Fluid Structure Interaction Simulation of Hood Flutter

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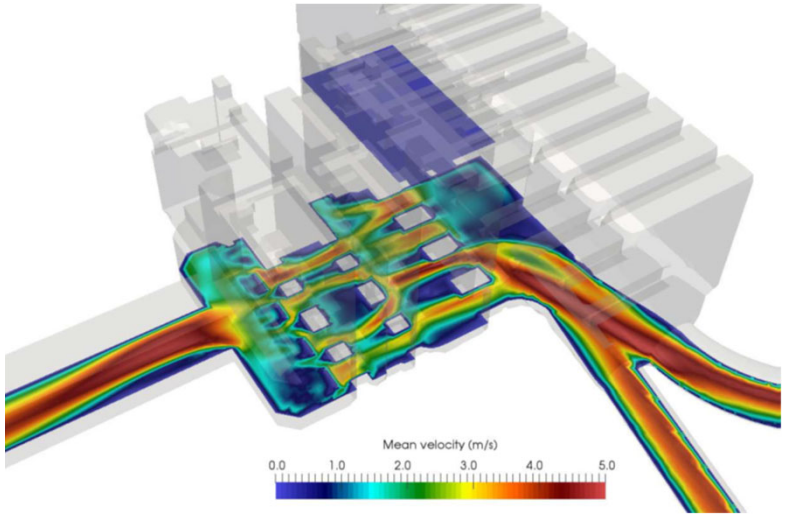
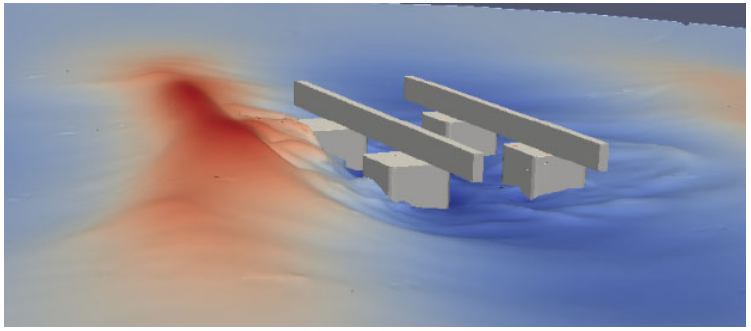
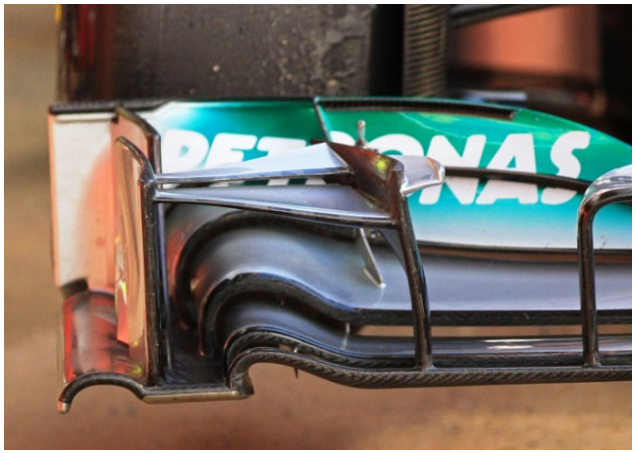
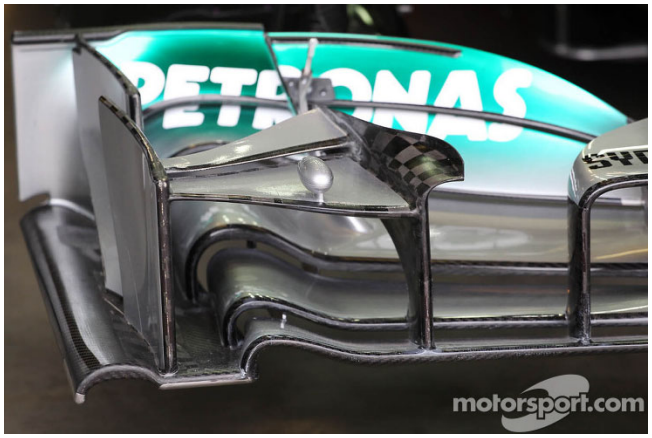
ARUP

