engineering center steyr

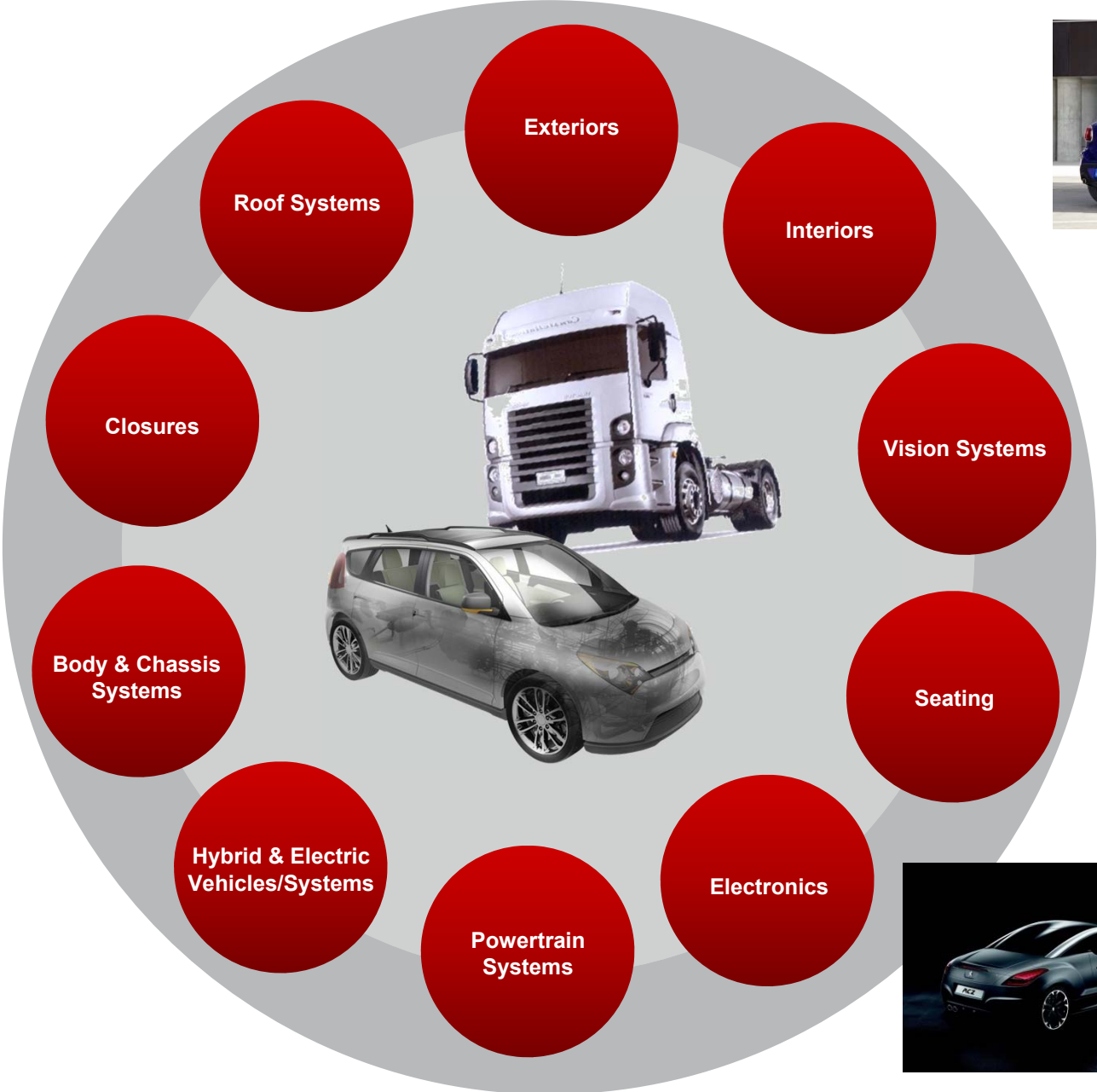# Exact Shape Models for Dip Painting Simulation and Isogeometric Analysis

M. Schifko, H. Riener

TERRIFIC Workshop

MAGNA's Global Product & Engineering Capabilities

- Exteriors
- Roof Systems
- Interiors
- Closures
- Vision Systems
- Body & Chassis Systems
- Seating
- Hybrid & Electric Vehicles/Systems
- Powertrain Systems
- Electronics

engineering + services

product systems

vehicle assembly

Dip Paint Simulation
CAE- Process

1. Data Preparation

MERGE software
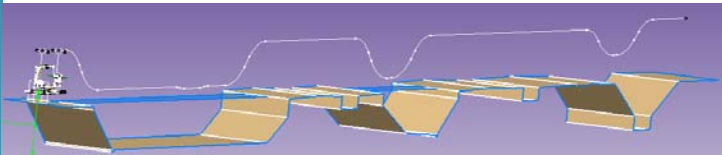FAST AUTOMATIC MERGE

- Triangular meshes
- BIW ~2000 parts
- Example: 1 hour
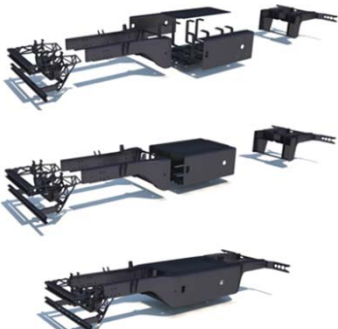
Example: Light Weight Frame

