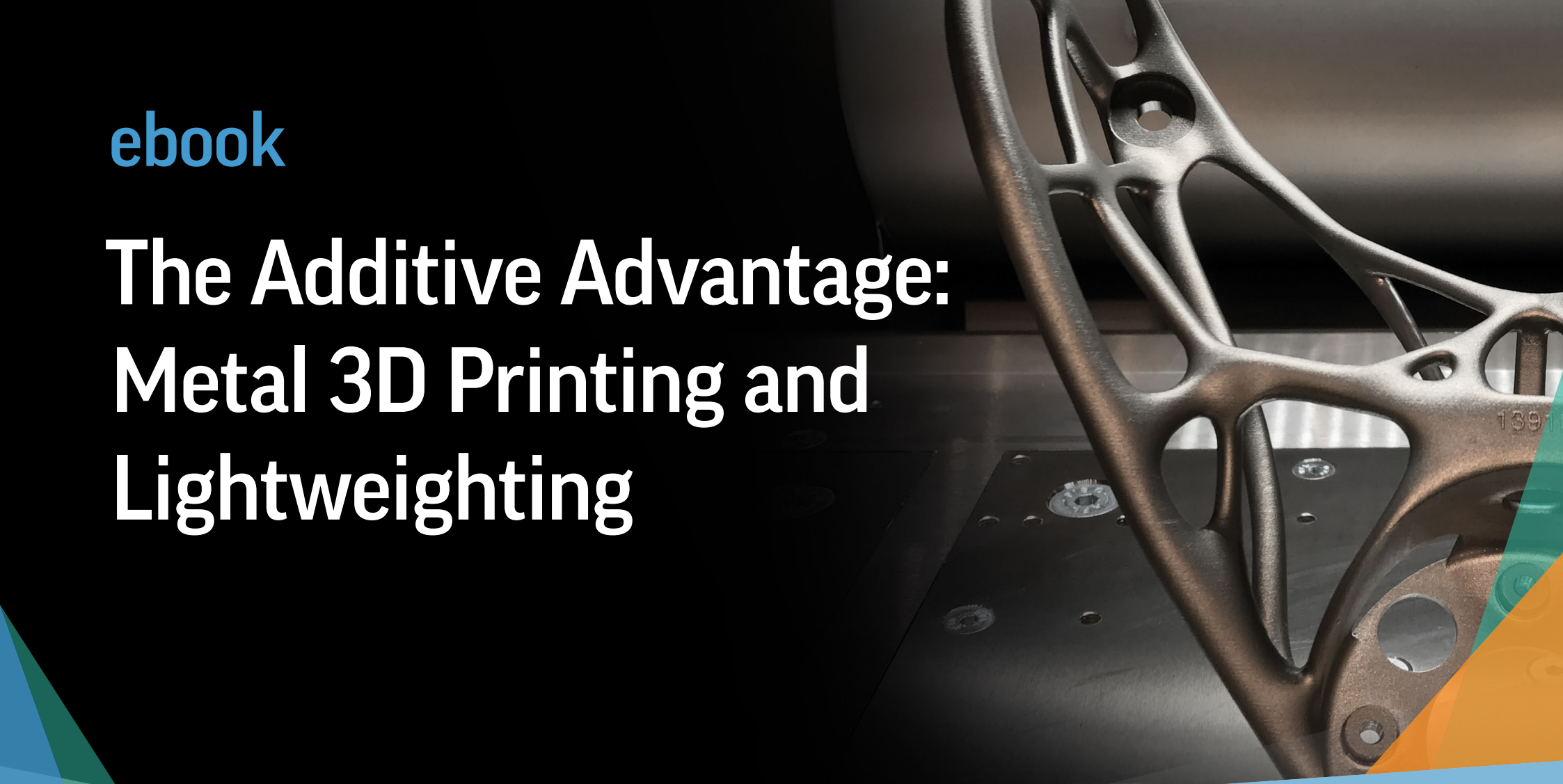
ebook

The Additive Advantage: Metal 3D Printing and Lightweighting



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Contents

The pressure is on to get weight out

Engineers everywhere have to deliver... and deliver again, consistent improvement in parts and systems is a standard part of the job.

Driving up fuel efficiency, while cutting operating costs and emissions: in aviation, aerospace, automotive or motorsports – its the same challenge. And the answer is – lighter parts.

But swapping heavy for light is just the first step in the marathon – to put real distance between you and the competition, you need innovation. A tried and tested, non-standard tool can give you the edge: metal 3D printing - also known as direct metal laser sintering (DMLS), direct metal printing (DMP) and metal additive manufacturing - is a game-changer.

This ebook is for curious and competitive businesses, engineers, and designers who want to unlock the advantages metal 3D printing has to offer. We will start with some basic concepts and definitions, provide actual and theoretical application examples, and share some design and manufacturing strategies you can incorporate to optimize your outcomes.

