Mitteilung

Fachgruppe: Aerodynamik bodengebundener Fahrzeuge

Development of a Computational Model for the NGT-Cargo Model based on Wind-Tunnel Data

K. A. Weinman[1*], Müller, T. S[1]., Fey, U[1], K. Ehrenfried[1] & C. Wagner[1,2]
[1]DLR Göttingen, Institut für Aerodynamik und Strömungstechnik
Bunsenstr. 10, 37073 Göttingen, Germany
[2]Technische Universität Ilmenau, Institut für Thermo- und Fluiddynamik
Am Helmholtzring 1, 98693 Ilmenau, Germany

*keith.weinman@dlr.de

The flow about a train is characterized by a large range of energetically significant flow scales which challenge accurate simulations using CFD methods. Nevertheless, the use of CFD methods for certification of trains is accepted with some restrictions by the transport industry. For example, the EN 14067-6 [1] standard permits evaluation of aerodynamic forces by means of computational fluid dynamics (CFD) simulations for full-scale or reduced model geometries under constant cross-wind conditions. At the present time there is no acknowledged international standard concerned with CFD drag prediction under unsteady on-flow conditions for rail vehicles. It is cost effective to develop sufficiently accurate CFD models to assist in the construction of appropriate standards.

The NGT-Cargo [2] is a DLR concept study examining methods of improving rail transport of cargo with the aim of increasing the volume of European rail freight traffic. Initial CFD validations against wind tunnel measurements for the NGT-Cargo concept vehicle have been presented in [3]. In that work both steady and unsteady on-flow conditions were examined. Results suggested the presence of systematic errors when drag values were compared across different configurations of the wind-tunnel model setup and their matched CFD calculations. A feature of the experimental setup that was not included in the initial CFD analysis is the removal of the boundary layer attached to the test section floor upstream of the moving belt by the use of both active and passive suction. The influence of active and passive suction on the computational drag assessment of the NGT-Cargo concept is discussed in the current work. The computational geometry is matched to the experimental geometry more accurately by constructing a catalog of CAD parts that precisely mimic wind tunnel components. Figure 1 illustrates a selection of the components from the parts catalog from which the wind tunnel geometry was constructed for this work.

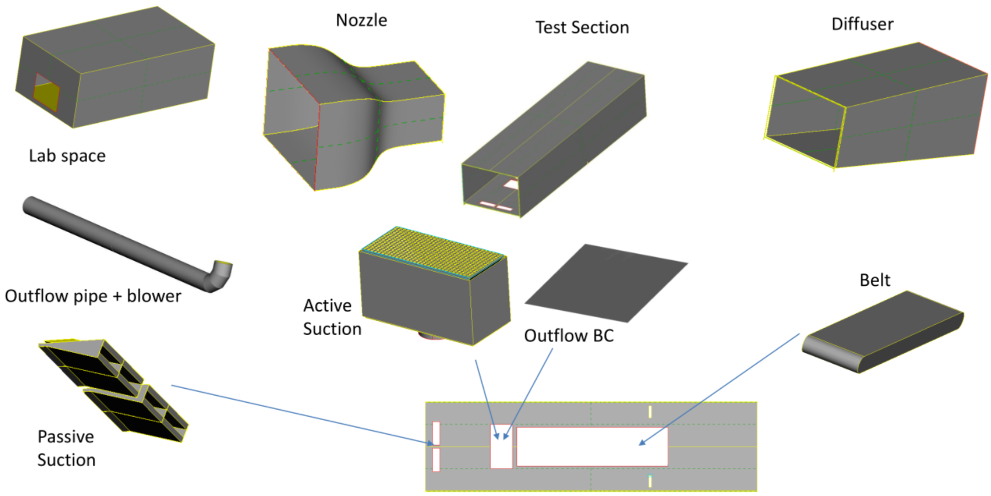

Figure 1: Some components of the CAD catalog.

