Topology & geometry based structure optimization using implicit parametric models and LSOPT

W. Pohl

Nov 2009

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Potential for Shape/Topology Optimization

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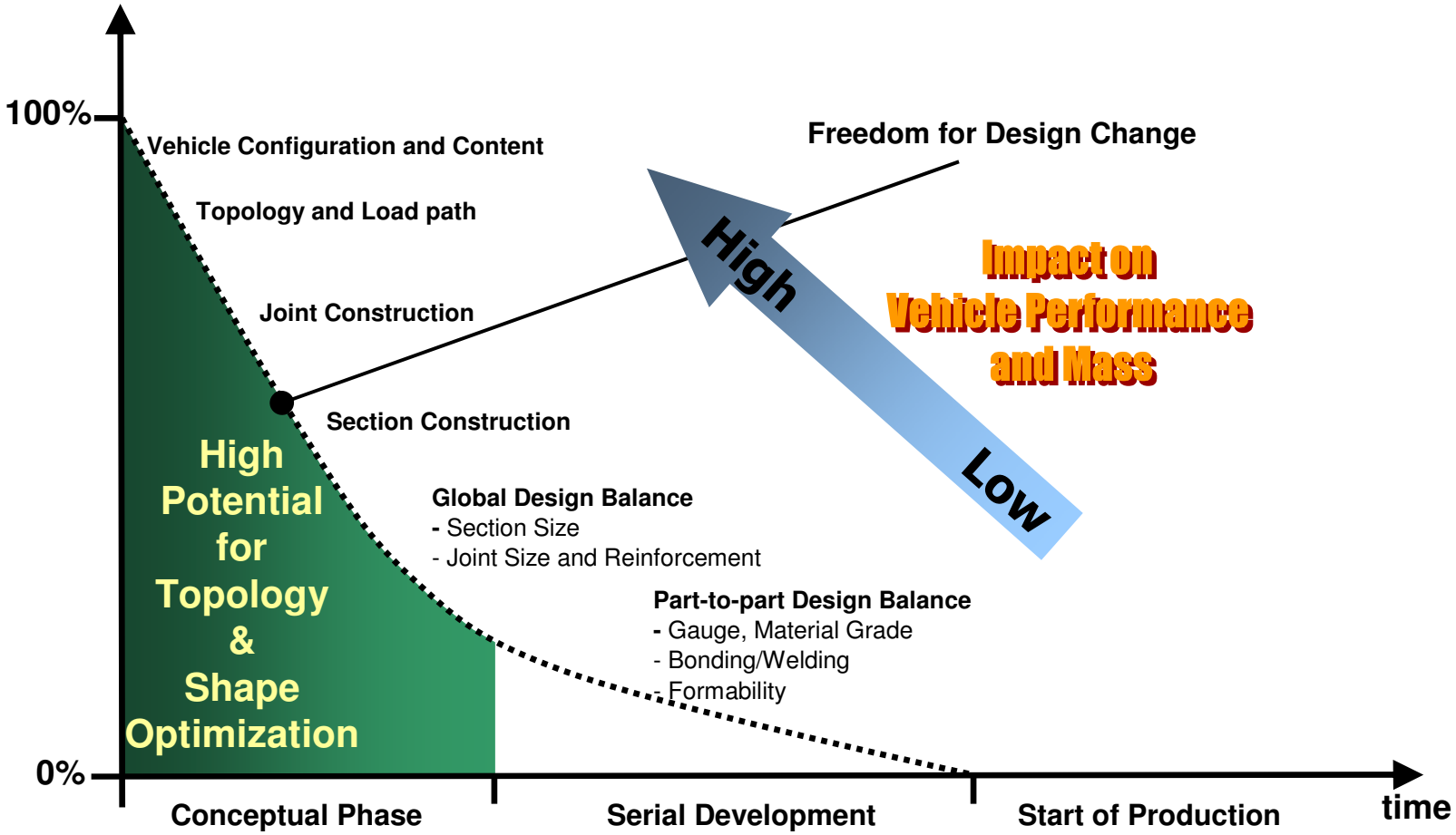

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Challenges in Shape/Topology Optimization

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- Theory is long known
- Optimization algorithms are mature
- Still Topology / Shape Optimization remains a challenge.

WHY?

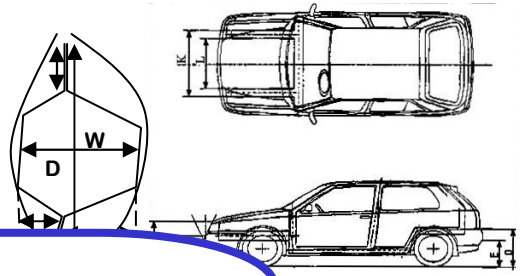
- FE based
  - limited to small geometric changes & no topological
  - Overwhelming number of design variables
  - Lack of design constraint management : non-manufacturable solutions
- CAD based
  - Over constrained/Incompatible geometries
  - Lack of associative meshing
- Furthermore process integration is also an issue

Geometry – Topology - Simulation – Optimization

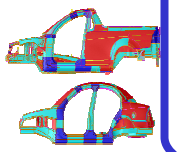
How to create a parametric simulation geometry

Styling
(IGES,

Package
(IGES, VDA)



arameters,



Parametric components, assemblies
(SFE CONCEPT LIBRARY)

Key for **upfront CAE** is

II. the **aut**
input de

Key for **upfront CAE** is

III: the **parametric explorat**
availabl
link to

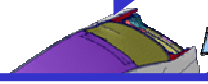
RADIOSS

PERMAS,

Key for **upfront CAE** is

IV: **Integration with CAD**

CAD Data
IGES, VDA, STEP, CATIA V5



Key for **upfront CAE** is

I. the existence of a **detailed enough Simulation Geometry**
derived from various data sources

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SFE CONCEPT From Scratch

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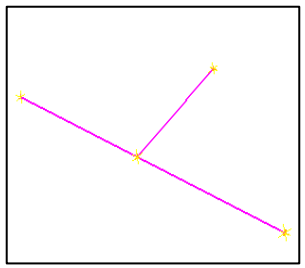
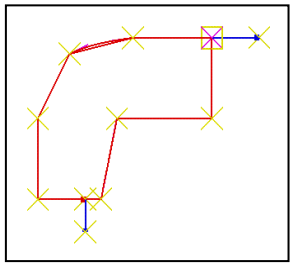
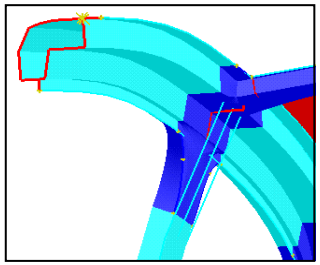
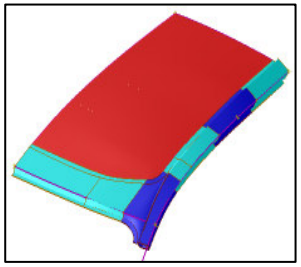
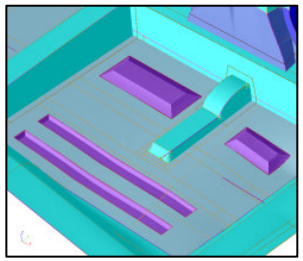
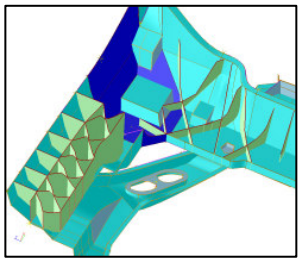
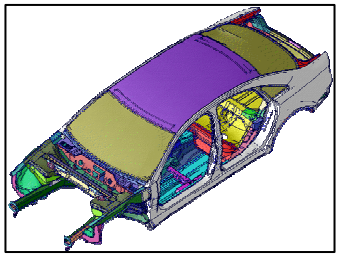
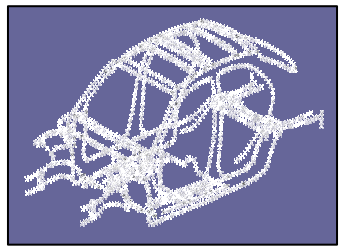
SFE CONCEPT Parametric Model

- Points and Lines
- Cross Sections
- Joints & Beams
- Freeform Surfaces
- Beads, Stamps, Ribs
- FE Meshes
- Welds, Adhesives
- Loading, Etc.

Explicit (C A D) versus Implicit (SFE CONCEPT)

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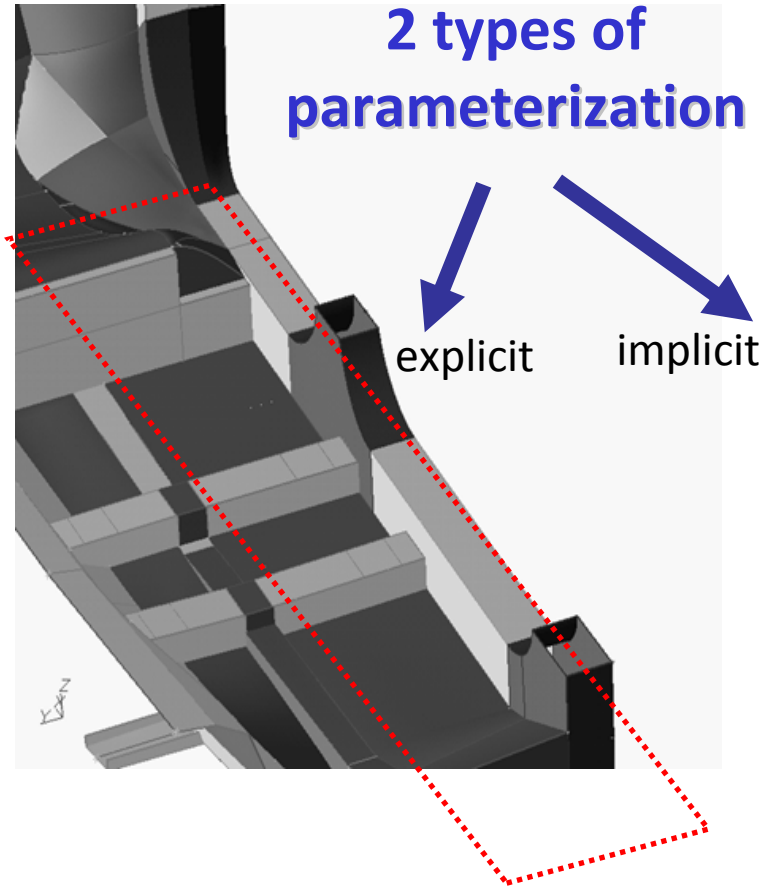
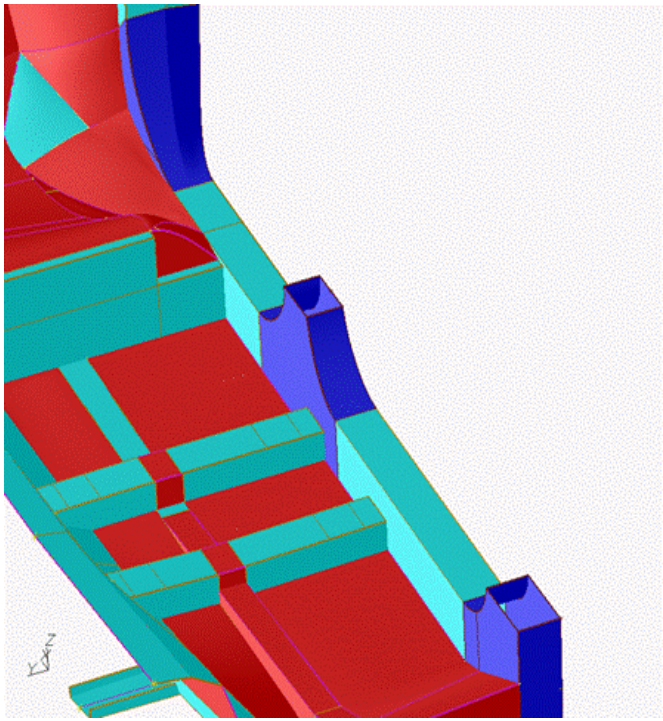
Explicitly parameterized geometry

- Parameter description for defining & maintaining geometrical and topological compatibility is ***nearly impossible***



Implicitly parameterized SFE CONCEPT geometry

- Parameter description for defining & maintaining geometrical and topological compatibility is ***very easy***