Less material with improved performance

So what is it that makes metal additive manufacturing such a special technology, compared to traditional, formative and subtractive methods? And why does it help reduce weight?

The keyword here is “additive” : layer by layer, parts are built upwards, adding material rather than removing it.

Additive versus other

In direct metal laser sintering, an high-powered laser, reading from a cross section on a CAD file, micro-welds particles of fine metal powder to form the exact shape. This enables several shifts in thinking and capability.

Design-driven manufacturing

The geometry you create on screen can be realized without complex cost adjustments or changes to the manufacturing approach. Organic shapes; tubular, hollow designs; and dense, lattice-filled structures are achievable at a flat rate.

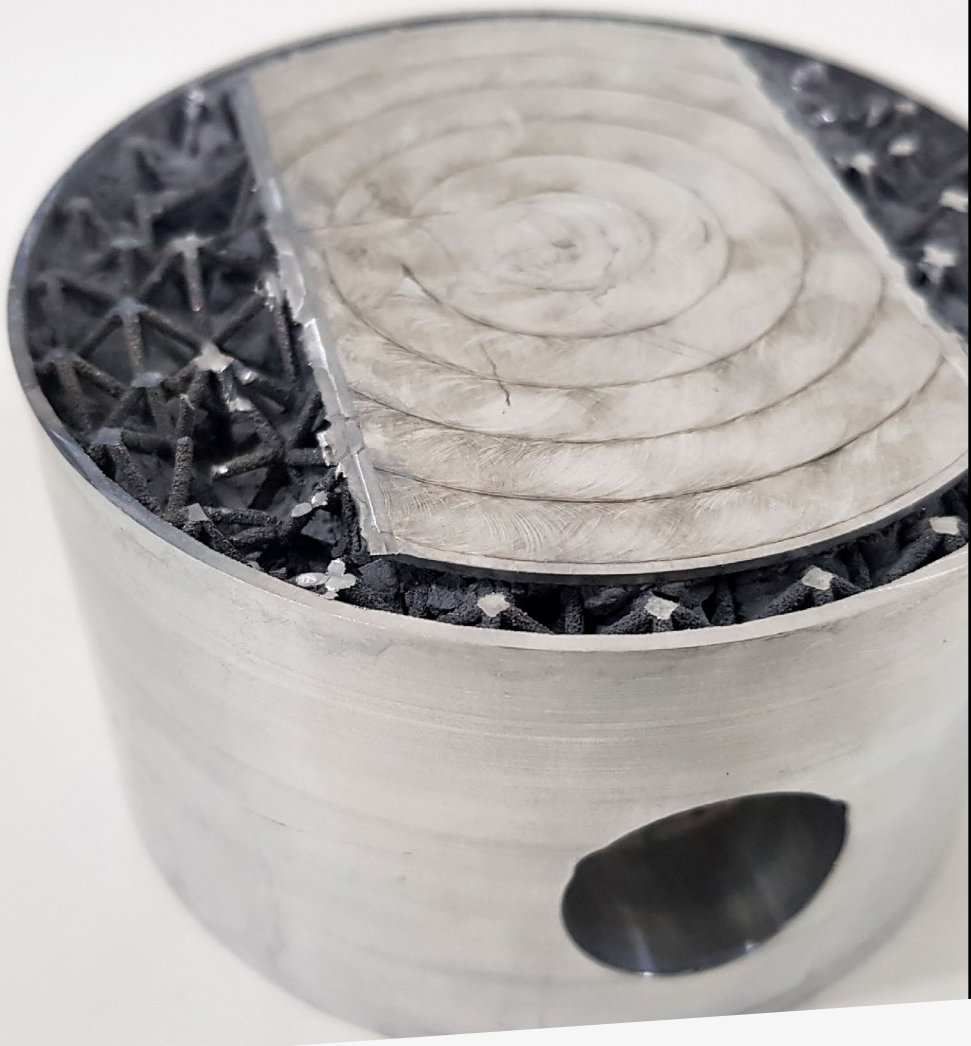
And that means there's no correlation between complexity and cost. In fact, sometimes, more complexity means lower costs - with less material and no need for assembly, or extending component lifetime.

New design rules

In metal 3D printing, material welds where prescribed and can be evacuated from regions it isn't wanted. Now, once unthinkable conformal shapes and complex curving channels are easily achieved without extra cost.

No tooling or casting constraints

In additive manufacturing, your design file is your tooling, which means there are very few constraints.

