Boeing's new winglets reduce fuel burn and noise

Turned-up wingtips are an increasingly familiar sight at airports and a cause of some surprise to passengers, accustomed to the traditional straight wing. What are they for and what do they do?

Turbulence shed from the wing contributes to fuel consumption, additional take-off thrust and resulting noise. The drag results from a number of sources, but that from the trailing vortex system is a major contributor, causing about one half of the total drag for a subsonic plane in optimum cruise flight. The vortex sheet is particularly intense near the wing tip.

Induced drag is given by:

$$\text{Induced drag} = K_i\,(lift)^2\,/\pi q(span)^2$$

Where q is dynamic pressure = $\frac{1}{2}\rho V^2$
ρ is air density
V is flight velocity
K_i is the induced drag factor

For a planar wing, the induced drag factor is approximately unity, but is lower for configurations with increased ratio of total trailing edge length to span. Wing tip winglets increase the ratio, but are more efficient if they are produced by a gradual transition, as blended winglets, rather than sharp edges. Fig 1 illustrates the transition. Prior to the development of blended winglets, the transition was sharper and not optimised, although the overall effect was beneficial.

Early installations of blended winglets, around 10 years ago, were Aviation Partners designs for the Gulfstream II. More than 100 sets have been fitted, currently at $520,000 cost and 10–14 days installation time. There is an immediate pay back of 7% extension in range and an increase in load capacity and cruise altitude. (www.aviationpartners.com)

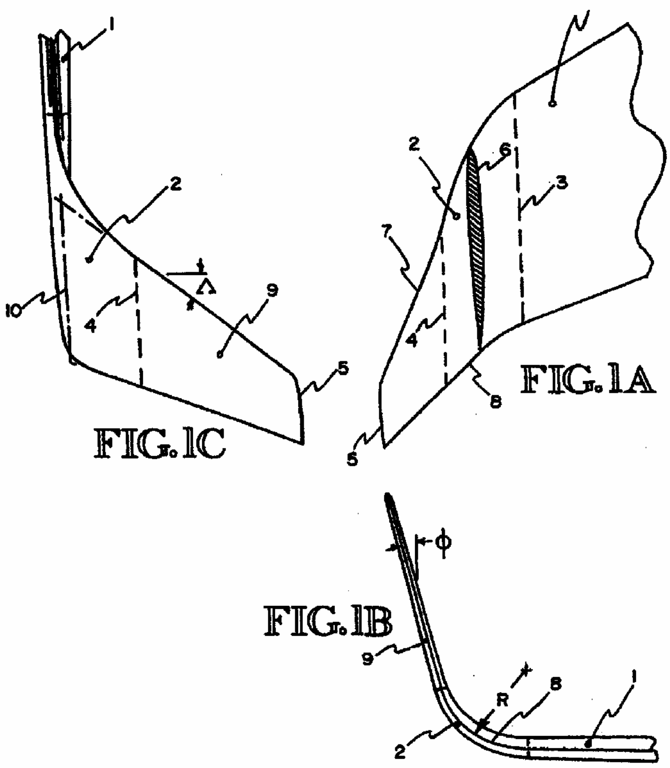

Figure 1. Blended Winglets
(From Louis B Gratzer, "Blended Winglet", US Patent No. 5,348,253, September 20th 1994

As the concept developed, Aviation Partners teamed up with Boeing to form Aviation Partners-Boeing, initially to provide winglets for Boeing Business Jets, on which they are now standard, but also to widen the application of winglets. An outcome of these developments has been recent FAA approval for winglets on the B737-800 series and other members of the Next Generation 737 family. The model's new CFM56-7 engines, produced by a joint venture of General Electric Co. and SNECMA, already meet noise limits well below current Stage 3 and are within the expected Stage 4 limits. The B737 winglets, about 2.5m high and extending the wingspan by 1.5m, give opportunities for further noise reduction. (www.boeing.com)

Hanover based Hapag-Lloyd is the first carrier to take B737-800's into commercial service, equipped with retrofitted winglets. The claims are for an additional 240km range, reduced fuel consumption of 5% in cruise, increased load capacity in excess of two tonnes and the noise affected area reduced by 6.5%. Of course, there is a danger that, if carriers make use of the increased load capacity, the lower noise advantage resulting from reduced take-off thrust will be lost. Other carriers converted to the concept of blended winglets, and flying the first production-fitted versions, are Air Berlin and South African Airways.

Winglets are not exclusive to Boeing. DuganAir Technologies (www.quietwing.com) has been offering retrofit winglets for some years, specifically to obtain Stage 3 noise levels out of Stage 2 planes, as an alternative to hushkits. Reductions of 3–5 EPNLdB are claimed on a 727-200A (Fig. 2). Airbus fits winglets on many of its planes, although Aviation Partners claims an exclusive on its patented blended winglets.

Some large industrial propeller fans are also fitted with aerodynamic winglets at the blade tip. These decrease the tip vortex, which occurs as air spills off the tip from the high to low pressure side of the fan, thus lowering the noise levels by 2 to 3 dB. (www.moorefans.com).

And, of course, large birds have variable wing tip feathers, winglets far more flexible and complex than the plane designers even dream of.

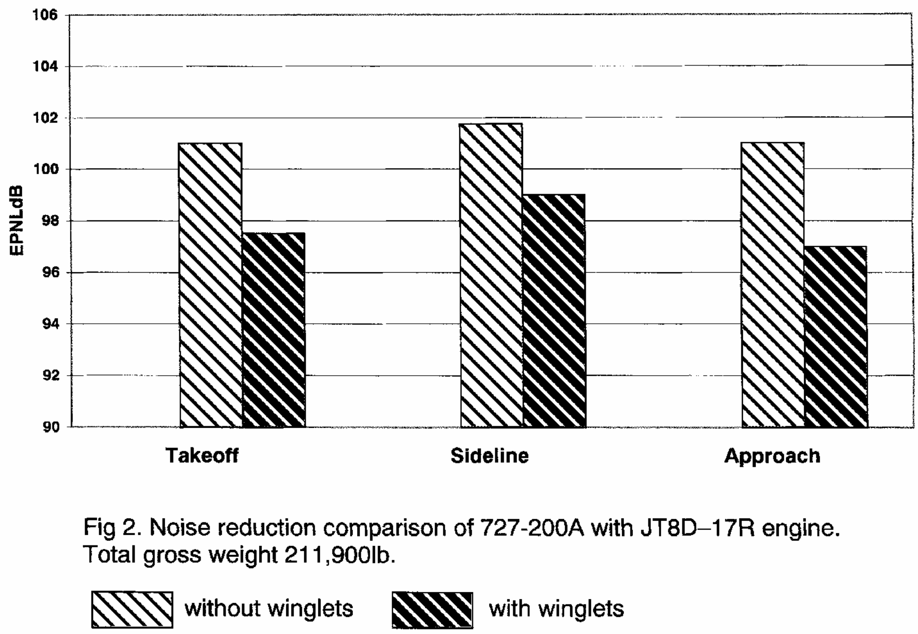

Figure 2. Noise reduction comparison of 727-200A with JT8D-17R engine. Total gross weight 211,900lb.