Fluid Structure Interaction of a spoiler on the DrivAer car model

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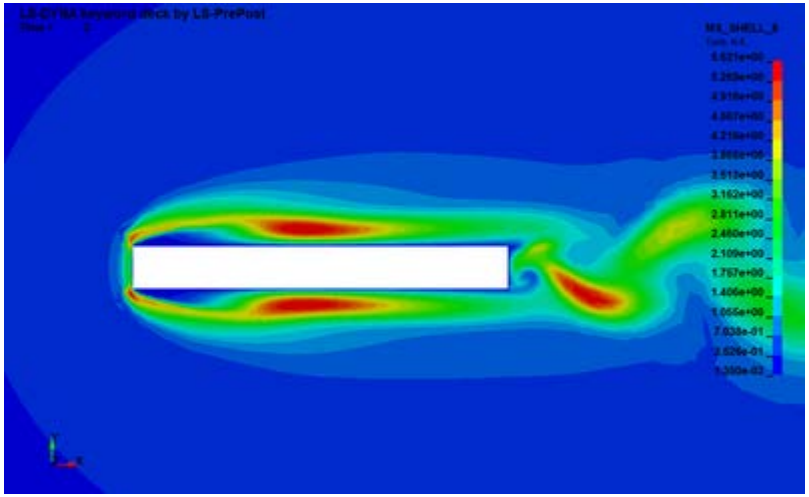
Outline

- Motivation – Fluid-Structure Interaction (FSI) in automotive
- DYNA Incompressible Fluid Dynamics (ICFD) solver
- DrivAer car model
- Validation study comparing pressure profile to wind tunnel results
- Loads on a generic spoiler
- Fluid structure interaction simulations
- Potential for use of ICFD for automotive FSI

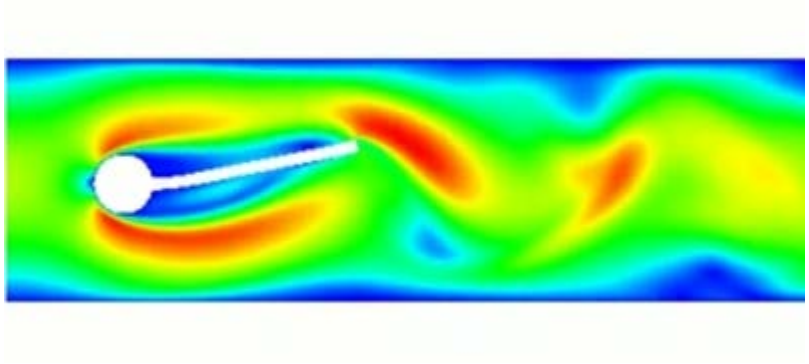
ICFD solver

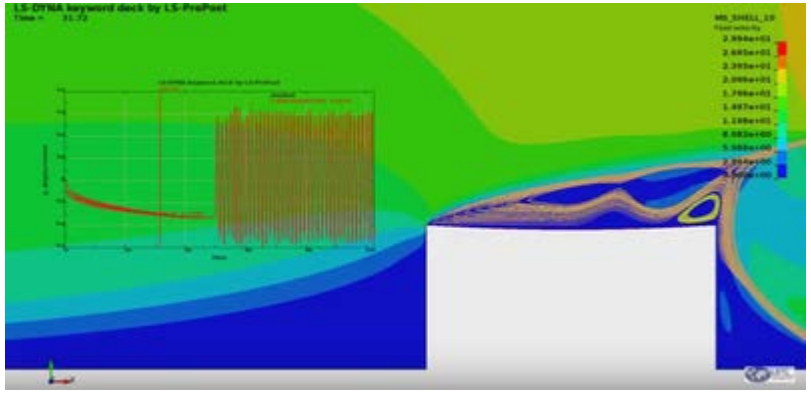
Features including:

- Incompressible flow
- Multiple turbulence models
- FSI coupling
- Thermal coupling
- Buoyant flows
- Free surface flows



- FSI coupling can be strong or weak.
- Validation cases on dynaExamples.com
- Mesh movement and automatic re-meshing