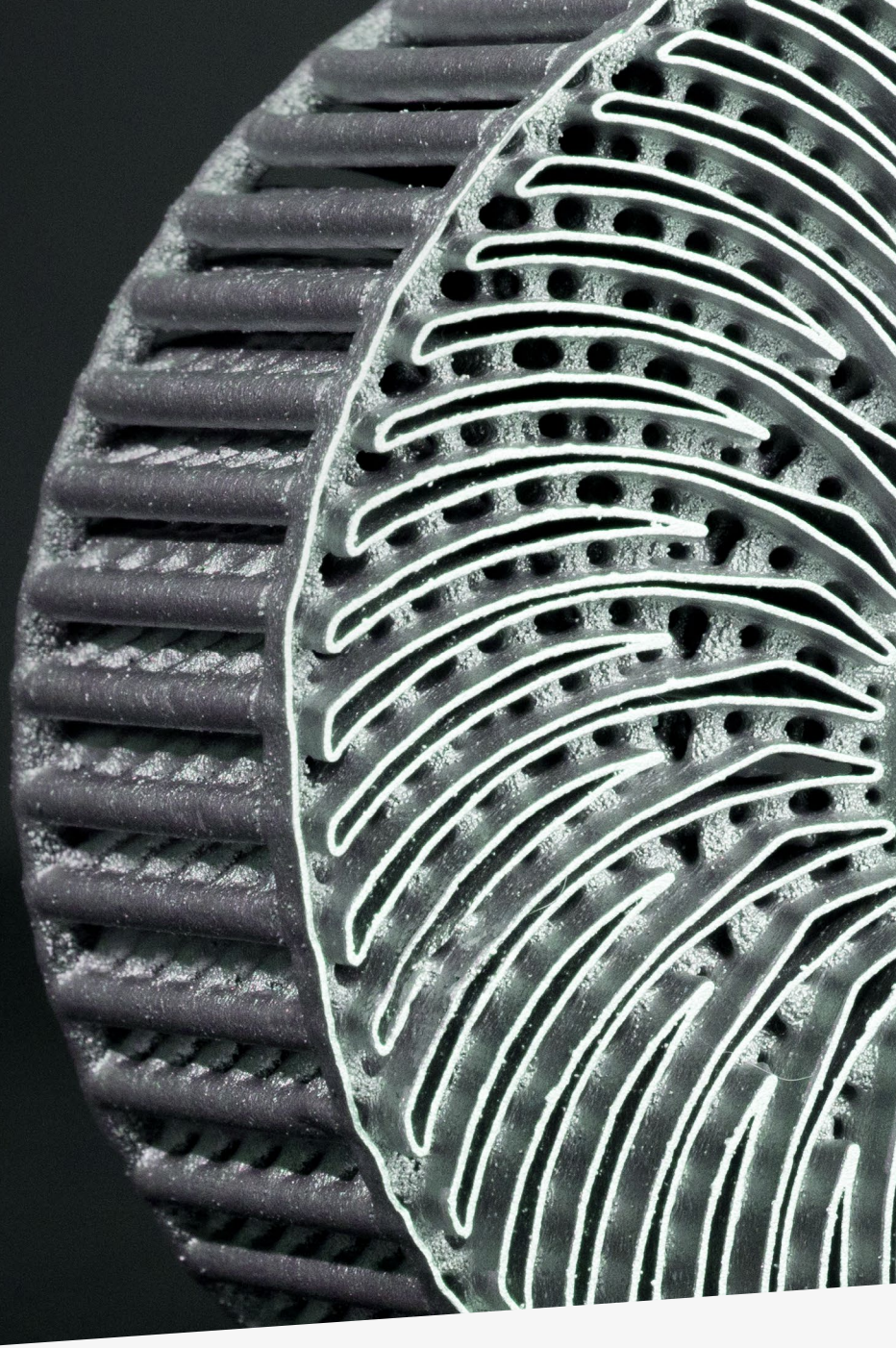


An engineer's disclaimer

> "I always find it difficult to look at one specific added value that additive manufacturing brings. The fact that you manufacture additively instead of subtractively per definition, in my opinion, always gives you lightweight solutions.
>
> This makes selecting examples for this ebook that only focus on "lightweight" very difficult for me. Lighter weight for me goes hand-in-hand with better stiffness, more complexity, or assembly reduction, so I struggle when I am asked to narrowly focus on a specific added value with this technology.
>
> If as a designer I have a new toolbox that can increase the performance of a system five different ways, why would I only focus on one? You can absolutely lightweight parts with additive, but you can do a lot more."

Koen Huybrechts, Senior Project Engineer, 3D Systems

Why lighter weight parts matter



“A lot more” might be an understatement - because metal 3D printing means a world of other, higher order value propositions for the engineer.

Component consolidation, increased performance, and supply chain efficiency are just some examples. But when you look at the costs of keeping objects airborne or putting a rocket into space, lightweighting enters a league of its own.

Fuel economy

In aerospace, even with modern advances in rocket re-use, sending a 22-ton payload into Low Earth Orbit (LEO) costs $62 million. That's $2,818 per kilogram.

