Wing-Body Junction Flow and Asymmetric Nose-Fairing

By

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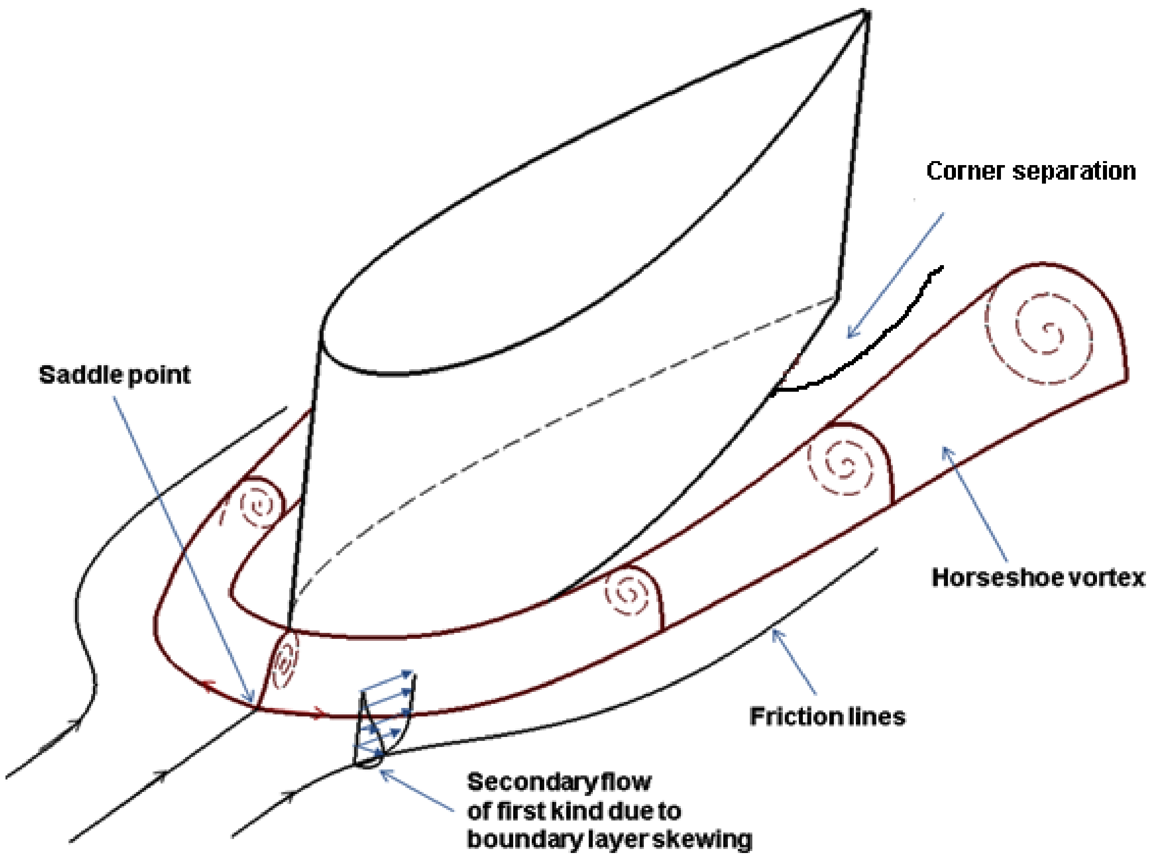
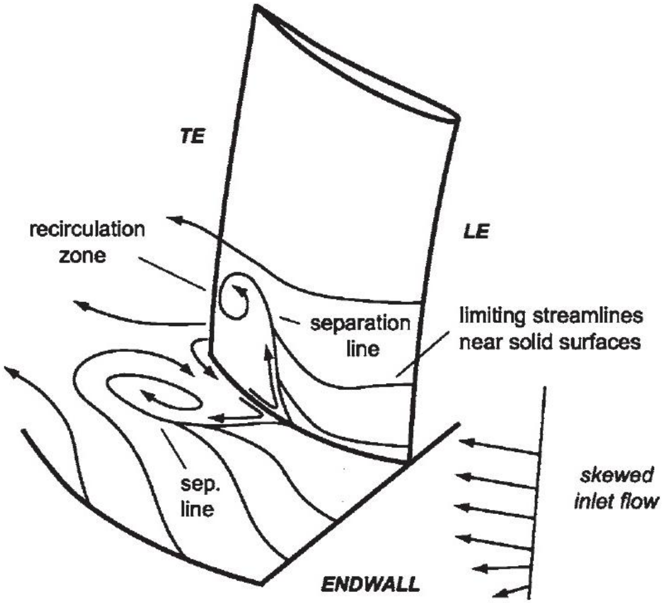
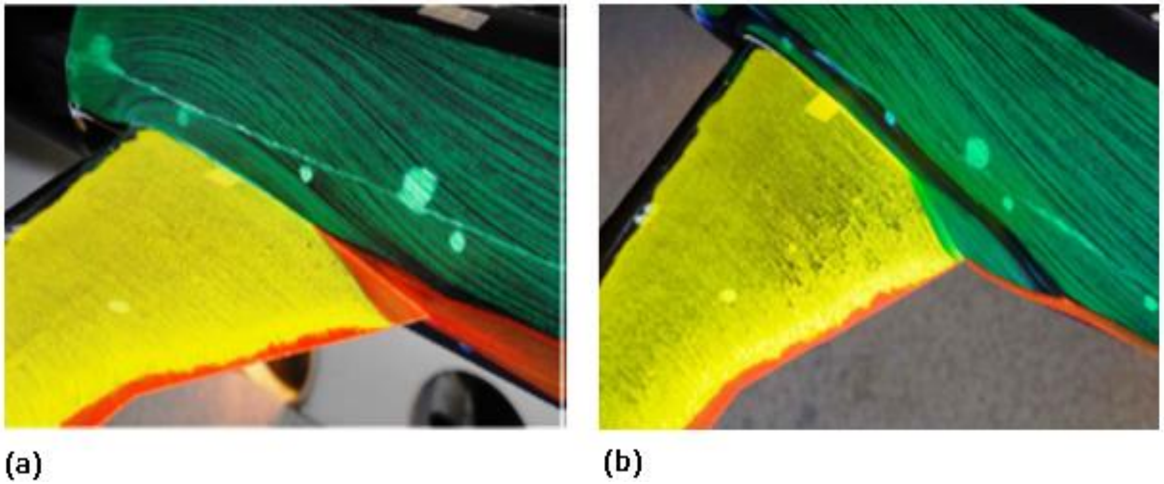
Wing-body interference flow



