Geometry related research and associated challenges

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Introduction

- Geometry related research
  - Simulation Intent
  - Generating efficient meshes using geometric reasoning
  - CAD features and parameterisation
- Issues that occur

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Computer-Aided Design

- Objective: support the use of a feature based CAD system
  - e.g. Siemens NX, Catia V5 (MCAD systems)
- Parameters are those which control the features in the CAD model's feature tree
- All our approaches aim to keep the feature history intact throughout
  - For many this is the model's "design intent"

Simulation Intent

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Simulation intent

Capturing high-level modelling and idealisation decisions to create a fit-for-purpose analyses

Cellular modelling

Equivalencing

Virtual Topology

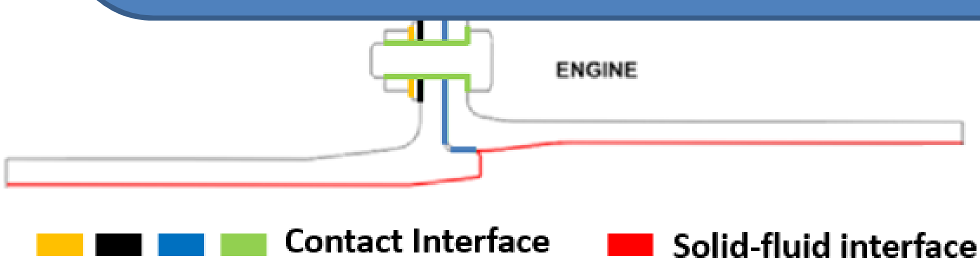
Cellular modelling

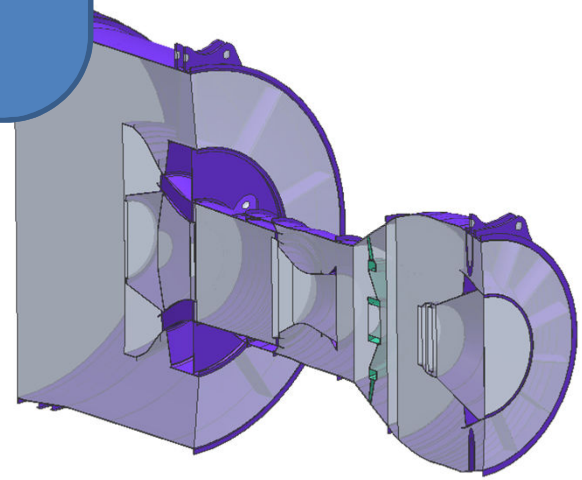
- Space divided into a non-manifold assembly of analysis “significant” cells
- R analyses
- In ht

Challenges:

-Creating the non-manifold model of space

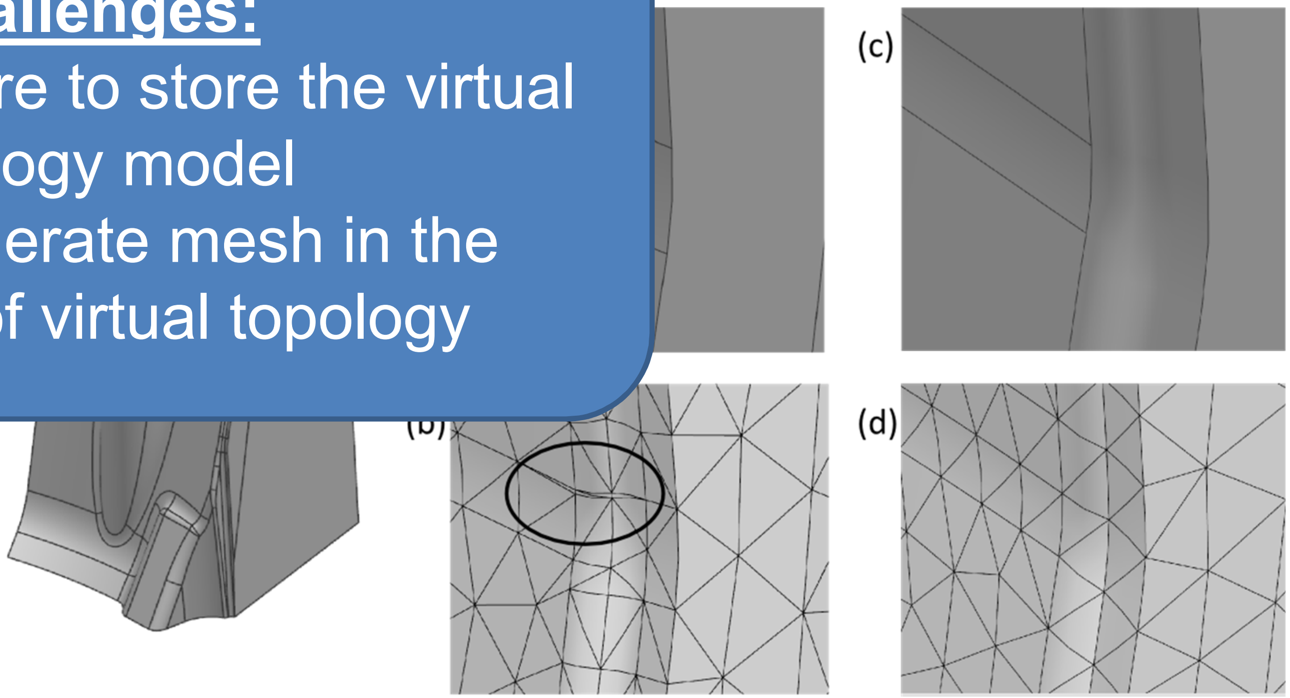
-Keeping a non-manifold version of the model alongside the version in the CAD system





