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How To Redesign Parts For Metal 3D Printing

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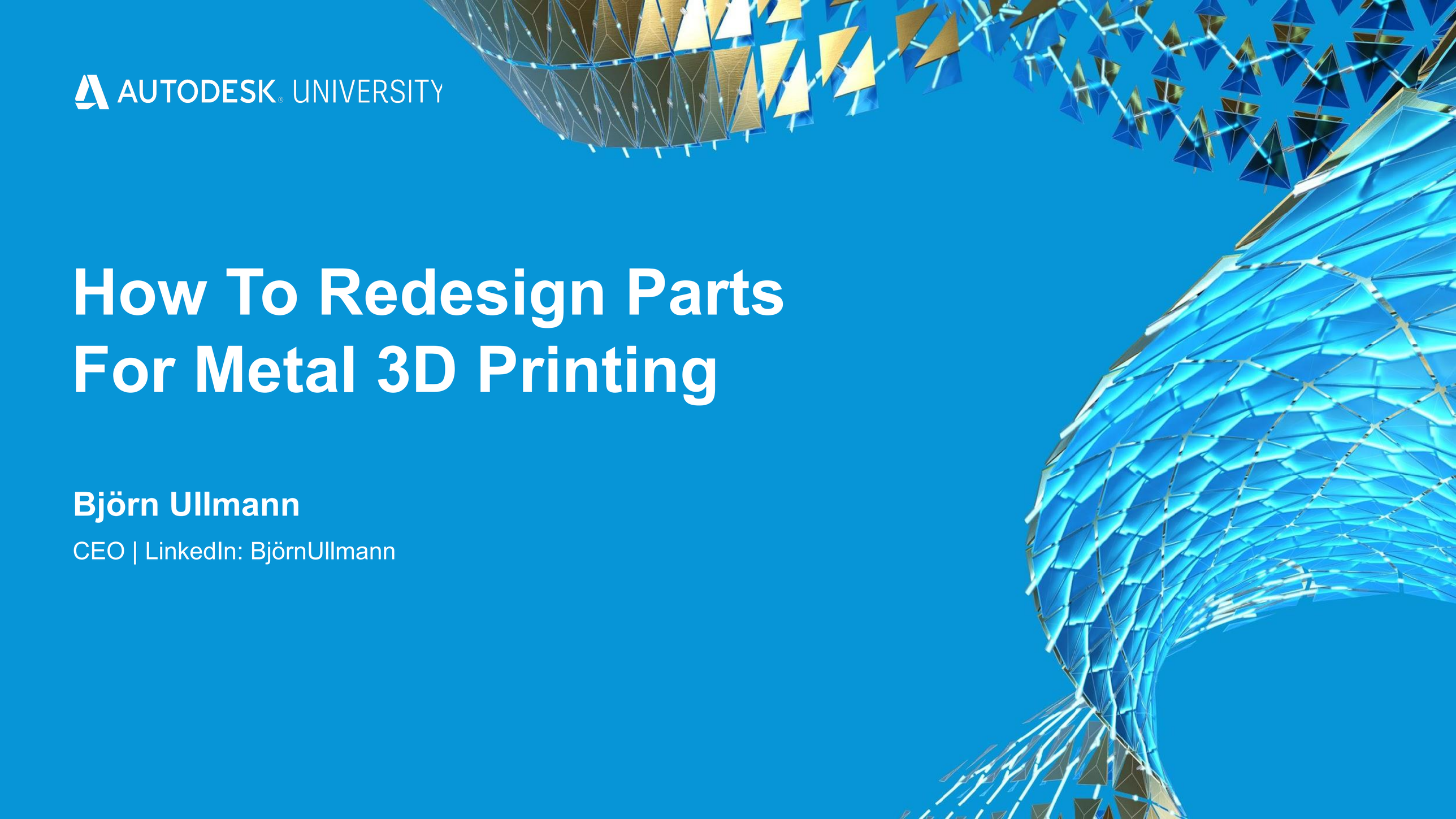


“Everyone can successfully use additive manufacturing technologies”

CEO & Founder of One Click Metal

With several years of experience in 3D printing, development and startups, Björn Ullmann brings his expertise not only to his company One Click Metal, but also to conferences and events. The newly founded start-up One Click Metal, with Björn as CEO, aims to make metal 3D printing more accessible and affordable and has developed a holistic metal 3D printing system that lowers the entry barriers into the technology, allowing any company to possess its own metal 3D printer.

