Pushing the Boundaries of CFD with HelyX®

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- About ENGYS
- What is HELYX?
- Beyond OpenFOAM
  - HELYX-Mesh
  - HELYX-GIB
- Conclusions

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Company | Overview

- CAE products and services
- Founded in the UK (2009)
- Leverage open-source solutions
- FOAM/OpenFOAM developers since 1999
- Solution platforms:
  - CFD → HELYX® / ELEMENTS / HELYX-OS
  - MDO → HELYX-Adjoint / DAKOTA
- 6 offices worldwide
  - UK, Germany, Italy, USA, Australia, RSA
- Well established resellers network
  - Japan, Benelux, Korea, China, USA

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What is HelyX ?

- General purpose CFD software suite
- Enterprise product → professional quality + open-source
- In production since 2010

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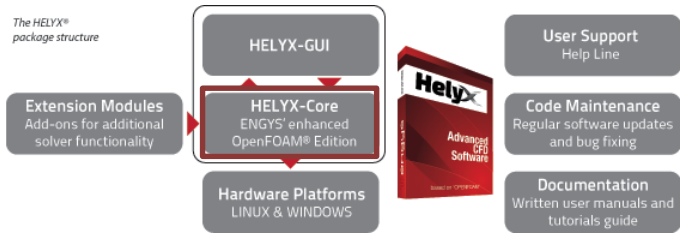
HelyX Core

- ENGYS' own open-source CFD simulation engine
- HELYX-Core vs. OpenFOAM
  - 2000+ files modified → bug fixes and enhancements
  - 400+ new files → new methods and solvers
- Primary development goal → improve user experience and solver quality
  - Ease of Use
  - Application specific capability
  - Meshing quality
  - Accuracy, Robustness & Speed



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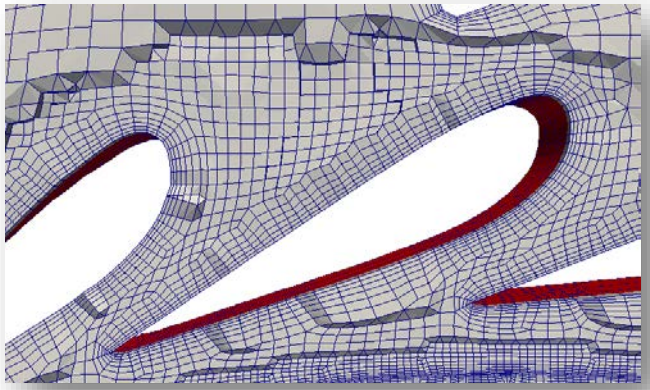
Beyond OpenFOAM | HelyX Mesh

New Meshing Approach | Motivations

- Generate high-quality CFD meshes on complex geometries fully automatically and fast
- Improve upon known limitations in OpenFOAM's *snappyHexMesh*:
  - Eliminate near-wall layers collapse
  - Non-iterative, one step layer insertion
  - No boundary face merging
  - Reduce 8:1 volume change at refinement interfaces
  - Mesh optimisation to improve overall cell quality



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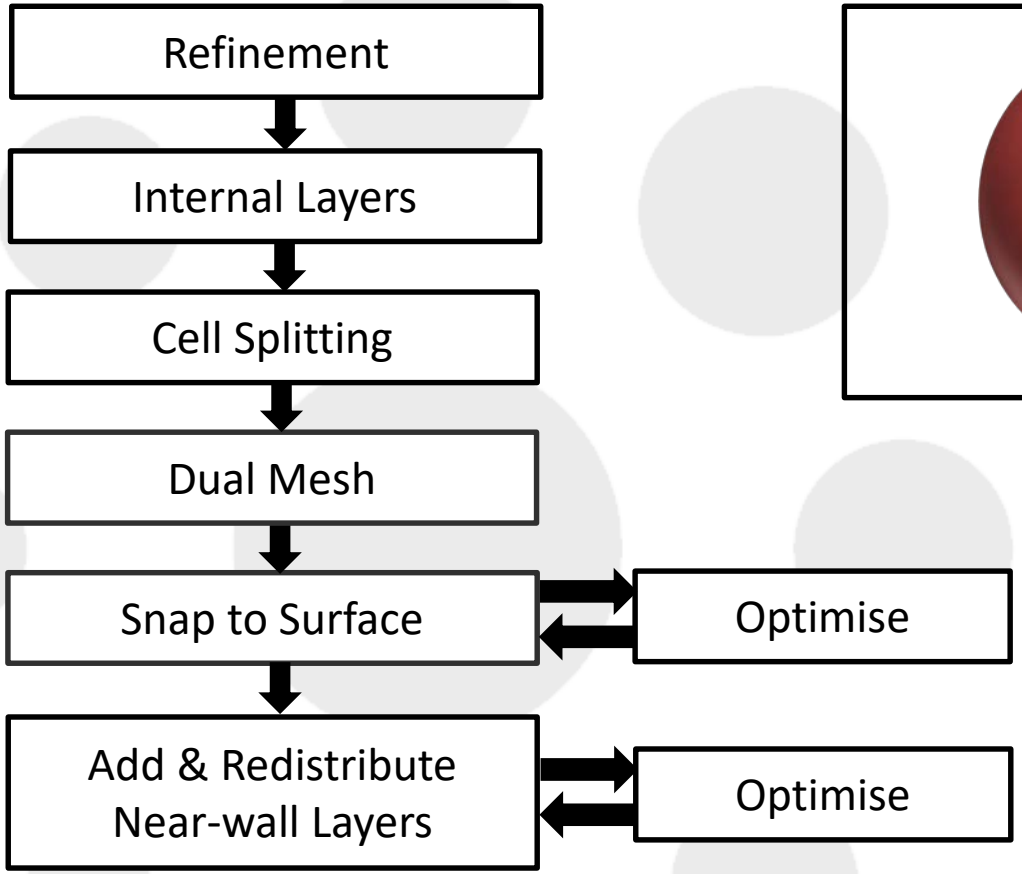
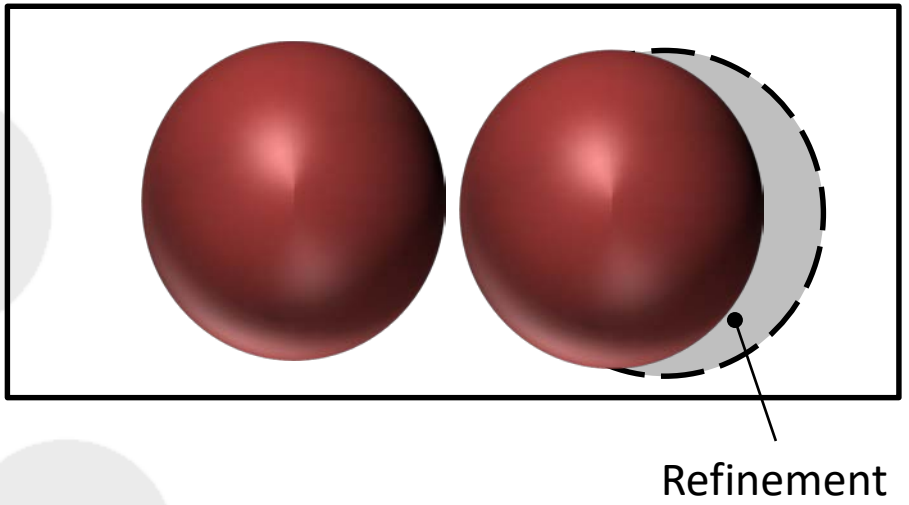
Beyond OpenFOAM | HelyX Mesh

