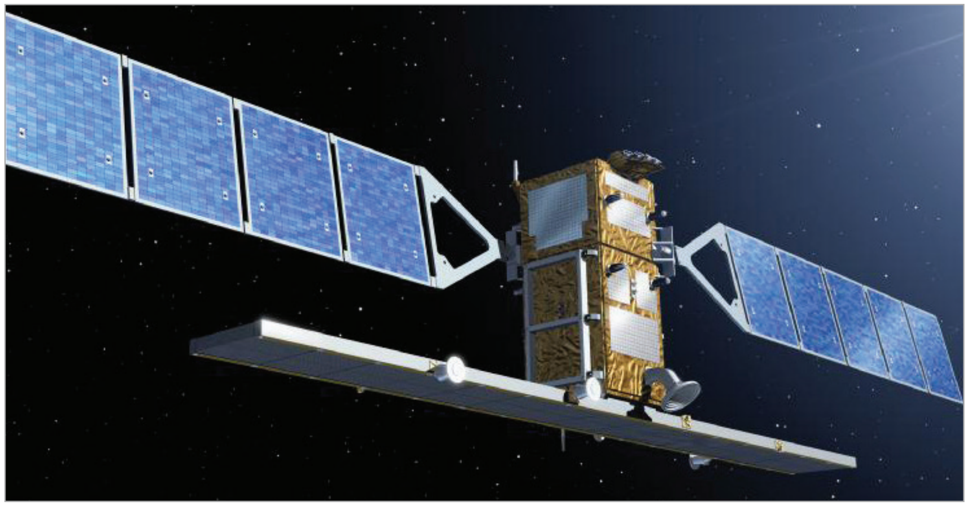
Maximizing the Potential of Additive Manufacturing with Design Optimization



Key Highlights

Industry
Aerospace

Challenge
Investigate the weight saving potential of additive manufacturing when combined with design optimization

Altair Solution
Performed topology optimization studies using a unique thermal-structural model of a satellite bracket

Benefits
- 48% mass reduction
- Thermal compliance reduced

The excitement around 3D printing or "additive manufacturing" (AM) has been growing exponentially with little sign of slowing down. The process of creating an object by layering material instead of subtracting it from a larger block is often cited as having the potential to revolutionize the manufacturing industry. As a result, companies from across a broad set of industries are attempting to find the potential impact that AM could have on their design and manufacturing processes. This is certainly true of the aerospace industry which has taken a leading role in the development, implementation and industrialization of AM.

Thales Alenia Space is a European aerospace manufacturer with presence in France, Italy, Spain, Belgium, UK, Germany and Poland. The company designs, integrates, tests, operates and delivers space systems for the defence, Earth observation, communication, navigation and security markets and have around 7,500 employees around the world.

During its own efforts to explore AM and its potential for space satellite development programs, Thales Alenia Space Spain wanted to conduct a research project to see how design optimization techniques could be used in conjunction with new manufacturing technology. After a detailed search into potential partners to conduct the research, Thales Alenia Space selected Altair ProductDesign due to Altair's expertise in both developing design optimization technologies and being able to effectively implement them in the aerospace industry.

Keywords: Topology optimization, additive manufacturing

Thales Alenia Space Success Story

"With optimization methodologies and Additive Manufacturing technologies in tandem, we have got unprecedented results in terms of mass saving and thermo-mechanical performances. In the future, we can easily imagine even more promising and inspiring results by thinking outside of the box."

Angel MARTINEZ MARTIN
Payload - Physical Design Manager
Thales Alenia Space

Thales Alenia Space chose a satellite's aluminium filter bracket as a test case for the study as it required a unique combination of both structural loads from the components that it supports, as well as thermal loads from the airflow through the filters and the temperature extremes of travelling to space.

The primary objective of the study was to use design optimization techniques to reduce the thermal compliance of the bracket, while also optimizing the component for weight and readying the final design for the additive manufacturing process.

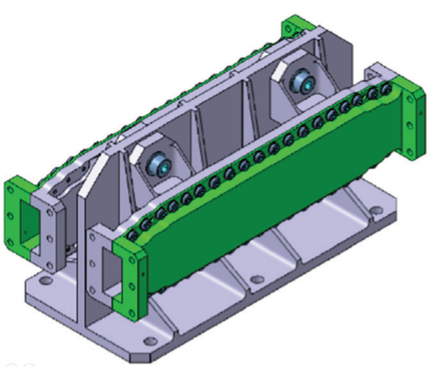
Creating a Thermal-Structural Model

Thales Alenia Space had two existing models of the bracket, one for thermal and one for structural analysis. Altair ProductDesign's first step was to convert these two models to a format that could be used with HyperWorks' OptiStruct structural analysis solver and at the same time, combine the two models together to create a unique thermal-structural model. By combining the models using HyperWorks' HyperMesh pre-processor, the effects of both sets of constraints could be explored in parallel; a vital step to find the optimal design that would satisfy all design requirements in a reasonable timescale.

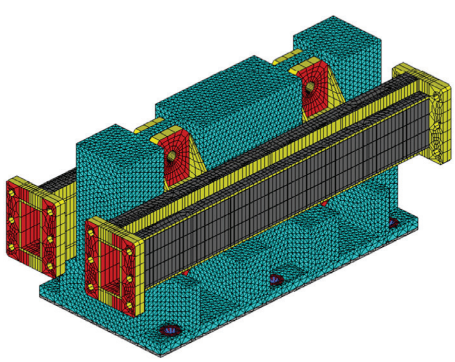
In order to ensure that this conversion process had not interfered with the predicted performance of the baseline design, the new model was analyzed and the results were compared. This comparison included modal, static, random and thermal loads supplied by Thales Alenia Space. The team found that there was an extremely close correlation between the performance of the original two models and the new combined version giving the team confidence in the model.

