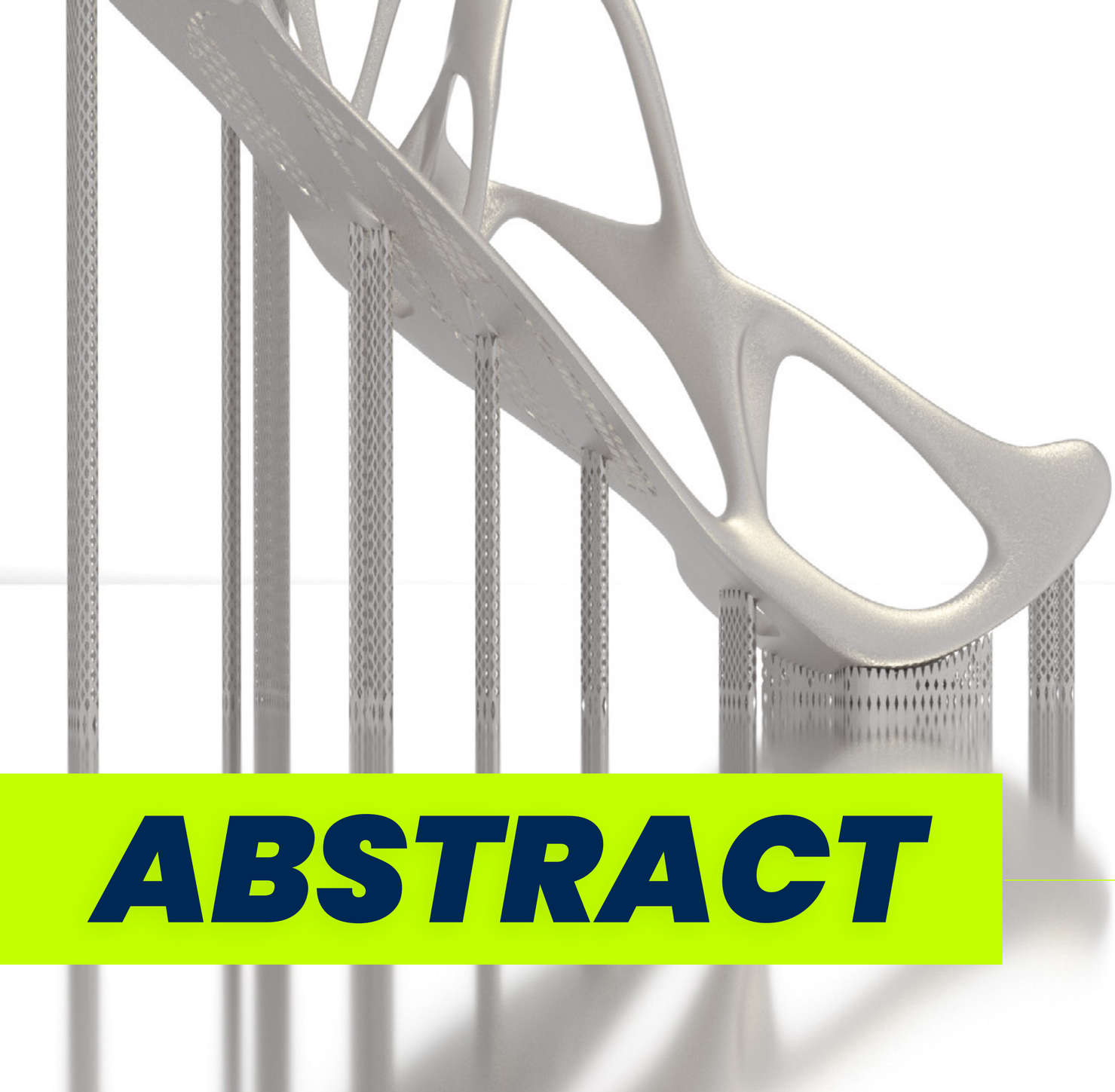
FREE FLOAT

THE SUPPORT-FREE PRINTING REVOLUTION

This SLM Solution's white paper reveals Free Float's origins, features, and practical applications. It also covers its impact on the additive industry, and future applications.

