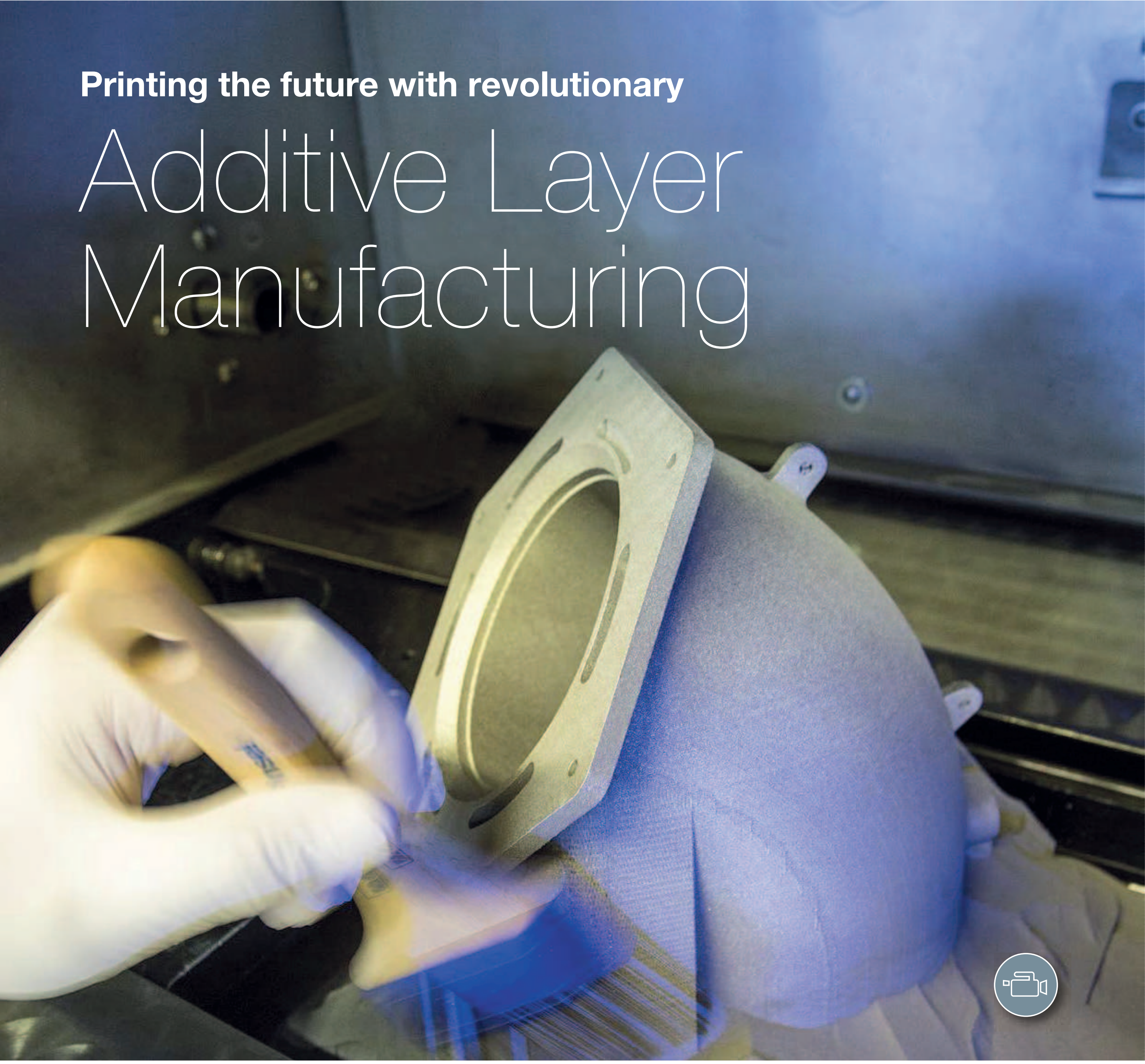
Printing the future with revolutionary

Additive Layer Manufacturing



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An innovative technology shaping the future of aviation

Across the Airbus Group, numerous projects are speeding-up the development of Additive Layer Manufacturing (ALM), also known as 3D-printing, to produce prototypes and components, potentially delivering more cost-effective and lighter aircraft parts. 3D-printing technology can also improve production efficiency while avoiding shortages of components on assembly lines.

