

Fachhochschule Aachen

Fachbereich Luft- und Raumfahrttechnik

Lehr- und Forschungsgebiet Karosserietechnik

imperia
AUTOMOTIVE ENGINEERING

I A M
INSTITUT FÜR ALLGEMEINE MECHANIK

RWTHAACHEN
UNIVERSITY

FH AACHEN
UNIVERSITY OF APPLIED SCIENCES

“Intelligent Car Body”

A Design Approach for Construction of a Virtual Car Body for Small Sized Batch Production based on LS-DYNA simulations

M.Sc. Anuja Nagle / FH Aachen

Prof. Dr.-Ing. T. Roeth / Imperia GmbH

11th LS-DYNA Forum 2012

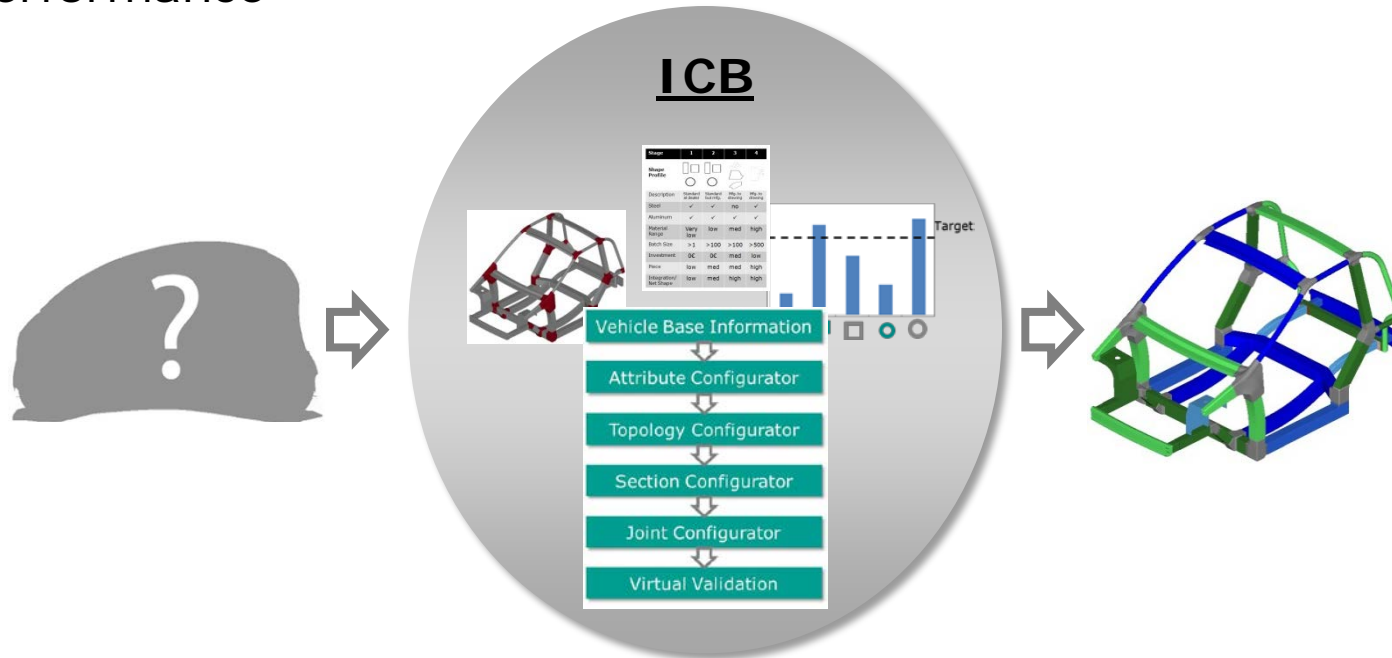
9th – 10th October 2012

- Introduction
 - What is “Intelligent Car Body - ICB”
 - Motivation
- Features of ICB
 - The “Flexbody”
 - Methodology of ICB
 - Fields of Intelligence in ICB
- Structural Intelligence
 - Attribute Configurator
 - Section Configurator
 - Virtual Validation
- Final remarks
- Contact

What is "Intelligent Car Body - ICB"

"Intelligent Car Body" is an approach, which aims at:

- Creating a tool which can guide the design engineer through the car body construction process in the initial design stages
- Constructing a car body which possesses intelligence in the fields of construction, manufacturing techniques and structural performance