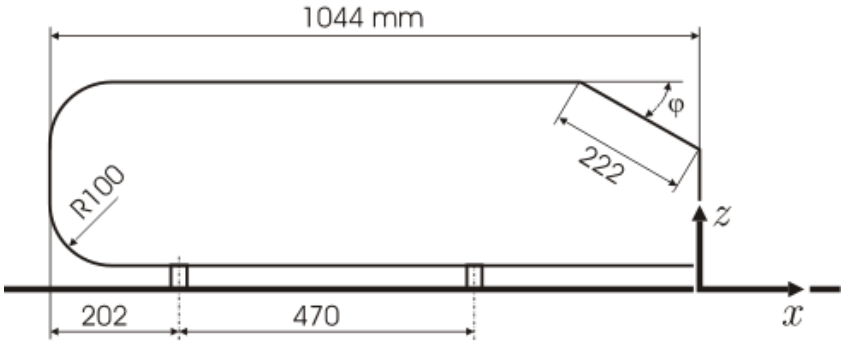


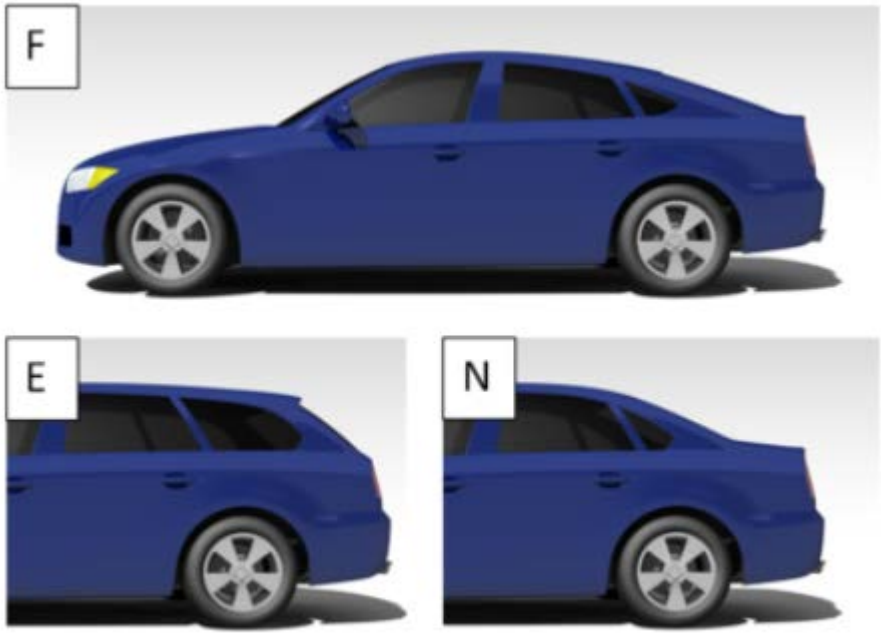


Images from dynaExamples.com

DrivAer Car model

- Generic car model Developed by Technical University of Munich (TUM) for aerodynamic studies
- More realistic than the simplified Ahmed and SAE bodies.
- Used for Validation of numerical models
- Some results from wind tunnel experiments are available – pressure profiles + global loads.