BY BENJAMIN HAAS



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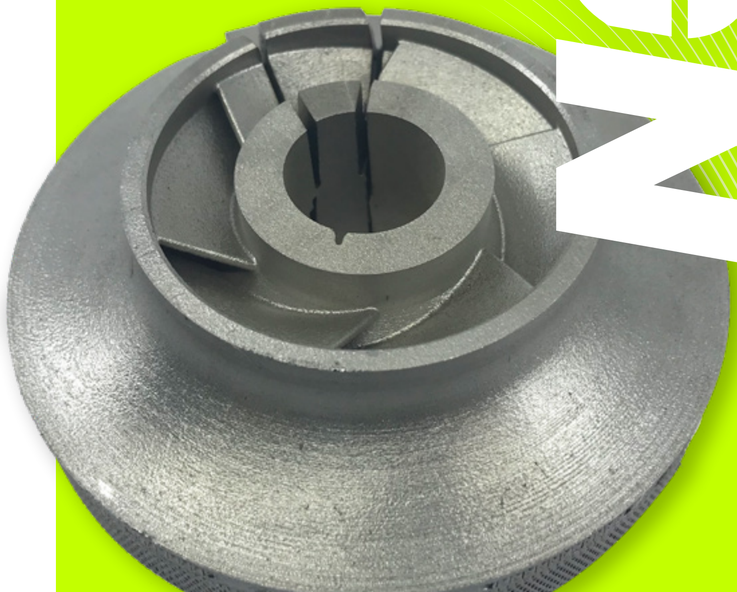
ABSTRACT

BIONIC DESIGN

Since its inception in the 1990s, metal AM technology has been rapidly evolving to reach its true potential, with industrial-scale production being possible. Multi-laser systems and massive build chambers allow us to build bigger, faster, and better parts with additive. Despite this, additive has had one major hurdle to overcome: Support structures

The need for support structures always has limited additive. These structures have always been necessary as they provide support for overhanging structures and remove excess heat away from the part. However, these amount to a substantial portion of the overall volume and add to extra material costs, build time, and post-processing times and labour costs.

This article introduces Free Float, a revolutionary technology that severely reduces or eradicates support structures as well as improving parts and unlocking complex geometry in the process. It also explores practical applications, its impact on the additive industry, and future applications.



THE PROBLEM WITH SUPPORTS

Since the 1990s, support structures have been an essential component of 3D printing. They are necessary to provide support for overhanging structures and play a vital role in the cooling process by absorbing and distributing excess heat away from the components. They also help to prevent part distortion.

Despite this, supports are still causing complications for end-users.

Supports need to be removed at a later stage, resulting in increased post-processing times

Design freedom is limited because support structures always need to be factored into the design equation

The time it takes to build supports is a significant component in the overall build time