Expectation: Evolution of Design

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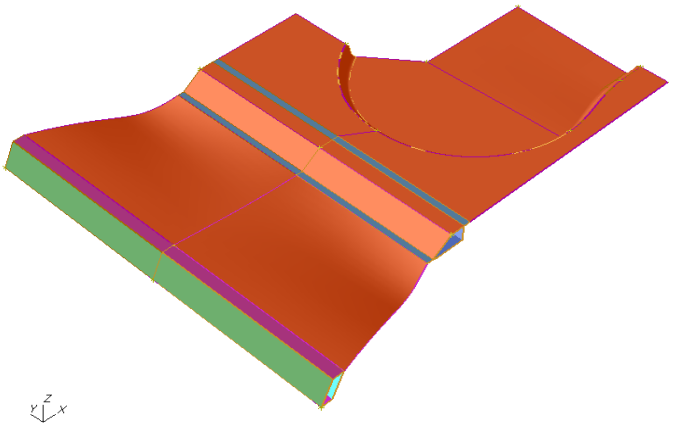
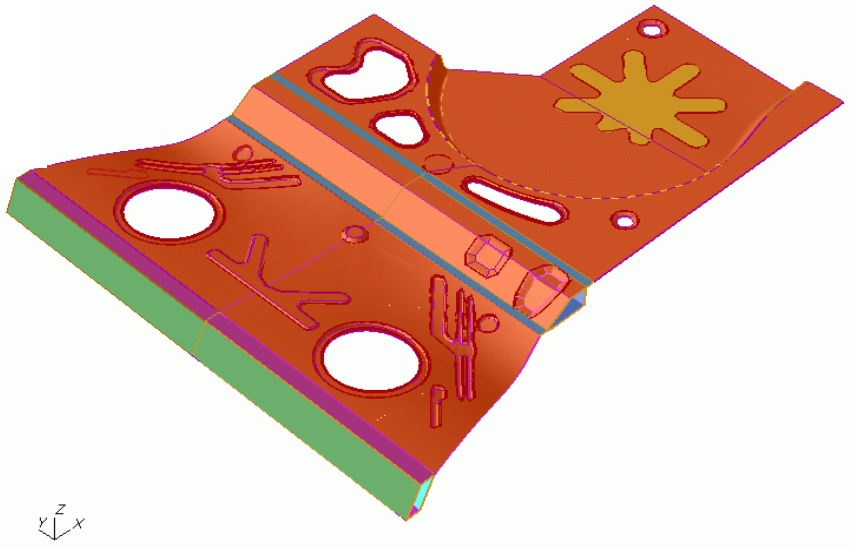
early design phase



Evolution of Design
... add complexity
without
„hierarchical constraints“

extended model



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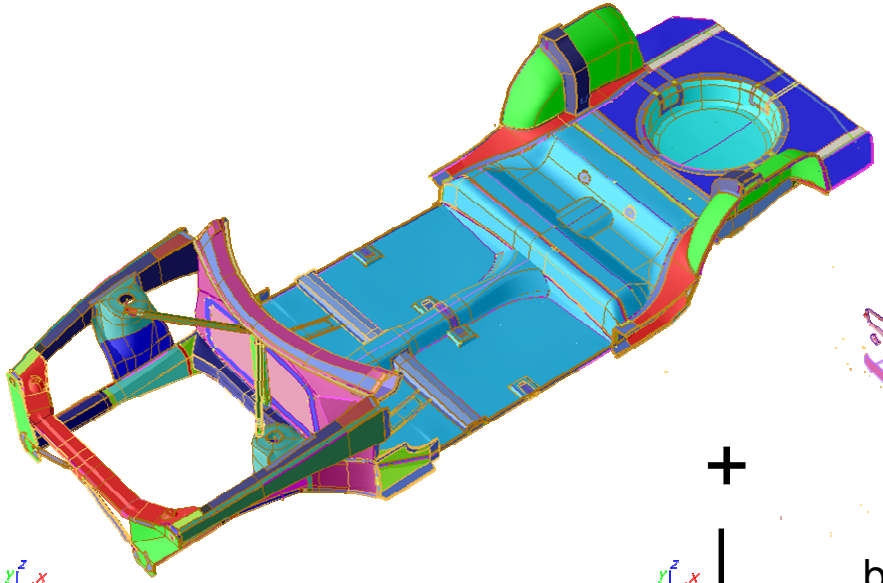
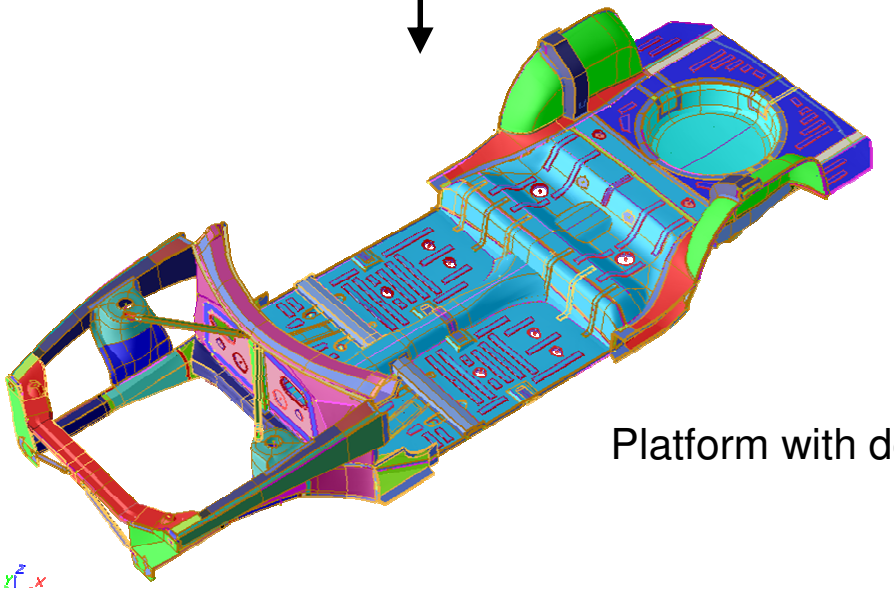


Platform without details

beads, stamps and cutouts as additional details stored in library



Platform with details

Expectation Design Maturity

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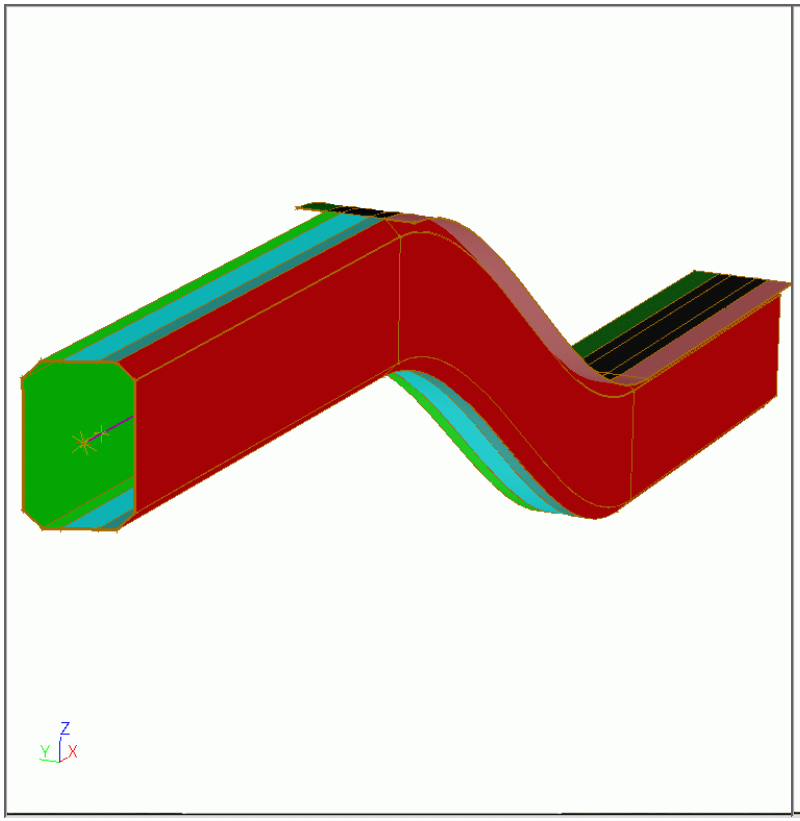
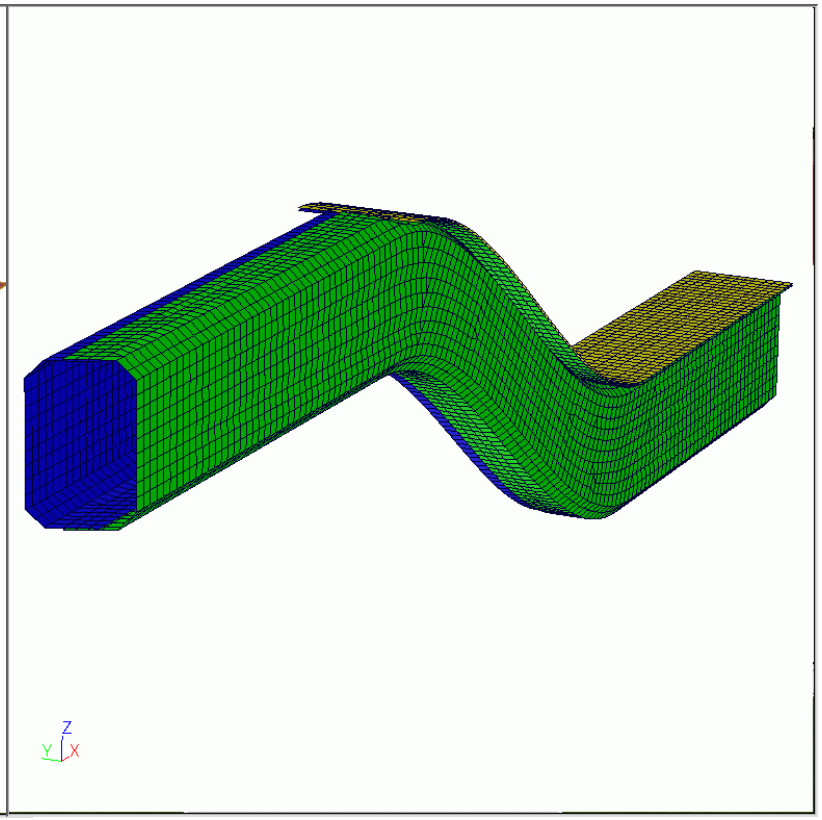
Topology & Geometry Changes – Automated Loop

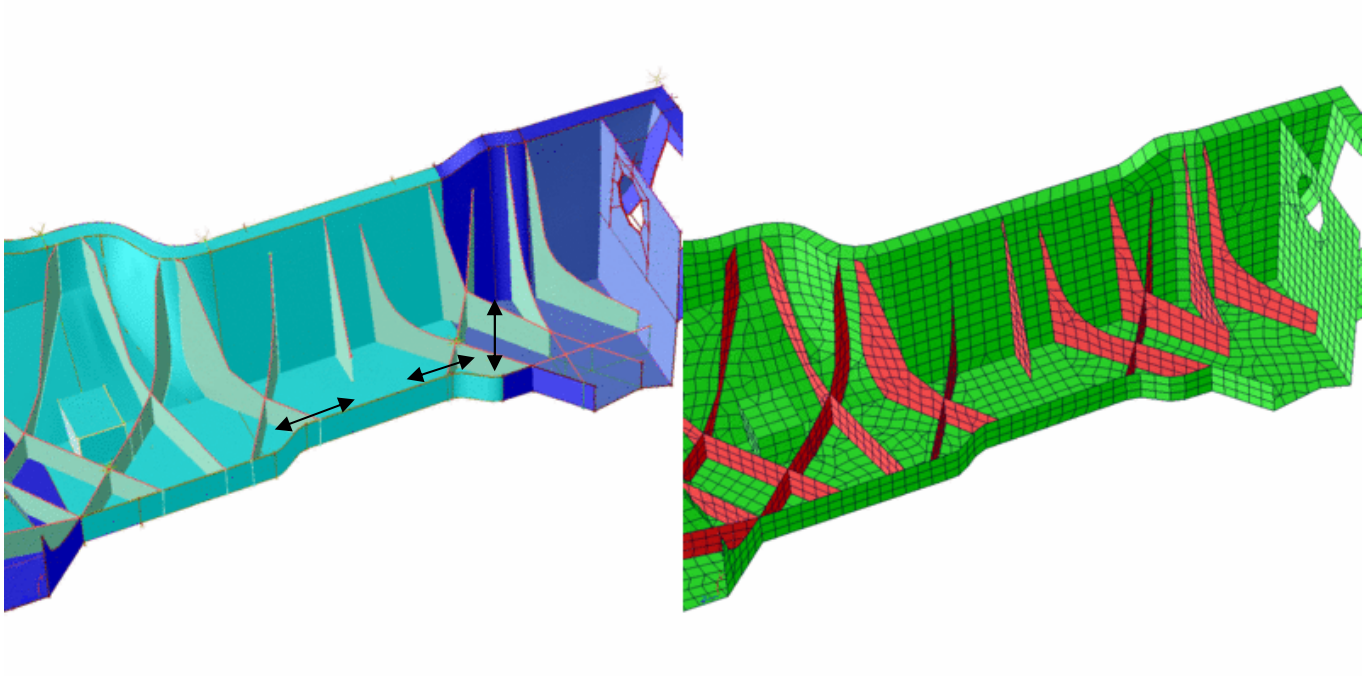


SFE CONCEPT Model



SFE CONCEPT FE Model

Expectation: Design Maturity



- Parametric Ribs Positioning, ON/OFF
- Rib Height, Length
- Ribs with any desired Shape
- Automesh to follow the geometrical changes

