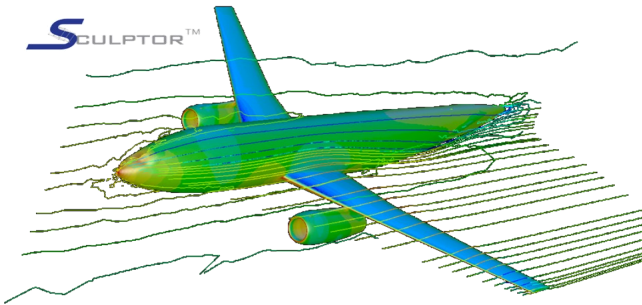


Commercial airplane 3D wing shape morphing with Sculptor™: *overview*



AERODYNAMIC EFFICIENCY: +8%

TURBINE NACELLE: UNCHANGED

SHAPE CONSTRAINTS: MAINTAINED

Why wing efficiency?

Commercial airplanes are encountering increasing efficiency requirements and emissions restrictions, hence major efforts are ongoing to innovate their aerodynamic design. For instance, the wing shape contributes substantially to the overall aerodynamic performance of the airplane. Typically 3D wing design should guarantee an improved ratio between aerodynamic lift force and drag force with respect to reference designs. The turbine engine nacelle and fuselage shapes might be already in a frozen design state and therefore become the constraints.

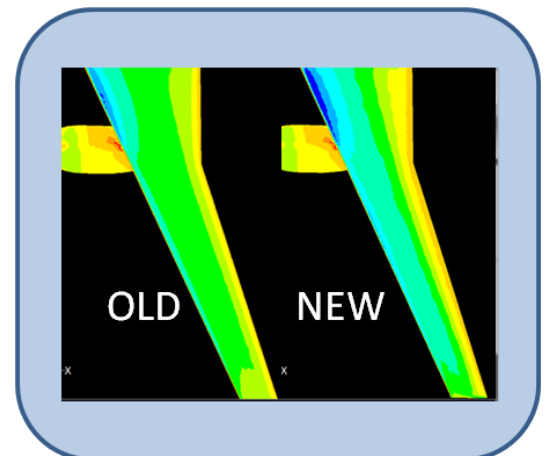
So What?

The 3D geometry of an existing commercial airplane wing had to be re-shaped in order to achieve efficiency improvements. The main goal was to increase the lift/drag ratio at subsonic cruise conditions, without modifying fuselage and turbine engine nacelle shapes.

All this was achieved through a new design process that minimizes costs, time and access to CAD resources and resulting in an improved CAD model.

Did They Succeed?

Sculptor™, coupled with a CFD code, allowed finding an improved 3D wing shape in just a few days, while with only CFD it would have taken several weeks. With subtle shape modifications, a sound 8% increase of overall lift/drag ratio was achieved—without affecting the fuselage and turbine nacelle shapes. Sculptor™ avoided time consuming operations on Computer Aided Design (CAD) model and on the computational grid, since its morphing took place over the CFD model directly. Finally, the optimized airplane shape was applied to the original CAD model.



Commercial airplane 3D wing shape morphing with Sculptor™: *details*

Re-Cad

Re-Mesh

CFD
Pre

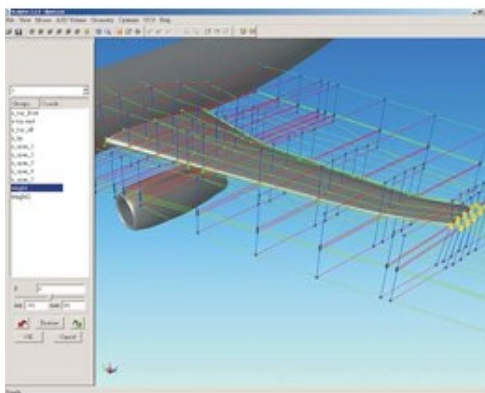
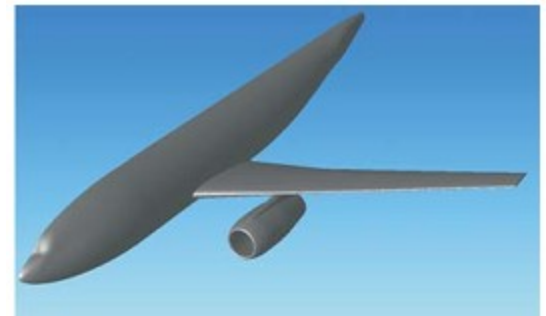
Mesh Morph