Support structures increase material usage

THESE FACTORS PROMPTED US TO WONDER, ***"IS A SUPPORT-FREE FUTURE VIABLE?"***

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INTRODUCTION

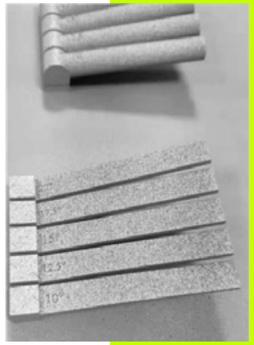
BIONIC DESIGN

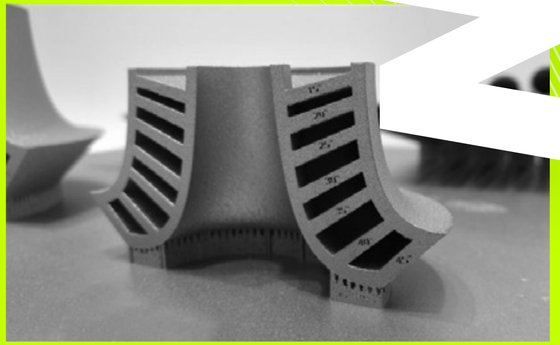
Metal additive manufacturing has been a rapidly developing technology since its introduction back in the 1990s. Before its introduction, CNC milling was the only option. This was done by pouring molten metal into a mold made through a complex multi-step process involving dipping into a ceramic slurry before spending hours hammering off the sand to release the cast parts utilizing outdated tools.

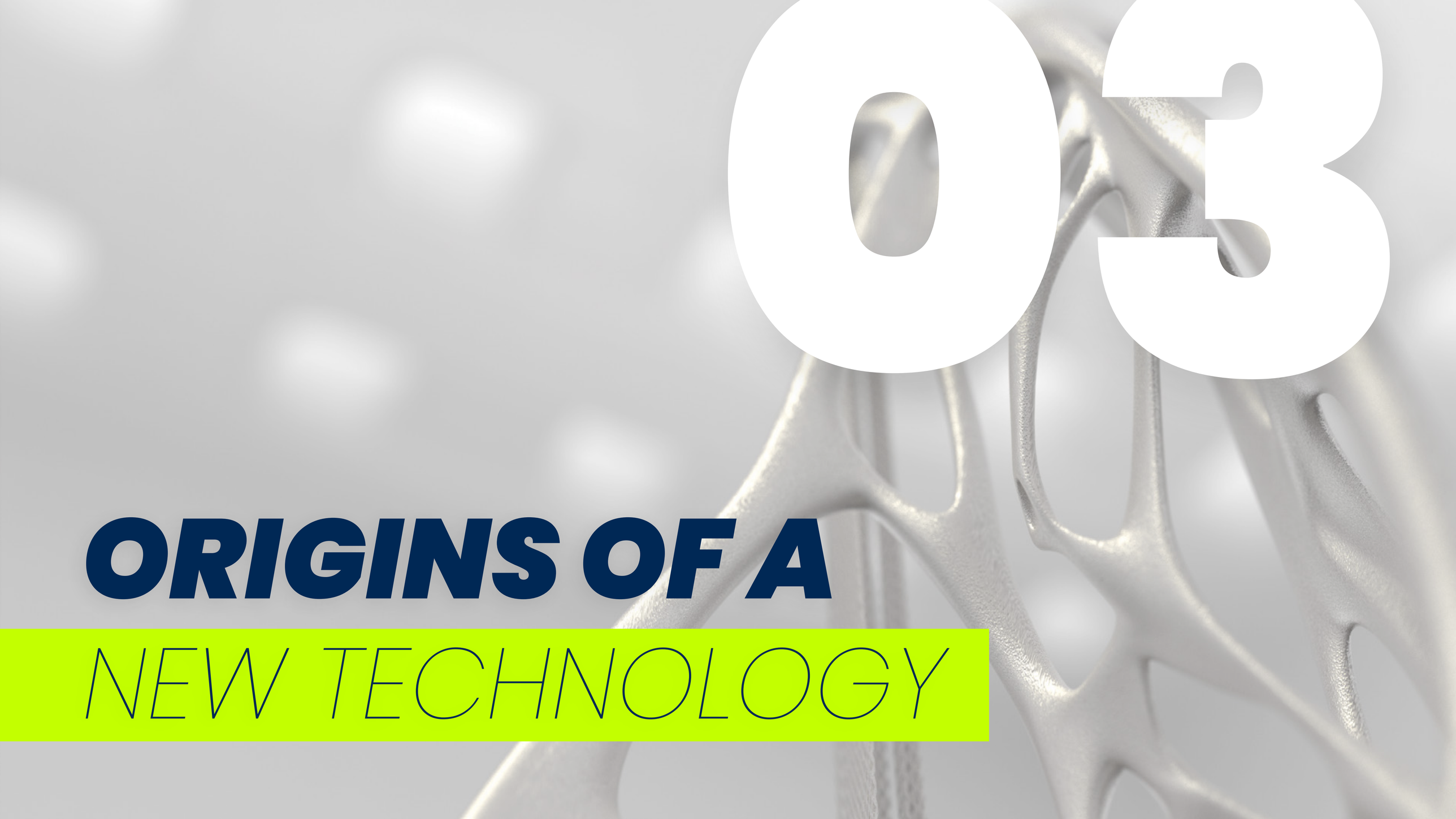
In comes additive manufacturing, a technology where rather than starting with a block and removing from it until you get your desired part, you start with an empty space and effectively 3D-print the part. Back in its inception, it took over 24-hours to 3D-print a piece the size of a matchbox with selective laser melting technology. In addition to this, parts need to be printed with support structures, structures made of the same metal used to support overhanging areas on the piece, and help orient it in the powderbed. Support structures also remove excess heat from the part that would otherwise deform or create structural impurities. There is a considerable amount of extra material needed for support structures and post-processing times often add to the overall build times.

