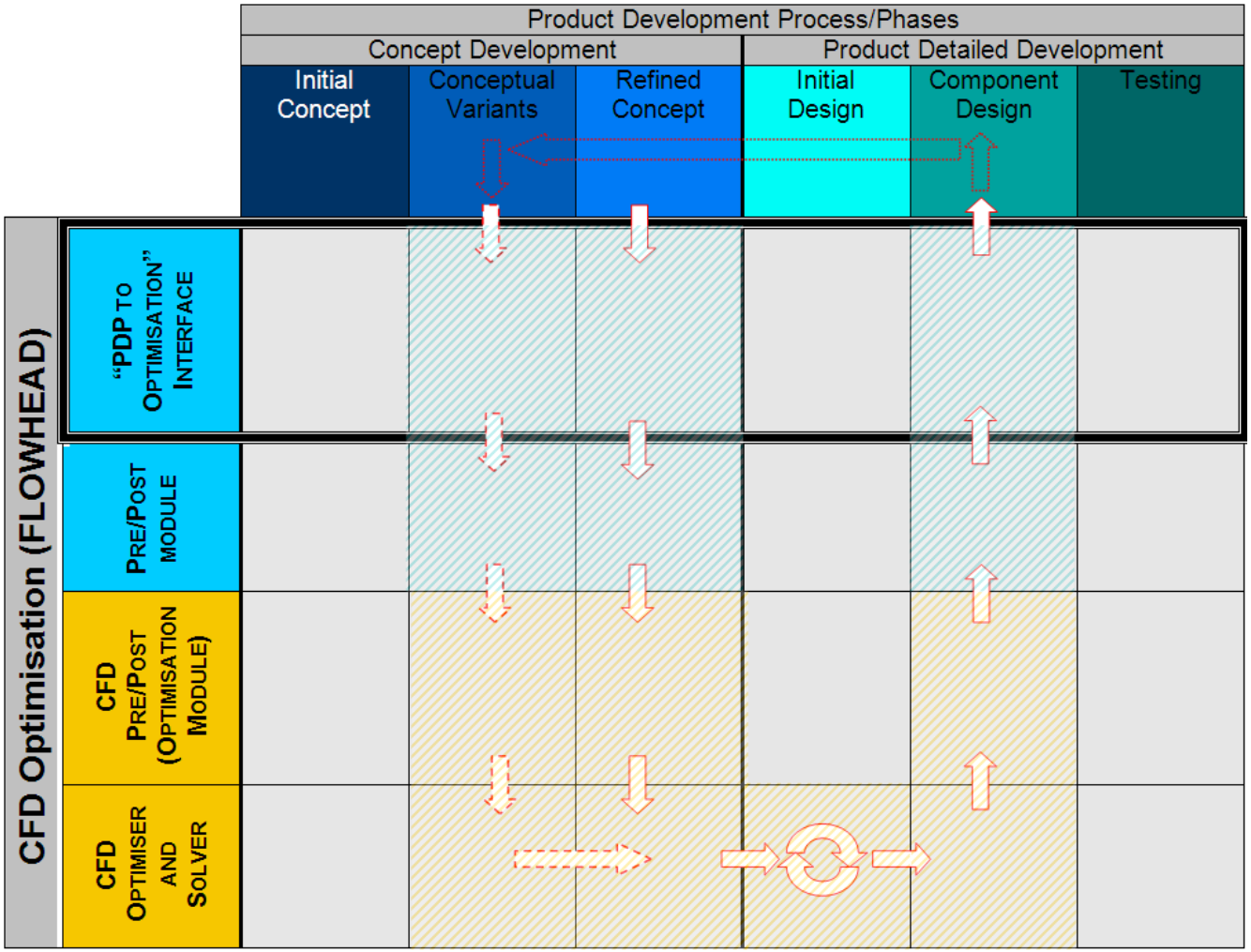
Conference on Industrial Design Optimisation for Fluid Flow
Munich, 28-29 March 2012

Interfacing of optimisation workflows with the product development process

Prof. Dr. Eng. Georgi Todorov, Dr. Eng. Konstantin Kamberov
3Clab, Technical University of Sofia

Existing automotive industry PDPs analysis

- **PDPs and CFD optimisation (FLOWHEAD) – embedding of workflows**



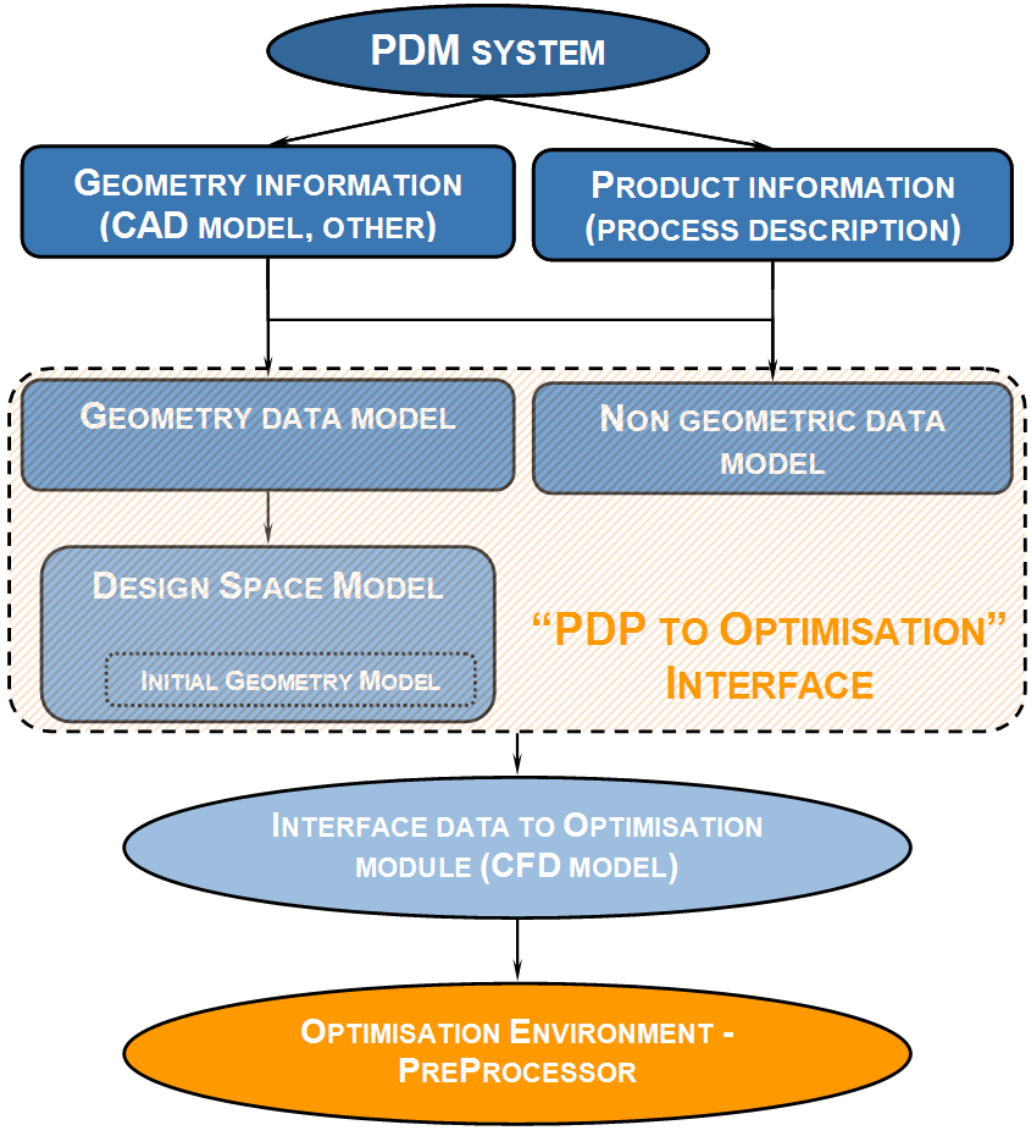
Existing automotive industry PDPs analysis

Two main interfaces:

- **PDM to CAD/SDM Model;**
- **CAD/SDM to CFD Model.**

Two types of information is transferred:

