USING ANSA FOR BEAMS AND SHELLS FE CONCEPT MODELS AT BMW

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KEYWORDS –
ANSA, Nastran, Optimization, Concept modelling, NVH.

ABSTRACT –
Car body development and optimization in early concept phases using beams and shells FE models is a well-established process at the BMW NVH department. The goal for these concept investigations consists of providing mainly qualitative answers for the full vehicle concept regarding prescribed functional targets, in particular for vibrations and acoustic comfort. Weight reduction and construction space potential is to be revealed and various concept variation investigations are to be performed.
When using beams and shells FE models the vehicle model is not defined in an exact geometrical way, but based on functional topological aspects divided into beams and plate structures. Different standard load cases for car body design and optimization have been defined based on detailed analysis of a series of customer relevant full vehicle functional performance targets with respect to vibration and acoustic comfort. The optimization model is completed by the definition of a target function, seeking an optimal car body structure within the feasible design space, satisfying all requirements and constraints of all specified load cases for minimal total car body weight.
In the course of switching from simple Nastran beam library profiles to PBxSECT profiles that allow an exact geometric definition of the beam cross section, ANSA has been established as “state-of-the-art” pre-processor for modelling these beam shell models. ANSA is enhanced by various User Scripts to leverage the existing process in terms of rapidness, efficiency and quality.
The paper provides an overview of the current process focused on the modelling aspects performed in Ansa, illustrated by an application case.

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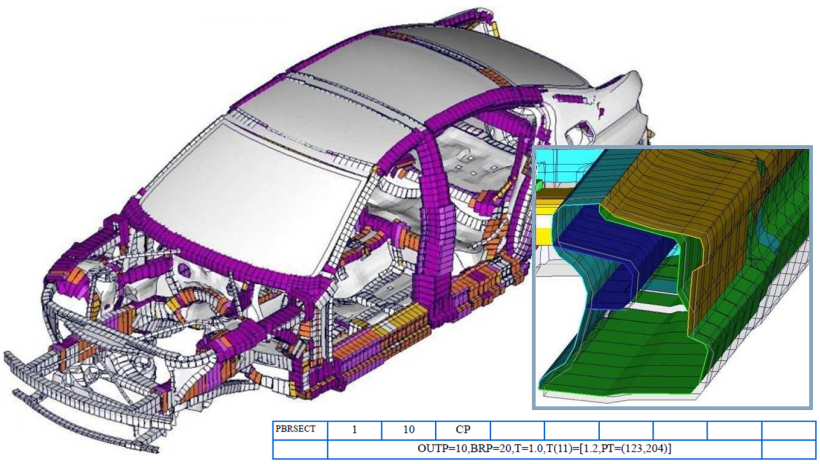

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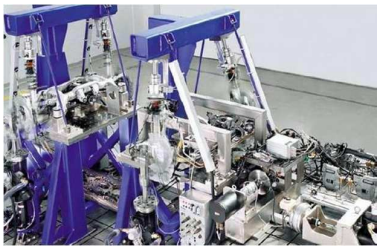

Mechatronical test systems

InfoCom

Safe and secure communication and information systems

Transport, Environment & Power Engineering

Operation of the Maglev test facility

Aeronautics

Structural airframe testing (e.g. A380)

Space

Operation of ESA-coordinated space test centers

Defence & Security

Development and operation of simulation and test systems

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Automotive

Analysis & Design

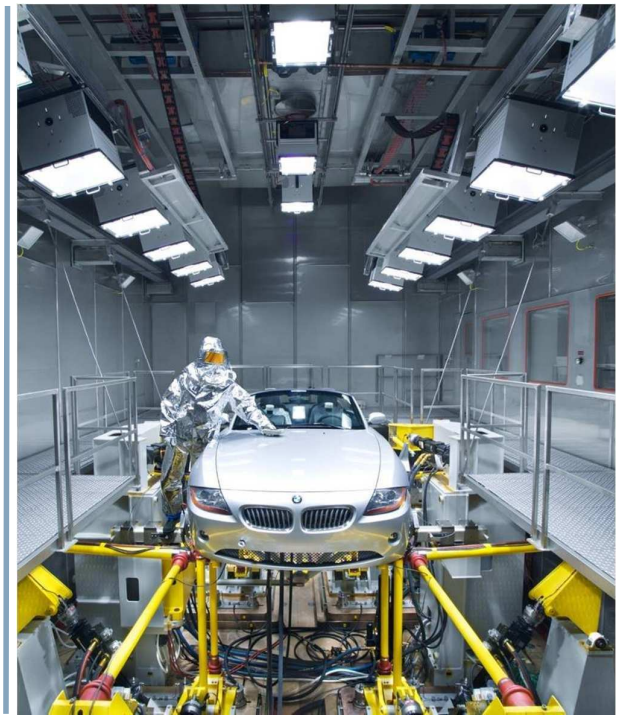
- Experimental analyses
- Computer-aided engineering
- Mechatronical system analyses

Realization

- Customer-specific testing facilities
- Test stands for service life testing
- System test stands with hardware-in-the-loop option

Operation

- Ottobrunn testing centre
- Testing facilities on customers' premises
- Customer-specific investment and operator models (chassis/body/drive system)



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BMW division “Akustik und Schwingungen”

- Since 2004 IABG supports BMW in terms of FE concept modelling with **Beams and Shells (B/S) FE concept models**.
- The BMW division “Akustik und Schwingungen” is responsible for NVH performance of all BMW Group car models. Involved in every design phase.

Initial phase → Concept phase → Series development → Refinement - Verification

Structural Dynamics and Vibrations

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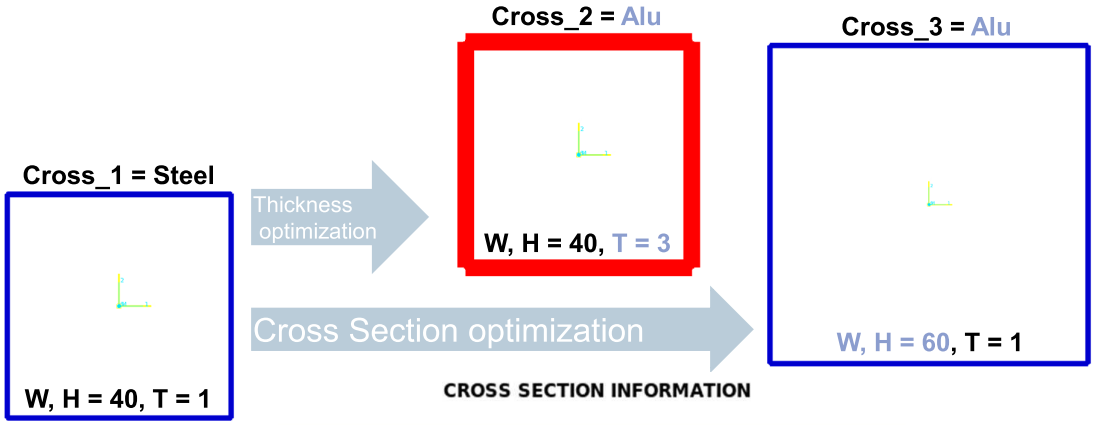
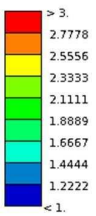
Why use Beams and Shells FE concept models?

