Experimental and Numerical Investigation of the Turbulent Wake Flow of a Generic Space Launcher Configuration

V. Statnikov⋆*, D. Saile*⋆⋆*, J.-H. Meiß*⋆*, A. Henckels*⋆⋆*, M. Meinke*⋆*, A. Gülhan*⋆⋆*, W. Schröder*⋆
⋆*Chair of Fluid Mechanics and Institute of Aerodynamics*
RWTH Aachen University, Wüllnerstraße 5a, 52062 Aachen, Germany
⋆⋆*Institute of Aerodynamics and Flow Technology*
German Aerospace Center, Linder Höhe, 51147 Köln, Germany

Abstract

The turbulent wake of a generic space launcher at hypersonic freestream conditions is investigated experimentally and numerically to gain detailed insight into the intricate base flow phenomena of space vehicles at upper stages of the flight trajectory. The experiments are done at $Ma_\infty = 6$ and $Re = 16 \cdot 10^6\, m^{-1}$ by the German Aerospace Center (DLR) [1] and the corresponding computations are performed by the Institute of Aerodynamics Aachen using a zonal RANS/LES approach [2, 3].

The outer geometry of the investigated space launcher configuration is approached by a generic model which consists of a cylindrical main body part, a rounded conical top and a double-wedge profiled strut orthogonally mounted at the main body due to the necessity to mount the model in the wind tunnel and to enclose supplies for the sensors on the model walls. To analyze the influence of the nozzle extension on the base flow field two different aft-body geometries consisting of a blunt base and an attached cylindrical nozzle dummy are considered.

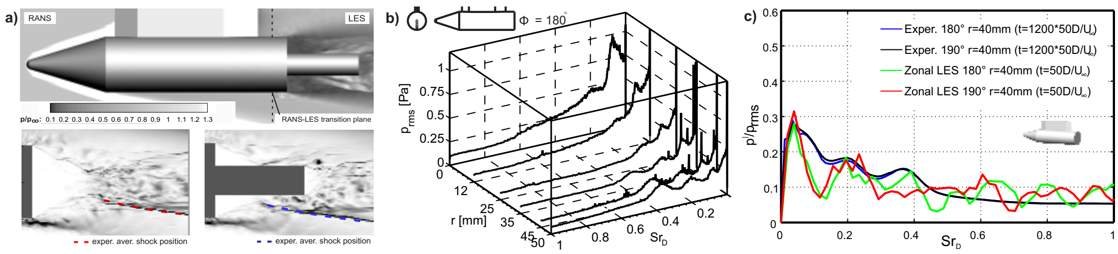

Figure 1: a) flow field topology and comparison of the shock positions; b) spectra of the high-frequency base pressure oscillation measurements; c) comparison of the spectra of the base pressure oscillation

Experimental and numerical results are compared with regard to the steady-state and dynamic wake flow characteristics (Fig. 1). High-speed schlieren measurements are used to detect the position of the recompression shock in the wake as well as to resolve the recompression shock oscillations dependent on the geometry of the afterbody. By analogy, the numerical results are analyzed in respect of the density gradient to compare the computed flow field to the experimental measurements and to validate the applied numerical method (Fig. 1a). The influence of the used aft-body extensions on the significant base flow characteristics is evaluated by a detailed analysis and comparison of the pressure distribution and its spectra along the base and nozzle walls. The high-frequency pressure transducer measurements provide spectra of the local base pressure fluctuations and information about the coherence of the pressure signal at different positions (Fig. 1b). Numerical results are compared to the experimentally measured pressure fluctuations and are additionally used to determine the reasons for the detected dynamic behaviour (Fig. 1c). The detailed results of the performed cooperative investigations on the unsteady base flow of the hypersonic generic space launcher configuration will be presented at the conference.

[1] D. Saile, A. Gülhan, A. Henckels, Investigations on the Near-Wake Region of a Generic Space Launcher Geometry. *17th AIAA International Space Planes and Hypersonic Systems and Technologies Conference*, AIAA-2011-2352.
[2] B. Roidl, M. Meinke, W. Schröder, Synthetic turbulence generation for a zonal RANS-LES method. Part I: Zero-pressure gradient boundary layers. Submitted to *Int. J. Heat Fluid Flow*.
[3] B. Roidl, M. Meinke, W. Schröder, Synthetic turbulence generation for a zonal RANS-LES method. Part II: Non-zero-pressure gradient boundary layers. Submitted to *Int. J. Heat Fluid Flow*.