For geostationary orbit, that number can jump into the tens of thousands per kilogram. In civil aviation, every kilogram carried can cost an airline hundreds of dollars per year, per plane. When you multiply that weight and cost across a fleet of aircraft, the total expense is huge.

Yet just as costs add up quickly, so too can savings.

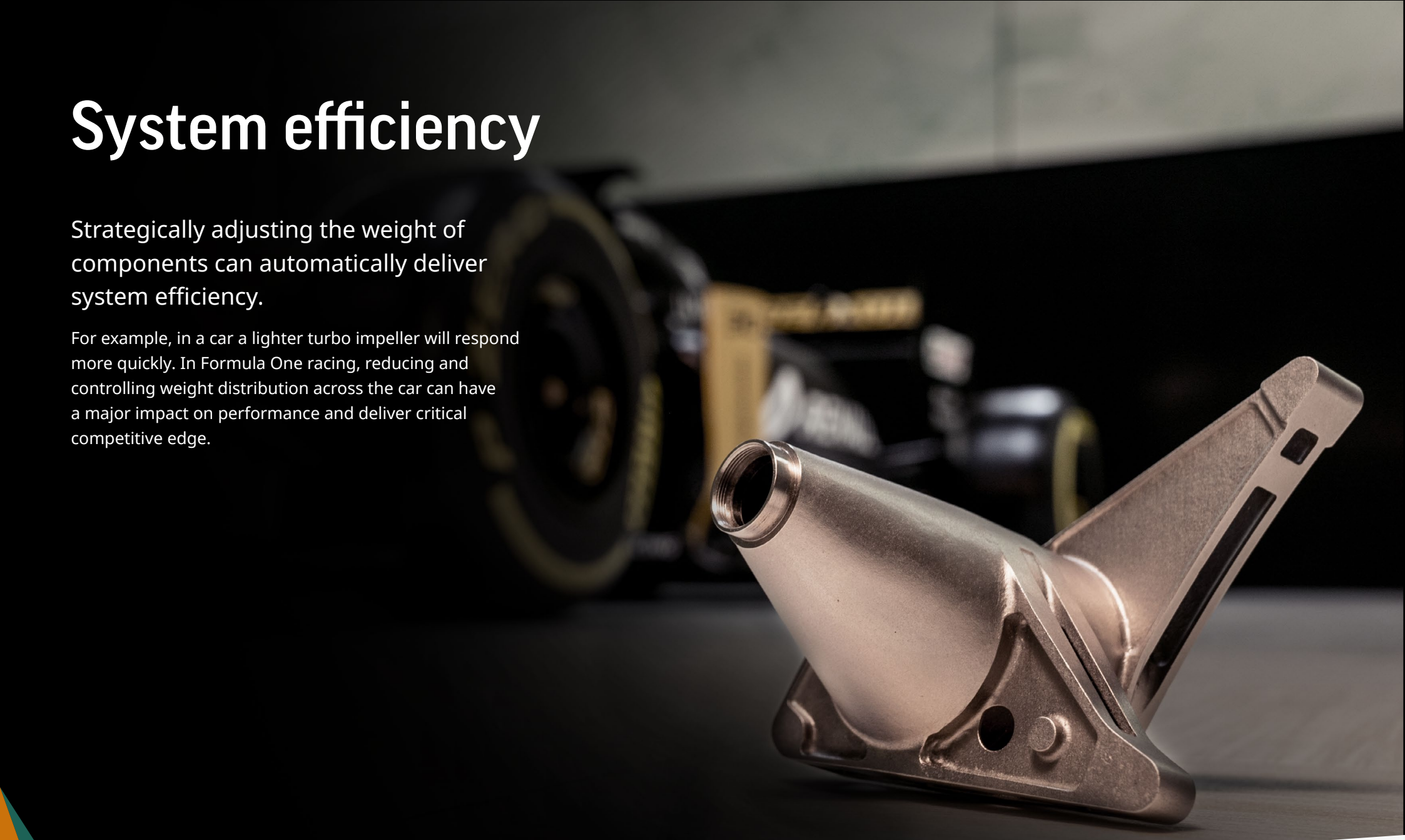
And everywhere - lightweighting opportunities are hiding in plain sight. Think of all the non-structural, non flight-critical metal components in an aircraft cabin. Storage hinges and latches, seat components - everywhere you look begs the question: have these items been optimized?

Could they be hollow instead of solid, or built with an internal lattice structure to cut weight without compromising functionality? Metal 3D printing offers hundreds of opportunities to take mass out and put fuel efficiency in.

System efficiency

Strategically adjusting the weight of components can automatically deliver system efficiency.

For example, in a car a lighter turbo impeller will respond more quickly. In Formula One racing, reducing and controlling weight distribution across the car can have a major impact on performance and deliver critical competitive edge.