- **Parameter optimization considering construction space**





CROSS SECTION INFORMATION

CROSS SECTION GEOMETRICAL RESULTS			
NAME	CROSS_1	CROSS_2	CROSS_3
ID	1	2	3
Area A	160	480	240
Moment of Inertia for bending Ix	42666.7	128000	144000
Bending Stiffness = E * Ix	100%	100%	112,5%
Mass = Rho * A	100%	100%	50%

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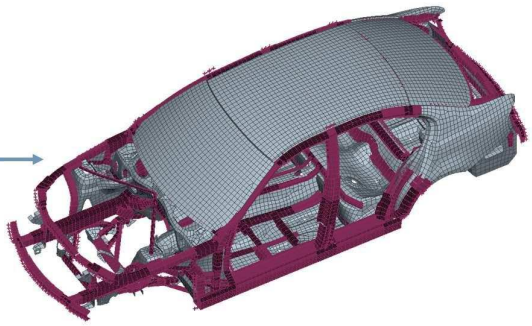
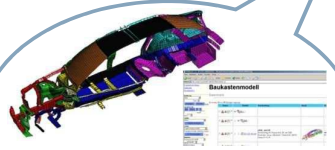
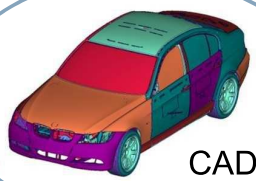
Features and input data for the Beams and Shells model

- Circa 10.000 nodes (FE fine Model: circa 1.5 million nodes)
- Beam properties defined with circa 500 different cross sections



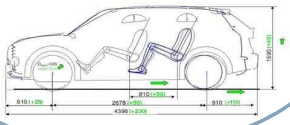


Previous FE Model



CAD

Sketches



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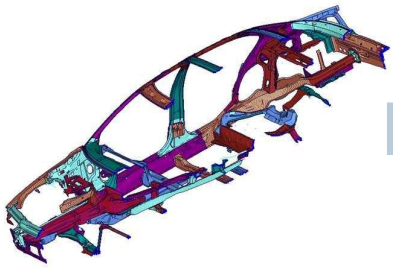
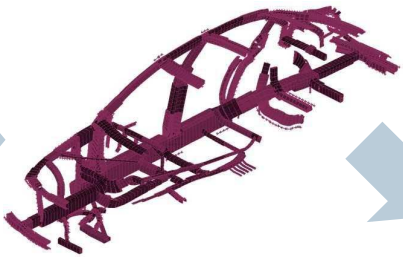
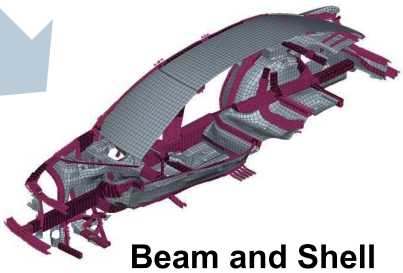
Separation of input model into carriers and panels

Carrier structure

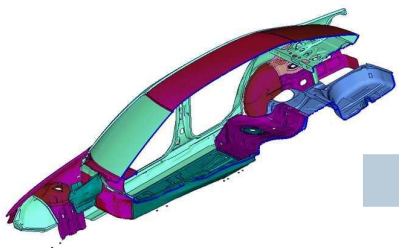


Beam elements

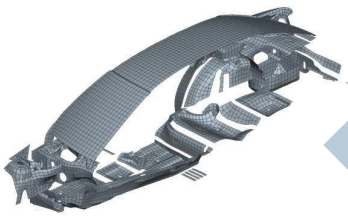




Beam and Shell model



Panel structure



Shell elements

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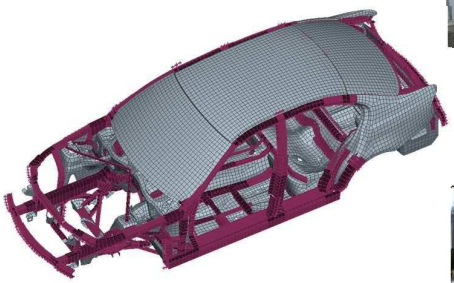
Optimization process

1500 Design Variables → 25 Load Cases → Numerical Optimization with Nastran Sol 200



Dynamic Stiffness

Static Stiffness

Steering Wheel

Roll Over

Crash

Functional Targets

Minimum Weight

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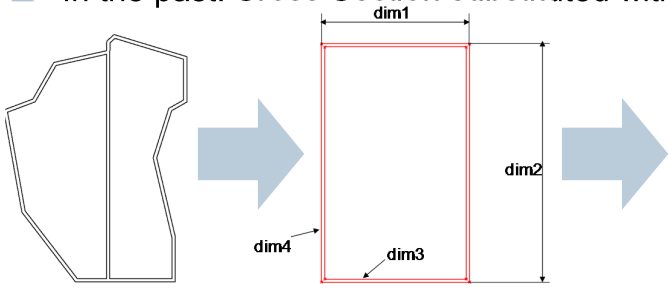
Design-Variables of Beam Cross Sections

- In the past: Cross Section substituted with equivalent Beam Library property



PBARL Simple Beam Cross-Section Property

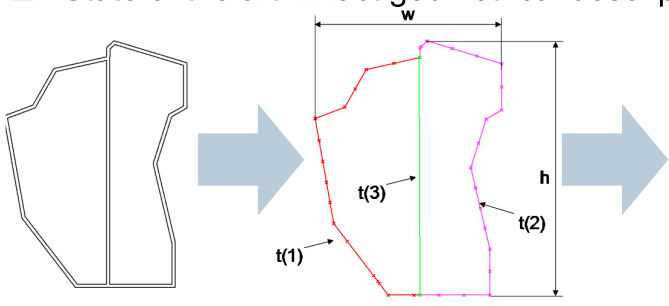
Defines the properties of a simple beam element (CBAR entry) by cross-sectional dimensions.

Format:

1	2	3	4	5	6	7	8	9	10
PBARL	PID	MID	GROUP	TYPE					
	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	DIM8	
	DIM9	-etc.-	NSM						

Desvars: dim1…dim4

- State of the art: Exact geometrical description with Nastran PBxSECT



PBRSECT Arbitrary Cross-Section for CBAR

Defines the shape of arbitrary cross-section for CBAR element.

Format:

1	2	3	4	5	6	7	8	9	10
PBRSECT	PID	MID	FORM	NSM					
	Data description for arbitrary section								

Example:

PBRSECT	1	10	CP						
	OUTP=10,BRP=20,T=1.0,T(11)=[1.2,PT=(123,204)]								

Desvars: w, h, t(1)…t(3)