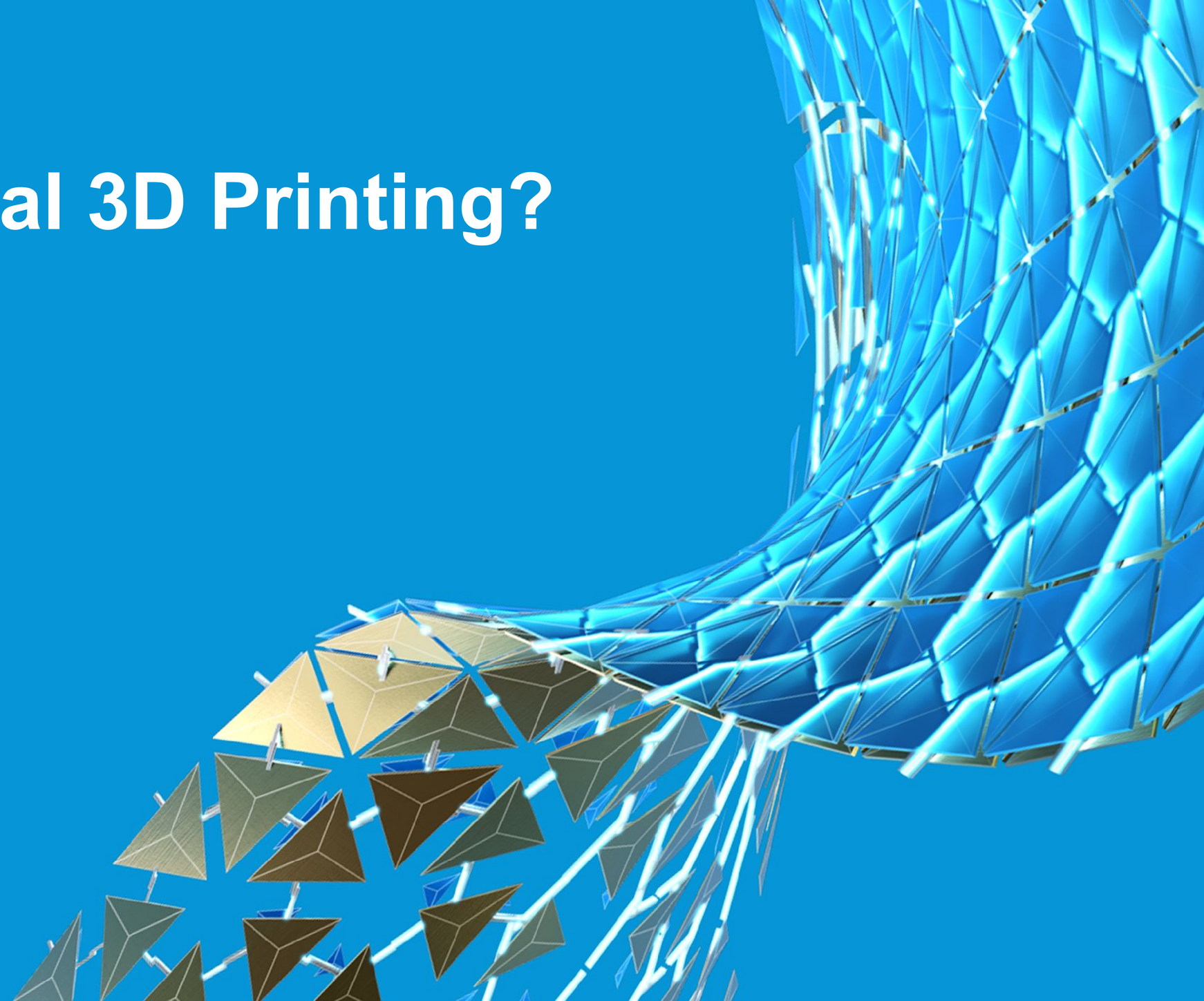
How To Redesign Parts For Metal 3D Printing