Feather light for spaceflight: radio frequency filters

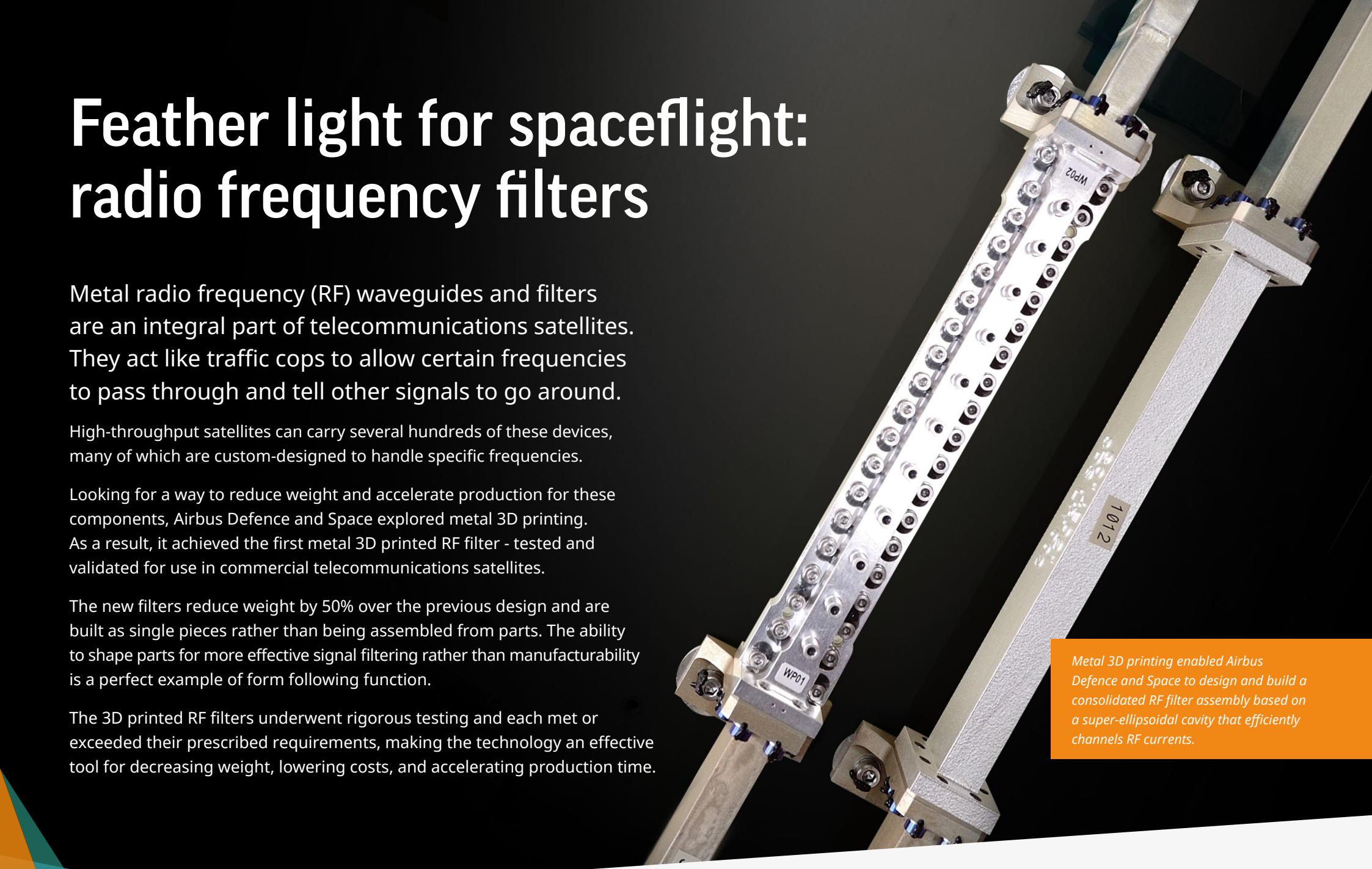
Metal radio frequency (RF) waveguides and filters are an integral part of telecommunications satellites. They act like traffic cops to allow certain frequencies to pass through and tell other signals to go around.

High-throughput satellites can carry several hundreds of these devices, many of which are custom-designed to handle specific frequencies.

Looking for a way to reduce weight and accelerate production for these components, Airbus Defence and Space explored metal 3D printing. As a result, it achieved the first metal 3D printed RF filter - tested and validated for use in commercial telecommunications satellites.

The new filters reduce weight by 50% over the previous design and are built as single pieces rather than being assembled from parts. The ability to shape parts for more effective signal filtering rather than manufacturability is a perfect example of form following function.

The 3D printed RF filters underwent rigorous testing and each met or exceeded their prescribed requirements, making the technology an effective tool for decreasing weight, lowering costs, and accelerating production time.



Metal 3D printing enabled Airbus Defence and Space to design and build a consolidated RF filter assembly based on a super-ellipsoidal cavity that efficiently channels RF currents.

