

Formula 1 Front Wing Flow Analysis

Lukas Brink





Front Wing



Generates

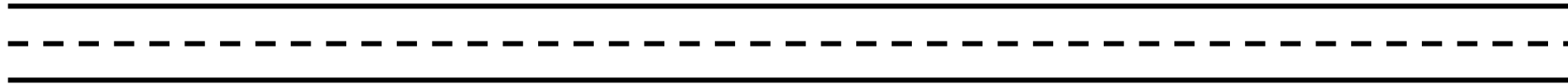
- Downforce
- Drag



Analysis

General Numerics Study

Meshing • Boundary Conditions • Schemes • Results

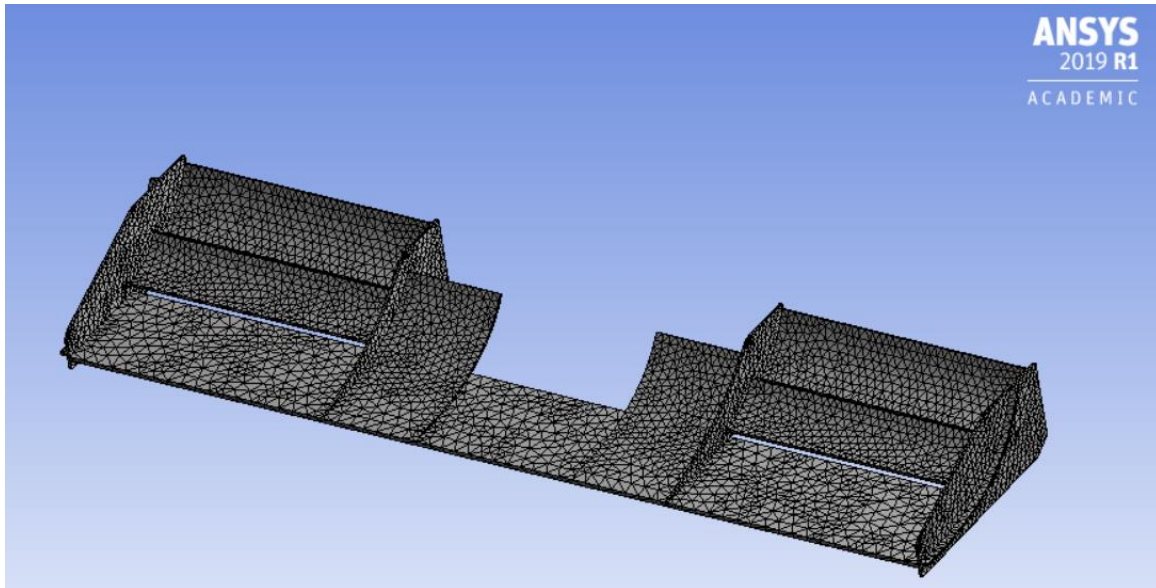


Case Study

Spa Francorchamps • Tailored packages • Results



General Numerics Study



Open  FOAM



General Numerics Study

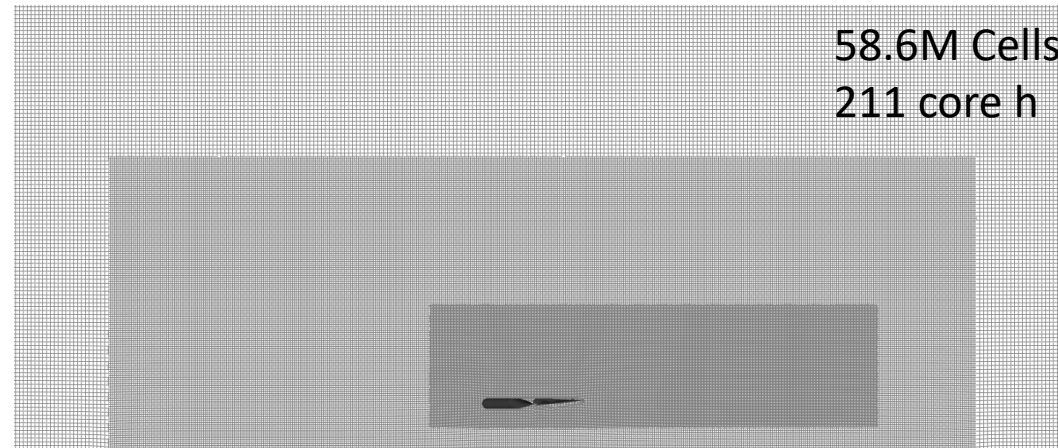
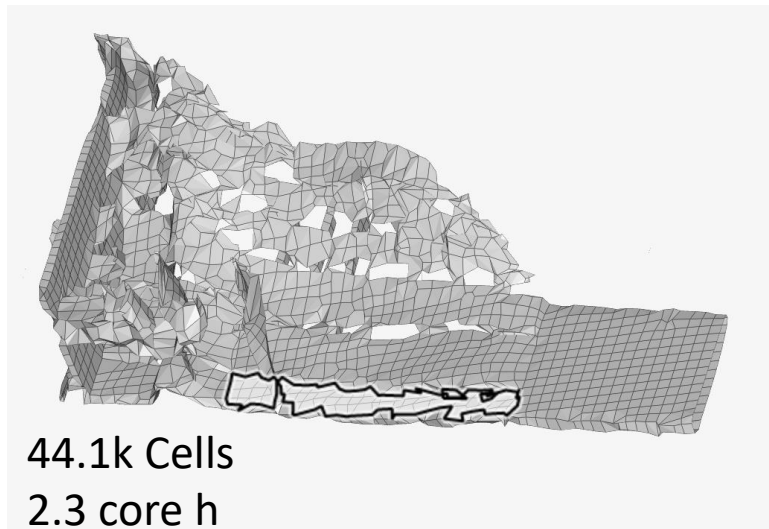
Meshing

- Unstructured Grid
- Hexagonal cells
- Variable element size
- Element quality implementation