New Meshing Approach | Methodology





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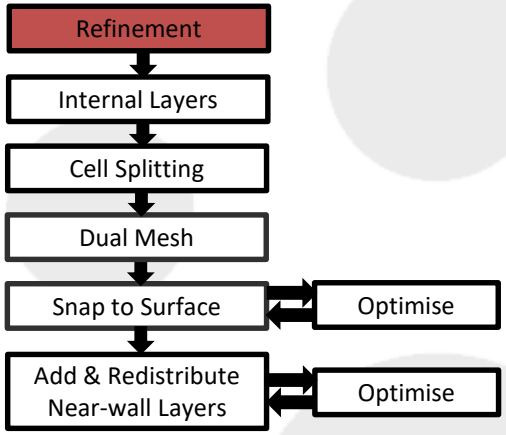
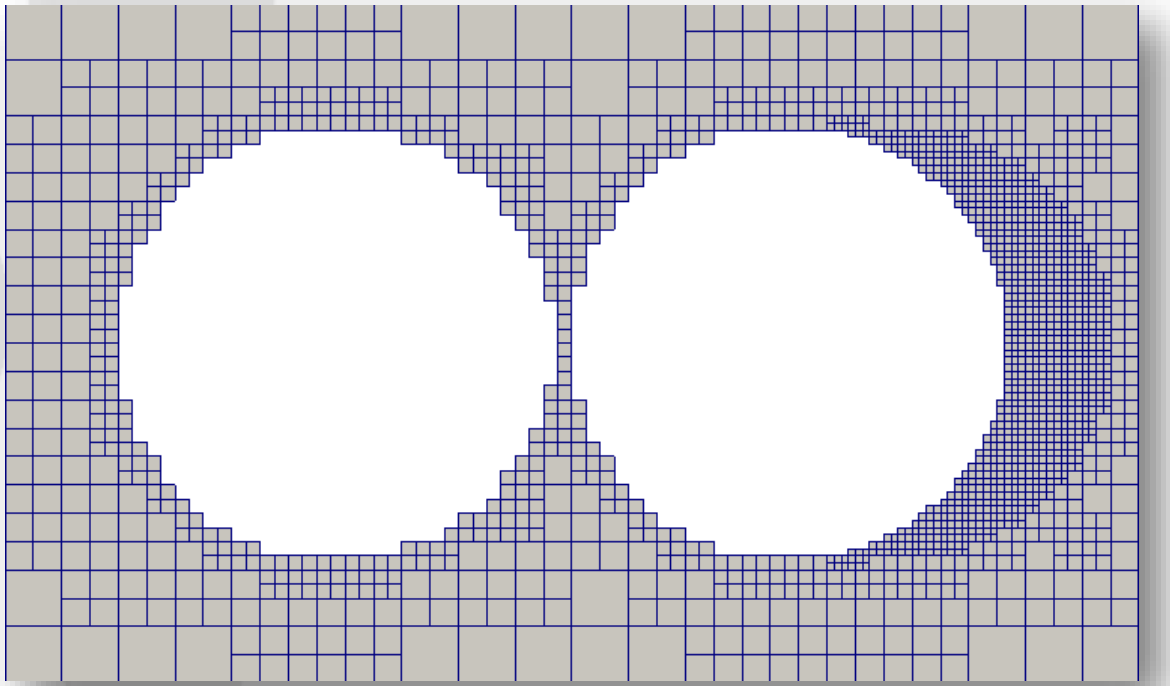
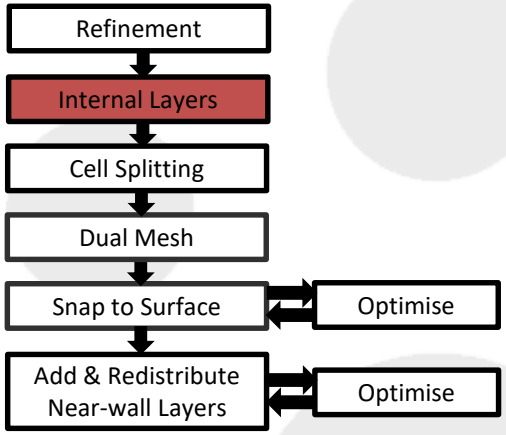
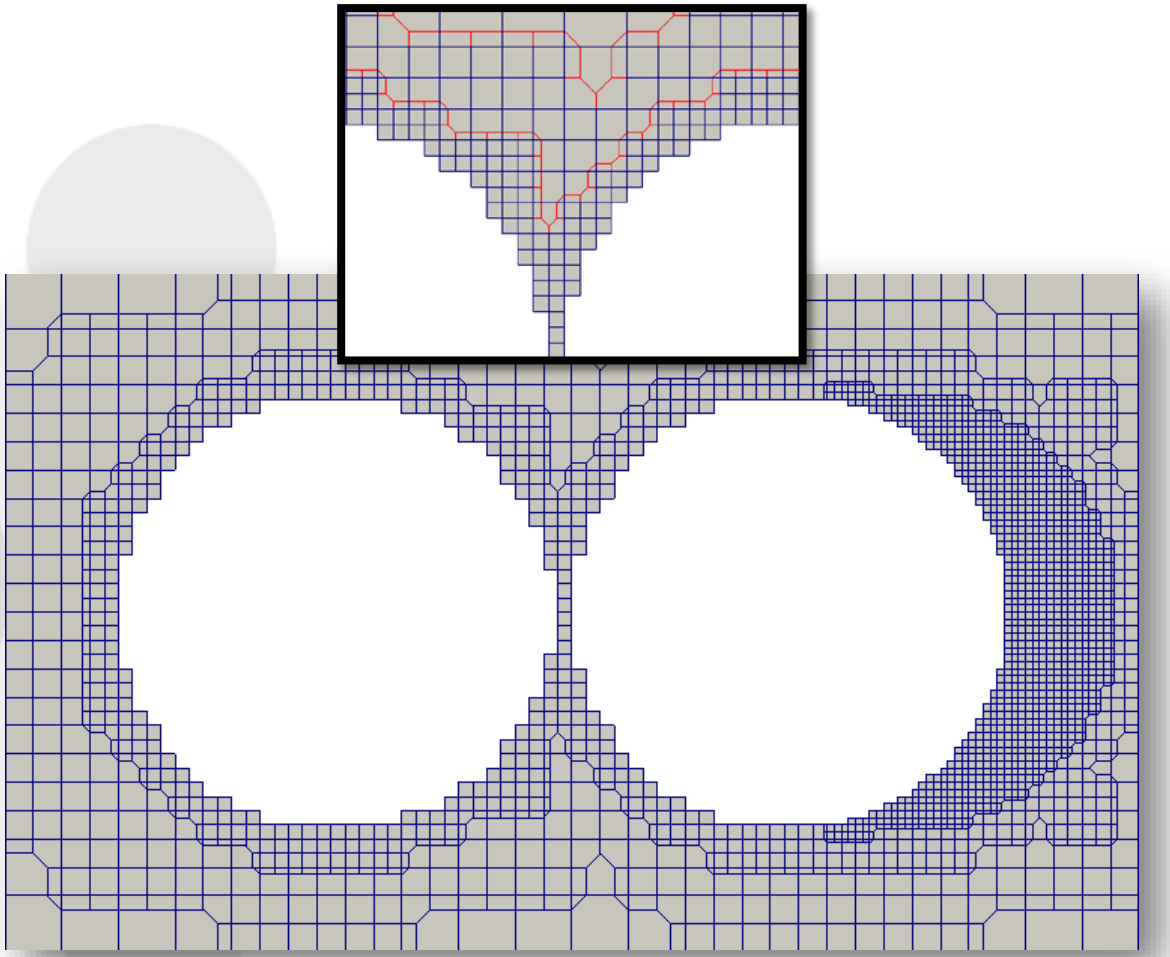
New Meshing Approach | Refinement