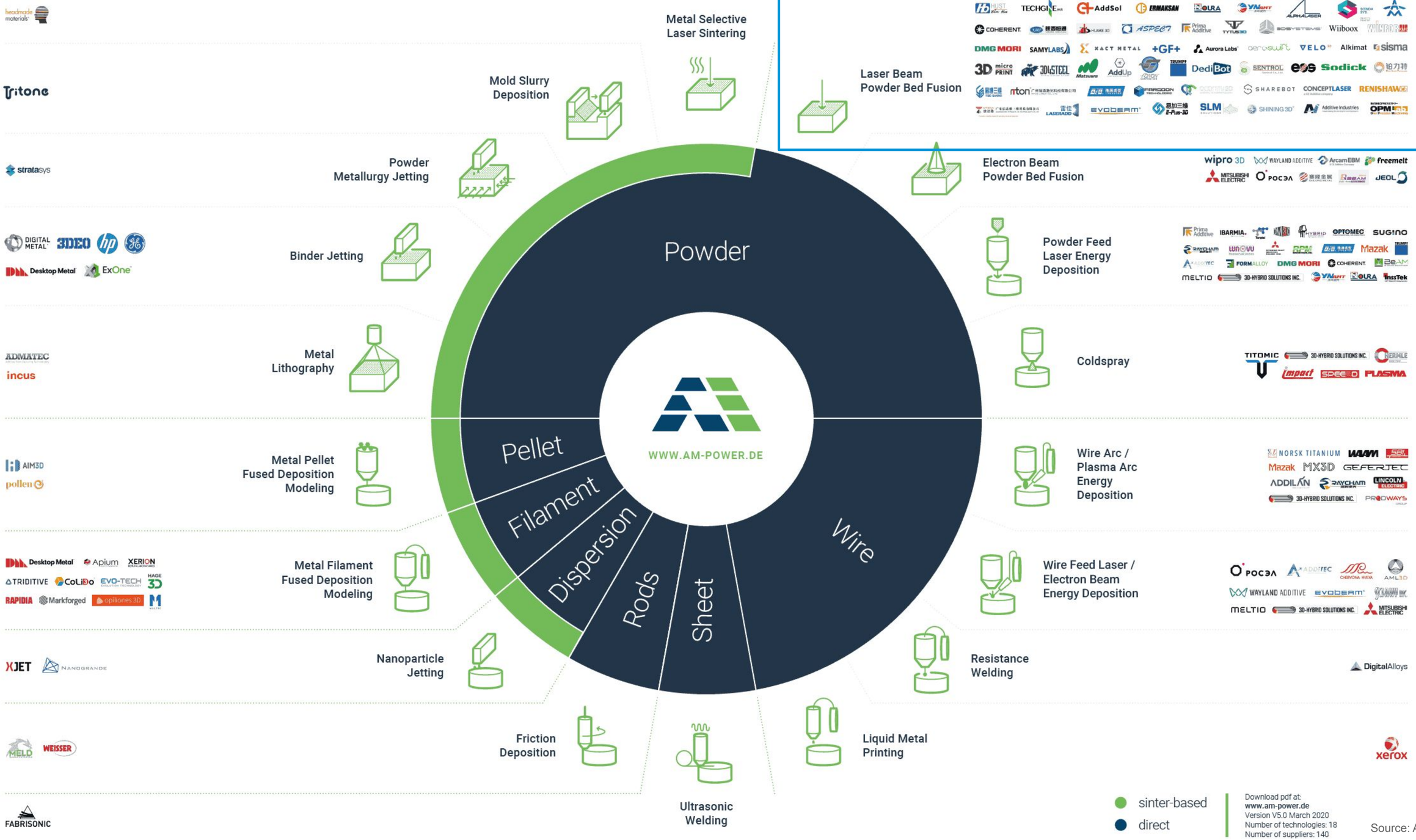
What do you learn? In this class, you will learn **how to best identify parts for redesign**.You'll learn the **limits and possibilities of metal AM**.