Corner flow separation



Schematic of corner separation

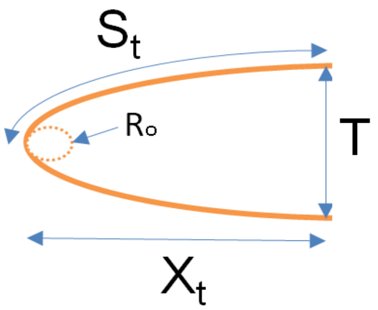


Corner separation at DLRF6 wing-fuselage configuration by Rudnik et al (2009)

Potential parameter controlling flow features around junction

Bluntness factor (BF): Introduced by Fleming (1990) it tries to account for the wing nose shape

$$BF = \frac{1}{2}\left[\frac{R_O}{X_t}\right]\left[\frac{T}{S_t} + \frac{S_t}{X_t}\right]$$



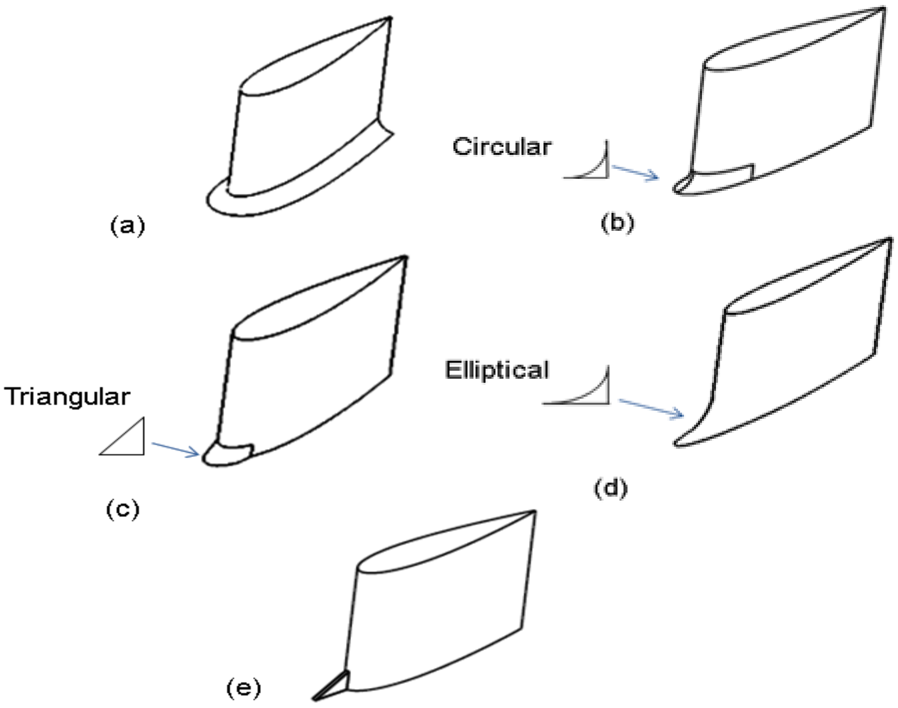
- Bluntness factor ranging from 0.028 to 0.32 can be found in the literature
- Blunt nose creates higher vortex stretching and form vortex of high intensity

Momentum deficit factor (Re_θ * Re_T) : Introduced by Fleming (1990) it tries to account the effect of approach boundary layer momentum thickness on the structure of horseshoe vortex

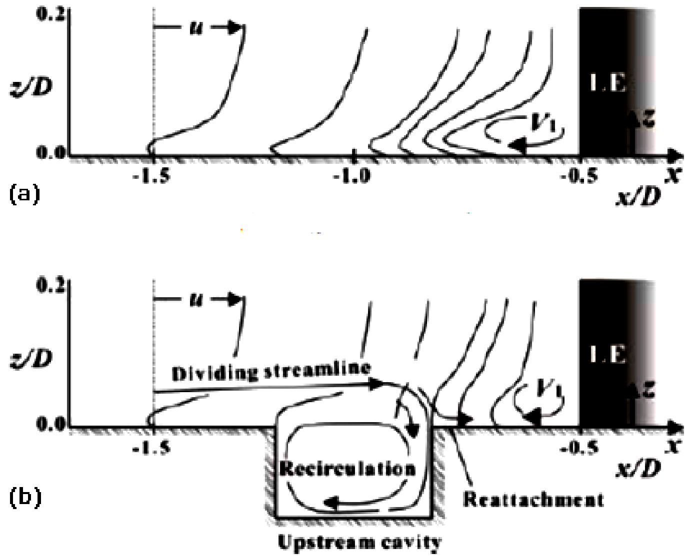
- Obtained by non-dimensionalising **$\rho U^2 \theta T$** by 1/(**$\rho \vartheta^2$**)
- MDF ranging from $0.7*10^8$ to $13*10^8$ can be found in the literature
- High MDF more structured vortex close to the BL plate