New Meshing Approach | Internal Layers





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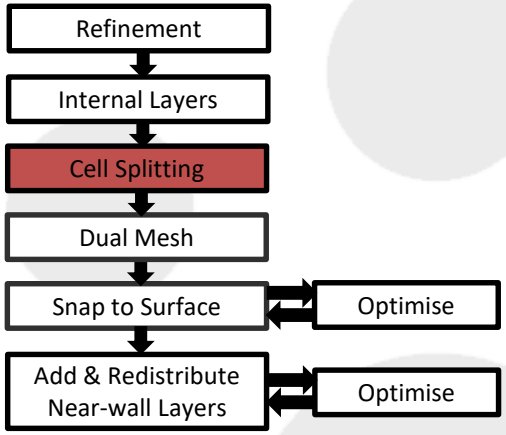
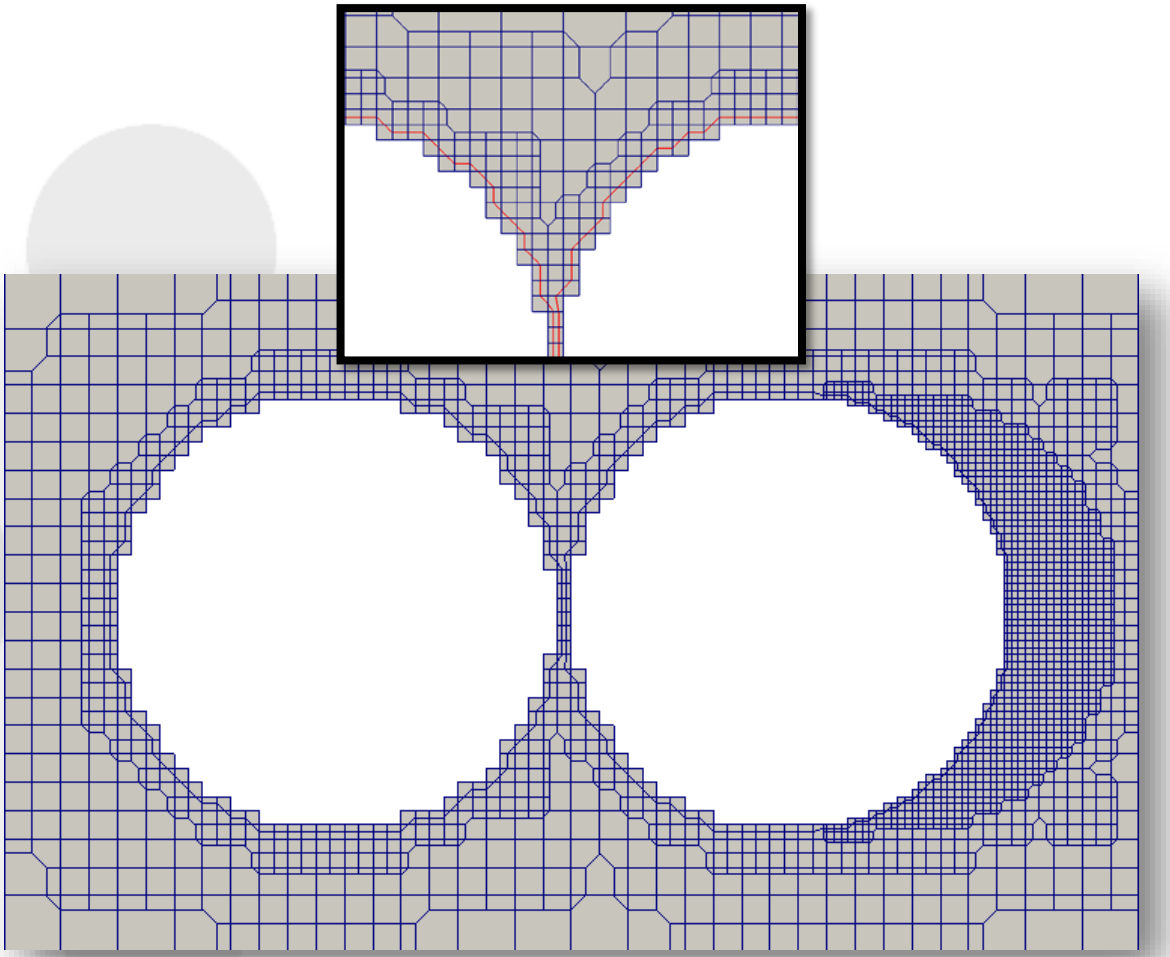
New Meshing Approach | Cell Splitting





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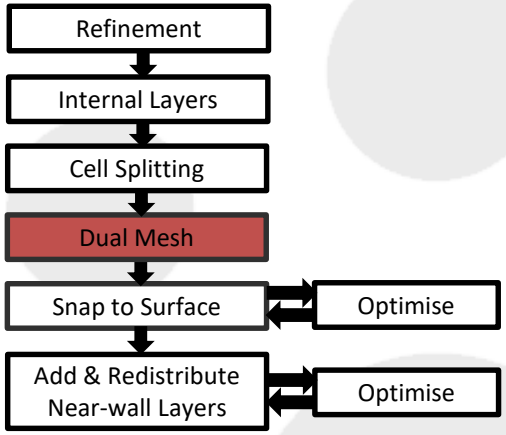
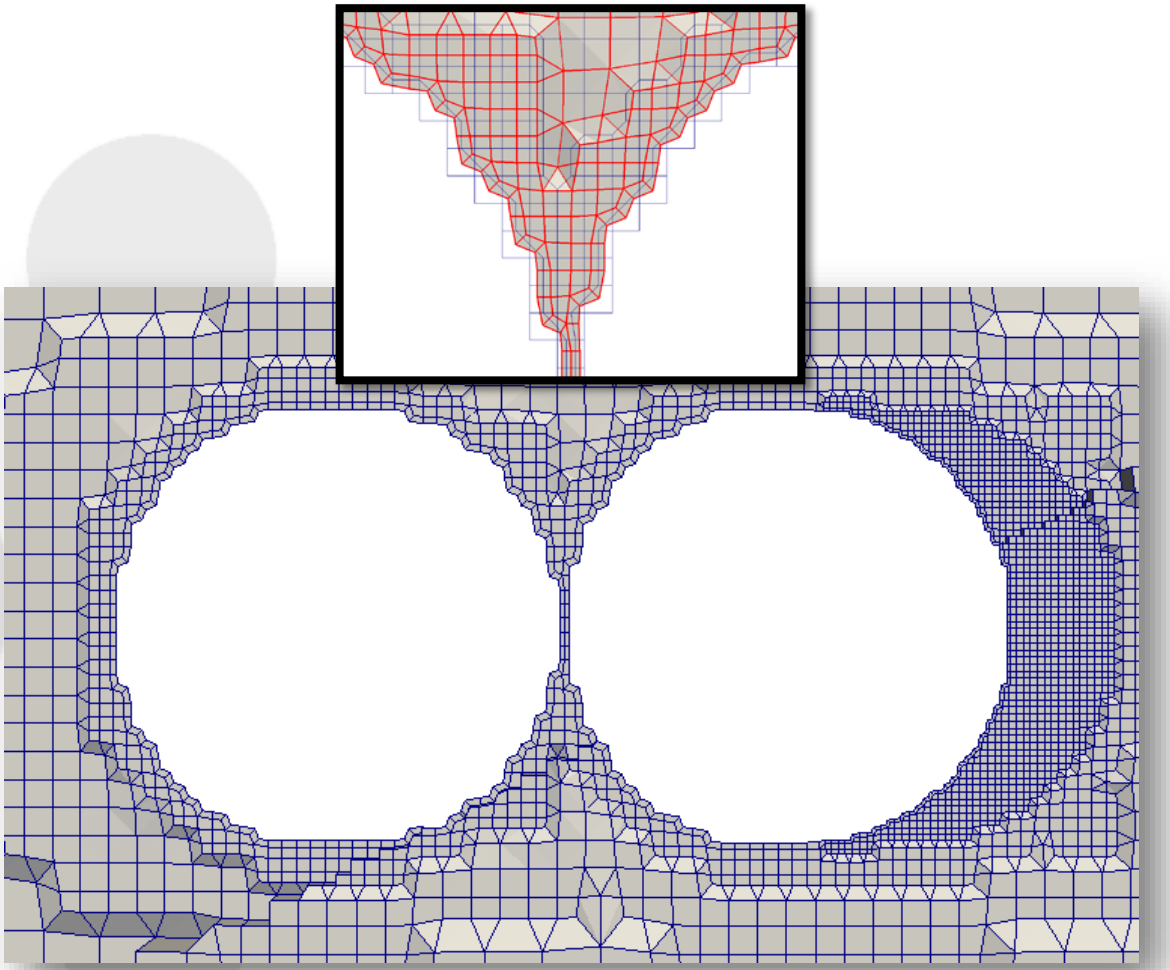
New Meshing Approach | Dual Mesh





