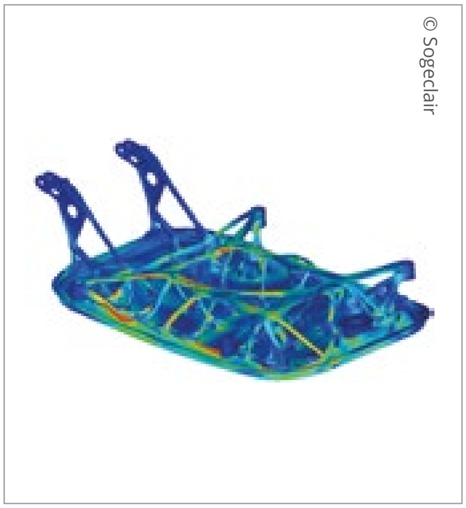
Success Story

Simulation, 3D Printing, and Casting: The Perfect Symbiosis for Large Aerospace Structures



Key Highlights

Industry
Aerospace

Challenge
Design of an aircraft access door with combined additive manufacturing and casting methods

Altair Solution
Topology optimization, FE analysis

Benefits
• Reduced development cycles
• Weight savings

Additive manufacturing, commonly known as 3D printing, is increasingly raising interest, especially in the aerospace industry where reducing mass and hence fuel consumption is a major goal. Additive manufacturing offers huge potential since it enables the creation of load-specific organic shapes. Weight reduction as a result of mass removal and integration of multiple parts and functions within a structure lead to time reduction and much more. However, as a relatively new method in aeronautics, additive manufacturing suffers from certification and qualification issues where a lot remains to be done. Manufacturing capabilities are still restrained by the size of 3D printing machines, which makes the technology unsuitable for larger components within a plane, such as an engine pylon or an access door.

The dimension issue is an obvious hurdle for 3D printing. An airplane door is, while being rather large – due to its complexity and function integration – a very promising part when it comes to potential cost reduction via a one-shot production method.

In a study, engineers from Sogeclair aerospace explored solutions for this problem by creating a development process combining the two methods of additive manufacturing and casting - their advantage to developing and manufacturing this airplane door. While casting is a five-thousand-year-old, well-validated process, additive manufacturing provides design freedom not currently offered by any other manufacturing method. To leverage the full potential of these combined methods, design and optimization of the door were handled using Altair's HyperWorks™ software suite.

Keywords: Sogeclair Aerospace, Additive Manufacturing, Topology Optimization, Casting Simulation

Sogeclair Success Story

"With Altair HyperWorks we have robust tools that offer a very efficient way of working for all of our projects. Altair OptiStruct, Altair HyperMesh and Altair HyperView are used basically on an everyday basis and help us to come to the best possible solutions for our designs." Matthieu Deloubes, project leader at the Innovation Department of SOGECLAIR aerospace.

SOGECLAIR aerospace, part of the SOGECLAIR S.A. group, is a major engineering partner and prime contractor for the aerospace industry. SOGECLAIR aerospace offers consultancy and management services in configuration management, aero structures, systems installation, aircraft interiors, manufacturing engineering, and equipment. The company's activities extend from the research and development phase to the supply of products. SOGECLAIR aerospace also offers production services through its subsidiaries and joint ventures: AviaComp, ADM, MSB, and PrintSky. The parts produced include fuel tank access doors using CFRP for the Airbus A350 and Bombardier C-Series, metallic floor structure for the Airbus A380 and business jet cabin interiors.

Simulation at Sogeclair

Sogeclair has been using Altair solutions for many years and relies heavily on the Altair HyperWorks software suite for simulation and development tasks. About 20 people regularly work with Altair tools, some of them in the innovation department at Sogeclair, which was responsible for the airplane door development.

The engineers use various Altair HyperWorks tools and rely heavily on Altair OptiStruct, an FEA solver and optimization tool, as well as Altair HyperMesh and Altair HyperView, which are applied for pre- and post-processing. OptiStruct is very much appreciated as an FEA solver and optimization software as it offers a series of interesting features to set up the optimization for the convergence of a satisfying solution. In addition to that, SOGECLAIR aerospace designers are working with Altair Inspire, the generative design/ topology optimization and rapid simulation solution, because it is easy to use and very valuable especially in the first design phase. SOGECLAIR aerospace uses all of the Altair tools via Altair's flexible unit-based licensing system.