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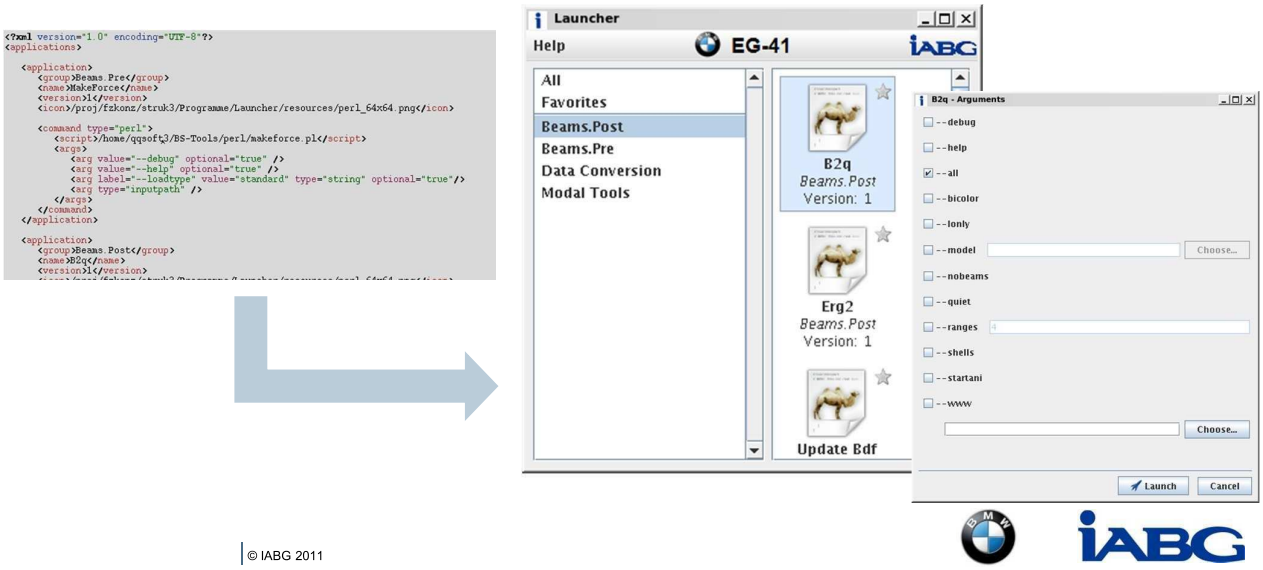
Launcher: Java-Interface for Beams and Shells tools and various proprietary applications

- Widely configurable by xml-files
- GUI for program options (e.g. for Perl scripts)
- Platform independant (Windows, Linux)
- Portable (integrated runtime environments)



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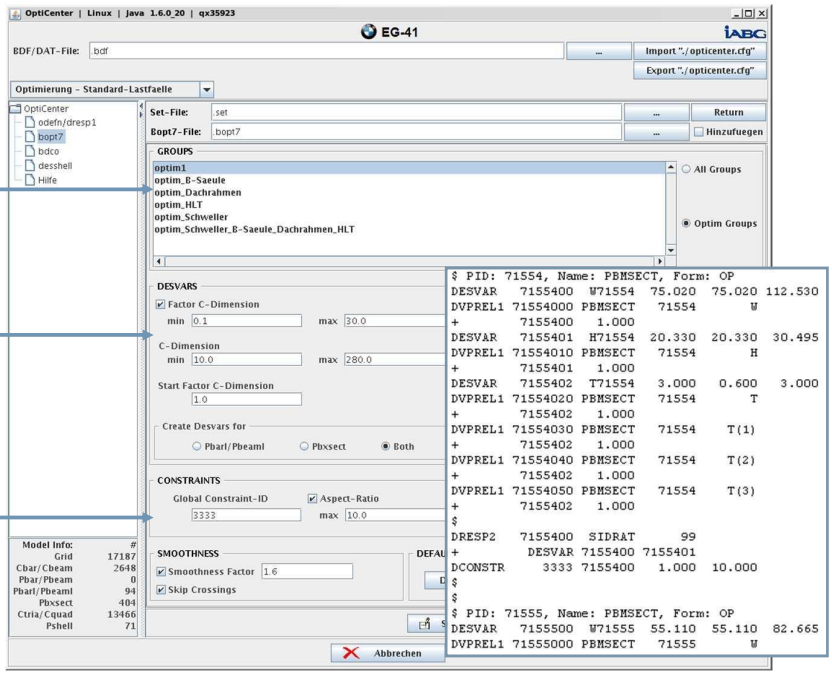
Design model: Massive creation of desvars, geometrical responses and constraints with OptiCenter

- Application region
- Desvars for outer dimensions and wall thicknesses
- Geometrical responses and constraints



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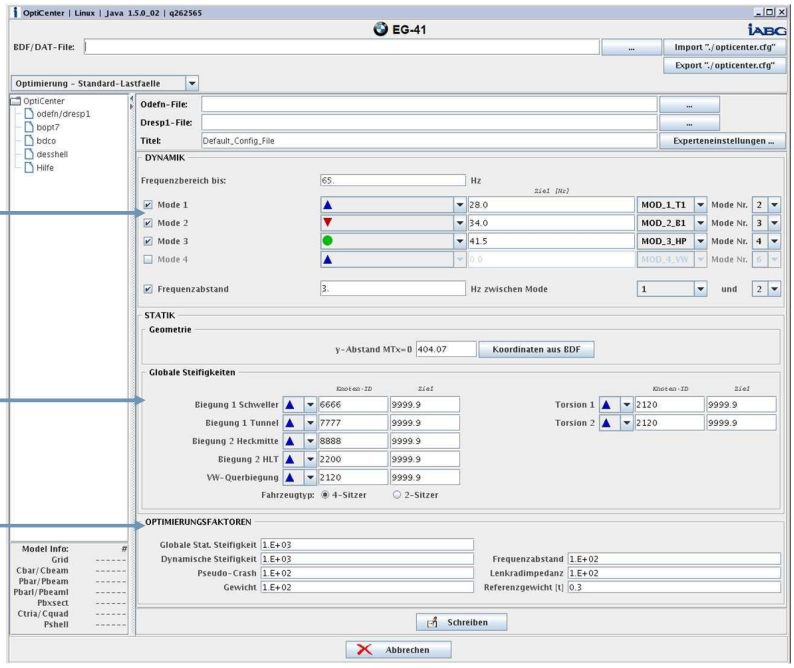
Design model: Creation of functional responses, constraints and objective function with OptiCenter

- Responses and constraints for dynamic stiffnesses
- Responses and constraints for static stiffnesses
- Weighting factors



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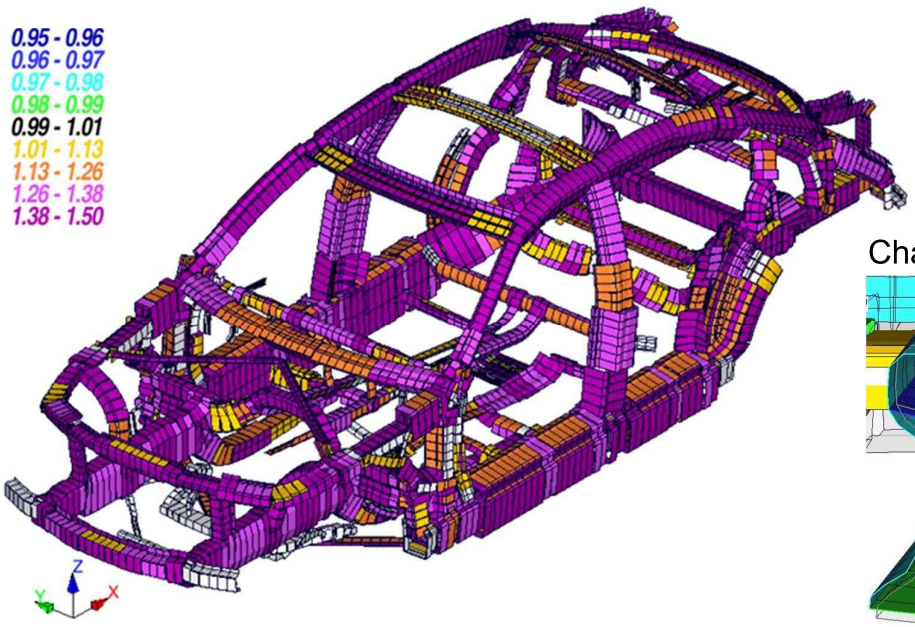
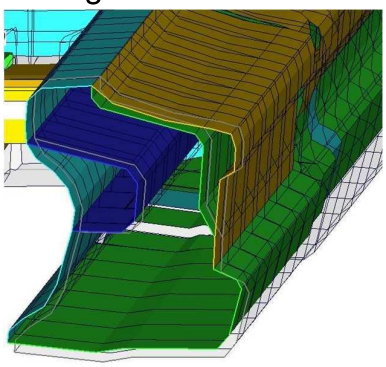
Post Processing: Visualization of optimization results