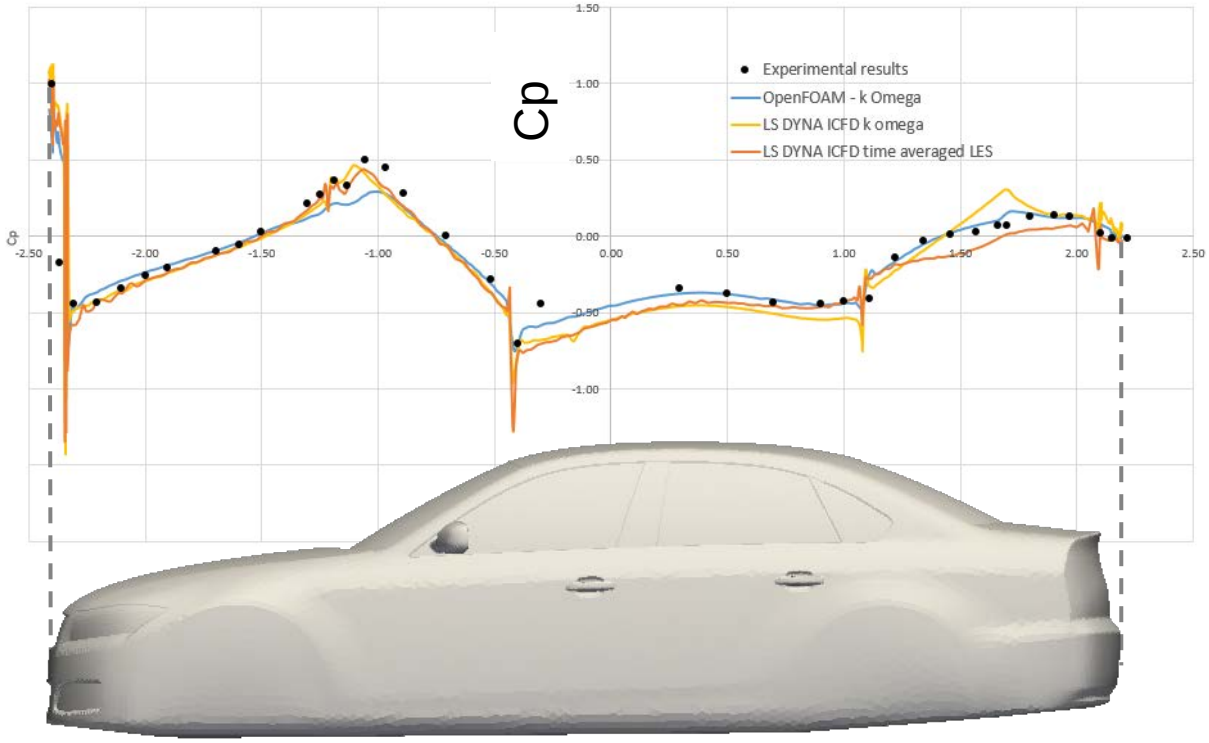


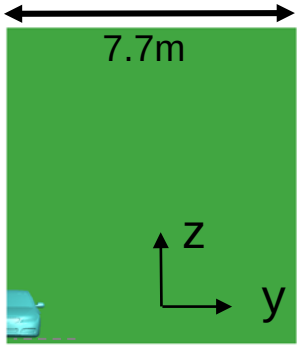
DrivAer body with different tops.

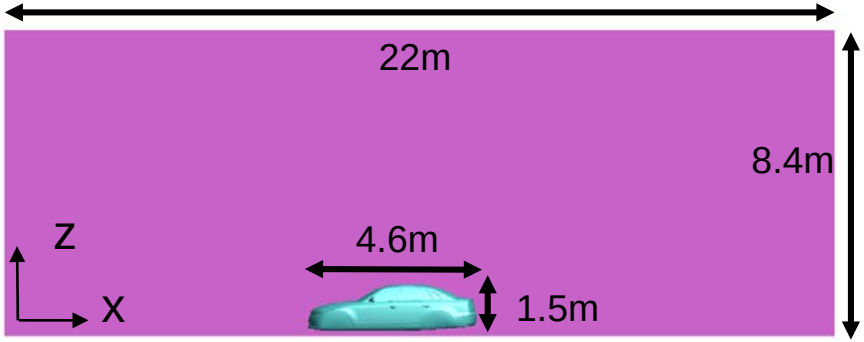
Images from TUM

Pressure profile on DrivAer model

- Comparison is made to experimental pressure profile from TUM
- Two ICFD simulations:
  - Steady state k-ω
  - Transient LES
- Steady state OpenFOAM k-ω simulation for comparison
- Flow is sensitive to turbulence model