How do you learn it? You will receive a few examples and then **see in Fusion 360 software how to redesign the parts keeping design-for-manufacturing (DFM) rules** for metal additive manufacturing (AM) in mind.

What's the goal? The goal is to redesign the parts **using simple operations in Fusion 360** to see that you **don't need an organic topology optimized part to get an economical use case**.

I. What Is Metal 3D Printing?




Powder
Pellet
Filament
Dispersion
Rods
Sheet
Wire
WWW.AM-POWER.DE
Laser Beam Powder Bed Fusion
Metal Selective Laser Sintering
Mold Slurry Deposition
Powder Metallurgy Jetting
Binder Jetting
Metal Lithography
Metal Pellet Fused Deposition Modeling
Metal Filament Fused Deposition Modeling
Nanoparticle Jetting
Friction Deposition
Ultrasonic Welding
Liquid Metal Printing
Resistance Welding
Wire Feed Laser / Electron Beam Energy Deposition
Wire Arc / Plasma Arc Energy Deposition
Coldspray
Powder Feed Laser Energy Deposition
Electron Beam Powder Bed Fusion
sinter-based
direct
Download pdf at:
www.am-power.de
Version V5.0 March 2020
Number of technologies: 18
Number of suppliers: 140
Source: AMPOWER

Metal 3D Printing | The Process Landscape

There are 18 different processes...

...to print metal 3D parts. LPBF or laser powder bed fusion is the most adapted and most mature manufacturing technology.

So, what is LPBF?

LPBF is an additive manufacturing process that uses a laser to melt thin layers of powder. Once the layer is solidified, a new powder layer is spread, and the process repeats until the part is created.

Synonyms (because LPBF has a lot of names)