Flow controls at the junction

- Passive control methods include nose fillet, boundary-layer fence, and a cavity in front of the nose

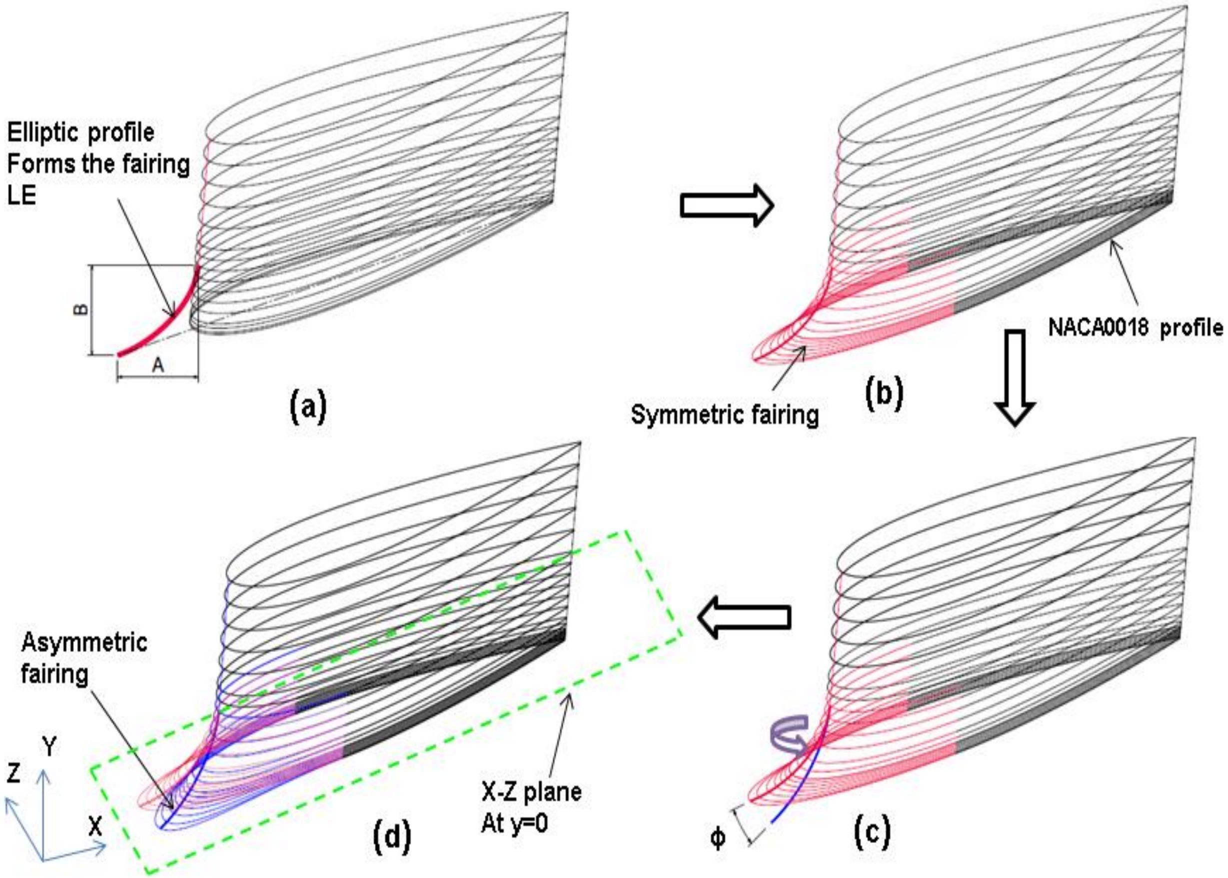


Different fillet shapes found in literature

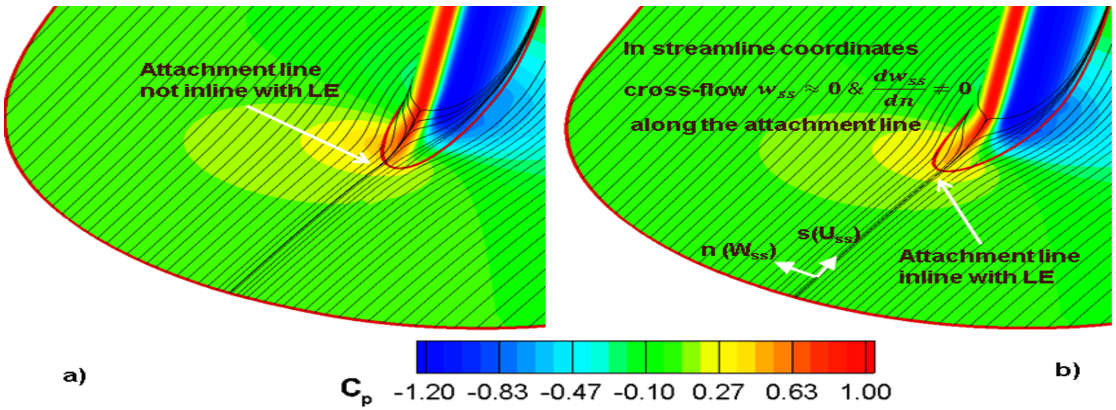


Effect of upstream cavity on the vortex strength

Asymmetric fairing design: Nose-fairing is designed for the wing at 4^{o} incidence