Background







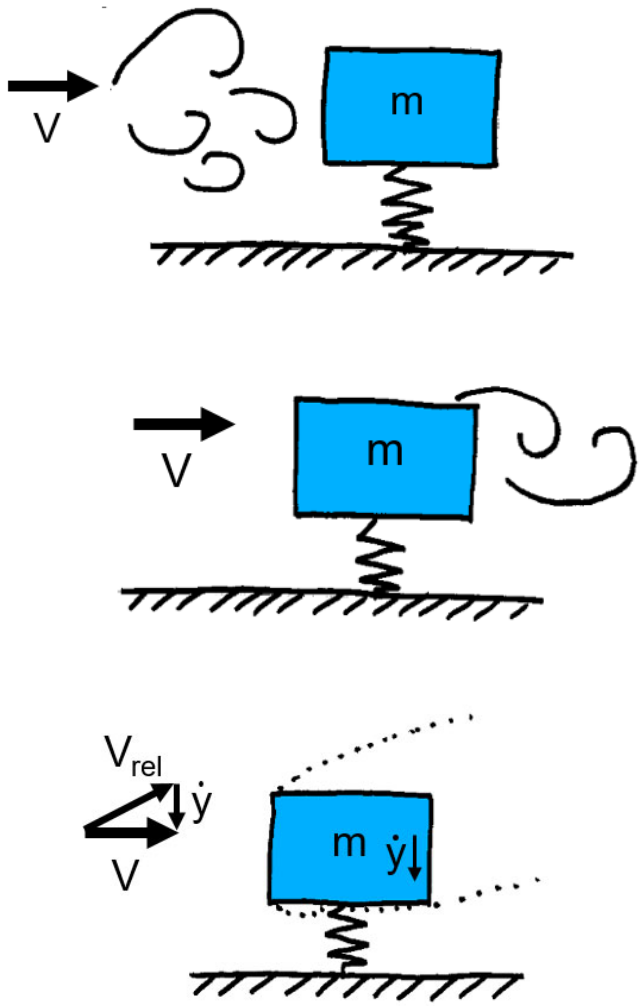


Hood Flutter

Hood flutter mechanisms

3 groupings for aeroelastic phenomena from Naudascher & Rockwell:

1. Extraneously Induced Excitation
2. Instability Induced Excitation
3. Movement Induced Excitation

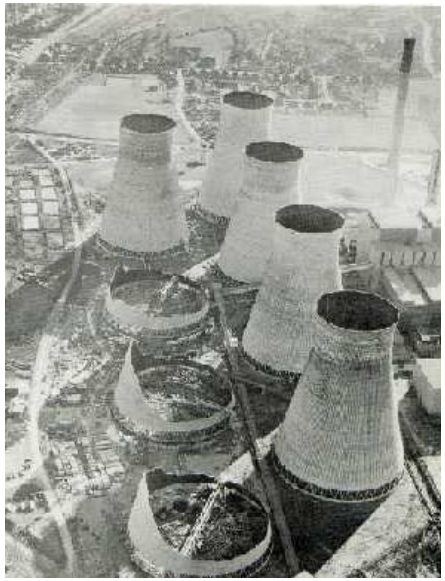


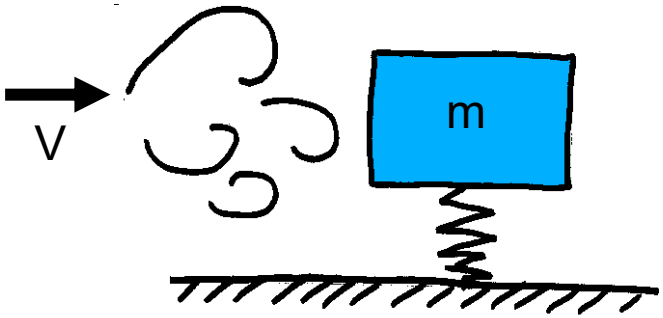
Extraneously Induced Excitation

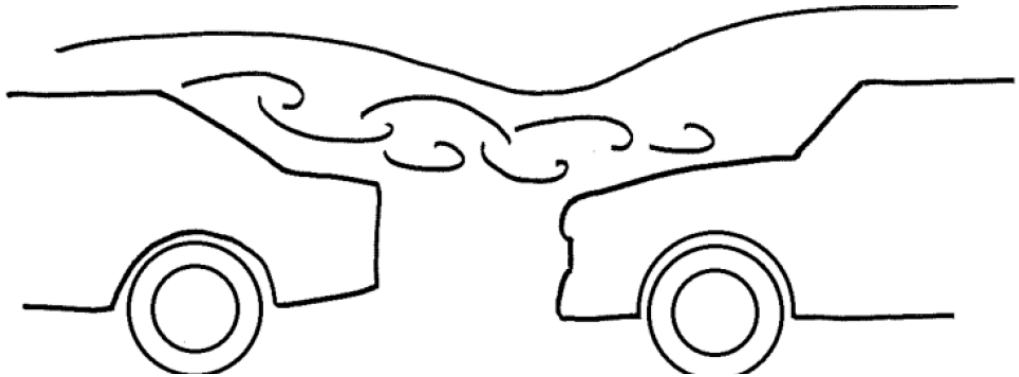
Excitation caused by fluctuations in the oncoming flow conditions

Examples:

- Buffeting
- Vortex shedding from upstream body





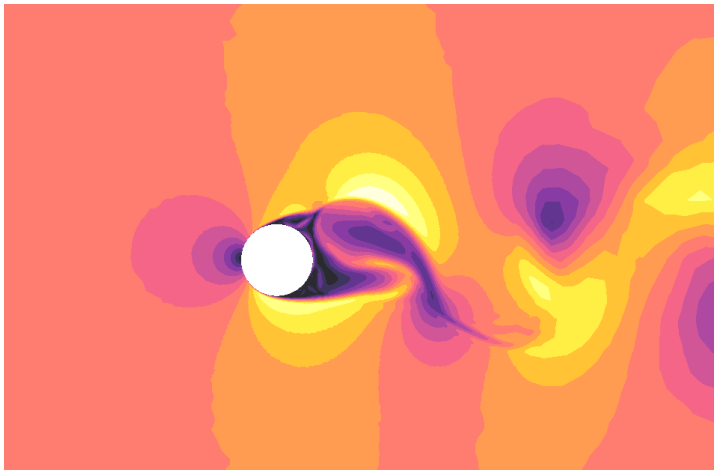


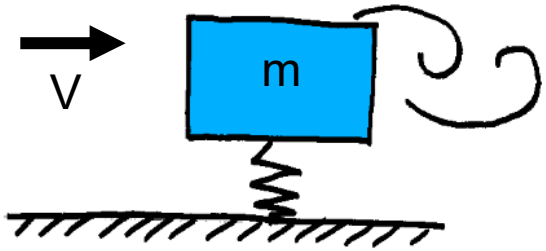
Instability Induced Excitation

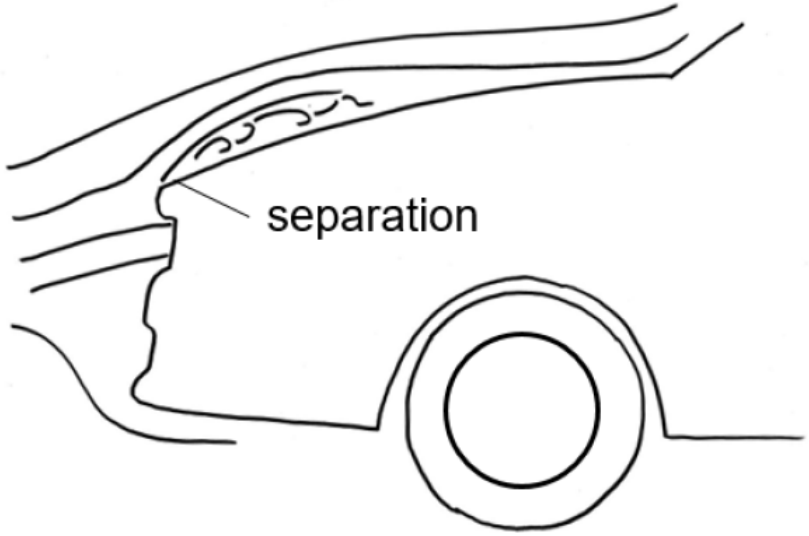
Excitation caused by flow instability about the structure

Examples:

- Vortex shedding
- Separation





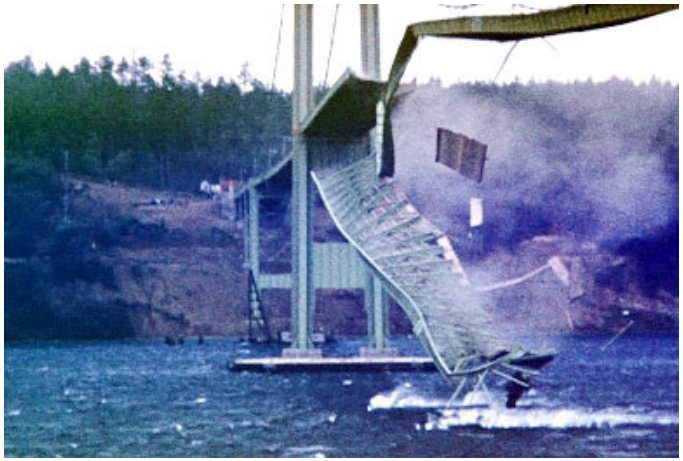


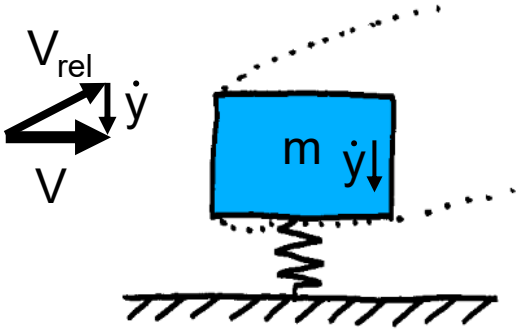
Movement Induced Excitation

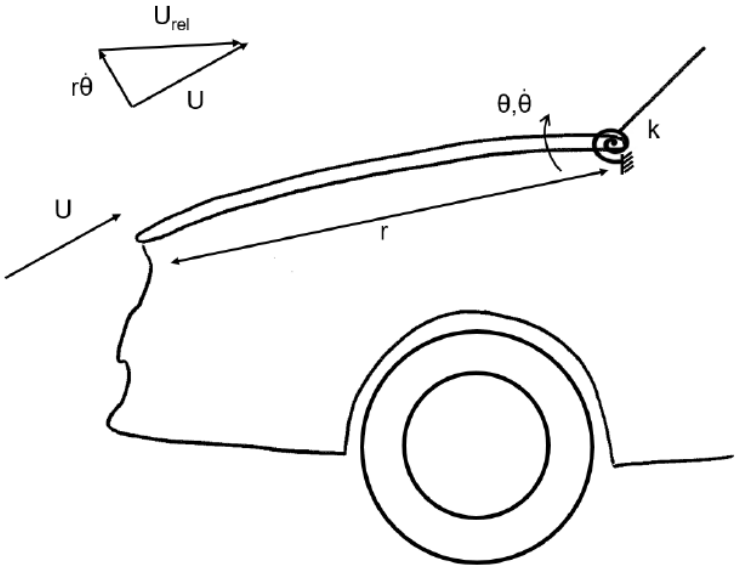
Excitation caused by fluid forces arising from movements of structure

Examples:

- Classical flutter
- Gallop



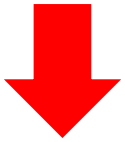




Hood flutter analysis

How can the risk of hood flutter be minimized by simulation during design stage?

