# Control of shock-induced separation over compliant surfaces

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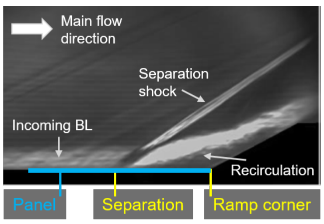
Shock/turbulent boundary-layer interactions (STBLI) with separation occur in many aerospace-transportation applications and detrimentally affect the aerodynamic performance and system integrity. Air-jet vortex generators (AJVGs) show promising effectiveness in controlling the shock-induced separation and in reducing the associated unsteadiness on rigid geometries[1]. However, many surfaces and structures in aerospace systems are not rigid, and the strong and unsteady aerodynamic loads imposed by STBLIs result in coupled dynamics with compliant surfaces[23].

We therefore aim to understand the effect of separation control with AJVGs on STBLI also over compliant walls, with the ultimate goal to reduce structural vibrations induced by the low-frequency unsteadiness of the shock system. An experimental study of a 24° compression-ramp interaction at Mach 2.52 over flexible panels of varying aspect ratio, with and without the influence of an array of AJVGs was carried out[4]. Two-component particle-image velocimetry measurements in the streamwise/wall-normal center plane of the model allow to analyze the velocity field and turbulence behavior; time-resolved focusing-schlieren visualizations (see Fig. 1(a)) were recorded at the model-center plane to analyze the shock motion, and we study the flexible-panel motion on the basis of digital image correlation (DIC) measurements. The schlieren and DIC systems are synchronized and record at 9.3 kHz.

AJVG control reduces the separation length effectively also on compliant surfaces[4]. However, the panel flutter seems to increase (see Fig. 1(b)). To be able to design more advantageous control configurations in the future, we shed light on the complex interplay of effects on turbulence and dynamics, including 3D effects due to the AJVG control and non-square flexible panels. We will present and discuss the correlations between the dynamics of the panel flutter and the dynamic mechanisms of the SWBLI, and in particular the response of this coupled system to the AJVG control.

a)




b)

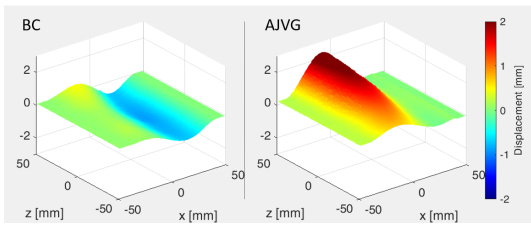



Figure 1: (a) Flow topology (Schlieren image). (b) Maximum overall panel deflection for the AR1.5 case. Left: baseline case; right: with AJVG control.

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[1]Ramaswamy and Schreyer, *AIAA J.* **59(3)**, pp. 927–939 (2021).
[2]Spottswood et al., *J. Sound Vib.* **443**, pp. 74–89 (2019).
[3]Daub et al., *AIAA J.* **54(2)**, pp. 670—678 (2016).
[4]Schreyer et al., TSFP12, Osaka, Japan, July 19–22, 2022