Design Guide for 3D Printing in Metal.

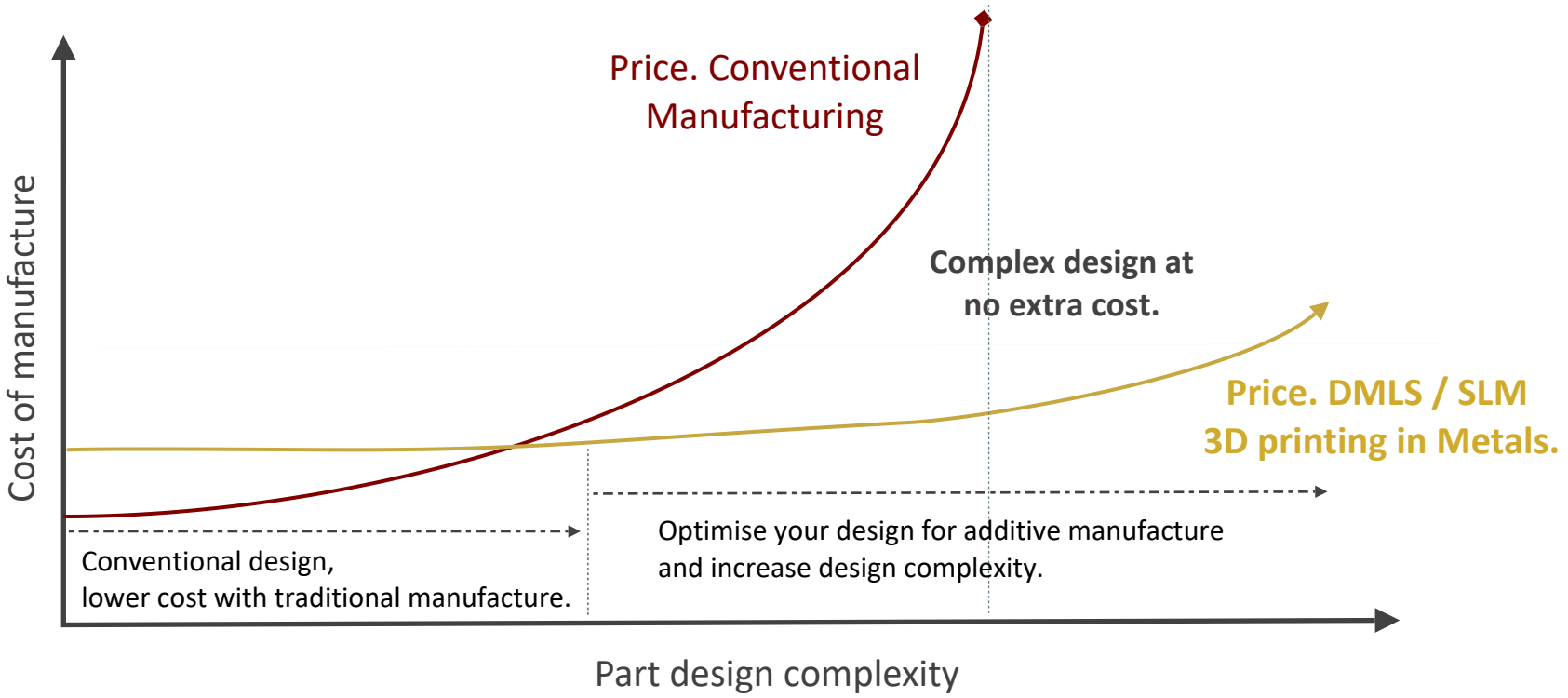
Additive Manufacturing by DMLS or SLM.

An introductory design guide for our metals 3d printing service.

v2.5 - 18th Dec 2017

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 z axis cost more than printing ‘flat’. More layers equals a longer build time.

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

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

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.