SLM - Selective laser melting

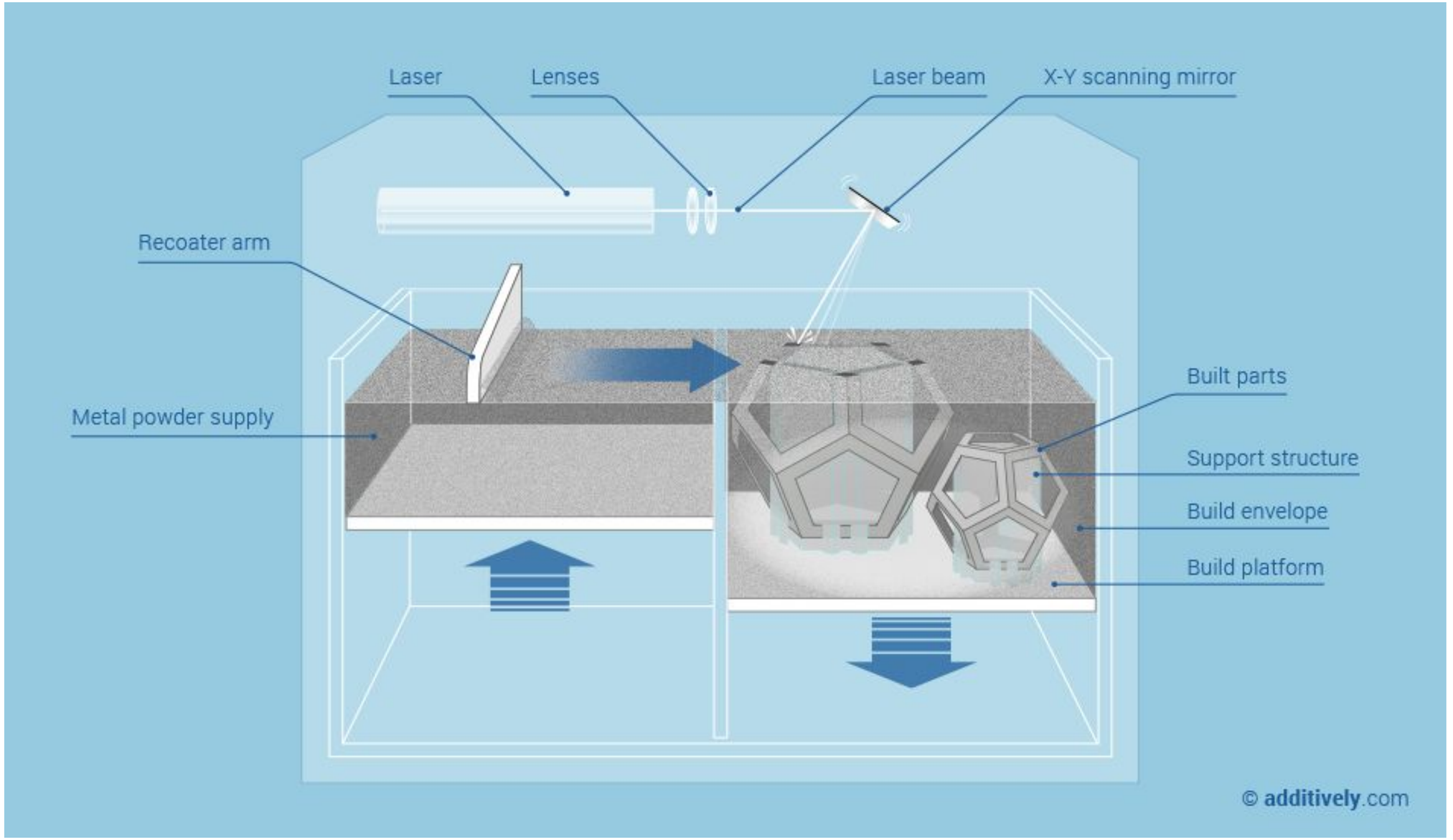
DMP - Direct metal printing

LMF - Laser metal fusion

DMLS - Direct metal laser solidification

Laser Cusing

LPBF | How Does It Work?



The LPBF-Process

Step 1

CAD Design

- Designing your parts with AM rules and build direction in mind

Step 2

Data Preparation

- Placing and orienting your parts in the build envelope.
- Placing supports
- Assigning process parameters

Step 3

Printing Process

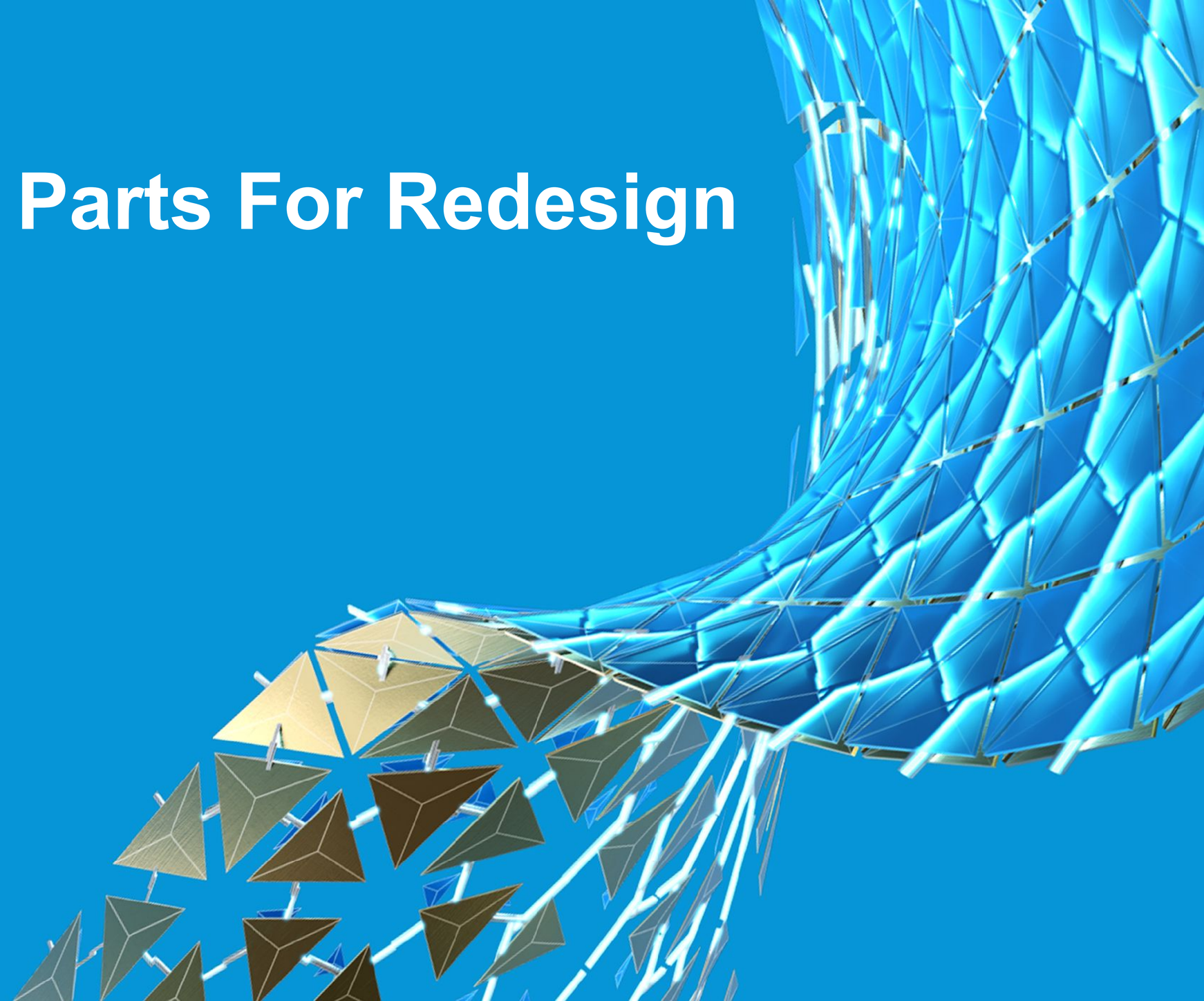
Fusing the part layer by layer onto the build plate