Challenges for small sized batch production

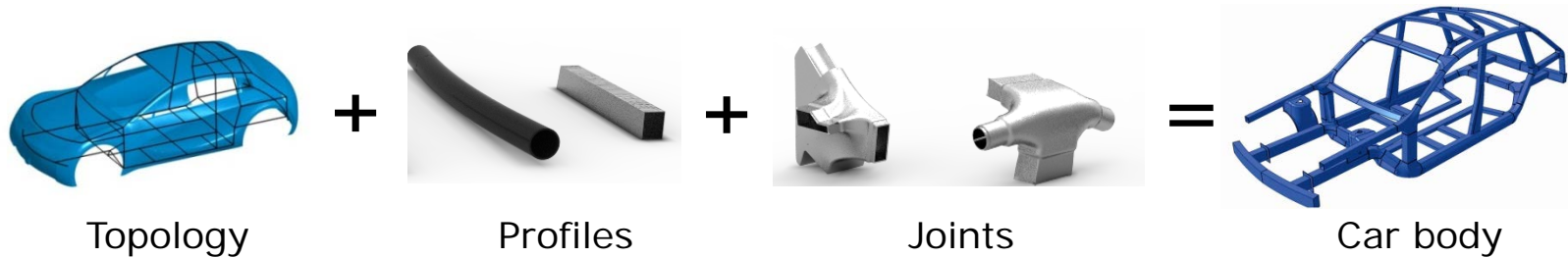
Bezeichnung		[Fzg./Jahr]	
		Min.	Max.
Einzelfertigung (Manufaktur)		1	5
Kleinstserie (Manufaktur)		5	50
Kleinserie	klein	50	200
	mittel	200	500
	groß	500	1.000
mittlere Serienfertigung	klein	1.000	10.000
	mittel	10.000	30.000
	groß	30.000	50.000
Großserienfertigung	klein	50.000	100.000
	mittel	100.000	300.000
	groß	300.000	offen

- Restricted knowledge for design
- High development time
- High development costs
- High capital investment
- Fast launching in market

Intelligent Car Body (ICB)

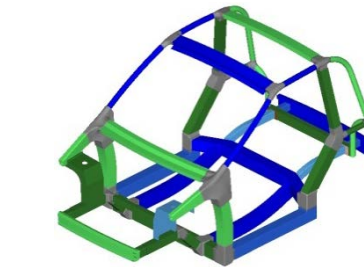
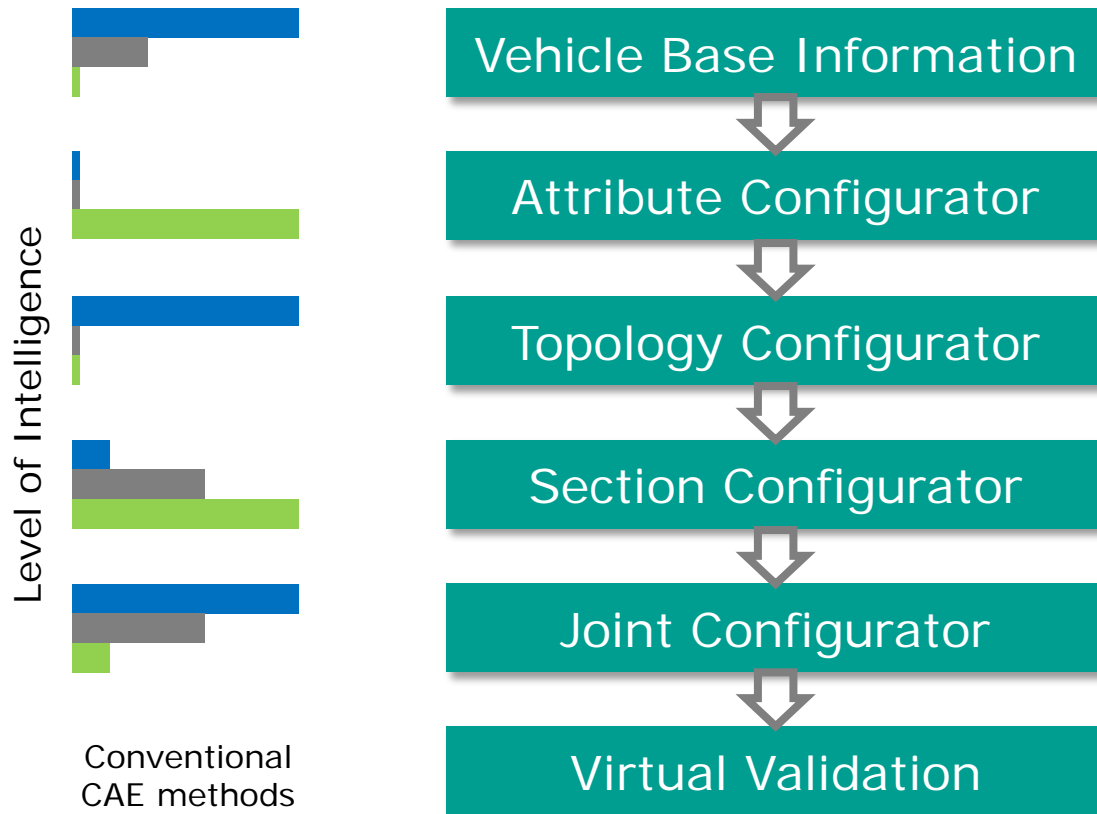
The “Flexbody”

