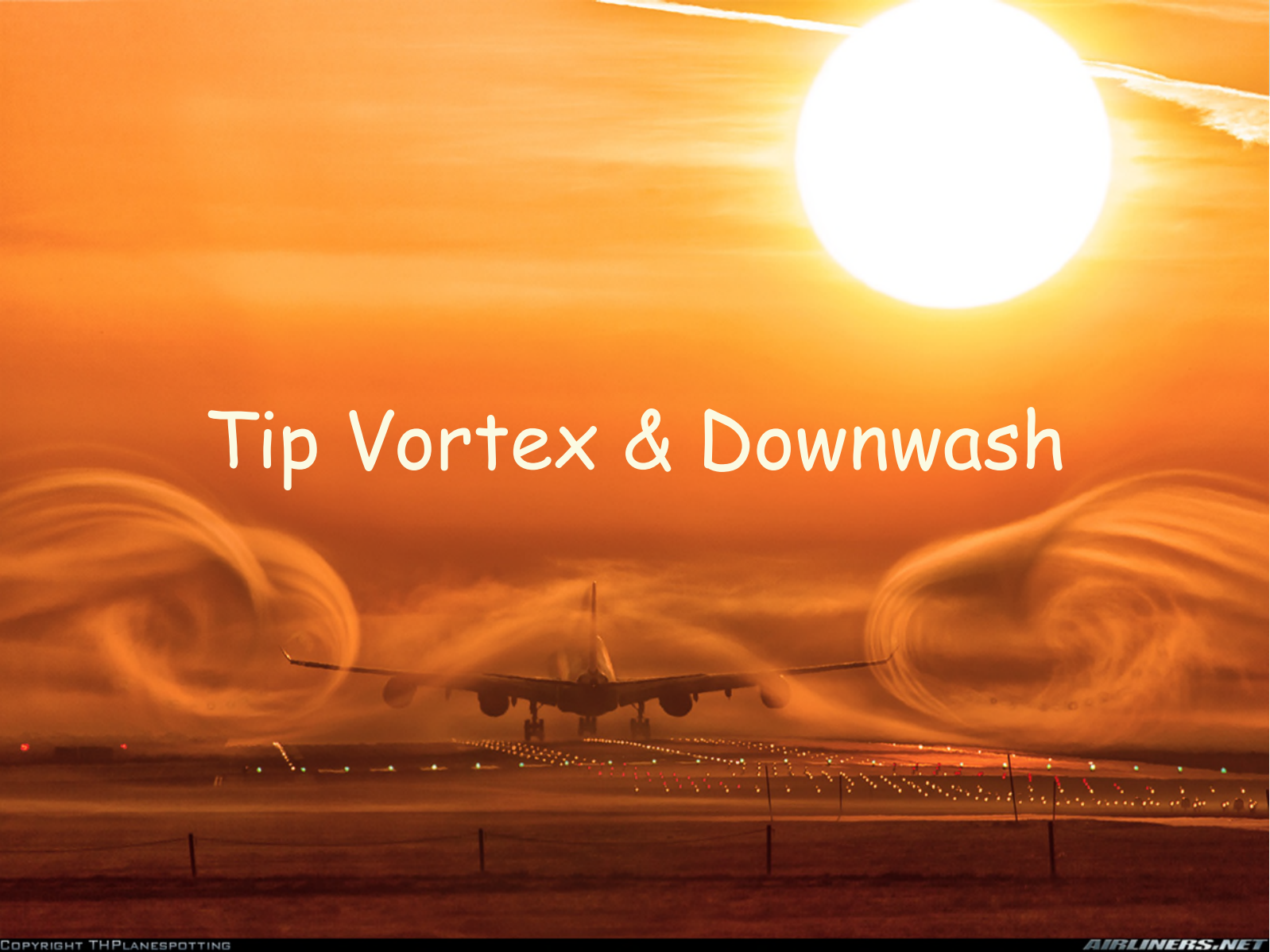
Tip Vortex & Downwash
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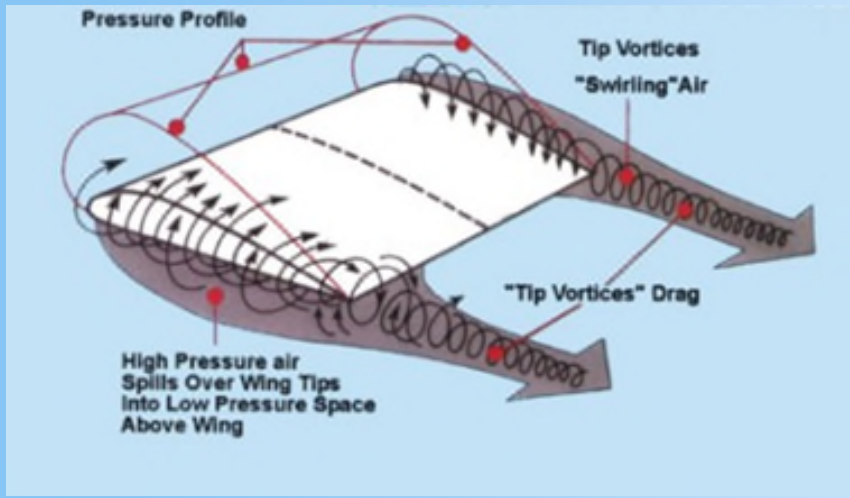
Tip Vortex principle