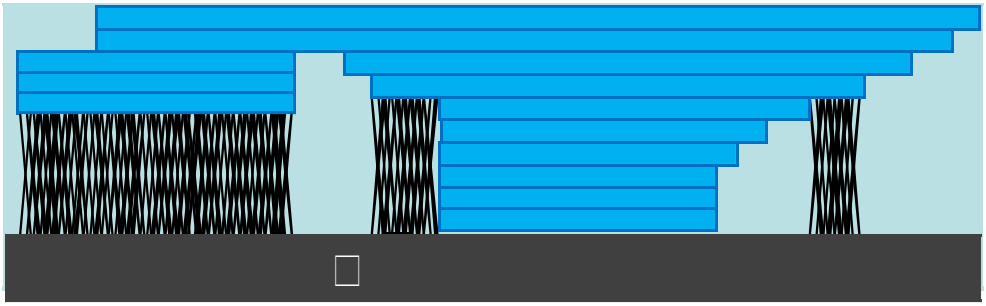
We generate the Support structures required for your design. They provide 2 functions during the build:

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.



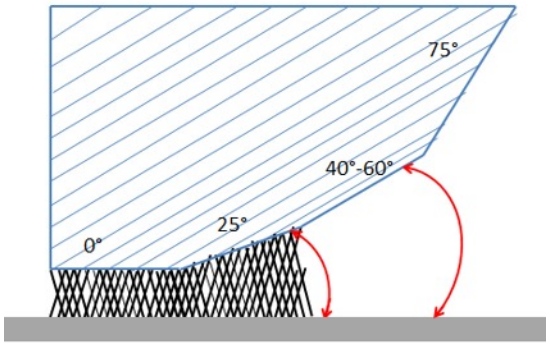
Part on build plate showing support structures.

Overhangs.

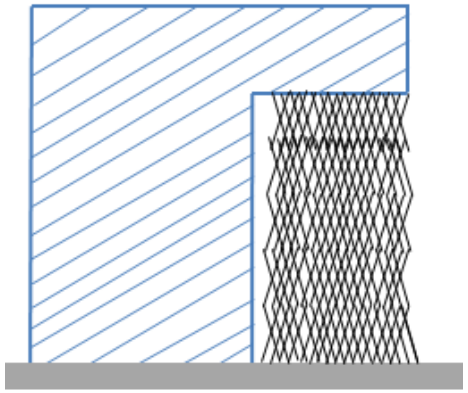
Overhanging sections of your part may need support structures.
Inclination angles of:

- 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.

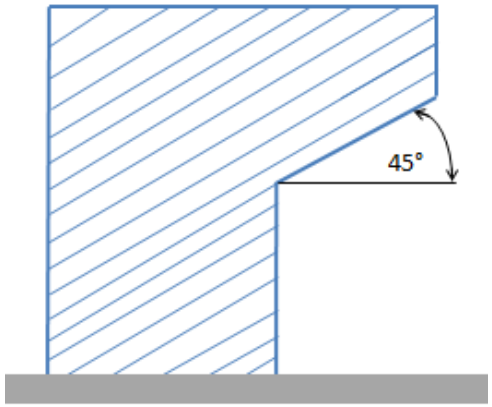
Support structures may be added to the base of the part to connect it to the build plate, geometry depending.



Support structure angles.



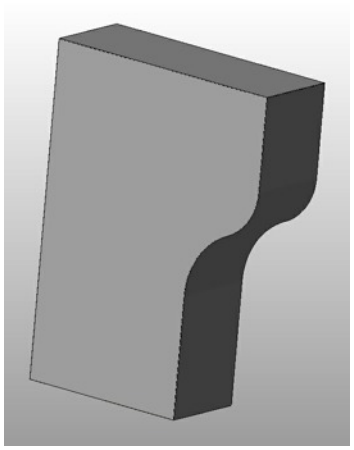
Avoid Right angled overhangs.



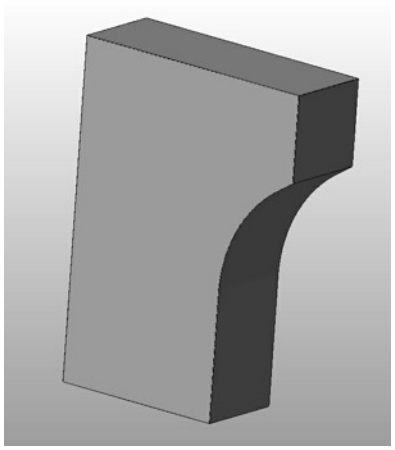
Optimise the design to avoid support.