- Changes in construction space



Changes in wall thickness



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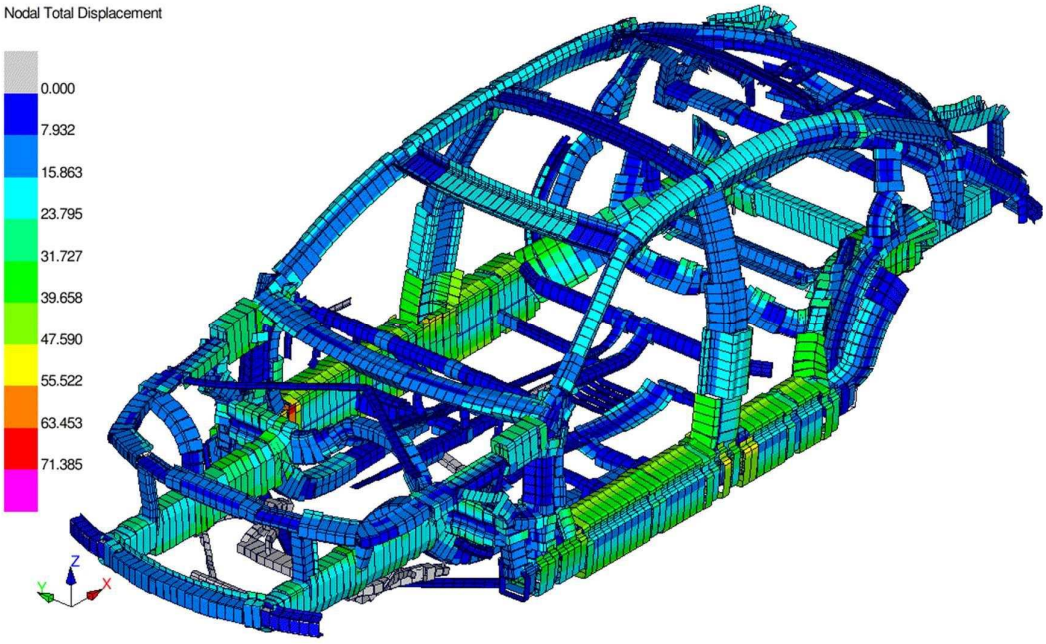
Post Processing: Visualization of optimization results

- Changes in construction space



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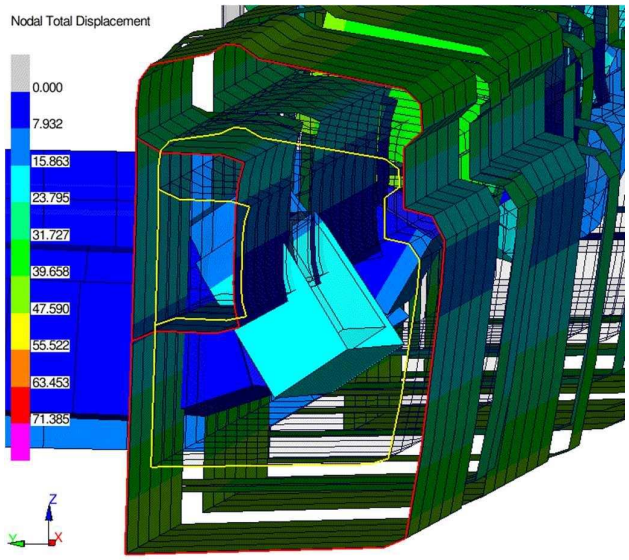
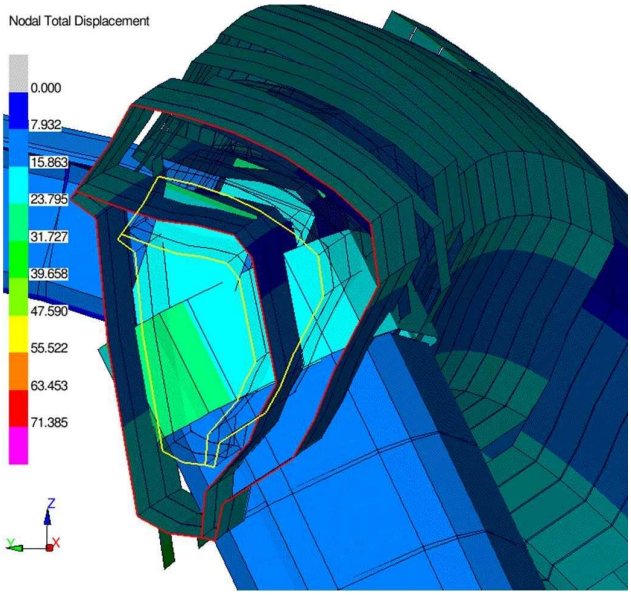
Post Processing: Visualization of optimization results

- Changes in construction space

Rocker panel



Roof carrier



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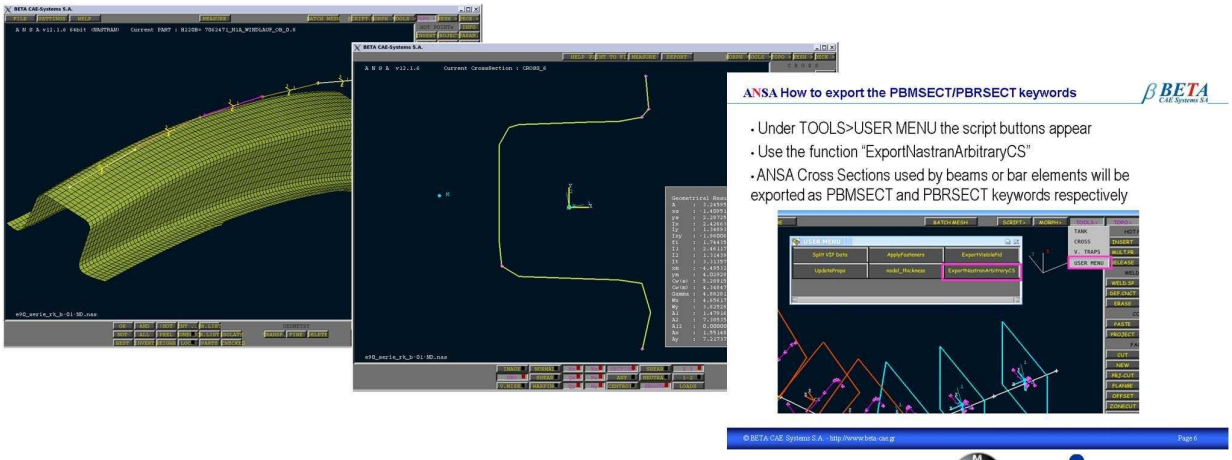
PBxSECT for B/S models: How we started

- PBxSECT introduced in Nastran 2005 as the result of a collaboration MSC-BMW, but at that time **not supported** by any commercial FE Pre-Processor
- Status in **ANSA 12**: Creation of Beams with **PBEAM** (A, I1, I2…) properties in the **Cross Section Tool**
- First **PBxSECT export** functionality provided by Beta Systems in March 2009 for ANSA 12.1.6 as **User Script**