General Numerics Study

Meshing



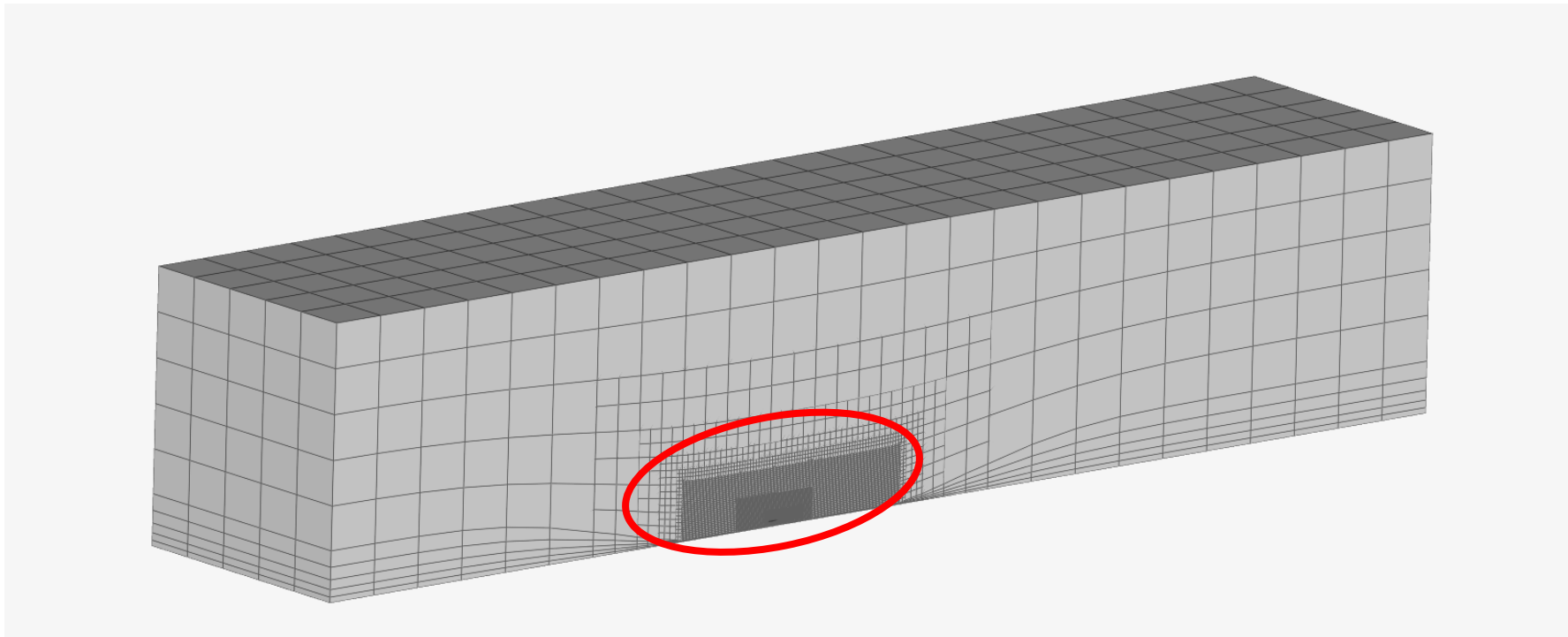
Balance accuracy and computation time



General Numerics Study

Meshing

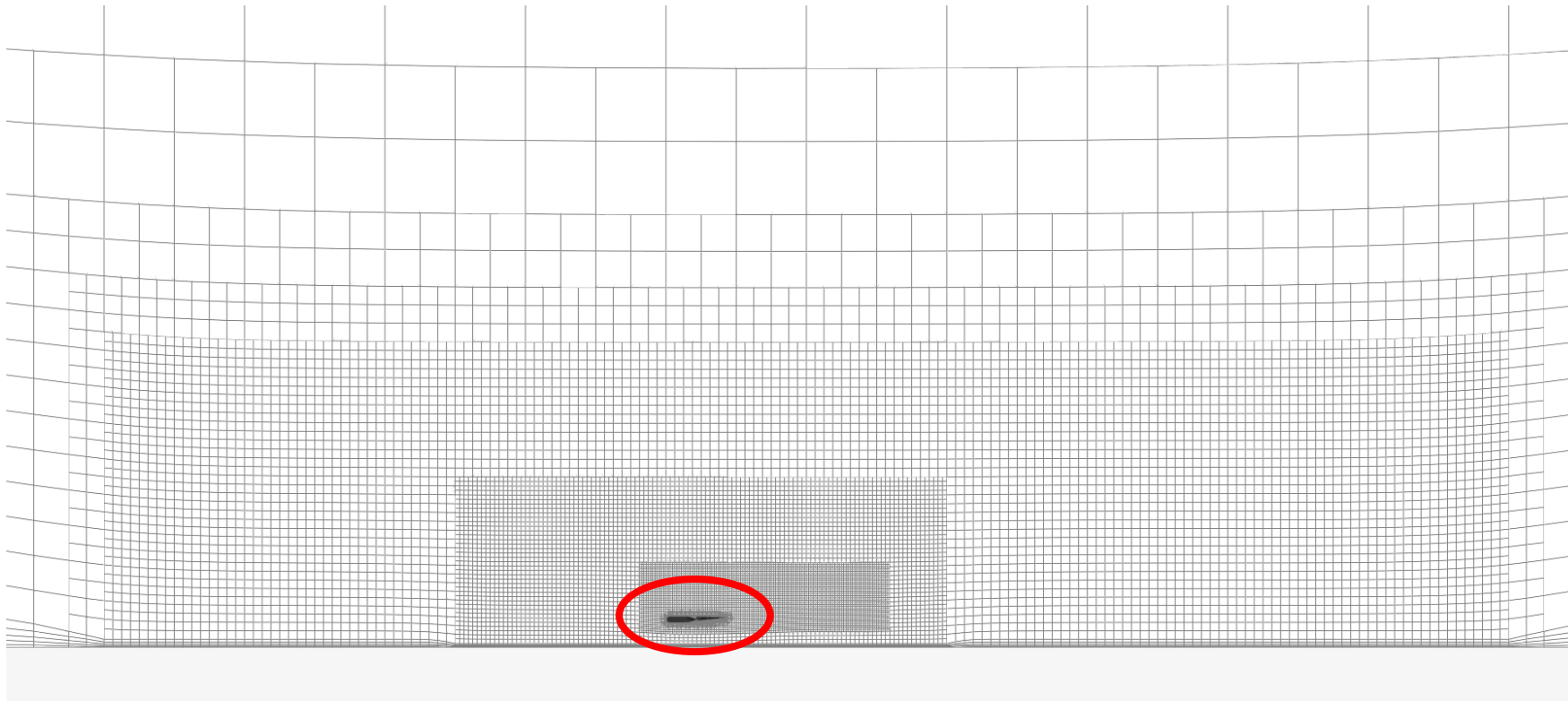
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General Numerics Study

Meshing

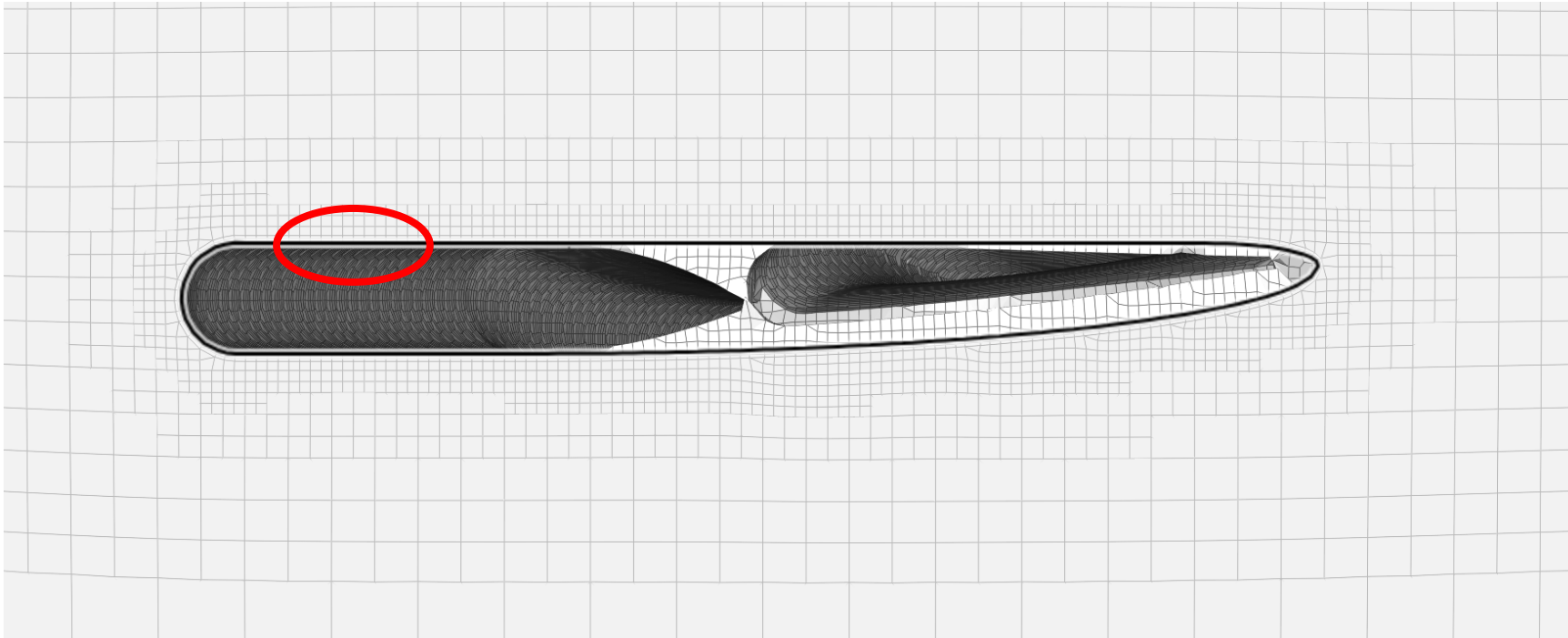
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General Numerics Study

