TERRIFIC

Towards Enhanced Integration of Design and Production in the Factory of the Future through Isogeometric Technologies

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www.terrific-project.eu

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European collaboration

The partners grouping is a well balanced mix of members coming from the contributing countries

SINTEF

Jotne

SIEMENS

Technische Universität Kaiserslautern

engineering center steyr

Johannes Kepler Universität Linz | JKU

TopSolid

Institut National de Recherche en Informatique et en Automatique | INRIA

AleniaAeronautica

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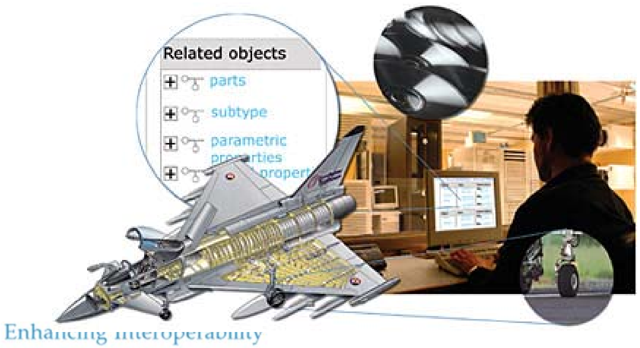
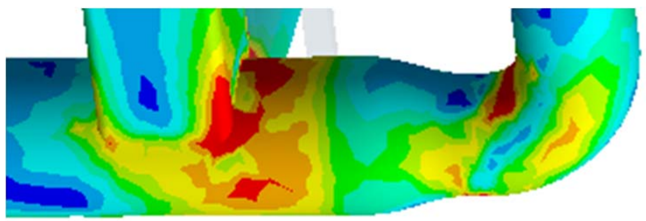
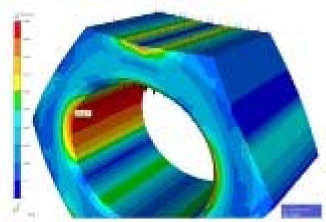
Our vision is to ....

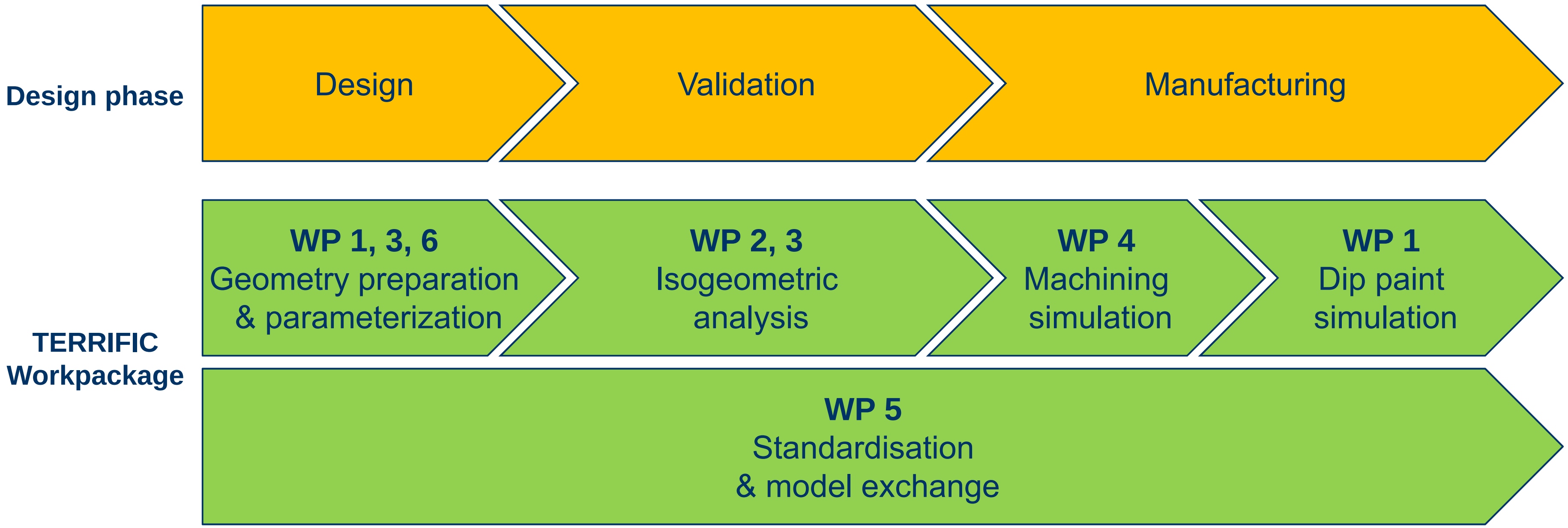
- provide and disseminate tangible evidence of the performance of the isogeometric approach in comparison to traditional ones in four important application areas as well as addressing interoperability and other issues that necessarily arise in a large-scale industrial introduction of isogeometry.