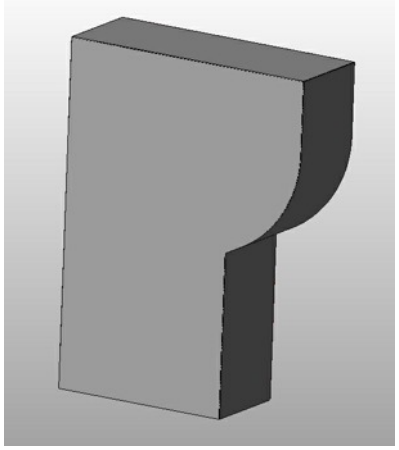
Managing Overhangs.

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

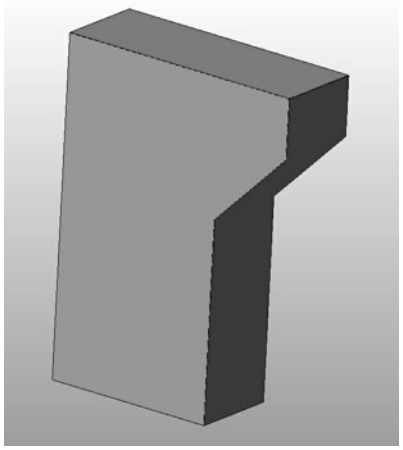


A double curve offers the optimum solution.

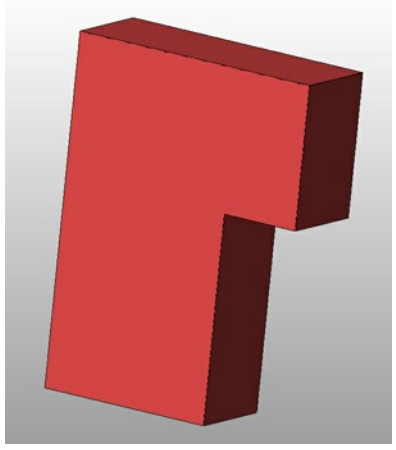




Concave or Convex radius sections avoid horizontal faces less than 45 degrees.



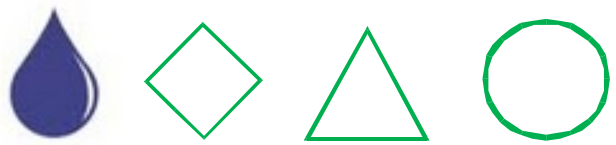
A chamfer with an angle greater than 45 degrees is another solution.



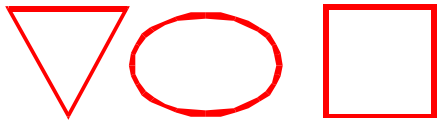
Avoid horizontal overhangs.

Inner Channels & Holes.

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



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



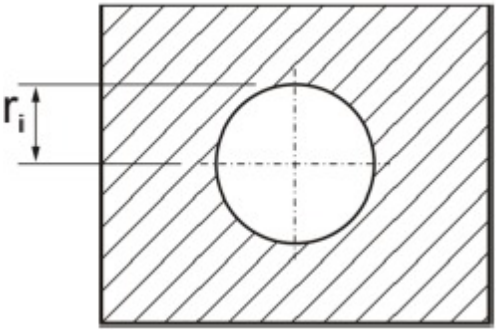
Avoid profiles with overhangs.

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.

Holes. Post Build Drilling.