Meshing

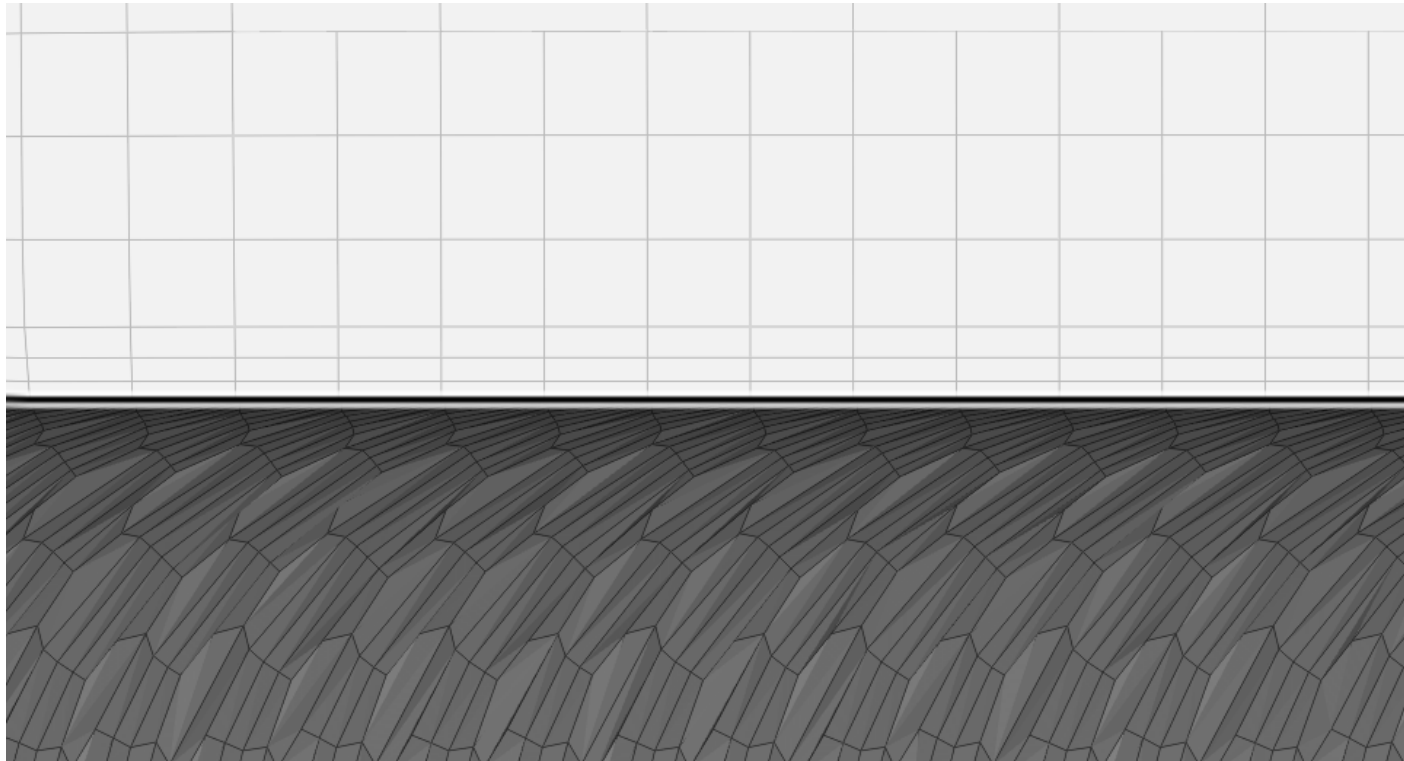
- Unstructured Grid
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General Numerics Study

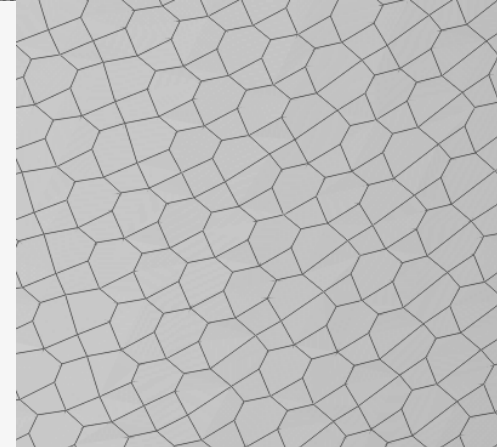
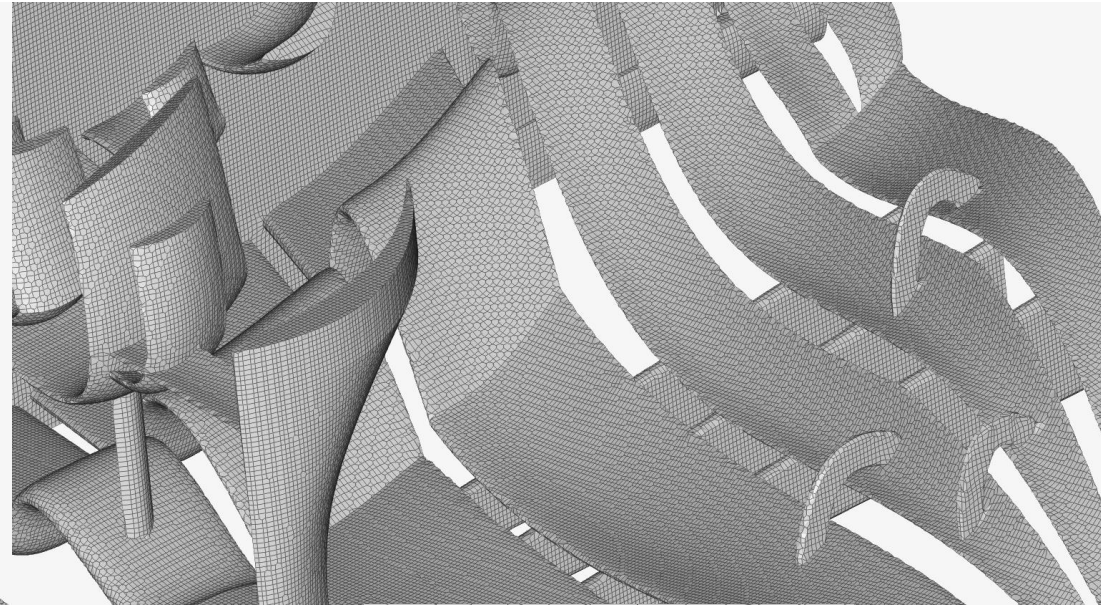
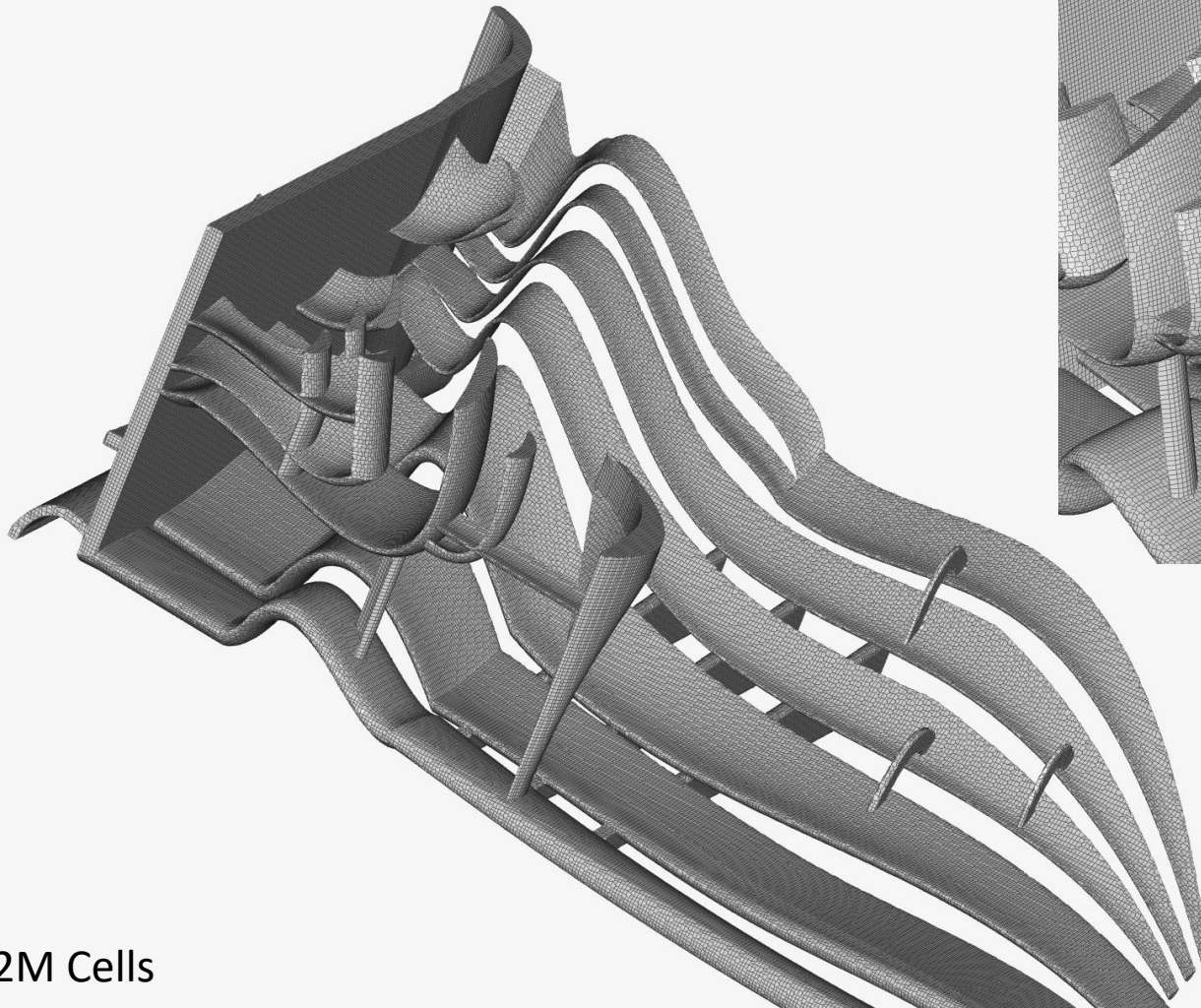
Meshing