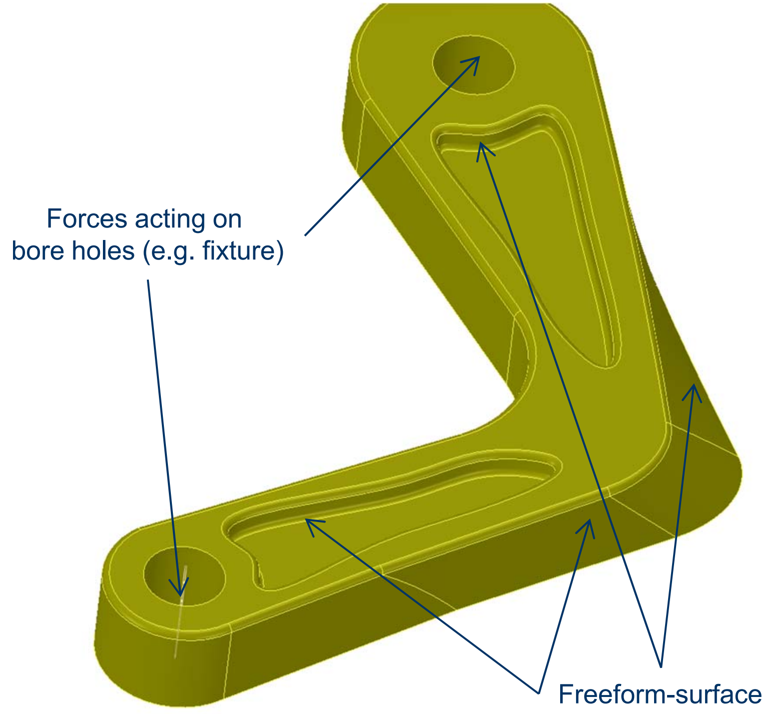


TERRIFIC WP‘s along manufacturing phases



Demonstrator Story

- A new mounting bracket has to be designed fulfilling geometrical space constraints. Further a limit on allowed stress is also given.
- The part is designed in CAD (considering guidelines necessary for IGA). Using this CAD-model a volumetric parametrization is done and finally an isogoemetric analysis (stress and eigenfrequencies) performed.
- The part is then manufactured demonstrating the capabilities of the isoparameterization of patches.
- In a last step a dip paint simulation for the final part is performed, showing advanced capabilities of dip-paint simulation software.



General design goal: part has to withstand a given mechanical load under geometrical constraints (available space & weight).

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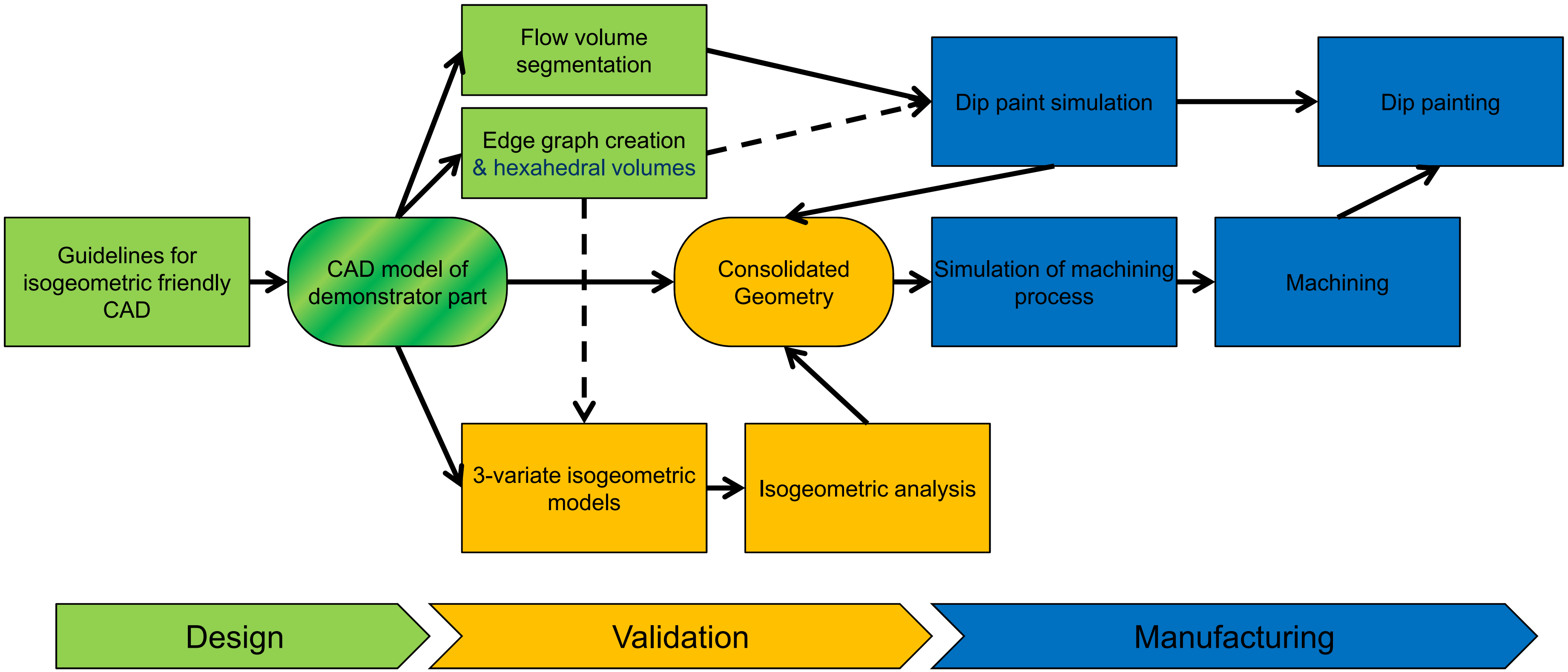
Solution modules and interconnection