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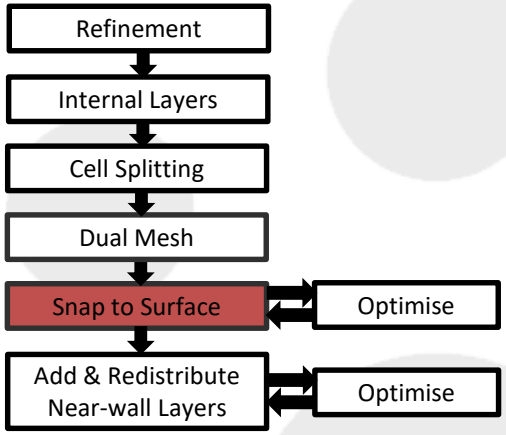
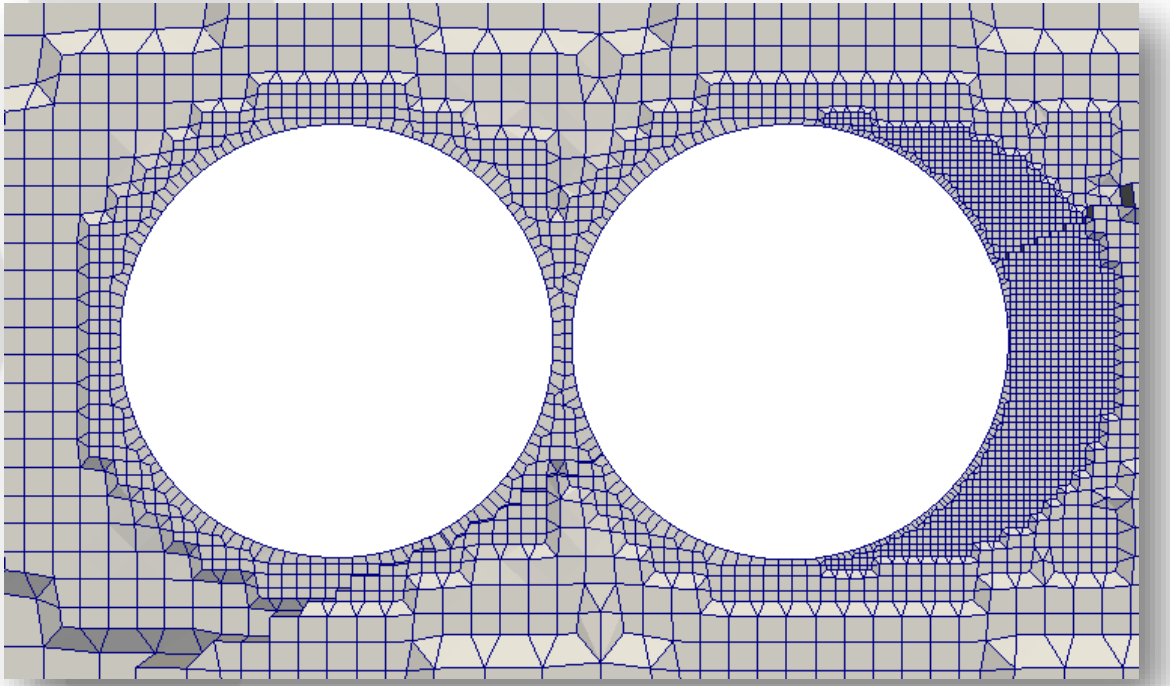
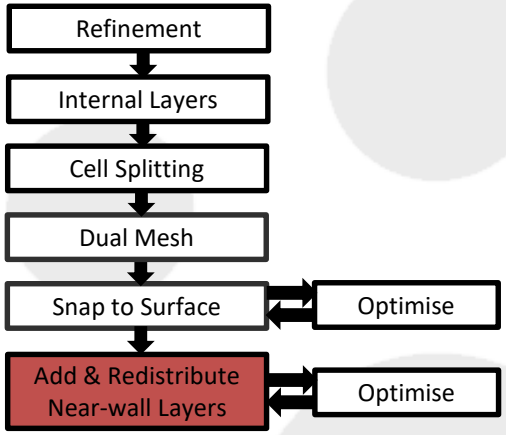
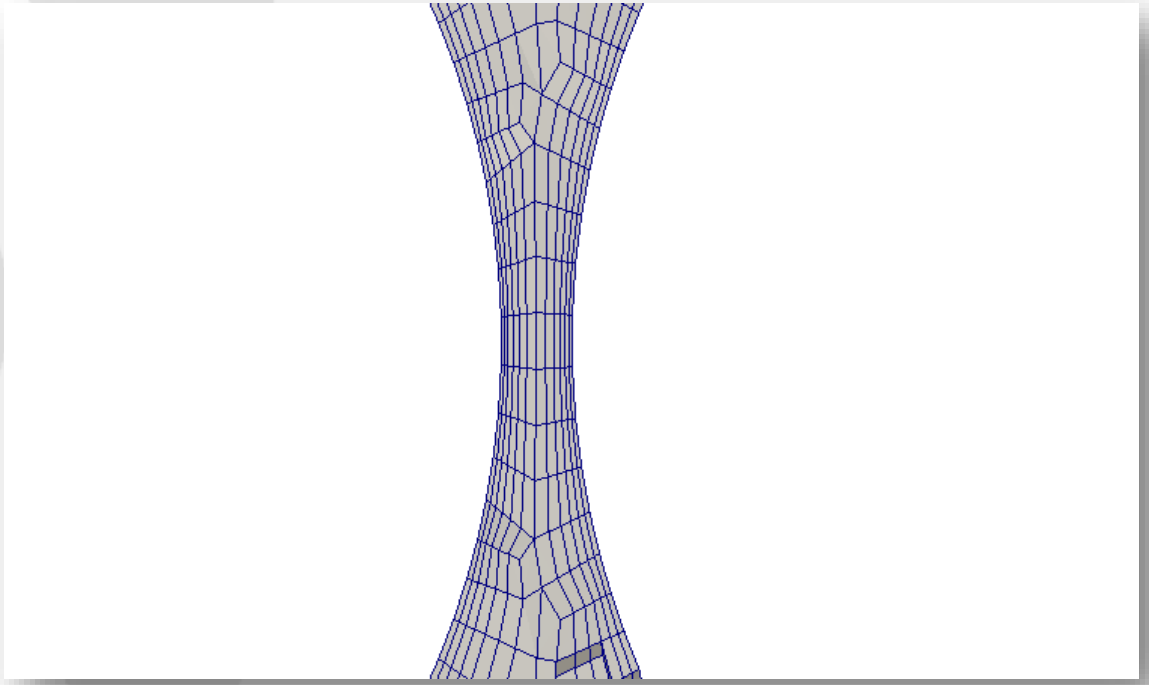
New Meshing Approach | Snapping