Optimized satellite brackets

These skeletal-looking 3D printed titanium brackets were created using topological optimization.

Topological optimization determines the most efficient placement of material to meet the performance specifications of a part. It considers parameter restrictions, anticipated loads, boundary conditions and other critical engineering factors to yield a unique, performance-based design.

These titanium brackets are 25% lighter than brackets manufactured by traditional means and offer a better stiffness-to-weight ratio. Metal 3D printing and the digital design process delivered four unique satellite brackets for this project and each was customized and optimized to its specific mounting location and delivered in half the time.

Within this reduced timeline it was possible to prepare the files; send them to print; and perform heat-treating, finishing and CNC milling as well as quality control analysis, cleaning and data traceability.

For many engineering groups, enlisting consultation services or contracting out metal 3D printing through an On Demand Manufacturing provider is an excellent way to access a high level of technology and expertise without dedicated facilities or staff.

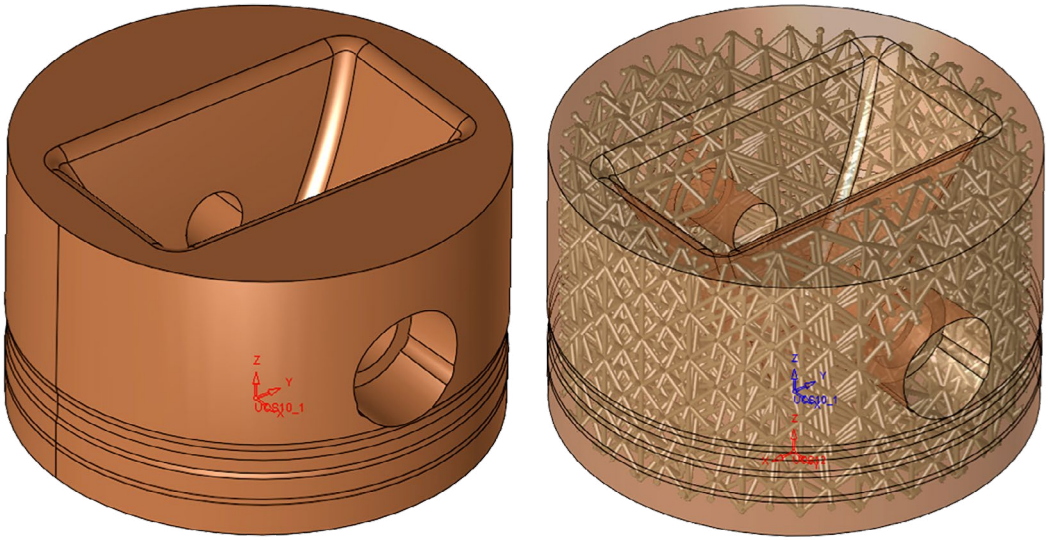
Topologically-optimized brackets deliver an innovative new approach to metal satellite parts for lighter weight and improved part performance.

Rethinking solids

Based on traditional machining and casting methods, metal parts are typically thought of as solid pieces of metal.

But with metal additive manufacturing, we can look past the restrictions of subtractive and formative manufacturing to new techniques. Metal parts don't have to be solid to perform to standard, and some even perform better when they're lighter and less solid.

Examples like this piston head show that once-solid parts can incorporate inventive designs to cut weight. Internal lattice structures, for example, can help cut weight by as much as 30-35% while delivering 100% functionality.



3D metal additive delivers 35% lighter-weight through internal latticework and partially sintered metal materials.