The catalog simplifies the task of creating computational geometries which model a range of wind tunnel configurations. For our application the onflow to a model inside a wind-tunnel test section should correspond to the situation of a vehicle moving at a constant relative velocity (U_b) to the stationary ground. Figure 2 demonstrates that the CFD model achieves this goal using passive/active suction and a moving belt under the model. In particular this corrected velocity profile mimics that of a top hat velocity profile containing more energy in the lower boundary layer which interacts directly with the model. RANS calculations completed with the moving belt and with both active and passive suction return a difference between

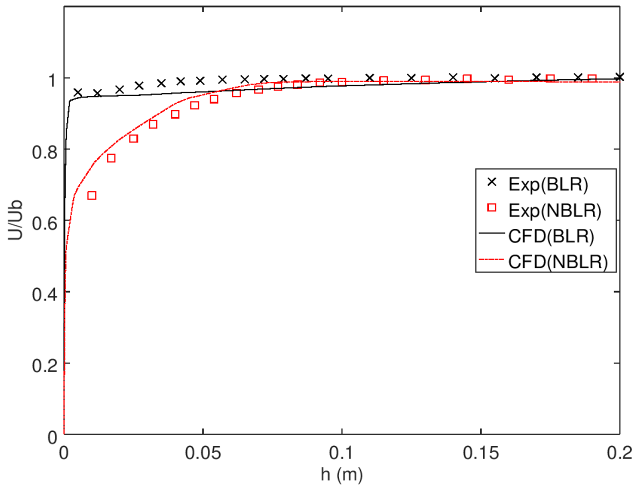

Figure 2: Wall normal velocity profiles. Exp: Experimental data [4]; CFD: Menter-SST turbulent transport model; BLR: boundary layer removal (BLR); NBLR: no boundary layer removal; *U/U$_b$*: velocity normalized with the tunnel bulk velocity (*U$_b$*); *h*: height above the wind tunnel floor.

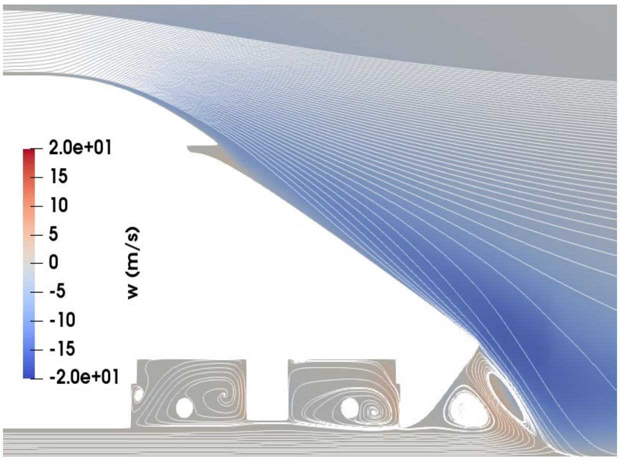

Figure 3: Contour plot of the w velocity component and streamlines about the trailing head of the NGT-Cargo vehicle obtained with upstream boundary layer removal (symmetry plane of model). Differences against the case without upstream boundary layer removal will be discussed in the paper.

computed and measured drag of four (4) drag counts. This can be compared with a difference of nine (9) drag counts using an intact upstream boundary layer [3]. The analysis presented in [3] demonstrated that further reductions in error are achieved when non-resolving hybrid methods are used – at present these calculations have not been completed and results should be available for presentation and detailed discussion in this STAB symposium. Figure [3] illustrates a contour plot of the *w* velocity component about the rear train head along the model's symmetry axis. The corrected onflow velocity profile results in velocity distributions which share the same characteristics as those obtained in [3], however there are differences which will be discussed in the presentation.

[1] DIN EN 14067-6:2018, Railway applications – Aerodynamics - Part 6: Requirements and test procedures for cross wind assessment, September 2018

[2] https://verkehrsforschung.dlr.de/en/projects/ngt-cargo,

[3] K.A. Weinman and Ehrenfried, K. (2022) *Unsteady onflow effects on model train drag.* In: New Results in Numerical and Experimental Fluid Mechanics XIV, Contributions to the 23rd STAB/DGLR Symposium Berlin, Germany 2022. A. Dillmann, G. Heller, E. Krämer, C. Wagner and J. Weiss (Ed.), Springer, 2024

[4] DLR-Projekt „Next-Generation-Train“, AP 0410, Meilenstein 04101912, Fey, U.: Inbetriebnahme des Laufbandes im SWG und Vermessung der Strömung, 2020