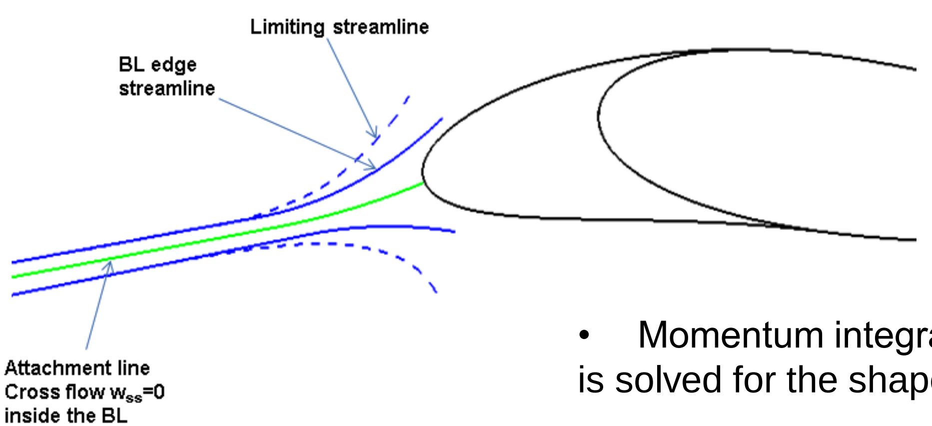
Sequence to arrive at asymmetric nose-fairing



Streamlines from invscid flow calculation

a) Symmetric fairing & b) Asymmetric fairing

at 4^o incidence



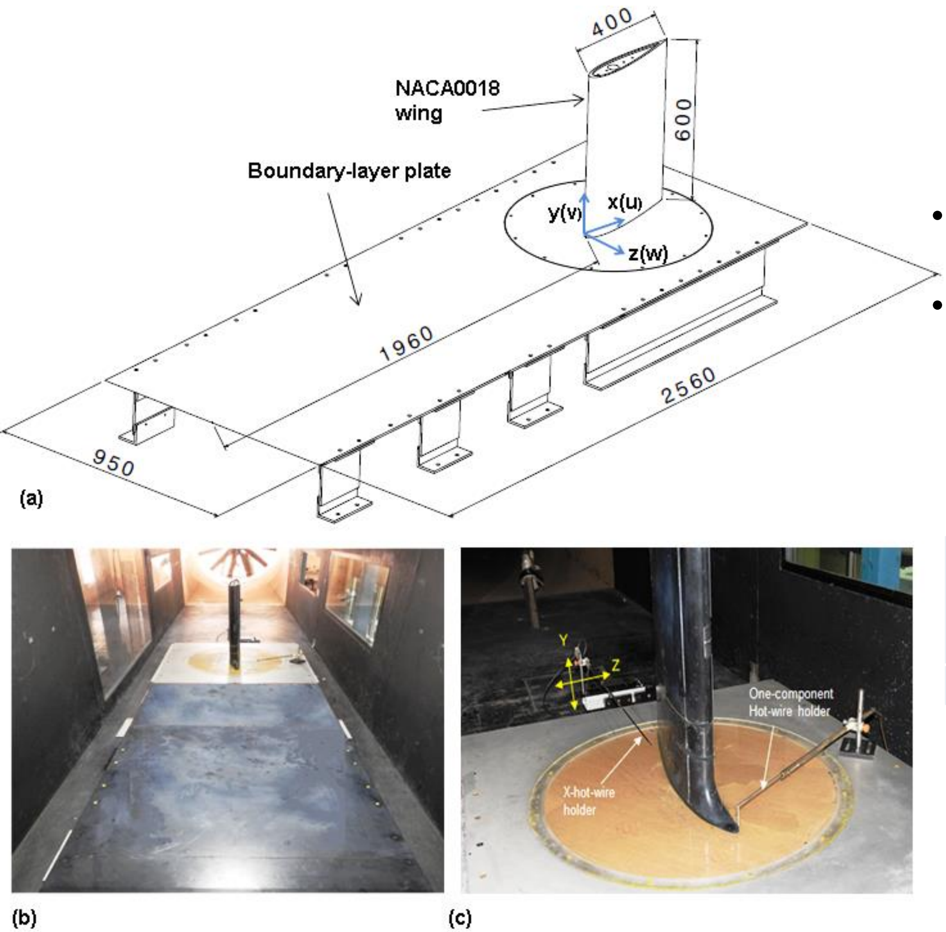
- Cross-flow velocity is zero inside the BL along the attachment line

- Cross-flow velocity derivative normal to attachment line is non-zero.

- Momentum integral equation along with the Head's entrainment equation is solved for the shape factor distribution along the attachment line

- Cross-flow velocity derivative model proposed by Oudheusden et al. (2004) was used in the momentum integral equation.