2. Get Paint Bath

- Place object on skid
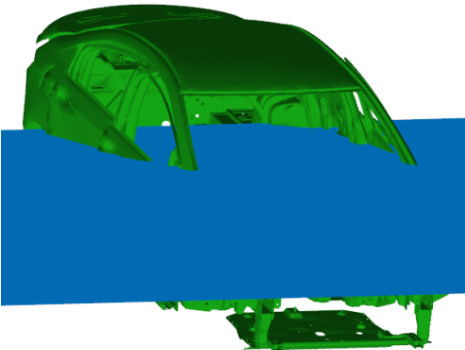- Run kinematic
- Get bath curve

3. Dip Paint Simulation
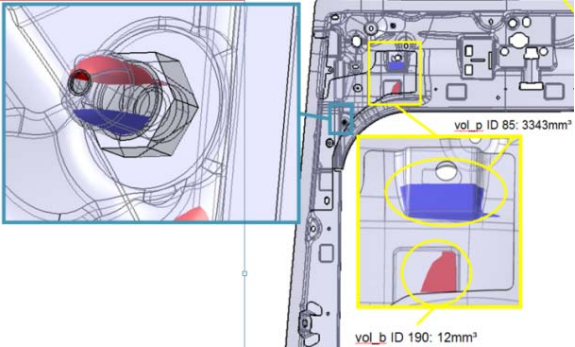
ALSIM software
DIP PAINT SIMULATION

- Load mesh
- Enter paint path
- Start Simulation

4. Reporting

- Detect Problem Areas and Causers
  - Gas bubbles
  - Liquid carry over
- 3D-PDF / Export CAD

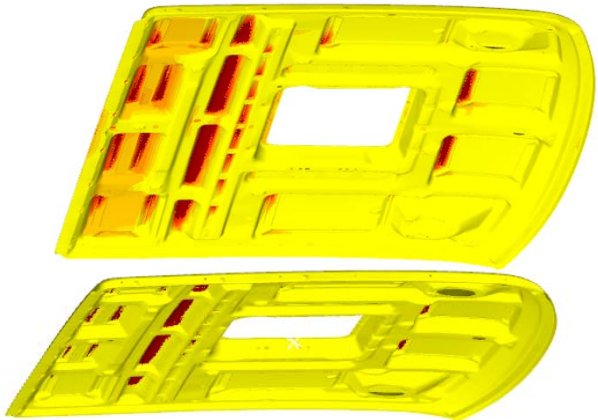vol_p ID 85: 3343mm³

vol_b ID 190: 12mm³

Enhancing Interoperability

5. Modification

- E.g. Additional hole
- E.g. Glue

Suggestion: Additional Hole
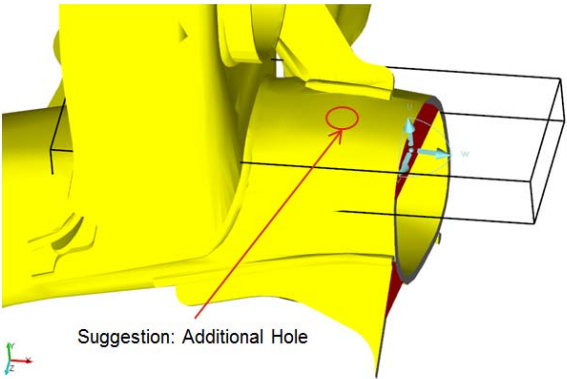
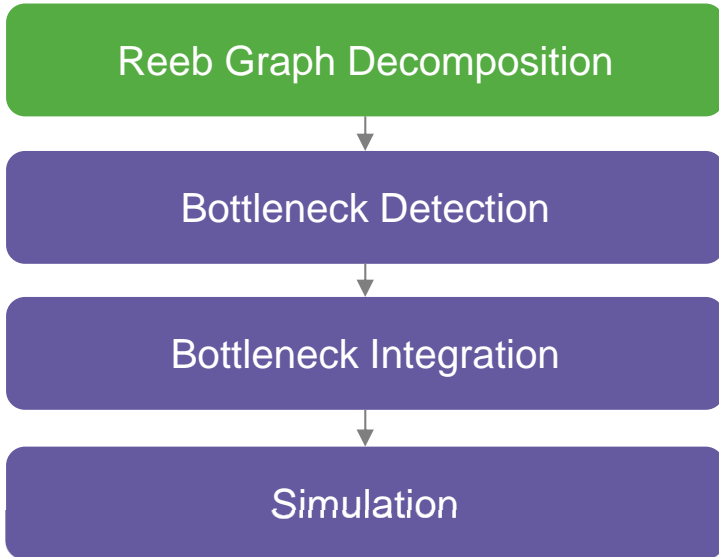## 6. Verification of changes by simulation