- Unstructured Grid
- Hexagonal cells
- Variable element size
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General Numerics Study

Meshing

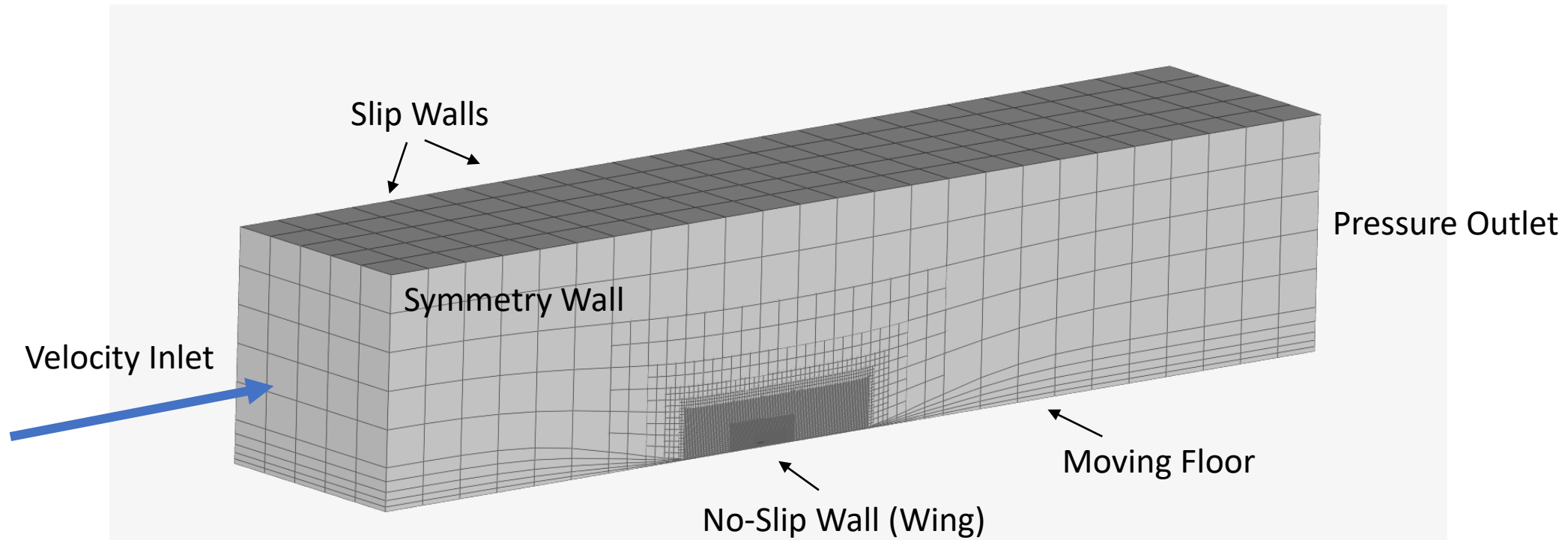


3.2M Cells



General Numerics Study

Boundary Conditions



General Numerics Study Schemes

- Interpolation: Linear or Cubic
- Integral approximation: Midpoint Rule
- Convection terms discretization: Bounded Upwind
- Gradient terms discretization: CellLimited Least-Squares
- Laplacian terms discretization: Gauss Linear Corrected

- Pressure: GAMG

- U, k, omega: Smooth solver

$$\int_t^{t+\Delta t} \left[\left(\frac{\partial \rho \phi}{\partial t} \right)_P V_P + \sum_f \mathbf{S}_f \cdot (\rho \mathbf{u} \phi)_f - \sum_f \mathbf{S}_f \cdot (\rho \Gamma_\phi \nabla \phi)_f \right] dt = \int_t^{t+\Delta t} (S_c V_P + S_p V_P \phi_P) dt$$

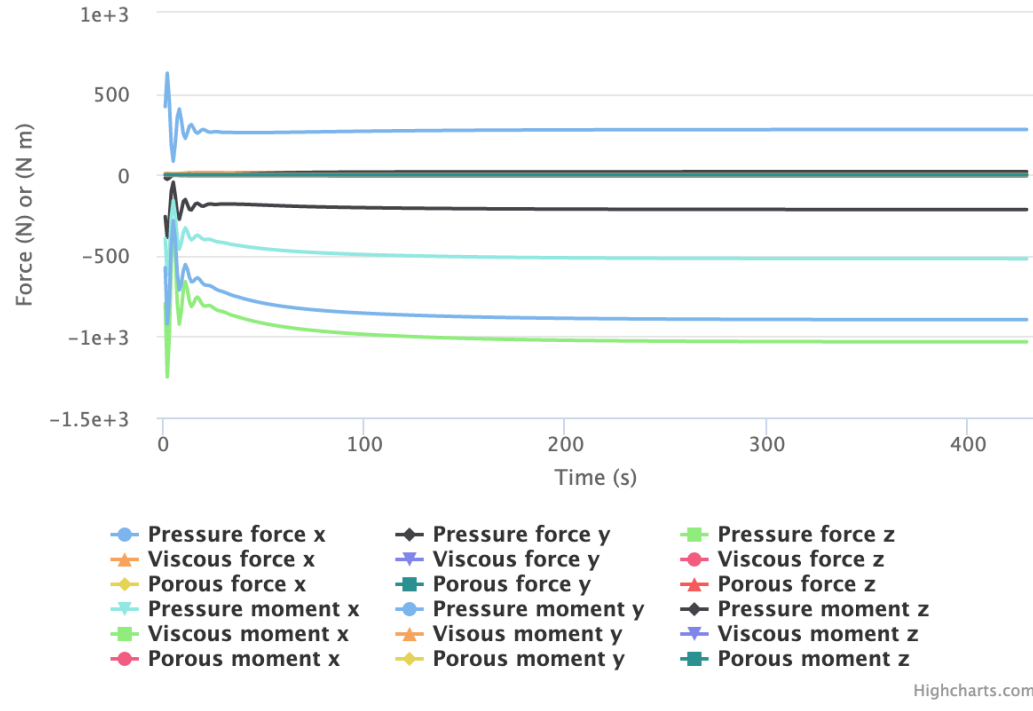
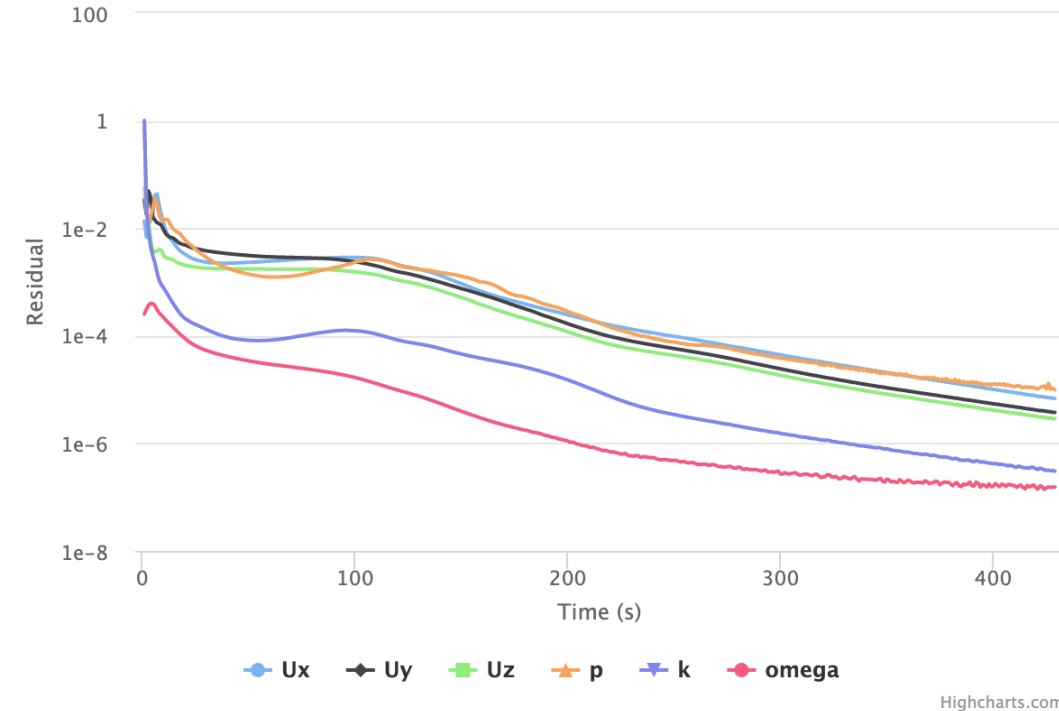
- Projection method: SIMPLE

