Big Metal Printing – Realising the Potential of Additive Manufacturing

In 2011, the South African aviation manufacturing solutions provider Aerosud and the South African Council for Scientific and Industrial Research (CSIR) teamed up to launch a challenging 3D printing project, Aeroswift. Featuring a new generation of metal additive manufacturing (AM) system with a bigger build volume than ever before, the goal of the Aeroswift project was to unlock the potential provided by the growing AM industry, improve market competitiveness, and provide South Africa with a unique competitive edge in metal AM.

With the Aeroswift system, it is possible to print much bigger parts than ever before, and print them 10 times faster than any other commercially available laser melting machine, allowing access to an entirely new way of additive manufacturing. To showcase the manufacturing scope and the capabilities of the printer and its build volume for very large aerospace components, Aeroswift collaborated with Altair to develop a methodology for designing large additively manufactured products. An Unmanned Aerial Vehicle (UAV) frame was designed as a demonstration and subsequently printed on Aeroswift. To improve manufacturability while meeting all component requirements, the project engineers used Altair Inspire™ and its topology optimization capabilities in the design process.

Think big, print bigger – the Aeroswift system is able to increase part size & complexity

The Aeroswift printer is capable of building large-scale 3D printed metal aircraft components in many metals, including titanium alloy. This material is widely applied in industry due to its combination of high performance and low weight. The design of the UAV frame was commissioned in titanium alloy to demonstrate aerospace technology for the powder bed fusion process on a large system such as the Aeroswift printer.

Industry
Aerospace

Challenge
Building a large metal UAV frame on the Aeroswift printer, while improving buy-to-fly ratio* and reducing development time and waste.

Altair Solution
Using Altair Inspire™ enabled engineers from Altair and Aeroswift to design a large unmanned aerial vehicle (UAV) frame for manufacture on the Aeroswift machine.

Benefits
- Optimize the topology of a drone chassis
- Realize an unprecedented 3D printing size
- Reduce development time, material, and waste

* The ratio of weight of material purchased for a part to the weight of the flying part.

In the first step, the project team specified the requirements of the UAV aircraft and frame. The Aeroswift engineers were looking to not just print the largest metal frame ever, they also wanted to showcase how to reduce build time and decrease the number of parts per assembly. By reducing waste, they would also achieve a better buy-to-fly ratio.

The design process included UAV flight requirement specifications, electronic component and drivetrain selection, mechanical design employing topology optimization techniques, aesthetic improvements and manufacturability improvements.

Satisfying all requirements – bigger, better, and faster to produce

There was a long list of demanding manufacturing requirements the engineers had to consider in their design. In addition to frame design specifications such as the build volume of the printer and a required symmetrical motor placement of the UAV, the team also had to include aesthetic aspects in the design process. They had to achieve flight times of minimum 15 minutes at a thrust to weight ratio of at least 2:5:1, while the frame stiffness also had to be maximized. It was also mandatory that it be possible for the final design to be printed using a powder bed fusion AM process with Titanium alloy Ti6Al4V.

Altair Inspire ensures printability and a better design

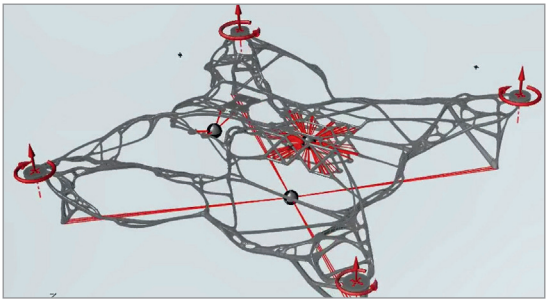
The Aeroswift project engineers needed to know how the material could be distributed optimally in a predefined design space. Due to specific structural and weight requirements, and the fact that free-form designs aren't manufacturable using traditional methods, the team decided to apply topology optimization using Altair Inspire to optimize the frame so that it could be additively manufactured. The team collaborated to develop a multi-step process to generate an optimal design in a reasonable amount of time.

"We are very pleased with the results – using Altair Inspire we could set up a process that helped us to achieve a topologically optimized UAV frame showing even better results than the benchmark. Without Altair and their tools, we would not have been able to leverage the full potential of additive manufacturing in the Aerospace Industry."

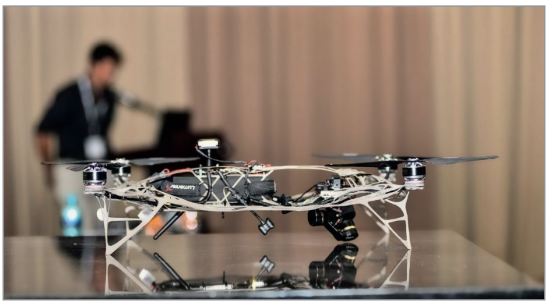
Jacobus Prinsloo, Operations Manager at Aeroswift

First, a basic concept design was created using primitive volumes with as little detail as possible, which was then imported into Altair Inspire to run a baseline finite element analysis. Subsequent optimizations and performance checks ensured that the generated topology facilitated all the required connections between the components of the assembly.

The engineers phased their topology optimization approach by opting to run a first step optimization with increased branch sizes, to reduce the computational complexity in finding primary load paths. This process produced the thickness boundaries which encompassed the optimal design. The Aeroswift team could then recreate the resulting geometry and run a second stage topology optimization with thinner branches. The process showed the transformation from a very basic design to a topology optimized design suitable for metal AM. The project engineers were pleased with the results since all the UAV frame requirements were met, including frame weight, thrust to weight ratio and flight time all while maintaining frame stiffness. The final design showed even better results than initially expected. "We are very pleased with the results – using Altair Inspire we could set up a process that helped us to achieve a topologically optimized UAV frame showing even better results than the benchmark," said Jacobus Prinsloo, Operations Manager at Aeroswift. "Without Altair and their tools, we would not have been able to leverage the full potential of additive manufacturing in the Aerospace Industry."



Altair Inspire model of topologically optimized UAV frame



Instrumented UAV ready to fly

Presenting the optimized design

3D printed optimized UAV frame

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