DESIGN GUIDE FOR 3D PRINTING IN METAL.

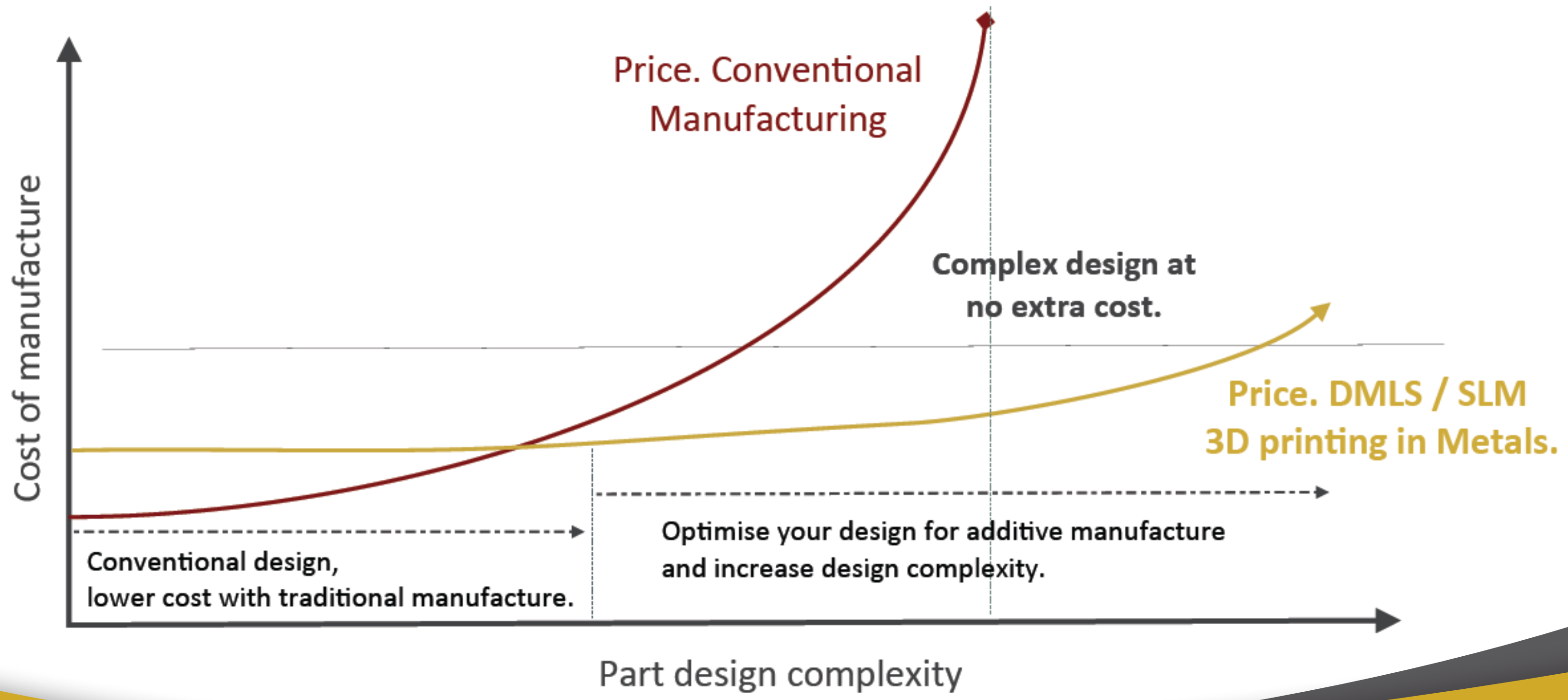
Additive Manufacturing by DMLS or SLM

An introductory design guide for our metal 3D Printing service

v2.6 - 10th Dec 2024

WHEN TO USE 3D PRINTED METAL?

If you have a complex design, or need short lead times, 3D Printing in metal is an attractive option. However for simple designs machining is likely to be more cost effective.



PRICING CONSIDERATIONS

Part Volume
One of the biggest factors in the price for DMLS \ SLM 3D Printing in metal is the volume of the part. Reducing the volume will reduce the price.

Part Orientation
Parts built 'tall' in the x axis cost more that printing 'flat'. More layers equals a longer build time.

However, using the optimum part orientation has big impact on part quality the need for support structures and price.

Minimising support structures at the design stage reduces post processing time, part cost and surface roughness.