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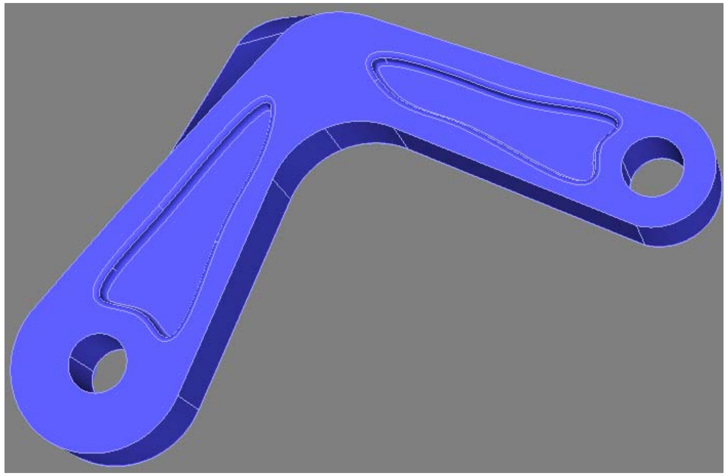
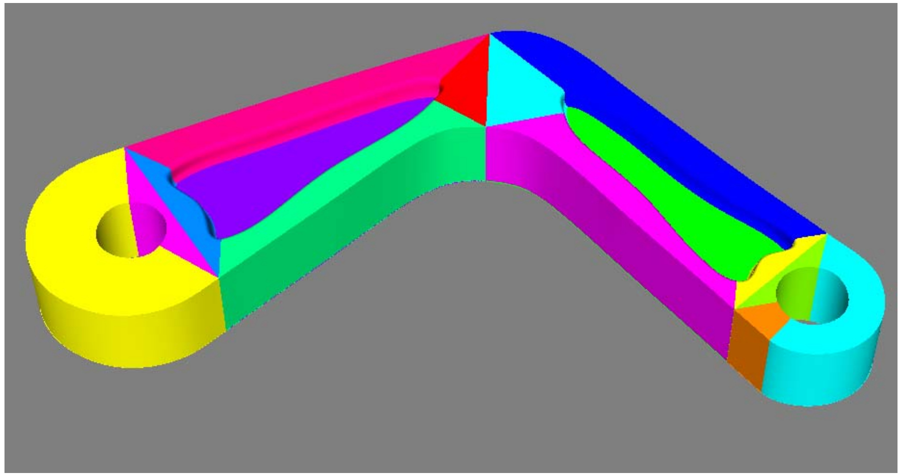
Creating an isogeometric model corresponding to demonstration part

- Aim: Given the demonstrator part in STEP format, create a model fit for isogeometric analysis
- That is: Transform the boundary represented CAD model with a number of trimmed surfaces to a trivariate block structured model with a minimum number of blocks. Each block is a non-trimmed NURBS volume. The blocks meet with exact C^0 continuity.



The initial boundary represented model with blends at the indentations



The current trivariate isogeometric model which has been used in the computations.