Virtual topology

- Defining the topology of an analysis model using operations on the topology of the original CAD model
  - No change in the underlying CAD model
  - …me CAD model



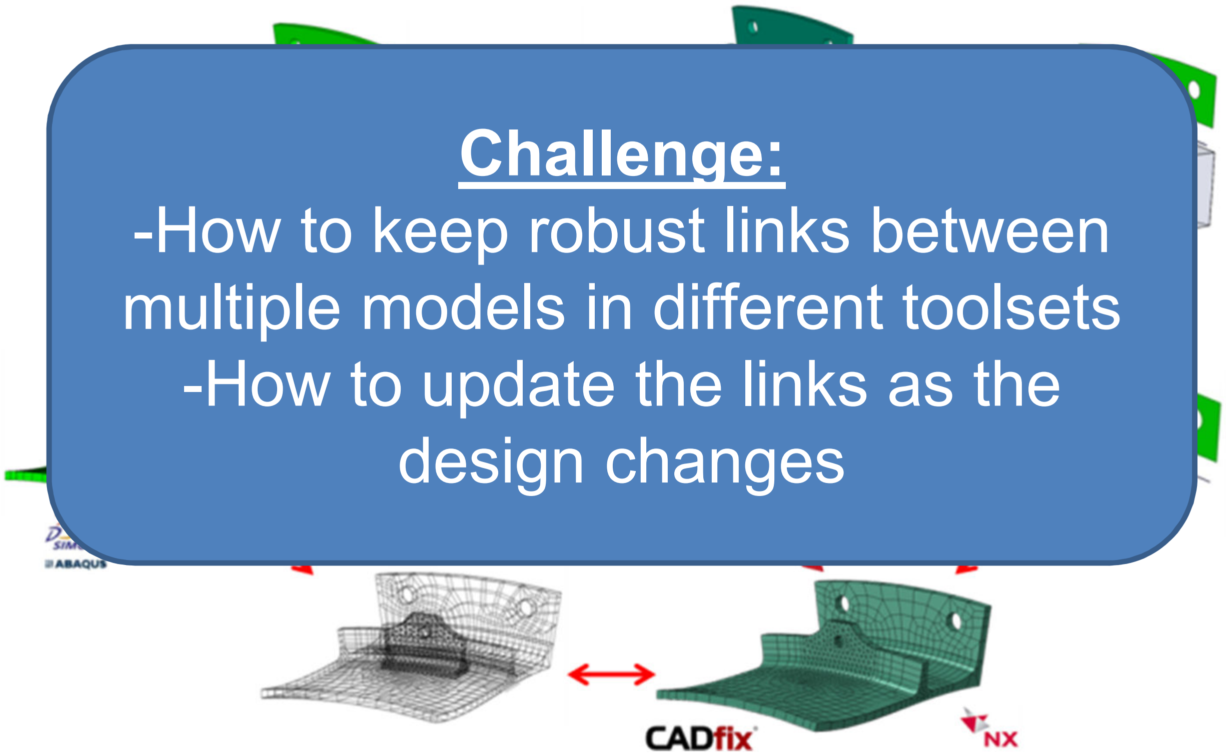
Challenges:

-How and where to store the virtual topology model

-How to generate mesh in the presence of virtual topology

Equivalencing

- Capturing how different CAD and analysis models represent the same regions of space (cells in the cellular model)



Challenge:

-How to keep robust links between multiple models in different toolsets

-How to update the links as the design changes

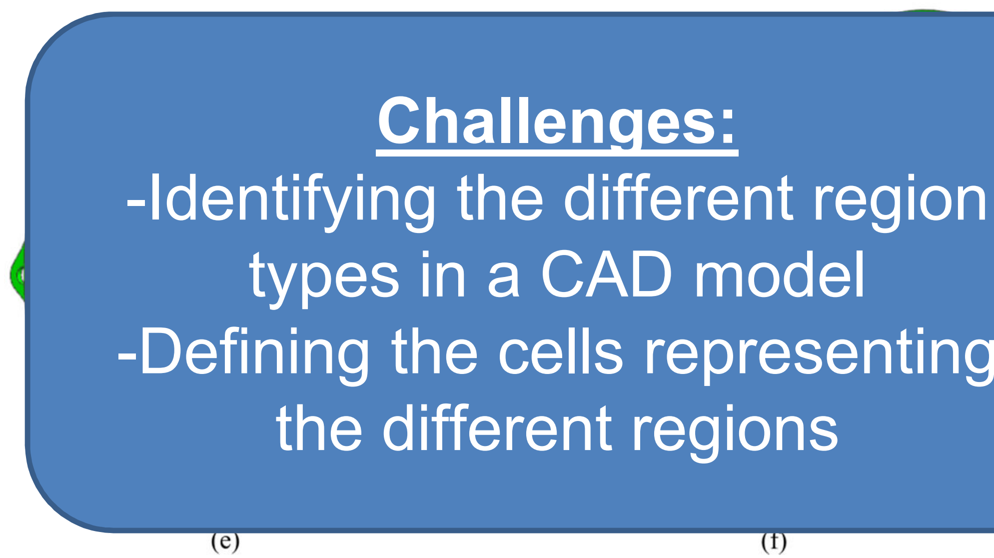
Simulation Intent

- So far we have:
  - Used the Parasolid kernel directly to compute all cells for a CAD model (solid and void)
  - Stored the cellular model in a relational database
  - Linked the NX CAD model to the Parasolid model
  - Used to database to implement and store virtual topology operations
  - Associated numerous analysis models with different combinations of cells

Generating efficient meshes using geometric reasoning

Geometric reasoning

- Match element shape to the geometry
- Decompose a model into:
  - Thin sheet regions
  - Long slender regions
  - Residual regions

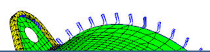


Challenges:
-Identifying the different region types in a CAD model
-Defining the cells representing the different regions

Generating efficient meshes

Dimensional Reduction

- Shell elements & thickness
- Beam elements & attributes
- Tet elements/point mass plus attributes



Sweep meshing

- Hex or wedge elements which are much larger laterally than they are thick
- Hex or wedge elements which are much longer along their length
- elements

Challenges:

-Dimensionally reducing thin-sheet and long slender regions

-Automatically calculating attributes

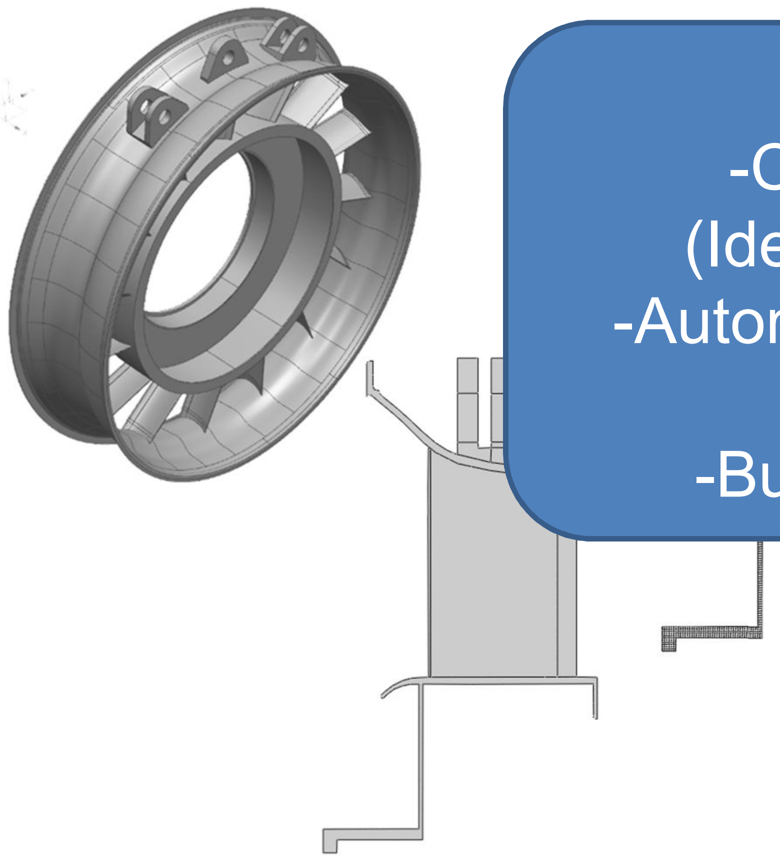
-Building contiguous meshes

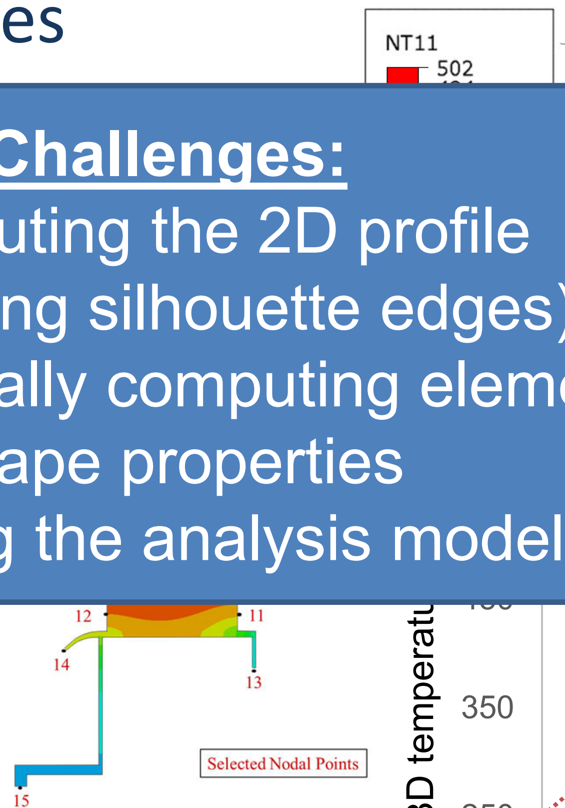
-Efficiently meshing residual regions

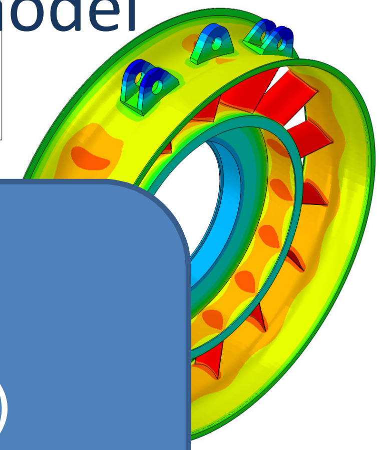
- So far we can:
  - Identify thin sheets using face pairs
  - Identify long slender regions using topologically connected loops of “4 sided” wall faces
  - Identify residual regions which are sweep meshable

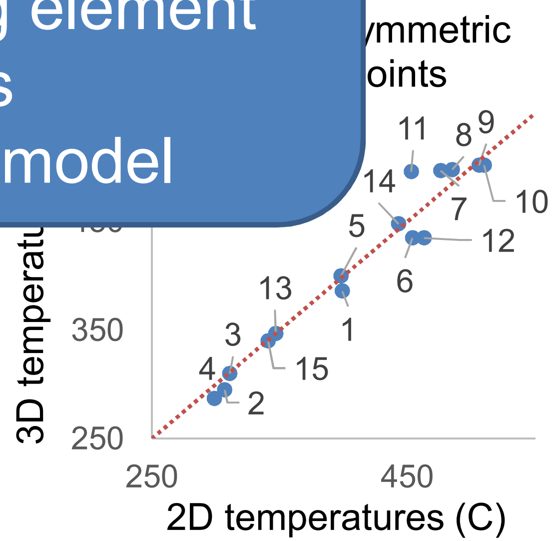
Quasi-axisymmetric models – dimensional reduction