How to add lightness: software

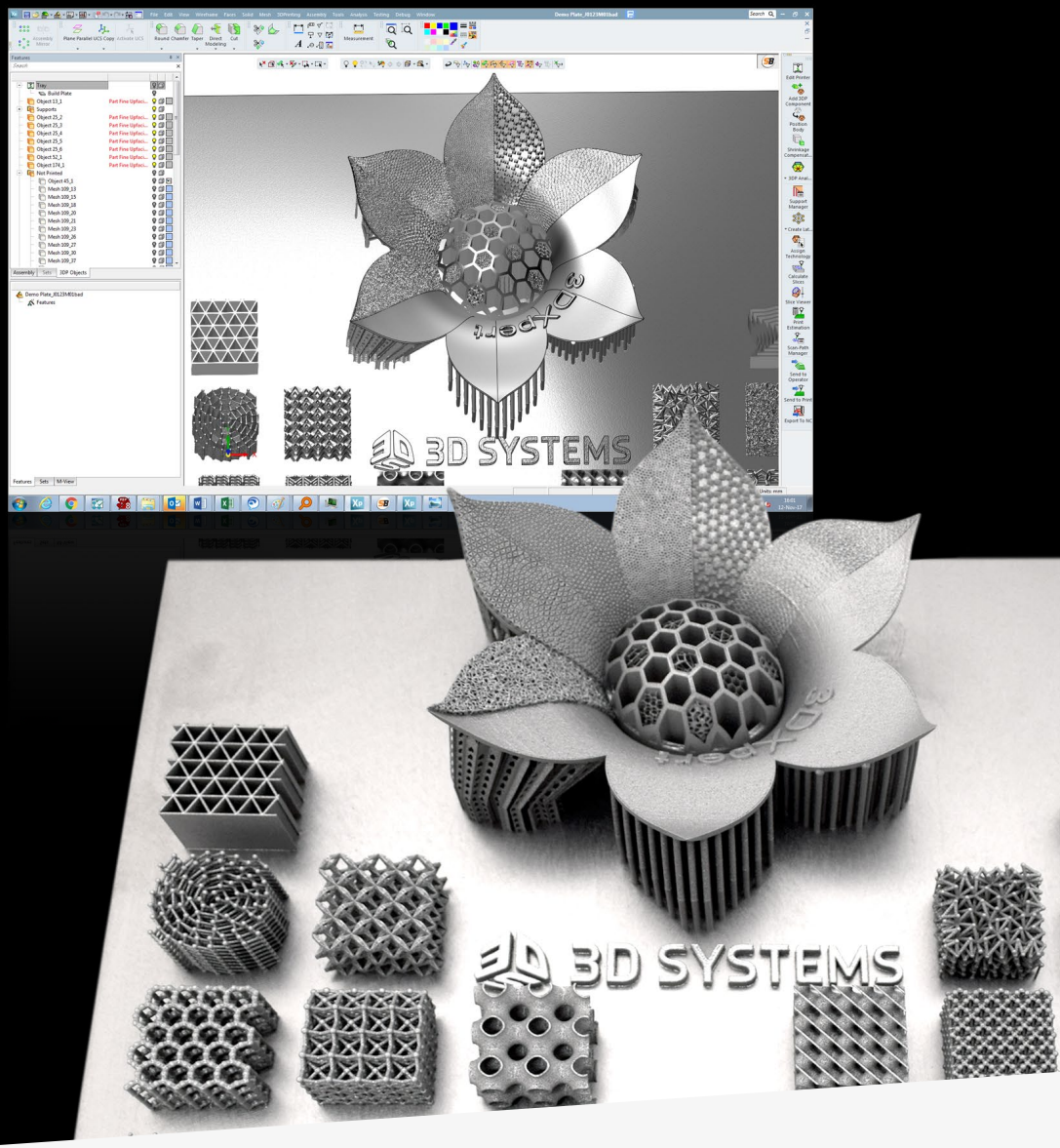
There are a number of off-the-shelf software packages that can be used to design a lighter part.

Most lightweighting workflows combine several of these packages, treating them as different tools in a toolbox. Some software is chosen simply to lay the groundwork design, while other packages offer advantageous simulation features. Software that works seamlessly with CAD data is ideal and typically includes light-weighting tools such as lattice-builders. Some software can also optimizes the additive workflow to fine-tune, prepare, and orient files as well as manage the printing process.

Learn more about your software options.

Design strategies for lightweighting include:

- Hollowing
- Topological optimization
- Applying internal lattice structures
- Consolidating assemblies to reduce fasteners



How to add lightness: Hardware and materials

3D files can be sent to print in a variety of metal alloys, including aluminum, titanium, cobalt chrome, and stainless steel, just to name a few.

When deciding which specific material or material supplier to use, it is best to focus your energies on those that have been thoroughly tested for the highest predictability of results. Given that less material is required for a lighter weight part, material quality and performance are a worthy investment.

If you plan to use metal 3D printing for critical applications, learn about advanced material and hardware options that have a track record of success in your industry.

Learn more about our metal 3D printers and materials.

How to apply lightweighting

Inspection and testing

Various kinds of 3D inspection software can be used to confirm that printed geometries match expected outcomes, both on the surface and structurally. Additional mechanical and functional testing is also recommended as part of any production validation process to ensure you have the appropriate combination of factors where process, material and finishing are concerned.

Consultation and/or contracting

If you are new to lightweighting or still considering a lightweighting approach, exploring your options through a third party provider like 3D Systems is an excellent way to gain experience and knowledge before bringing a new technology in-house.