Challenging the God of Winds – Making "One Shot" Possible with Simulation, 3D Printing and Casting

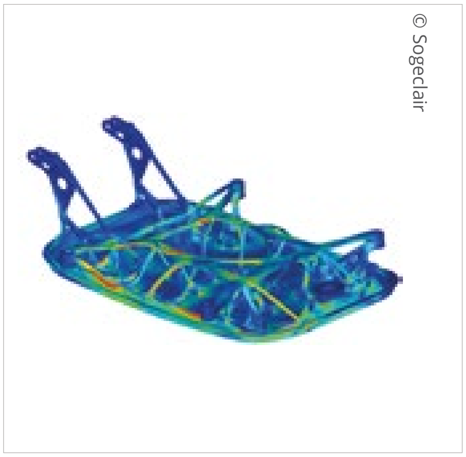
The example chosen in this study is an Ebay access door located at the nose fuselage which is used by operators for airplane inspection and maintenance. The Ebay access door turned out to be an interesting case study in many ways as the team faced some tricky engineering challenges: The door is too big to be feasible using DMLS (about 800 mm x 500 mm x 250 mm), it is made of AS7G06 aluminum which is not yet qualified in aeronautics using DMLS, and it possesses a very thin skin with very tight dimensional and geometrical tolerances.

Named EOLE after the Greek god of winds, the study describes the investment casting applied on an aircraft access door. The manufacturing process is based on investment casting from a 3D printed resin pattern. The EOLE study was led by SOGECLAIR aerospace and was done in collaboration with CTIF, Ventana, and voxeljet. voxeljet is a leading manufacturer of 3D printing systems for industrial applications that specializes in Powder-Binder-Jetting of plastic and sand.

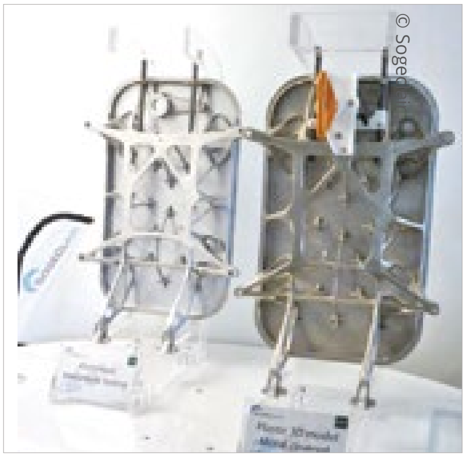
The major technical problem addressed in this project was casting an aircraft access door (class 2F part) in "one shot" and nearly net shape integrating a thin skin with organic stiffeners. With the aim to demonstrate that this is possible, the engineers involved in this study followed a systematic roadmap ensuring that all project requirements are met. The optimization study lasted about two months, involving eight topology optimization runs and four mechanical stress checks to achieve a satisfying design.

Among the many challenges the engineers faced in this project, two were of utmost importance. For casting, the skin thickness had to be set at the minimum feasible wall thickness. This is important because the outer surface of the door, considered a part of the fuselage, has to fulfill very tight dimensional and geometrical tolerances. Another tricky point on the access door was the connection between the skin and the stiffeners. In order to handle this, SOGECLAIR aerospace sketched some ideas which

Altair Inspire: Topology Optimization of the EOLE access door



Altair OptiStruct: FEM Analysis of the EOLE access door



Molding prototype (left) and 3D printed plastic model (right)

were used for a CAD model and the subsequent process simulation.

At the beginning of the study, topology optimization was used in the concept phase of the design process to optimize the material layout within a given design space, which was one of the main constraints. In a subsequent FE analysis, the engineers investigated the optimized design.

The ensuing casting simulation, in particular solid fraction, enabled the engineers to improve the design of the part and to minimize the presence of defects (shrinkage, cracks, etc.).

Filling and solidification simulations were run in order to accurately predict the position and size of certain defects such as incomplete filling areas or air bubbles. Then, feasibility samples were made for representative areas of the aircraft access door, especially the trickier ones. On the basis of these samples, SOGECLAIR aerospace finally manufactured the access door at real scale, and 3D printed it in PMMA resin using the binder jetting technology. According to this procedure, the resin was first soaked into barbotine and coated with a shell composed of several layers of sand to build the mold. Next, the mold was heated and the resin could be eliminated. Finally, the access door was casted and heat treated after removal from the mold. The result was an optimized access door, which aside from the correct dimension, fulfilled all the important requirements of this project.

Benefits of the Symbiosis of Simulation, 3D Printing and Casting

SOGECLAIR aerospace was very pleased with the results of the simulations they received with the Altair HyperWorks tools since the new design met all the objectives. While a lot still remains to be done on the certification and qualification side before such a solution will fly in a future aircraft, using Altair solutions enabled the engineers to effortlessly optimize the door design, in particular with regard to weight savings. Among the benefits the simulation offered, SOGECLAIR aerospace appreciated the vast amount of time the engineers saved when working with Altair software. As the simulation produced quick results, the engineers could use their precious time for engineering work in the development process. Altair solutions enabled SOGECLAIR aerospace to reduce development cycles and times, as it would have been a lot more time-consuming to achieve the same results without the help of simulation.

As soon as the certification of the parts manufactured with this method is set, SOGECLAIR aerospace will have an advanced simulation process in place to be applied to many more potential components to further optimize the overall aircraft characteristics.

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