- Automatically reduce to an axisymmetric model
- Calculate shape properties







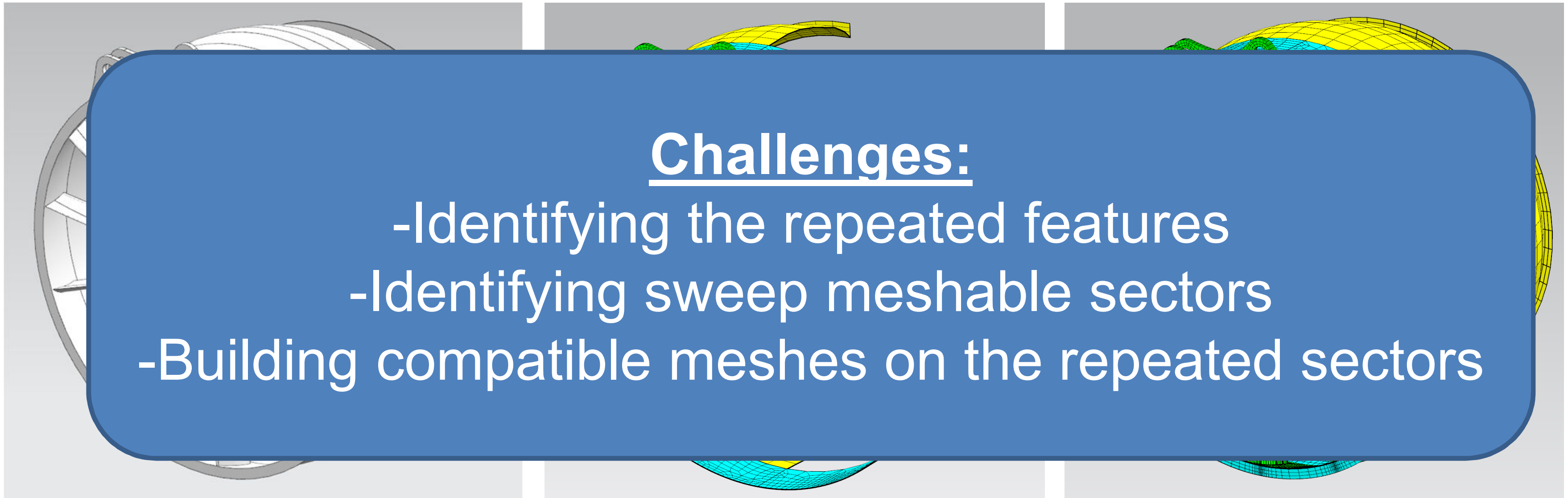


Challenges:

-Computing the 2D profile
(Identifying silhouette edges)
-Automatically computing element shape properties
-Building the analysis model

Quasi-axisymmetric models – identifying repeated sectors

- Identify the minimum number of repeated sectors in the model
- Identify efficient meshing strategies for the repeated features



Challenges:

-Identifying the repeated features

-Identifying sweep meshable sectors

-Building compatible meshes on the repeated sectors

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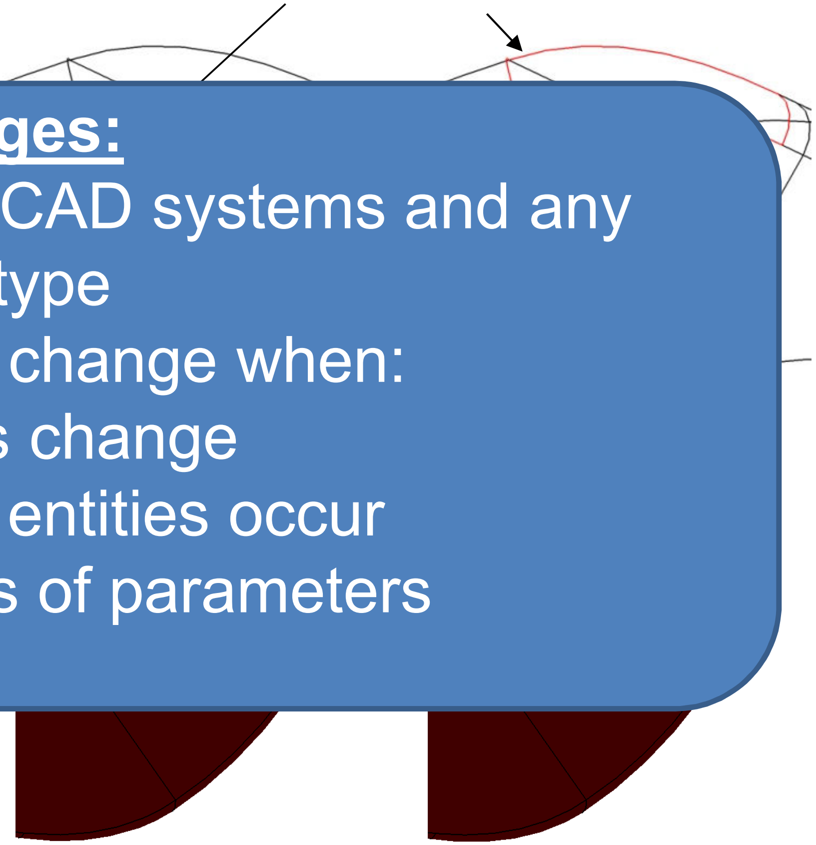
CAD features and parameterisation

Design velocity

- A measure of boundary movement caused by a parameter change



Challenges:

- We want to use different CAD systems and any feature type

-Measuring shape change when:

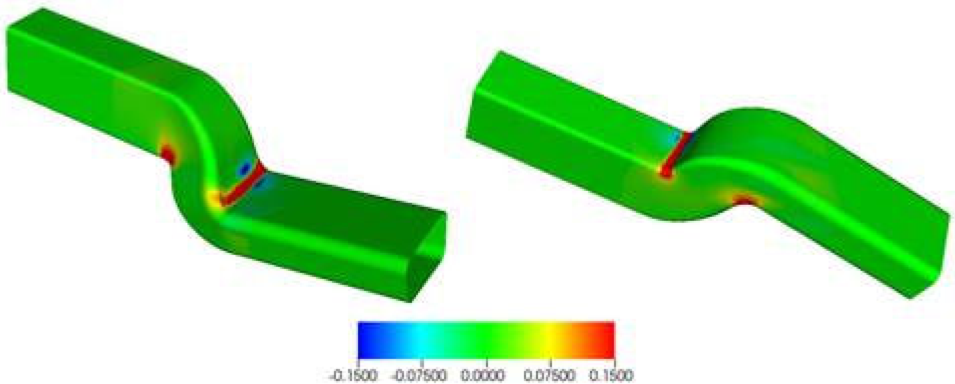
>Face labels change

>New topological entities occur

>Models with 1000s of parameters

Adjoint analysis

- Provides a prediction of the change in performance which occurs if the model boundary is moved