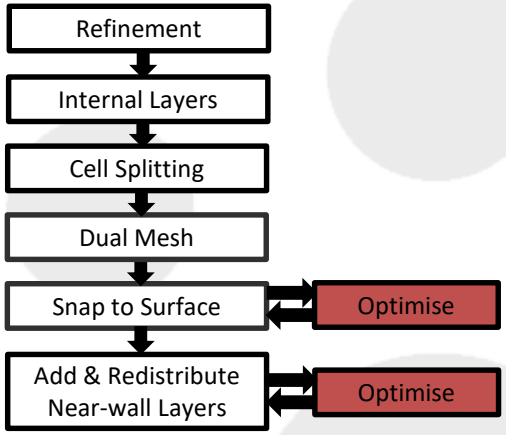
New Meshing Approach | Layers Addition





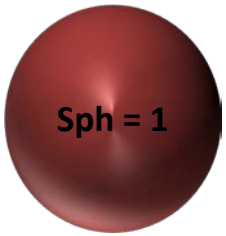
Beyond OpenFOAM | HelyX Mesh

New Meshing Approach | Optimise Quality

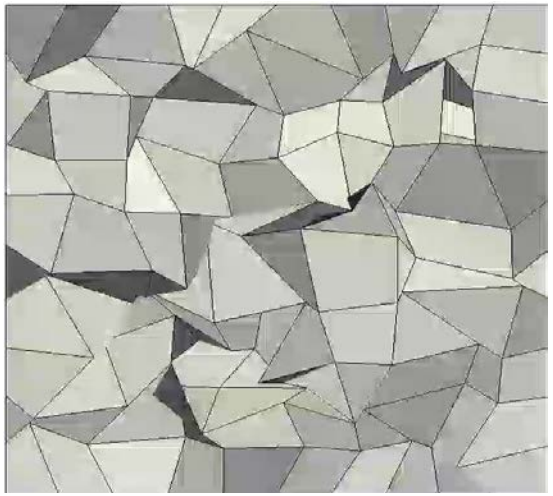


- Optimise for Sphericity

$$Sphericity = \frac{\left(\frac{6}{\pi}V_c\right)^{1/3}}{\left(\frac{1}{\pi}S_c\right)^{1/2}}$$



- Constrain boundary nodes to slide on the surface
- Respect mesh feature edges



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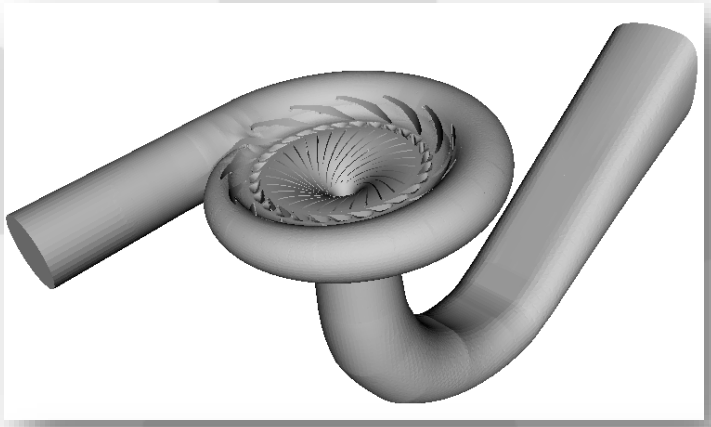
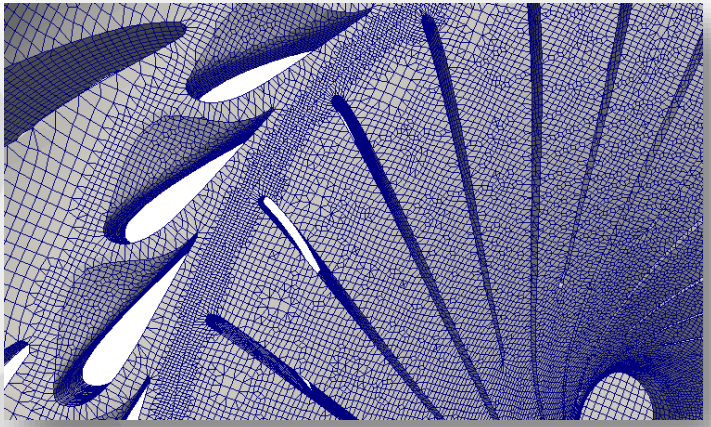
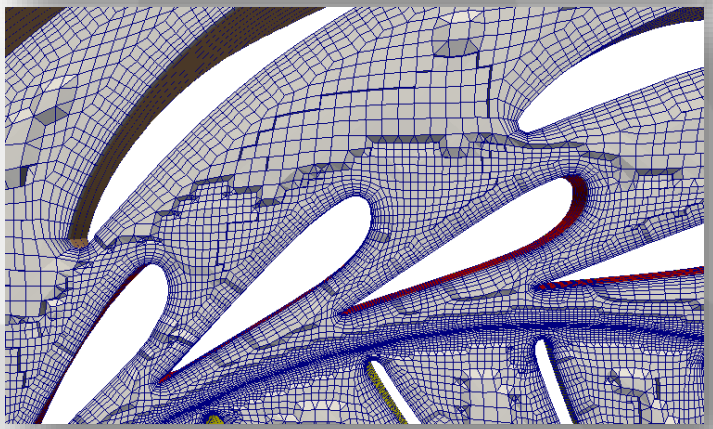
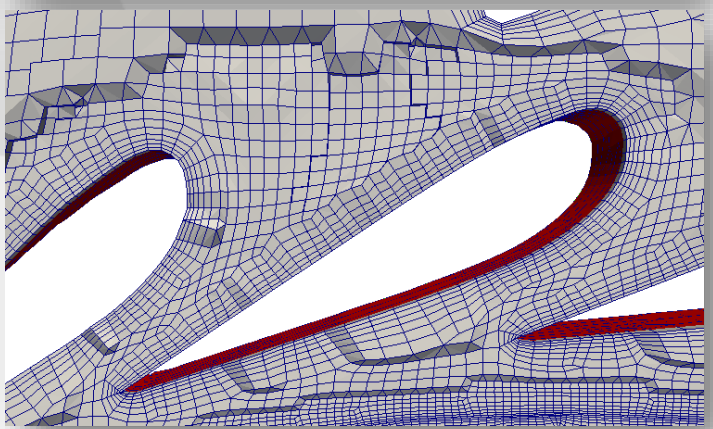
New Meshing Approach | Examples