- Data Preparation
- Dip Paint Simulation
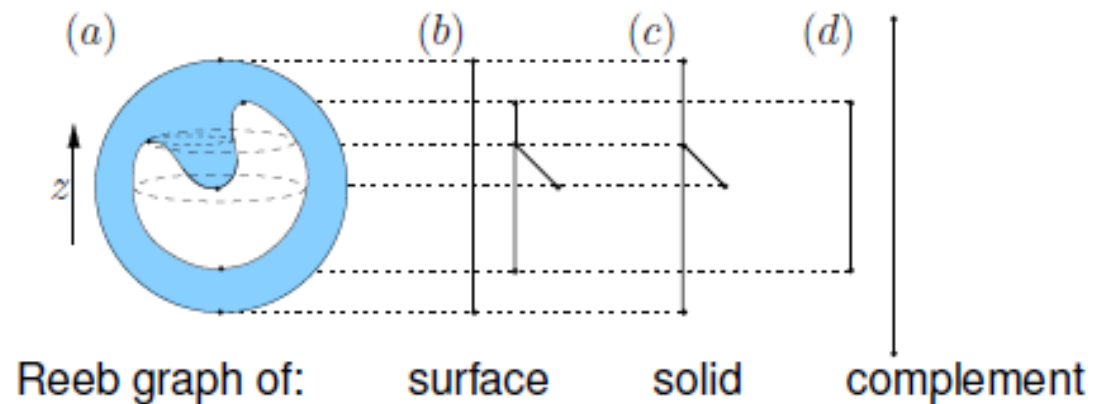- Reporting

Technique for
Volumetric Consideration (VoF)

Reeb Graph Decomposition

↓

Bottleneck Detection

↓

Bottleneck Integration

↓

Simulation

BIW consists of 1000-2000 meshes

- **Goal: Reduce Computation Time**
- **B-Reps (e.g. Δ -mesh)→ Volumina mesh by Reeb graph method**
- **e.g., entire car body ~8 000 elements**
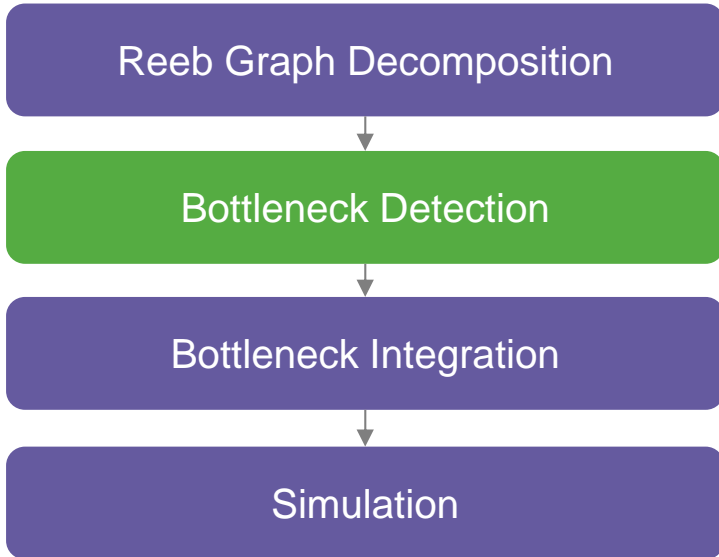- **tetrahedral mesh of entire car body 20 Million elements**

Different Reeb graphs for a solid

z

(a)   (b)   (c)   (d)

Reeb graph of: surface   solid   complement

Application
Fill & Drain Module

Reeb Graph Decomposition

↓

Bottleneck Detection

↓

Bottleneck Integration

↓

Simulation

- **Fill&Drain in time-domain**
- **Consideration of velocity trough narrow gaps (bottle necks)**
- **New distance field approach for detecting bottle necks**

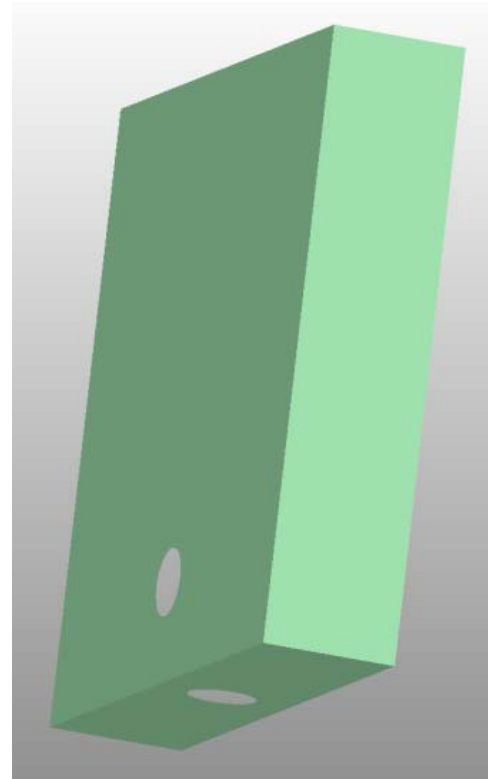TERRIFIC Demonstrator
showing bottlenecks
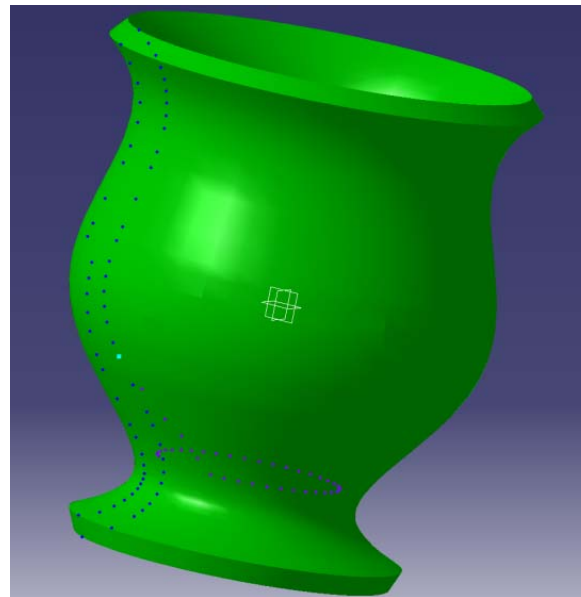
Starting from vertex

