# Preliminary investigations of jet installation noise influenced by a vortex generating liner at the nozzle inner wall.

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## Nozzle with a vortex generating liner

As part of the EU project DJINN we performed preliminary investigations on a novel noise reduction technology, see Ref. [1]. The “Vortex Generating Liner” (VoGeL), described in general terms in the patent application, see Ref. [2], is a bias-flow acoustic liner for the inner wall of flow ducts. Through the vectorization of the face sheet perforate or through the permeability distribution, the VoGeL generates streamwise vorticity that influences the in-duct boundary layer, or, in the nozzle case, the shear layer of a jet. A single realization of a VoGel Nozzle has been tested in isolated configuration and with a simulated jet-wing interaction at the JExTRA small-scale jet facility, see Figure 1. The experimental validation of the facility is presented by comparing frequency spectra with similar measurements from other jet rigs in Refs. [1] and [3].

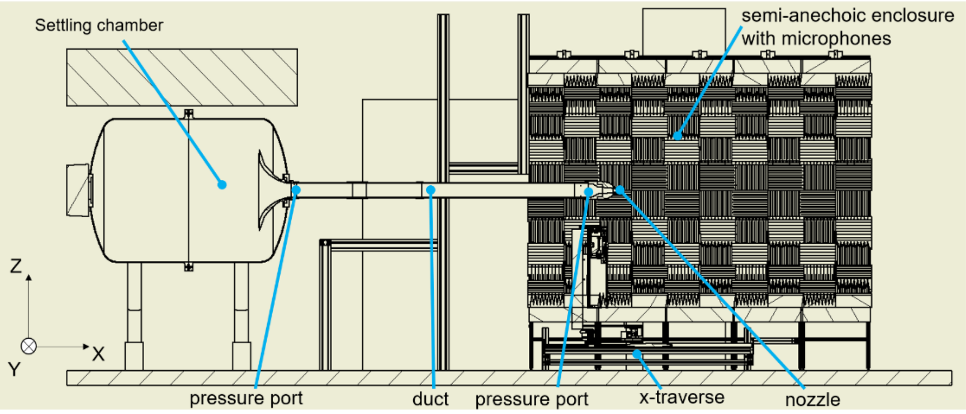


*Figure 1: The JExTRA small-scale jet facility at DLR Berlin.*

The tested nozzle features a slightly diverging extension section, applied to a baseline convergent nozzle. The extension generates a positive static pressure gradient in the flow direction, which drives a bypass flow through the extension’s inner wall and into the duct flow through the porous inner wall, see Fig. 2. The inner wall has four perforated panels with varying orientation of the perforation to the wall normal. The setup has two symmetry planes. The porous inner wall has perforations that are vectored such that streamwise vortices are generated in the boundary layer. Pitot measurement in the jet plume demonstrated that the flow field is influenced by the VoGeL bias flow, several jet diameters downstream the nozzle exit, where the jet mean flow is deformed from a circular into an elliptical cross-section for isolated jets. The flow alteration is strong also in installed configurations, see , including the effect of a flat plate to simulate the wing.

Excess noise generated by the bias-flow has been observed in the measured acoustic spectra of isolated jets. When the nozzle-exit Mach number is increased, the excess noise over the baseline nozzle is reduced. For installed configurations, a noise reduction well over 3 dB is measured in correspondence of the spectral region associated with the jet-wing interaction tones. The reduction is greater when the VoGeL is rotated to maximise the turbulence levels on the flat plate.

Our observations indicate that the studied realization of the VoGeL is a candidate for experiments in the transonic or supersonic regimes, where it could reduce acoustic noise in both isolated or installed

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configurations. In general, the strong effect on the convective flow, indicates that the technology could be further studied and optimised for the reduction of jet and jet-installation noise.