- Francis99 Pump → 5 million cells – 6 near-wall layers



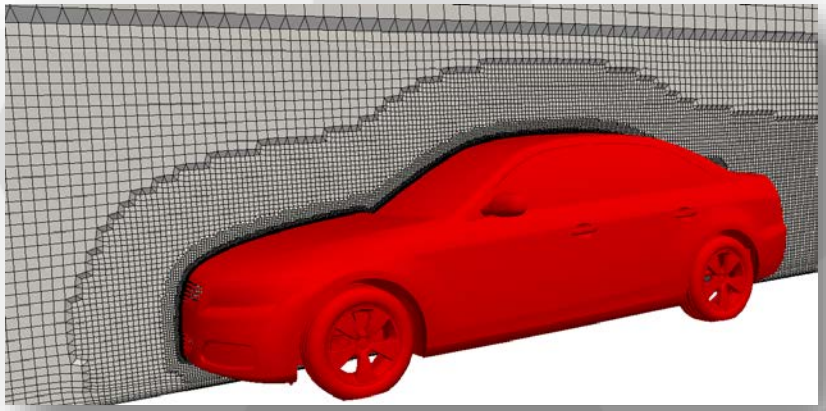


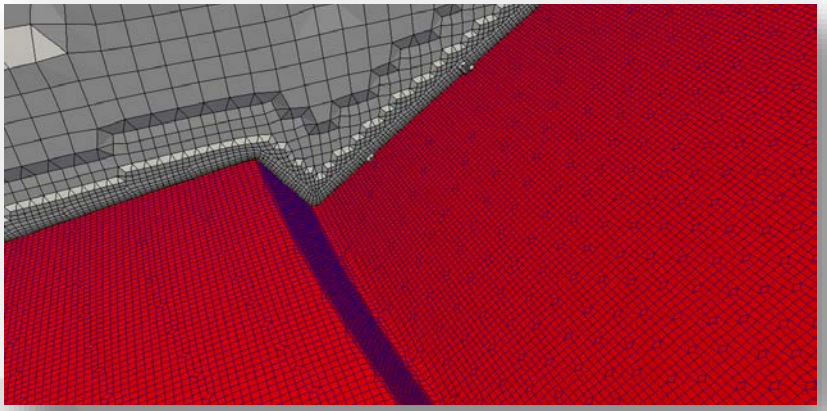


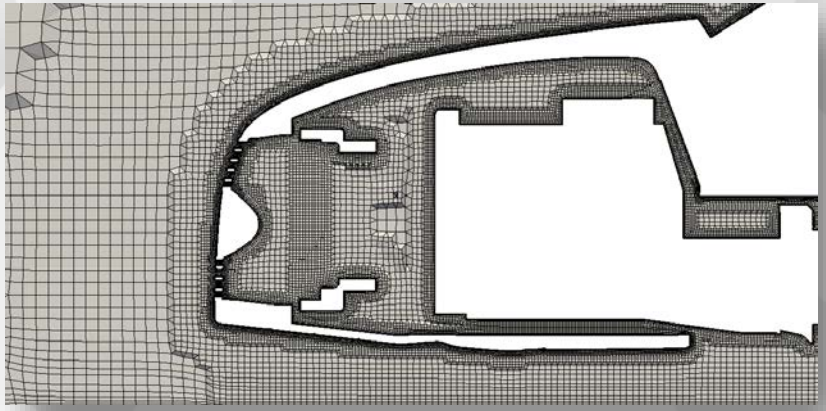


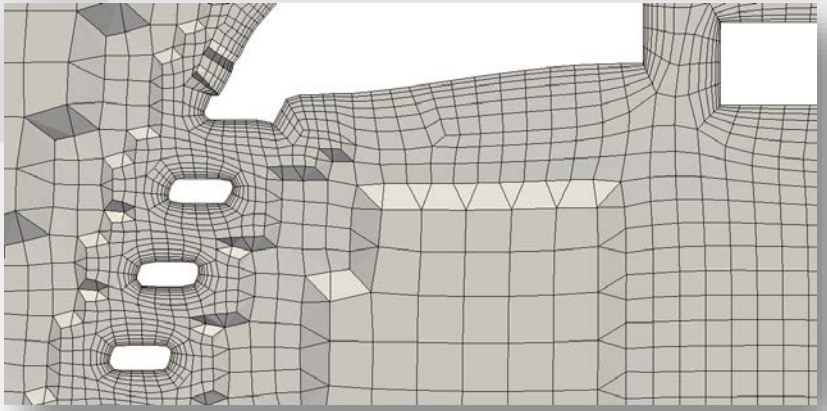
New Meshing Approach | Examples

- DrivAer → 37 million cells – 6 near-wall layers









Geometry courtesy of TUM

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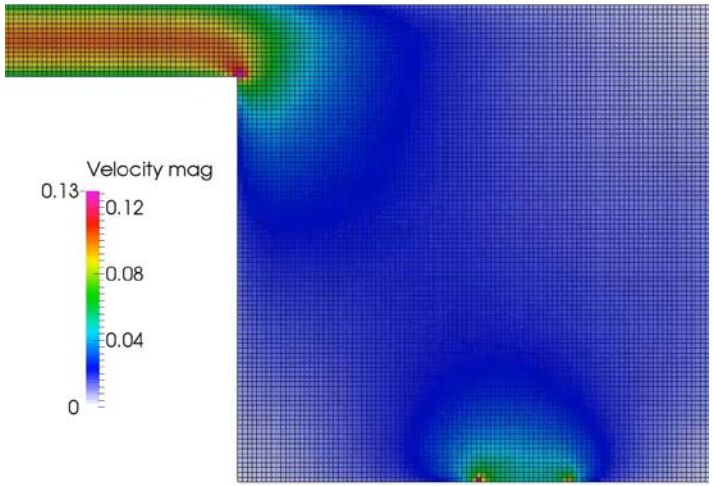
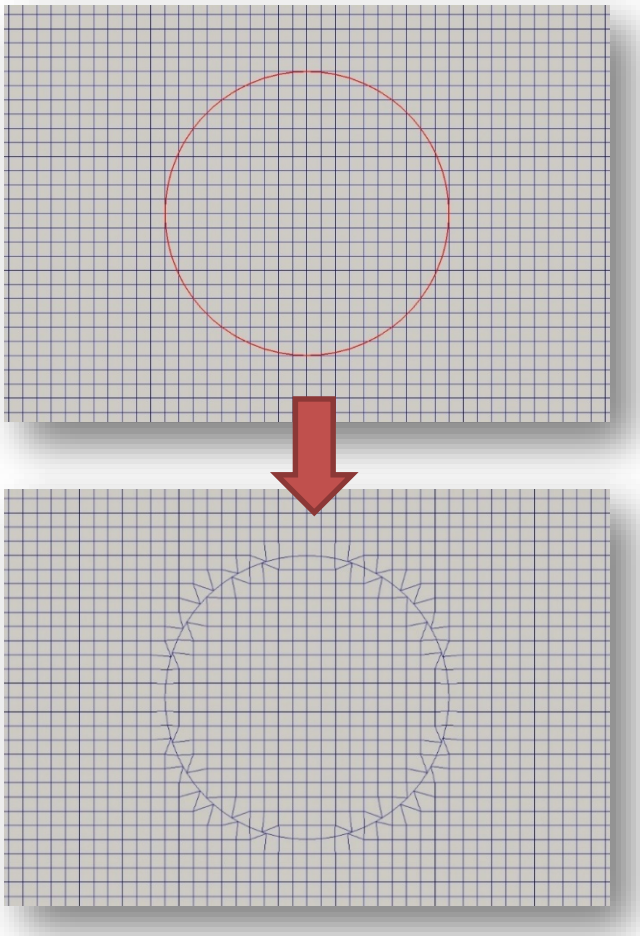
Immersed Boundaries (IB)

- Traditional IB approach:
  - Apply boundary condition at a virtual fluid-solid interface
  - Resistance/porosity added to "solid cells" in the matrix to block the velocity
- Lacks accuracy (especially in turbulent flow cases)
- In-situ IB primal results do not exactly match boundary fitted equivalent