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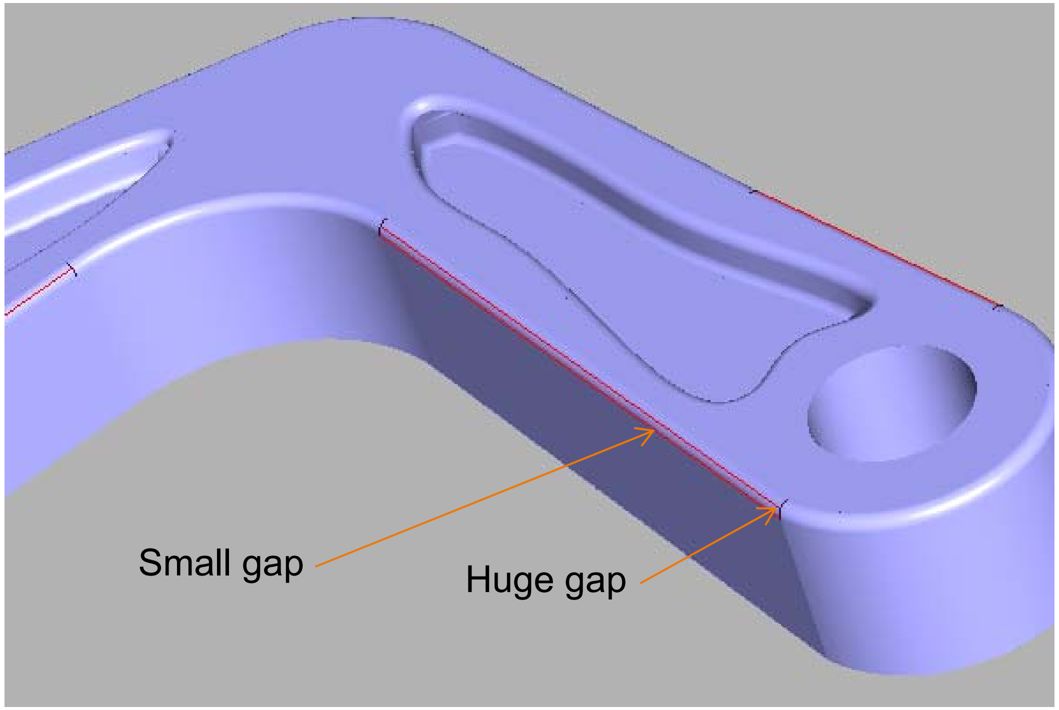
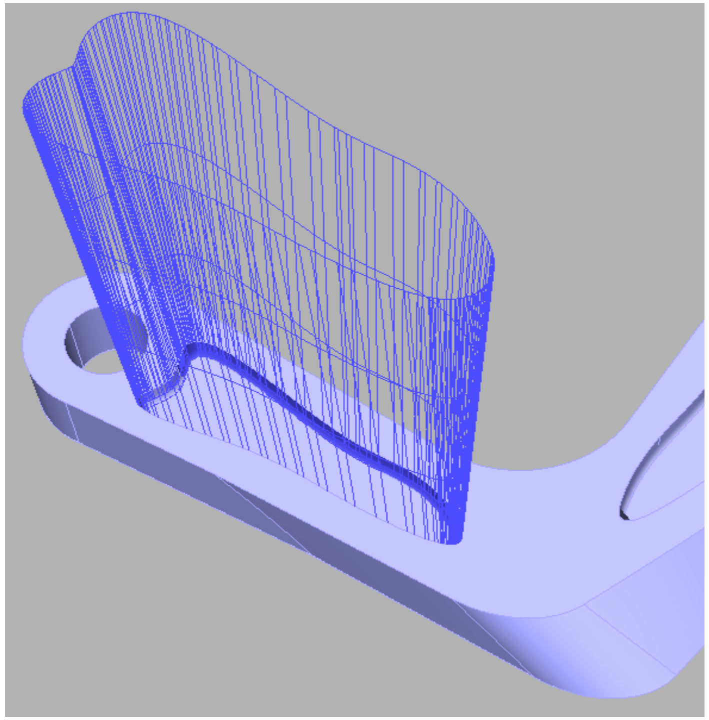
Isogeometric Preprocessing
Examples of quality issues



The first and most complex version of the part had large gaps in the outer blend. This version has not been pursued further due to these findings



Features of the input geometry, in this case the parameterization, has led to an initial preprocessing of the geometry and modified decisions in the remodeling process

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Isogeometric Preprocessing: Design guidelines