- Turbulence model: K-Omega SST



General Numerics Study

Results - Convergence



Residual

$$|\mathbf{A}\phi^k - \mathbf{b}| = |\mathbf{r}^k|$$

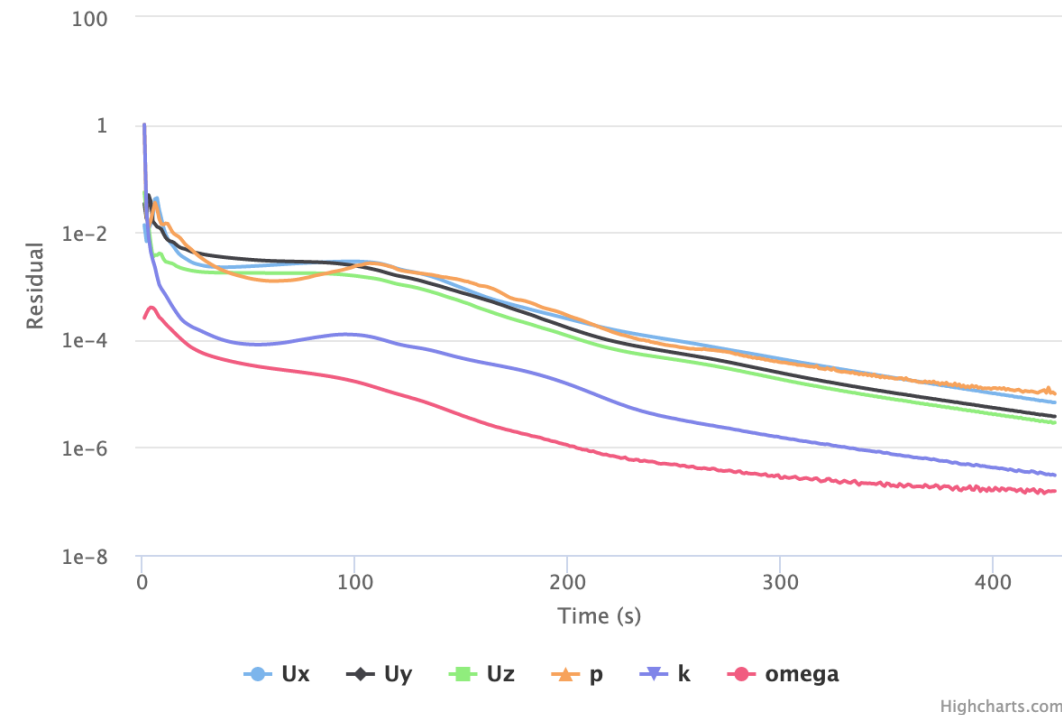
Solution

$$\text{Residual} = \frac{|\mathbf{r}|}{\text{Normalization factor}} < \text{Tolerance}$$