- “Flexbody” construction concept

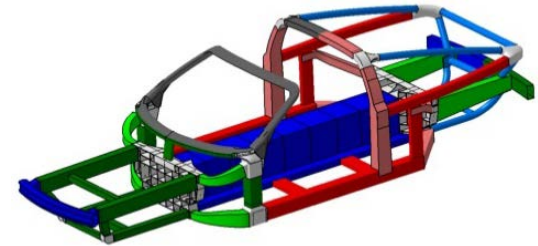


Source: Imperia GmbH

- “Flexbody” is advantageous for small series vehicle production
 - Optimizes production cost according to batch size
 - Quick adaption to meet individual vehicle specifications



ec2go e-car-sharing
Source: FH Aachen



Lampo3
Source: Protoscar / TK-SE / Imperia GmbH

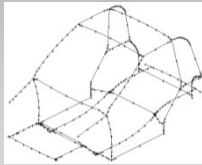
■ Geometrical Intelligence ■ Manufacturing Intelligence ■ Structural Intelligence / CAE data

“ICB” employs knowledgebase at three levels

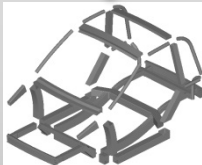
Geometrical Intelligence

For parametric CAD construction

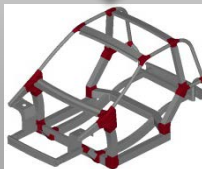
Step 1:
Topology



Step 2:
Profiles



Step 3:
Joints



Manufacturing Intelligence

For selection of materials and manufacturing processes

Profile database

Stage	1	2	3	4
Shape Profile				
Description	Standard at dealer	Standard but mfg.	Mfg. to drawing	Mfg. to drawing
Steel	✓	✓	no	✓
Aluminum	✓	✓	✓	✓
Material Range	Very low	low	med	high
Batch Size	> 1	> 100	> 100	> 500
Investment	0€	0€	med	low
Piece	low	med	med	high
Integration/Net Shape	low	med	high	high

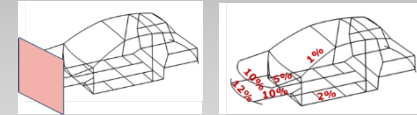
Joint database

Stage	1	2	3	4
Technology				
Steel	✓	✓	no	no
Aluminum	✓	✓	✓	✓
closed section	no*	✓	✓	no*
Material Range	high	med	high	high
Batch Size	> 1	> 100	> 100	> 500
Investment	0€	Low	Med	high
Piece	High	High	med	low
Integration	med	high	med	low

Structural Intelligence

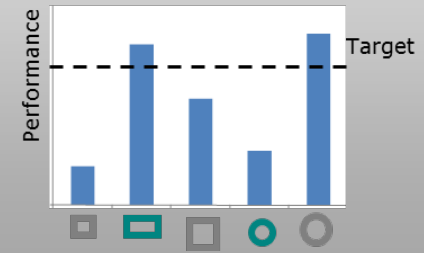
For optimum design of profile cross sections