Step 4

Unpacking and Postprocessing

- Removing the powder
- (heat treatment)
- Remove parts from build plate
- Remove support
- blasting
- CNC Machining

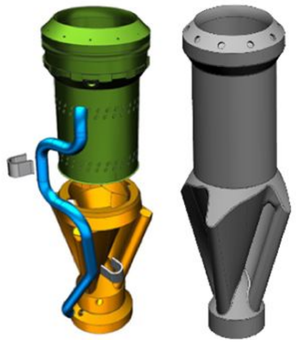
II. Identifying Parts For Redesign



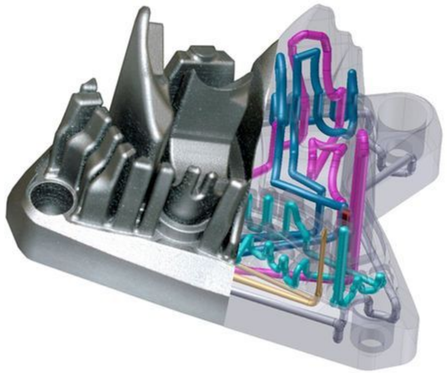
What Are Suitable Parts Or Assemblies?

HIGH DEGREE OF MACHINING

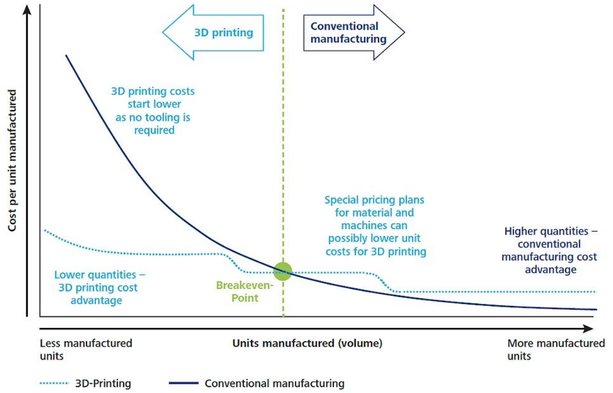
ASSEMBLIES WITH MANY PARTS



PARTS WITH INTERNAL CHANNELS



LOW VOLUME PARTS



High Degree Of Machining

Parts that have a high degree of machining are a good candidate for 3D printing in general. The cost of printing the part can easily be lower than conventional manufacturing processes.

Components made from high strength alloys like Inconel or CoCr alloys can be printed first and are only machined on functional surfaces to reduce tool wear.

Small inaccessible features can usually be printed very easily.