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Expectation: Parameter Summary

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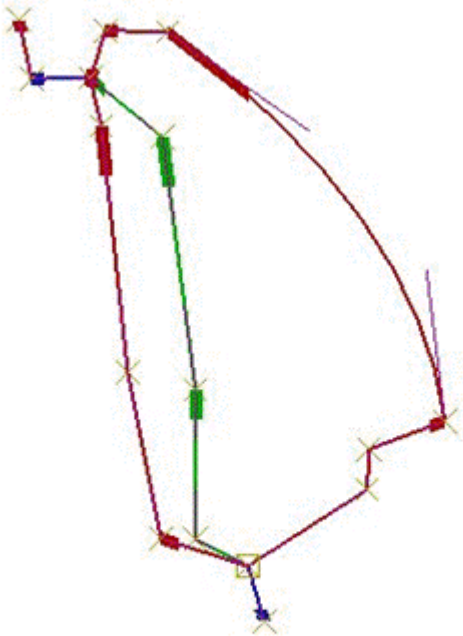
- Roof Rail Section



Expectation: Parameter Summary

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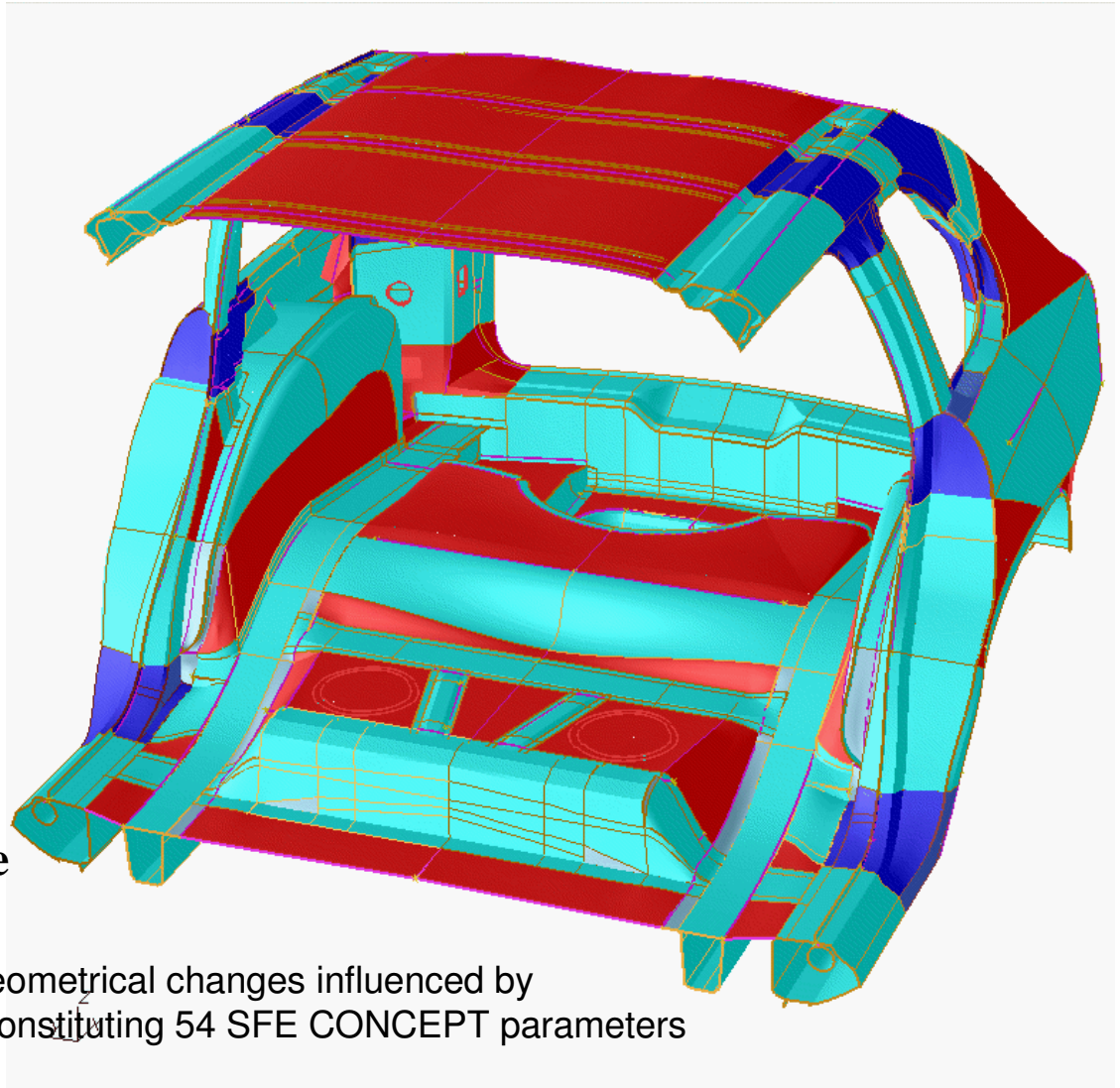
Optimization taking several simultaneous changes into account



Source: Porsche

Representation of geometrical changes influenced by
4 Design variables constituting 54 SFE CONCEPT parameters

Expectation: Reusability -Library

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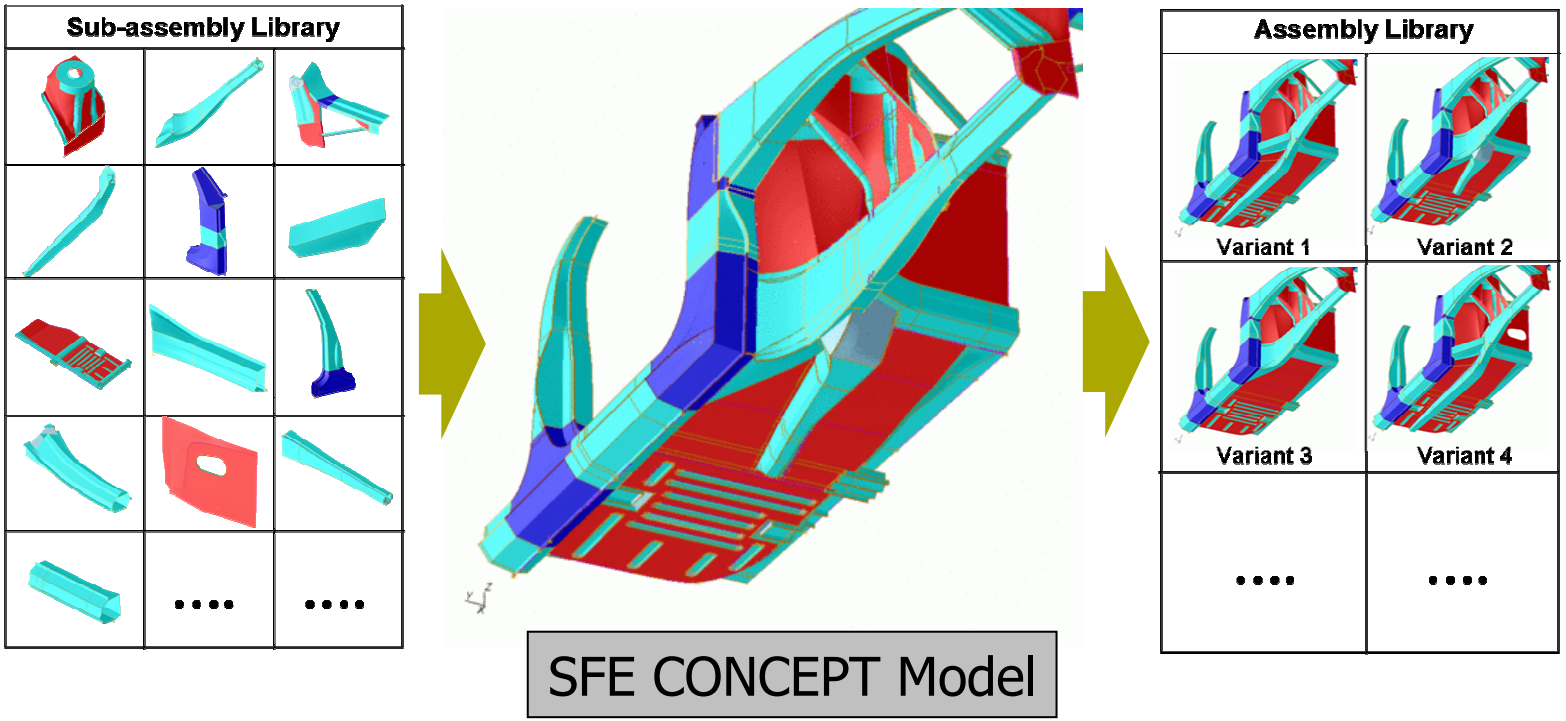

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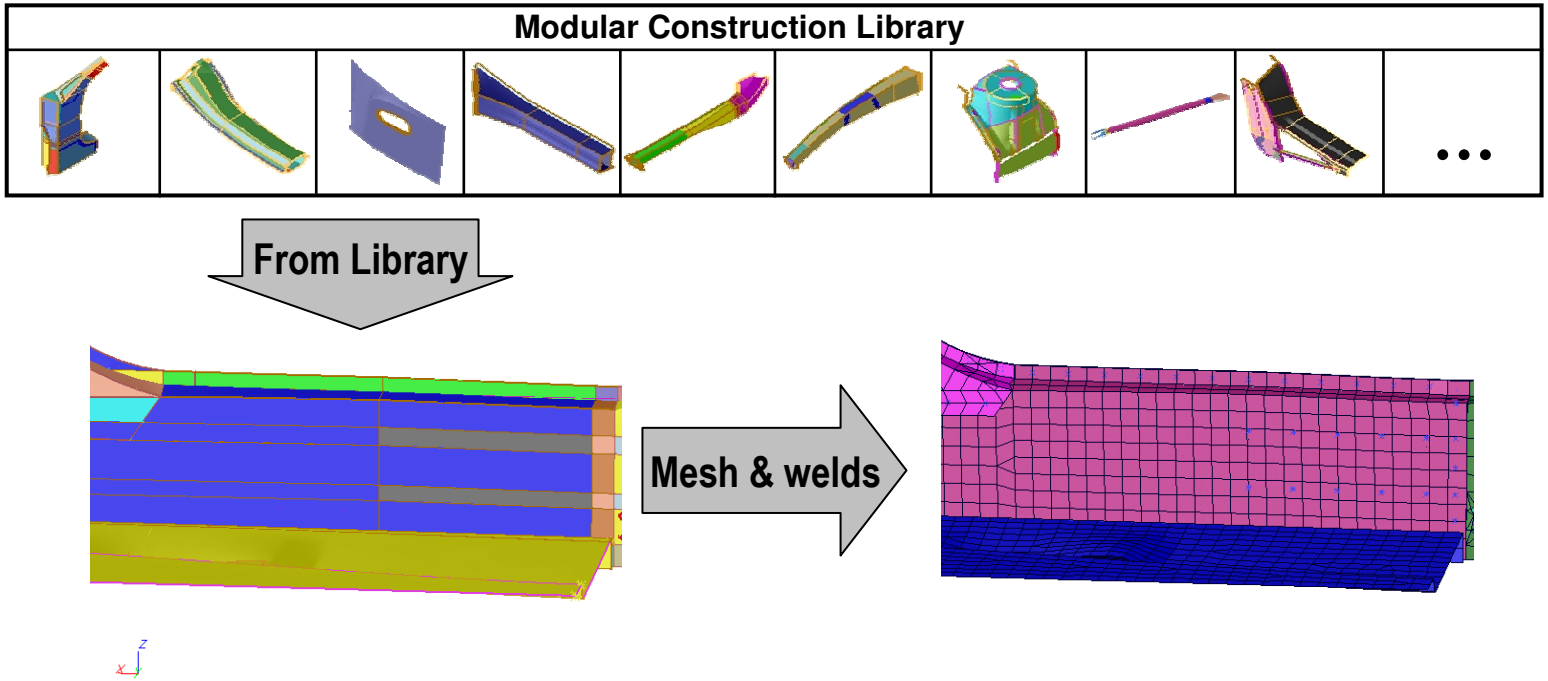
Expectation: Reusability -Library