Geometric Immersed Boundaries (GIB)

- New method proposed by ENGYS
  - Perform snapping at the interface
  - All quantities needed from FV updated
- Same accuracy as real boundaries
- Work with every solver and operation
- Apply any boundary condition using common interface
- Cover both static and dynamic applications



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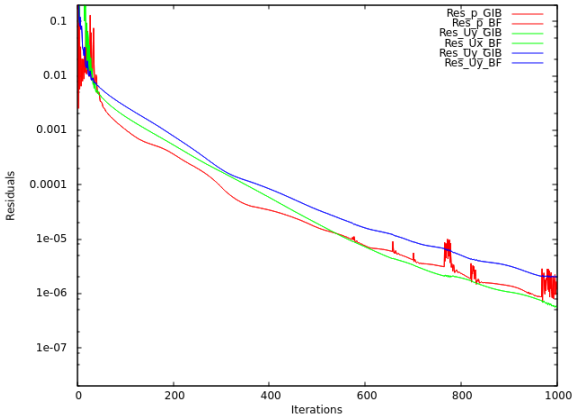
GIB Implementation

- 30 new classes added to OpenFOAM base code
- Changes in >100 existing classes
- `OpenFoam` libraries:
  - `polyMesh/patch` to insert the GIB classes
  - `GeometricField` macros to automate the operators
  - GAMG agglomerator
- `finiteVolume` libraries:
  - `fv(s)PatchField, fvPatch`
  - `fvm, fvc` operators
- Complete parallelisation

Beyond OpenFOAM | HelyX GIB

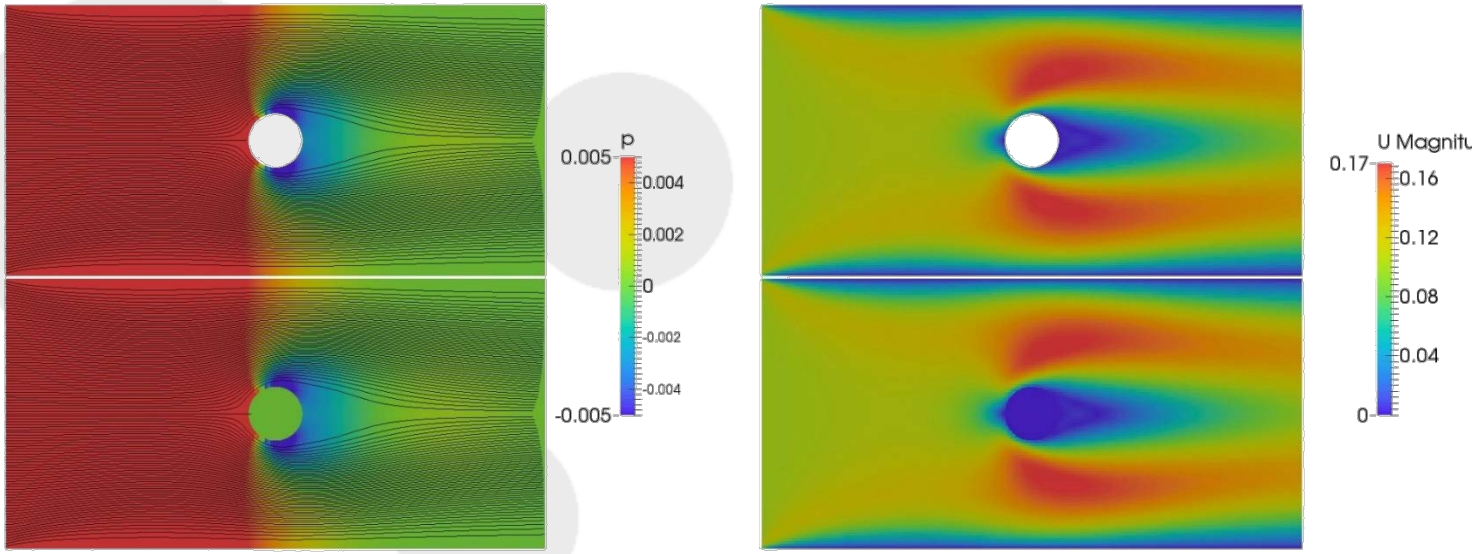
Static GIB | Stationary Cylinder

- Body-fitted vs GIB cylinder results
- Identical residuals-results (machine accuracy)



Body-Fitted

GIB



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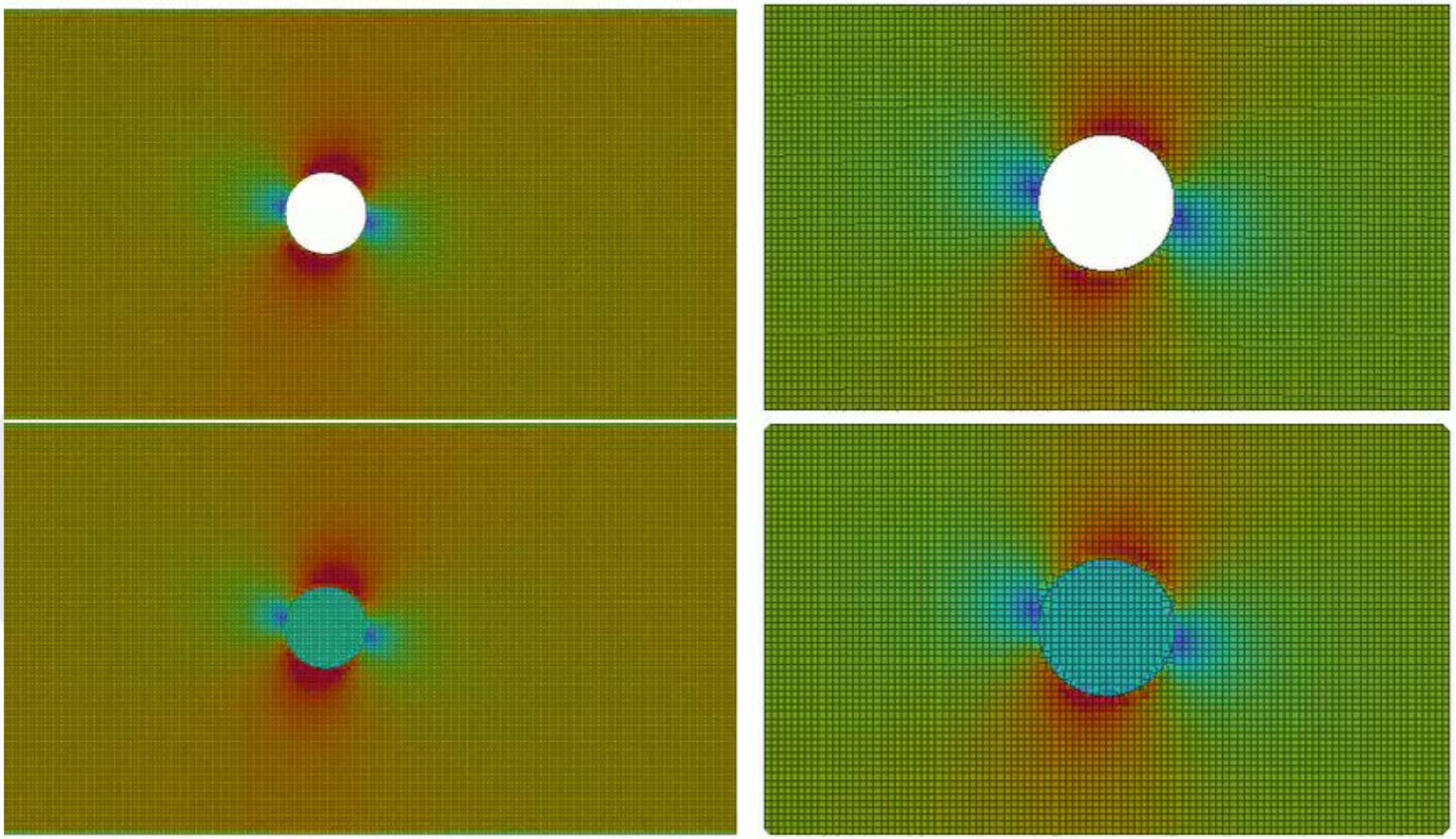
Beyond OpenFOAM | HelyX GIB

