

3rd Automotive CFD Prediction Workshop: Case 1: Windsor Squareback at Yaw Data Submission

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Introduction

This document defines the data submission requirements for Case 1 of the Third Automotive CFD Prediction workshop which computes the Windsor model (with no wheels) at a small 2.5 degree yaw.

Reference Conditions

The reference frontal area used for force and moment coefficients is defined by the vehicle height and width and rounded to be 0.112m^2 . The reference length used for pitching moment is the wheelbase 0.6375m .

The CAD geometry of the model has its origin on the ground plane, in the symmetry plane midway between the wheels. The coordinate system has x in the streamwise direction (hence the nose is negative x), z upwards and hence positive y is towards the right of the vehicle.

With this coordinate system, drag is in the positive x-direction, lift is in the positive z-direction, pitching moment is around the y-direction with a nose up moment being positive. The vehicle has been yawed by 2.5 degrees, but the grid retains the tunnel coordinate system. **The force and moment coefficients are in the reference frame of the yawed vehicle – not the wind tunnel reference frame.** For the rotated model in the supplied grids, the vehicle should produce a positive side force.

The freestream velocity magnitude and pressure used in the definition of force coefficients should be taken from a probe at $[-2.0, 0, 1.3]\text{m}$. This is ahead of the car, on the centreline and near the roof. It replicates the approach taken in the wind tunnel and means that the freestream velocity magnitude and pressure is slightly different to that applied as a boundary condition to the inlet. There are no corrections applied to the CFD data.

Data Submission

In comparison to the second Automotive CFD Workshop, the PIV planes stay fixed within the tunnel whilst the pressure tappings on the model have moved due to the small rotation about the origin.

The required data is split into six parts:

1. Information about you, your code, simulation parameters and force and moment results, filenames of the remaining data supplied by you
2. Surface pressure coefficient line data: along the vehicle symmetry plane surface cut (Group 1); the upper glasshouse horizontal cut (Group 2)

3. X velocity component and turbulence kinetic energy profile ahead of the model. (normalised by your reference velocity magnitude, $x=-1.0\text{m}$, $y=0.0$, $z=0.0$ to 0.2m)
4. Time histories of force and moment data (time in seconds or iteration number, drag, lift, side force and pitching moment coefficient)
5. Surface pressure coefficient data over the base surface (Group 4)
6. Velocity cut planes to match PIV measurements at $y=0\text{m}$, $z=0.194\text{m}$, $x=0.630\text{m}$, $x=0.922\text{m}$ (normalised by your reference velocity magnitude).

Parts 1-4 are compulsory if you wish your results to be included in the workshop, Part 5 and 6 are optional but highly recommended. You are encouraged to upload your time histories to the 'meancalc' tool so that a consistent evaluation of the mean can be generated. The data should be provided using a simple multicolumn text format as either an .xlsx or .csv file using the templates provided which are number 1 through 6. In the case of parts 5 and 6, if preferred these can be use the Enight Gold format with a case file and associated geo and dat file.

The first file has a final section which defines the names of the files that make up the rest of the submission.

For the surface pressures cuts and base pressure, the reported x,y,z should be in the coordinate system of the vehicle. For the boundary layer profile and PIV planes the reported x,y,z should be in the coordinate system of the tunnel.

Within the package there four STL files which define the PIV cutting planes (these are particularly useful in STAR-CCM+).

You may have more than one submission for a single participant (i.e. different turbulence models, or grid). Each submission should be packaged into a single zipped tar file or zip file.

The naming convention is:

ID_Lastname_grid_TYPE_TURBMODEL_vN.tar.gz

Where:

ID: submission ID allocated to you by the organisers

Lastname: last name of submitter

GRID: g1, g2 or g3 or own

TYPE: RANS/URANS/DES/DDES/IDDES/LES/DNS/LBM/OTHER

TURBMODEL: underlying RANS or SGS model,

KE/RKE/SA/KW/SST/RSM/EARSM/SMAG/DYNSMAG/WALE/SIGMA/OTHER

N is 1 for your original submission

Please keep to the predefined words (e.g. just OTHER for any model that does not fit the descriptors, rather than using your own words, further down the file more information can be supplied).

Upload your submission to the shared onedrive drop off folder (link supplied separately)

If you need to resubmit/upload a newer submission (i.e. noticed an error), then please resubmit with an incremented version number in the file name. The scripts to process will just use the highest number available.