- Coupled design velocity and adjoint sensitivity can be used for optimisation

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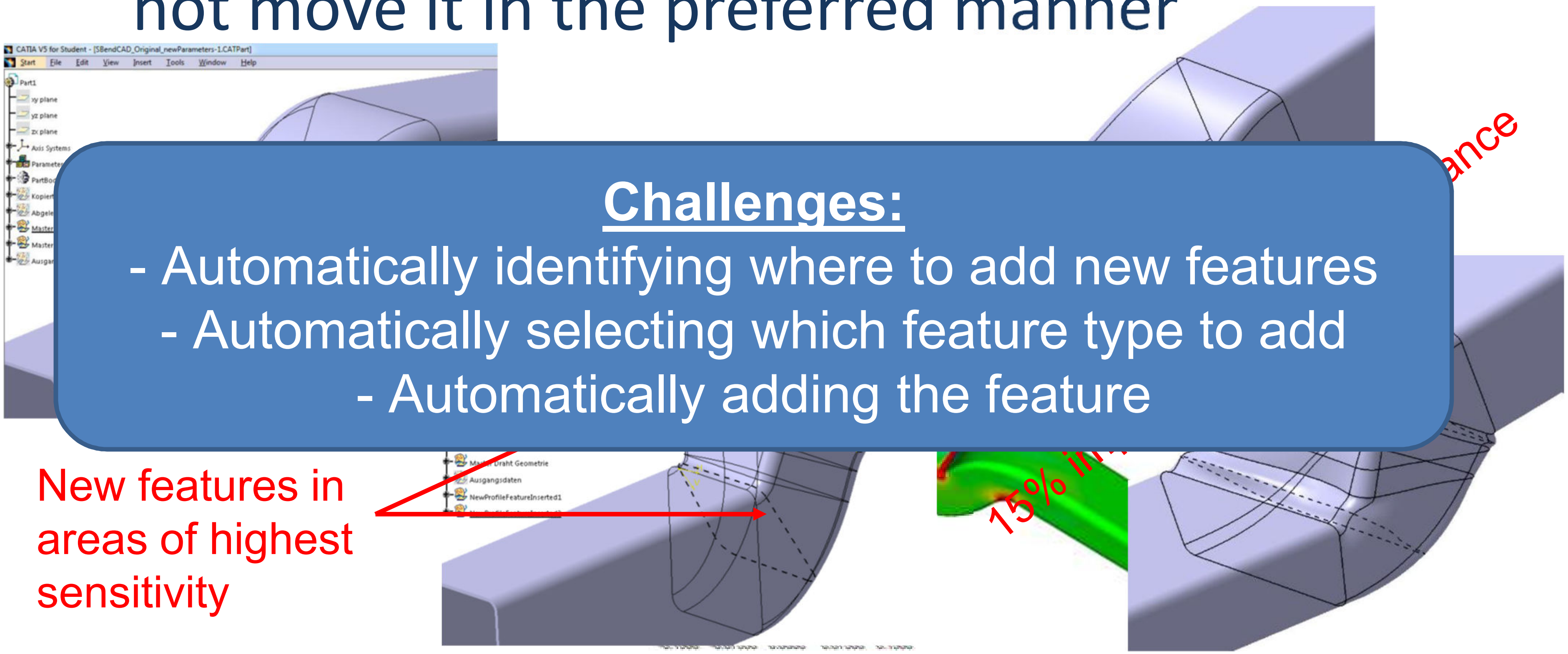
Updating the CAD model

- Can adjoint information be used to update the features in the CAD model if existing ones do not move it in the preferred manner



Challenges:

- Automatically identifying where to add new features
- Automatically selecting which feature type to add
- Automatically adding the feature

New features in areas of highest sensitivity

What has been achieved?

- Developed CAD system independent geometrical and topological cellular representations
- Linked CAD and CAE models
  - manifold and non-manifold representations, geometry idealisations, parameters and boundary movement
- Reduced reliance on hard geometric decompositions

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What is needed?

- Models with automatic parameterisation updating
- Robust automatic decomposition and meshing tools
- Analysis model updates linked to design changes
- Meshing in presence of virtual topology operations

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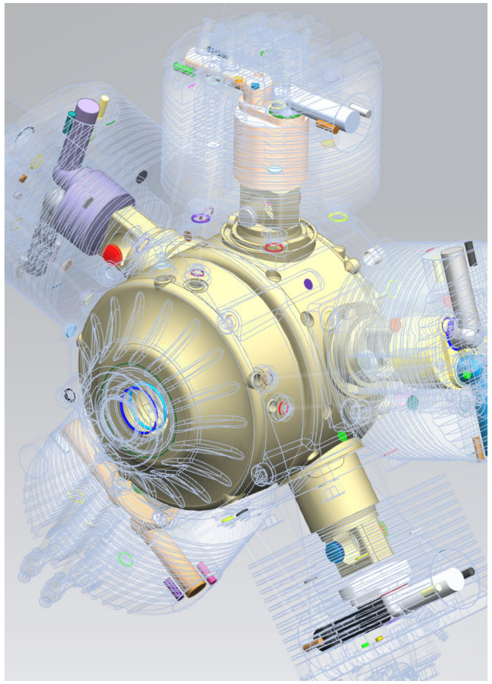
ECCOMAS

ECCM – ECFD 2018

6th European Conference on Computational Mechanics (Solids, Structures and Coupled Problems) ECCM 6

7th European Conference on Computational Fluid Dynamics ECFD 7

June 11- 15, 2018, Glasgow, UK



Minisymposia MS194

NEXT GENERATION DIGITAL MOCK-UPS FOR MULTI-PHYSICS SIMULATION

- FE pre-processing techniques
- CAD-CAE integration
- Assembly modelling