One way coupled CFD and FEA – Apply pressure time histories from CFD to FEA model	Fully coupled FSI simulations	Aeroelastic wind tunnel tests	Track testing



Requirements:

- Accurate representation of Physics
  - Strong, two way Coupling
  - High fidelity CFD
  - Bonnet gap opening
  - Engine bay flows
  - Opening mechanism
- Scalability

Outline of study

1. Validation of ICFD solver using DrivAer generic car model

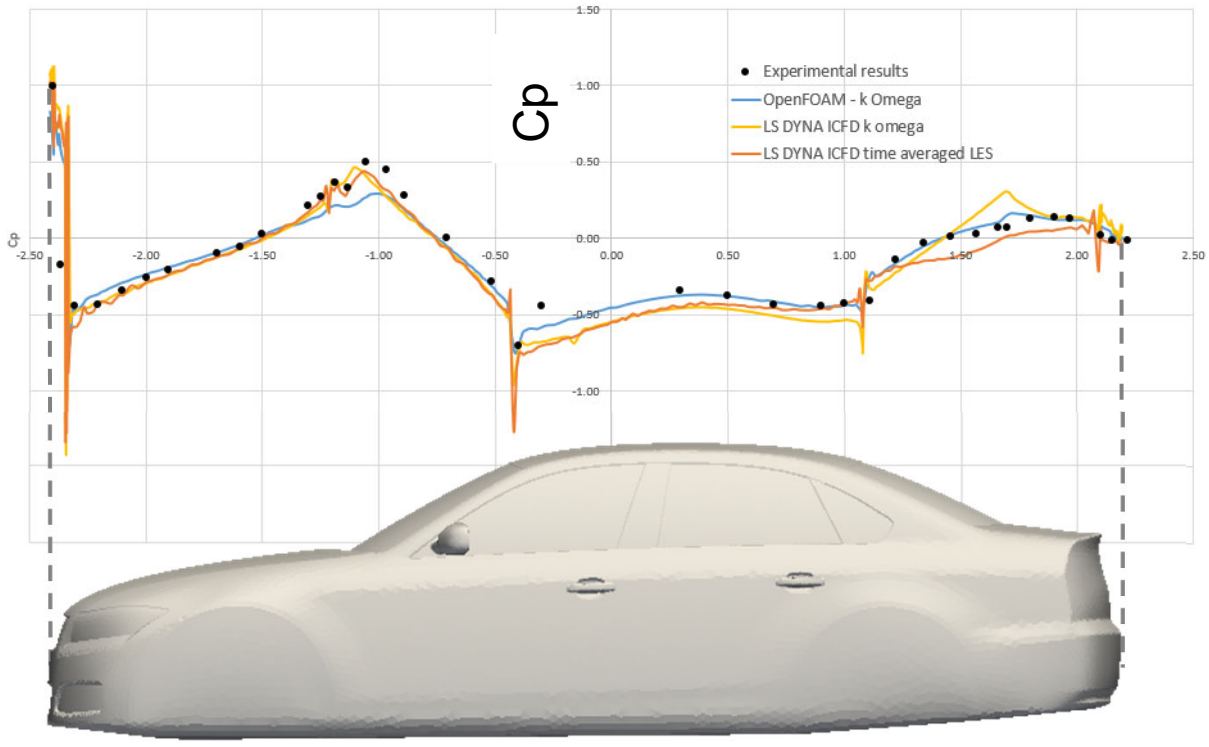
2. Simulation of unsteady loads from the wake of a preceding car

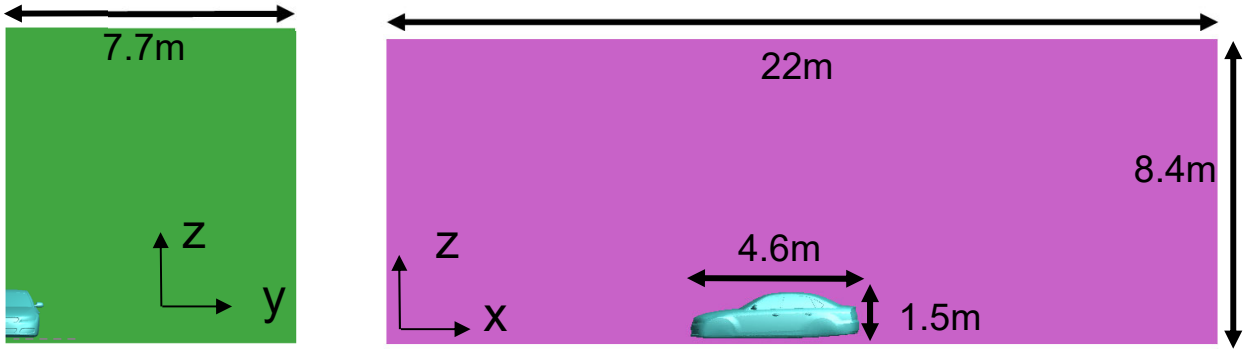
3. FSI simulations of a spoiler on the DrivAer car