↓

Add neighbors to
distance field

↓

Distance to start vertex
is below a demand

↓

Self-intersecting
boundaries
of distance fields
= bottle neck

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SEVENTH FRAMEWORK
PROGRAMME

Application
Fill & Drain Module

Reeb Graph Decomposition

↓

Bottleneck Detection

↓

Bottleneck Integration

↓
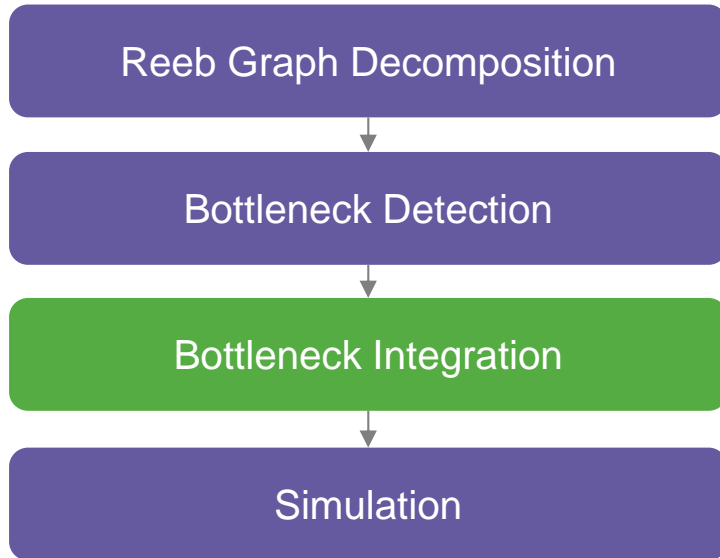
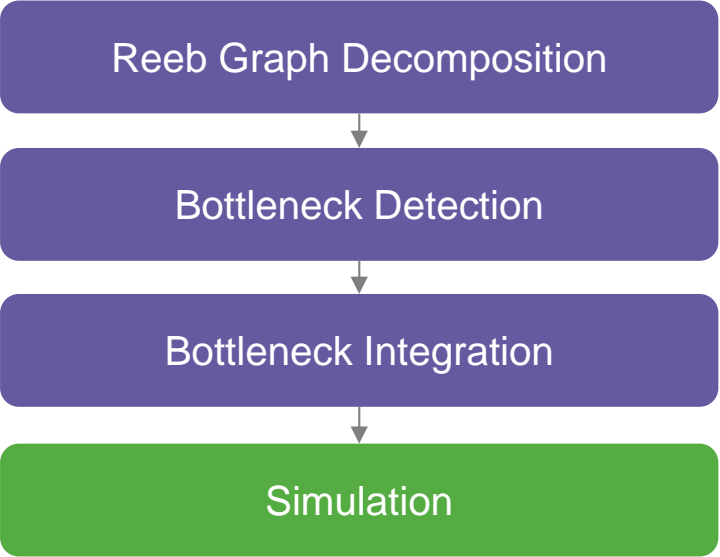Simulation

- **Integration of the bottle neck into the Reeb graph by assigning the borders of patches**

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SEVENTH FRAMEWORK
PROGRAMME

Dip Paint Simulation

- Reeb Graph Decomposition
- Bottleneck Detection
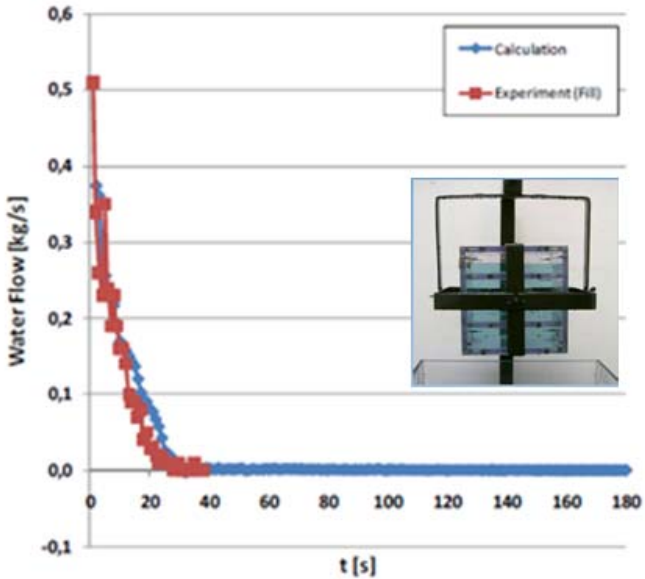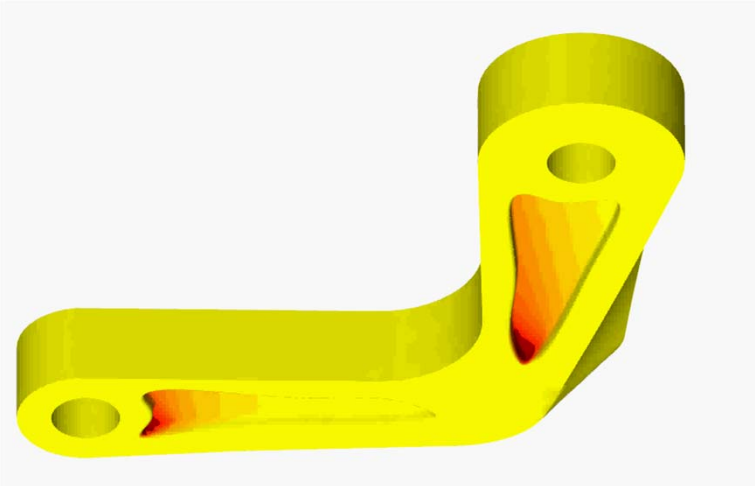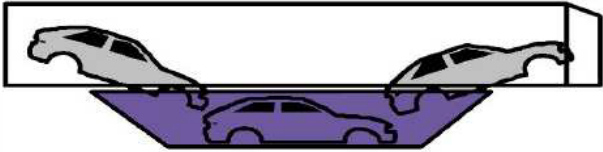- Bottleneck Integration
- Simulation

