions Vol. 83

[3] Shaw, Greg; Lessley, David J.; Ash, Joseph L.; Sochor, Mark R.; Crandall, Jeff R.; Luzon-Narro, Javier; Arregui-Dalmases, Carlos (**2014**): **Side impact PMHS thoracic response with large-volume air bag.** In: Traffic injury prevention 15 (1), S. 40–47. DOI: 10.1080/15389588.2013.792109.

Thank you very much for your attention!

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