Experimental setup

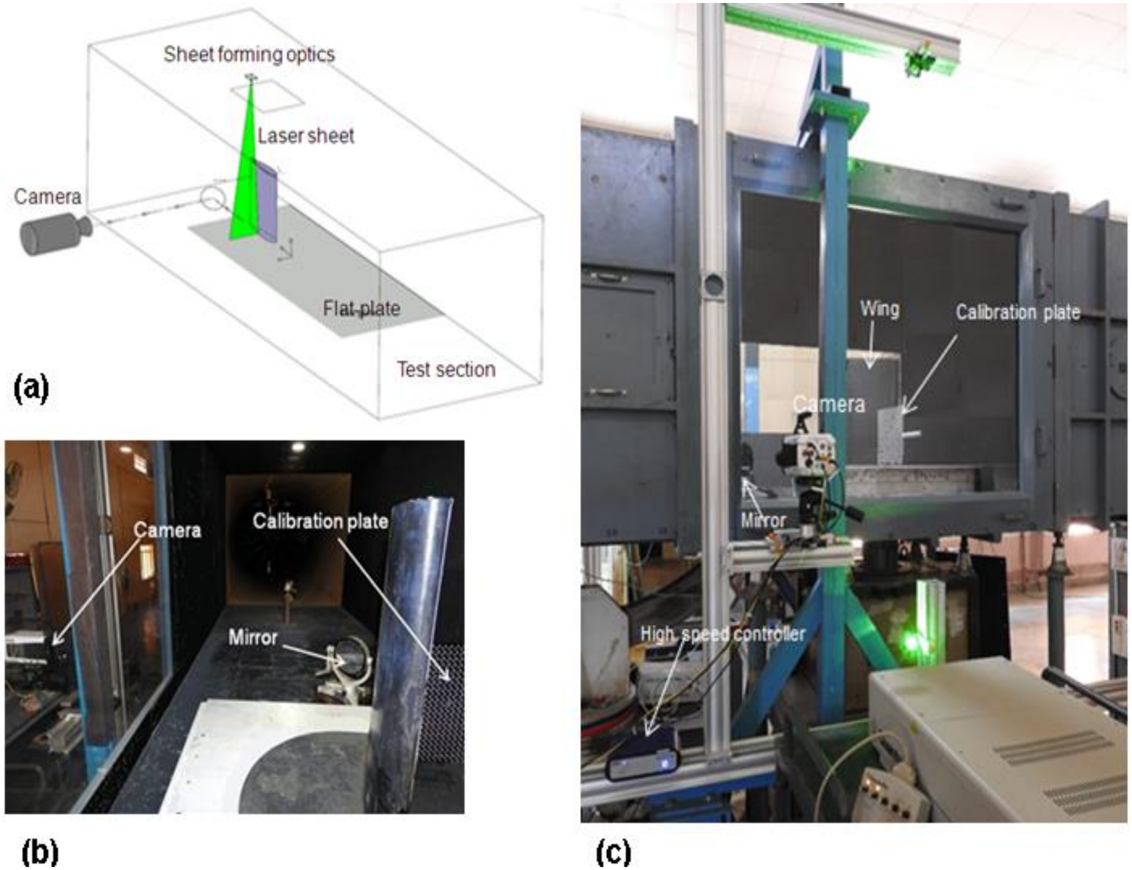


- NACA0018 profile was used in making rectangular wing
- Nose-fairing is designed for the wing at 4^o incidence

T mm	C mm	δ mm	BF	U_∞ m/s	H	Re_θ	Re_T	Re_C (10^6)	MDF (10^8)
72	400	~30	0.07	31	1.3	5600	$1.3*10^5$	0.7	7.3

On-coming 2D-boundary-layer properties, at -0.5c upstream of the wing leading edge