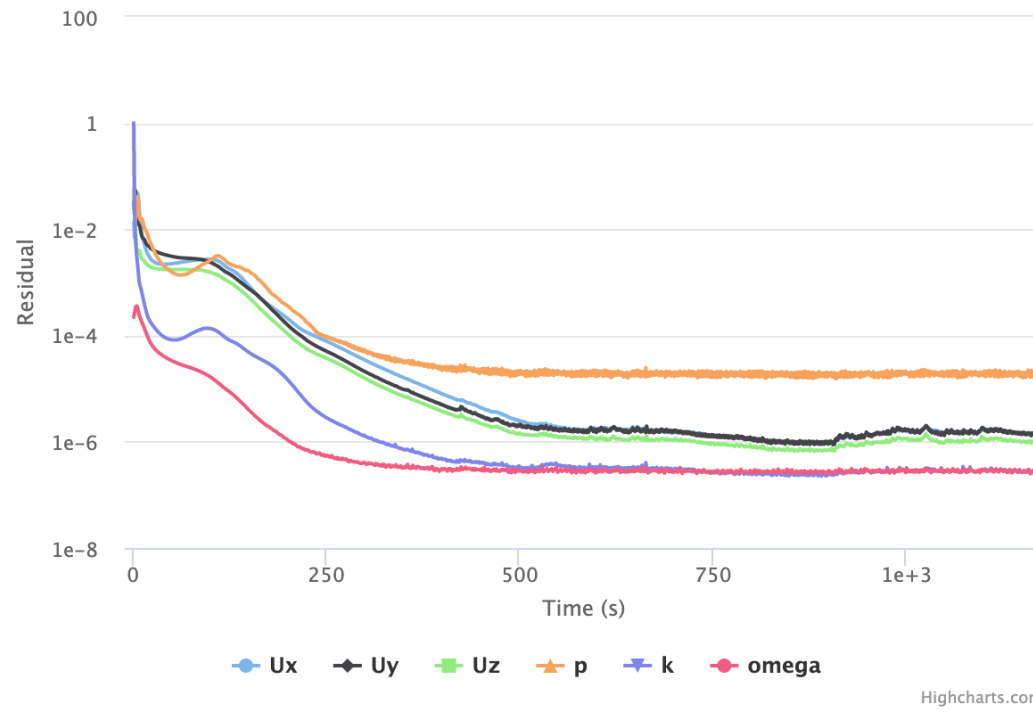


General Numerics Study

Results - Convergence



Linear Interpolation

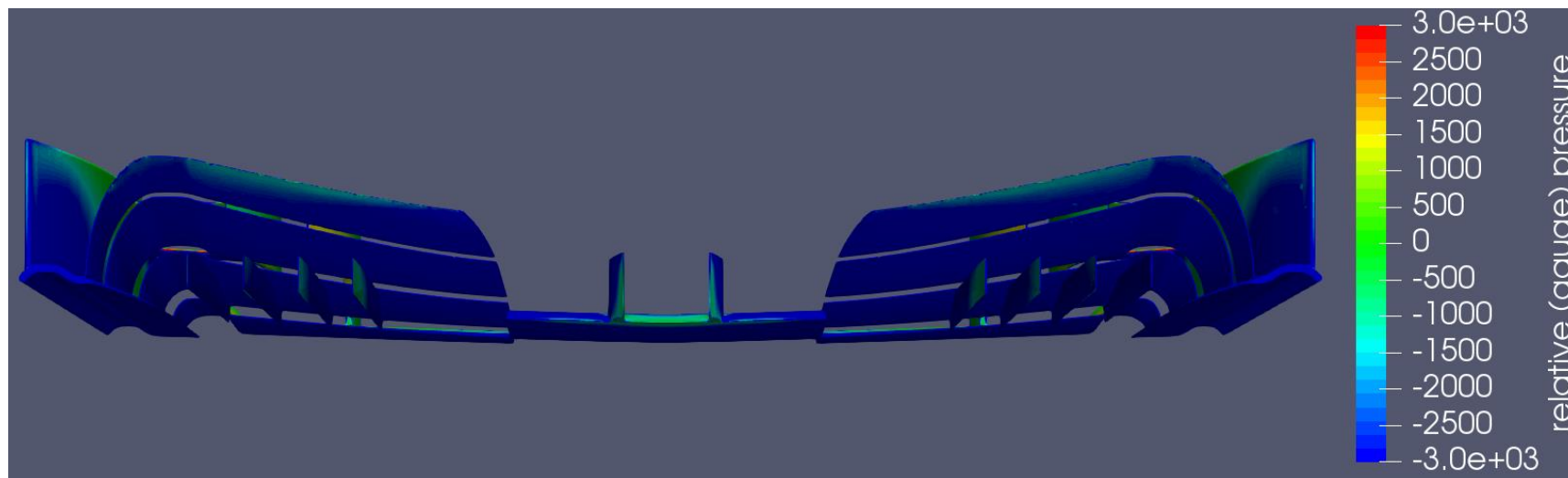
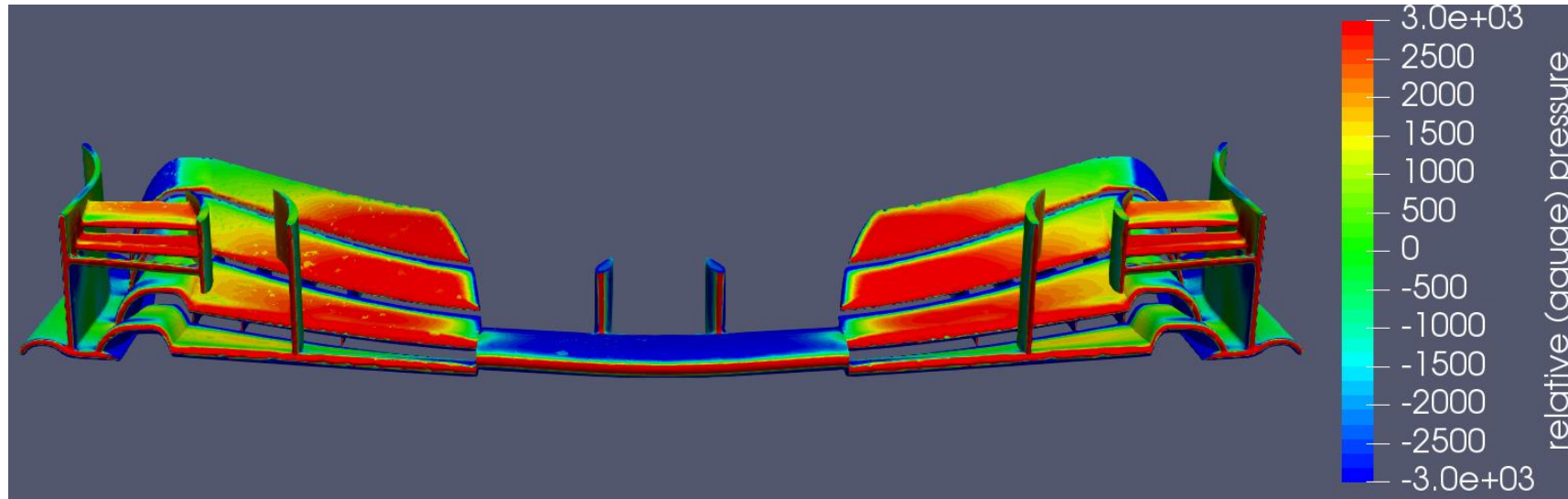


Cubic Interpolation



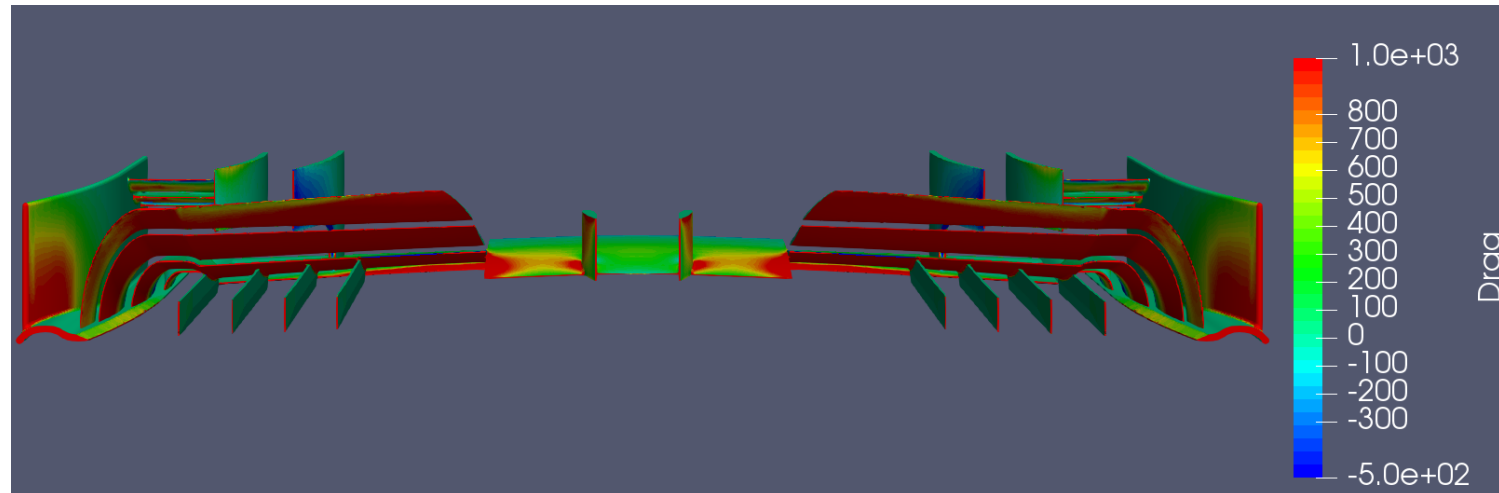
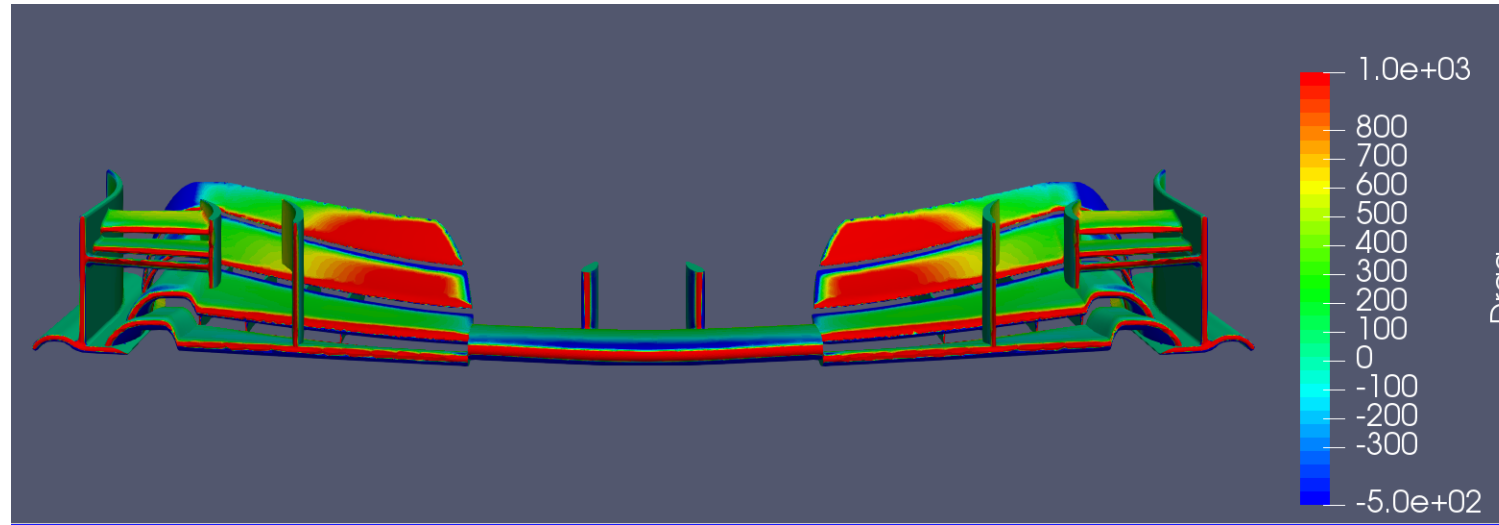
General Numerics Study