4. 2D FSI simulations of separated flow over a flexible hood

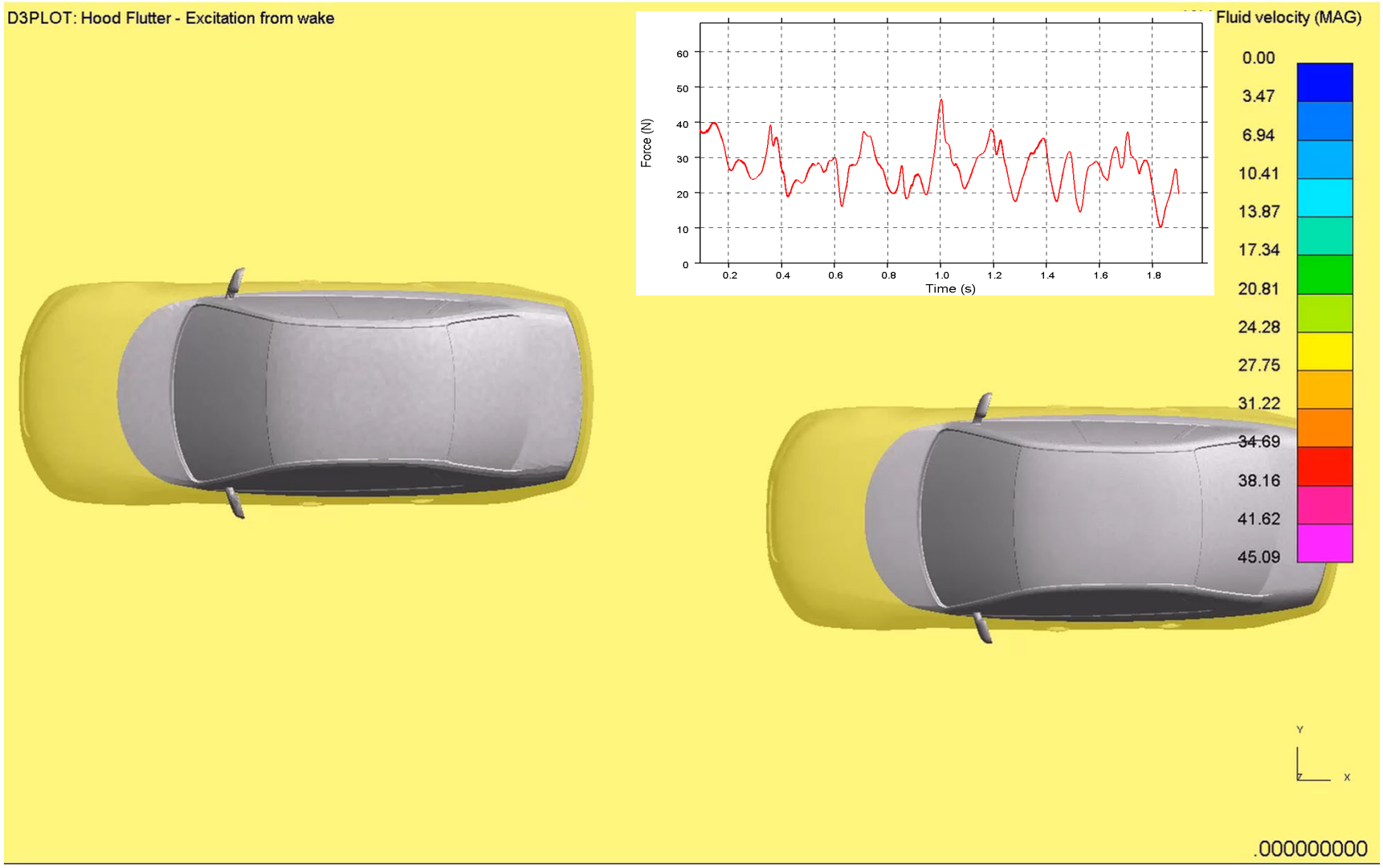
Pressure profile on DrivAer model

- 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



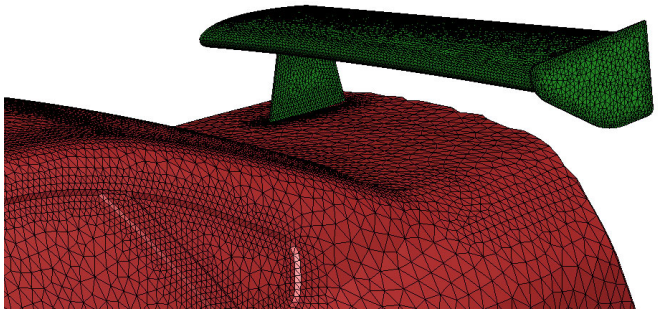


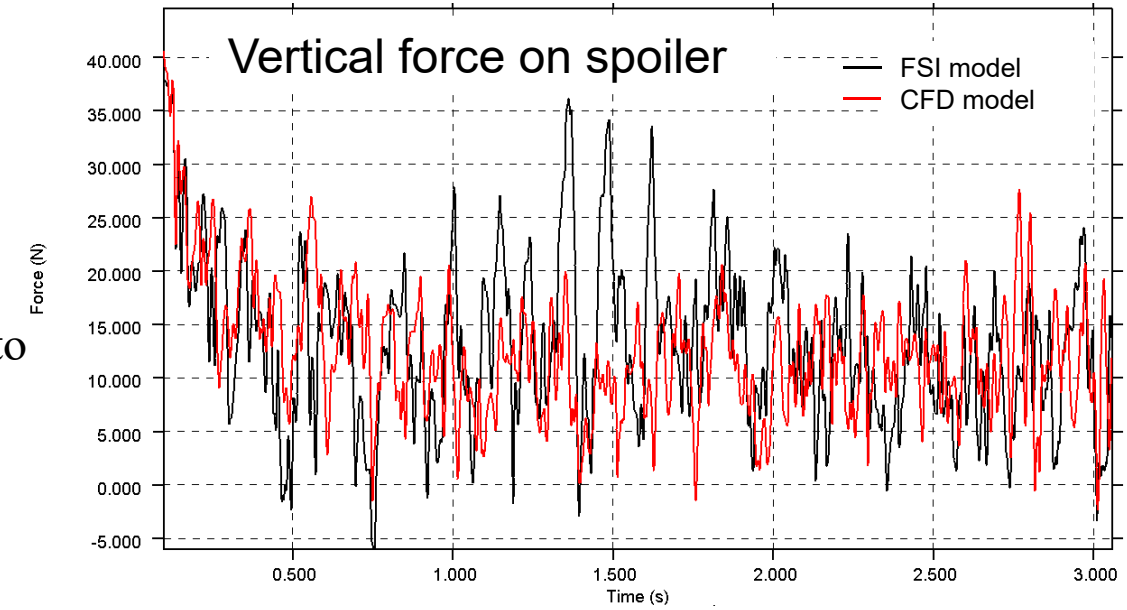
Time-varying loads from wake of preceding vehicle