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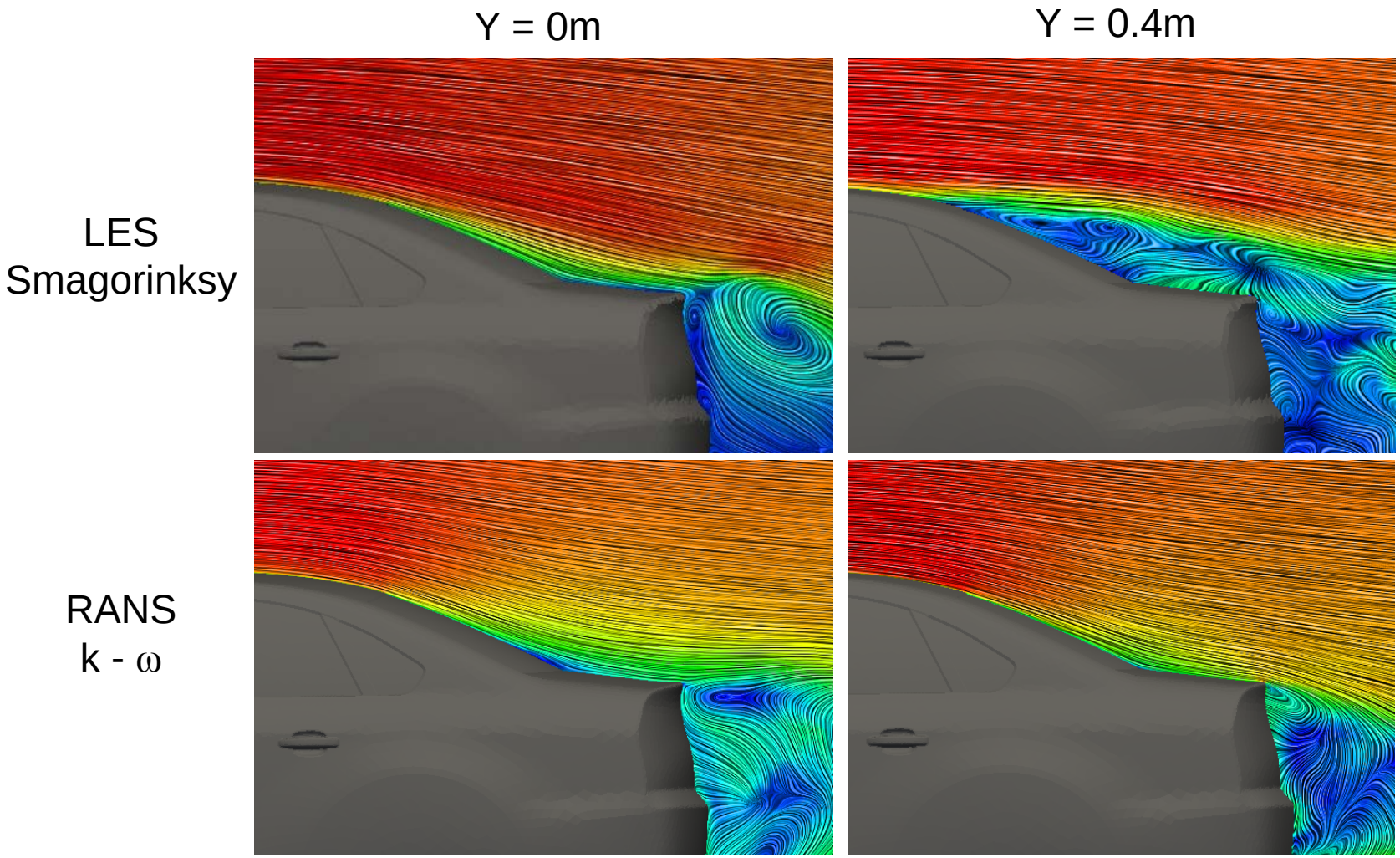
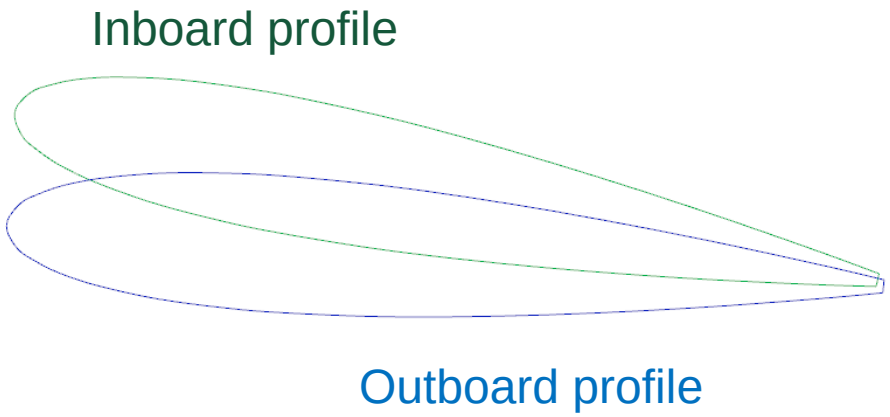
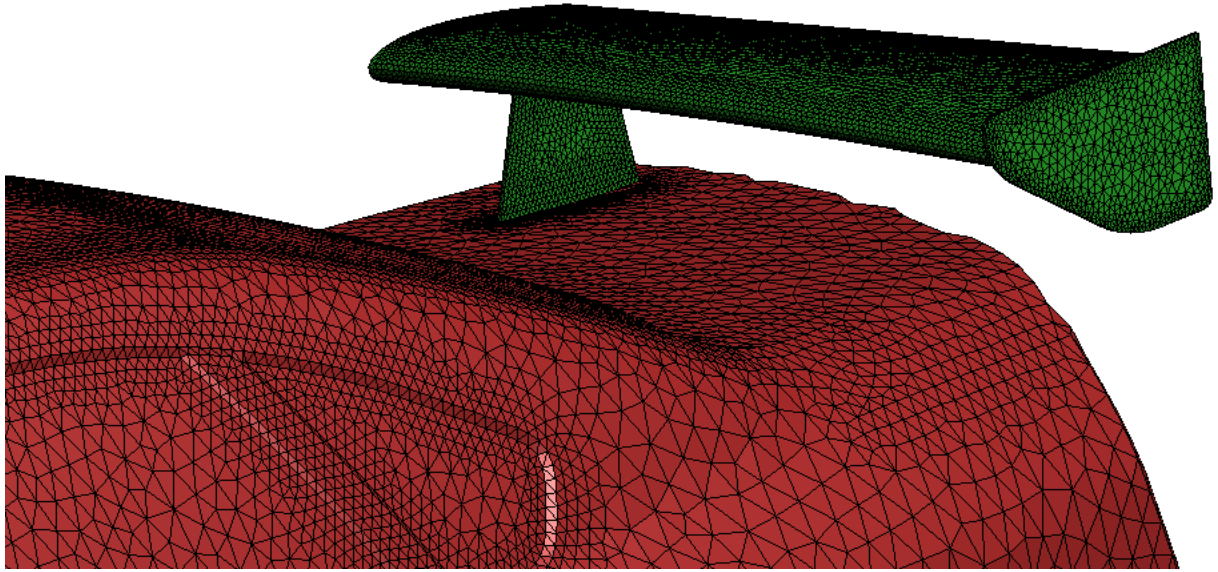
Velocity profile around rear window