Experimental Pressure Probe Locations

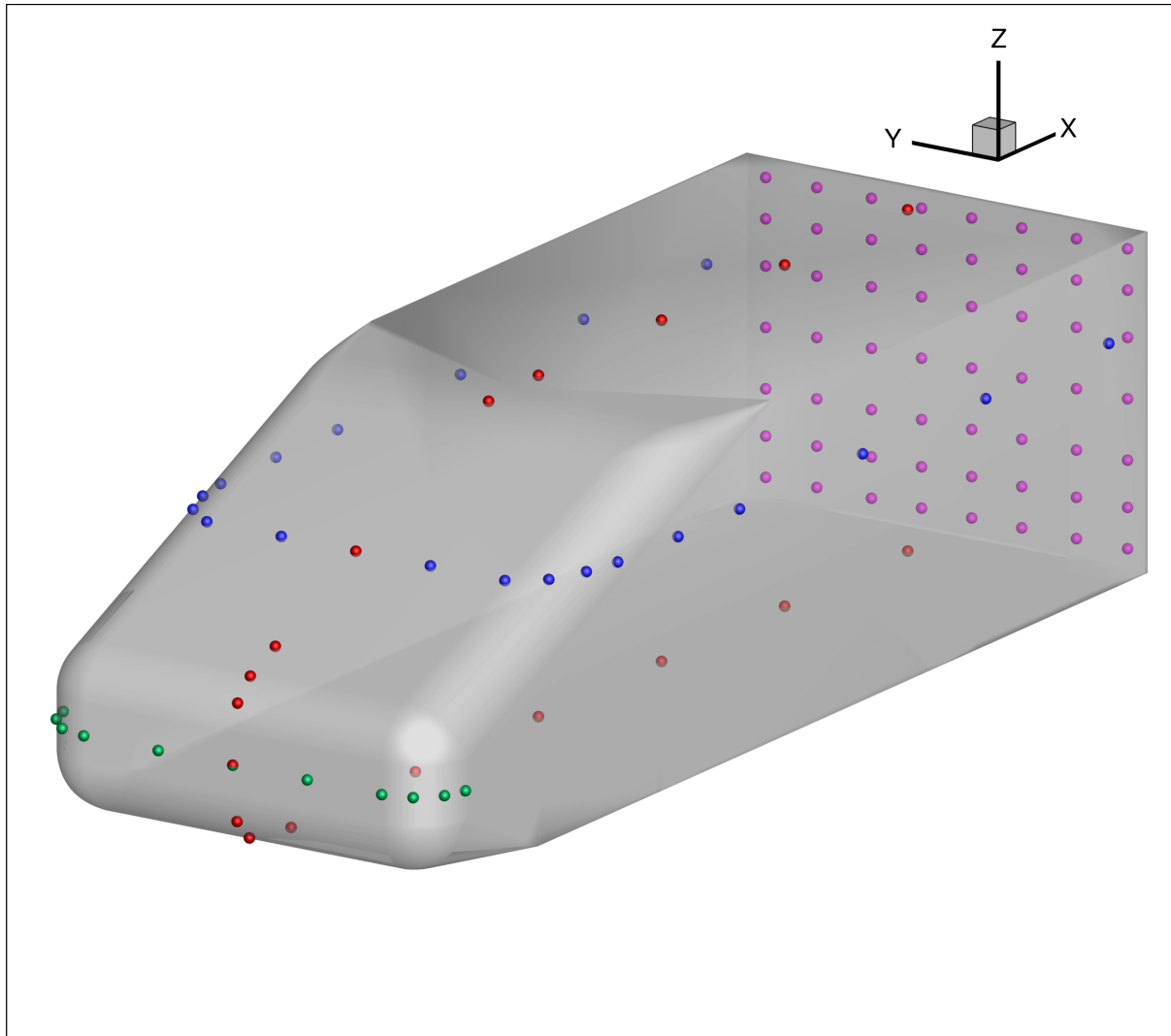


Figure 1: Experimental pressure tapping locations

Group 1 is a vertical cut plane through the symmetry, Group 2 is a horizontal cut plane at $z=0.2595\text{m}$, Group 3 is around the ‘bumper’ and is not required here, Group 4 is a grid at the base. The supplied data should be at the resolution of your surface grid (i.e. not just at the experimental tapping locations).