Three decades later, metal AM has risen to disrupt traditional manufacturing forever. Now we have 216 litre build cylinders and 600x600x600mm build envelopes that far exceed the size of a matchbox. We also have 12-laser systems capable of insane speeds, the same matchbox-sized piece that used to take 24 hours can now be done in a few minutes. While traditional manufacturing techniques such as CNC milling are still popular, additive is quickly catching up and is now capable of true industrial-scale production. Additive is now established in aviation, automotive, medical and space industries and is gaining serious ground in them. Despite this, support structures have lingered as a necessary component of additive, but this is set to change with the launch of Free Float.

Free Float is a revolutionary software that makes it possible to print parts with far fewer support structures, in some cases, without the need for any support structures at all. The software also increases overall part quality with smoother surfaces, sharper edges, and better integrity. In addition, this breakthrough software is retrofittable on most SLM Solutions' systems and set to usher in a new era of industrial-scale support-free printing.







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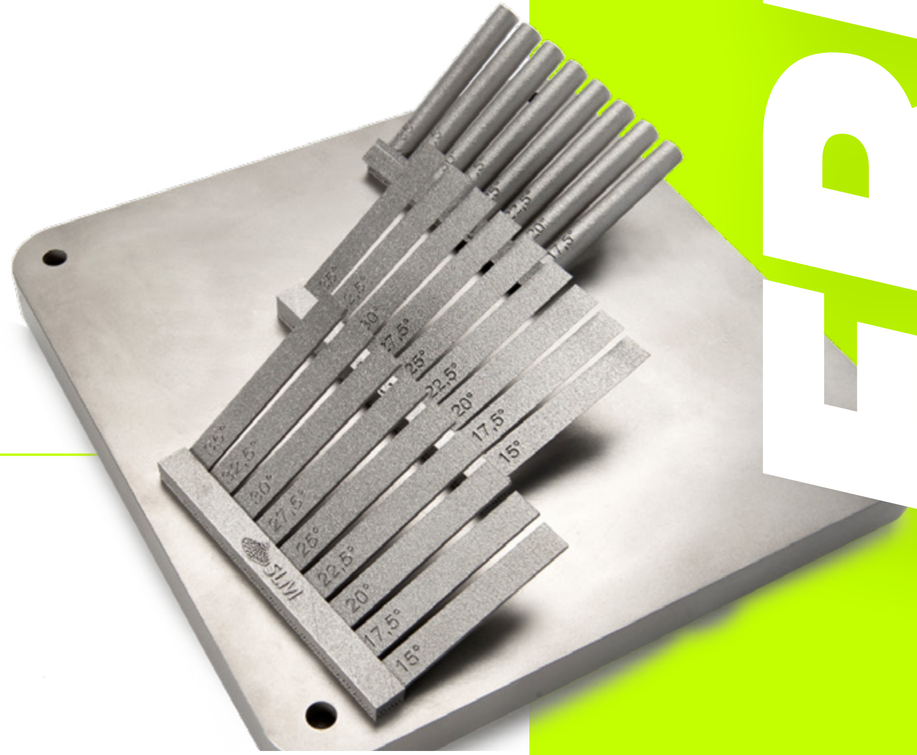
ORIGINS OF A *NEW TECHNOLOGY*