Load distribution

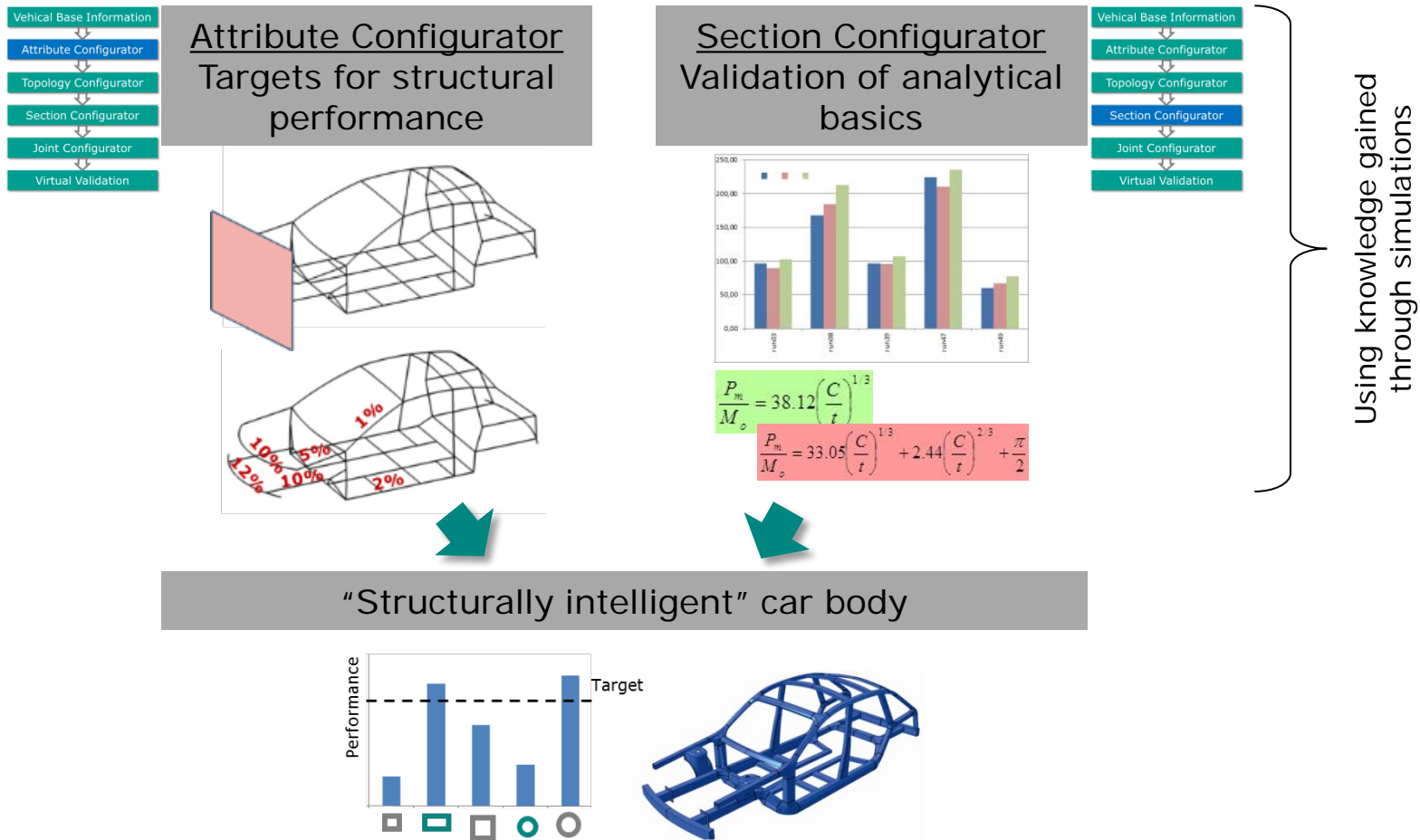


Analytical evaluation

Profile selection



- Aim: To predict the structural performance of a car body in early design stages and hence reduce the optimization time.