The first metal parts produced with this method (figures 1 & 2) are beginning to appear on a range of Airbus aircraft - from the latest A350 to the A300/A310 Family aircraft.

A quick overview about the 3D-printing technique indicates:

- Lighter parts due to structural, biomimetic redesign and the choice of materials used
- Shorter lead times – as production moulds and tooling are no longer needed due to the part's regeneration in a virtual 3D environment
- Less material used due to an additive production process (rather than subtractive)
- A significant reduction in the manufacturing process' environmental footprint

The technology process

Instead of producing a part by milling a solid block of material, Additive Layer Manufacturing (ALM) "grows" parts and products using base materials such as aluminium, titanium, stainless steel and plastics.

Adding thin layers of material in incremental stages, generates parts, enabling complex components to be produced directly from Computer-Aided Design (CAD) information sent to the 3D-printer.
At the same time as the material layers are built-up, so is a layer of supporting material for the following layers (see building principles overleaf).

"This game-changing technology decreases the total energy used in production by up to 90 percent compared with traditional methods".

Figure 1:
Belt panel on an A310
cabin crew seat

Materials of interest

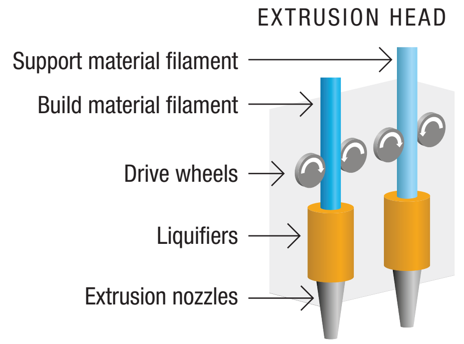
The range of materials used encompasses high performance plastics such as Polyetherimide (PEI), PEAK/PEK (polymer), FullCure (acrylic-based photopolymer), Polyamide, Accura and Greystone, to high performance metallic alloys including Titanium (Ti), Aluminium (Al), Maraging steel as well as graded materials.
In industries outside aviation, materials used to make free-form shapes can include concrete and glass, and even edible ingredients such as chocolate.

For the A350 aircraft, Airbus has produced and incorporated a variety of 3D-printed plastic and metal brackets, whose material and structural properties have been tested and duly certified.

Figure 2:
The flight crew rest compartment bracket installed on A350

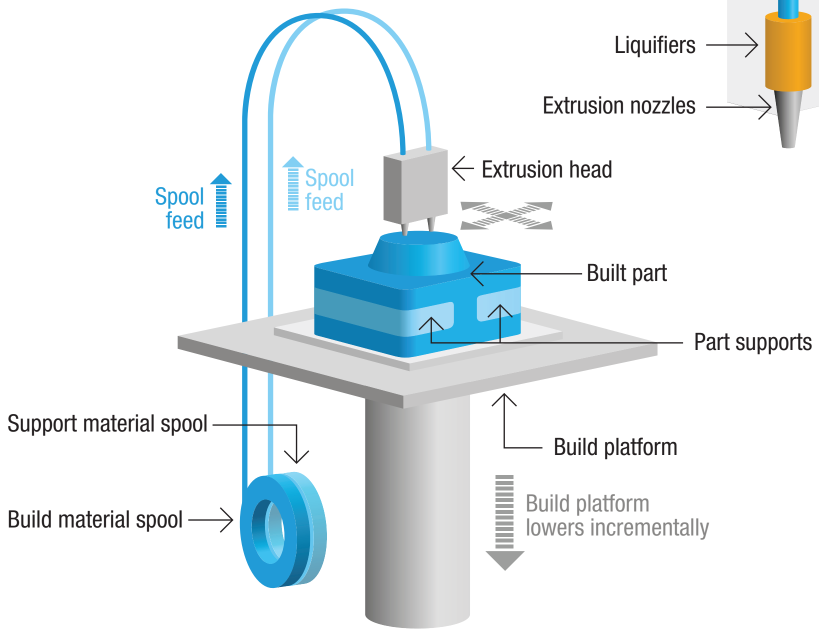
Building principles of 3D-printing

The 3D-printing currently being used and developed by Airbus uses variations of two different building principles:
Fused Deposition Modelling and **Laser Beam Melting***