Results – Pressure Visualization



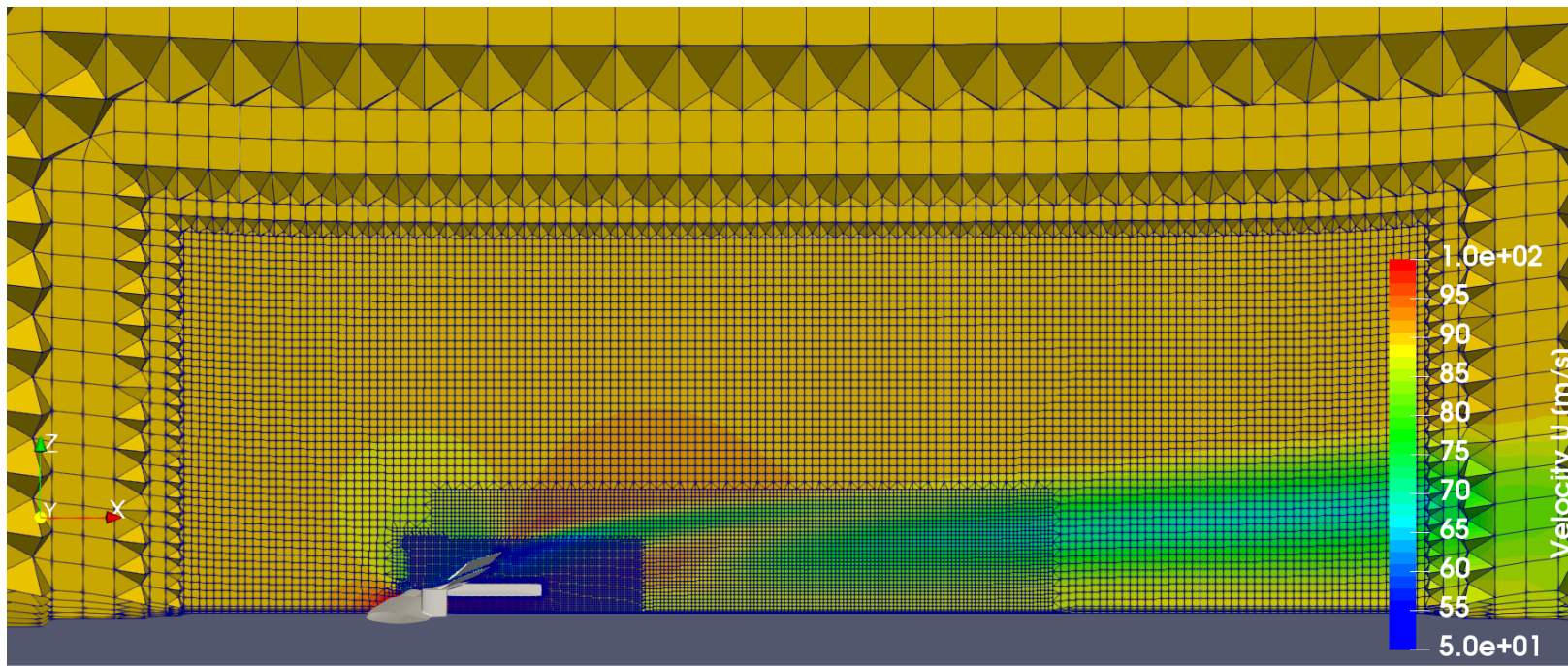
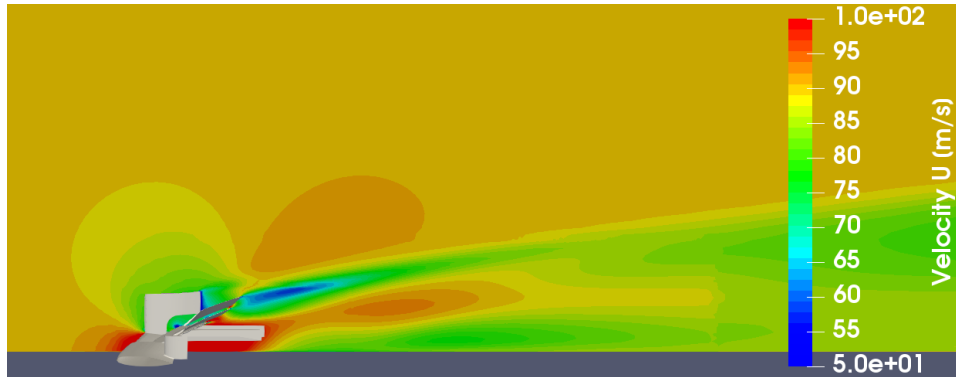
General Numerics Study