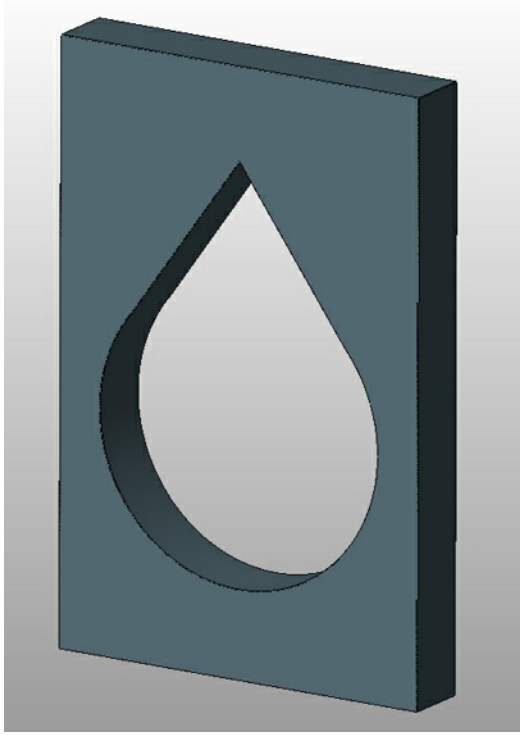
Where holes are required in your design, design them undersized so they can be drilled as part of the post build processing. Drilling assures the accuracy and roundness of critical hole features.



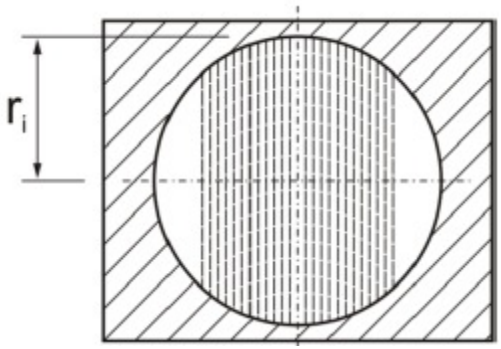
Hole diameter less than 4.5mm - No support required.

Inner Channels.

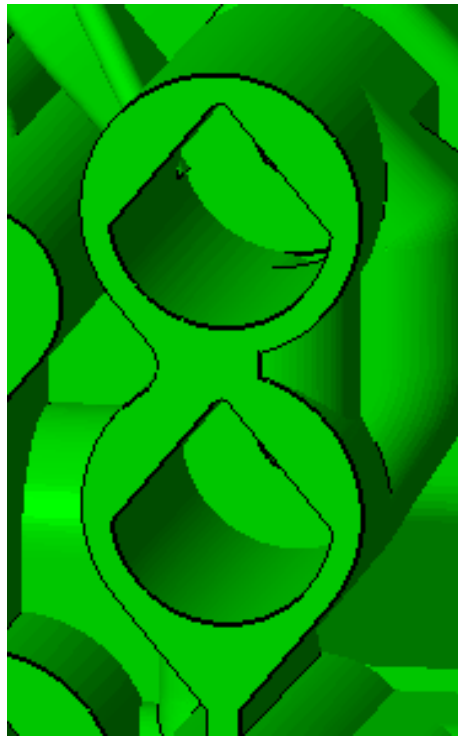
Tear Drop profiles offer the best solution for inner channels.



Tear Drop shaped profiles for internal channels remove the need for support structures.



Hole diameter over 4.5mm will require support and\or an Optimised and more costly, build orientation.



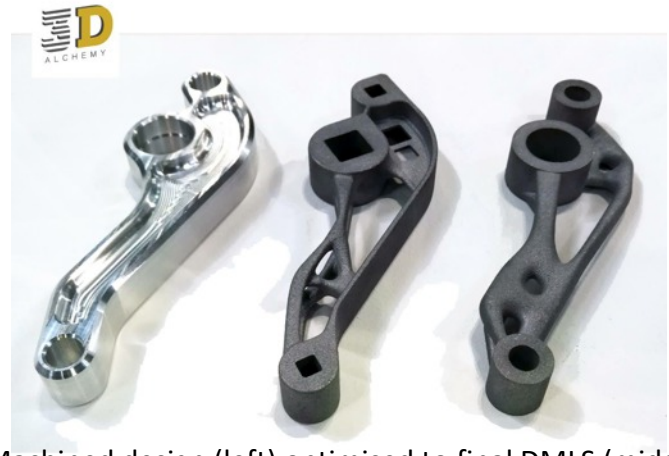
Example of channels optimised for DMSL / SLM

Reduce Volume.