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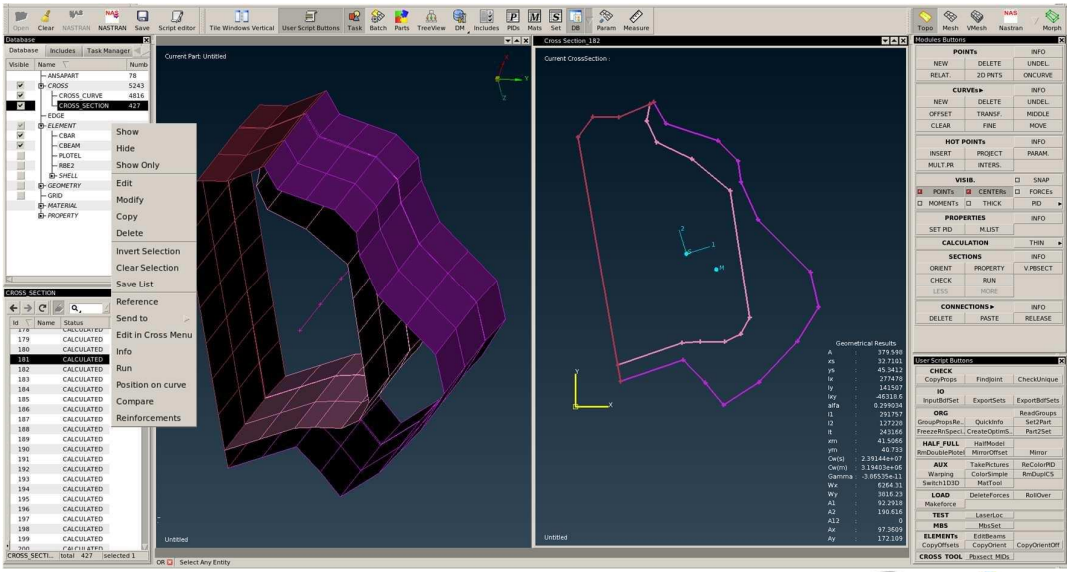
PBxSECT for B/S models: Where we are now

- PBxSECT properties **fully supported** in ANSA 13.1
- **3D-Visualization** of Beam structure
- Cross sections **comfortably editable** in Cross Menu



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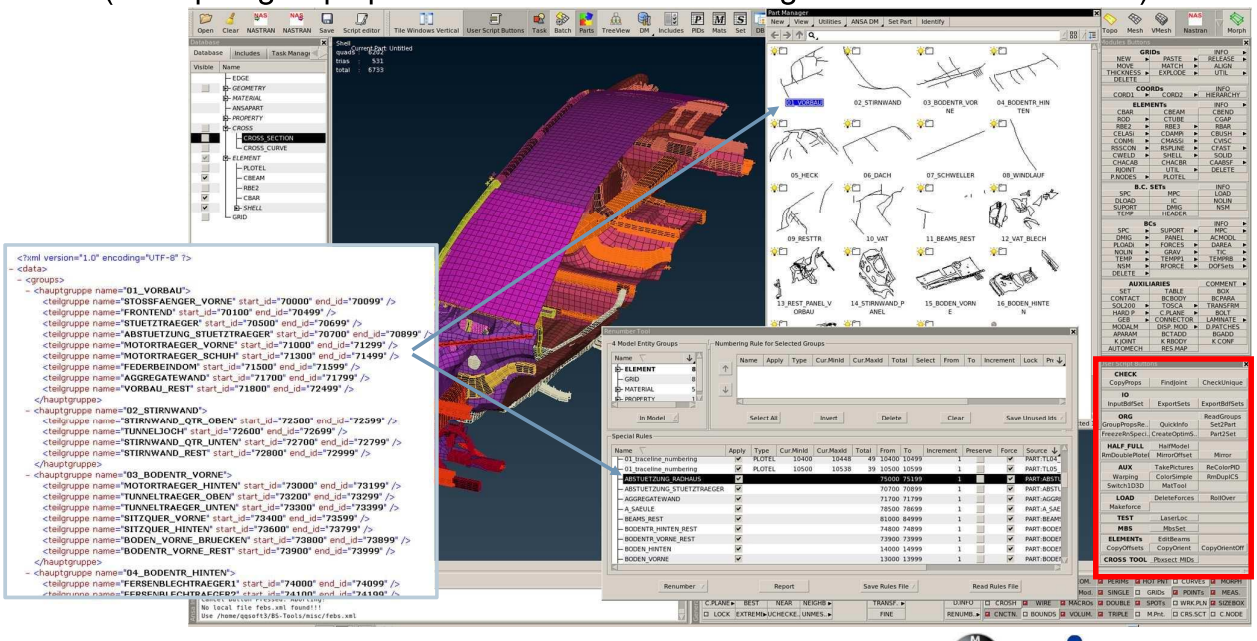
PBxSECT for B/S models: User Scripts

- Until now, ANSA is **adapted** for the B/S-process by ca **25 User Scripts** (example: groups/parts creation and numbering rules based on xml-file)



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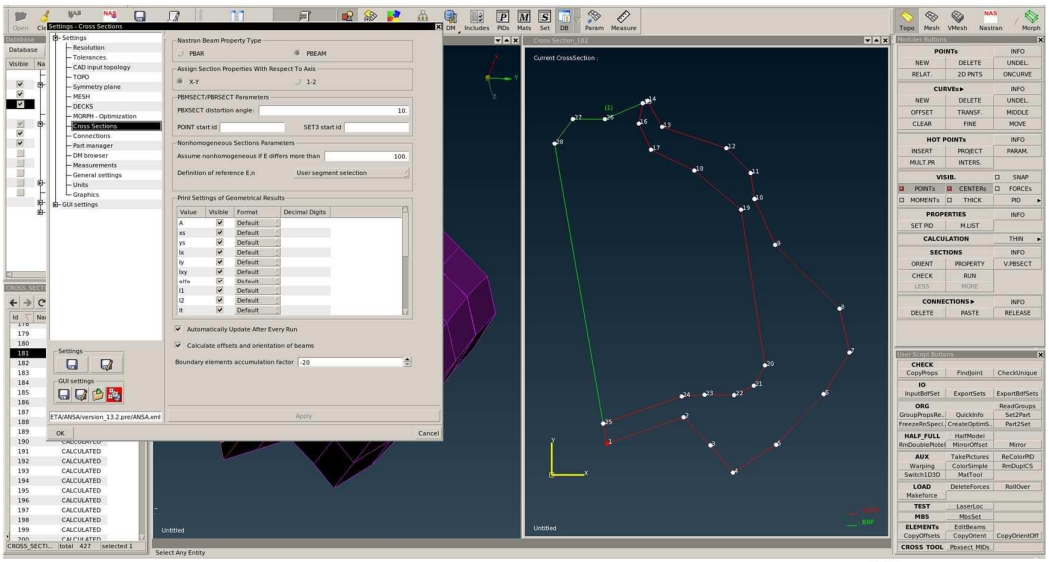
PBxSECT for B/S models: Next developments

- **Visualization** of Nastran PBxSECT **description**
- **Control** of PBxSECT parameters (Point-ID, Set-ID, distortion angle)
- **Check** for valid PBxSECT Syntax of Cross Section ….



