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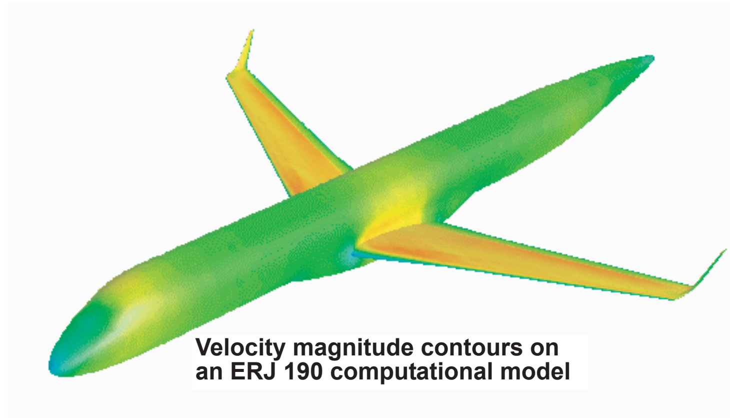
Winglets Provide a Measurable Performance Lift

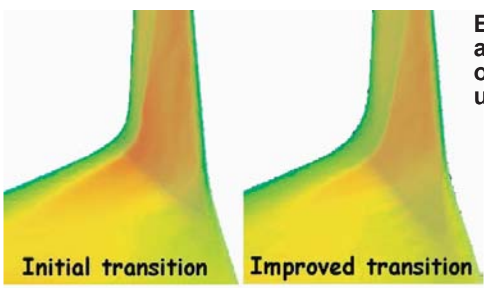


Velocity magnitude contours on an ERJ 190 computational model

Courtesy of Embraer

Embraer, based in São José dos Campos, Brazil, ranks among the four largest commercial aircraft manufacturers in the world. In 1989, subsonic wind tunnel tests conducted by Embraer at Centro Tecnico Aeroespacial (CTA), a Brazilian research agency of aerospace technology, indicated the potential benefits of fitting winglets onto the tips of existing aircraft wings. Since that time, Embraer has used CFD to help design winglets for several of its aircraft models, bringing about considerable improvements in the performance of all of them.

A winglet is a wing-like surface attached to the tip of the wing that is used to improve fuel efficiency and climbing capability. It accomplishes this by acting like a small sail with a lift component that generates a traction force, draining energy from the tip vortices. Consequently, it reduces the vortex strength, lowering induced drag. "Induced drag represents 30-40 percent of the total drag of a transport air-plane at the cruise condition, so it has a big impact on fuel consumption," explains Bento Silva de Mattos, senior engineer at Embraer. "Because the induced drag coefficient is proportional to the square of the lift coefficient, a reduction in drag improves climbing capability as well, because the lift coefficient is high at this condition."



Example of aerodynamic optimization using CFD

Despite the benefits of winglets, there are some drawbacks that need to be addressed. For example, the bending moment at the wing root is higher, and may require additional structural reinforcement of the wing. The viscous drag of the winglet can be too great, nullifying the reduction of the induced drag. Winglets have to be carefully designed so that these and other problems can be overcome. It is here that CFD can help by offering rapid turnaround times for parametric configuration studies. For example, it was through FLUENT simulations that the transition between the wing and winglet was optimized to achieve the best performance.

Winglets were first used on the EMB 145 SA, an aircraft used for early-warning duties and airspace control. They were then applied to the Legacy business jet, a derivative of the ERJ 135 regional jet. For this model, a prototype was designed, tested, and released within four months of the original concept. The results from the flight tests clearly showed that the designed winglet configuration fulfilled all expectations of the performance improvements. The ERJ 170 and ERJ 190 are newer regional jets with winglets that were incorporated during the original design phase.

Despite the fact that winglets have been in use for many years, optimization of winglet design had been difficult because the complex airflow patterns around these wing-mounted airfoils could not be understood through wind tunnel testing. The Reynolds number has a big effect on the flow structure; f light tests always showed larger drag reductions than the ones from wind tunnel data. Using simulation results as a guide, the engineers fine-tuned the winglet geometry to further reduce induced drag, improving fuel consumption. "We evaluated seven designs in only one month, ending up with a shape that was even more successful than we had hoped for," says Silva de Mattos.