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Laminar Flow Control along the Attachment Line of a Swept Wing

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Promoting laminar flow over the wings and empennage of an aircraft can result in a significant reduction in skin-friction drag, and consequently, fuel consumption. Although many techniques were successfully developed to promote laminar flow, all work under the assumption that the initial starting flow, also known as the attachment line, is laminar.

Assuming laminar flow at the attachment line is not guaranteed, especially in the case where the wing section is attached to a solid wall (e.g., fuselage or wind tunnel wall). In this type of configuration, the turbulence that develops over the solid wall can propagate along the attachment line, resulting in attachment line contamination and turbulent flow over the entire wing.

One proven approach in preventing attachment line contamination is to use Laminar Flow Control (LFC) such as wall suction at the leading edge ([1], [2], [3]). In the frame of the NACOR and HLFC-Win projects, funded by the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme, low speed tests were conducted at the ONERA F2 Wind Tunnel facility on an ONERA DTP-A model outfitted with a leading edge suction system, as shown in Figure 1. Various micro-perforated panels, manufactured by Aernnova, were mounted on the leading edge and tested to investigate the effect of: porosity (defined as the ratio of the open area over the total area of the panel), hole diameter, and suction flow rate on the effectiveness of wall suction as an active anti-contamination device. The model was also mounted at two different sweep angles to further understand the limits of operation of wall suction at Reynolds numbers based on leading edge geometry, $\bar{Re}$, representative of those found in transport aircraft flight conditions.

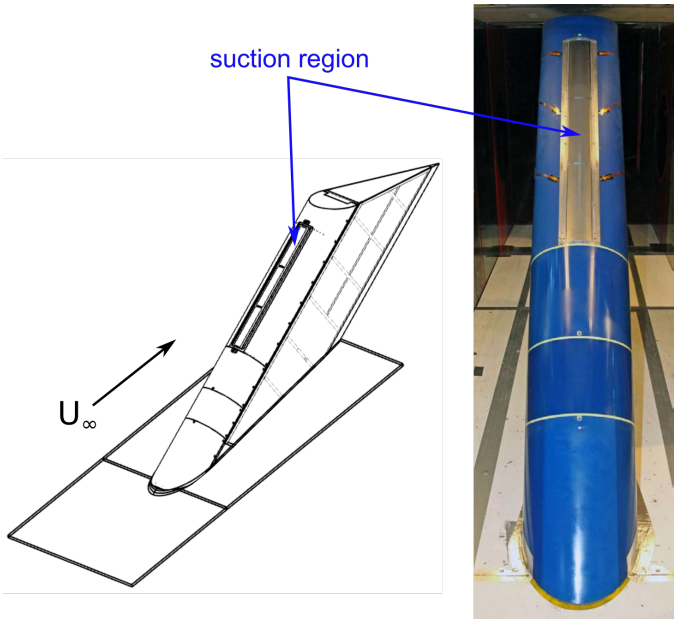

Figure 1: Experimental set-up of the DTP-A model outfitted with a wall suction system and mounted in the ONERA F2 WT.

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