Optimizing for Additive Manufacturing

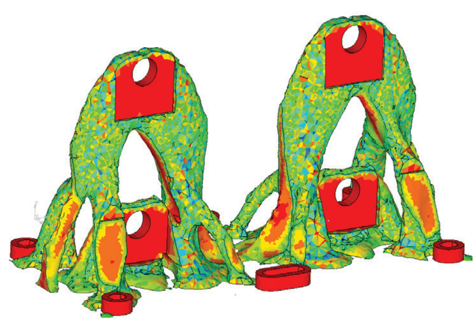
Satisfied that the new model was an accurate representation of the physical bracket, the Altair ProductDesign team could



Geometry of the original filter bracket design

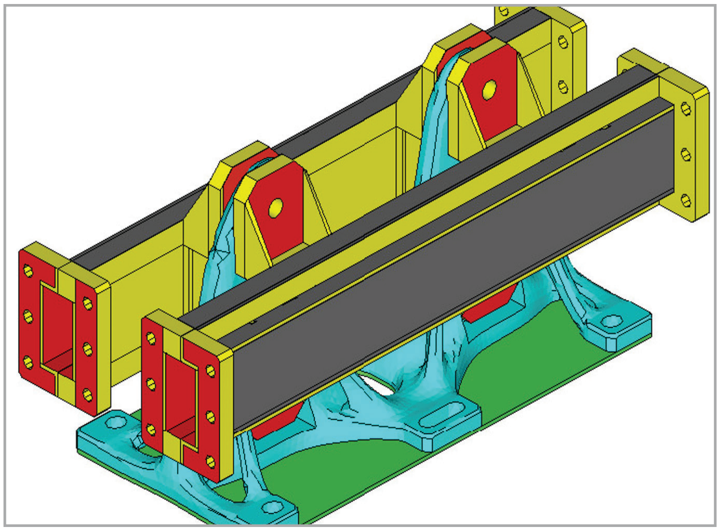


Defining the designable space of the thermal-structural model



The topology optimization result from OptiStruct

A summary of the optimization process performed by Altair ProductDesign



The topology results were interpreted by Altair ProductDesign into a manufacturable design

A rendered image of the final bracket design, optimized for additive manufacturing

move on to the design optimization stage. Using OptiStruct, the team set up the model and specified numerous constraints that the technology would have to adhere to in order to provide a satisfactory solution. For example, the bracket was given minimum and maximum values for temperature, stress and normal mode frequency, as well as specifying that the design would need symmetric planes, all while reducing thermal compliance and bringing weight down by at least 15 - 20%.

Using OptiStruct, the bracket was divided into sections of 'designable' (areas where OptiStruct could remove material), and 'non-designable' space (areas where material had to remain in place such as fixing points). This information is combined with the structural and thermal loading data from Thales Alenia Space along with the constraints data. Using topology optimization techniques, OptiStruct is able to suggest a new material efficient design that places material where it is required to meet the performance criteria while removing it from areas that do not positively affect the design. The suggested geometry from OptiStruct was then interpreted by Altair ProductDesign's engineers into a layout that was more suitable for the AM process and converted to a manufacturable CAD model.

Achieving a 48% Reduction in Mass

By combining the optimization technology with AM created a design that was significantly different from the original. If Thales Alenia Space were using more traditional manufacturing methods, the material efficient, organic looking geometry that OptiStruct suggested during the study would need to be heavily altered to create a component that could feasibly be manufactured in a cost efficient way. These necessary alterations often add weight back into the design, moving it away from the ideal weight and performance optimized solution. By combining topology optimization techniques with AM means that the new organic bracket could actually be produced with limited deviation from the optimized balanced design.

The new design for the bracket achieved a 48% reduction in mass when compared to the baseline, far beyond the 15 – 20% reduction that Thales Alenia Space was trying to achieve. In addition, the thermal compliance of the filter bracket was successfully reduced while maintaining the same structural performance of the original, much heavier design.

The study successfully demonstrated the potential impact that AM could have on Thales Alenia Space's products when combined with design optimization techniques. Unique, weight and performance efficient designs that are created during the topology optimization process can now be produced with minimal edits to the ideal shape meaning that the maximum amount of weight and material can be saved.

The collaboration between Altair and Thales Alenia Space has proved highly beneficial. The companies' combined team of engineers are now taking the study further and exploring the potential performance and weight improvements could be achieved with the introduction of lattice structures within the bracket design.

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About Altair

Altair is focused on the development and broad application of simulation technology to synthesize and optimize designs, processes and decisions for improved business performance. Privately held with more than 2,000 employees, Altair is headquartered in Troy, Michigan, USA and operates more than 45 offices throughout 22 countries. Today, Altair serves more than 5,000 corporate clients across broad industry segments.

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About Altair ProductDesign

Altair ProductDesign is a global, multi-disciplinary product development consultancy of more than 800 designers, engineers, scientists, and creative thinkers. As a wholly owned subsidiary of Altair Engineering Inc., the organization is best known for its market leadership in combining engineering expertise with computer aided engineering (CAE) technology to deliver innovation and automate processes. Altair ProductDesign utilizes proprietary simulation and optimization technologies (such as Altair HyperWorks) to help clients bring innovative, profitable products to market on a tighter, more efficient time-scale.

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About HyperWorks

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