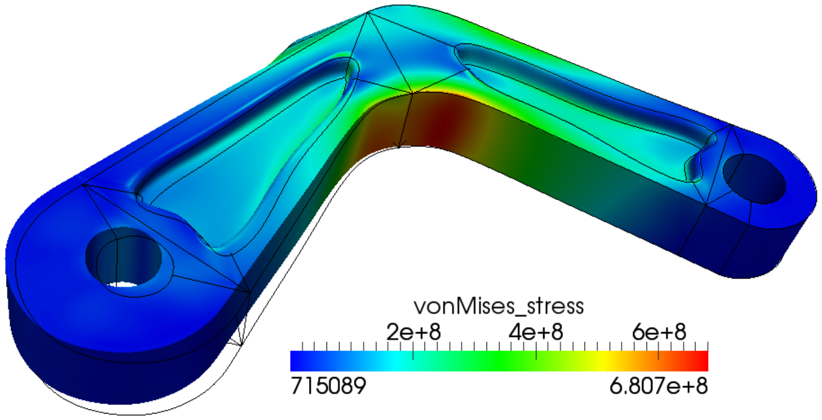
- General remarks
  - The design of isogeometric compatible models is a crucial point in the modeling-simulation process.
  - The introduction of unnecessary sophistications in the geometry parametrization can break the seamless interaction between modeling and analysis. In order to maintain the interaction between modeling and analysis a set of modeling guidelines were defined.
- Guidelines:
  - Trimmed surfaces are not analysis suitable.
  - Given a multipatch model, the control points describing inter patch boundaries, should match.
  - The format used to exchange geometry information should be a list of untrimmed isogeometric compatible entities.
  - The listed points correspond to sine qua non conditions for a natural design-analysis information exchange. More restrictive conditions could arise depending on specific applications of the model, for example conditions on map singularities, or conditions boundaries normal vectors.
- More care is needed for set-up of CAD model

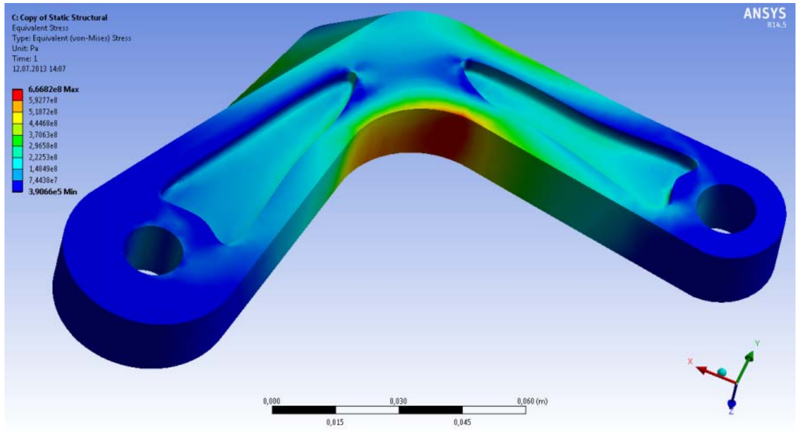
Mechanical analysis of demonstrator

- Task & actions:
  - Perform mechanical analysis of demonstrator part
  - Use isogeometric multi-patch finite element solver for linear elasticity
  - Analysis-suitable parameterization of geometry
  - Consider material parameters of the actual part
  - Compute deformations, stresses and eigenfrequencies
  - Validate results versus commercial software ANSYS

Mechanical analysis of demonstrator

- Results for linear static analysis:





IGA:
- 15 patches, 9 174 DOF
- u_max: 7.00 mm
- σ_max: 680.7 MPa

ANSYS:
- 104 602 elements, 144 744 nodes, 434 232 DOF
- u_max: 6.98 mm
- σ_max: 666.8 MPa

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Mechanical analysis of demonstrator

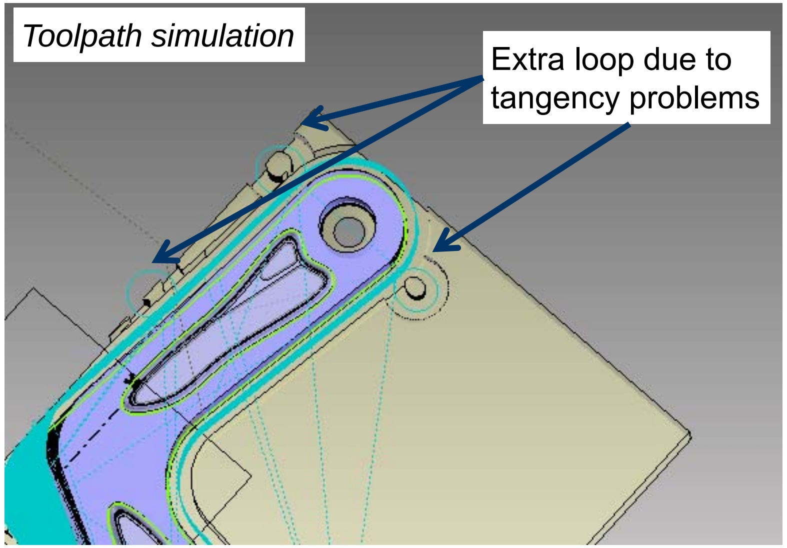
- Results for eigenfrequencies:

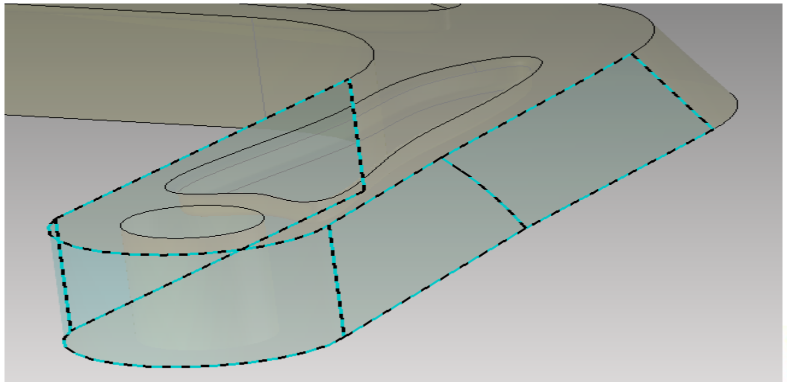
	k	1	2	3	4	5	6
IGA	f_k [Hz]	220.4	357.5	735.7	1223.2	2133.1	3337.9
FEM	f_k [Hz]	219.5	356.4	732.3	1221.2	2127.8	3340.0
	dev. [%]	0.42	0.31	0.46	0.16	0.25	0.06

- Summary of results:
  - Isogeometric multi-patch solver for structural mechanics was successfully applied to an industrial problem with challenging geometry
  - Very good agreement of IGA and ANSYS results for linear static and eigenfrequency computations

Isogeometric machining

- Current geometry description by STEP accounts for several inconsistencies during machining
  - Tangency problems
  - Gaps in surface description can lead to tool breaks
- Computing & Replacing surfaces
  - Analysis
    - Curvatures
    - Visualization ZEBRA Mode
    - Isoparametric Curves
    - Comparison with initial surfaces
  - Visual tests
    - Zebra Mode
    - Realistic rendering
  - Machining
    - Toolpath
    - On the Machine