90 % time saving with Sculptor™

Time advantage in creating any new configuration after the initial one.
*"Exports to CFD"

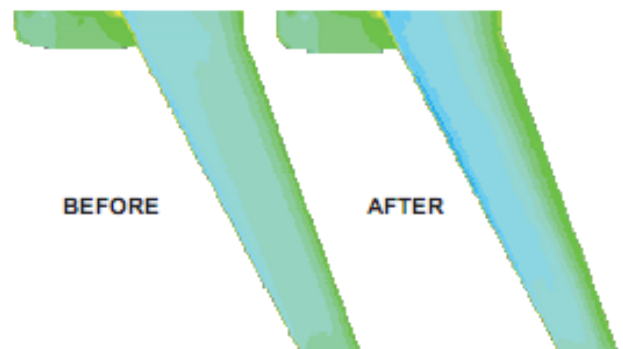
Sculptor™ enables the user to easily parameterize a 3D commercial airplane wing, respecting the assigned shape constraints. It also remove the re-CAD, re-mesh and pre-process operations for each new design iteration, by modifying the shape of the CFD model directly. Once the improved design was found, it allowed the transfer of the deformations to the original CAD model directly

A reference 3D wing geometry had to be refined with respect to a defined industry standard design. Fuselage and nacelle shapes had to be left untouched. The airplane aerodynamic lift/drag ratio had to be maximized at subsonic cruise conditions.



Using Arbitrary Shape Deformation (ASD) volumes, fifty configurations were instantly generated by Sculptor by changing the parameter values — without the need of re-creating the mesh. New configurations were then automatically submitted to a CFD analysis code and evaluated. Finally, the best configuration was selected and its shape was applied to the original CAD model

Sculptor™'s morphing technology was applied over a Computational Fluid Dynamic (CFD) model of the commercial airplane, to define the optimal 3D shape of its wing. The original mesh was imported and the wing was prepared for morphing while respecting the nacelle and fuselage shape constraints. Ten parameters and the objective function were defined, Sculptor was then connected to the CFD solver



CFD and Sculptor™: **faster and cheaper design**



Sculptor™, coupled with a CFD code, allowed finding the optimal engine inlet port geometry in just one week. With only CFD code, it would have taken several weeks or months. The total costs were 86% less with respect to the traditional design method. In the table below the breakdown of the costs is presented, based on the estimation of man-hour cost of (\$90 / hour), CFD code hourly cost (\$10.75 / hour) and a Sculptor™ hourly cost of (\$10.75 / hour). 80 designs needed to be evaluated.

	TIME		COSTS	
	Without Sculptor	With Sculptor	Without Sculptor	With Sculptor
Time / Cost to mesh the first design	4 h	4 h	\$403	\$403
Time / Cost to re-CAD and re-mesh designs after initial	75 h	0 h	\$7,556	\$0
Time / Cost to re-set Boundary Conditions for all designs	7.5 h	0 h	\$756	\$0
Time / Cost to set up the case in Sculptor™	0 h	2 h	\$0	\$202
Total Time / Cost	86.5 h	6 h	\$8,715	\$605

On this project, the use of Sculptor™ enabled the user

to save more than \$8,000 and 80 hours

About Sculptor™

Sculptor™ is developed by Optimal Solutions Software LLC, based in Idaho, USA. The Optimal Solutions Management team is comprised of some of the most experienced CFD-based shape optimization personnel in the business. Since 1990, the research team has expended thousands of man-hours in designing and refining the Sculptor™ software program to its present form. Through the development of the Sculptor™ world-class, patent-pending product family, Optimal Solutions has been able to effectively address the current barriers that prevent the efficient use of digital simulation.

www.optimalsolutions.us

Apply Sculptor to your model for free

The team at Optimal Solutions Software is happy to perform a no-cost initial design assessment on your model. Contact us today and we will obtain the deformation constraints from you and demonstrate how Sculptor can save you time and money. We have worked with all sizes of companies and have NDA's in place with most major firms and can quickly get to work on your model.

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