



# Topology optimization and DMP combine to meet GE Aircraft engine bracket challenge

Re-design by Frustum Inc. Technology and 3D Systems' Direct Metal Printing expertise cuts weight of aircraft bracket by 70% while meeting functional requirements



The conundrum of balancing the design of a part with the constraints of manufacturing has existed since the Industrial revolution. Conventional manufacturing techniques have limited capabilities to realize complex geometries or organically shaped components on a cost effective way. This results often in components where functionality and performance are a trade-off.

Now that 3D printing, especially Direct Metal Printing (DMP), has become a viable manufacturing alternative, the constraints imposed by traditional manufacturing have been very much removed. In response to this, software tools for Multi-Disciplinary Design Optimization are now emerging to deliver a convergence point: Topology optimization software is now capable of generating the most efficient designs for one-step manufacturing on the latest generation of DMP systems. Basically, what you model is what you manufacture.

This confluence of technologies was demonstrated recently in a project undertaken by software company Frustum and 3D Systems' On-Demand Parts service, Quickparts. The project was a publicized challenge by GE Aircraft to reduce the weight of an aircraft bracket while maintaining the strength needed to meet all of its functional requirements, primarily supporting the weight of the cowling while the engine is in service.

## The critical nature of weight

Since the beginning of motorized travel on land, air or sea, engineers have strived to balance the demands of weight vs. strength. The balancing act has become more critical in recent years with greater worldwide manufacturing competition, stricter energy conservation measures, escalating cost and delivery time pressures.

Weight is especially crucial for modern aircraft. Although a Boeing 737 weighs approximately 65 metric tons, eliminating only one pound in weight can generate savings of hundreds of thousands of dollars each year for airline companies. Spread that number out to include all aircraft worldwide and the savings are upwards of \$10 million according to a GE Aircraft white paper.

## Optimizing the design

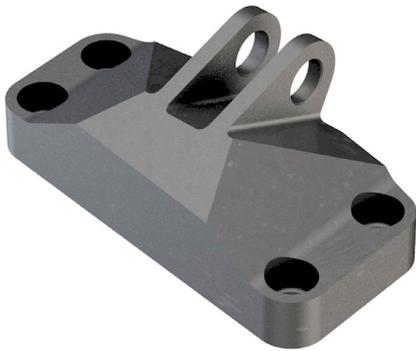
For the GE Aircraft challenge, Frustum's software for topology optimization provided the first steps in tackling critical weight vs. strength issues.

Topology optimization determines the most-efficient material layout to meet the exact performance requirements of a part. It takes into consideration the given space allowed, load conditions of the part and maximum stresses allowed in the material.

Frustum's software automatically generates optimized geometries from existing CAD files. It creates material between the design features to make optimally stiff and lightweight structures. Smooth and blended surfaces reduce weight and minimize stress concentrations.

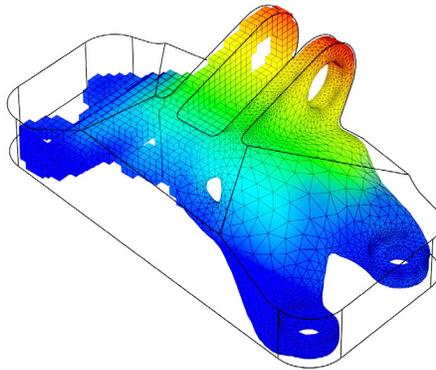
"Based on an existing conventional part design, our software automatically produces optimized geometry for Additive Manufacturing, without needing to do any remodeling," says Jesse Blankenship, CEO of Frustum.





**GE's original design**

The original design of the bracket used in the GE Aircraft challenge. The re-designed bracket was required to fit within this volume and meet load requirements while reducing the overall weight of the part.



**Cloudmesh optimization**

The topology optimized part design generated by Frustum's software.



**Final DMP part**

The GE Aircraft engine bracket redesigned by Frustum and manufactured by Quickparts on a 3D Systems ProX DMP 320 printer. The new part passed all the load condition requirements specified by the GE challenge and stayed within the same footprint while reducing weight by a staggering 70 percent.

Unlike parts manufactured by traditional CNC or casting methods, the complexity of the model generated by topology optimization is of no concern, as DMP handles extremely complex models as easily as simplistic ones. Complexity comes at no cost.

**Providing the 3D printing expertise**

Once the initial design was generated, 3D Systems' expertise came into play.

3D Systems' On-Demand Parts Manufacturing service, Quickparts is the world's leading provider of unique, custom-designed parts, offering instant online quoting, expertise in 3D design and printing, and proven manufacturing services support. This worldwide service is especially well-versed in the more complicated aspects of Direct Metal Printing.

"Direct Metal Printing is much more complex than plastics printing," says Jonathan Cornelus, business development manager for 3D Systems Quickparts. "We help our customers to develop parts suitable for DMP, with minimized risks for part distortions or build crashes. We print components using optimized parameters based on our long-term experience in printing parts for customers."

**Manufacturing a better part**

In the case of the GE aircraft bracket, Frustum's software took the original CAD file and performed the topology optimization in one step, delivering an STL file.

3D Systems provided manufacturing advice on the process, material specifications, the best build orientation to deliver optimal part properties, achievable tolerances, and identified potential risk for deformations. The part was built on a 3D Systems ProX™ DMP 320 system.

The ProX DMP 320, introduced in early January 2016, offered several advantages for optimizing the weight vs. strength for the aircraft bracket.

Preset build parameters, developed by 3D Systems based on the outcome of nearly half-a-million builds, provide predictable and repeatable print quality for almost any geometry.

A totally new architecture simplifies set-up and delivers the versatility to produce all types of part geometries in titanium, stainless steel or nickel super alloy. Titanium was chosen for the GE aircraft bracket, based on its superior strength even when material is thinly applied to lower a part's weight.





*“When the best of both worlds in design and manufacturing align, extraordinary things happen within the coveted benefits of better, faster and cheaper,” says Cornelus.*

Exchangeable manufacturing modules for the ProX DMP 320 system reduce downtime when moving among different part materials, and a controlled vacuum build chamber ensures that every part is printed with proven material properties, density and chemical purity. The small portion of non-printed material can be completely recycled, saving money and providing environmental benefits.

**An eye opener**

The completed part, designed by Frustum and DMP-manufactured by 3D Systems, passed all the load condition requirements specified by the GE challenge and stayed within the same footprint while reducing weight by a staggering 70 percent.

“This is the kind of project that should be a real eye-opener for automotive and aerospace companies, where reducing weight while providing the same or improved functionality is the lifeblood of their design, engineering and manufacturing operations,” says Cornelus.

Beyond the design and performance of the part itself, Cornelus points out that topology optimization teamed with DMP can often consolidate multi-part assemblies into a stronger single part, eliminating fasteners and connectors that are often the cause of failures.

Finally, there is the coveted advantage of speed. Production-grade parts in tough materials such as stainless steel, titanium and nickel super alloy can be turned around by 3D Systems in as little as two weeks to satisfy the ever-quickening pace in myriad industries.