2D PIV setup

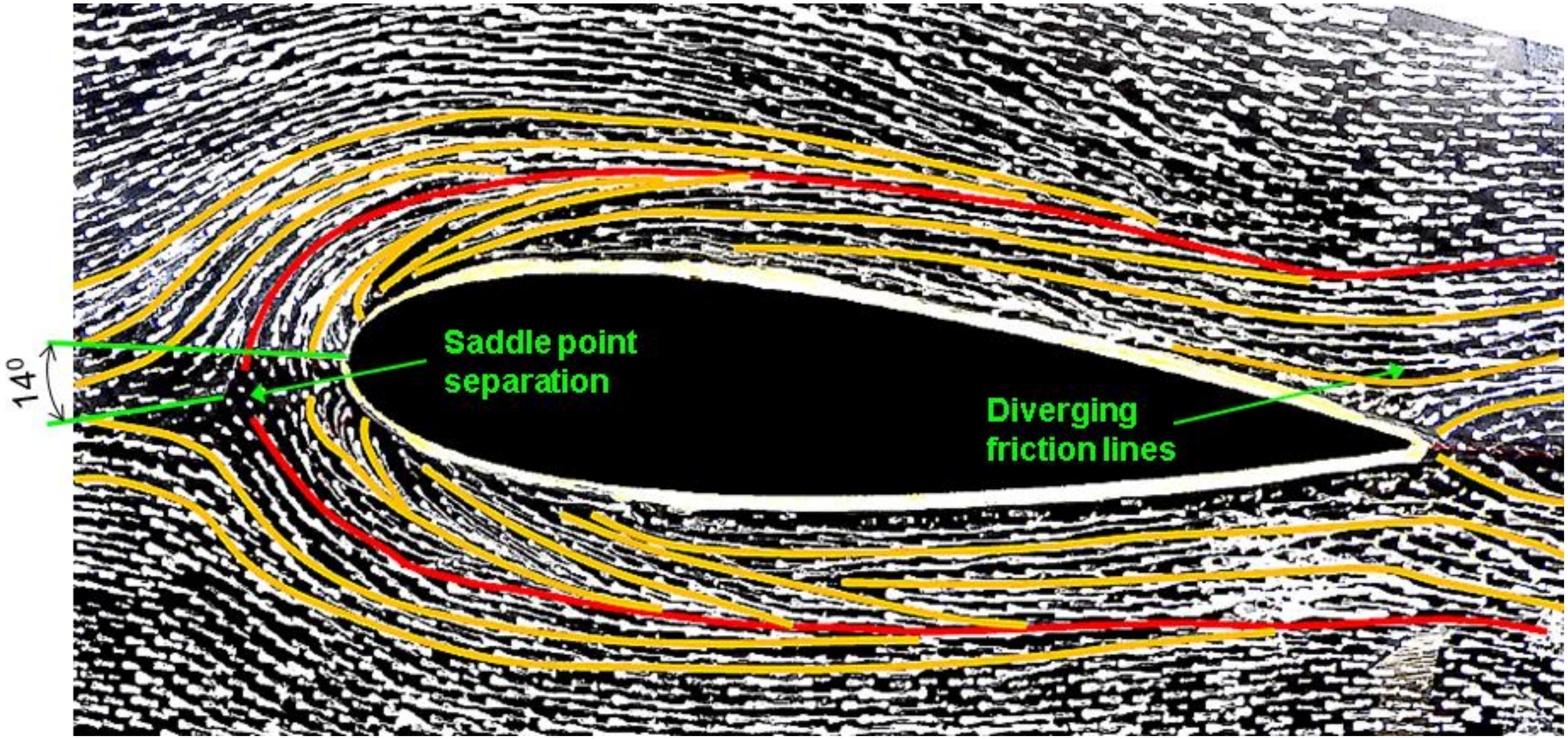


a) Schematic representation of the PIV setup b) Image from inside the test section showing the mirror, calibration plate, wing model and the camera c) Image from outside the test section showing laser equipment and the camera mounting setup

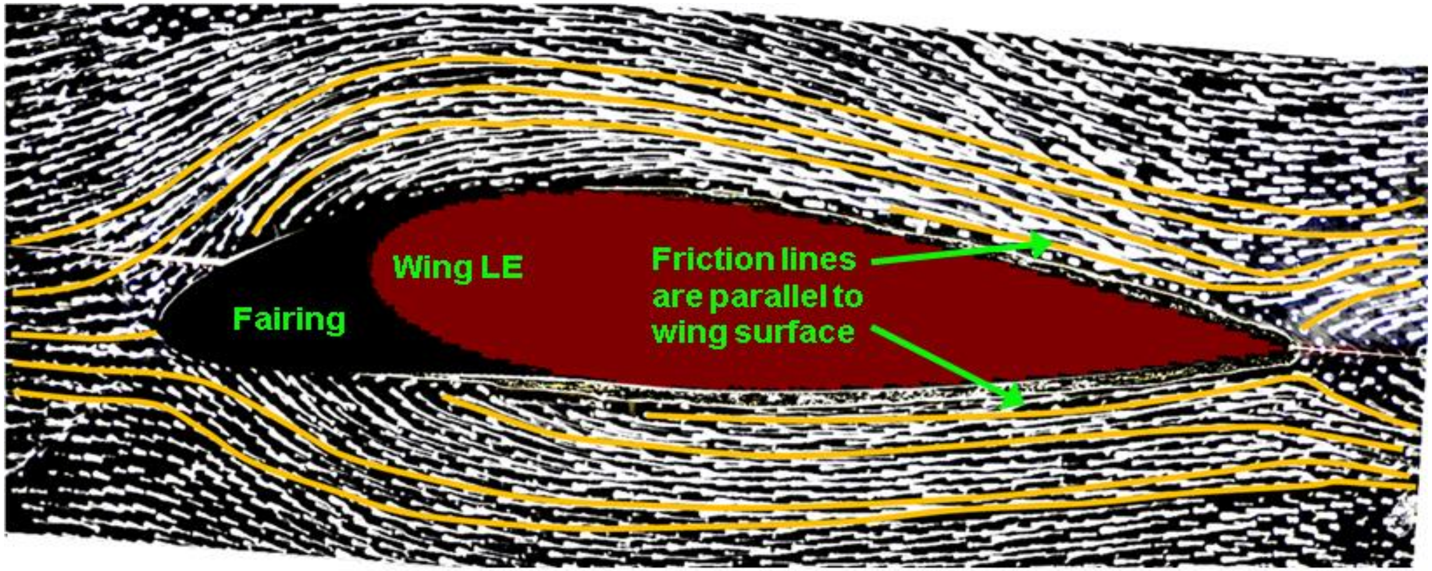
Experimental results: 4^o wing incidence