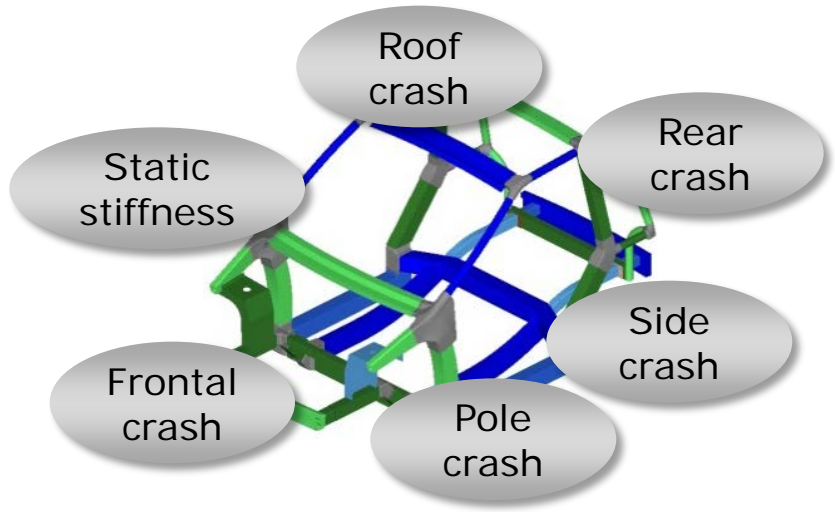


a. Attribute Configurator: "Safety Model"

- Step 1: Creating a "Safety Model" for the target car body

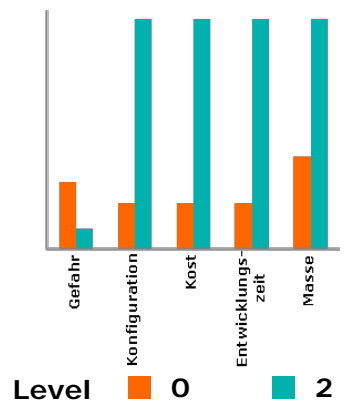
Crashtest		Level	Barriere		Winkel	Geschwin.	Beschreibung	Bild	
Position	Regelung		Typ	Überlap-pung					Abmaße
Frontalkrash	FMVSS 208	1	starr	100%	0°	32 - 56 km/h	starre, feststehende Battre		
	FMVSS 208	2	starr	100%	30°	32 - 56 km/h	starre, feststehende Battre		
	ECE R 94	1	verform-bar	40%	1000 X 450 X 650 mm	56 km/h	200 mm über Boden		
	Euro NCAP	2	verform-bar	40%	1000 X 450 X 650 mm	56 km/h	200 mm über Boden		
Lenkanlage bei Unfallstößen	ECE R 12						bei Frontalaufprall => ECE-R42 verwenden		
Seitencrash	ECE R 95	1	verform-bar		1500 X 500 mm	90°	50 km/h	260 mm über Boden, Barriere wiegt 950 kg, Mittelachse der Barriere geht durch R-Punkt des Fahrers	
	Euro NCAP	2	verform-bar		1500 X 500 mm	90°	50 km/h	260 mm über Boden, Barriere wiegt 950 kg, Mittelachse der Barriere geht durch R-Punkt des Fahrers	

"Safety Model"



Selected loadcases

Level
 0: mandatory
 1: recommended
 2: "best-in-class"

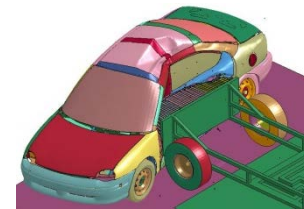
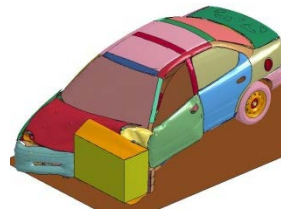
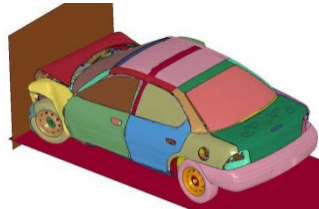


a. Attribute Configurator: Benchmark

- Step 2: Generating a benchmark using numerical simulations



Chrysler Neon



...



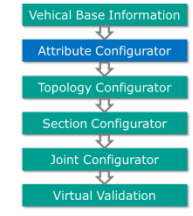
Ford Taurus



...