- Use parametric model components or assemblies in current design
- These components know where they attach and what type of connections they have
- Automatic shape and size adaptation based on target model
- Part layers are automatically recognized and connected

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Reusability – “Parametric Model Library”

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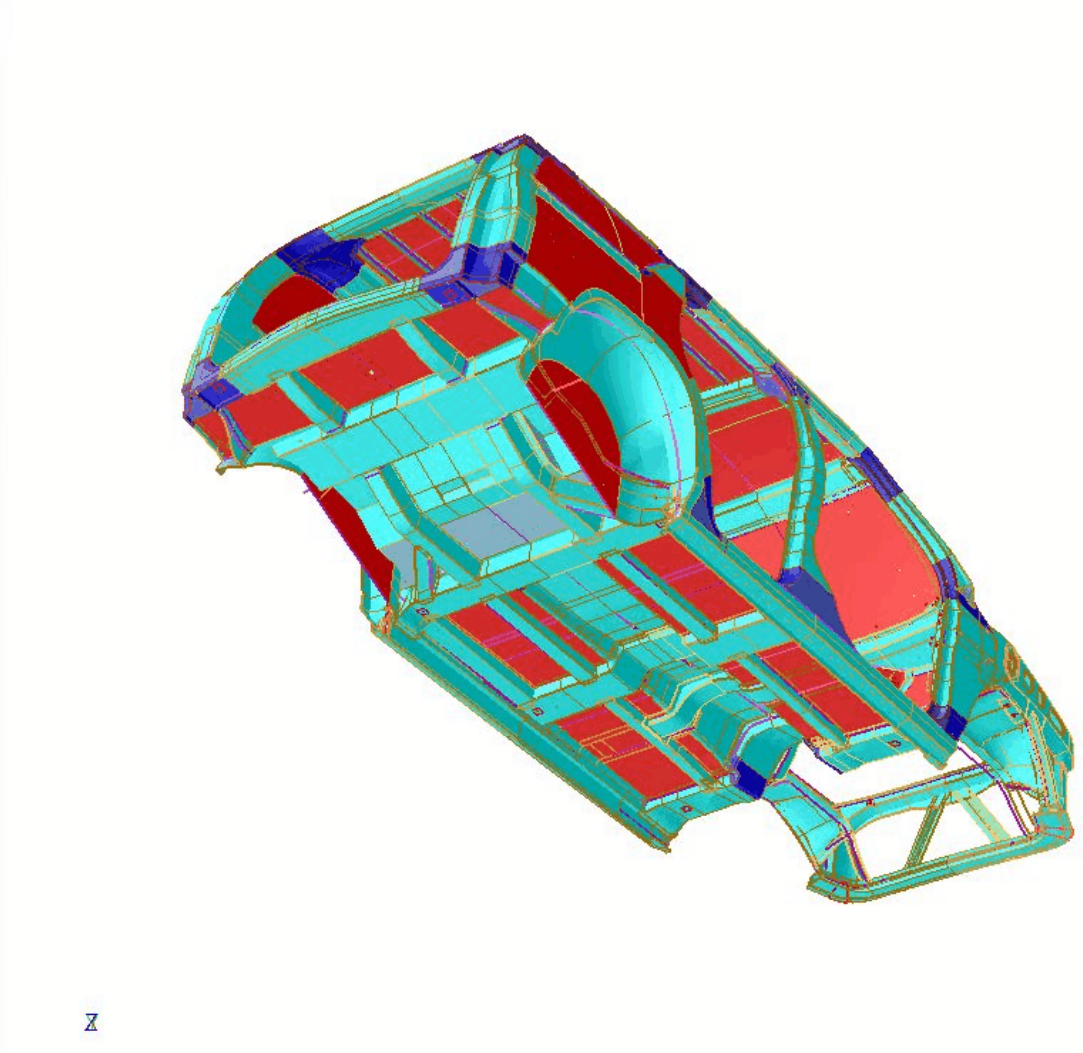

- Floor concepts & Commonalities

New Concepts

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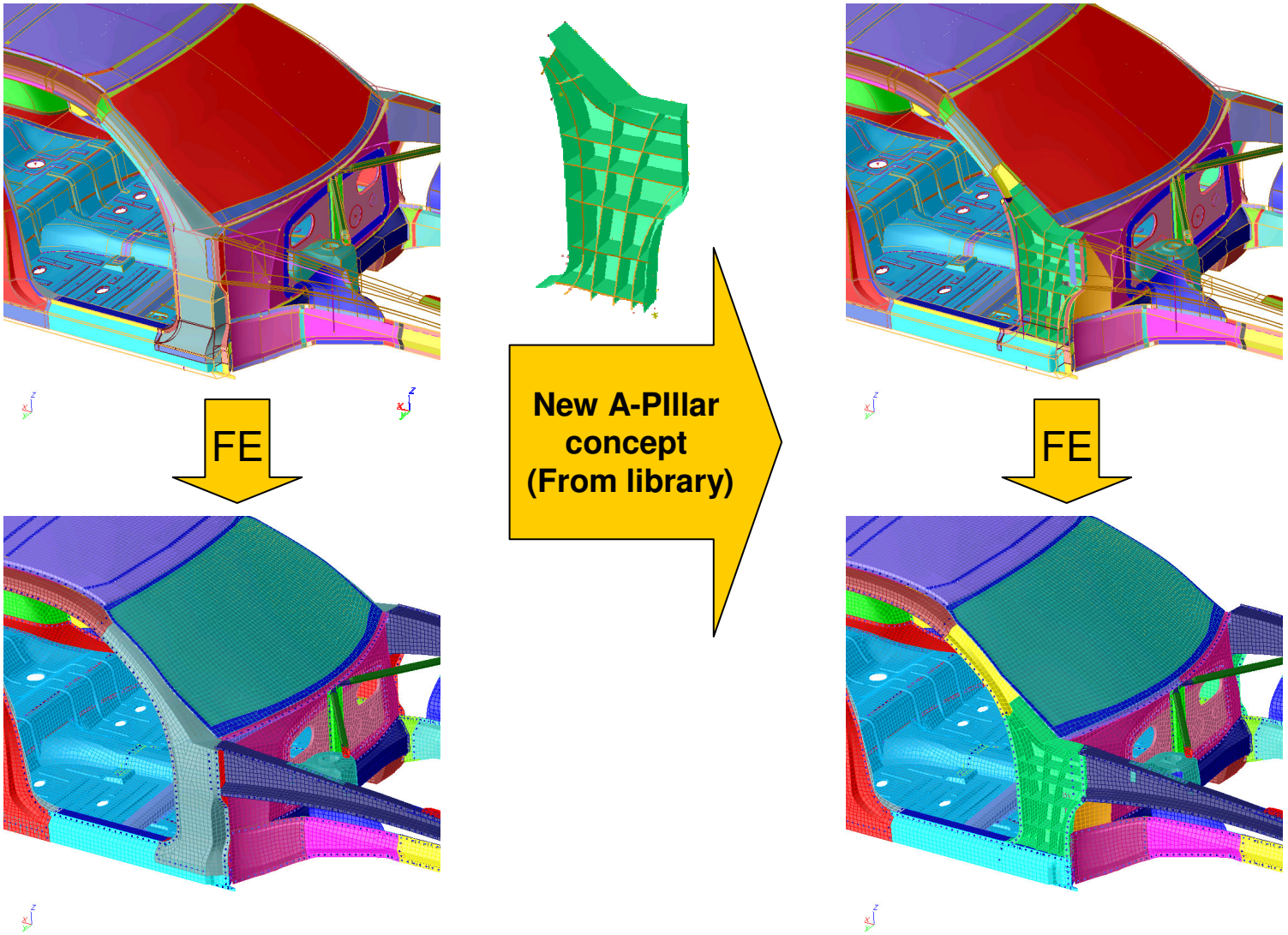
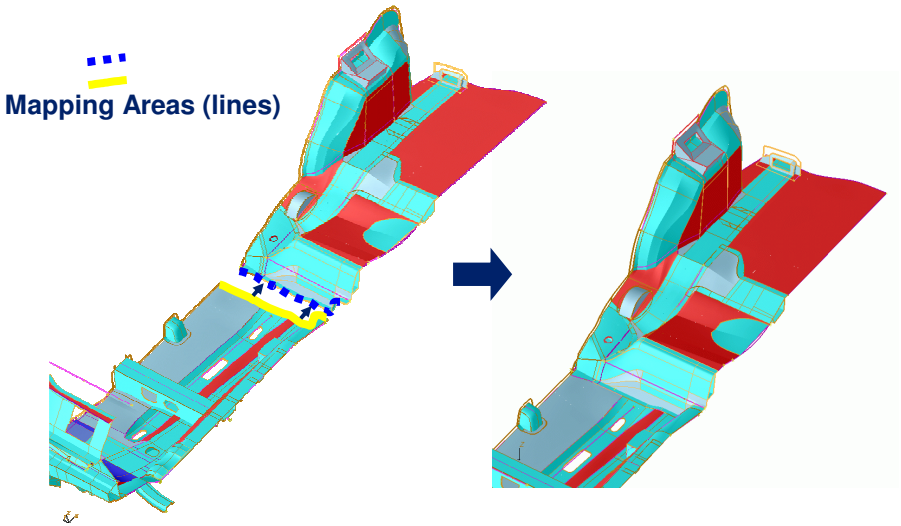