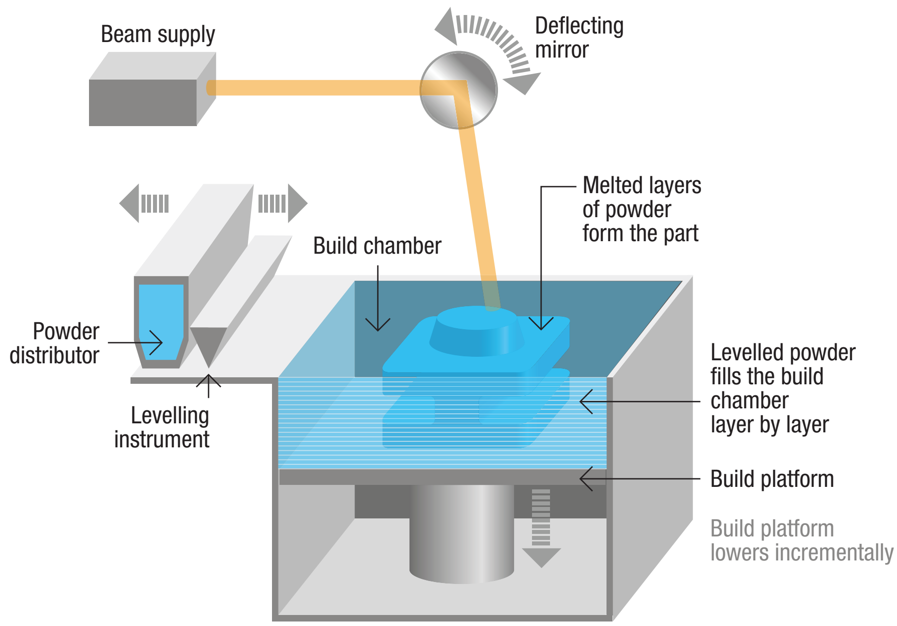
Fused Deposition Modelling (FDM)

FDM is used to generate plastic parts. 3D objects are built by printing fine layers of liquefied building material filament onto a building platform that fuse with the layer beneath.
At the same time a support material is printed in order to allow printing of the building material further up the object of features that hang from the main structure.
The build platform moves down incrementally to print the following layer. Once finished the printed support parts are removed.



Laser Beam (Powder Bed) Melting

Airbus uses variations of powder bed melting for metallic materials such as titanium alloys.
3D objects are built by having a fine layer of powdered building material levelled over the building platform, which is then exposed to a (laser or electron) beam which welds part of the powder, melting and joining it to the preceding layer to become the final 'printed' 3D part.
The powder that is not melted remains in place to become a support for features further up the object that hang from the main structure.
The build platform moves down incrementally to 'print' the following layer. Once finished the remaining unmelted powder is removed and recycled.



*Laser Beam Melting

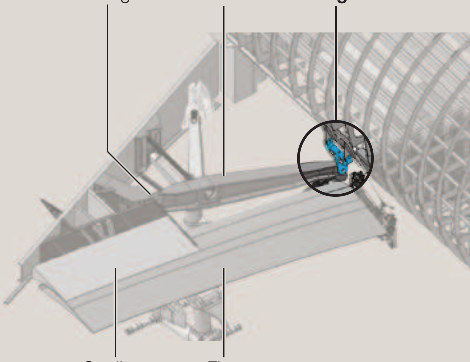
Laser Beam Melting (LBM) is an additive manufacturing process that uses 3D CAD data as a digital information source and energy in the form of a high powered laser beam (usually an ytterbium fiber laser) to create three-dimensional metal parts by fusing fine metallic powders together. The industry standard term, chosen by the ASTM F42 standards committee, is laser sintering, although this is acknowledged as a misnomer because the process fully melts the metal into a solid homogeneous mass. The process is also sometimes referred to by the trade names DMLS or LaserCusing. A similar process is Electron Beam Melting (EBM), which as the name suggests, uses an electron beam as the energy source.