FREE FLOAT

Free Float had initially been discovered as a by-product during a research project back in 2018. The project's focus was on thin-walled components or sharp edges, as it was apparent that the existing process would still give you a decent result, but the last few percent to a perfect part were still missing. While achieving a good result on the outside, the inside was often inconsistent. This was due to over-melting caused by an increased energy input, leading to a loss of accuracy and part quality. So our engineers started digging deeper.
At first, the changes required to address the over-melting were implemented manually. On a developer level, it is pretty easy to manipulate the process, vary laser power, scan speed, or other parameters. After some trials, the over-melting was eliminated. In addition to this, our engineers found out that an optimized process does not only help for removing over-melting from the process–they also realised that the part quality and the cooling process made support structures unnecessary to some extent. This is when we realised we had discovered something extraordinary. Starting with larger arches and free-floating bars, our engineers got addicted and began pushing the limits of how far we could go with our latest discovery. Soon, the first build job successfully finished: a handful of flat bars, triangular-shaped bars, and hollow cylinders out of a stainless steel 15-5PH – and to our surprise, down to an angle of 15°. All of that was accomplished in 2018. Although this was a massive discovery for additive at the time, it was still far off from any practical application. We didn't see a point in charging our customers for an overly manual process and a complicated user interface. Despite this, we believed that this technology was meant for everyone, not just the R&D geeks and material scientists. So we started working on a tool that makes it as easy as possible to apply all of the great benefits to anyone working on a part.
The first iteration of this software tool reduced support structures as well as creating a more stable melt pool in thin-walled and sharp geometries. This led to fewer materials, post-processing, and a higher part quality. In 2019, we showed the world the first industrial use cases and reduced the 15° angle in long-range geometry to just 10°.



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FREE FLOAT

TODAY

We took all of the learnings from the early developing days into a convenient and easy-to-use product: Free Float. It uses an .slm file consisting of a ready sliced part geometry, a parameter file, and if necessary, any support structures where they cannot be avoided. Free Float does not interfere with the vector orientation or sorting of the sliced data. It also doesn't manipulate process parameters allocated to a specific type, e.g., hatch or downskin. The .slm file is then loaded into our software suite. Now we are ready to start assigning Free Float Profiles. These profiles correlate with the various benefits of Free Float, and there are three to choose from:

LOW

Slight improvements on part quality (smoother surface, no over melting, less porosities), reduction of few necessary supports on non-critically angled sections

MEDIUM

Better surface finish, increased support reduction, and medium improvements on part quality

HIGH

Maximum possible reduction of supports, improved surface finish, and overall part quality

As we know, our customers can have wildly creative designs, so we thought of another feature: Application Ranges. This allows for a selected application of profiles, i.e., only where you need them. As every build is different and not every part requires Free Float, there is also the option not to choose a profile and leave the part as it is. As soon as every profile is assigned to the correct part in the right application range, a new .slm file is created and ready to run on most of SLM Solutions' systems built in 2018 or newer. We started by offering Ti6Al4V and IN718 in a 30 µm layer thickness with more materials and material thicknesses to be added in the future. In the end, you will be able to either optimize an existing build geometry with less supports or think of radically new designs that were not even possible before. Free Float allows for radically new designs, especially when it comes to internal sections, cooling channels, overhangs, or diameters.