New topology, new material concept

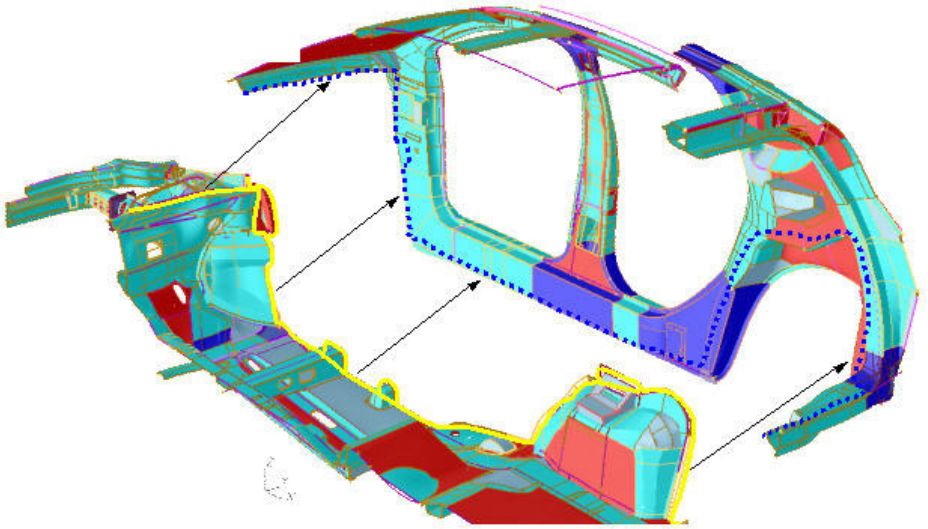
Upfront CAE

Parametric Geometry– First Part for the Upfront Process



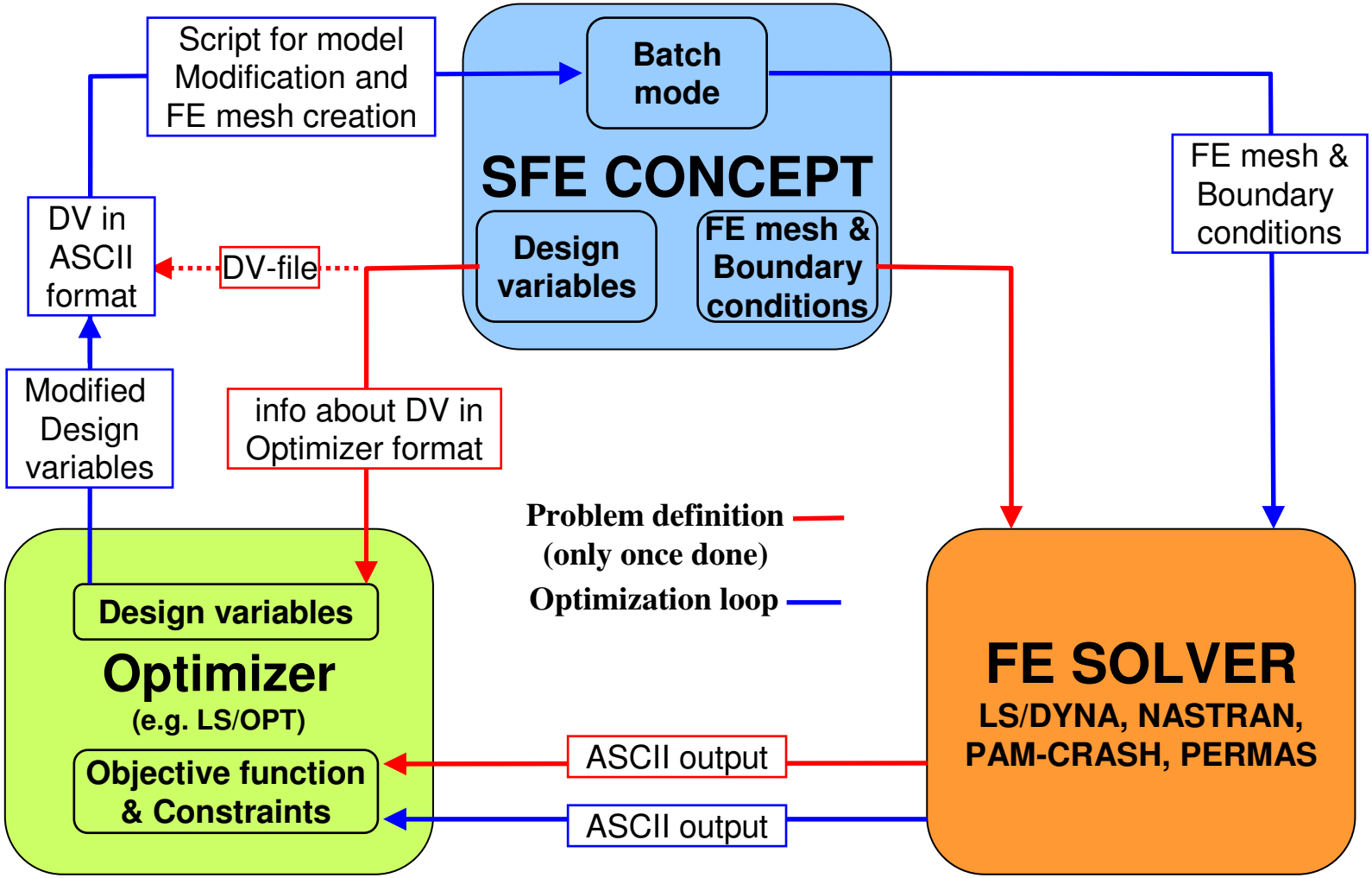
Platform Components
Rear Structure

Platform Components
& Top Hat Structure



Component Assembly – Platform and Top Hat Structure

Optimization loop



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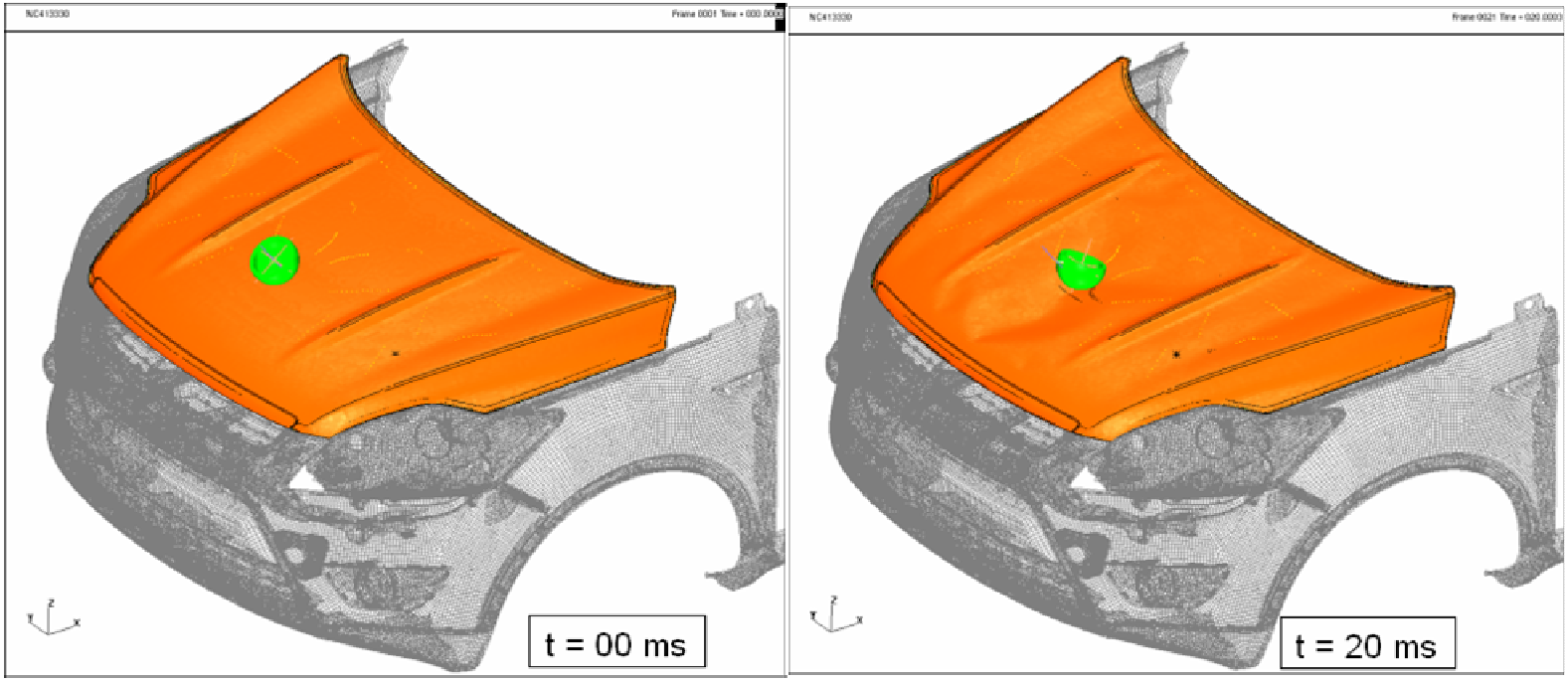
Optimization – Example Pedestrian Protection Hood



Courtesy of : Ford

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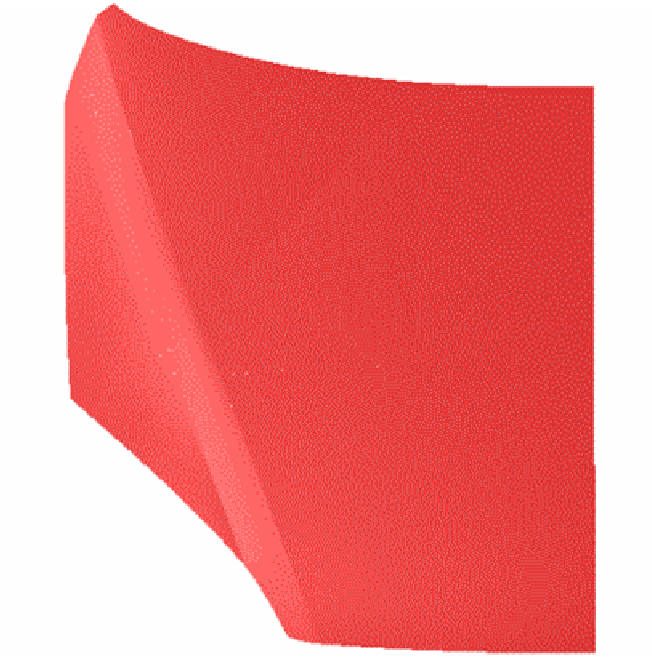
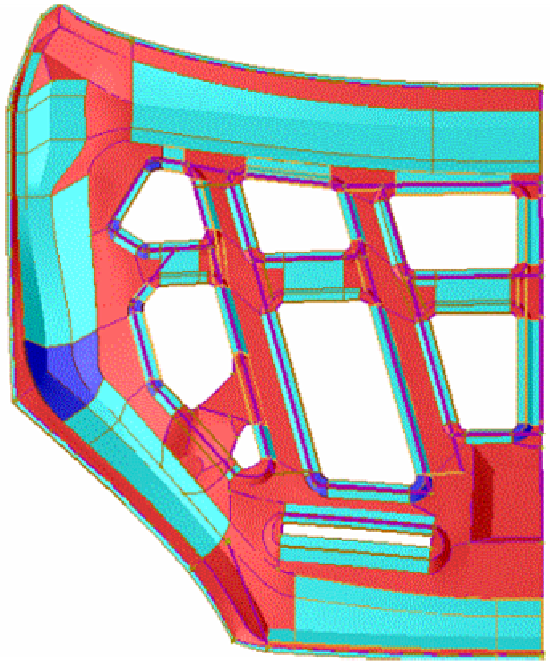
Optimization – Example Pedestrian Protection Hood

Hood panel



Hood structure



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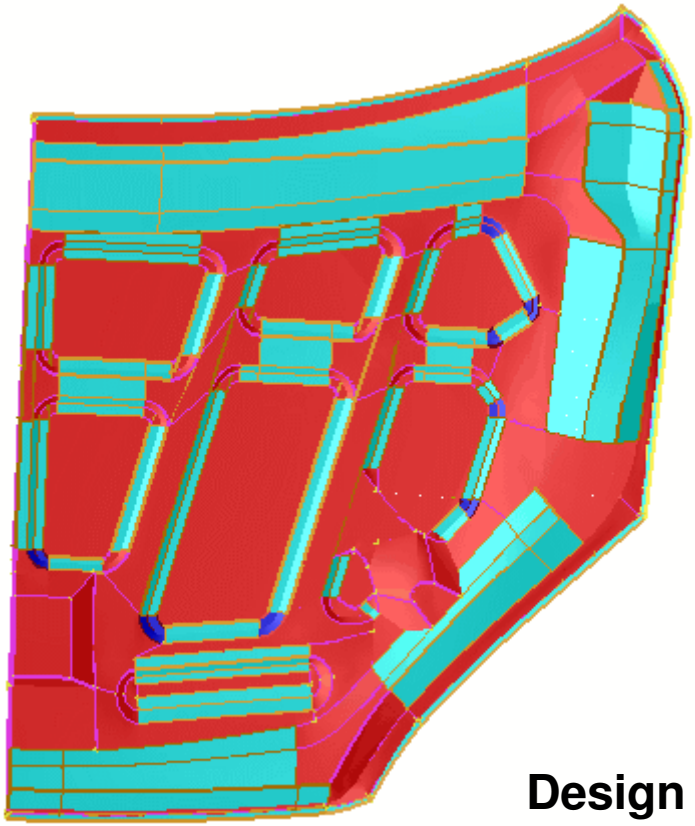


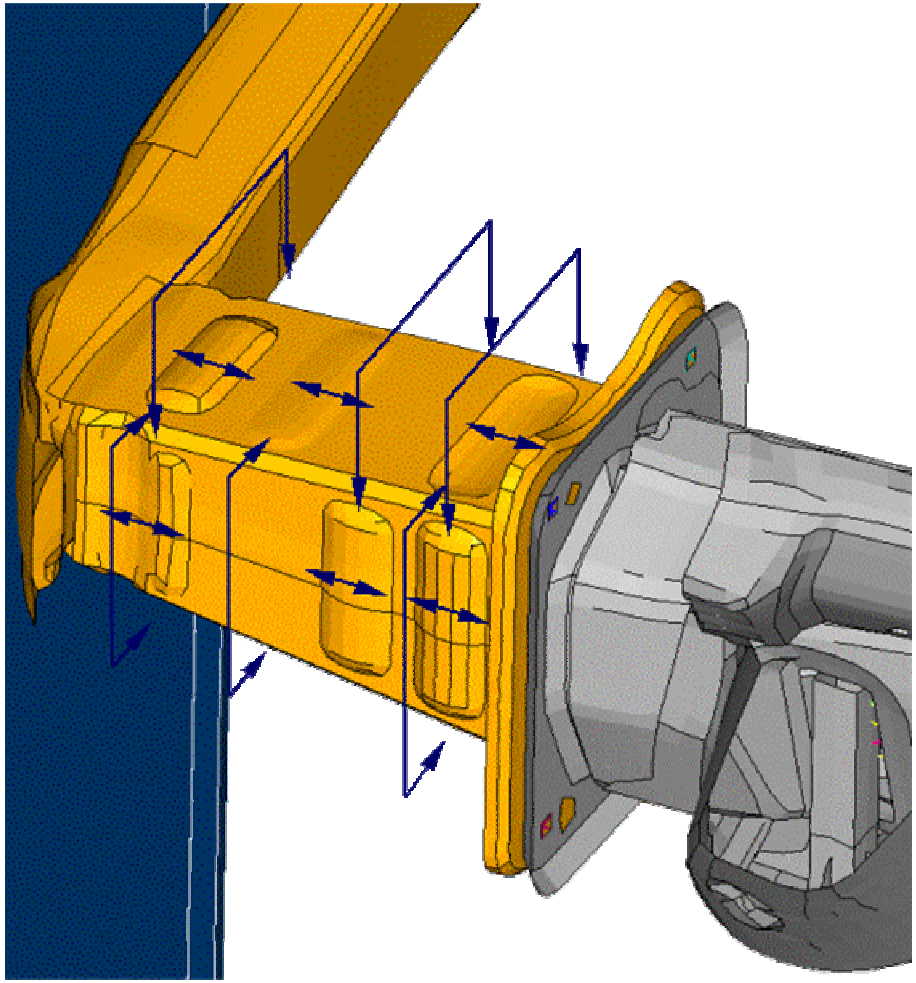
Example:
Moving the center Cross Member
=> Modifying Design Variable