CFD model with spoiler

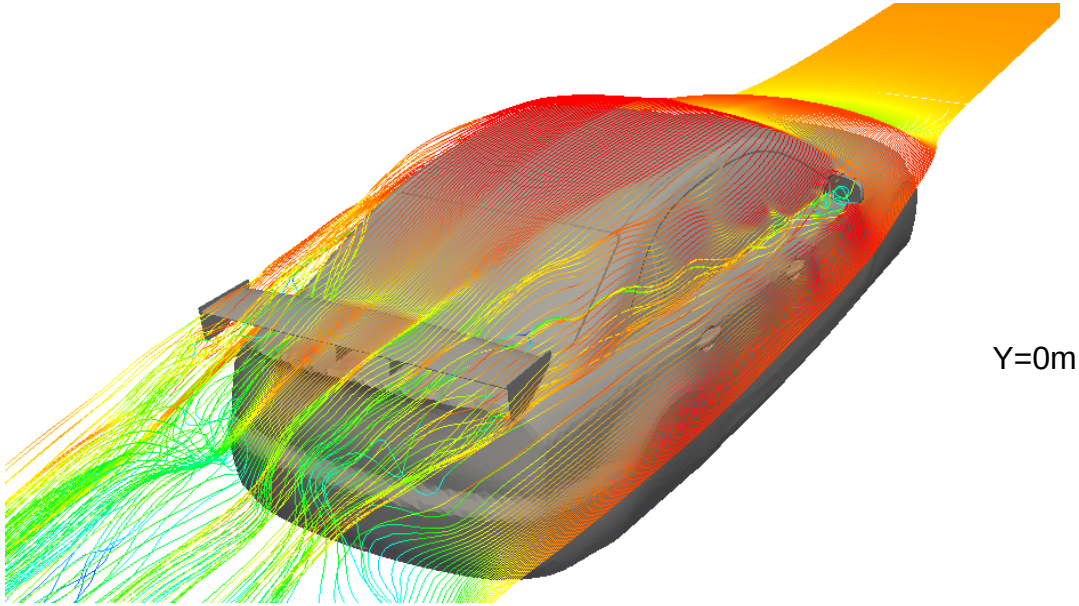
- Generic spoiler with end plate drawn
- NACA0012 profile used
- Profile rotated inboard to prevent separation