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FIELD

CASE

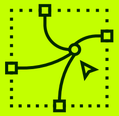
It all started with a part that we had built multiple times over the past years. Originally designed for AlSi10Mg, the part was eventually built in almost every alloy we offer. With one of the first trials for Free Float, the necessary amount of support structures on the part was reduced by 96% with just the use of the medium profile. For the next iteration, we wanted to push limits of what was possible and only supported critical sections, which were connected to the base plate and some vertical components. In the end, the number of support structures was reduced by 99% - while still applying the medium profile. The part came out just like it did with supports, except the post-processing work was done in 5 minutes instead of 1.5 hours. As for data preparation efforts, the provided Free Float software allowed for an easy assignment of profiles. By default, the medium profile is assigned to all parts automatically, and editing the application ranges afterwards is very intuitive. This is a crucial enabler for us because of the ease of use as well as the fantastic results we get with it.

Impellers are a great part to use with Free Float. Due to their design and working principle, they cannot have any support structures at all on the inside. Up until now, impellers were built at an angle, meaning supports were necessary on the outside, but build time and necessary powder usage increased. Free Float realizes flat builds without internal supports and only supports on the vertical sections, allowing to save time and powder.

AN ECOSYSTEM OF BENEFITS

Drastically reduce or eliminate supports

Freeing up space for more parts



Retrofittable on most systems

Savings in metal powder

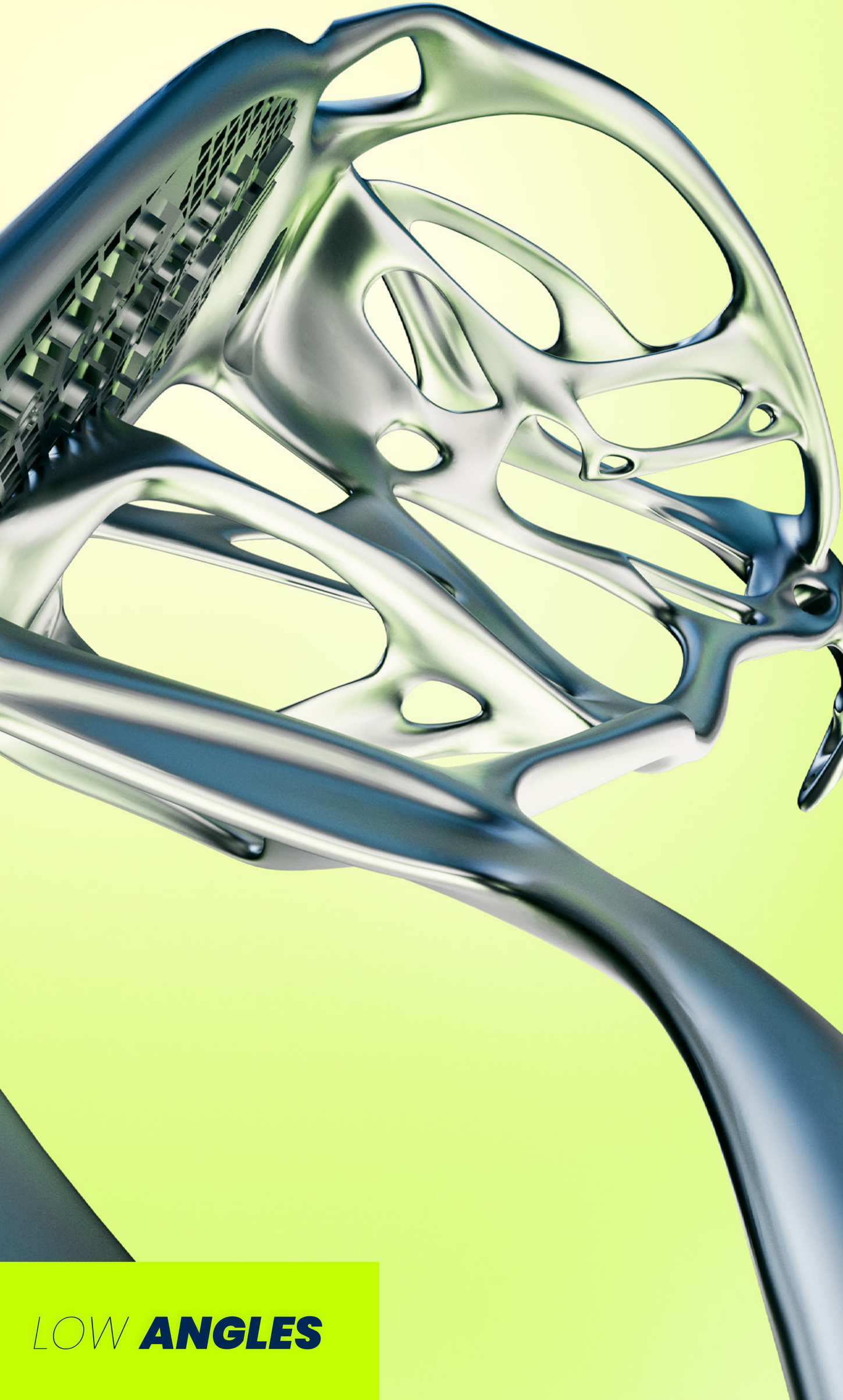
Productivity

Unlock new design possibilities

Less post-processing times

Less scrap

Simple solutions workflow....no PHD required!



LOW **ANGLES**

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REIMAGINING

ADDITIVE

NEXT

When Additive Manufacturing came along, it seemed like it opened up endless possibilities in the way we conceptualize parts, design parts, and make parts. Suddenly, everything seemed possible; complexity came for free and complete freedom to design – except it wasn't. Even though new designs were indeed possible, the limiting factor of support structures was still there. While support structures serve a fundamental purpose overall such as heat transfer or preventing distortion, they are not an integral part of the structure, so