

Forward AM – Giving Wings to Aerospace

Ultrasint® PA6 FR



Ultrafuse® PPSU

In the aerospace industry, every single gram counts.

As a matter of fact, the #1 way for aerospace companies to save money is reducing weight. Why? It's simple: The lower the weight, the lower the fuel consumption and emissions. Vice versa: The higher an aircraft's payload is, fuel consumption, emissions, speed, and ultimately safety will all suffer.

Project Breakdown

Industry	Aerospace
Product	Airflow Pipe
Why Forward AM?	End-to-end solution combined with broad materials spectrum
Forward AM Materials used	Ultrasim® Ultrasint® PA6 FR Ultrafuse® PPSU
The result	Pressure-loss optimized air duct for the aerospace industry
Solution suitable for industry sectors	Aerospace, Electronics, Public Transportation

Ready for Takeoff – with Additive Manufacturing

Additive Manufacturing opens up a myriad of new application opportunities, especially for the aerospace industry – lightweight construction, major functional enhancements, and hitherto undreamt-of combinations of specialized materials. In short, Additive Manufacturing offers a huge competitive edge.

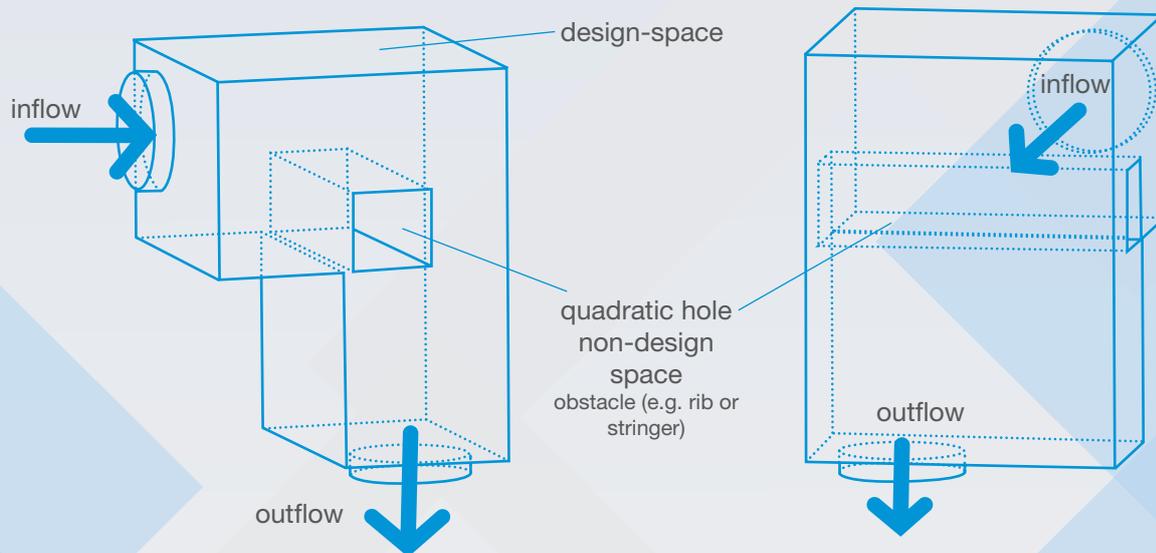
No wonder that the aerospace sector is a prime mover in Additive Manufacturing: Leading manufacturers are relying on AM to minimize supply chain bottlenecks, cut warehousing requirements, and reduce material wastage from traditional manufacturing processes. In AM, material is added rather than removed – and this process also reduces waste, a key sustainability aspect in this day and age.

Applying AM professionally in the aerospace industry can also result in lower fuel consumption and less carbon dioxide emissions, competition-beating factors that all players seek.

The Challenge We Faced

Constructing an aircraft means working out how to control internal airflow. Fresh air is vital for passengers and crew, while precise airflow control is crucial for controlling cabin pressurization and temperature.

Guiding air efficiently around corners and minimizing pressure loss while respecting a predefined design space (see figure below) is already a challenge itself. Perfect geometry is required to ensure ideal functionality – and when air ducts are applied in aircraft design it gets even more complicated, as space constraints and curved cabin walls need to be integrated. Plus, an air duct needs to be heat-resistant and flame-retardant. Of course, we also need to remember that weight is a major limitation factor on aerospace component design.



3D description of the airflow challenge.