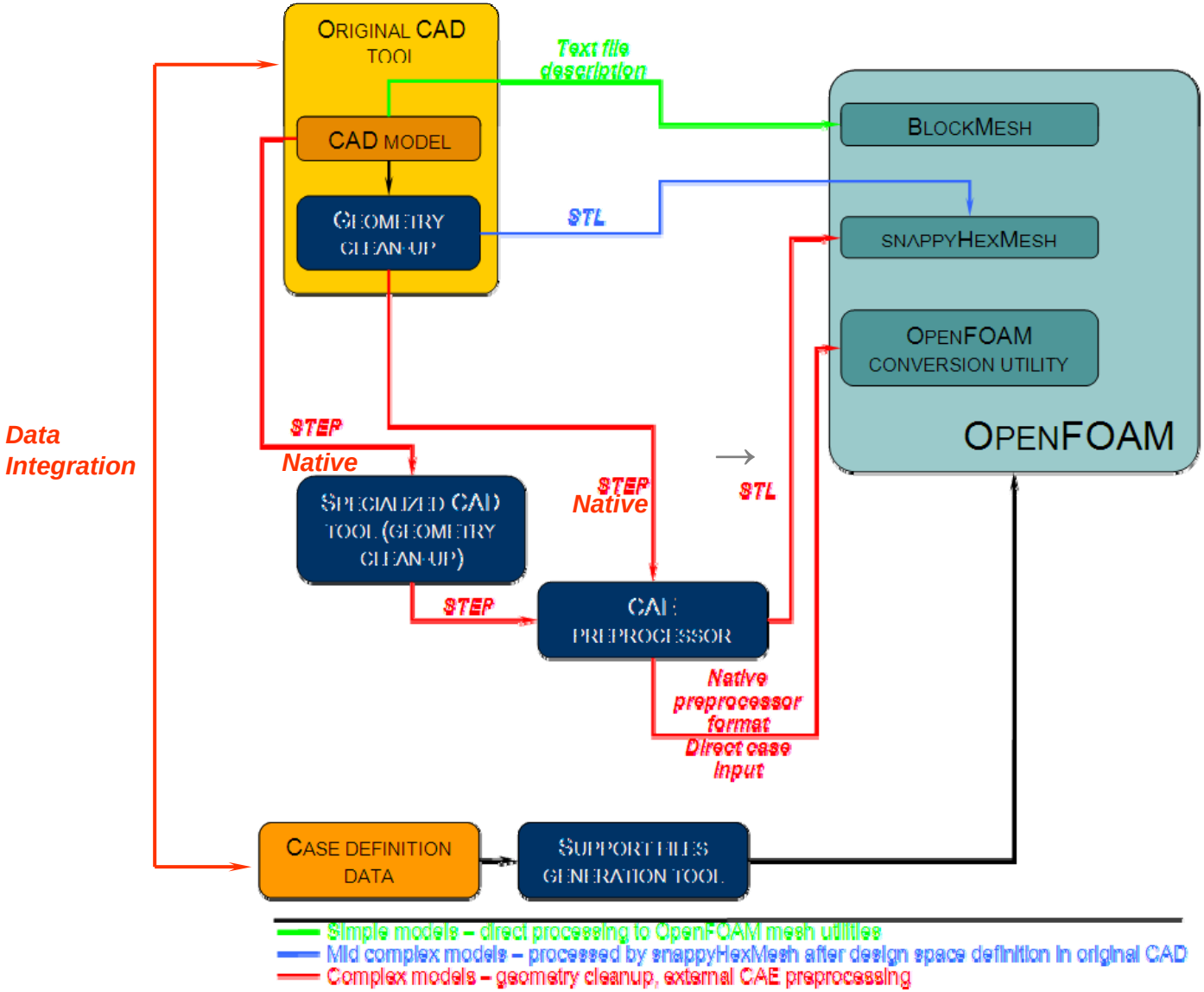
- **Geometric;**
- **Non geometric.**



Major steps needed to transfer data to optimisation module

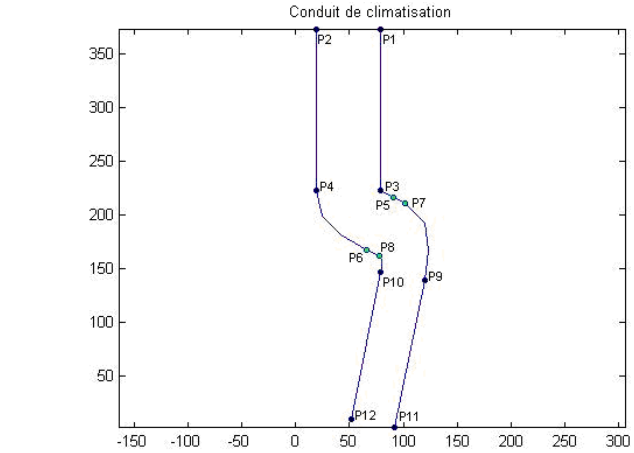
- Stage: PDP:
  - "Extract" model/design space from available in the PDP stage geometry model
  - Define the task (objective function, parameters, etc.)
- Stage: Preprocessing:
  - Model data transfer
  - Geometry clean-up
  - Mesh generation
- Stage: Interface to optimization module:
  - Model set-up
  - Model transfer to optimization module
  - Manufacturing constraints
- Stage: Post processing (Interface back to pdp):
  - Optimized geometry transfer back in CAD model

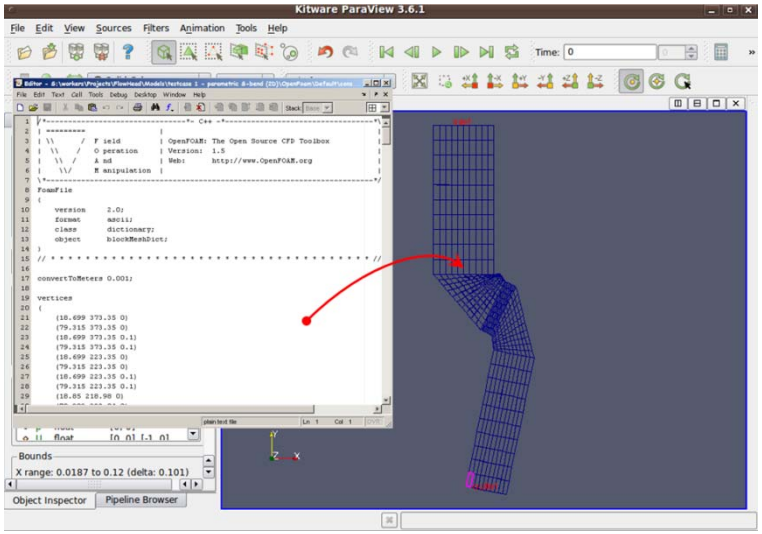
Combined approach for data interfaces



Test cases: simple and mid complex models

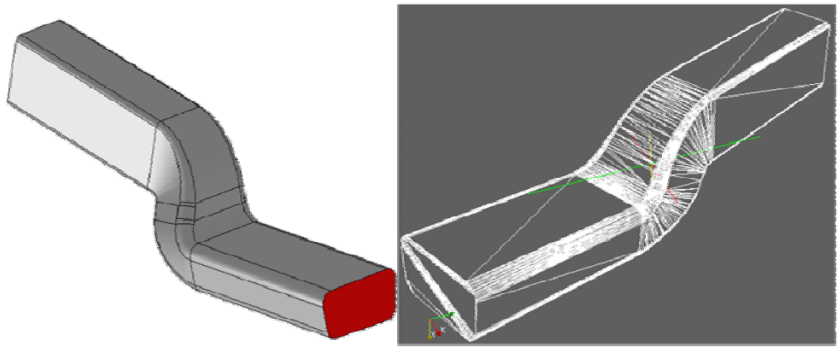
Simple model (text file description)

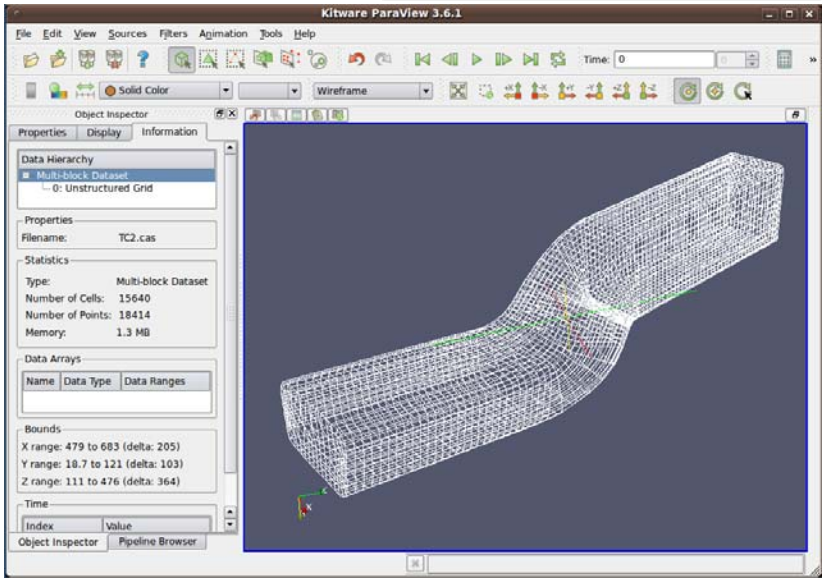




No1 Parametric S-bend 2D

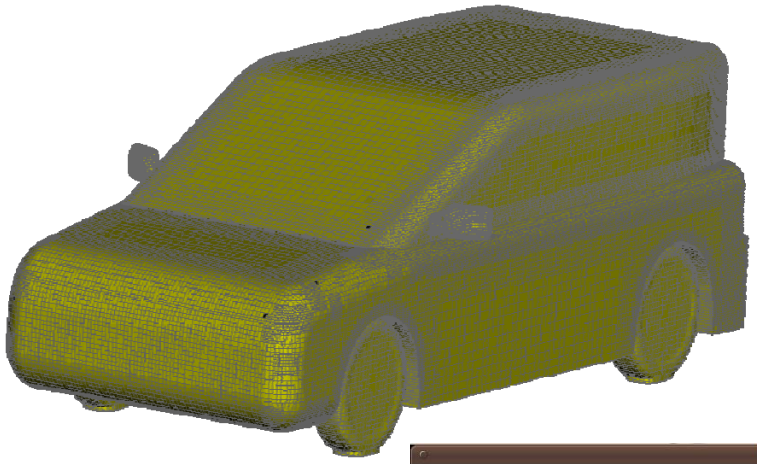
Mid complex model (direct STL to OpenFOAM environment)