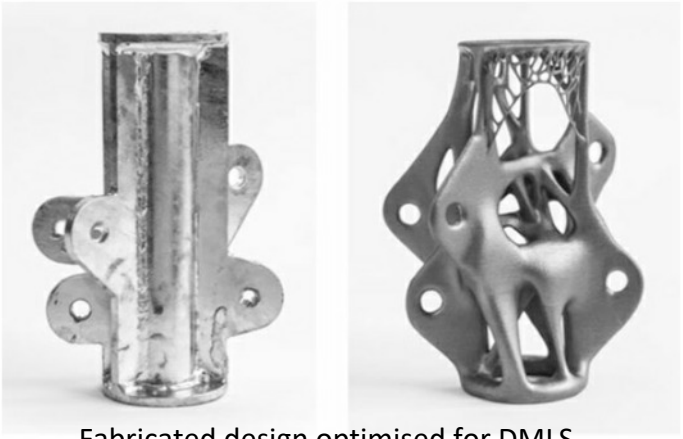
Before and After. Less is more.
Reducing part volume reduces part price and gives you light weight but strong designs. The first 2 images show traditional designs which have been optimised for 3D printing.

- 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 first example holes are converted to squares to avoid supports, ready for machining post build.

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



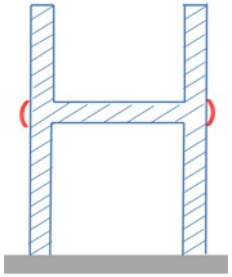
Machined design (left) optimised to final DMLS (middle)



Fabricated design optimised for DMLS.
(Arup Amsterdam)

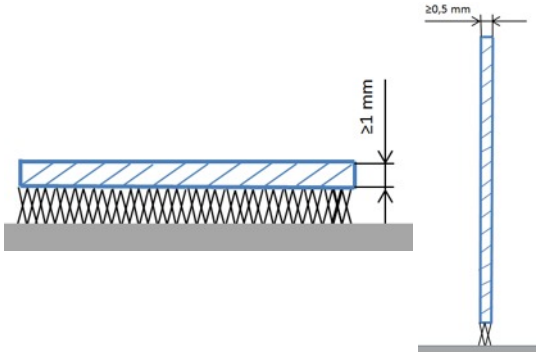
Other considerations.

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.



'Bulge' caused by volume jump.

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 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.

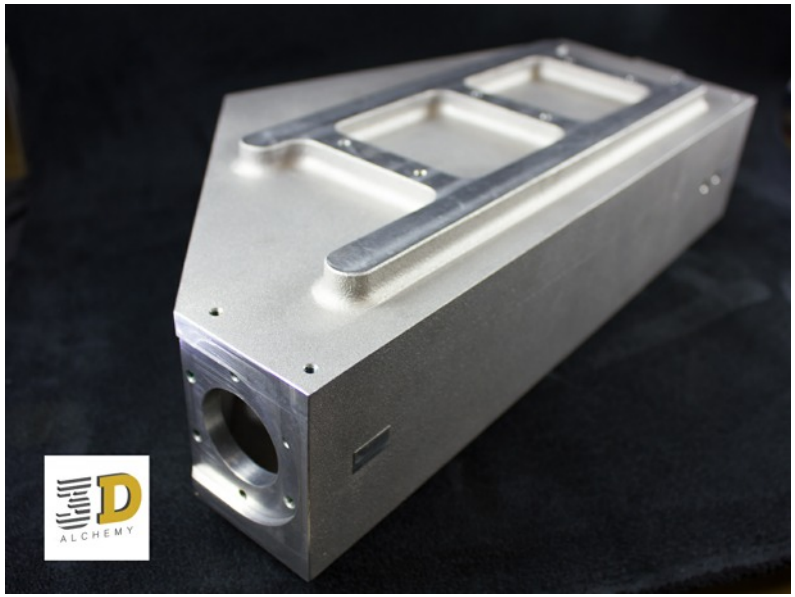
Powder Removal.
Parts are built in a volume of metal powder. Provision needs to be made to remove powder from any internal channels & voids.

Post Build Processing.

Additional Services.
In addition to support removal and shot blasting mentioned earlier in the document we offer a full range of post build engineering services. These include:

- Milling & machining
- Turning
- Heat treatment
- Polishing

Please supply engineering drawings for quotation if required.



A large Aluminium part with additional machining to specification.