New opportunities for optimisation driven design

The flexibility of 3D-printing widens the potential of what can be formed, building parts in exactly the right shape and proportion to take stress only where it is needed.

EXAMPLE

Optimisation of a swing link

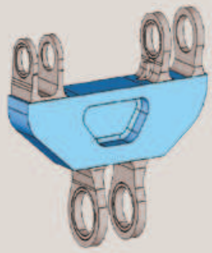


Step 1 - Analyse the baseline design

to evaluate exactly what functions the part has to perform such as volume needed, stiffness constraints.

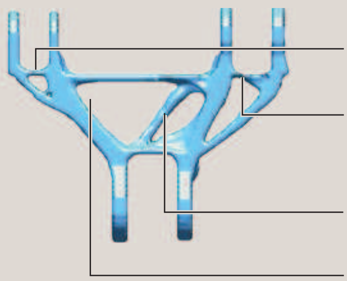
Step 2 - Design space allocation

The lugs are considered as optimally designed for their function and as such are not an important part of the re-design.



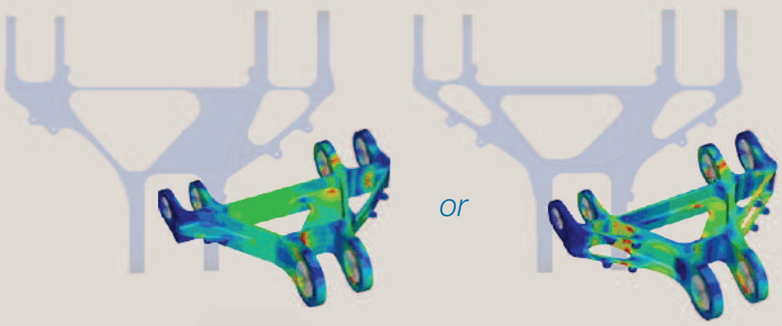
Step 3 - Topology optimisation

Revealing the load paths and formulate structural principles.



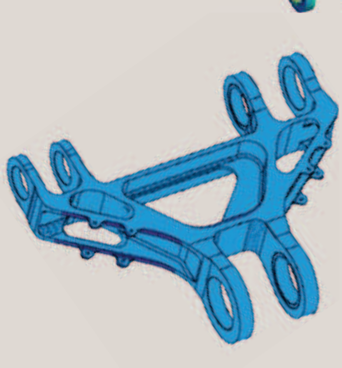
Step 4 - Rapid concept design

Interpretation following the topological load paths then validation of the tension carried for each interpretation.



Step 5 - Detailed sizing

Optimisation of the new design proposal, structurally perfecting each form.



Result:

The final swing link design carried out by the Airbus Optimisation Centre weighs less to fulfil exactly the same task.

Biomimetic structure design, or... what nature teaches us

(see biomimicry article in FAST 49)