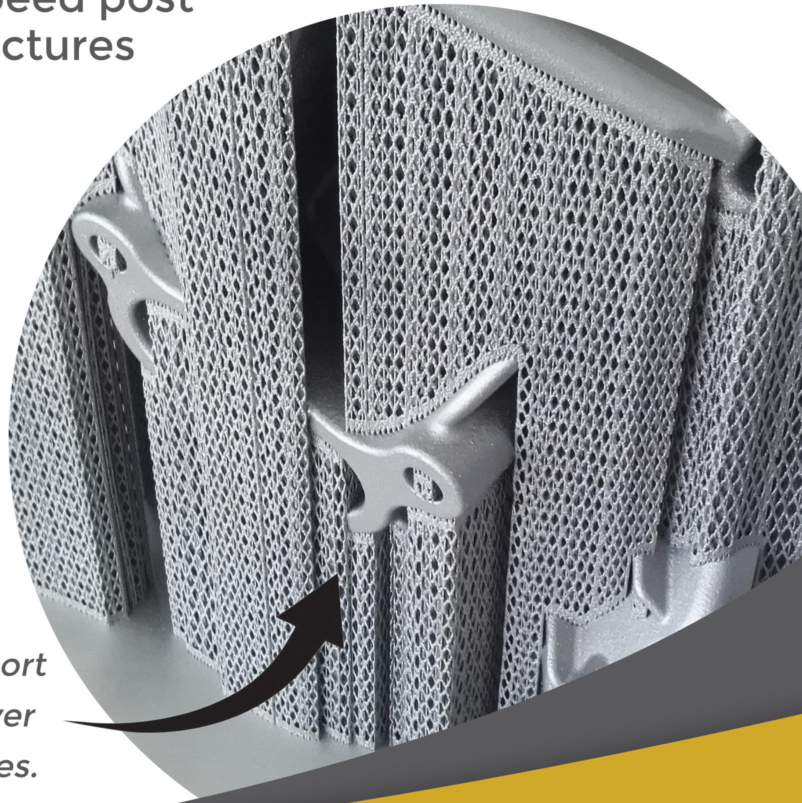
SUPPORT STRUCTURES

Optimising the build orientation of your part is critical to get the best build quality and pricing. The correct build orientation helps minimise support structures, reduce the build time, improve surface finish and speed post build machining. Designing to reduce the need for support structures gives you better parts at a lower price.

We generate the Support structures required for your design.
They provide 2 functions during the build:

Mechanical
- Fix the part to the build plate.
- Ease separation from the build plate.
- Stabilise overhanging structures.

Thermal:
- Reduction of residual stresses.
- Minimising \ preventing warping & cracking.
- Preventing localised heat build up.



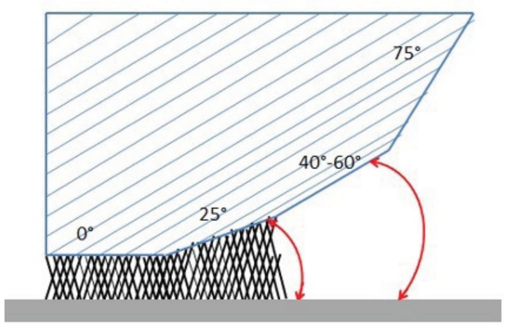
Sacrificial support structure on over hanging features.

OVERHANGS

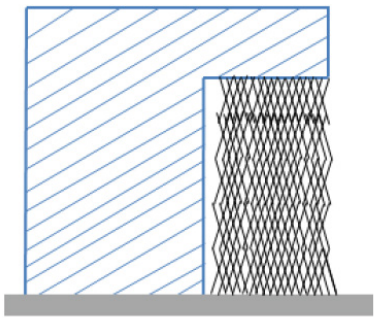
Overhanging sections of your part may need support structures. Inclination angles of:

> Less than 40° will need support structures.
> Between 40° and 60° may need support.
> Over 60° should not need supporting.
> Overhangs, especially 90° should be avoided.

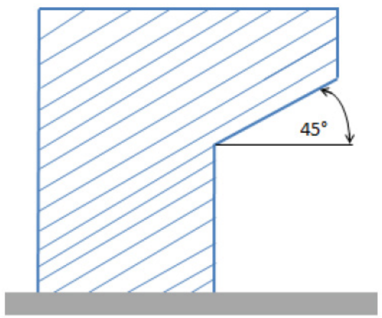
Support structures may be added to the base of the part to connect it to the build plate, geometry depending.



Support structure angles.