they have always been something we have wanted to eliminate. There are multiple ways of doing this, but in the end, the simple solutions usually win: removing them manually is fast, reasonably inexpensive, and does not require a lot of prerequisites. Unfortunately, as designs became more complex, it also became evident that support structures would find their way into a part or at least hide somewhere in them so that it is impossible to remove them. This prevented a lot of great designs from being built or ended up in additional post-processing, such as electrochemical processes, which was not always an option.

With Free Float, we have found a way to significantly reduce the number of necessary supports. In some specific cases, parts can be built without any supports at all. Either way, Free Float allows for new design capabilities, leveraging metal AM to what it had been intended in the first place: a breakthrough in manufacturing. This revolution in additive is very comparable to the invention of safety elevators. Most buildings were limited in height, rarely passing five floors as it was too many flights to climb, and older lifting platforms were deemed unsafe for general use. Despite this, some taller buildings already indicated the direction to go – upwards. People had always dreamed of reaching new heights, but the safety elevator took this to a whole new level, allowing architects to realize their long-lived dreams and create buildings in an unprecedented way. Soon skyscrapers transformed the landscape, and our cities changed forever. Although the race started already more than 100 years ago, architects worldwide are still keen to set new records, culminating in Burj Khalifa's 828m.

Free Float empowers SLM®system's users with the ability to remove support structures, unlock new complex geometries, use low-angled designs, reduce scrap without sacrificing overall build time Free Float is making AM onto the level it is always meant to be: an enabling technology for complete freedom of design. With Free Float, we are one giant leap closer to making full use of the SLM® technology, opening up a whole new level of what we thought was possible. It may just be seen as a simple tool, but in the end, the right tools in the hands of skilled people can do magic. We cannot wait to see the Burj Khalifa of metal AM. Like the invention of the safety-elevator in the 1850s, we can only begin to imagine the impact this breakthrough technology will have on additive, benefiting designers and engineers that are now only restricted by the limits of their imagination.

SLM SOLUTIONS

THANKS!