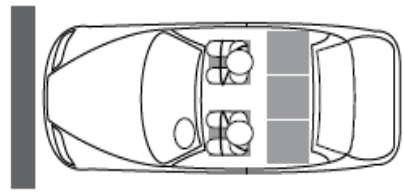
Knowledge gained from the numerical simulations

- Typical trends of force-displacement curves
- Energy of deformation
- Distribution of deformation energy in the car body components

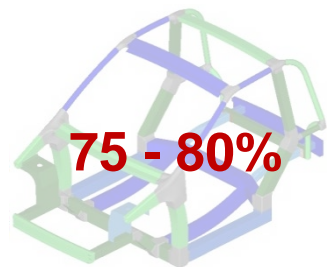


a. Attribute Configurator: Targets definition

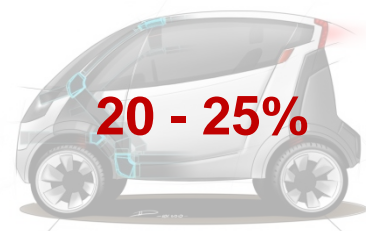
- Step 3: Defining performance level for the target car body*
 - Distribution of energy during deformation



Frontal crash against rigid wall

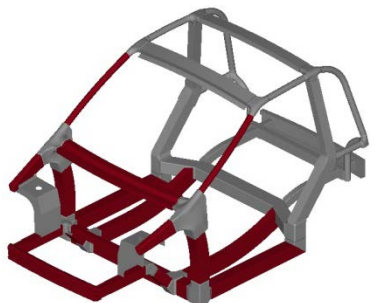


Car body

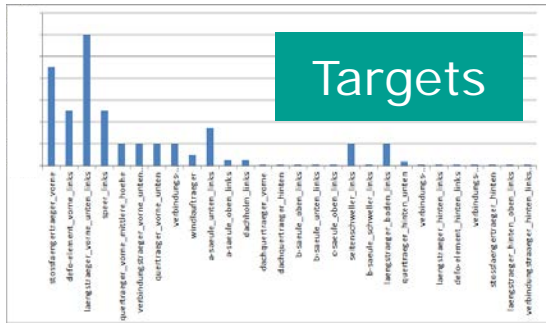


Other parts

- Targets for individual profiles



Profiles having high influence

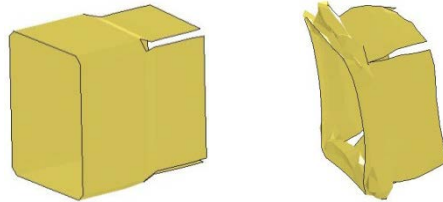


Profile No.	Description	Mode of deformation	
		B:Bending A:Axial	P:Plastic E:Elastic
11	stosspennedraeger_vorne	B	P
97	defo		P
96	laen		P
17	spe		P
21	quer		P
10	verb		P
23	quer		P
22	verb		E-P
300	windlauftraeger	B	E-P
15	a-saeule_unten_links	B	E-P
32	a-saeule_oben_links	B	E-P
13	seitenschweller_links	A	E-P
110	laengstraeger_boden_links	A	E-P

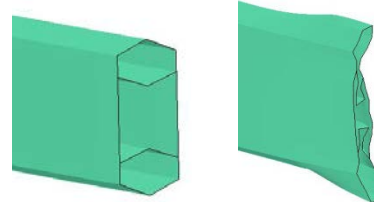
*Example for frontal crash

b. Section Configurator: Types of loads

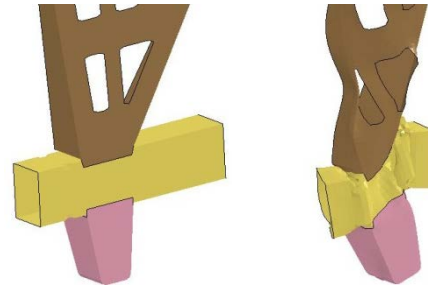
- Modes of deformation observed in "Flexbody" profiles



Axial folding



Crumpling



Mixture of folding and bending

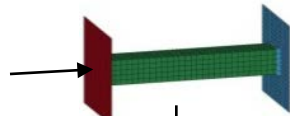


Components not loaded to their full capacity

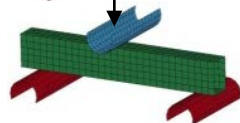
...

- Basic modes of deformation (-> simple loads)