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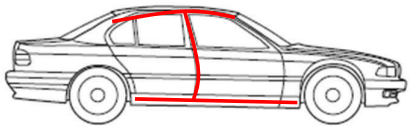
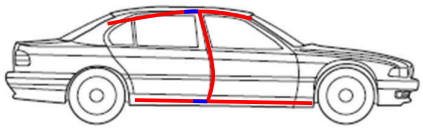
Topology modification: adding a 2nd b-pillar

- **Historic reference: L7 (1997-2001)**

1994 – 2001
7er

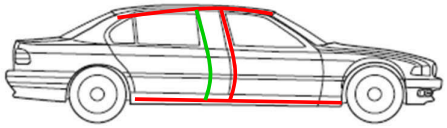


1994 – 2001
7er L



Extension

1997 – 2001
L7



Extension +
2nd b-pillar

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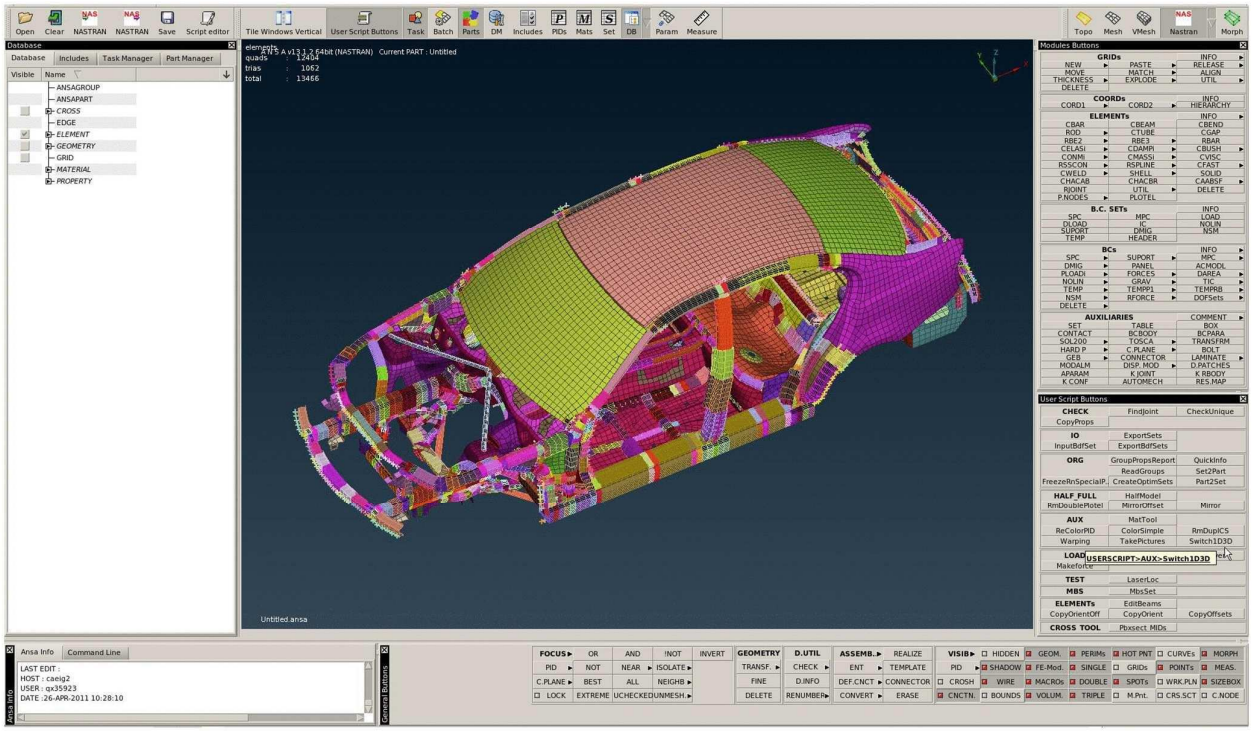
Topology modification: adding a 2nd b-pillar



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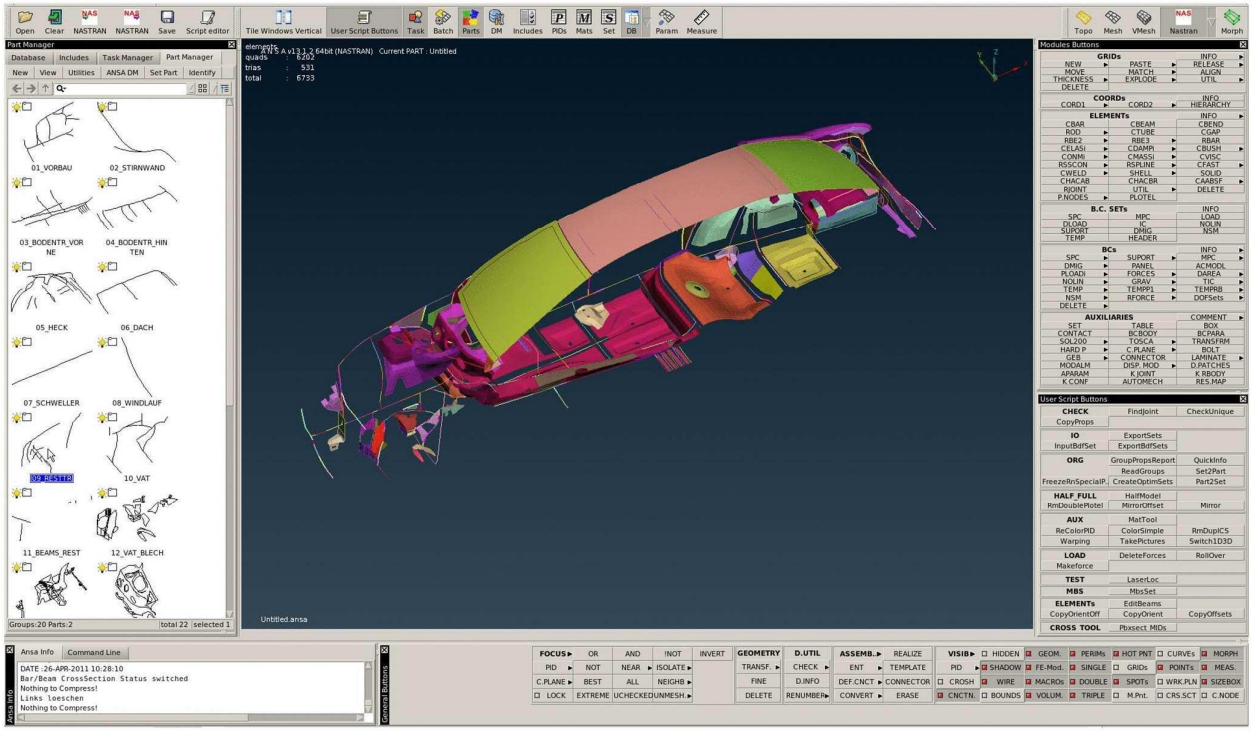
Topology modification: adding a 2nd b-pillar