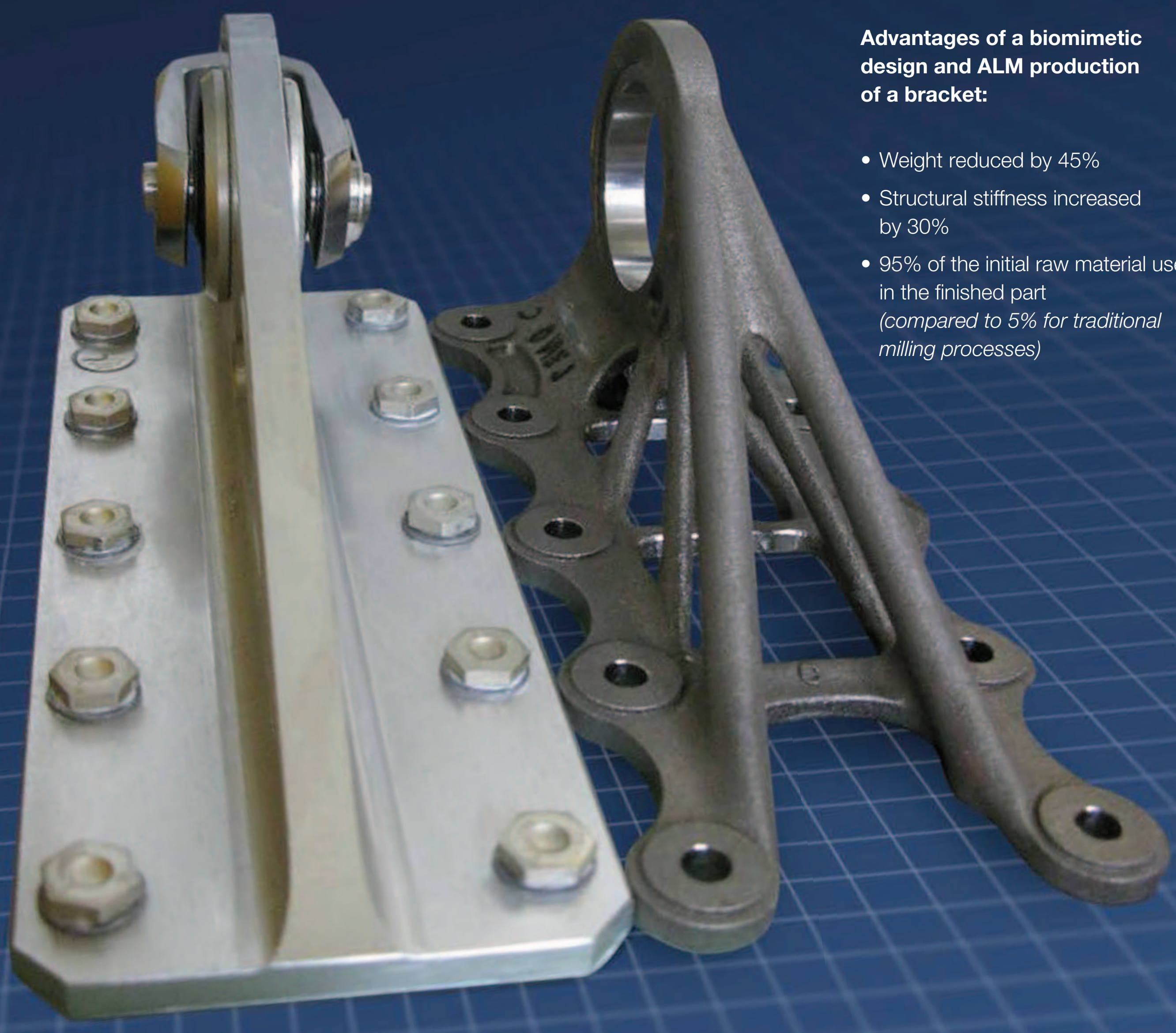
Biomimicry is the imitation of models, systems, and elements of nature for the purpose of solving complex human problems. Additive Layer Manufacturing represents a paradigm shift in structure design because it allows the reproduction of complex forms that nature has taken millions of years to evolve to the optimal structure for a particular task.

The lightness that biomimicry permits - for at least equal structural stiffness - will directly result in less fuel burn, and as a consequence reduce airlines' operational costs and environmental footprint.

"We are at the point of a step-change in weight reduction and efficiency - producing aircraft parts which weigh 30 to 55 percent less, while reducing raw material used by 90 percent is the next industrial revolution".

Advantages of a biomimetic design and ALM production of a bracket:

- Weight reduced by 45%
- Structural stiffness increased by 30%
- 95% of the initial raw material used in the finished part *(compared to 5% for traditional milling processes)*