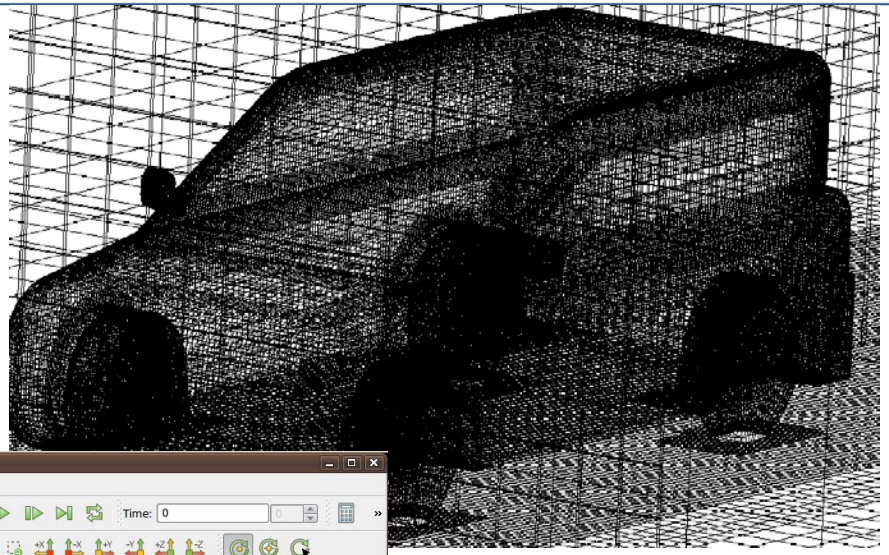


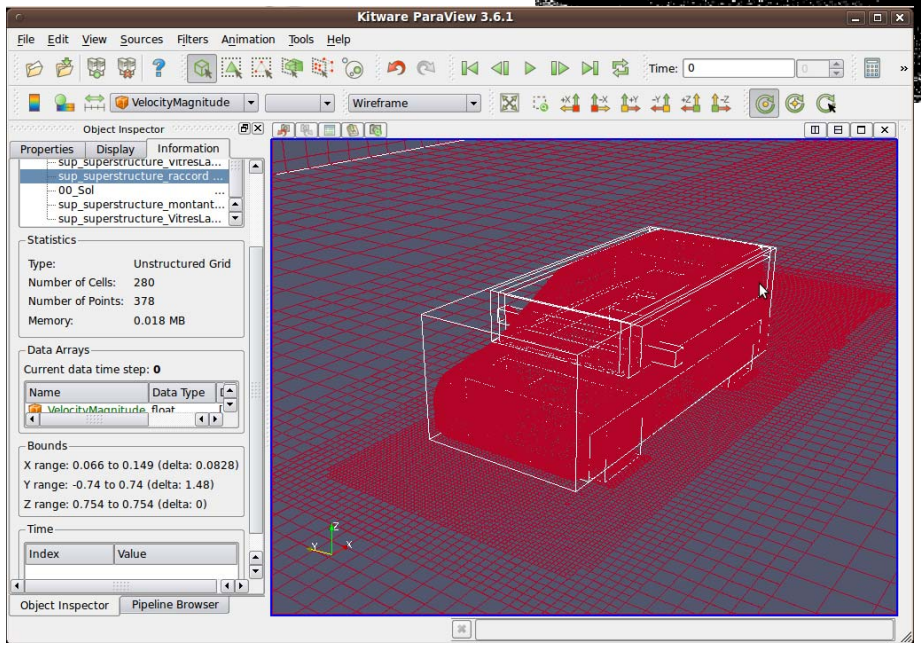


No2: Airduct VW Golf Plus – 3D

Test cases: complex models







No7 Side mirror

Complex models: Geometry clean-up of design space

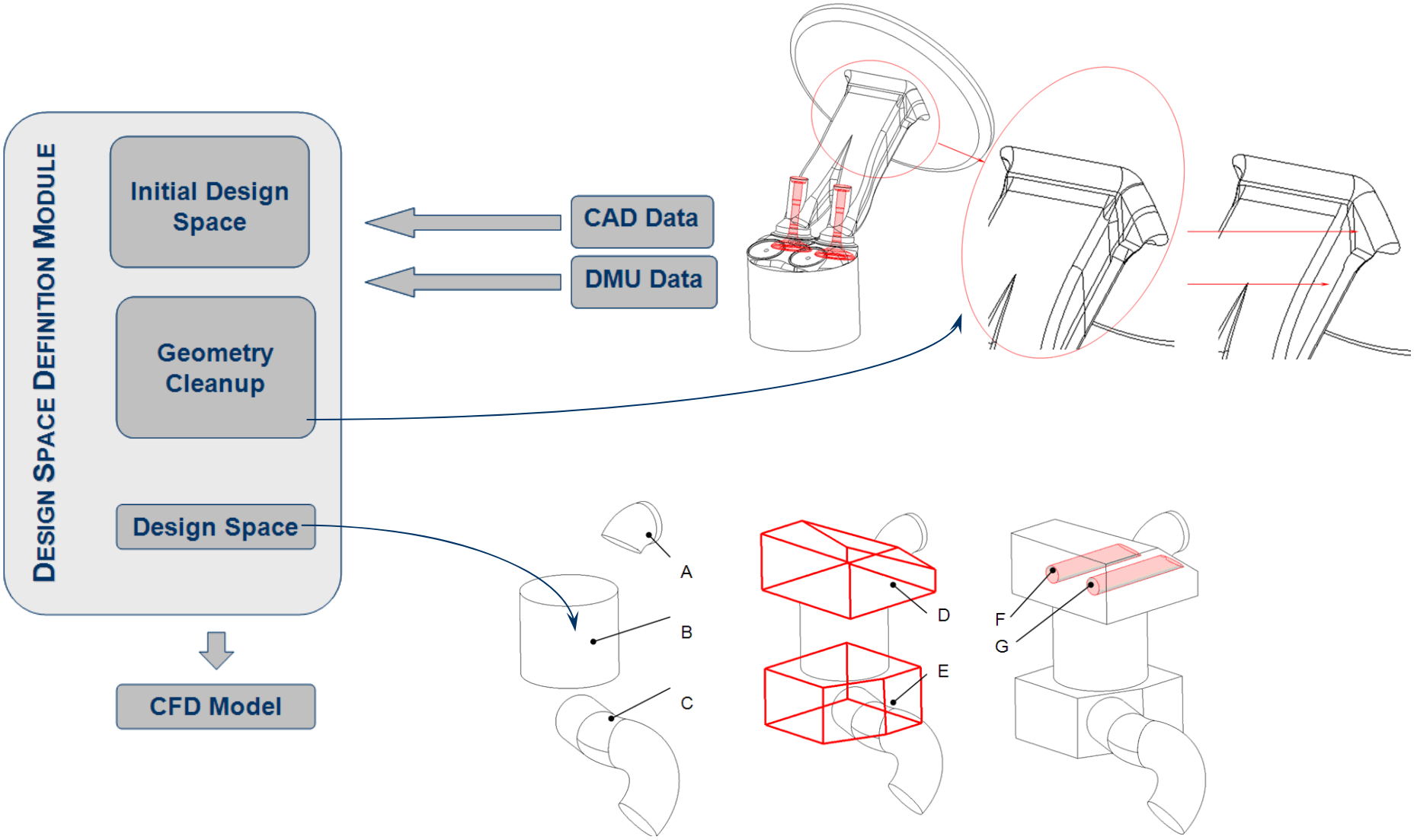
Tools, used for initial design space cleanup could be:

- **Conventional CAD tool (CATIA, NX, Pro/E, SW, etc.) only – the design space is formed in a CAD program entirely;**
- **Conventional CAD and CAE Preprocessing tools – initially defined in CAD environment design space is additionally formed in the CAE preprocessor, used also for mesh generation;**
- **Specialized CAD tool and CAE Preprocessing – entire initial design space could be cleaned up using available tools in specific CAD tools with or without initial preparation in the conventional CAD system.**

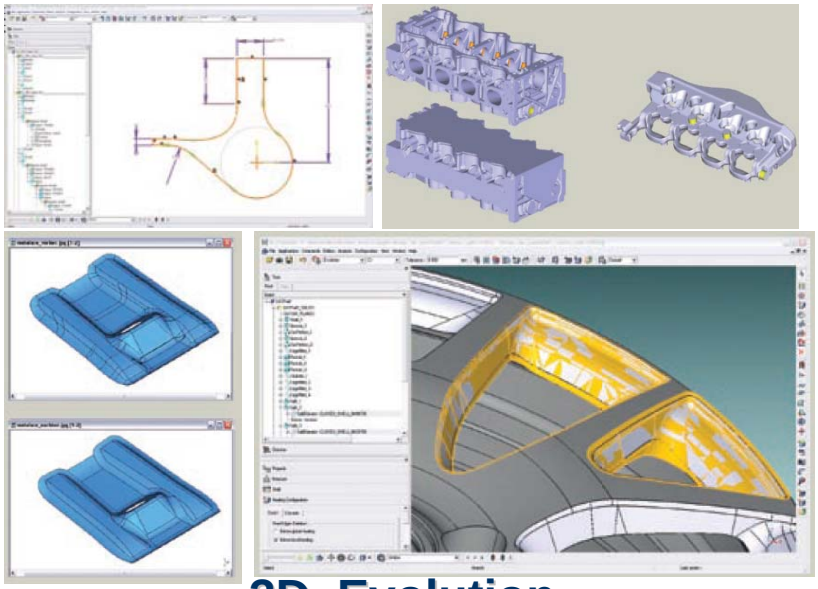
Different practices for design space definition, using CAD tools, exist. Most common are:

- **volume operations (Boolean, additional geometry modeling)**
- **cross sections (definition of characteristic cross sections).**

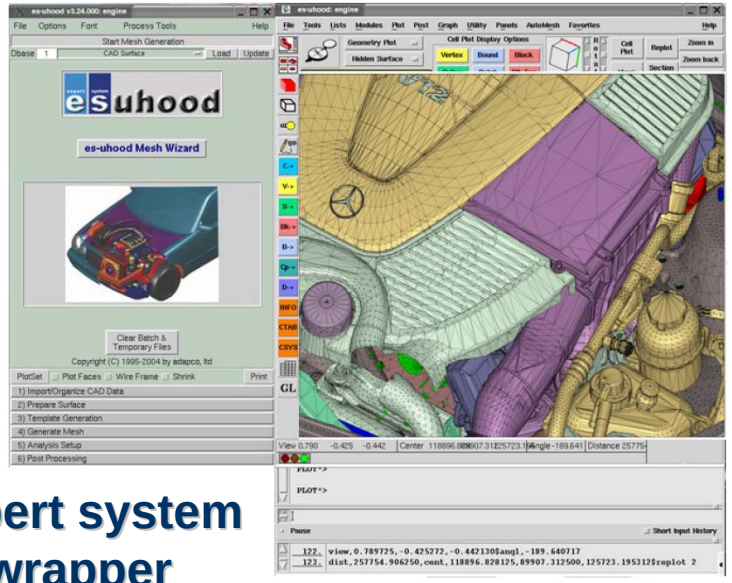
CAD Geometry Preprocessing to CFD optimization



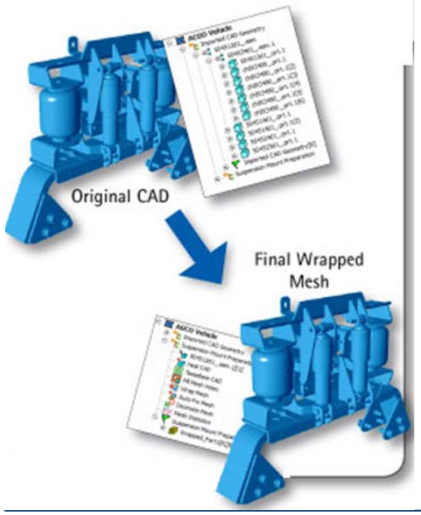
Geometry clean-up using specialized modules (samples)