Oil-flow visualization

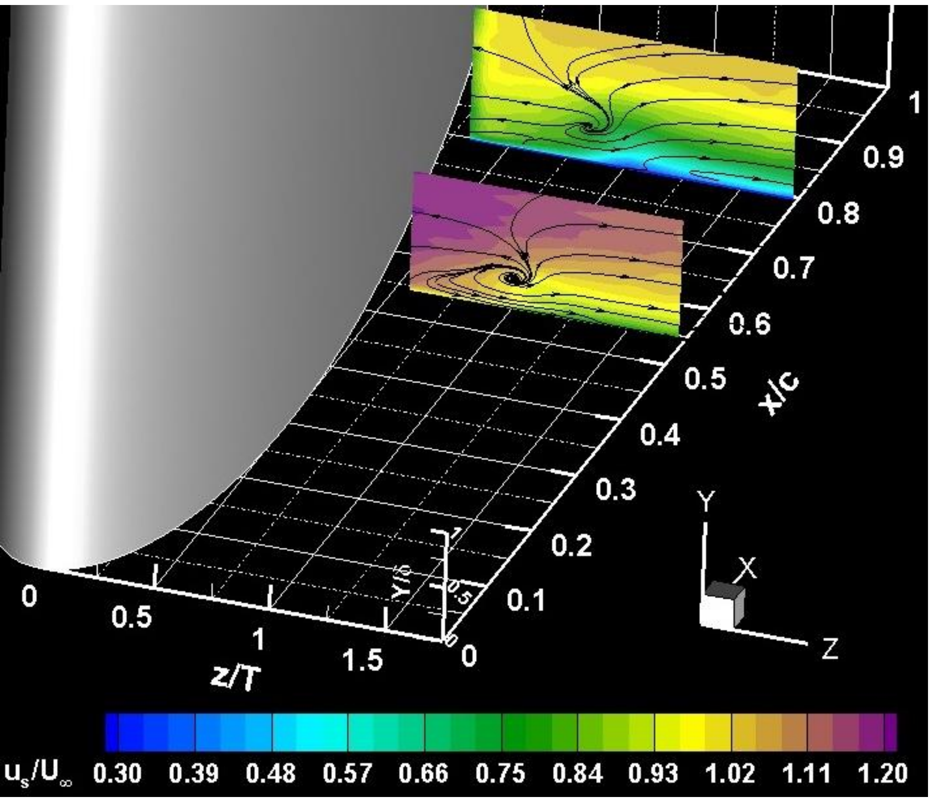
Unfaired configuration



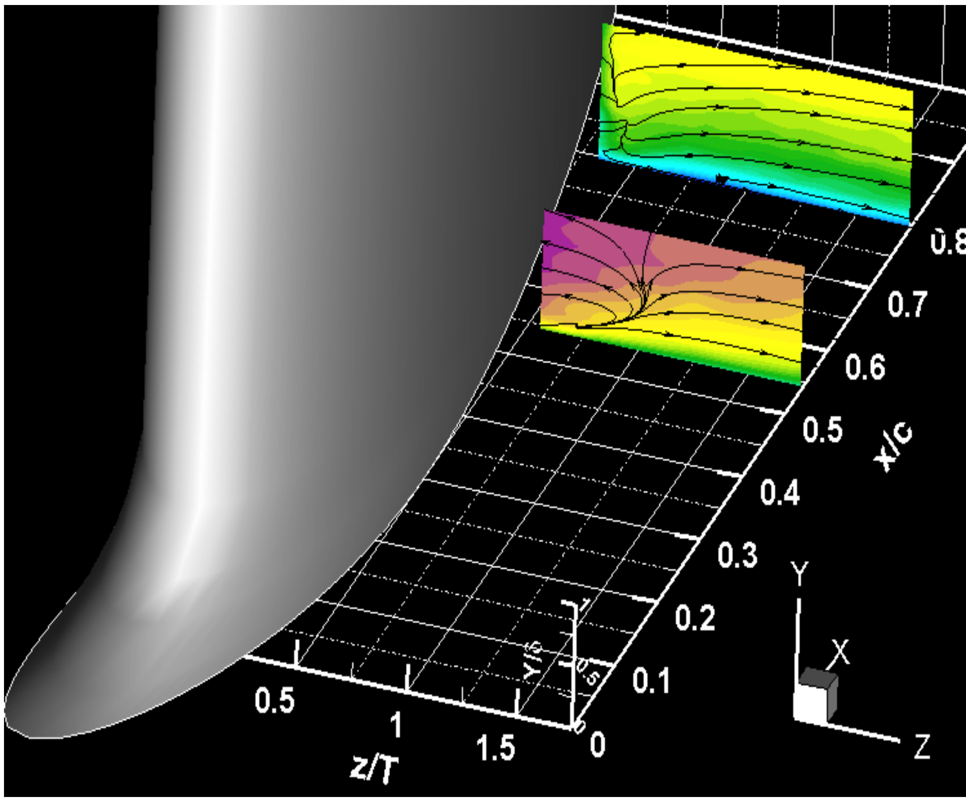
Faired configuration : 4° wing incidence