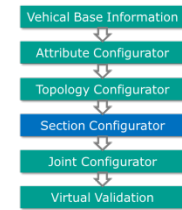
- Axial failure



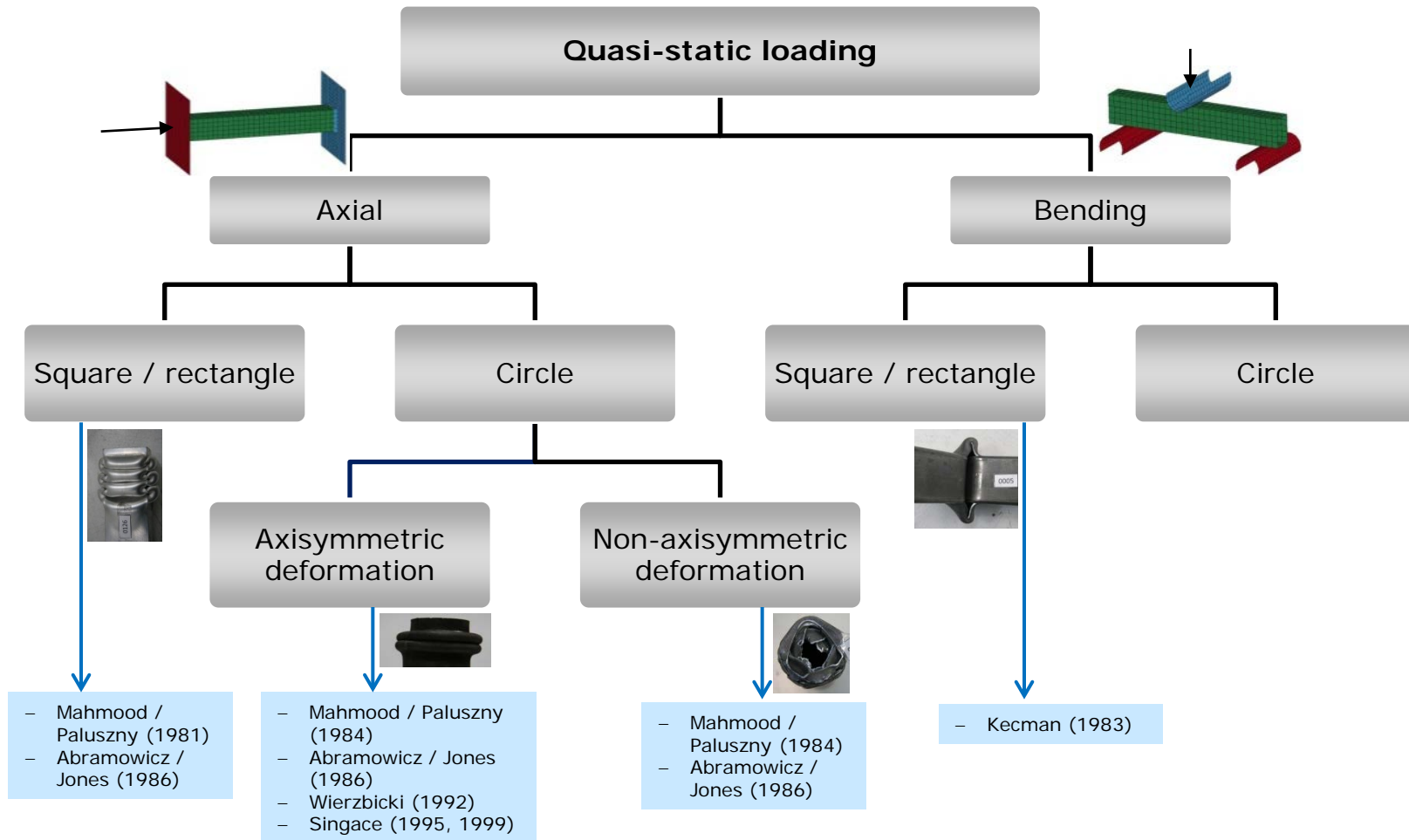
- Bending failure



b. Section Configurator: Analytical Basics



- Available analytical models for simple loads



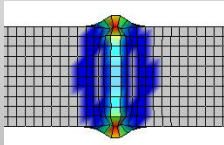
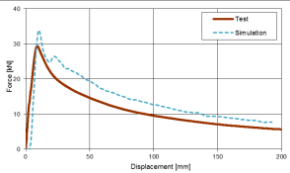


b. Section Configurator: Validation



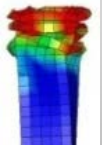
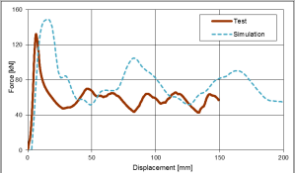
- Validation of analytical models for simple loads