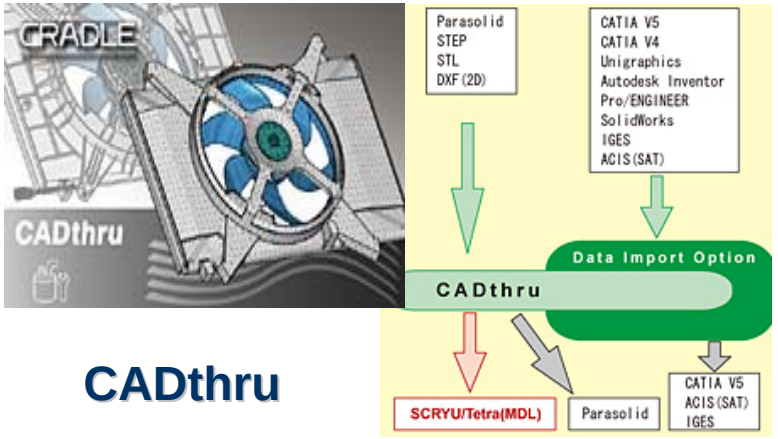
3D_Evolution



Expert system wrapper

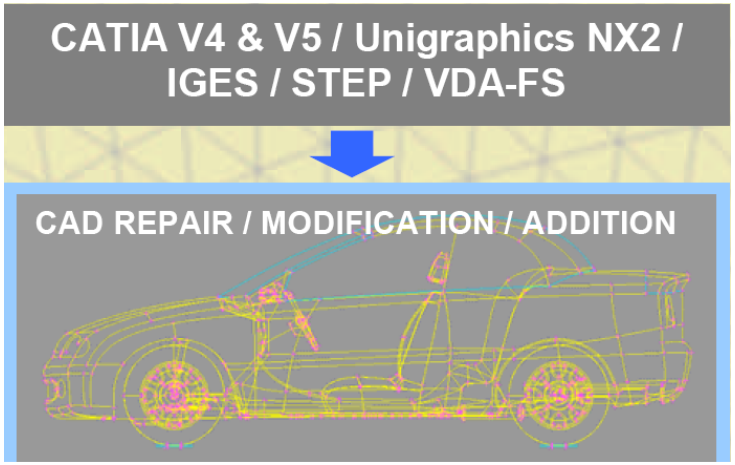


PowerDELTA & PowerCLAY

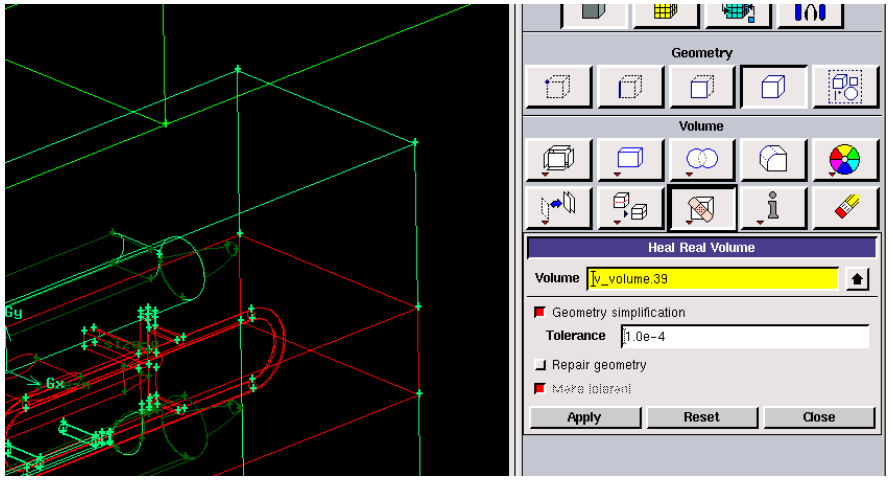


CADthru

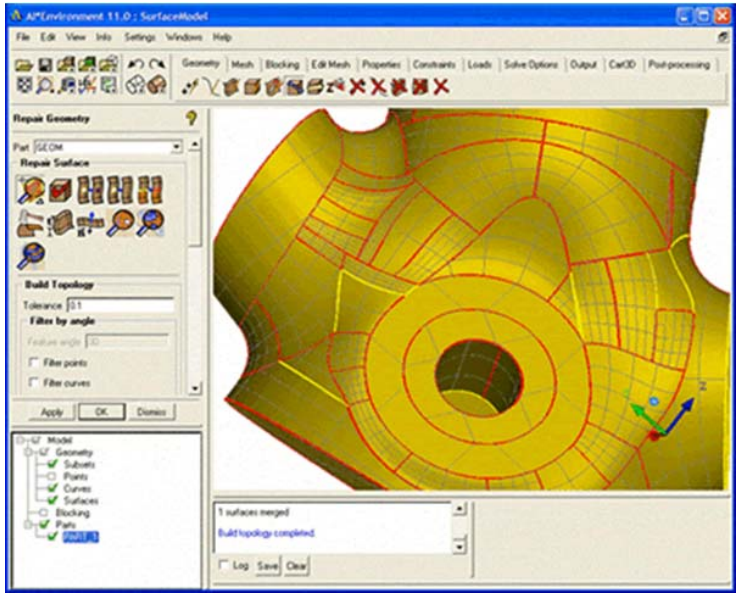
Geometry clean-up using conventional preprocessors (samples)