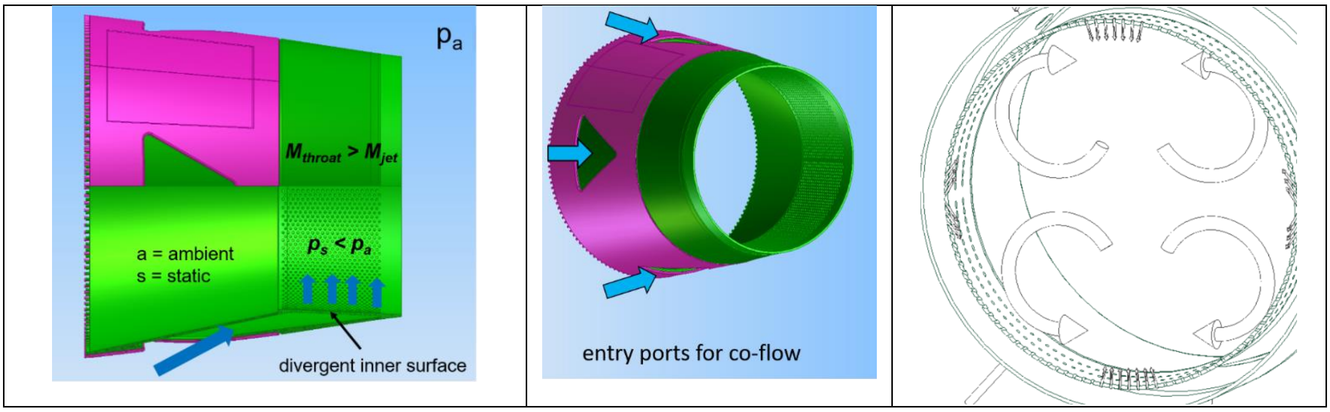


*Figure 2: Schematic of the nozzle extension with the Vortex Generating Liner (VoGeL). Left and centre: airflow through the double wall of the nozzle extension, right: vortex field generated by the vectored perforation of the liner.*

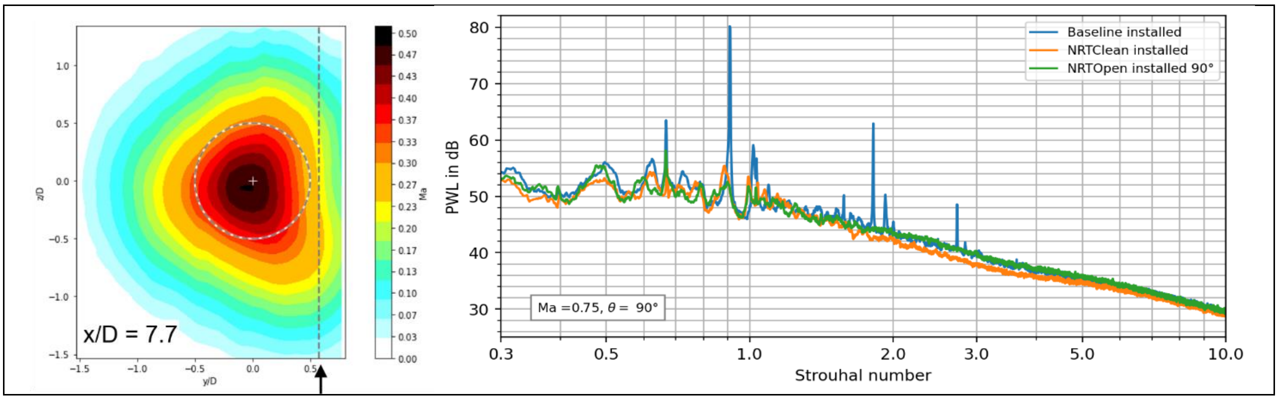


*Figure 3: Mean flow of the jet (left) and frequency spectra measured at θ=90° to the jet axis. The VoGeL nozzle strongly influences the mean flow cross section at 7.7 diameter downstream the nozzle exit. It suppresses tonal components that are generated by the interaction of the jet with the installed plate.*

## References

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