CTR-XMBR/POS-X" = 0.0 - 3.0

Design Model 1

Courtesy of : Ford

Optimization – Example CD34x Bumper Crash Can



- Crash can thickness (0.05 mm increments)
- Crash can material (ZSTE → DP600)
- 6x Trigger positions
- 5x Trigger depression shape (inward, outward, flat)
- 2x Trigger width
- **In total: 15 Design Variables**

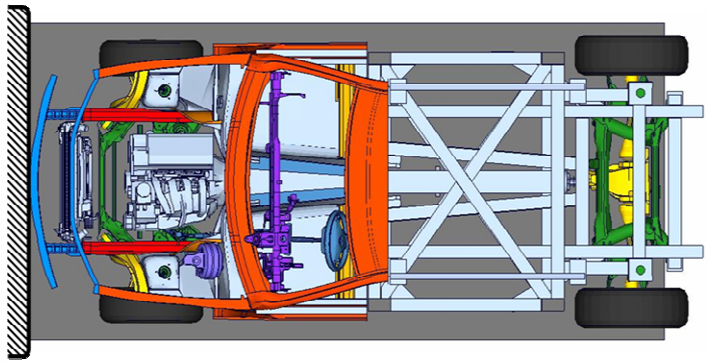
Owner: Jörgen Hilmann

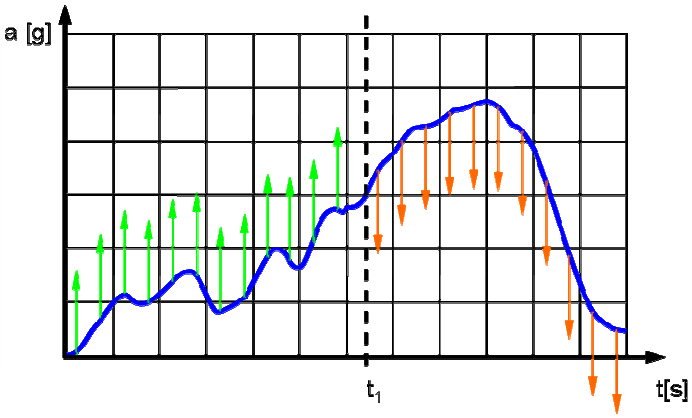
BMW AG
O. Meyer
17.03.2009

Funktionsauslegung in frühen Entwicklungsphasen

Integrierte Form- und Attributsbeeinflussung zur Crashoptimierung

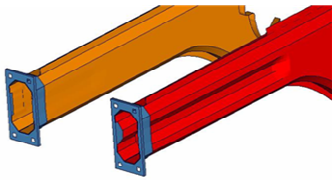
Modell und Zielfunktion





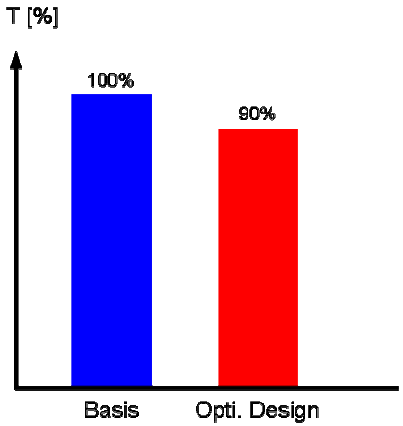
Optimierungsergebnis

Formänderung

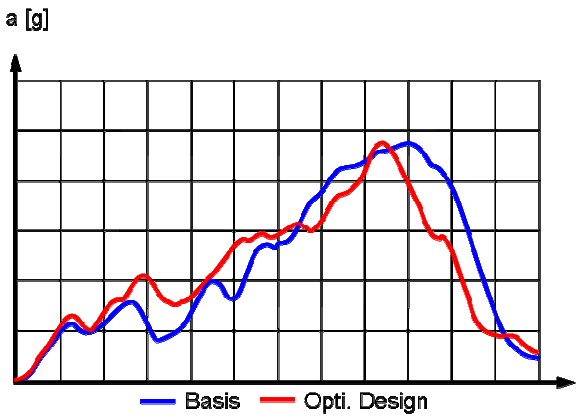


Basis Opti. Design

Wandstärkenreduktion

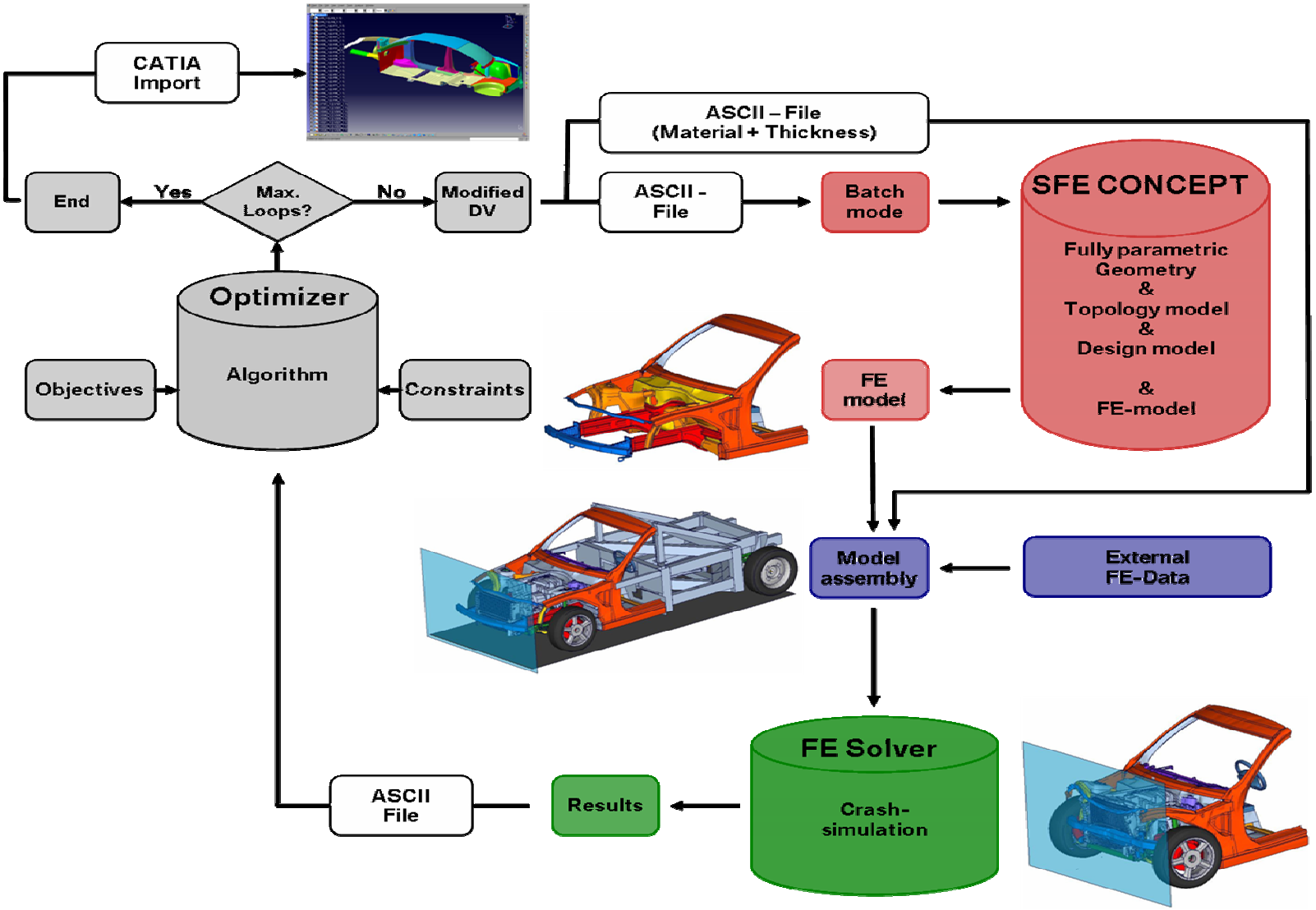


Pulsoptimierung



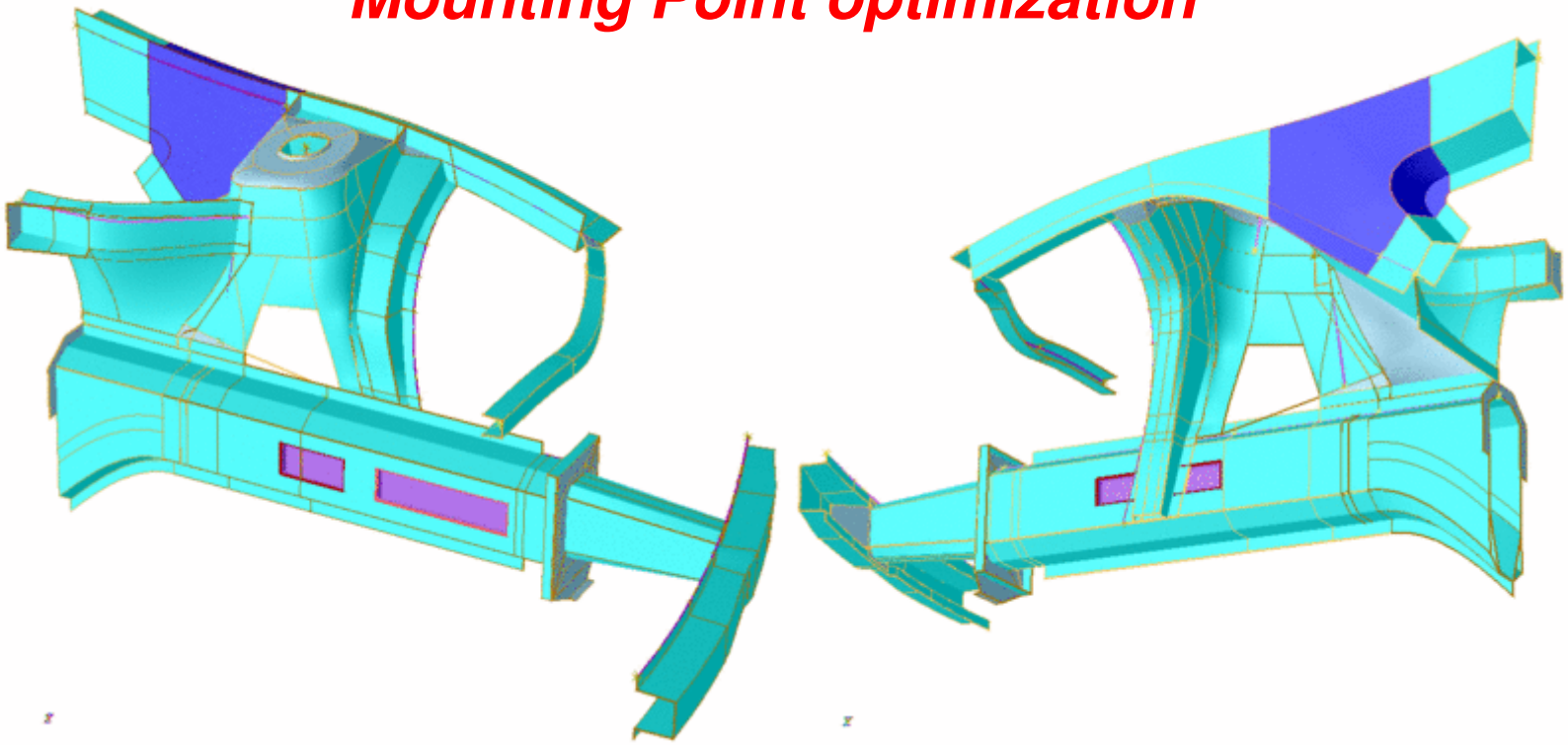
Funktionsauslegung in frühen Entwicklungsphasen