ANSA



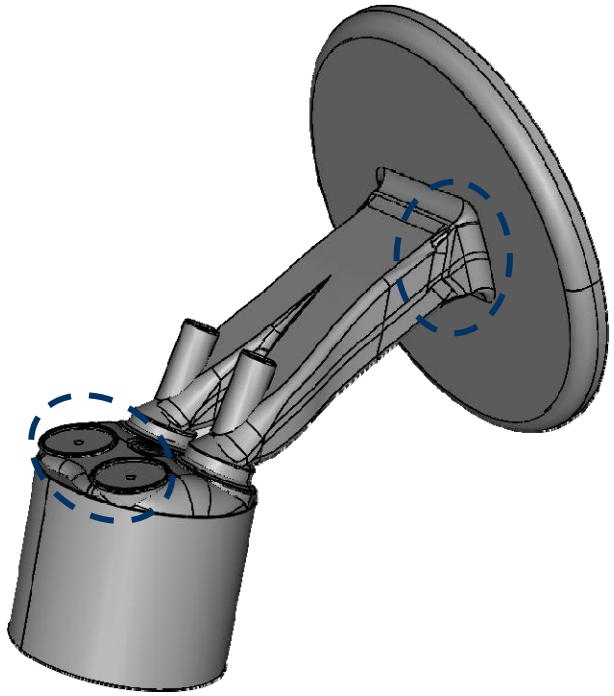
GAMBIT

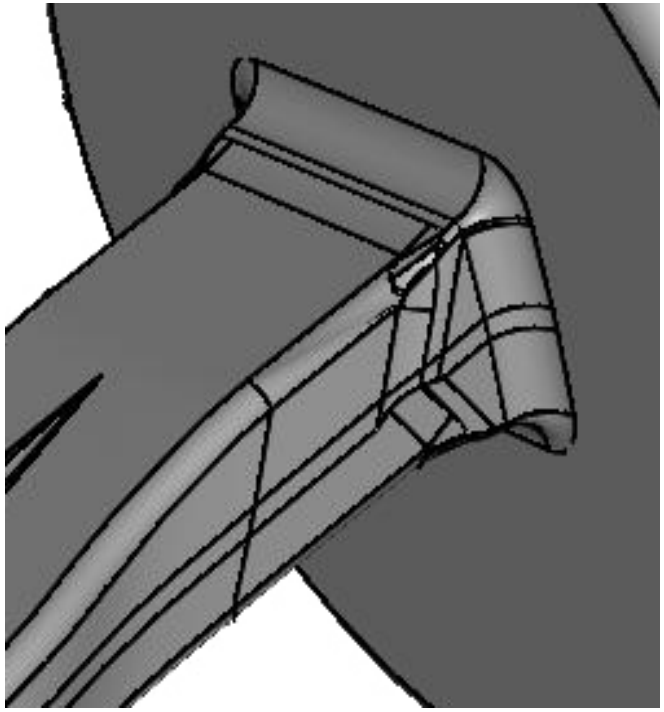


ANSYS ICEM CFD

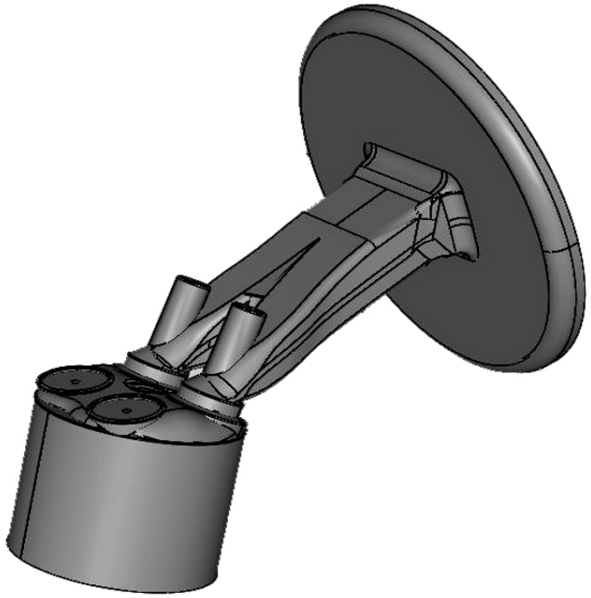
Geometry Clean-up: Sample

Initial design space: 424 surfaces



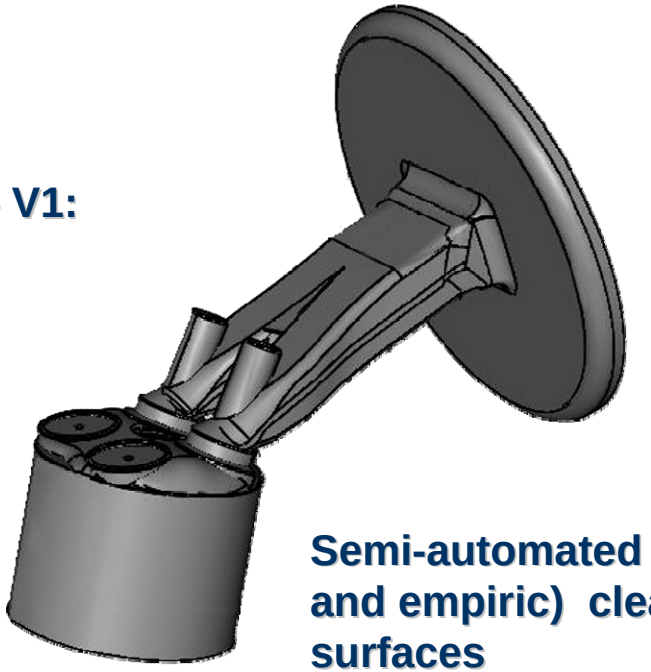


Geometry Clean-up: Sample



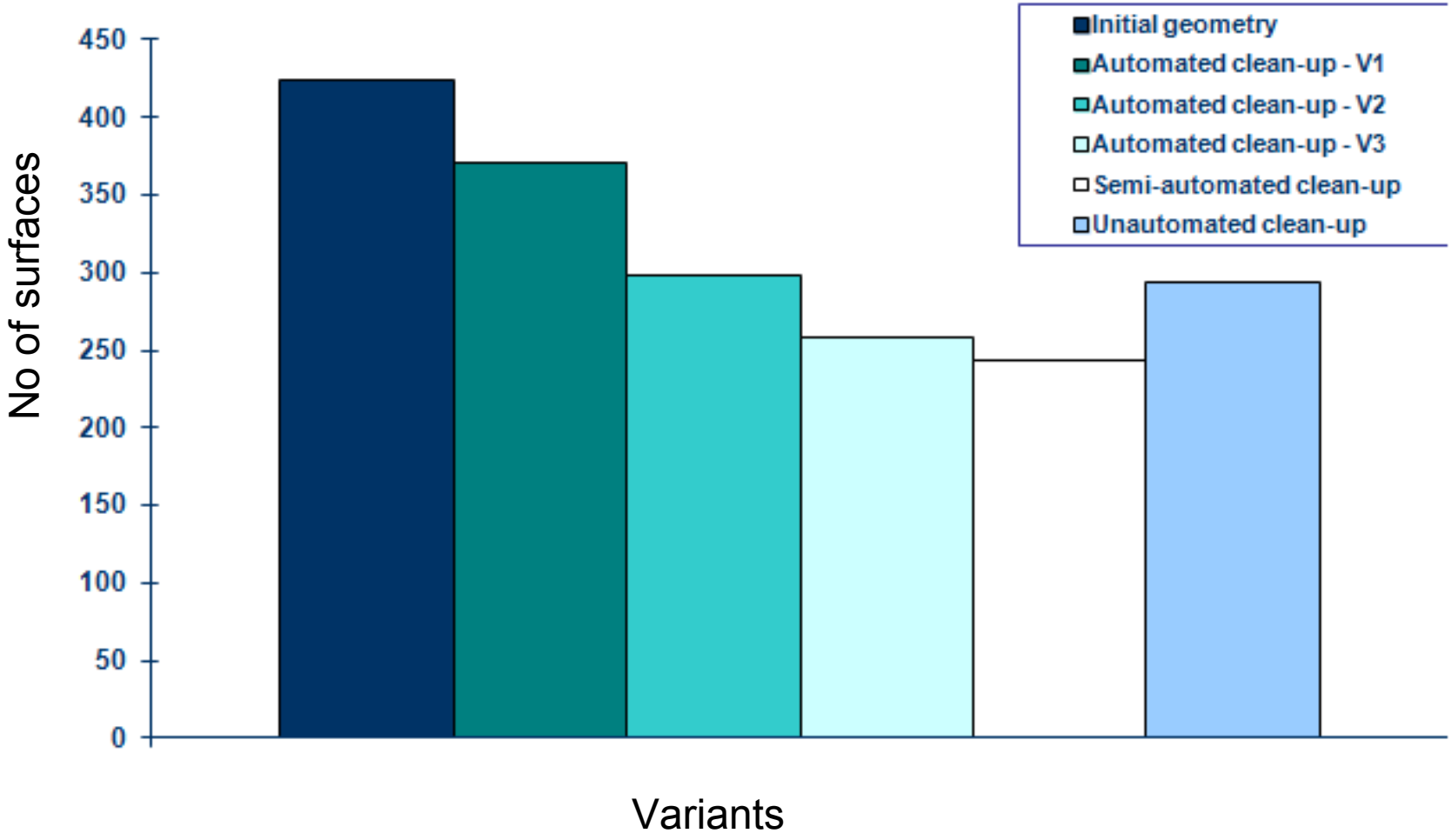
Automated clean-up – V1: 258 surfaces

Unautomated clean-up: 294 surfaces

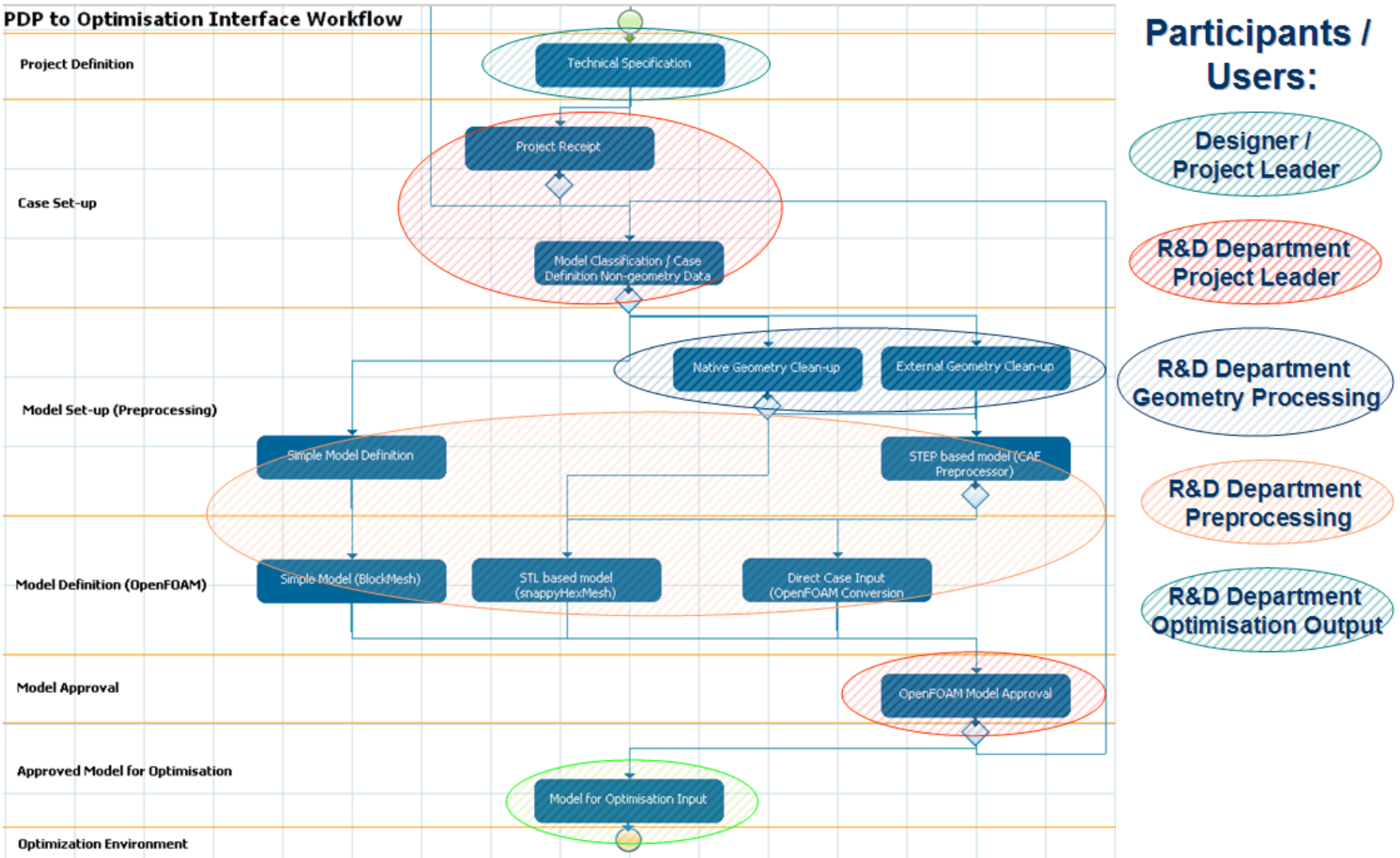


Semi-automated (automated and empiric) clean-up: 244 surfaces

Geometry Clean-up: Results



PDP to Optimisation Interface Workflow Software Solution



PDP to Optimisation Interface Workflow Software Solution

WORKFLOW:

Technical Specification
→ Definition
→ Description
→ CAD Data

Project Receipt
→ Notification
→ TechSpec Review
→ Project Receipt

Model Classification

Optimisation Case Definition

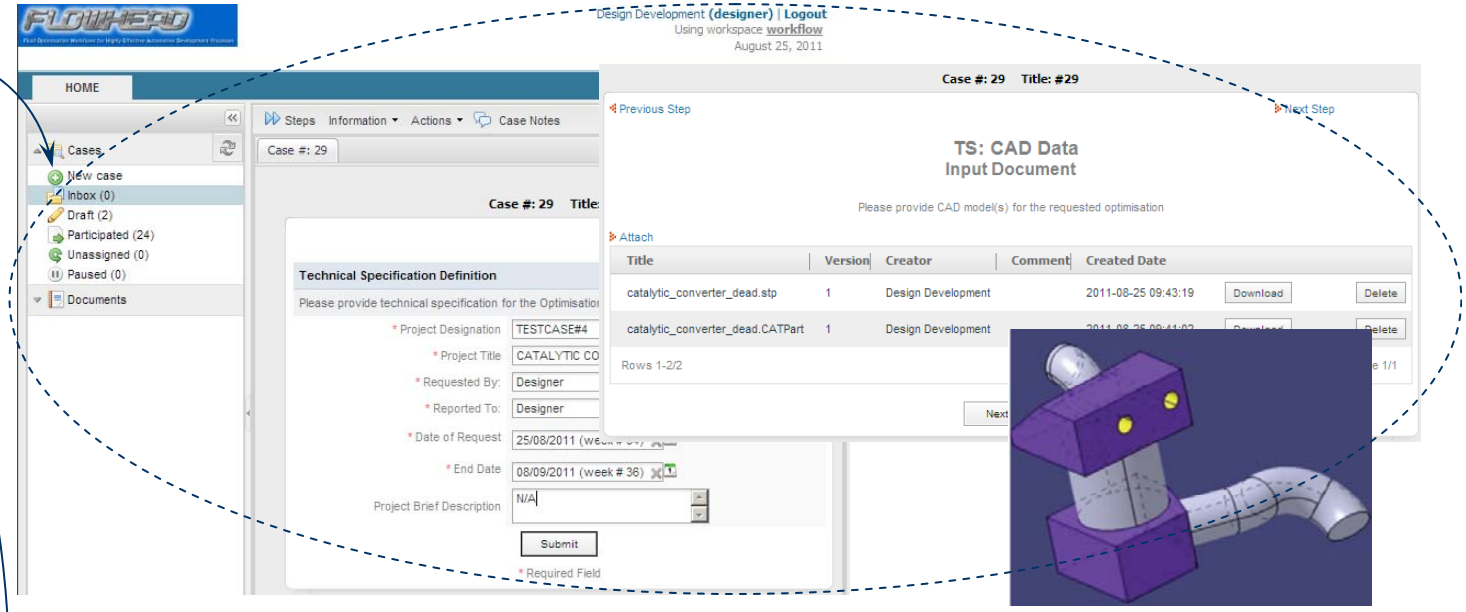
Geometry Processing
→ Notification
→ Download Input Data
→ Define Output
→ Upload Output Data

Preprocessing
→ Notification
→ Download Input Data
→ Define Output
→ Upload Output Data

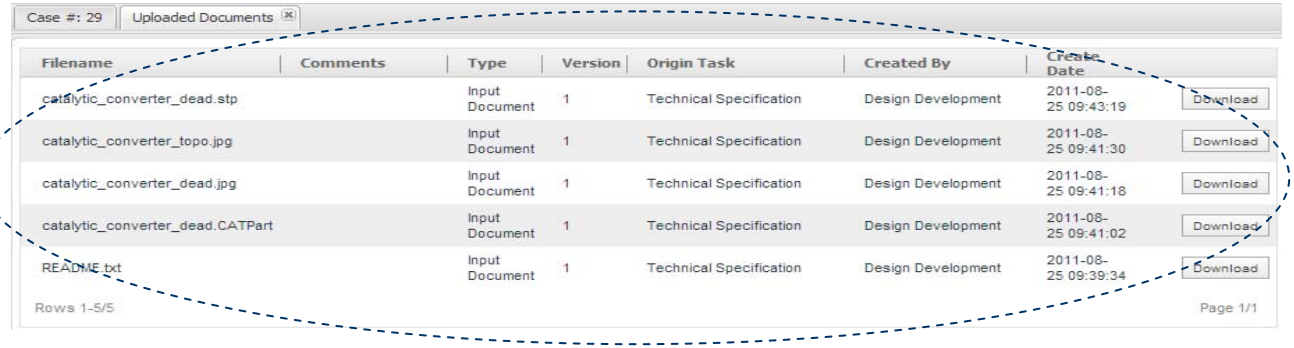
OpenFOAM Case Definition
→ Notification
→ Download data
→ Upload Output Data