Results – Drag Visualization



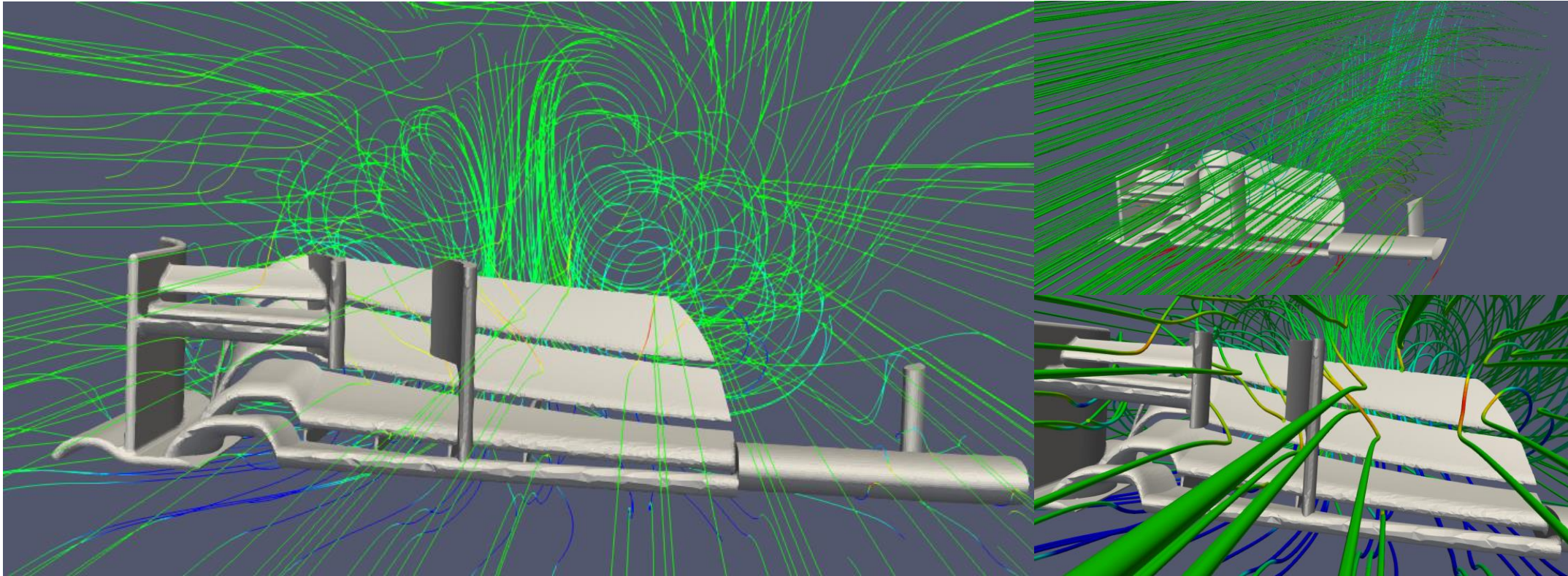
General Numerics Study

Results – Flow Visualization



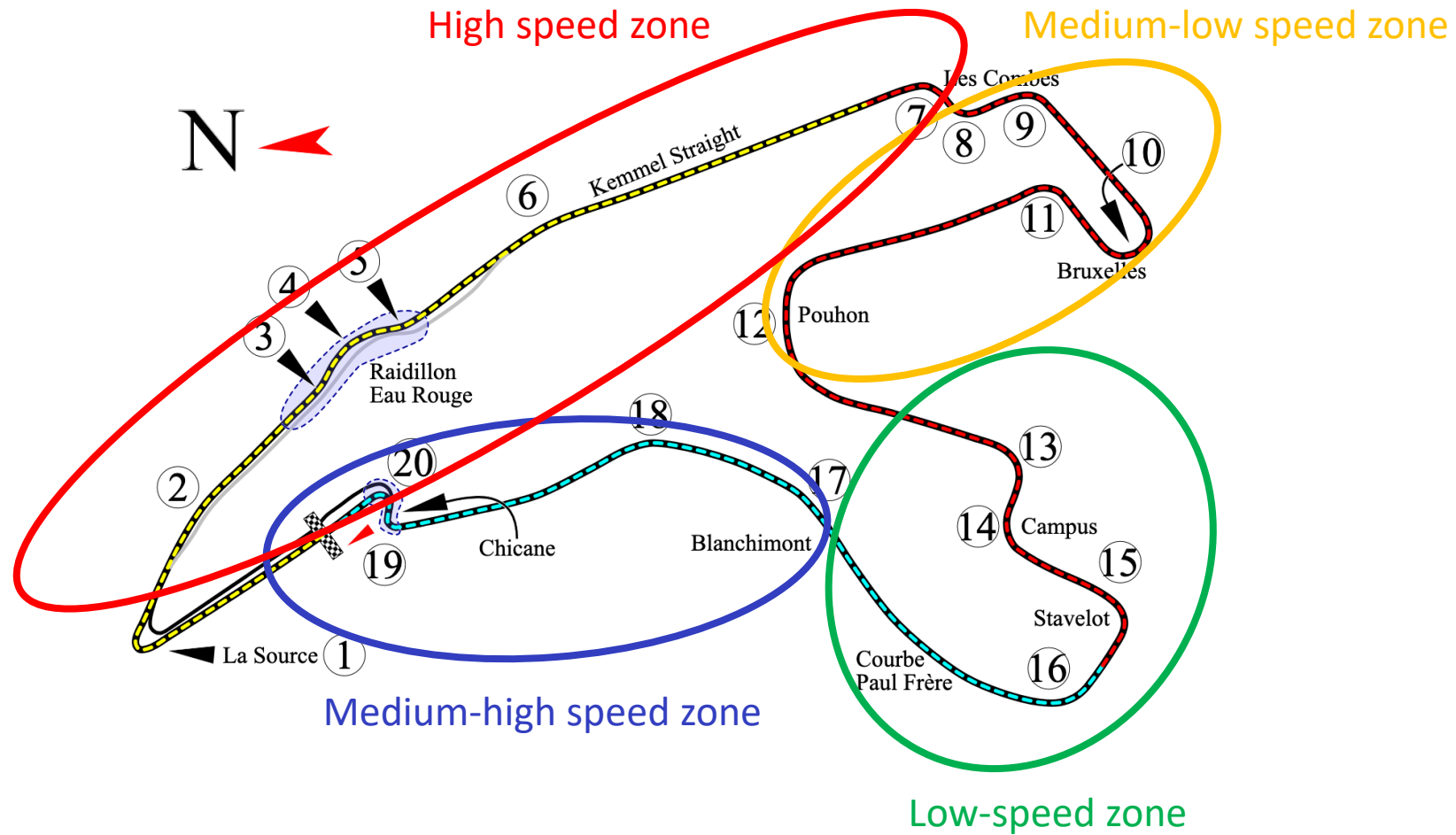
General Numerics Study

Results – Flow Visualization



Case Study

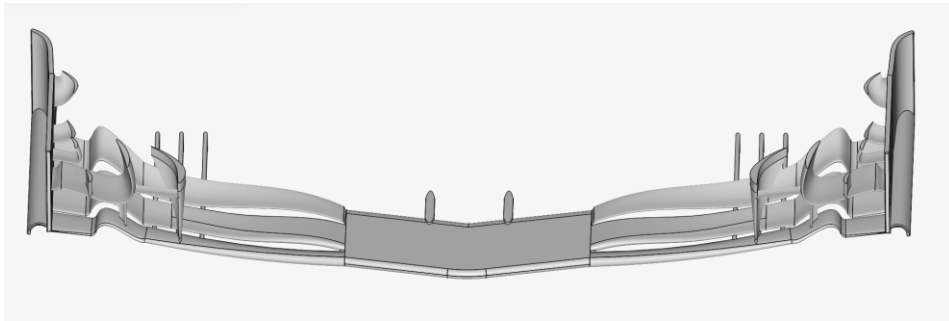
Spa Francorchamps



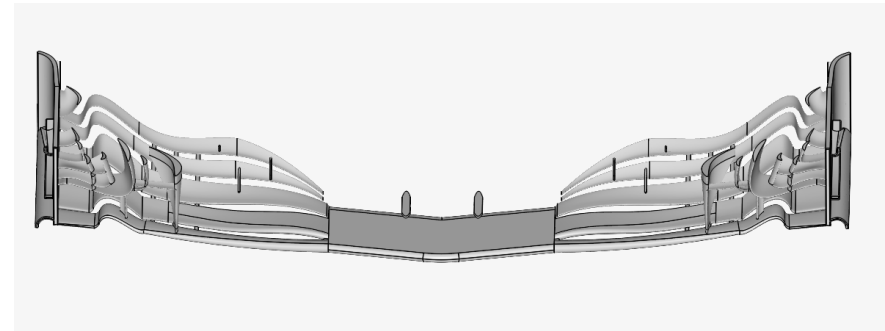
Case Study

Spa Francorchamps – Tailored Packages

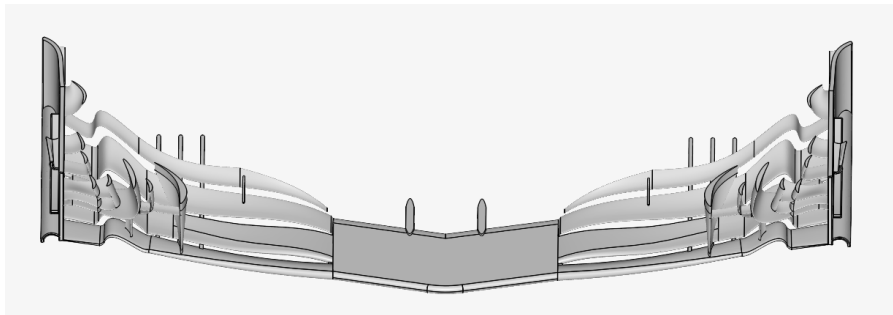
High speed zone



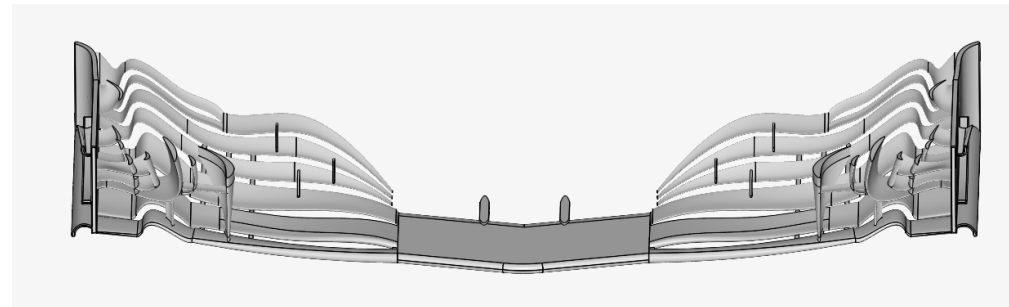
Medium-low speed zone



Medium-high speed zone



Low-speed zone



Case Study

Spa Francorchamps – Results

High speed zone

Downforce	471 N
Drag	108 N

Medium-low speed zone

Downforce	784 N
Drag	174 N

Medium-high speed zone

Downforce	670 N
Drag	153 N

Low-speed zone

Downforce	850 N
Drag	209 N



Thank you

End of 2.29