- **Bernoulli's Principles by considering**
  - *Pressure*
  - *Velocity*
  - *Time*
  - *Gravity*
  - *Density (constant for water and air)*
  - *Incompressibility*
  - *…*

TERRIFIC Demonstrator
liquid draining off

TERRIFIC Demonstrator
moving gas bubbles

Validation CUBE

Automatic segmentation of B-Rep solids into hexahedral volumes

CAD model reconstruction

Edge Graph Refinement

Segmentation

Multi-Patch NURBS volume parameterization ready for IGA simulation

1. Edge graph detection of TERRIFIC Demonstrator
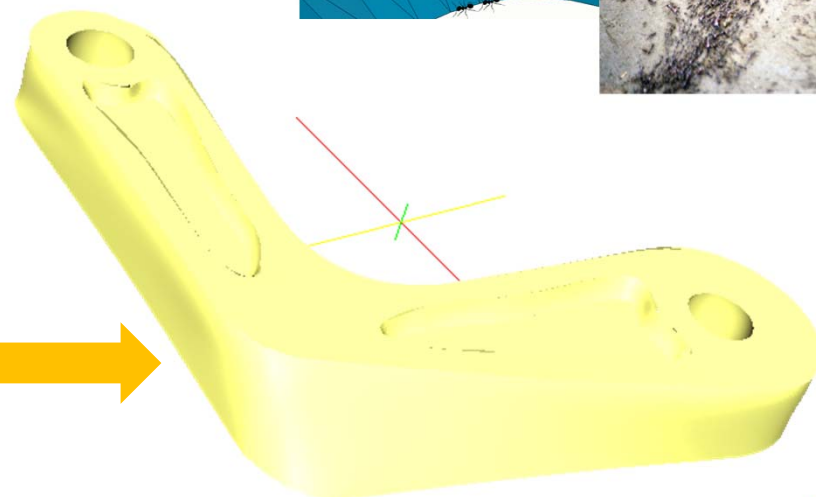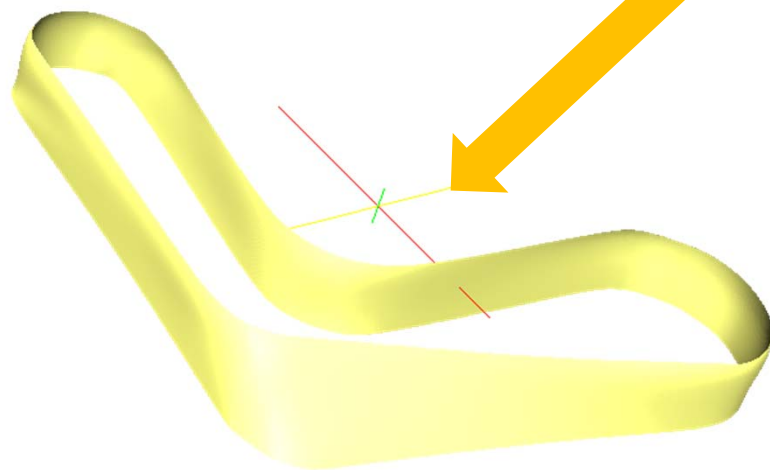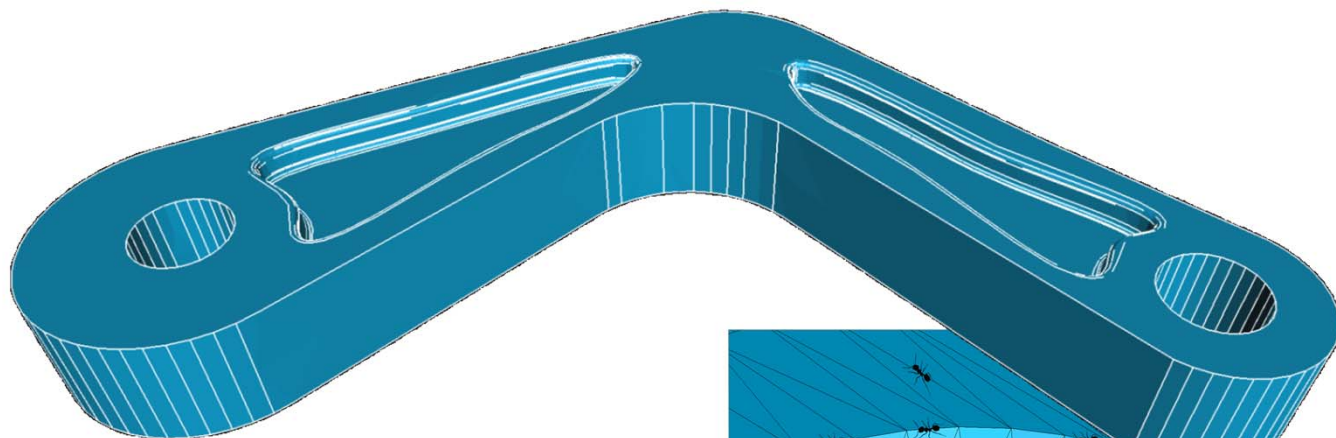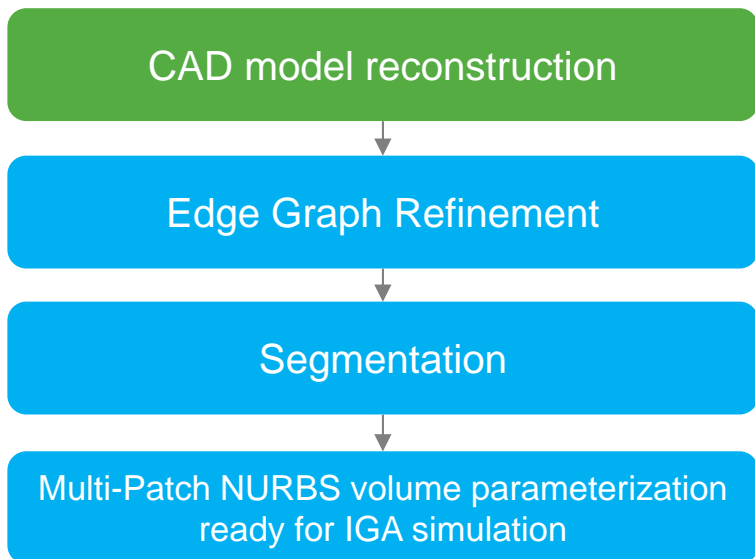
2. Outside face trimmed to one surface