Model Approval

Model Finalisation
→ Notification
→ Download data
→ Upload Modified Data



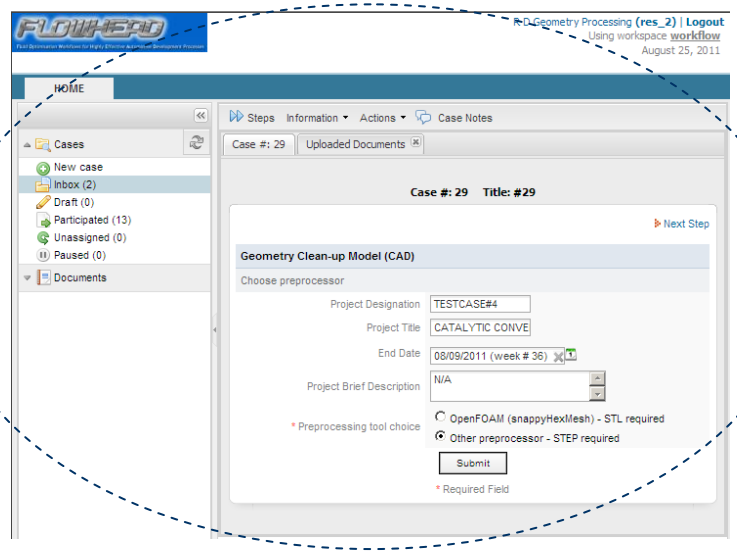
Download and review

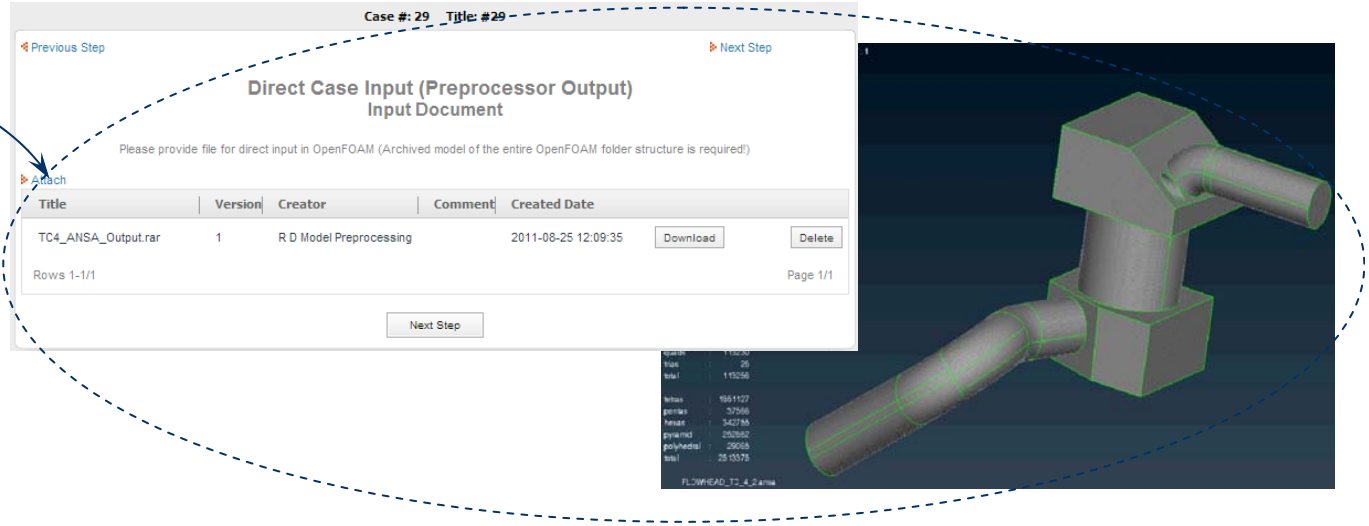


PDP to Optimisation Interface Workflow Software Solution

WORKFLOW:

Technical Specification
→ Definition
→ Description
→ CAD Data
Project Receipt
→ Notification
→ TechSpec Review
→ Project Receipt
Model Classification
Optimisation Case Definition
Geometry Processing
→ Notification
→ Download Input Data
→ Define Output
→ Upload Output Data
Preprocessing
→ Notification
→ Download Input Data
→ Define Output
→ Upload Output Data
OpenFOAM Case Definition
→ Notification
→ Download data
→ Upload Output Data
Model Approval
Model Finalisation
→ Notification
→ Download data
→ Upload Modified Data

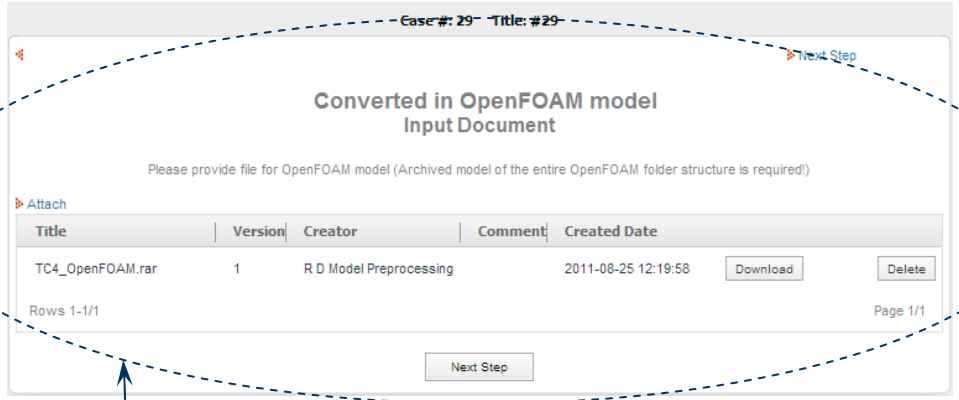


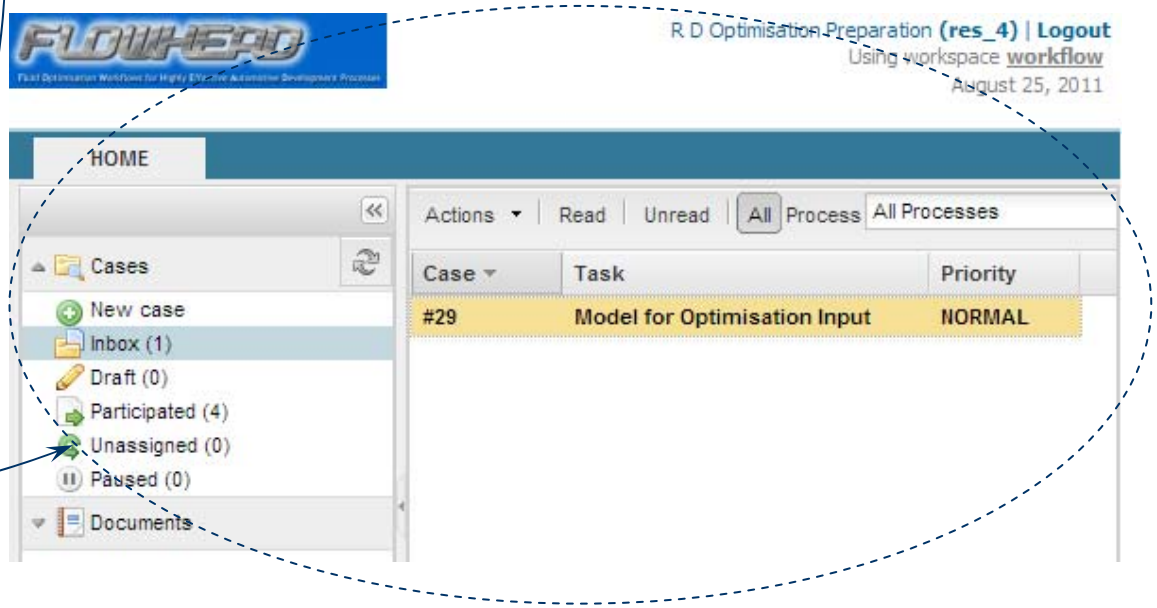


PDP to Optimisation Interface Workflow Software Solution

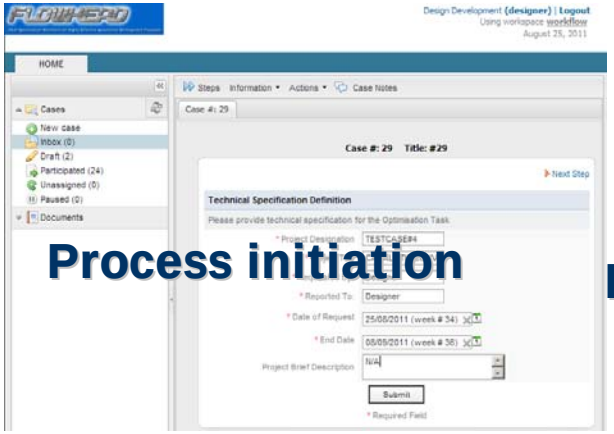
WORKFLOW:

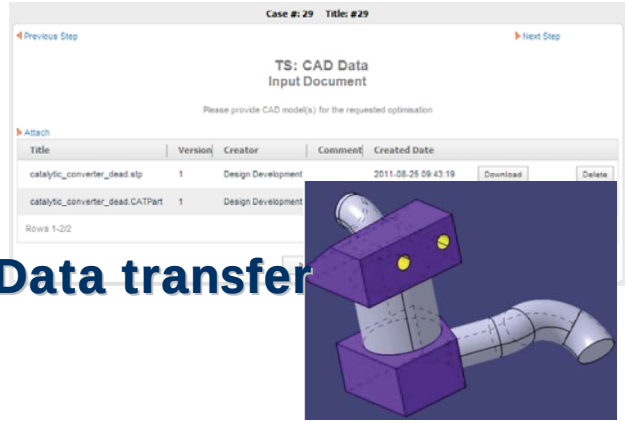
Technical Specification
→ Definition
→ Description
→ CAD Data
Project Receipt
→ Notification
→ TechSpec Review
→ Project Receipt
Model Classification
Optimisation Case Definition
Geometry Processing
→ Notification
→ Download Input Data
→ Define Output
→ Upload Output Data
Preprocessing
→ Notification
→ Download Input Data
→ Define Output
→ Upload Output Data
OpenFOAM Case Definition
→ Notification
→ Download data
→ Upload Output Data
Model Approval
Model Finalisation
→ Notification
→ Download data
→ Upload Modified Data