Integrierte Form- und Attributsbeeinflussung zur Crashoptimierung



Tower Modification

Mounting Point optimization



SFE CONCEPT Design Variables

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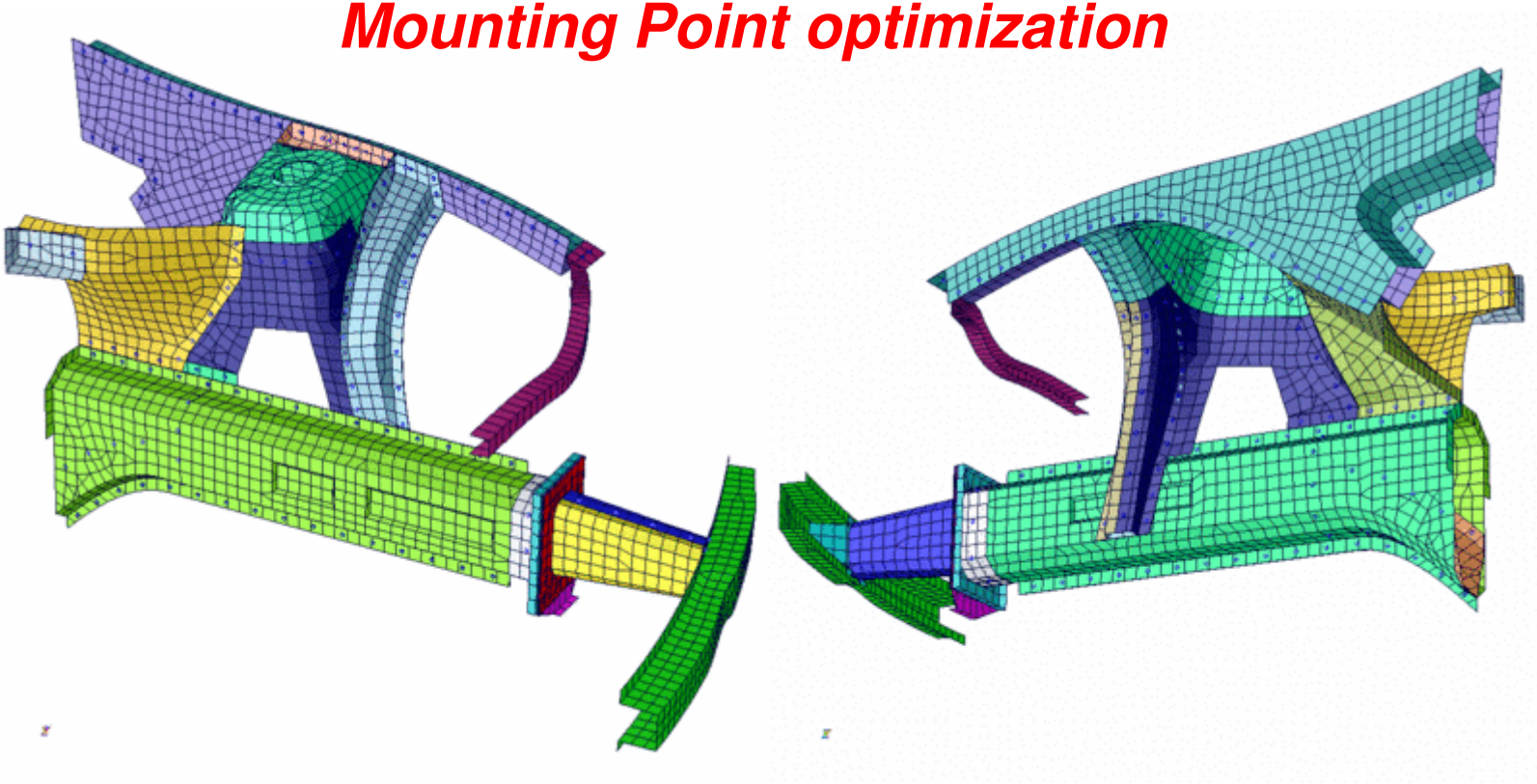
Mounting Point optimization



SFE CONCEPT FE Mesh

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Bead Shape Change

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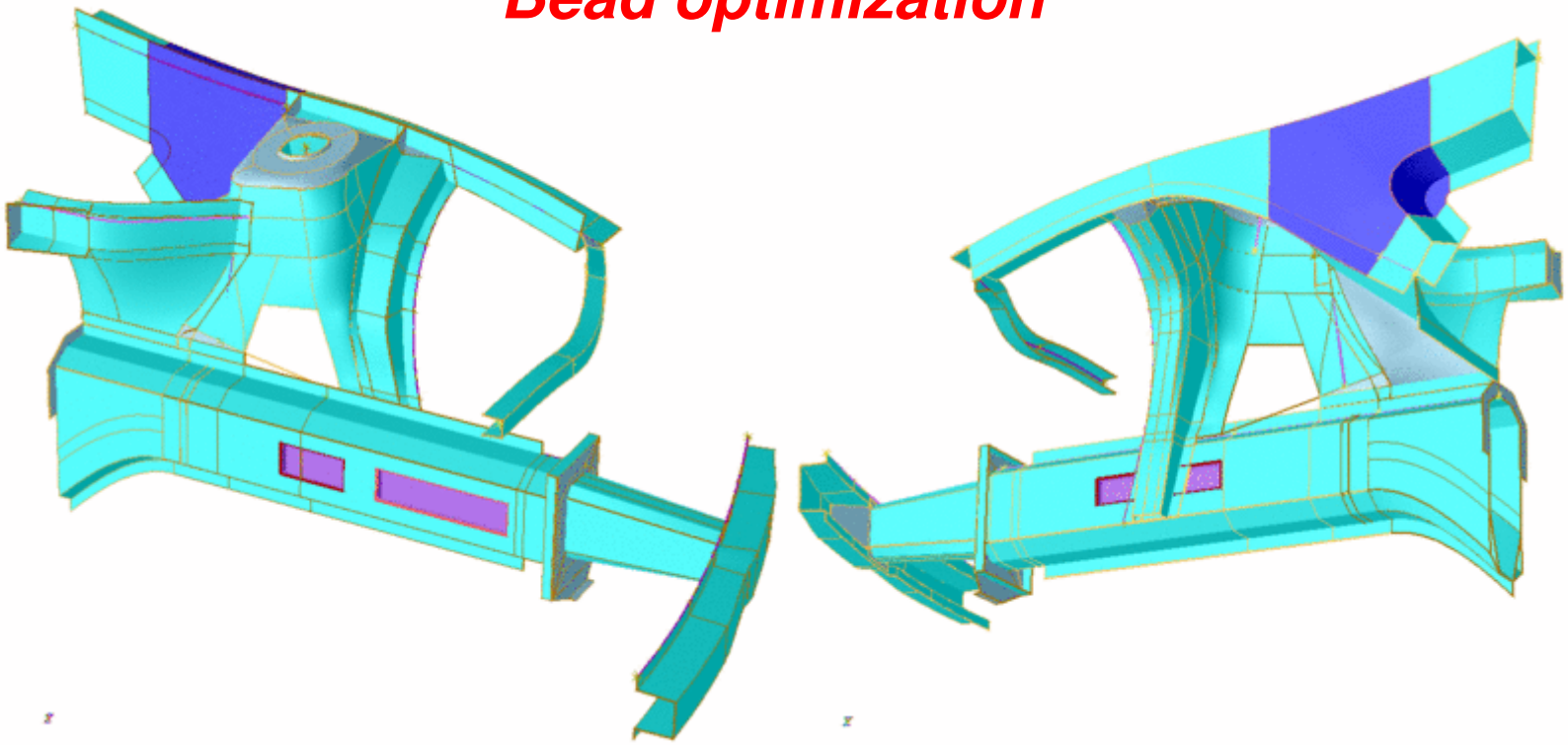
Bead optimization



SFE CONCEPT Design Variables

Bead Shape Change

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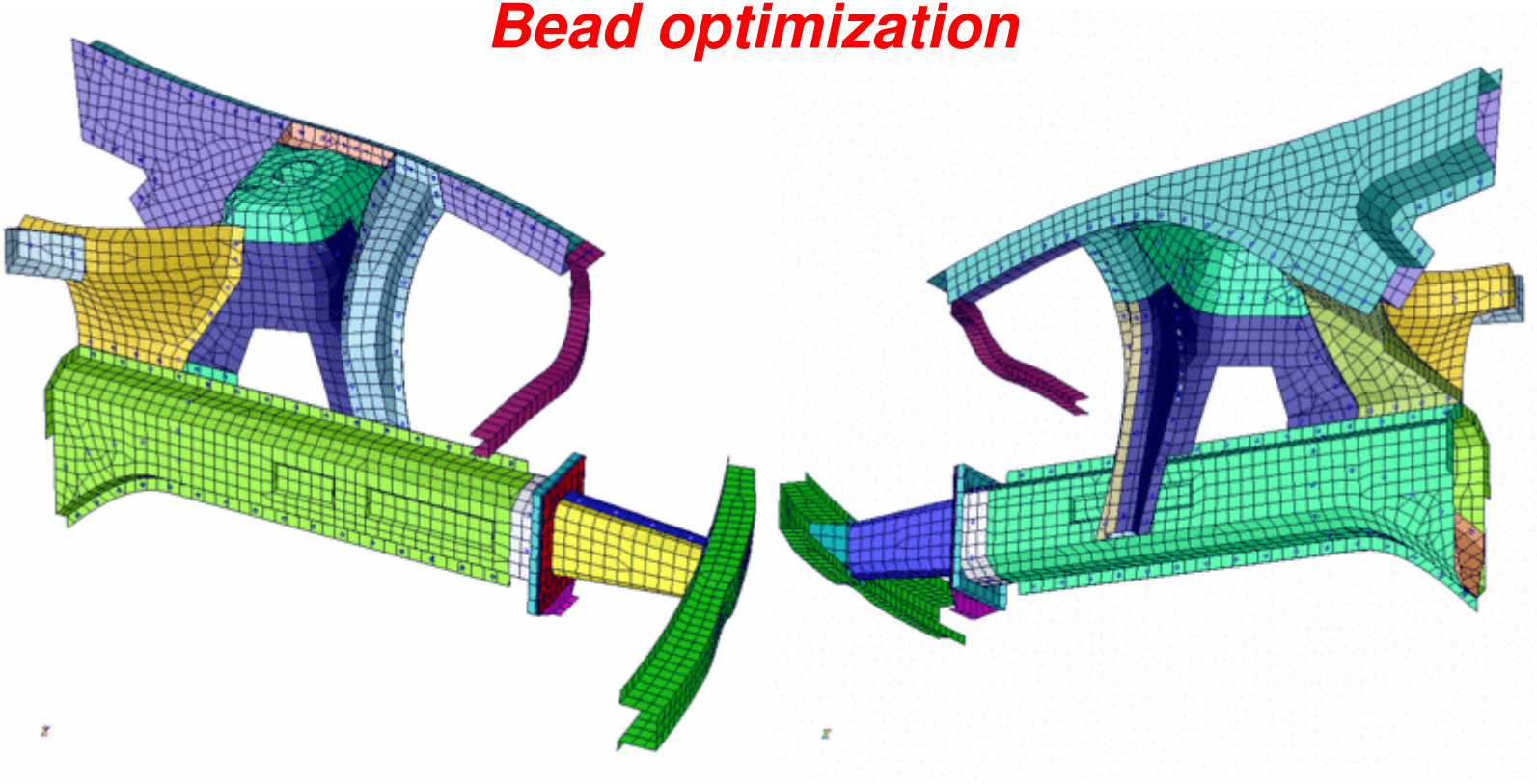
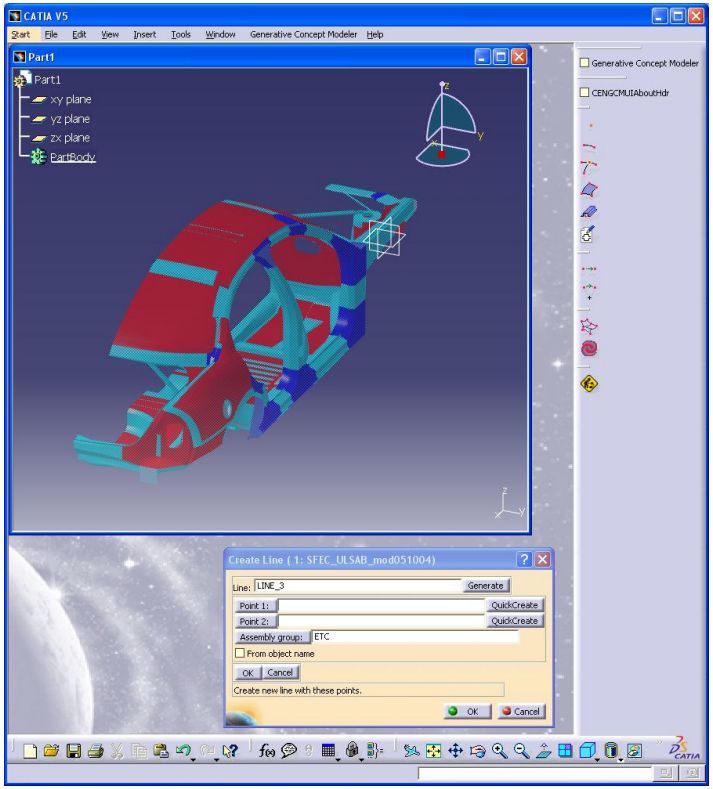
Bead optimization