3. Reconstructed CAD- model

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Enhancing Interoperability

SEVENTH FRAMEWORK
PROGRAMME

Automatic segmentation of B-Rep solids into hexahedral volumes

CAD model reconstruction

↓

Edge Graph Refinement

↓

Segmentation

↓

Multi-Patch NURBS volume parameterization ready for IGA simulation

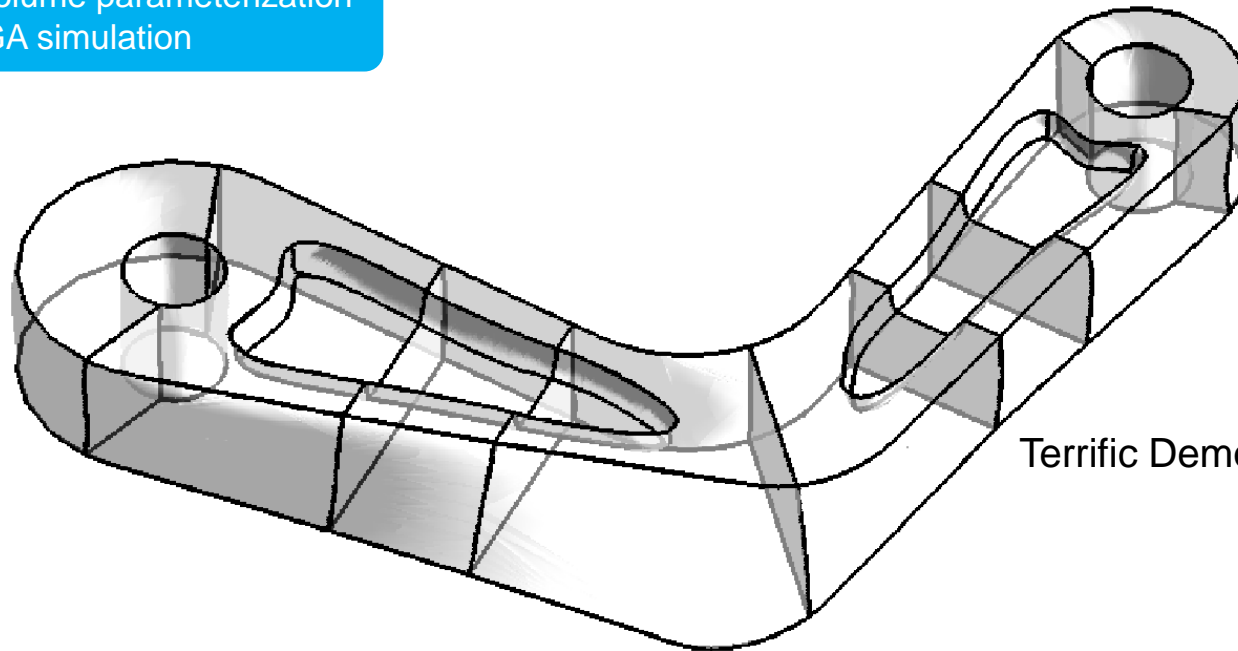- **Edge graph refinement**
- **Cutting into 3 vertex-connected pieces**

Terrific Demonstrator

TERRIFIC
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SEVENTH FRAMEWORK
PROGRAMME

Automatic segmentation of B-Rep solids into hexahedral volumes

- CAD model reconstruction
- Edge Graph Refinement
- **Segmentation**
- Multi-Patch NURBS volume parameterization ready for IGA simulation

- **Cutting into base solids**
- **Predefined segmentation into hexes**

Terrific Demonstrator

TERRIFIC
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SEVENTH FRAMEWORK
PROGRAMME