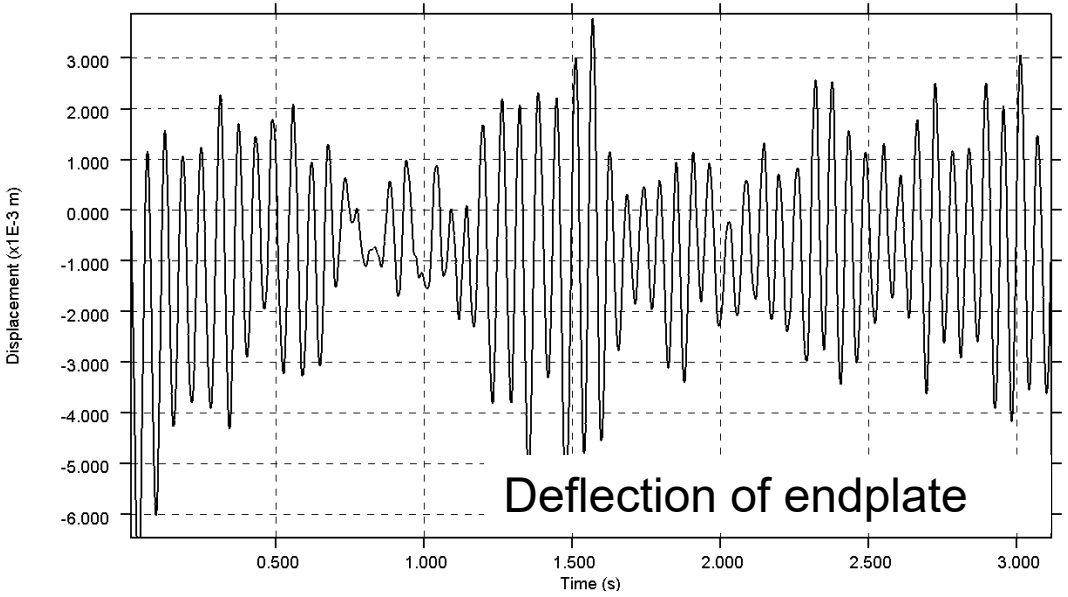


FSI of spoiler

- 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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