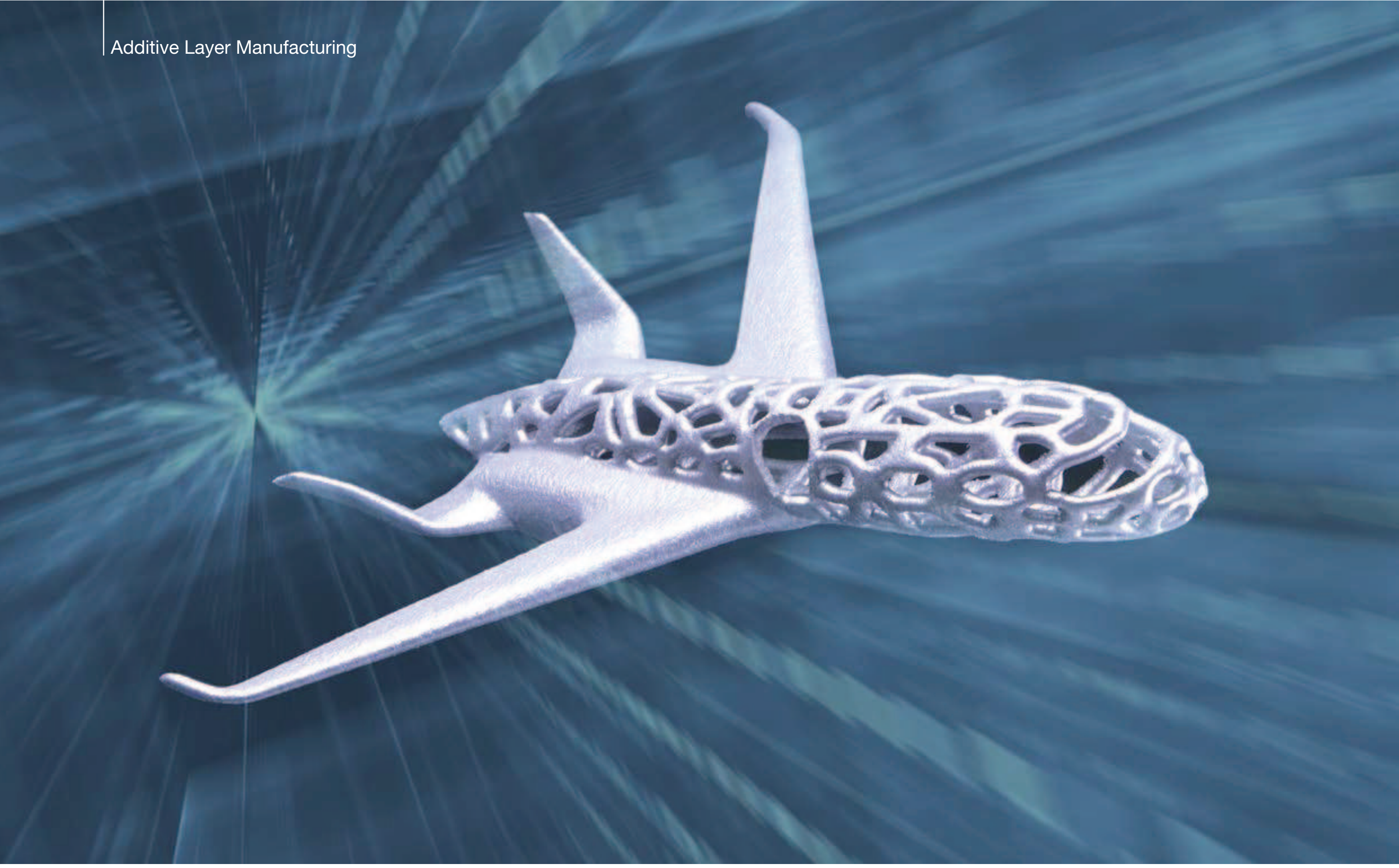
Future by Airbus
cabin concept design

The future of biomimetic structure design

As illustrated by the biomimetic bracket, this new approach could be very useful in the design of customized parts in all areas of the cabin.

In time, complete airframes such as those imagined in the Future by Airbus' concept design, could be built mimicking the bone structure of birds which is both light and strong, carrying tension only where necessary.

By using biomimetic structures, the fuselage will have the strength it needs, where it needs it, making it possible to add features like oversized doors for easier boarding and panoramic windows.