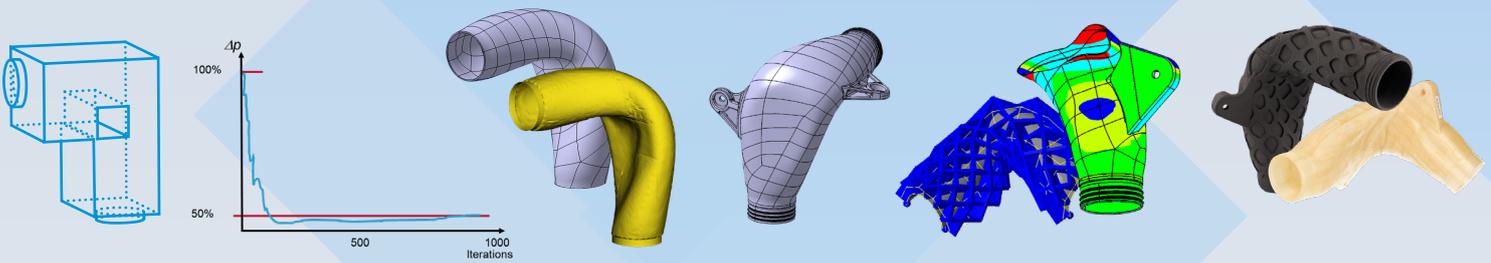
Virtual to Real – A Lightweight, Better-performing Aerospace Part

At Forward AM we took up the challenge to develop an air duct optimized for the aerospace industry. In fact, we redesigned the entire component geometry.

To understand the challenge fully, we first ran an exhaustive Ultrasim® simulation under differentiated operating parameters to replace laborious and costly material testing. We then applied our bespoke Virtual Engineering software to rethink the part from zero. This approach enabled us to identify a radically new design solution based on AM technology and materials.

By applying the following process steps we developed a unique optimal alternative to traditional air ducts used in aircraft:

The process flow shows the steps from initial part to the optimized part.



In working out the design we specifically engineered it for printing via both Fused Filament Fabrication (FFF) and Laser Sintering (LS). The improved air duct design was then printed using two of our flame-retardant materials: Ultrasint® PA6 FR, and Ultrafuse® PPSU. (PPSU is still under development)

Ultrasint® PA6 FR is an advanced engineering polymer powder containing a halogen free flame-retardant (FR) additive. Combining excellent mechanical and thermal performance with flammability requirements, it's a perfect choice for aerospace as well as electronics and public transport applications. Ultrasint® PA6 FR successfully passed Aerospace Vertical Flammability (12 and 60 s), Smoke Density and Smoke Toxicity (FST) tests.

Material Properties Ultrasint® PA6 FR

Tensile Strength (MPa)	41 (X), 27 (Z)
Young's Modulus (MPa)	2450 (X), 2450 (Z)
Elongation at Break (%)	2.6 (X), 1.2 (Z)
Charpy Impact unnotched (kJ/m²)	7 (X), 4 (Z)
HDT B (0.45 MPa, dry) (°C)	207

Ultrafuse® PPSU is one of the most flexible filaments on the market. It can be printed on many open platforms and works for both Bowden and direct-drive extruders. Its excellent inherent flame-retardant properties make it an outstandingly suitable material for aerospace component manufacturing applications.

Material Properties: Ultrafuse® PPSU

Tensile Notched Impact Strength (MPa)	51.6 (ZX), 65.10 (XY)
Flexural Modulus (MPa)	1999 (ZX), 2152 (XY)
Elongation at Break (%)	3.2 % (ZX), 6.5 % (XY)
Impact Strength Izod notched (kJ/m²)	5.5 (ZX), 12.0 (XY)
Impact Strength Izod unnotched (kJ/m²)	14.3 (ZX), 119.0 (XY)
HDT at 0.45 MPa (°C)	218



Printing Guidelines for FFF

Nozzle Temperature	390-410 °C
Build Chamber Temperature	170-210 °C
Bed Temperature	220 °C
Bed Material	BASF fiber-reinforced build sheet
Nozzle Diameter	≥ 0.4 mm
Print Speed	25-50 mm/s

Result: Lightweight Aerospace Air Duct with Optimal Functionality

Forward AM delivers a solution that adds real value for aerospace industry customers – by combining the vast potential of Additive Manufacturing, Ultrasim®-based Virtual Engineering, and our highly advanced engineering-grade materials.

The redesigned air duct displays the best-possible surface contour for minimum pressure loss. It can easily be adapted to any other specific construction parameters, directionality or number of nozzles, while achieving very significant space and weight savings.

Building on extensive experience in aerospace component manufacturing, we know that part and process optimization for Additive Manufacturing is crucial for the industrial AM products of the future. At Forward AM we provide our customers with an end-to-end virtual workflow, deep material expertise, and industry-leading AM process knowhow.

**How can we support
your Additive Manufacturing
project?**

Simply get in touch!

**www.forward-am.com
sales@basf-3dps.com
Phone: +49 6221 67417 900**