Experimental PIV Slice Locations

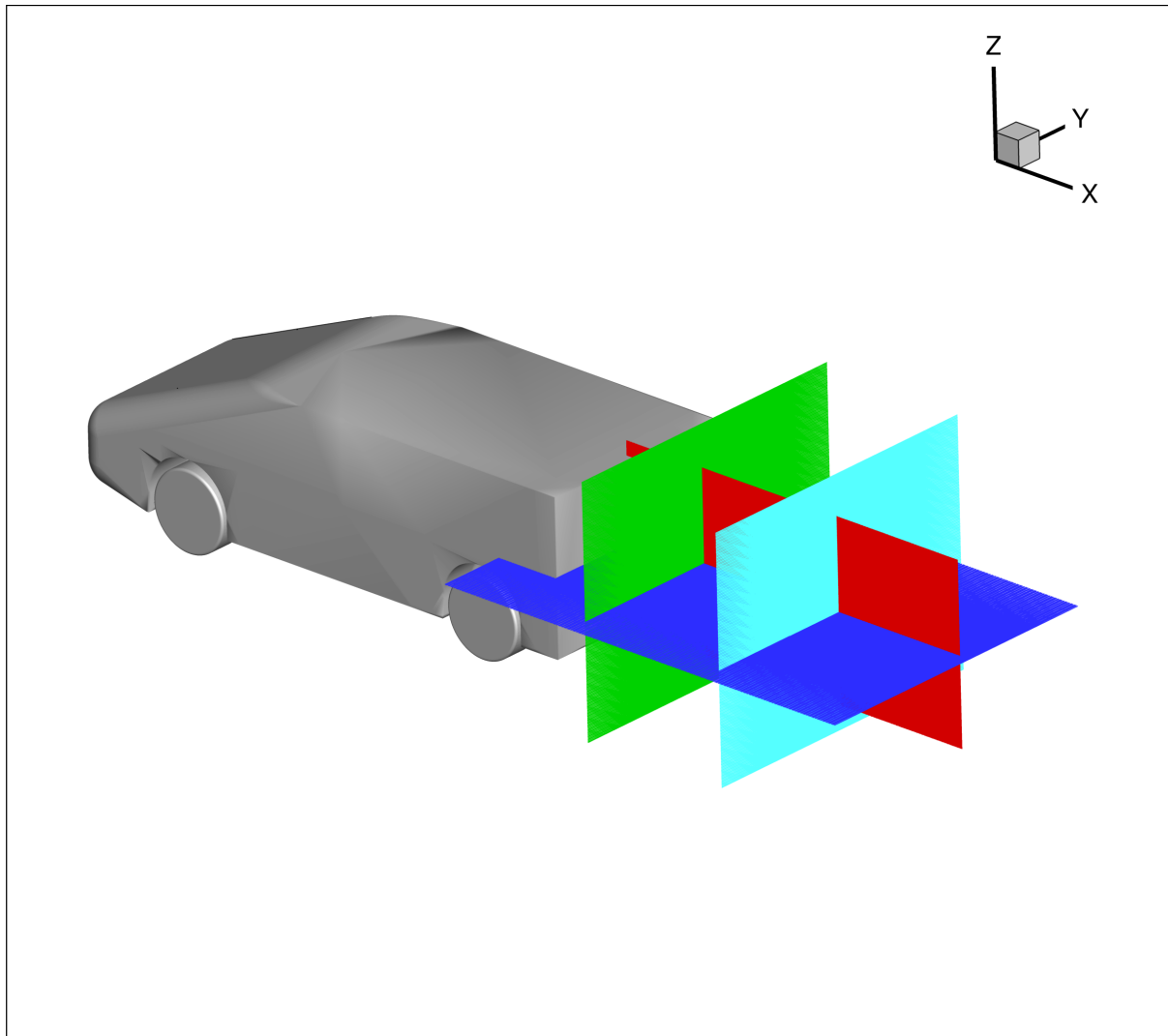


Figure 2: Experimental PIV slices

The vertical slice (red) is defined by: $y=0\text{m}$, $x=0.467\text{m}$ to 1.184m , $z=0.0\text{m}$ to 0.366m

The horizontal slice (blue) is defined by: $z=0.194\text{m}$, $x=0.36\text{m}$ to 1.20m , $y=-0.3\text{m}$ to 0.3m

The cross flow slices (green and light blue) are defined by: $x=0.630\text{m}$ and $x=0.922\text{m}$, $y=-0.3\text{m}$ to 0.3m , $z=0\text{m}$ to 0.44m .

References

- [1] G. Pavia and M. Passmore, “Characterisation of Wake Bi-stability for a Square-Back Geometry with Rotating Wheels,” in Prog. Veh. Aerodyn. Therm. Manag. (J. Wiedemann, ed.), (Cham), pp. 93–109, Springer International Publishing, 2018.
- [2] Varney, M., “Base Drag Reduction for Squareback Road Vehicles,” Loughborough University, Feb, 2020. [10.26174/thesis.lboro.11823759.v1](https://doi.org/10.26174/thesis.lboro.11823759.v1)
- [3] https://repository.lboro.ac.uk/articles/dataset/Windsor_Body_Experimental_Aerodynamic_Dataset/13161284
- [4] Johl, G., Martin A. Passmore, and Peter M. Render. 2010. “Design Methodology and Performance of an Indraft Wind Tunnel,” The Aeronautical Journal, September 2004. <https://hdl.handle.net/2134/6674>

Version History

0.2 23 June 2022: clarify coordinate systems

0.1 8 June 2022: initial unreleased version