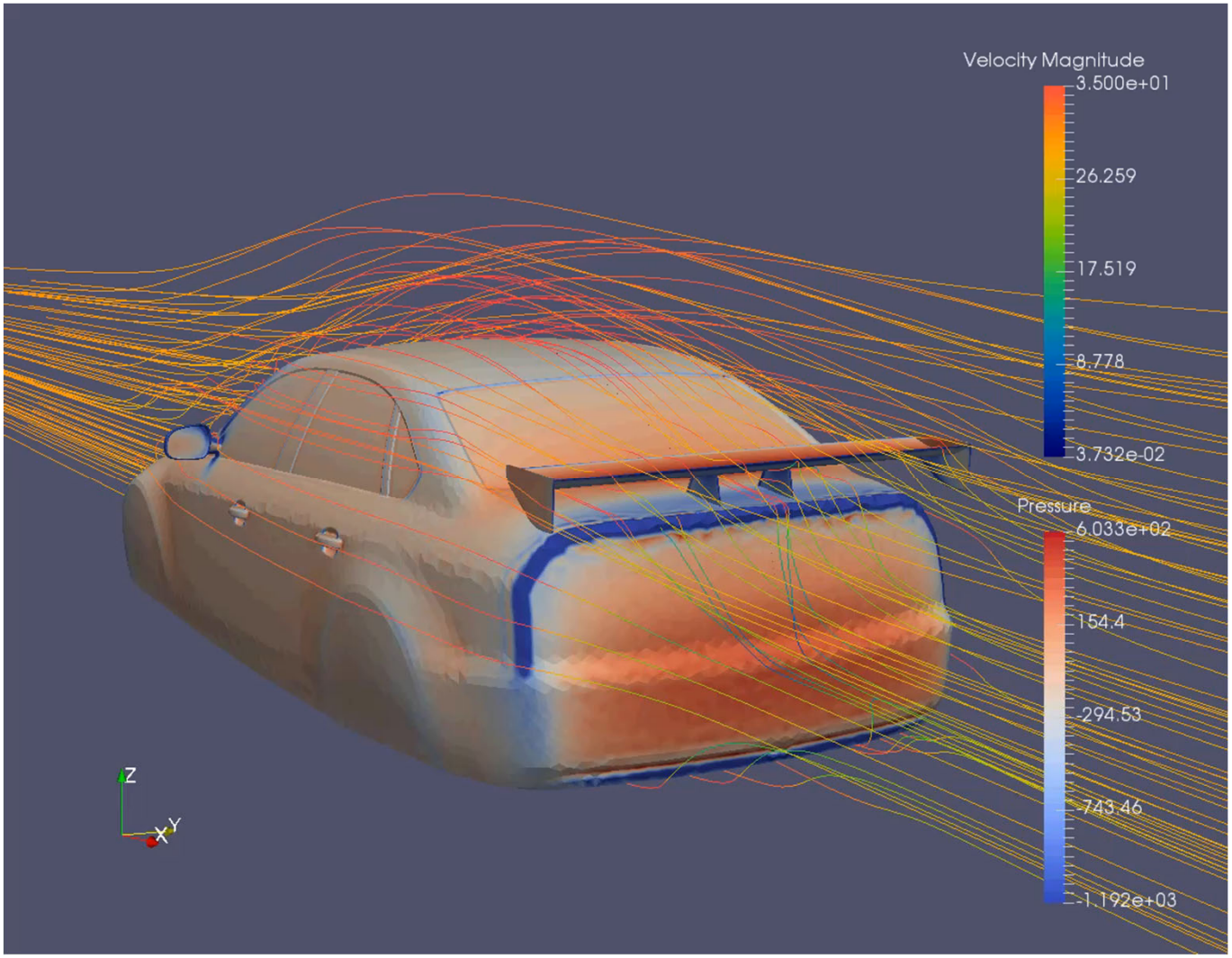
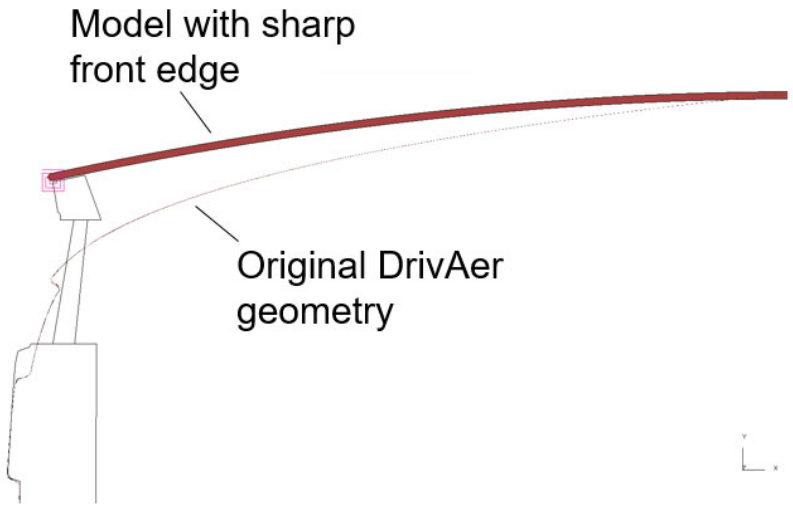
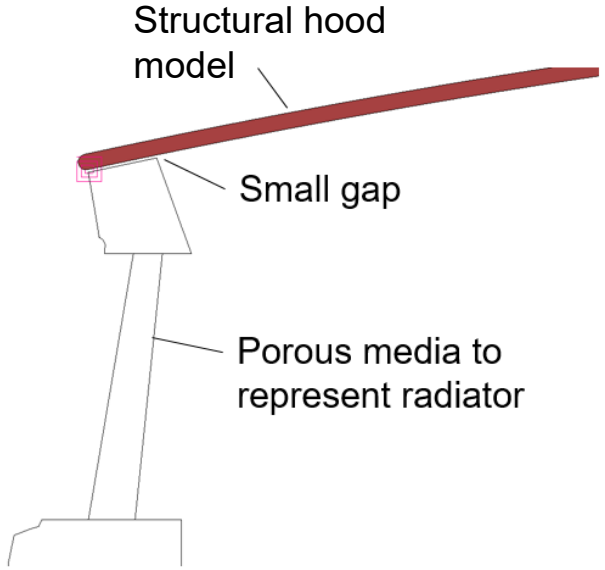
Video of FSI with spoiler