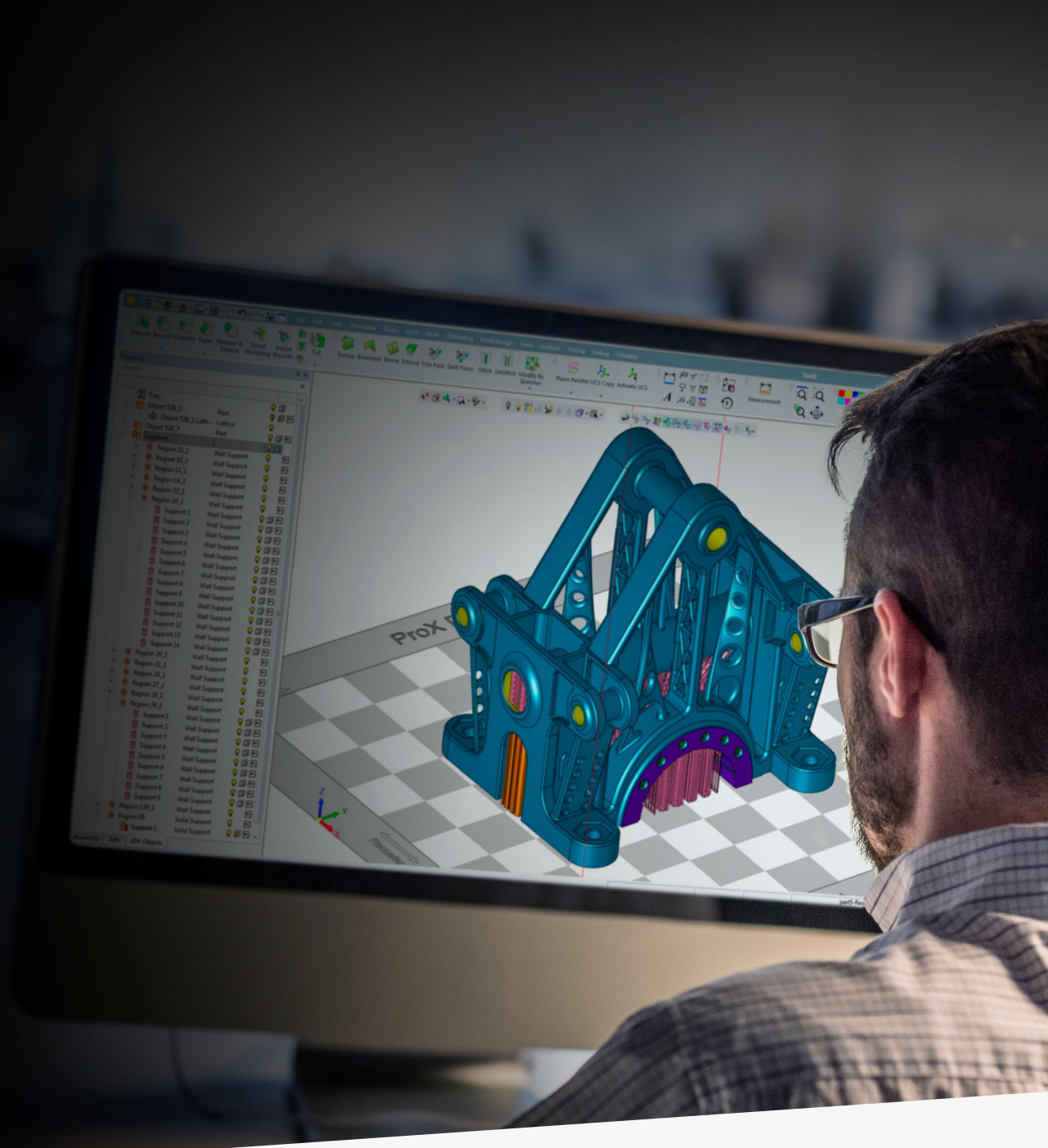
Through On Demand Manufacturing services and global Customer Innovation Centers, 3D Systems is able to consult on or contribute to your light-weighting project with a range of services, from design through production.

3DXpert™

3DXpert is an all-in-one software solution for metal additive manufacturing that streamlines and optimizes the design, simulation, printing and post-processing of metal parts.

The rich toolset of 3DXpert includes an extensive library of lattice creation options with unmatched control over lattice features as well as FEA based analysis to verify structural requirements. Patent pending 3D Zoning technology allows different print strategies to be assigned to different lattice and solid structures to optimize part quality and print time.

Learn more about 3DXpert.



The ProX® DMP 320

The ProX DMP 320 is a high-throughput, high repeatability metal 3D printer that generates high quality parts from the most challenging alloys.

It comes with integrated software, material and expert application support. 3D Systems' metal solutions offer a low Total Cost of Operation (TCO) through short set up times, very low gas consumption and best powder quality preservation.

Learn more about the ProX DMP 320.

Metal materials

Ranging from aluminum, maraging steel, steel and various grades of titanium to nickel and cobalt chrome alloys, 3D Systems offers you an extensive portfolio of sophisticated, ready-to-run metal alloys for Direct Metal Printing (DMP) with thoroughly tested build parameters for 3D Systems' DMP printer range.

It’s a competitive climate in the industries where lightweighting makes a difference, and there are lucrative incentives on the other side of improvements. You just have to know where to start.

Our experts are here to support you.
Get in touch today - we will be right with you.

Get in Touch

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