Dynamic GIB | Moving Cylinder

Body-Fitted

GIB



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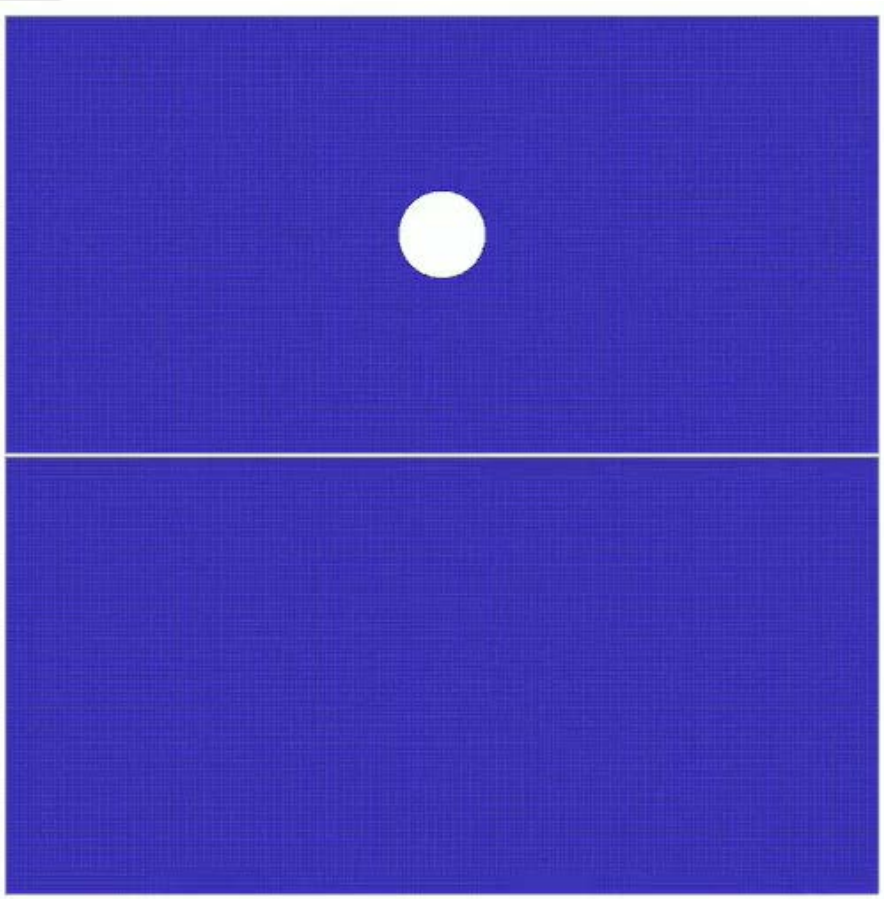
Dynamic GIB | Cylinder Wall Collision

Body-Fitted

GIB



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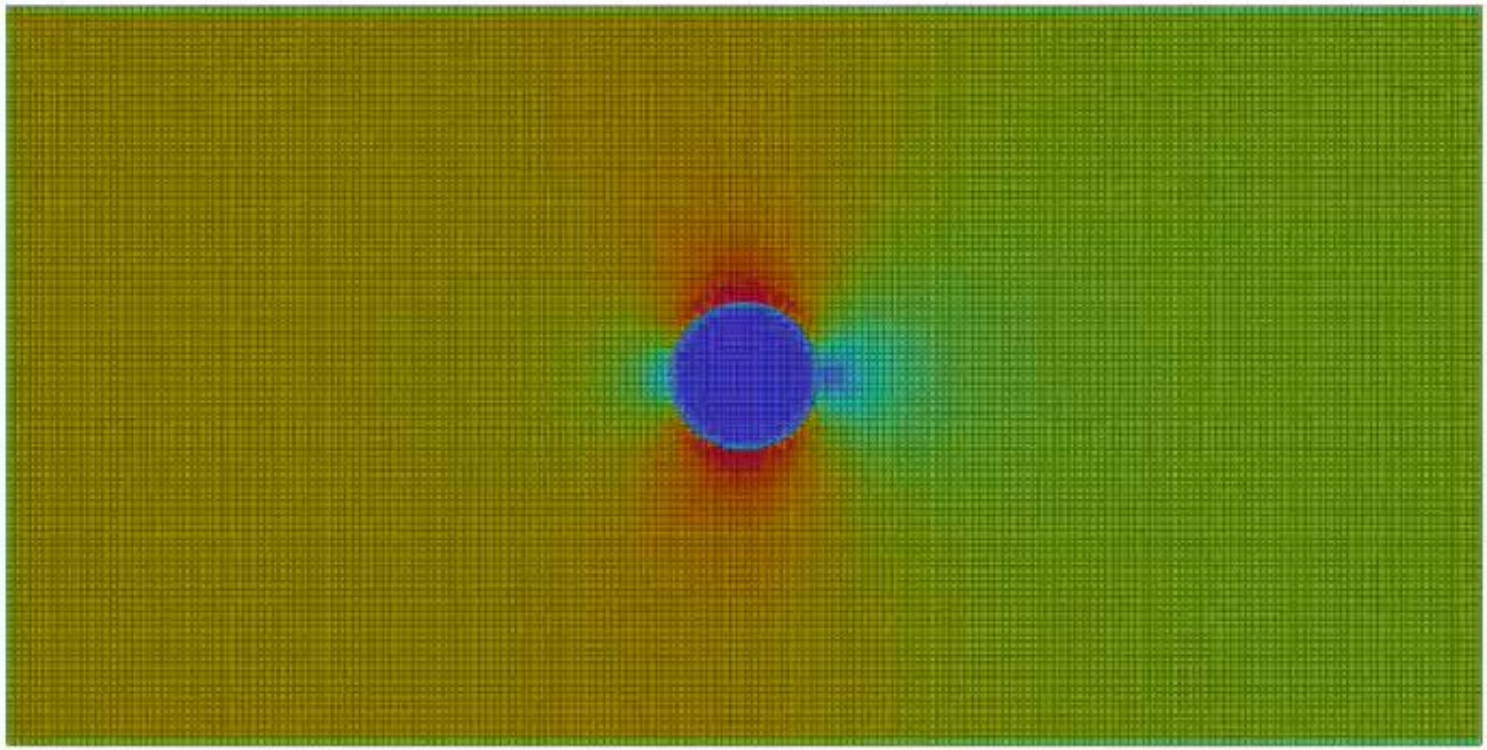
Dynamic GIB | Pulsating Cylinder



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Conclusions

- Pushing the boundaries of CFD technology is at the very core of what we do at ENGYS
- OpenFOAM offers a good development platform for advanced CFD solver applications
- Deep knowledge of the OpenFOAM code is a necessity
- Complexity is an issue
- Quality assurance is an issue
- Accountability is an issue
- Is the use of OpenFOAM cost-effective in industry?
- OpenFOAM → open project, developer centric
  HELYX → enterprise-class product, user centric

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Q & A

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