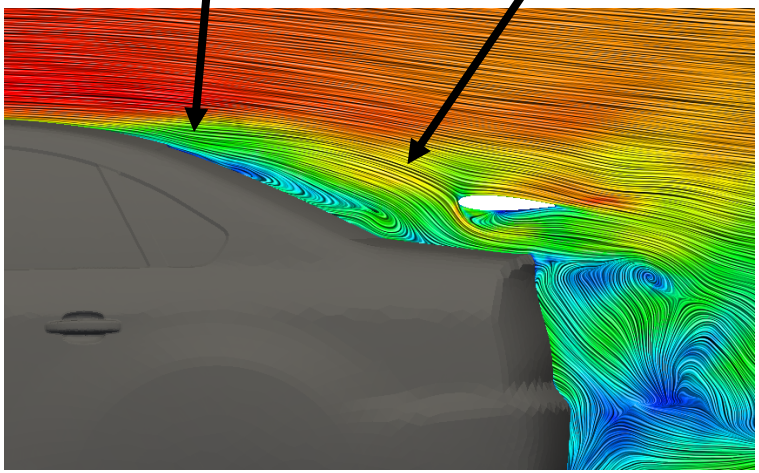


CFD results with spoiler

- LES model used
- Flow is attached on centreline, separated out wider.
- Cannot generate significant lift in wake of rear window