SFE CONCEPT FE Mesh

- **Full integration in CATIA V5 integriert means:**
  - native CATIA V5 model
  - all parts/components of the SFE CONCEPT model are available within CATIA for further use with full SFE CONCEPT functionality
  - One single GUI in CATIA „look & feel“



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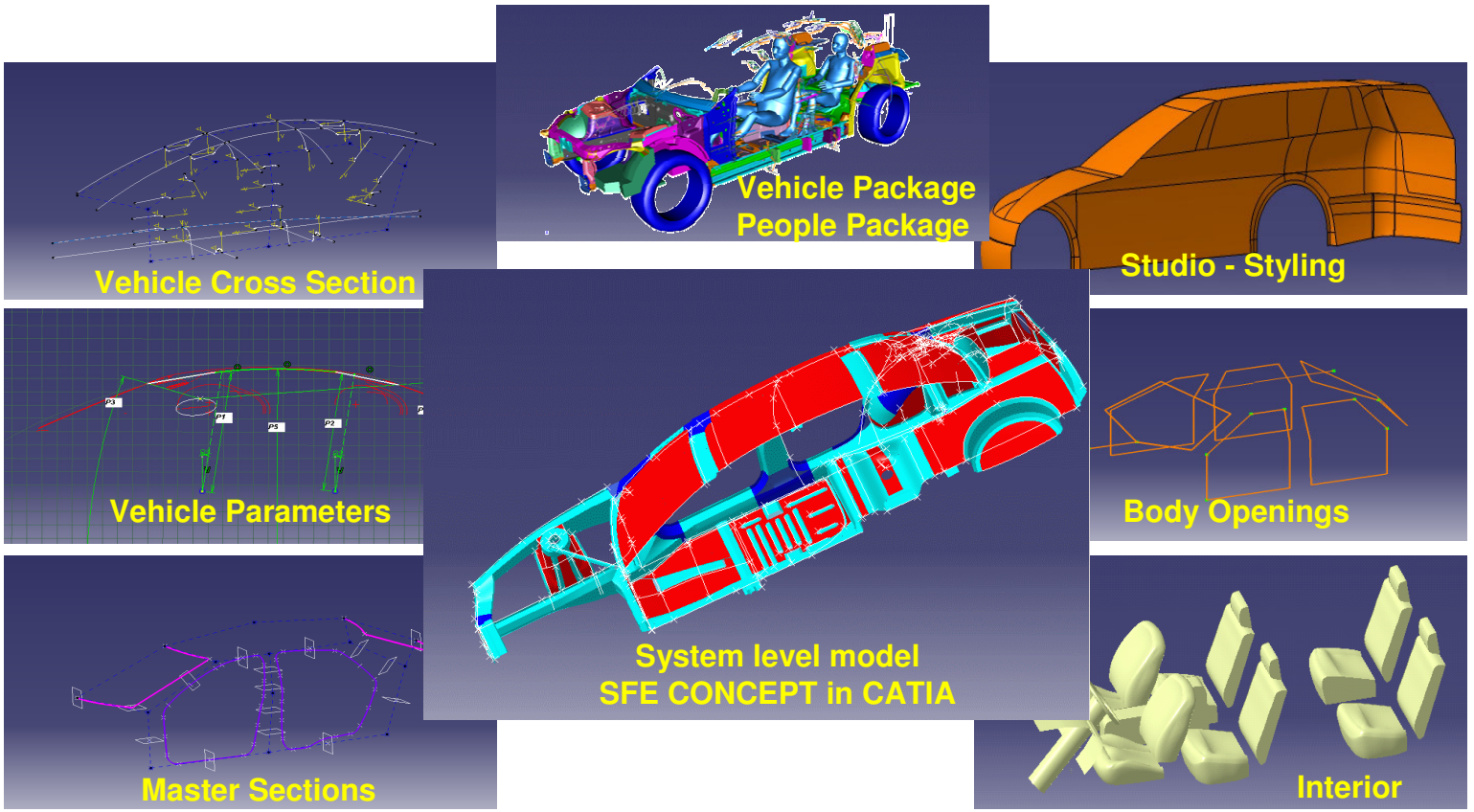
– during modeling existing CATIA-data (packaging, styling) may be referenced/used **associatively**



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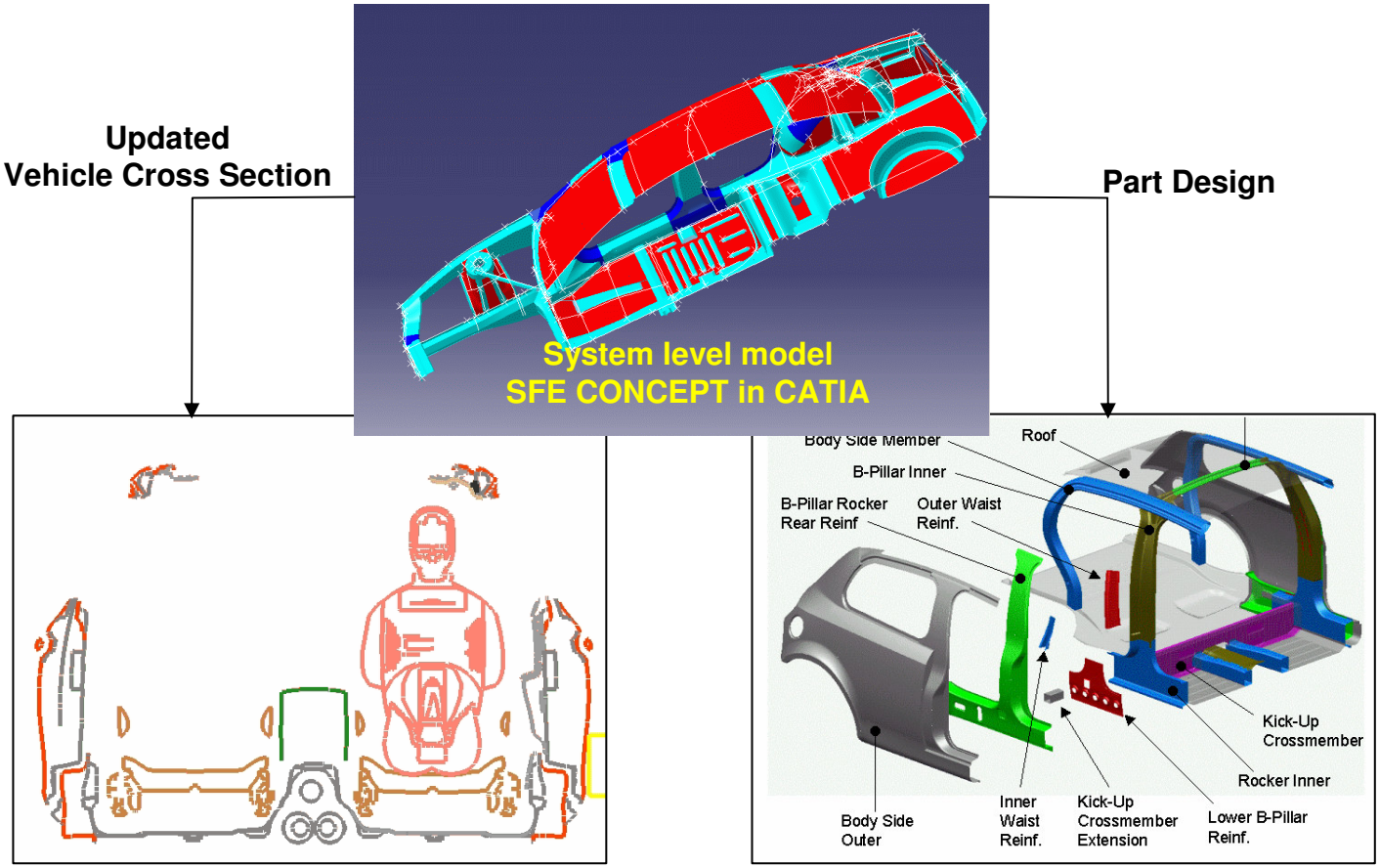
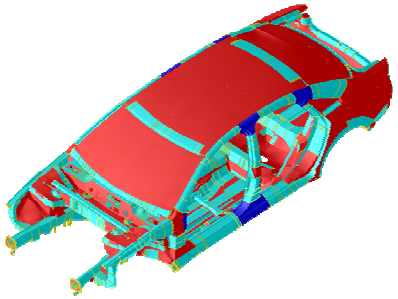
– easy data exchange between employees, depart= ments, suppliers; the CATIA document (CATPart / CATProduct) owns all data

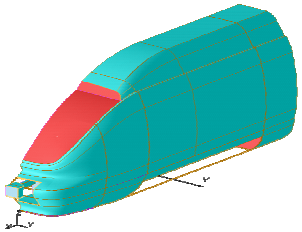
– **use of CATIA as established platform**

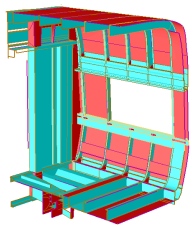


SFE CONCEPT applications

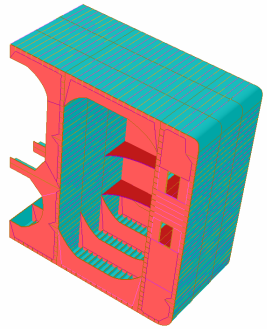


Automotive

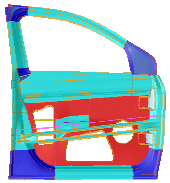




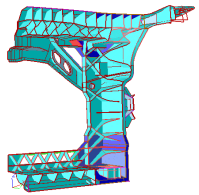
Trains



Shipping

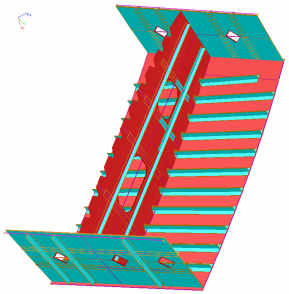


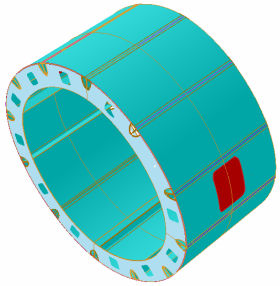
Front Door



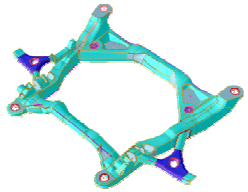
Radiator Support

White goods

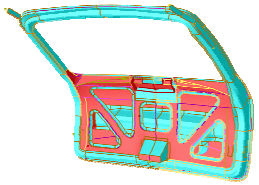




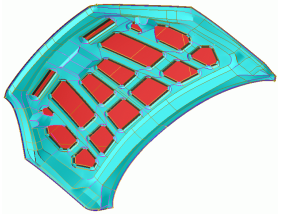
Aerospace



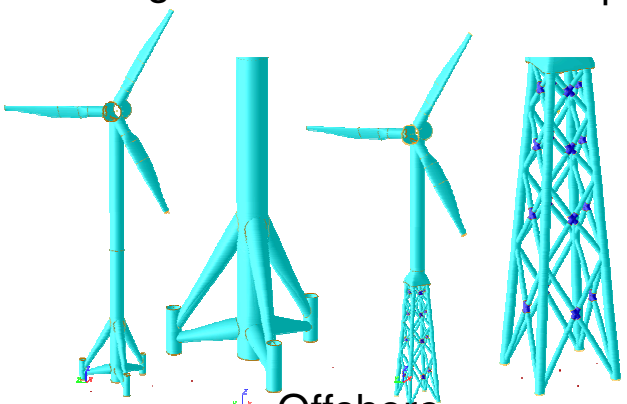
Front Sub-frame



Lift Gate



Hood



Offshore

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Summary

- Automated Process
- Pre-learning through Tradeoff Studies
- Best Common Practices
- Reusable Models and Components
- Parametric Models
- DOE Studies
- Multi-disciplinary Optimization (MDO)

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Thank You!

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