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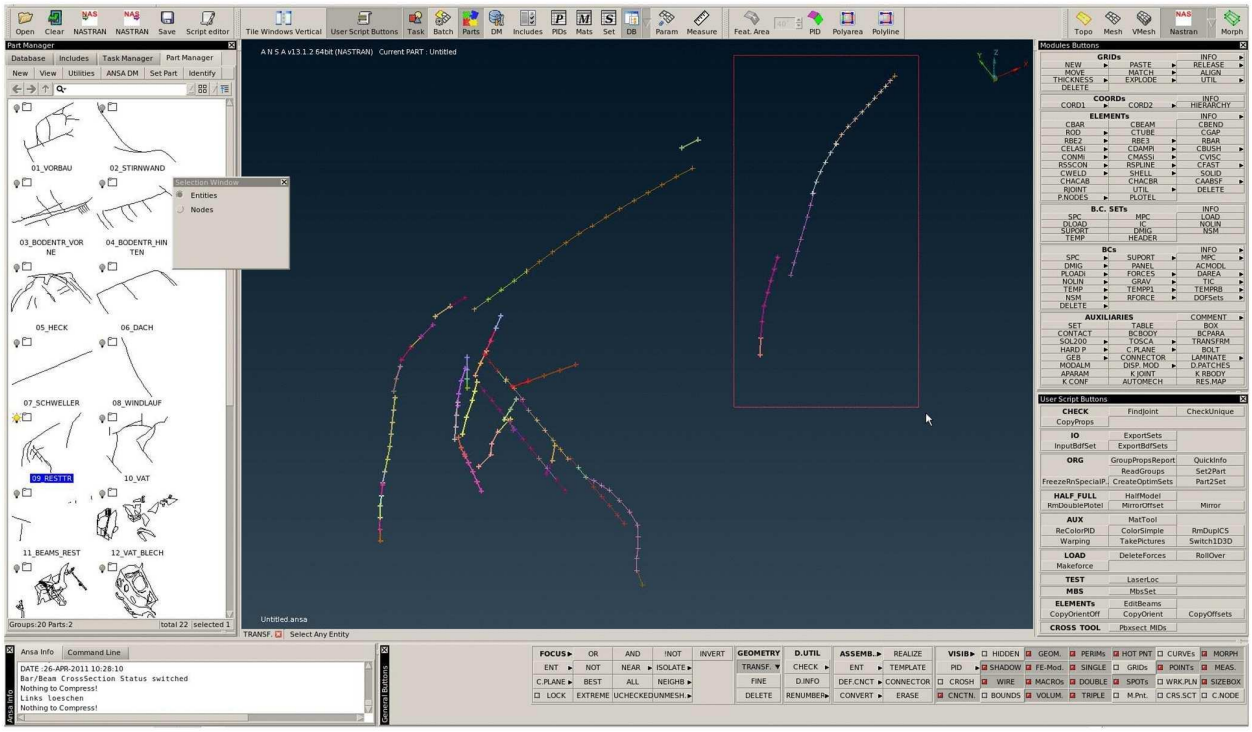

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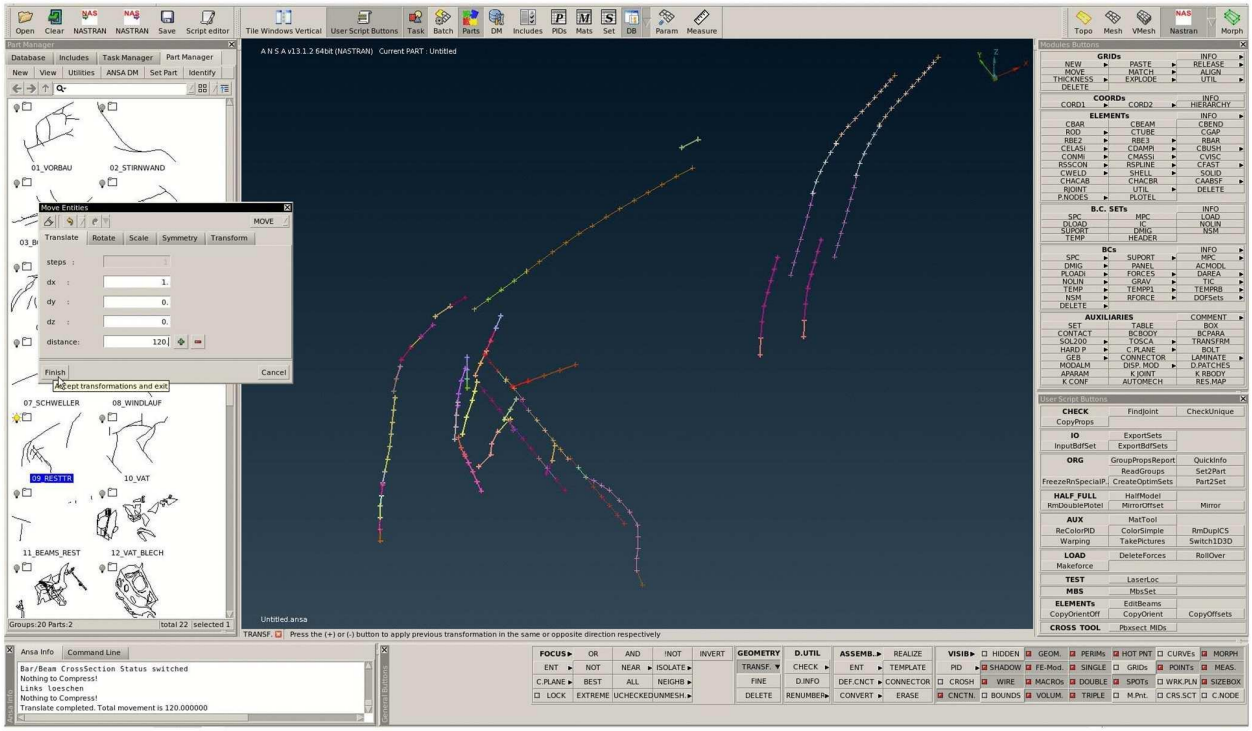
Topology modification: adding a 2nd b-pillar



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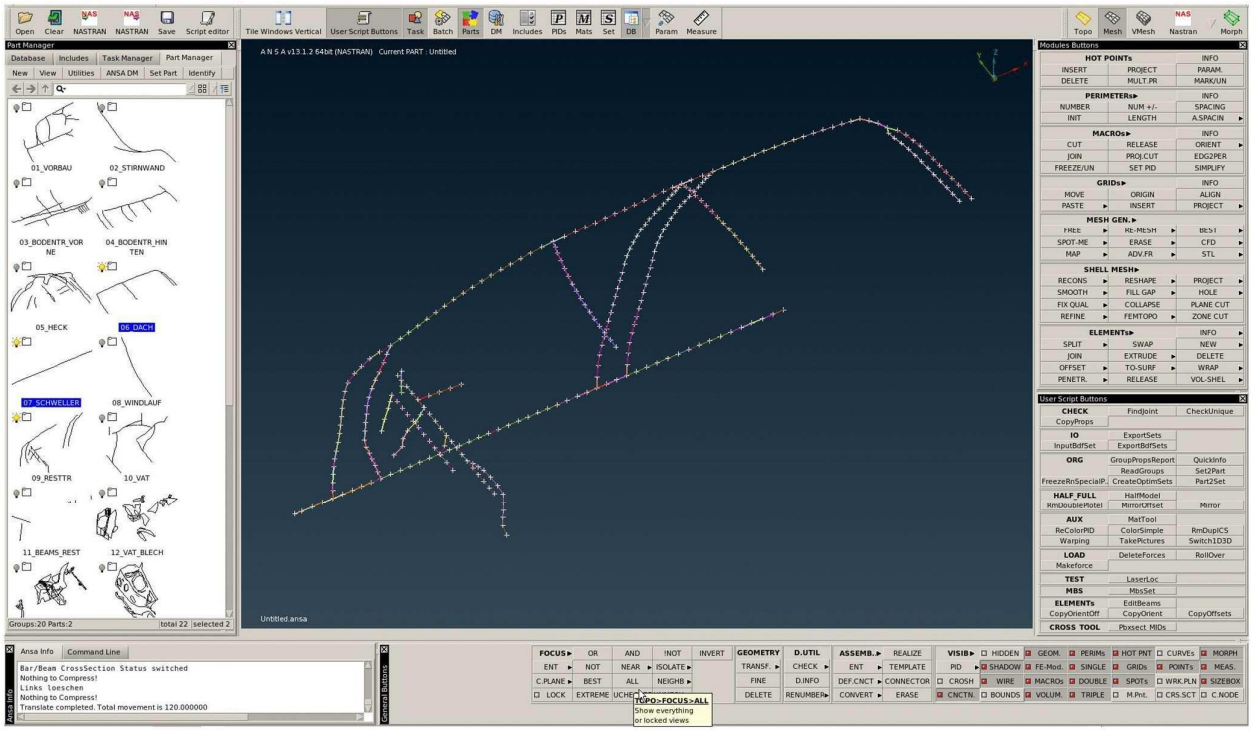
Topology modification: adding a 2nd b-pillar