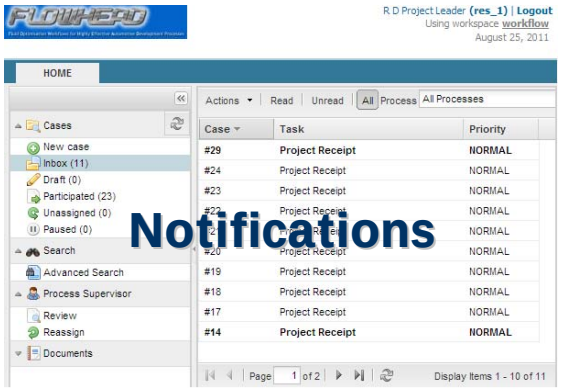


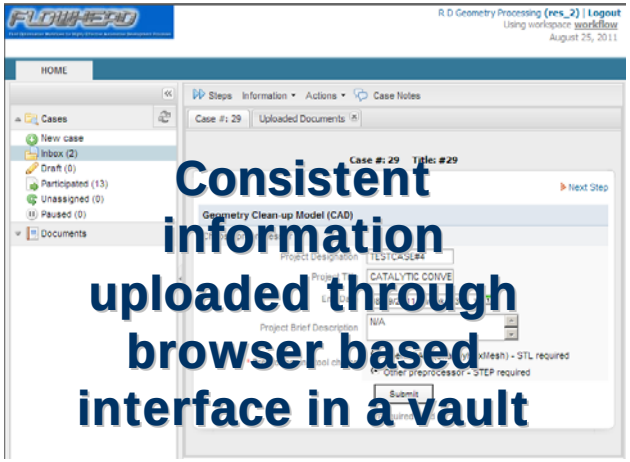


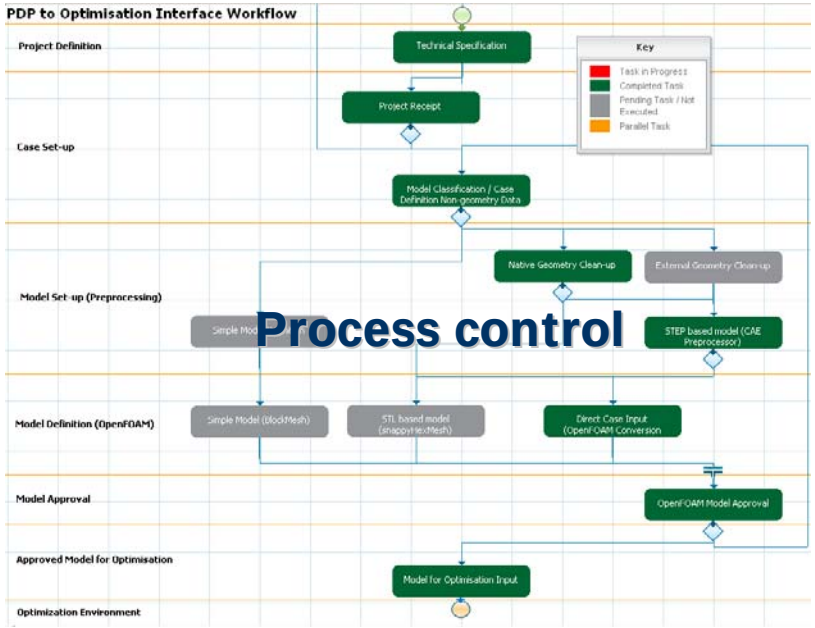
PDP to Optimisation Interface Workflow Software Solution











Major features in the Interface Workflow Software Solution

- **Browser-based interface was developed as demo case**
- **Management of groups and users**
- **Internal and possible mail notifications**
- **Consistent information in vault**
- **Possible connection to external databases**
- **Open Source (Possible customization)**

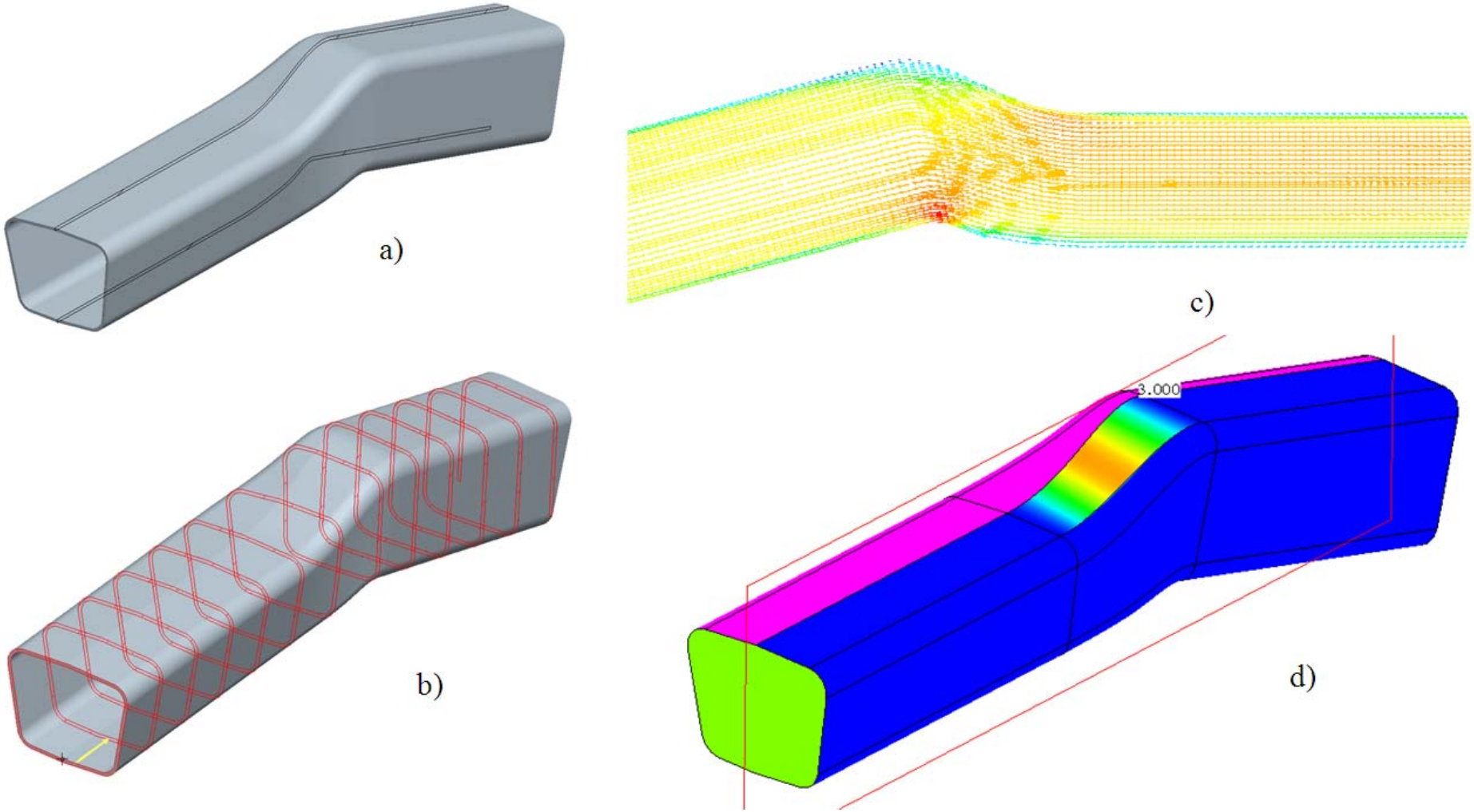
Manufacturing Constraints in 2 Groups

Processing Operations		Assembly Operations	
Shaping	Solidification processes Particulate processing Deformation processes Material removal processes	Joining processes	Welding Brazing Soldering Adhesive Bonding
Property-enhancing	Heat treatment	Mechanical assembly	Threaded fasteners Press fitting Molding inserts Integral fasteners
Surface processing	Cleaning Surface treatments Coating Thin film deposition		

Major Constraints:

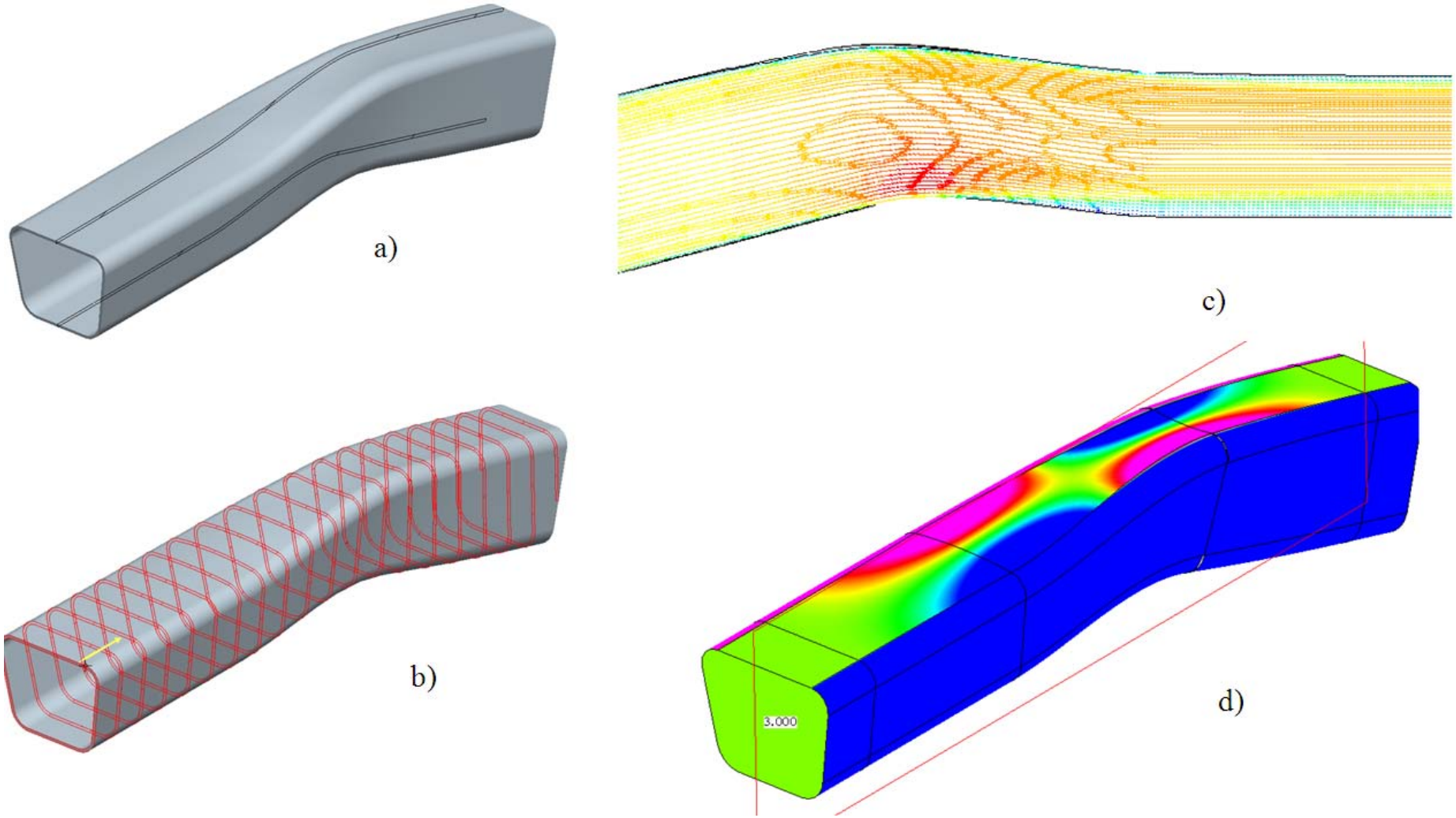
- **Processing Operations:**
  - ✓ **Parting line / ejection direction;**
  - ✓ **Draft angles;**
  - ✓ **Wall thickness;**
  - ✓ **Radius/curvature;**
  - ✓ **Warpage;**
- **Assembly Operations:**
  - ✓ **Accessibility**