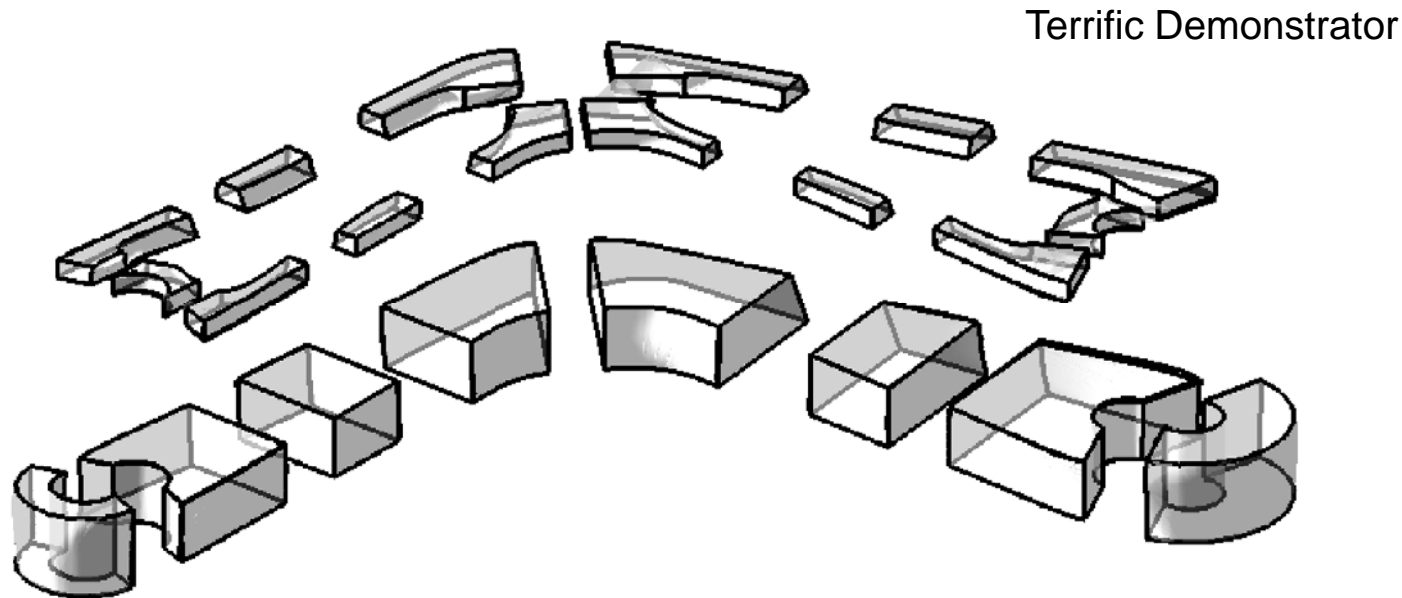# Automatic segmentation of B-Rep solids into hexahedral volumes
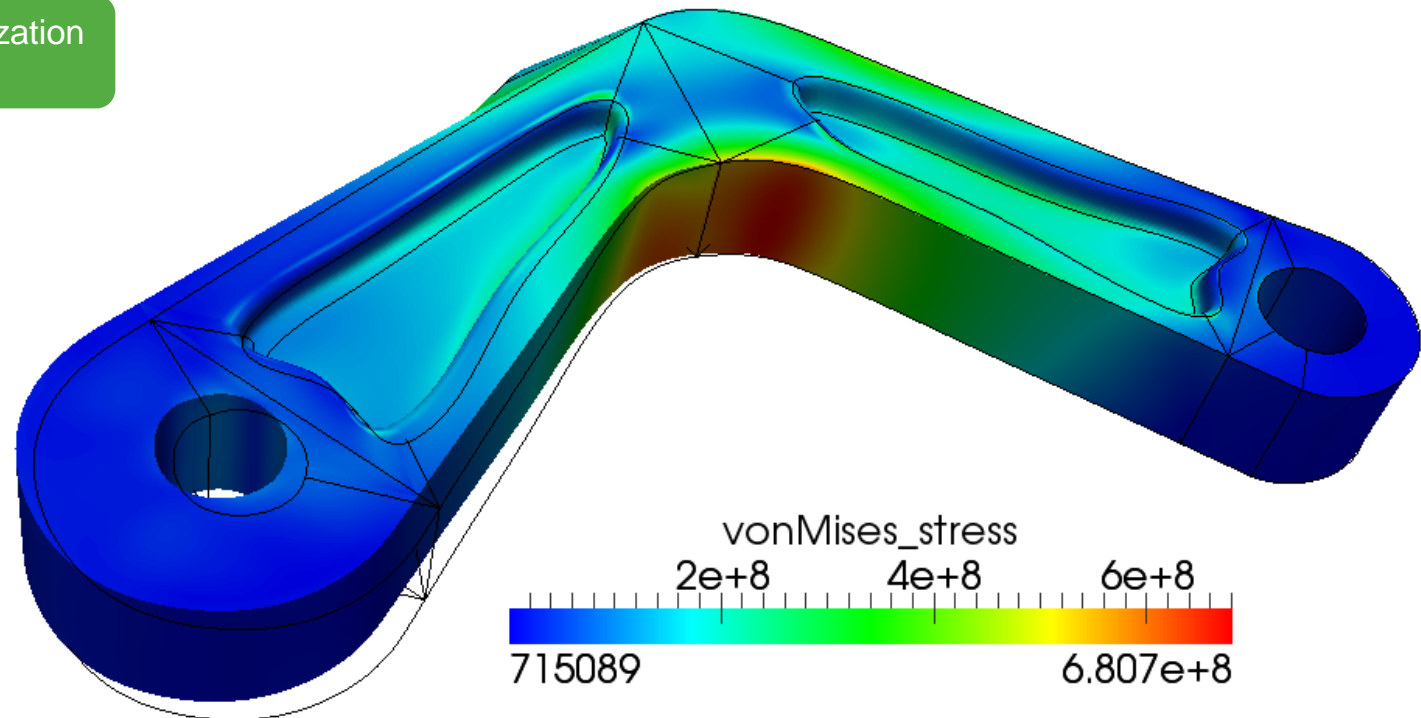
CAD model reconstruction