y=0.4m



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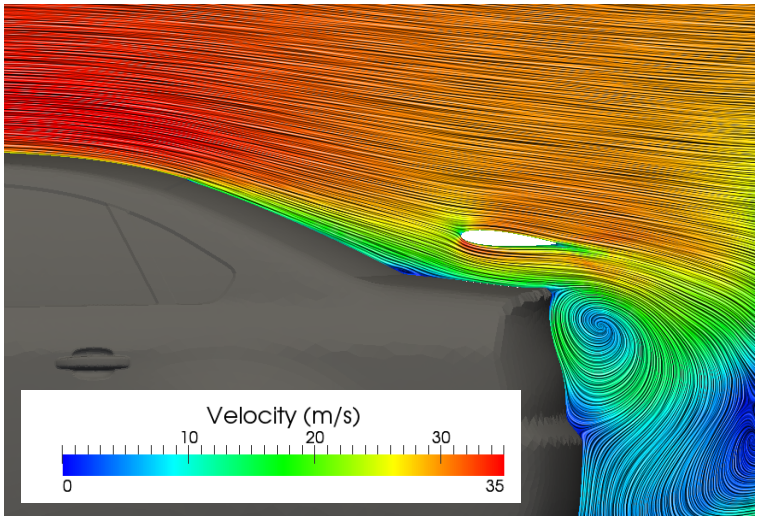
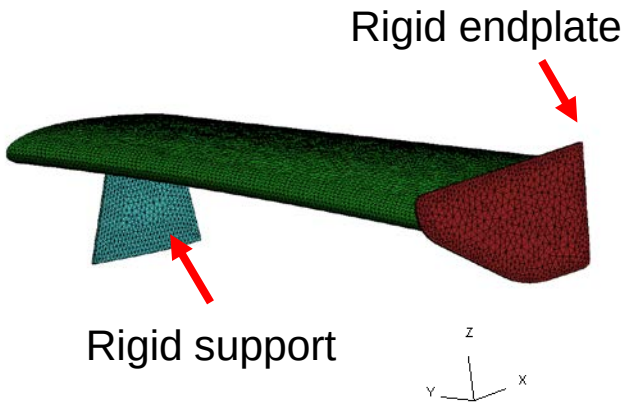
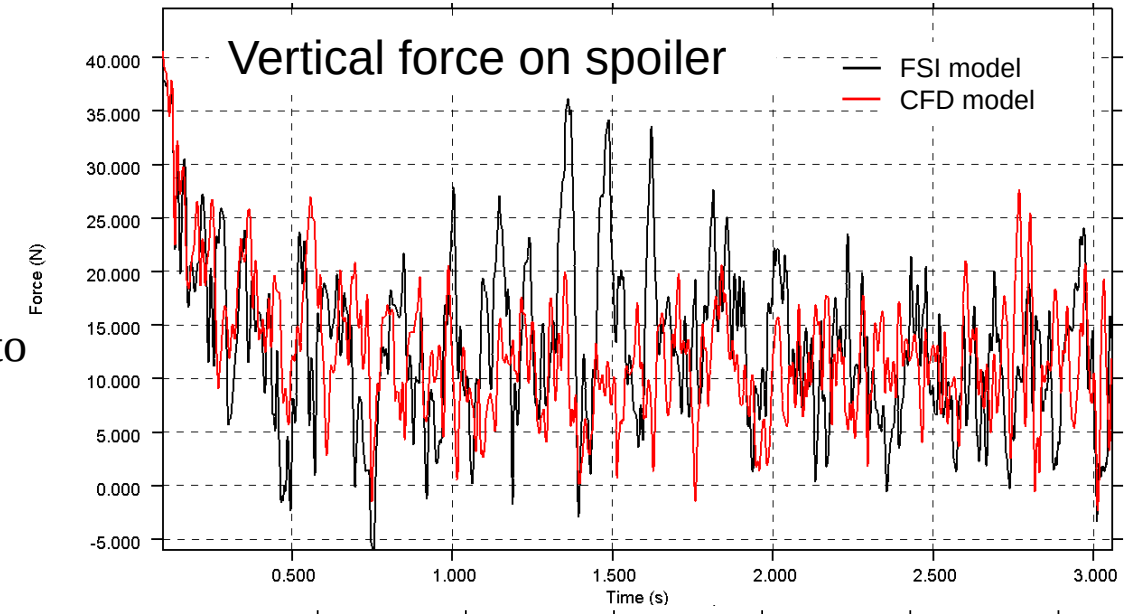
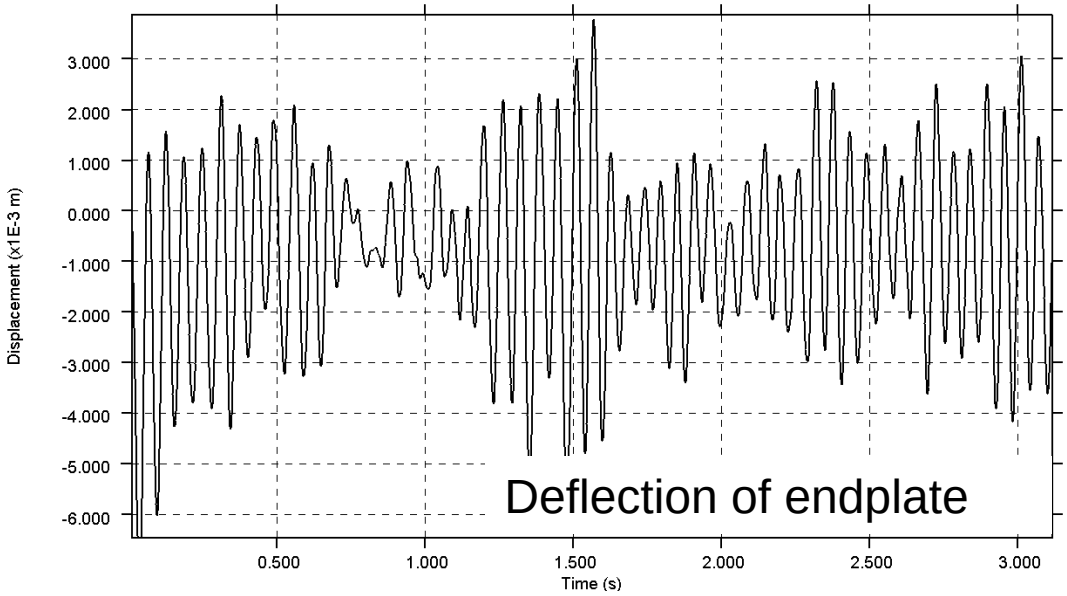


FSI model

- Structural model of plastic spoiler added
- Some difference in vertical loads, but load fluctuates due to eddies from rear window
- Endplate of the spoiler visibly deflects