Check of Initial Design Space



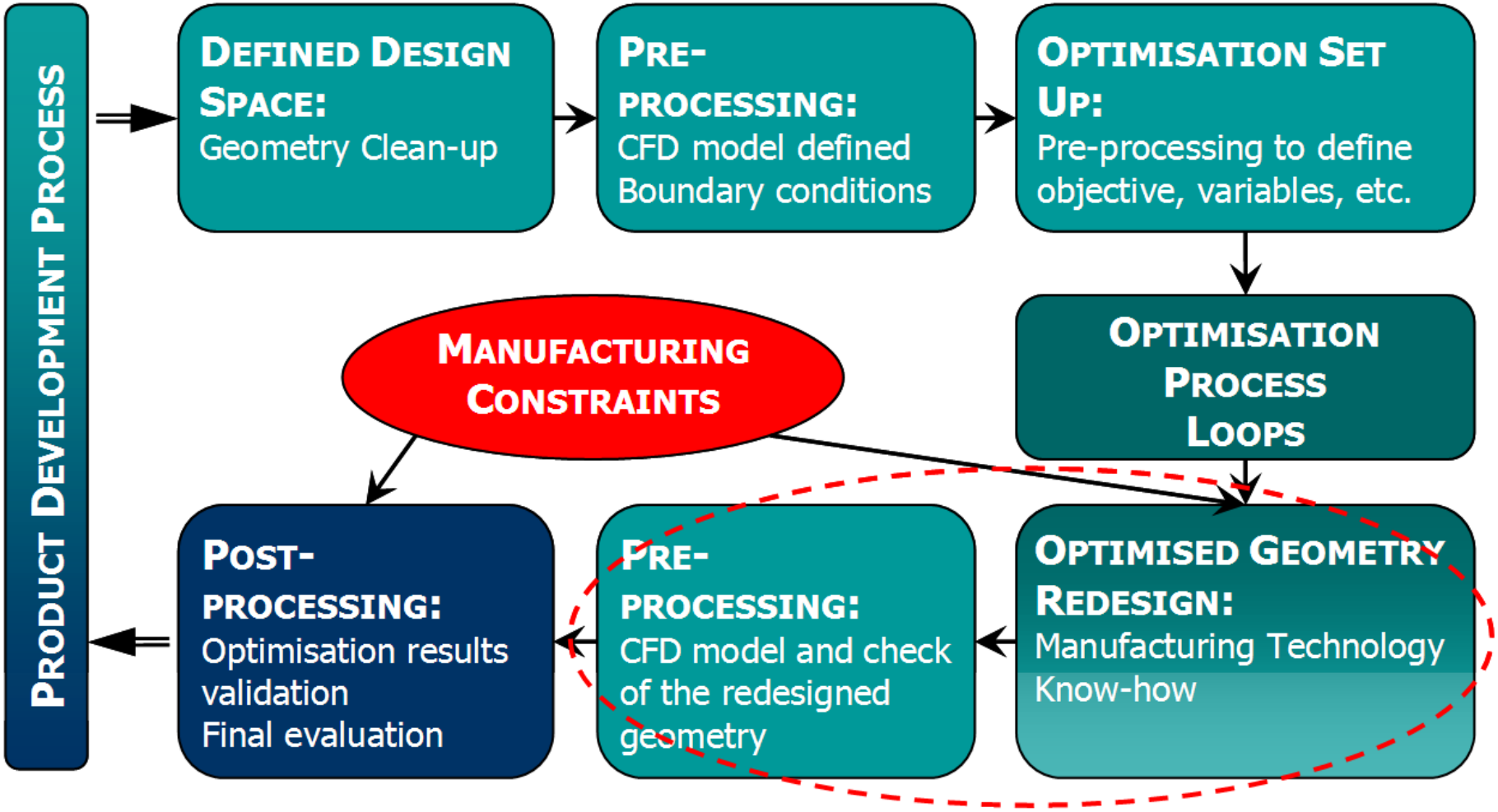
a) Design geometry – blast moulded structure; b) Thickness check; c) CFD solution results; d) Draft check

Check of Optimised Design Space



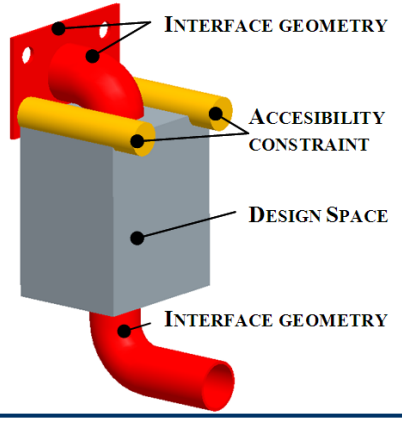
a) Design geometry – blast moulded structure; b) Thickness check; c) CFD solution results; d) Draft check – shadowed zones available

Typical Application of Manufacturing Constraints in CFD Optimisation Workflow



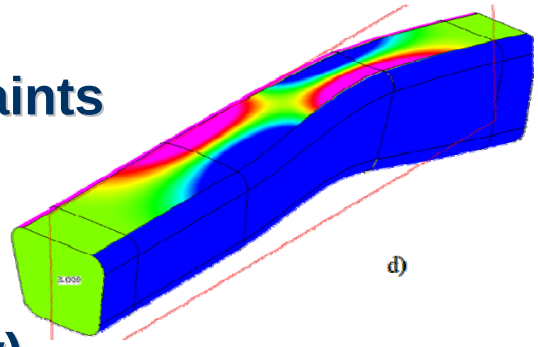
Manufacturing Constraints Implementation in Optimisation Workflow

Preliminary Manufacturing Constraints (that influence the initial design space)

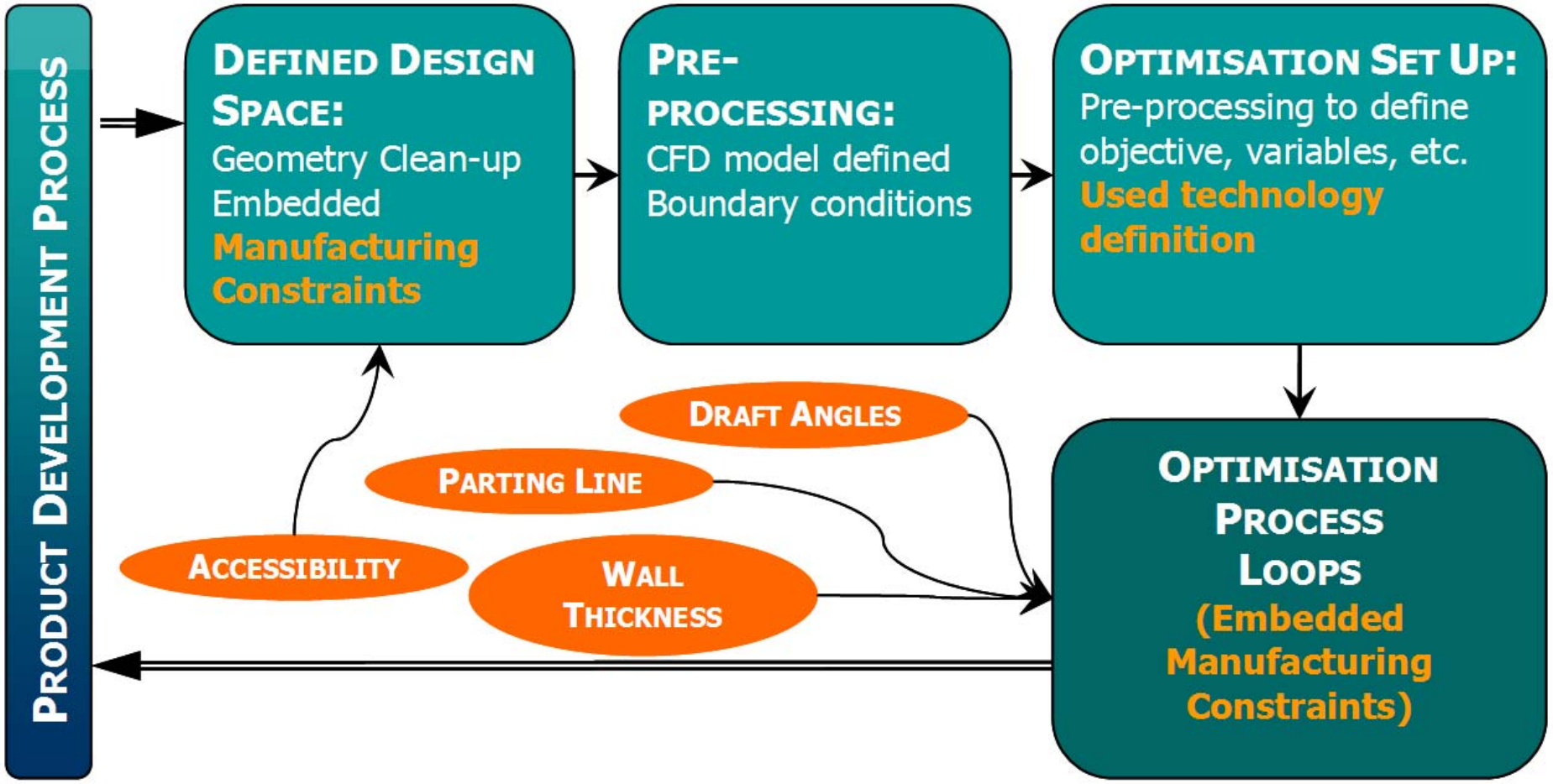


Major groups of Constraints

Optimisation Manufacturing Constraints (that depends on technology for manufacturing the particular geometry)



Modified CFD Optimisation Workflow – with embedded manufacturing constraints in “Design Space Definition” and “Optimisation Process Loops”



Summary

- A combined approach for PDP to CFD optimisation data interface is developed, based on provided analysis of existing automotive industry PDPs
- Approach verification is performed based on predefined test cases (airduct and side mirror)
- A user-friendly interface, suitable for PDP integration, is developed to enable simple preparation of CFD optimisations – automated assistance of model generation; user-friendly preparations of the optimisations; effective and robust data storage of results, models; compatibility to existing systems;
- A process for the generation of design spaces for CFD topology optimisation based on CAD and/or DMU data is developed;
- Relevant manufacturing constraints are identified and analysed
- General Optimisation Workflow with embedded manufacturing constraints was worked out.

THANK YOU FOR YOUR ATTENTION