↓

Edge Graph Refinement

↓

Segmentation

↓

Multi-Patch NURBS volume parameterization ready for IGA simulation

- **Possible data export**
  - **Parasolid**
  - **SINTEF G2 format**

Terrific Demonstrator

vonMises_stress

2e+8   4e+8   6e+8

715089   6.807e+8

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SEVENTH FRAMEWORK PROGRAMME

Conclusion

CAD

B-Rep (Δ-mesh)

B-Rep Repair

Dip Paint Simulation

Reeb Graph Decomposition

Bottleneck Detection

Bottleneck Integration

Simulation

Automatic segmentation of B-Rep solids into hexahedral volumes

CAD model reconstruction

Edge Graph Refinement

Segmentation

Multi-Patch NURBS volume parameterization ready for IGA simulation

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SEVENTH FRAMEWORK
PROGRAMME
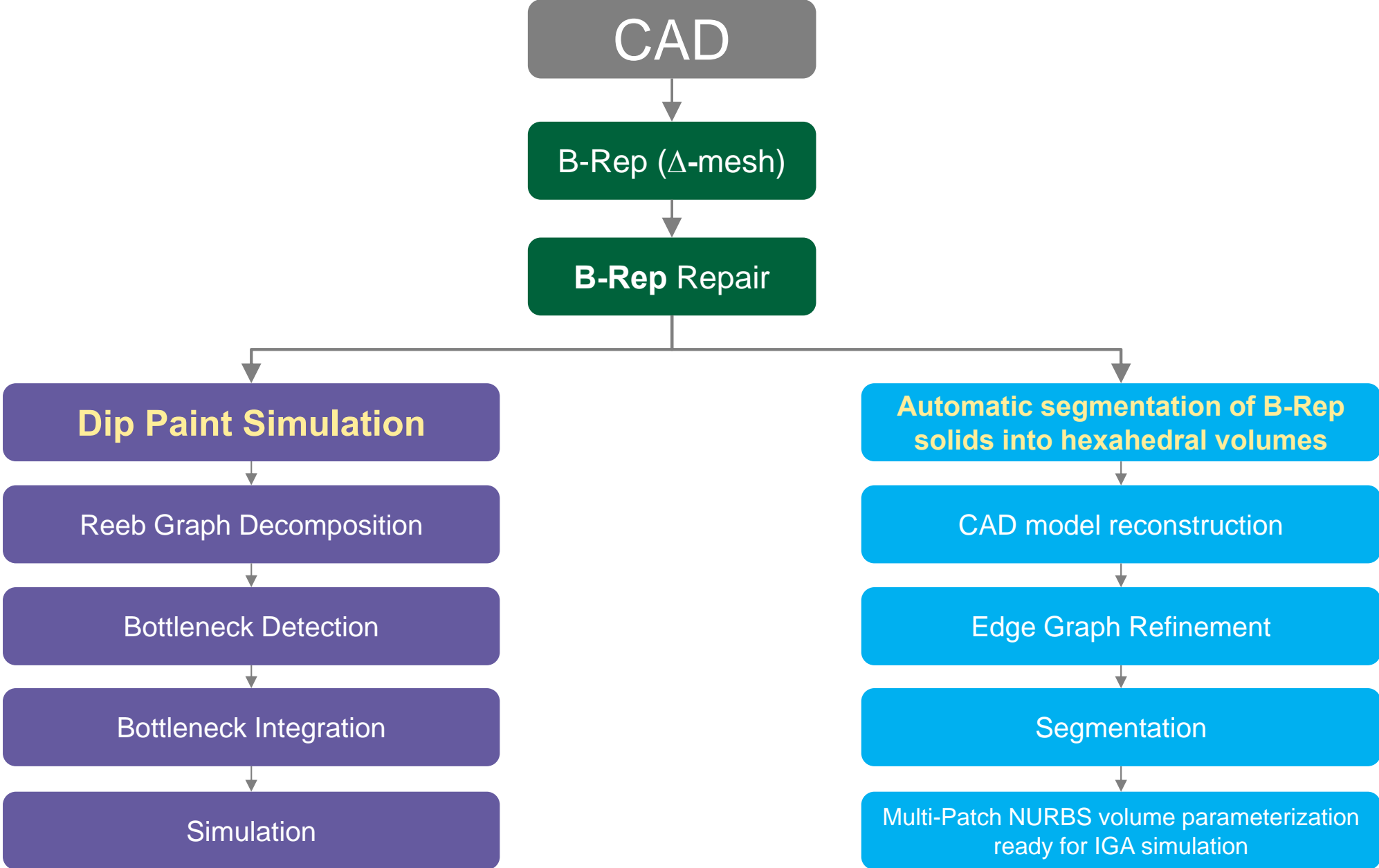
Thank you for your attention!

The future is ours to make.

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PROGRAMME