Benefits of 3D-printing

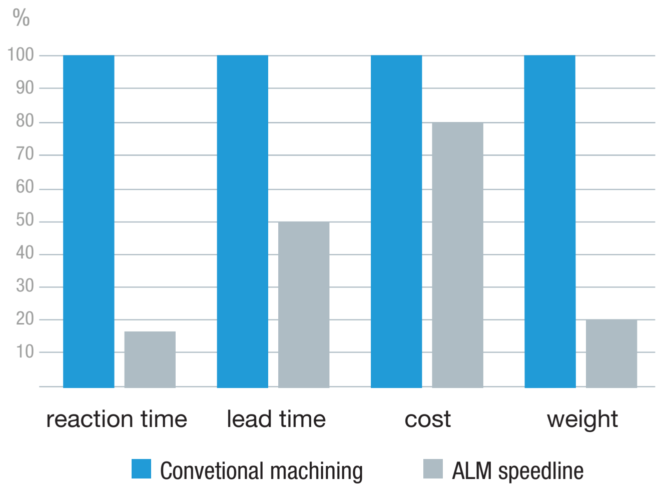
3D-printing makes it simpler to produce very complex shapes, therefore, parts designed for and manufactured by ALM can have a natural and topologically optimised shape, which would be impossible if producing them from a solid block of material. Such parts are significantly lighter, faster to produce and ultimately much less expensive than conventional ones.

- Weight reduction - up to 50%
- Non-recurring cost saving (no tooling) - up to 90%
- Green technology (less energy) - up to 90%
- Improved lead time delivery - up to 75%
- Functional integration (e.g. of cooling channels)
- Simplifying assemblies due to part reduction
- Shortened R&D time (one-shot testing)
- Lightweight design through biomimetic structures
- Customized products
- Highly complex geometries (e.g. hydraulic manifolds)
- Tool, jig and ground support equipment manufacture
- Ensure production for spare part shortages
- Replicate parts that are out of production
- Enabler for next generation airframe design

ALM in the assembly line: print and go

Beyond its use to build parts that are already flying, Airbus Group is looking into using ALM technology to avoid shortages during the manufacturing process.

Conventional machining compared with the ALM speedline



3D-printing spares

Airbus is actively working towards using 3D printing technology as a spare parts solution due to the ease and cost effectiveness of producing out-of-production spare parts on-demand. This year, the first "printed" component – a small plastic crew seat panel – flew on an A310 operated by Canada's Air Transat. The lead time for such a part can be as little as one day, if the component is based on an existing design, while redesigned parts can be produced in less than two weeks.

Eco-efficient manufacturing - minimising the environmental footprint

ALM represents a new alternative to production processes such as milling, melting, casting and precision forging, producing only 5% waste material instead of up to 95% from current machining. The high flexibility in part design, production and testing offers considerable benefits to the customer in terms of cost and time.

The ramp-up phase

3D-printing is being progressively integrated into new design and manufacturing in the supply chain, starting small but steadfast in the fields of prototyping, tooling and on-demand production. Airbus has teamed up with major 3D-printing stakeholders to cover the process end-to-end, ensuring the production of certifiable structural components based on consistent tested material properties and meeting the requirements of a rigorous certification process.

Airbus Concept Plane

Future candidates for 3D-printing

Airbus is looking at the entire aircraft: cabin, system and structural components, as well as manufacturing and tooling. It will also play a major role in the production of spare parts.

In the coming years 3D-printing could potentially account for thousands of aircraft and ground support equipment components.

Each day we are stepping closer to the "Future by Airbus".

CONCLUSION

Additive Layer Manufacturing (ALM), also called 3D-printing, is an innovative technology shaping the future of aircraft component manufacturing. Harnessing CAD software, ALM is being used to construct 3D objects by melting and building up a solid product layer by layer.

Components produced provide significant advantages in terms of reduced weight and production lead time compared to traditional manufacturing methods, while reducing waste and, as a consequence, the environmental impact.

3D-printed airworthiness certified parts are already appearing on Airbus aircraft, and the list of parts proposed as candidates for 3D-printing is constantly growing.

This new manufacturing method is not only being considered for aircraft parts but also for the production of jigs, tools, Ground Support Equipment as well as spare parts.

As technology develops we may one day see the first entire aircraft built using ALM.