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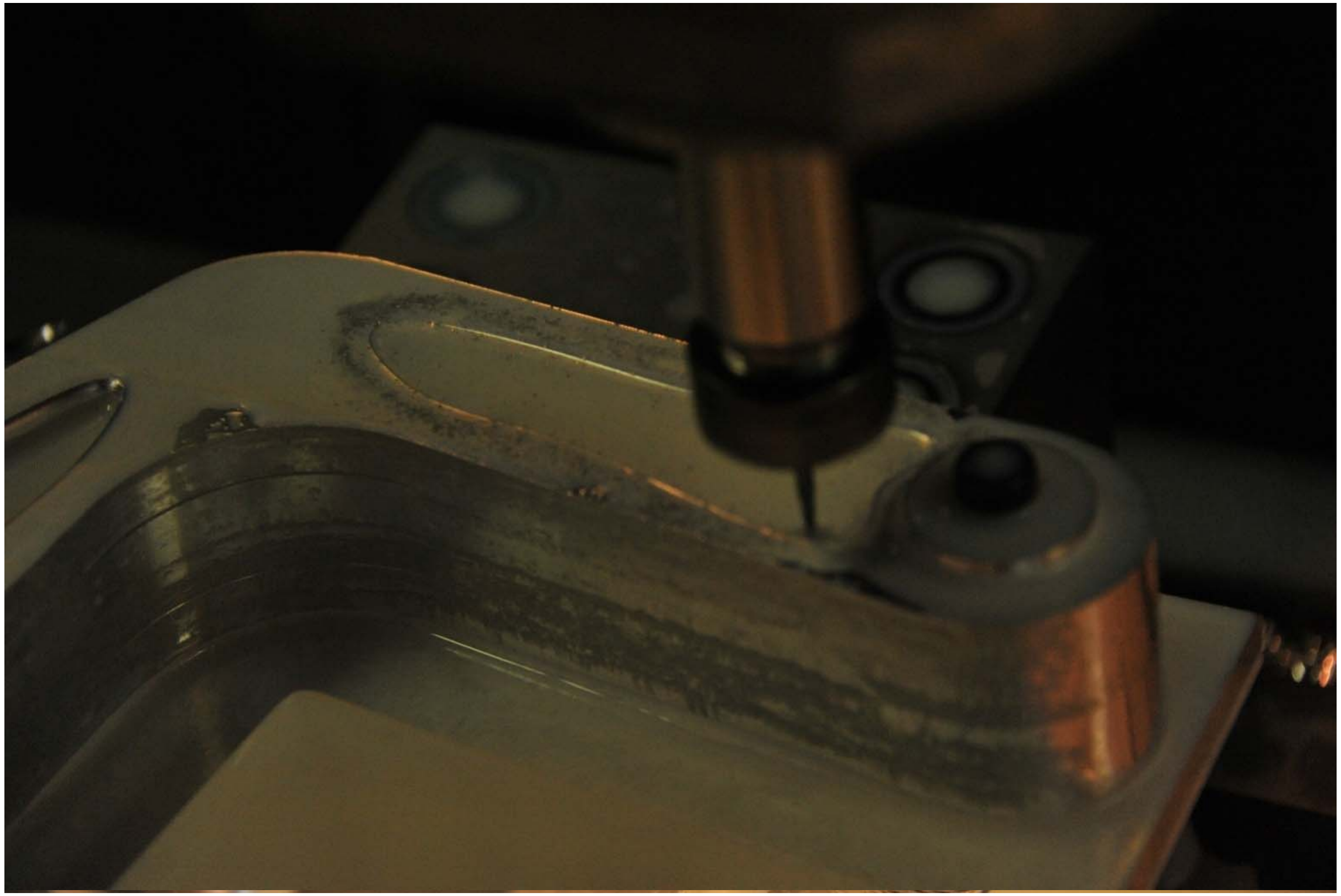
Machining



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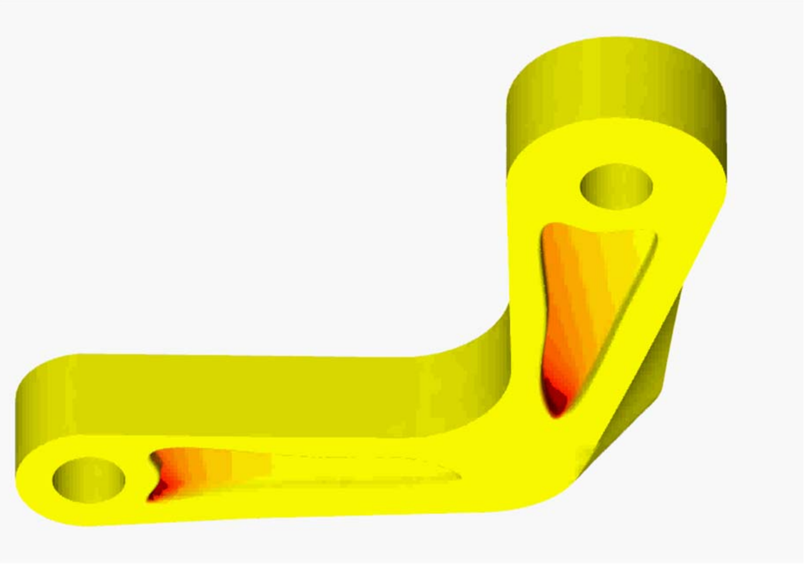
Dip Paint Simulation of demonstrator

- Tasks & actions:
  - Perform dip paint simulation of demonstrator part
  - Use triangular boundary representation as input
  - Perform the volumetric representation (using Reeb Graphs for flow path calculations)
  - Perform the simulation (prototype)