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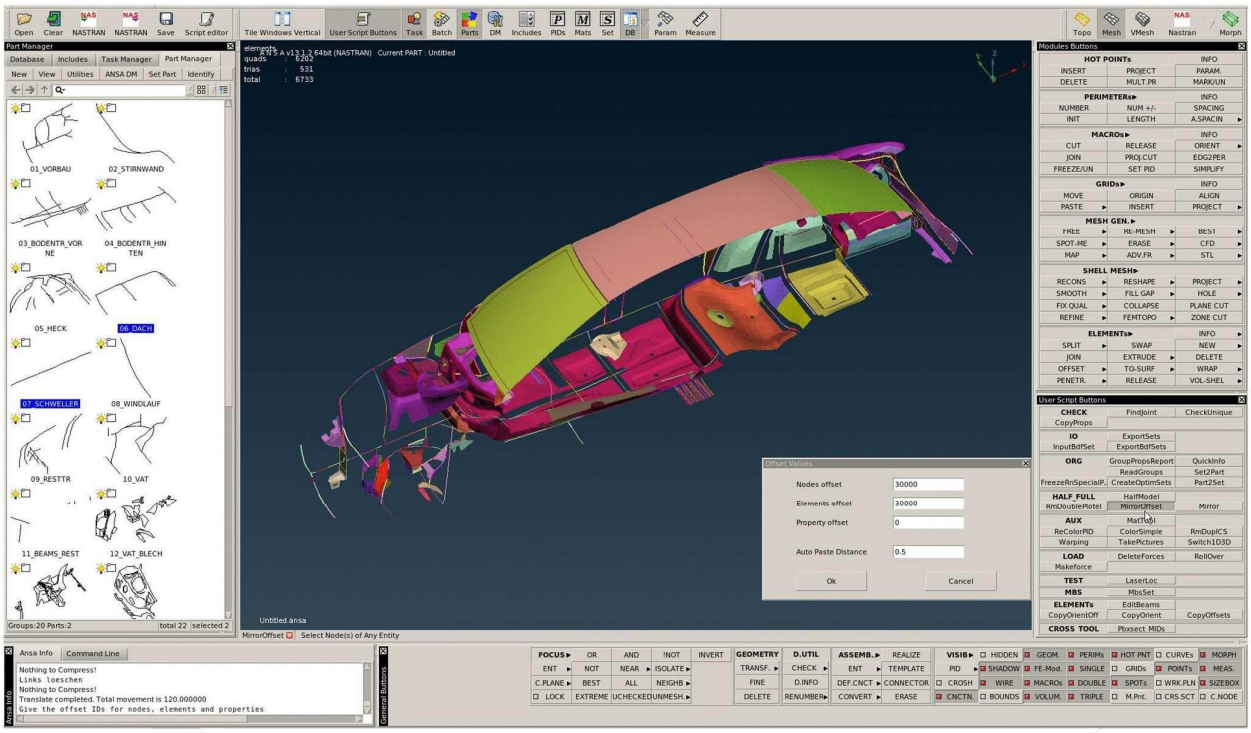
Topology modification: adding a 2nd b-pillar



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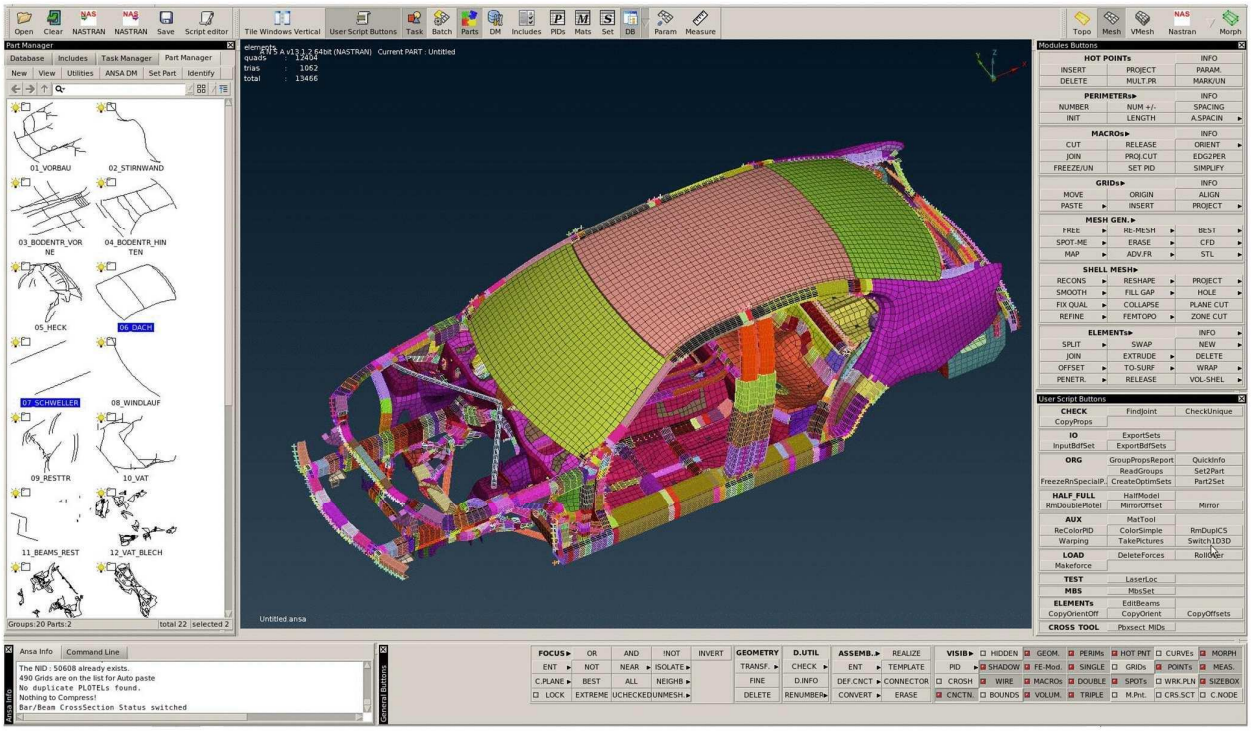
Topology modification: adding a 2nd b-pillar



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Summary and Conclusion

- The beams and shells FE concept modeling and optimization process is **well established** at the BMW NVH department and is used extensively in all early phase car development projects for **designing optimal car body structures**.
- Over the years **an extensive set of proprietary tools** has been developed for building these types of models and for post-processing.
- **ANSA** has been established as **"state-of-the-art" pre-processor for PBxSECT** models with an exact geometric definition of the beam cross section.
- The PBxSECT capabilities in ANSA enhanced by various User Scripts leverage the existing process in terms of **speed, efficiency and quality**.

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