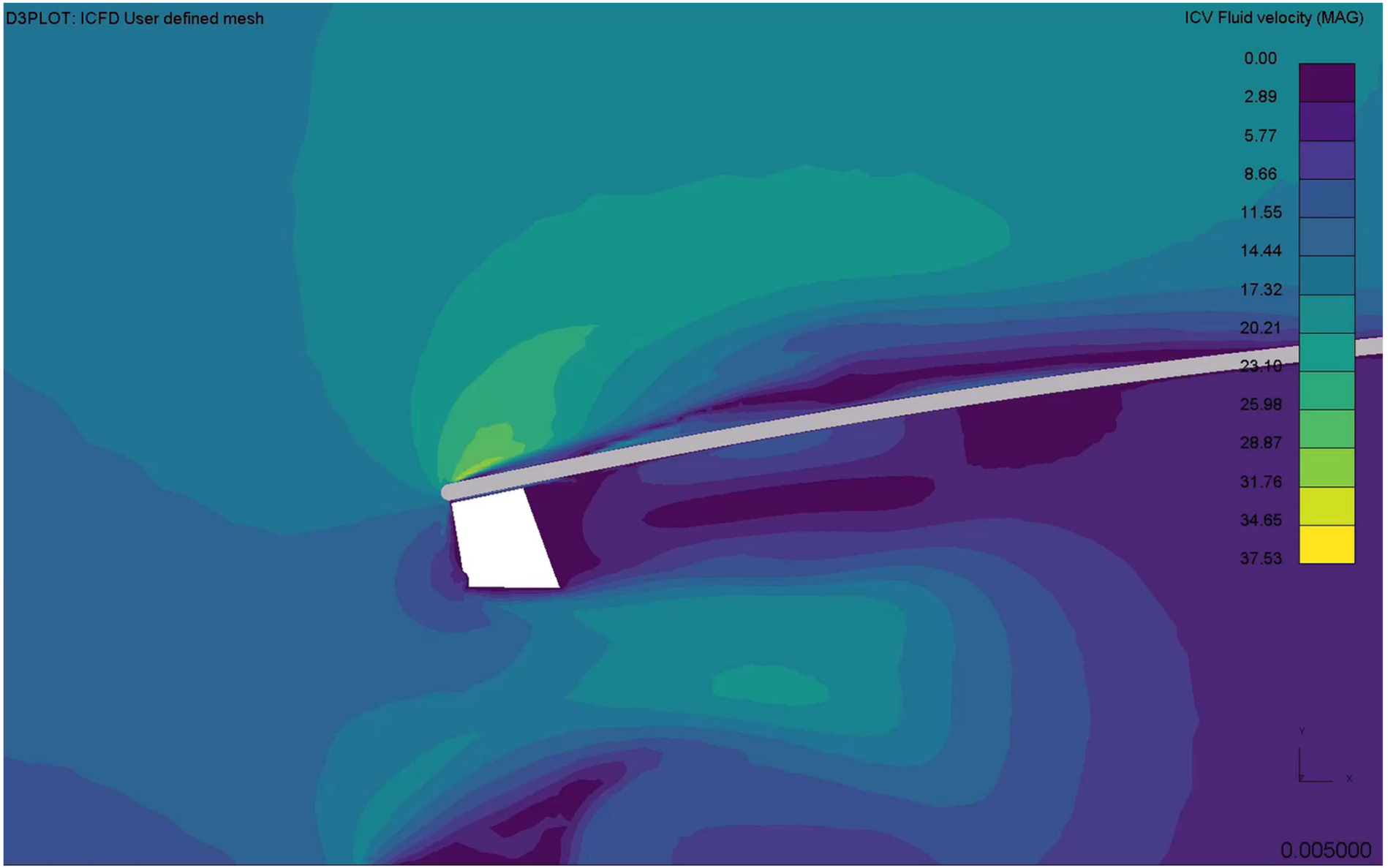
2D FSI of flexible hood

- Hood leading edge raised to promote separation
- Thin gap under hood can open up
- Non-linear spring on front edge to act as contact





2D FSI with flexible hood



Conclusions

- Validation of pressure profile
- Complex models, long run times
- Instability issues associated with remeshing
- Difficulty in modelling gap opening
- Validation required with results from aero-elastic wind tunnel testing.

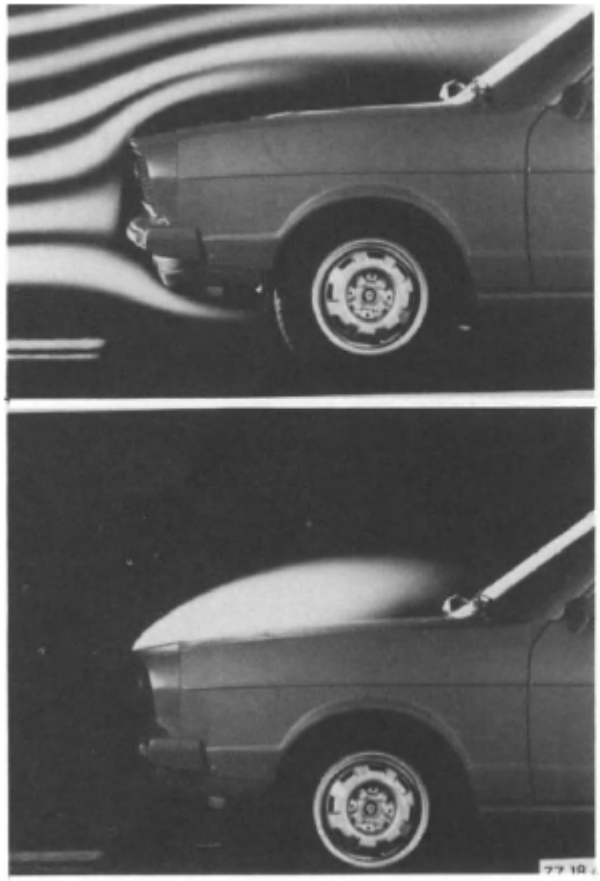


Figure 6.3 Separation bubble made visible by means of smoke, which is injected either as streaks into the undisturbed flow or into the separated flow, after ref. 6.6