Test and simulation data

Three point bending

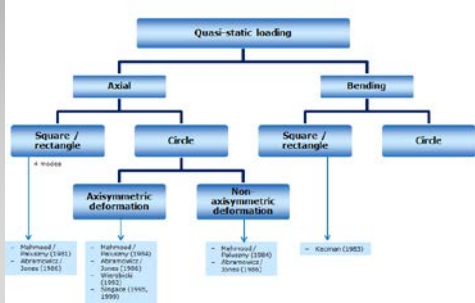





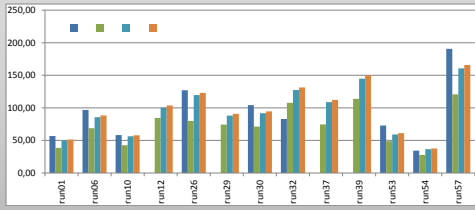
Axial compression







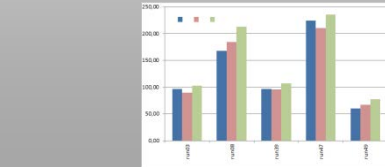
Comparison with analytical models


Models for different types of loads







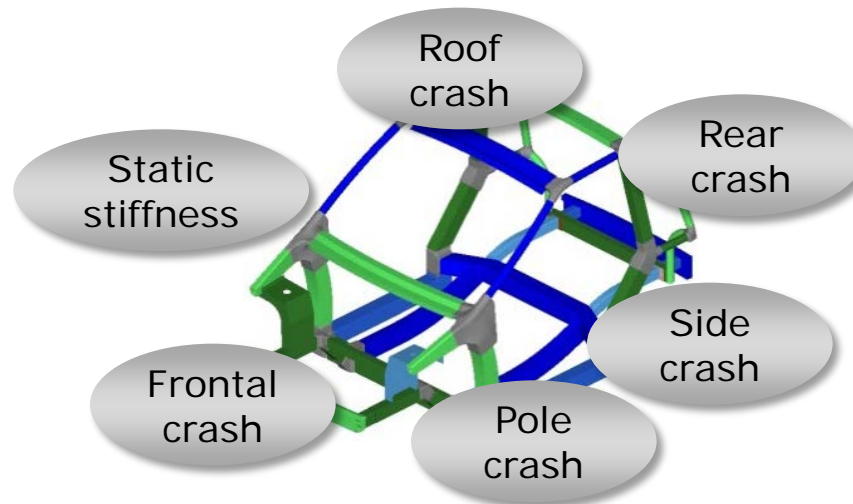




c. Virtual Validation

- Validating the constructed car body for various loadcases

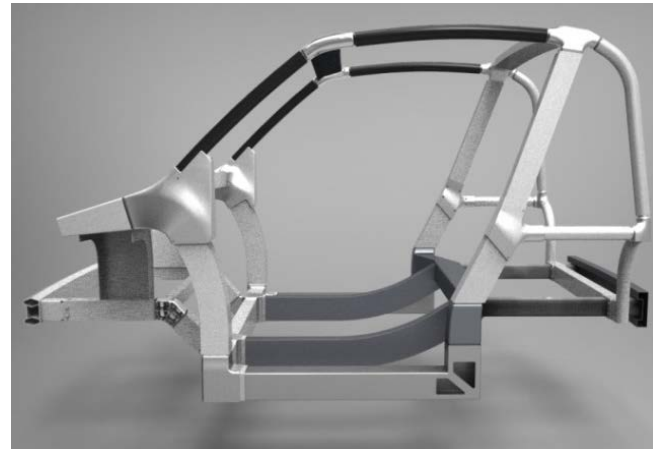
	Component based (ICB approach)	Complete vehicle (CAE)	Vehicle testing
NVH – Static stiffness – <i>Dynamic stiffness</i>	X	X	no
Crash / Crush	X	X	optional
Durability	no	optional	X



Final remarks

Advantages of the proposed approach

- Connects various steps in car body development process in a logical order and hence facilitates transfer of data
- Data is generated from CAD / CAE and is proposed to use as “knowledgebase” for car body design



Contact

Thank you for your attention!

M.Sc. A. Nagle

“Automotive Body Engineering”
University of Applied Science Aachen
Boxgraben 98-100
52064 Aachen
Tel.: 0241/6009-52934
E-Mail: nagle@fh-aachen.de

Prof. Dr.-Ing. T. Roeth

Imperia GmbH
University of Applied Science Aachen
Soerser Weg 9
52070 Aachen
Tel.: 0241/60833-0
E-Mail: roeth@imperiam.info