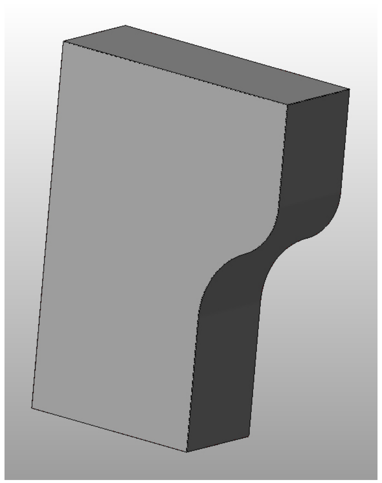
Avoid Right angled overhangs.



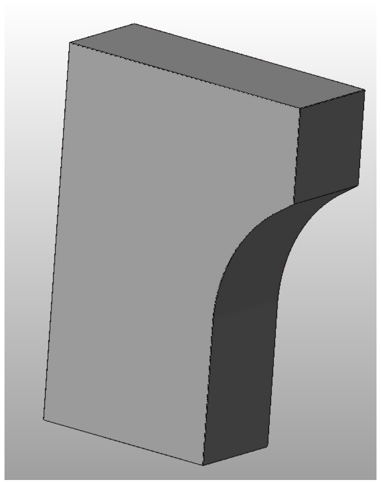
Optimise the design to avoid support.

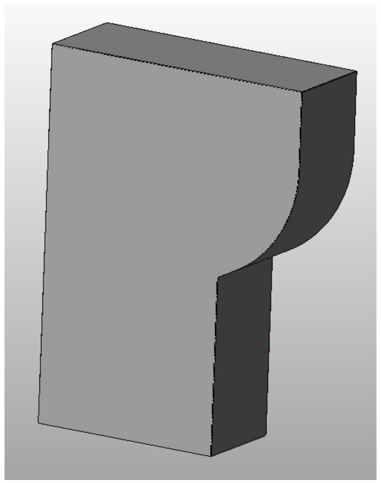
Managing Overhangs

Support structures can be eliminated from overhanging features with the use of curves or chamfers:

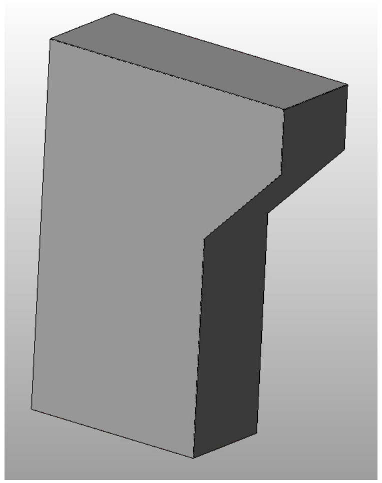


A double curve offers the optimum solution.

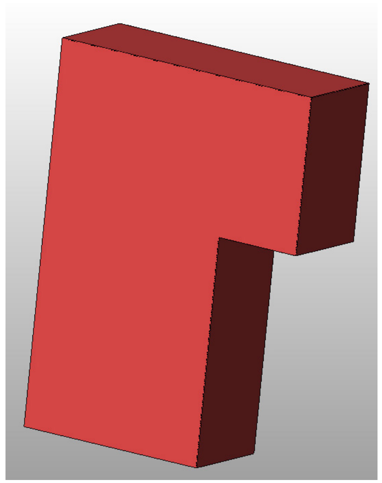




Concave or Convex radius sections avoid horizontal faces less tan 45 degrees.



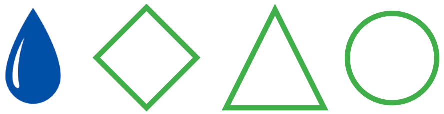
A chamfer with an angle greater than 45 degrees is another solution.



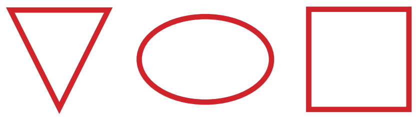
Avoid horizontal overhangs.

INNER CHANNELS & HOLES

The ideal shape for inner channels is influenced by the need to avoid support structures. Tear-Drop shapes are ideal as they minimise overhang and are self supporting.



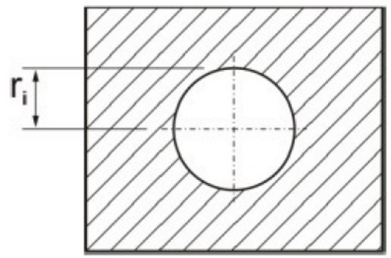
'Tear Drop' or small circular channels remove the need for support structures.