Dipping in

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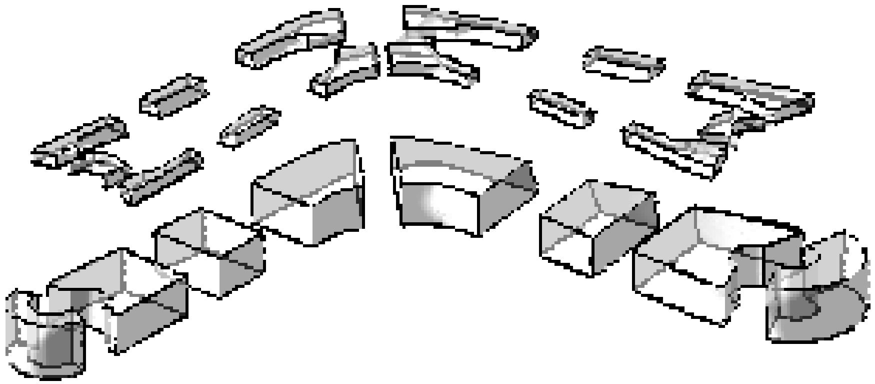
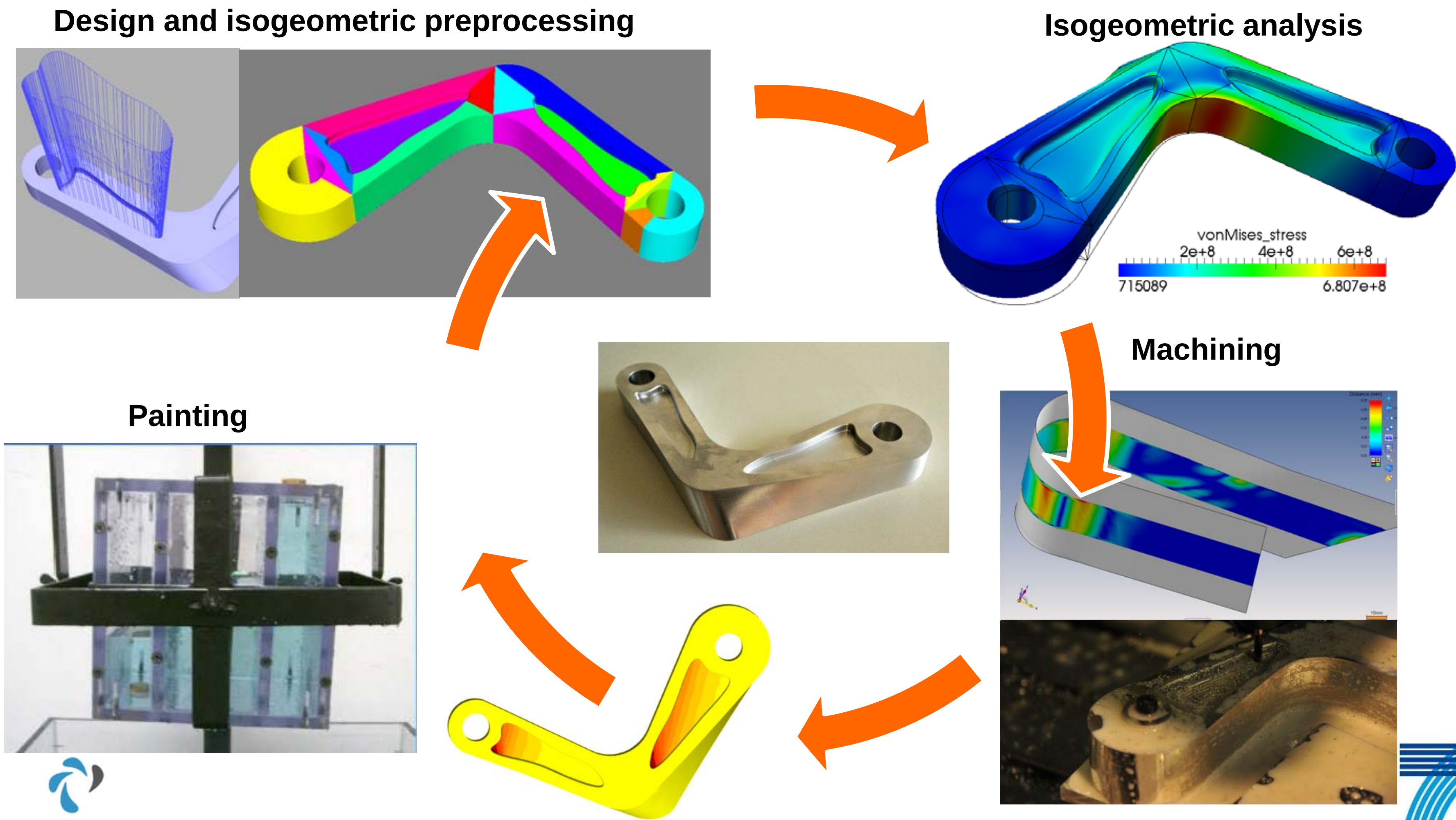
Dip Paint Simulation of demonstrator

- Summary of results:
  - Application:
    - Prototype works for demonstration part
    - Flow paths visualization is currently not available
    - Very good accuracy with reality
  - Simulation Techniques:
    - Feature detection and isogeometric segmentation used as preprocessing for isogeometric analysis



TERRIFIC:Integrated description allows seamless workflow



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