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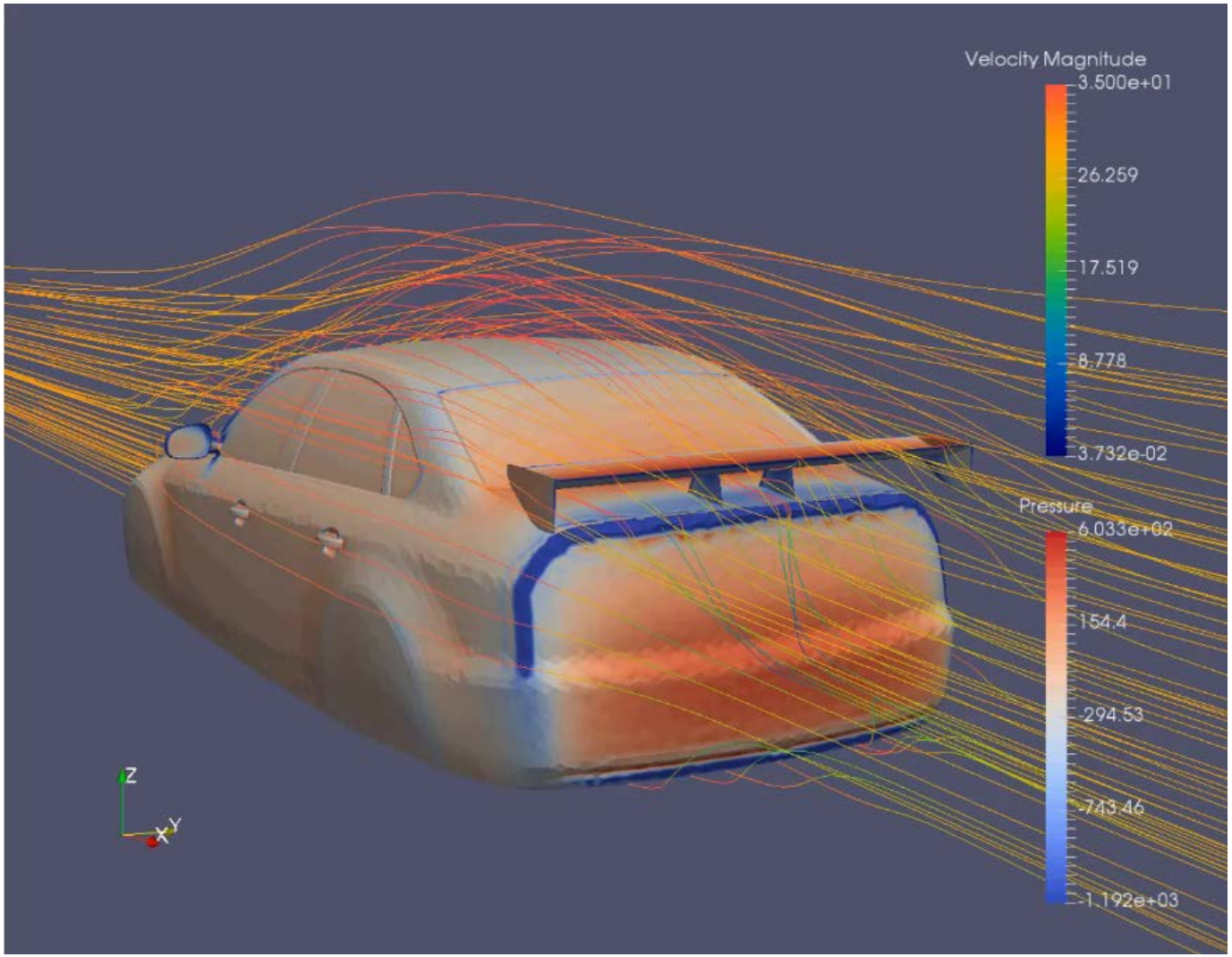
Video of FSI with spoiler



Potential for future use

- LS-DYNA ICFD is a powerful platform for performing FSI analysis
  - Widely used solid mechanics solver
  - Well validated solid mechanics and fluid mechanics solvers
  - Robust coupling between the two solvers.

- Offers numerous benefits over other techniques:
  - Can pick up non-linear behaviour (e.g. effect of displacements on flow field)
  - Quick and easy compared to aeroelastic wind tunnel tests

- Stress outputs could be used to check for fatigue. Could help minimise weight.