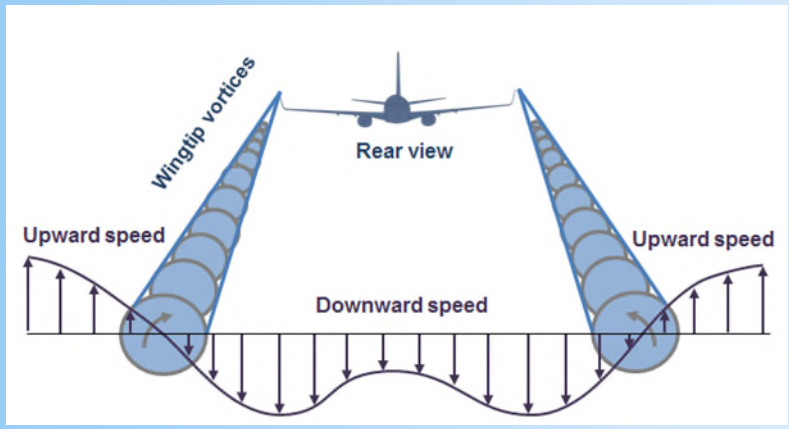


Learjet 75

Vortices form because of the difference in pressure between the upper and lower surfaces of a wing. The tendency is for particles of air to move from the lower wing surface around the wing tip to the upper surface (from the region of high pressure to the region of low pressure). The combination with oncoming free-stream flow leads to the formation of Tip vortices.

The stronger the wing lift, the stronger the pressure differential, the stronger the Tip vortices

From Tip Vortex tp Downwash



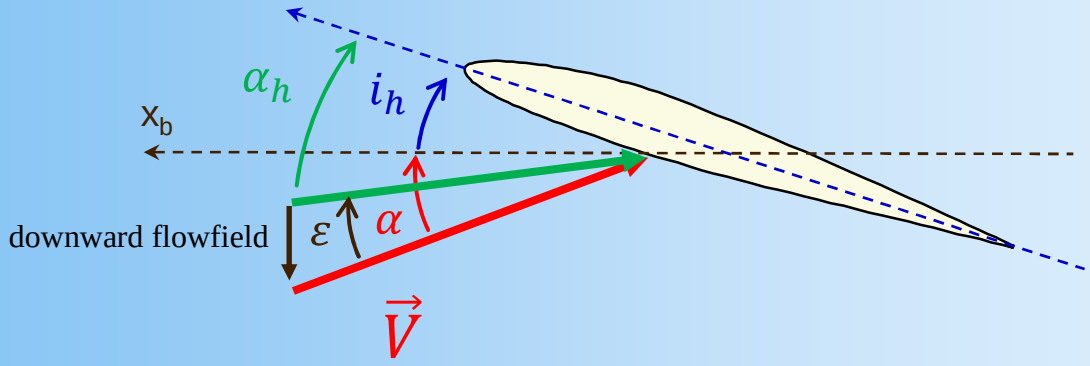
As far as we move aft from the wing, this produces a general downward flowfield between both vortices. As a result, there is a decreasing of the angle of attack :
The wing sees an angle of attack equal to α , the Horizontal Tail Plane sees $\alpha - \varepsilon$

The downwash angle ε is a function of α : $\varepsilon = \varepsilon_0 + \frac{\partial \varepsilon}{\partial \alpha} \cdot \alpha > 0$

$\frac{\partial \varepsilon}{\partial \alpha} > 0$: more α, more lift, more tip vortices, more downwash

$\varepsilon_0 = -\frac{\partial \varepsilon}{\partial \alpha} \alpha_0$: for $\alpha = \alpha_0$, zero lift, zero tip vortices, no downwash

General expression of HTP angle of attack



Taken into account the Horizontal Tail Plane setting, i_h

The general expression of the local angle of attack is :

$$\alpha_h = \alpha - \varepsilon + i_h = \alpha\left(1 - \frac{\partial\varepsilon}{\partial\alpha}\right) - \varepsilon_0 + i_h$$