Avoid profiles with horizontal overhangs.

Over sized holes or unsupported sections can fail.

The internal path for channels should be curving, avoiding the horizontal where possible. Think curved pipe work, with minimum horizontal paths.



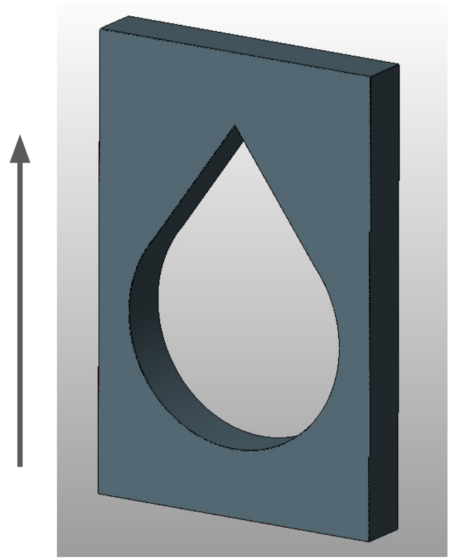
Hole diameter less than 7mm - No support required.

Holes. Post Build Drilling

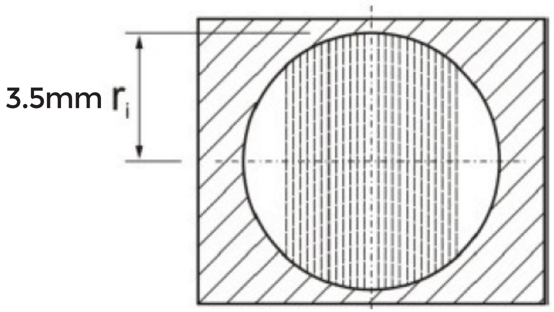
Where holes are required in your design, design them undersized so they can be drilled as part of the post build processing. Drilling assures the accuracy and roundness of critical hole features. Minimum channel diameter is 1mm. Maximum unsupported channel diameter is 7mm.

INNER CHANNELS

Tear Drop profiles offer the best solutions for inner channels.

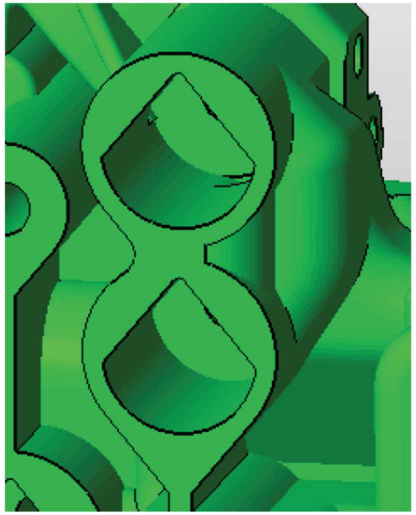


Tear Drop shaped profiles for internal channels remove the need for support structures when built in the displayed orientation.



Hole diameter over 7mm will require support and / or an optimised and more costly build orientation. Holes and channels less than 1mm may not form.

Cylinders and tubes are typically built 'tall' to avoid internal support.



Example of channels optimised for DMSL / SLM. Avoiding horizontal overhangs.

REDUCE VOLUME

Before and After. Less is more
Reducing part volume reduces part price and gives you light weight but strong designs. The images show traditional designs which have been optimised for 3D printing.

- Build orientation is selected (tall in both cases).
- Excess material is removed, reducing part volume and build time.
- 'Overhang' features are profiled to avoid the need for support structures, speeding up post build finishing.
- Lattice like structures used for strength while avoiding solid volume.
- Use Finite Element Analysis to confirm design integrity.
- In the top example, holes are converted to squares to avoid supports, ready for machining post build.

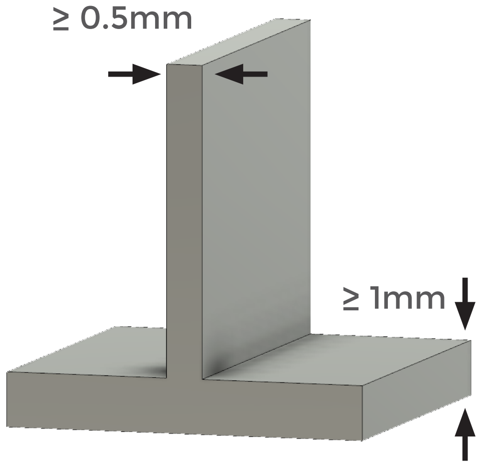
Strong, lower weight parts. Ideal for aviation and motor sport.