Mean velocity (u) contours on suction side: At x/c=0.54 & 0.79

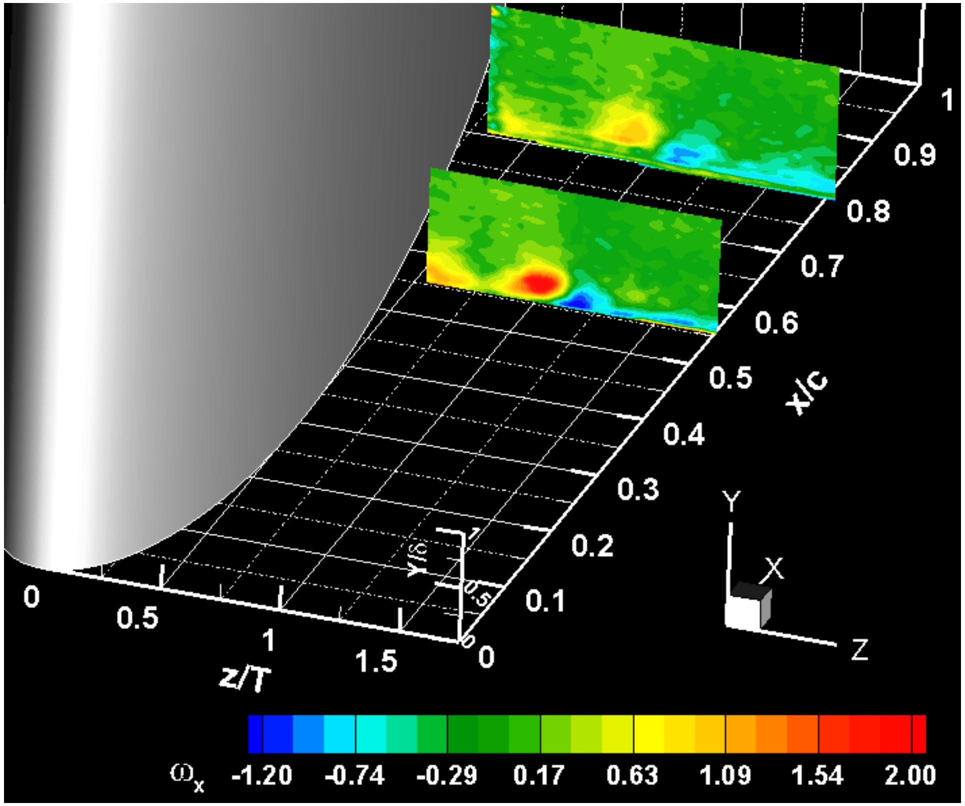


Unfaired wing at 4º incidence

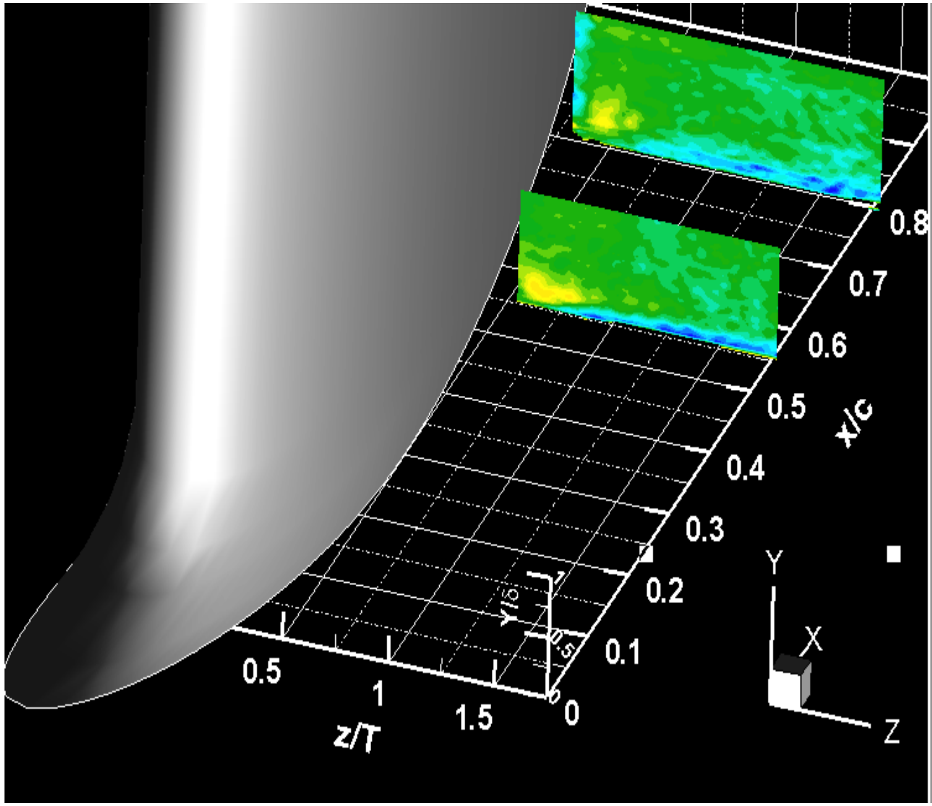


Faired wing at 4º incidence

Mean vorticity (ω_x) contours on suction side: At x/c=0.54 & 0.79

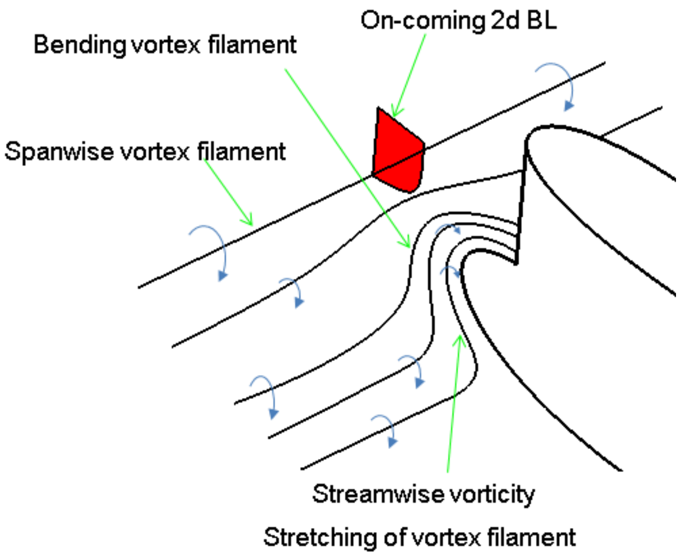


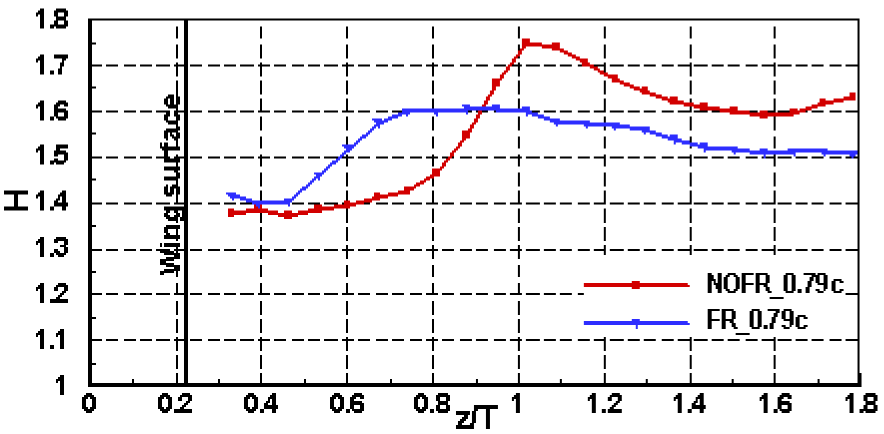
Unfaired wing at 4º incidence



Faired wing at 4º incidence

Shape factor distribution





Thank You