Machined design (left) optimised to final DMLS (middle).

Fabricated design optimised for DMLS. (Arup Amsterdam).

OTHER CONSIDERATIONS

Wall Thicknesses
Generally wall thicknesses of ≥ 0.5mm are possible but is dependent on material and part geometry. Horizontal walls should be ≥ 1mm. The thermal conductivity of your selected alloy influences the minimum wall thickness achievable.



Minimum wall thicknesses.

Large Volume Jumps
These should be avoided. The thermal expansion and contraction of different volumes or wall thicknesses can cause bulges. This can be managed with build orientation or design changes.

Where parts taper to a point, the design should be optimised to round off the point.

Material porosity. Usually none, air tight when walls are greater than 0.8mm. Please call for a copy of our helium leak test results.

Material Density. 99.5% of normal metal.

Support Removal
Support structures are removed in post processing. Support in hard to reach areas may make support removal hard or impossible.

Surface finish in areas where support has been removed will be rougher than surfaces without support structures.

Surface Finish:
Surface quality after the building process is about Rz35µm - RZ50µm.

As part of the post build finishing this will be optimised to Rz20µm - Rz30µm by hand finishing, shot peening or vibratory grinding.

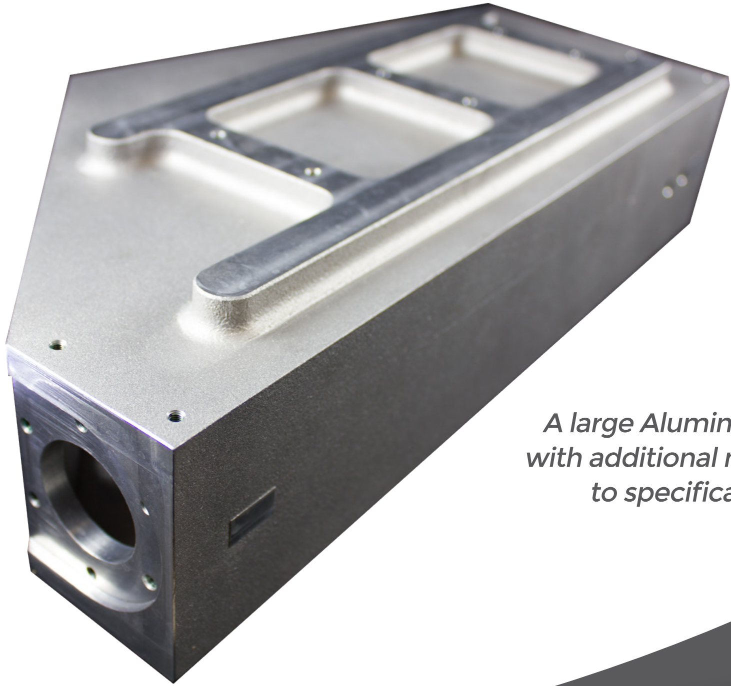
Powder Removal
Parts are built in a volume of metal powder. Provision needs to be made to remove powder from any internal channels & voids.

POST BUILD PROCESSING

Additional Services
To achieve specific tolerances we offer a full range of post build engineering services.
These include:

- Milling, machining & drilling.
- Turning.
- Heat treatment.
- Polishing.

Please supply engineering drawings or quotation if required.



A large Aluminium part with additional machining to specification.

SUMMARY

	Value	Notes
Wall Thickness	≥ 0.5mm (vertical) ≥ 1mm (horizontal)	Alloys with higher thermal conductivity may require thicker walls. Avoid large sections of thin walls which may warp.
Holes and channels	Max 7mm **unsupported** Min 1mm	Unused powder will need removal. Round holes over 7mm will require access to remove support structures. 'Teardrop' channel profiles may not require support.
Cylinders	Ideally built tall	Minimises support requirement and accuracy.
Text	Font size 8 Depth 0.3mm	Ideally engraved, not raised.
Tolerance	+/- 0.3mm typical	We can mill and turn built parts to conform to drawing specifications. Please avoid asymmetrical tolerances.
Surface Roughness	Rz20μm - Rz30μm typical	
Threads	M20 + possible but coarse	Threads best added post build. Drawing required to price.
Assembled Parts	0.1mm gap 0.8mm gap	Allow for separately build parts to be assembled without a 'press fit'. Allow for conjoined moving parts built at the same time.
Unsupported overhangs	> 45° from the horizontal build plate	The closer to the horizontal the more likely support structures will be required. See page 6 for examples.