Source: IOT Business News

Assemblies With Many Parts

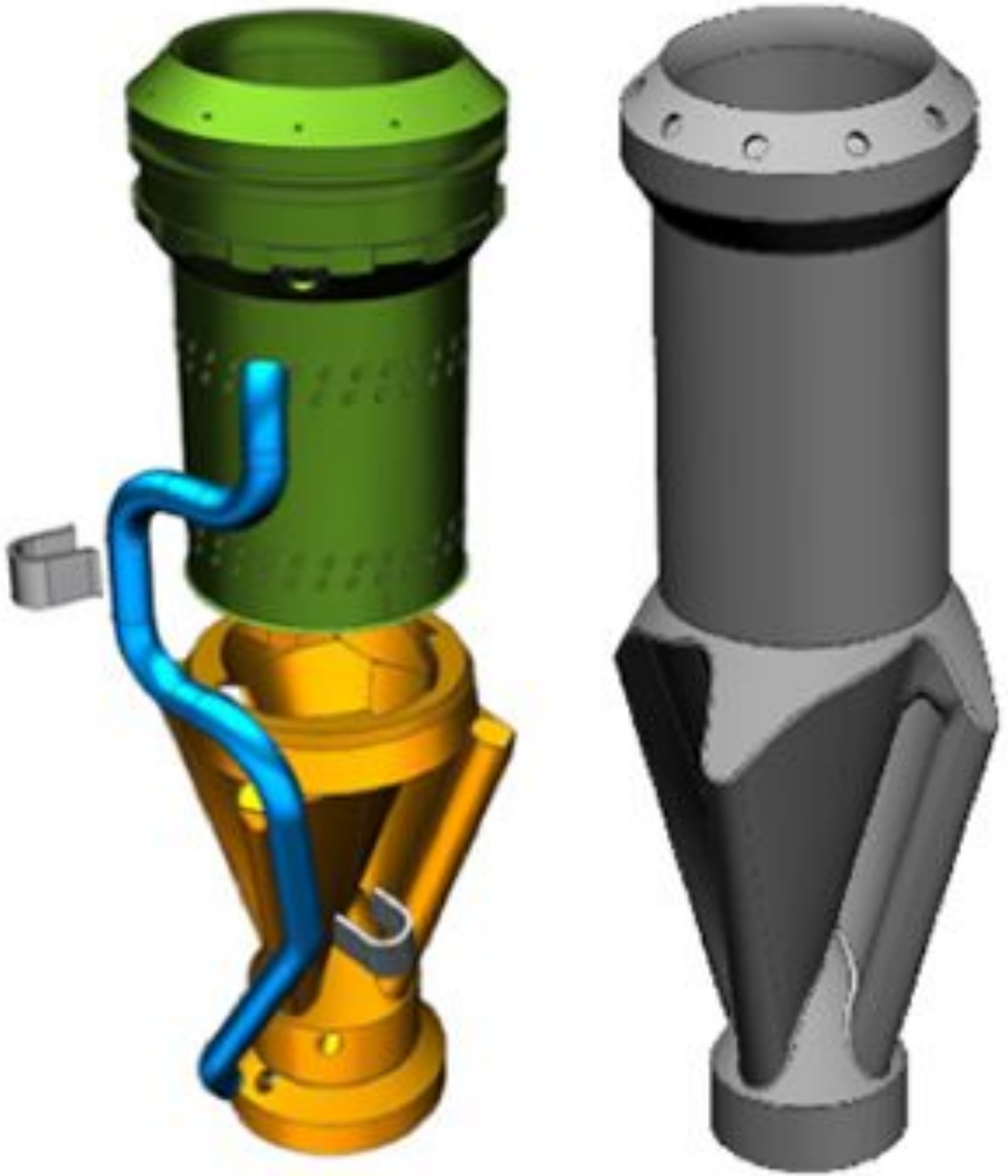
Combining many parts into one gives you two advantages:

1. You have less parts to handle
2. You have less joining operations

→ Reduced handling and quality control efforts

Example:

Siemens burner head 13 parts combined to one



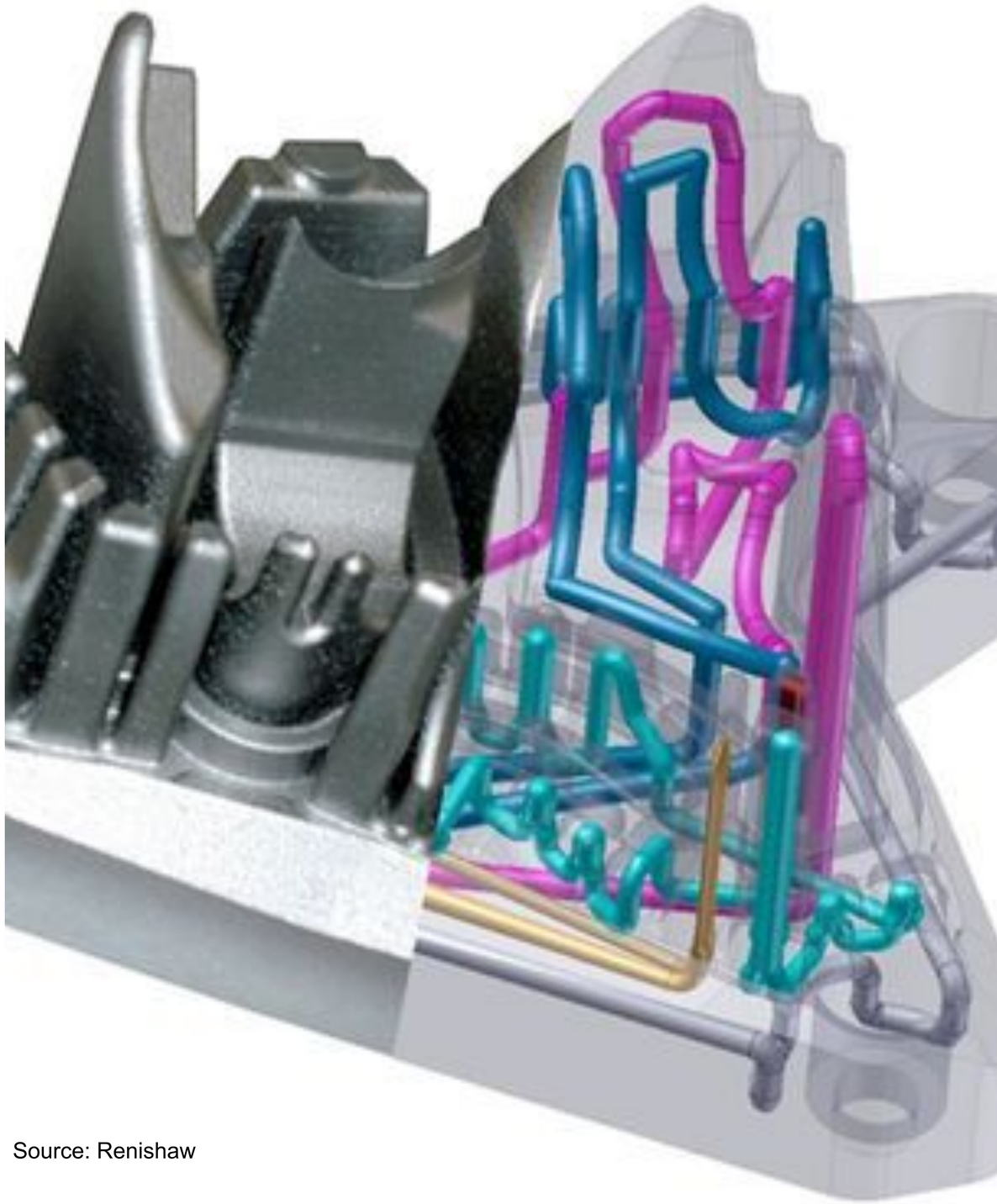
Source: Siemens AG

Parts With Internal Channels

Components that have internal channels are good candidates for metal 3D printing.

Tooling:
One example are injection molding toolings. With cooling channels close to the contour of the part the cycle time can be reduced significantly. Therefore a more expensive tooling can be justified

Manifolds:
In Manifolds the distribution of the fluids can be handled better. The pressure drop can also be optimized.

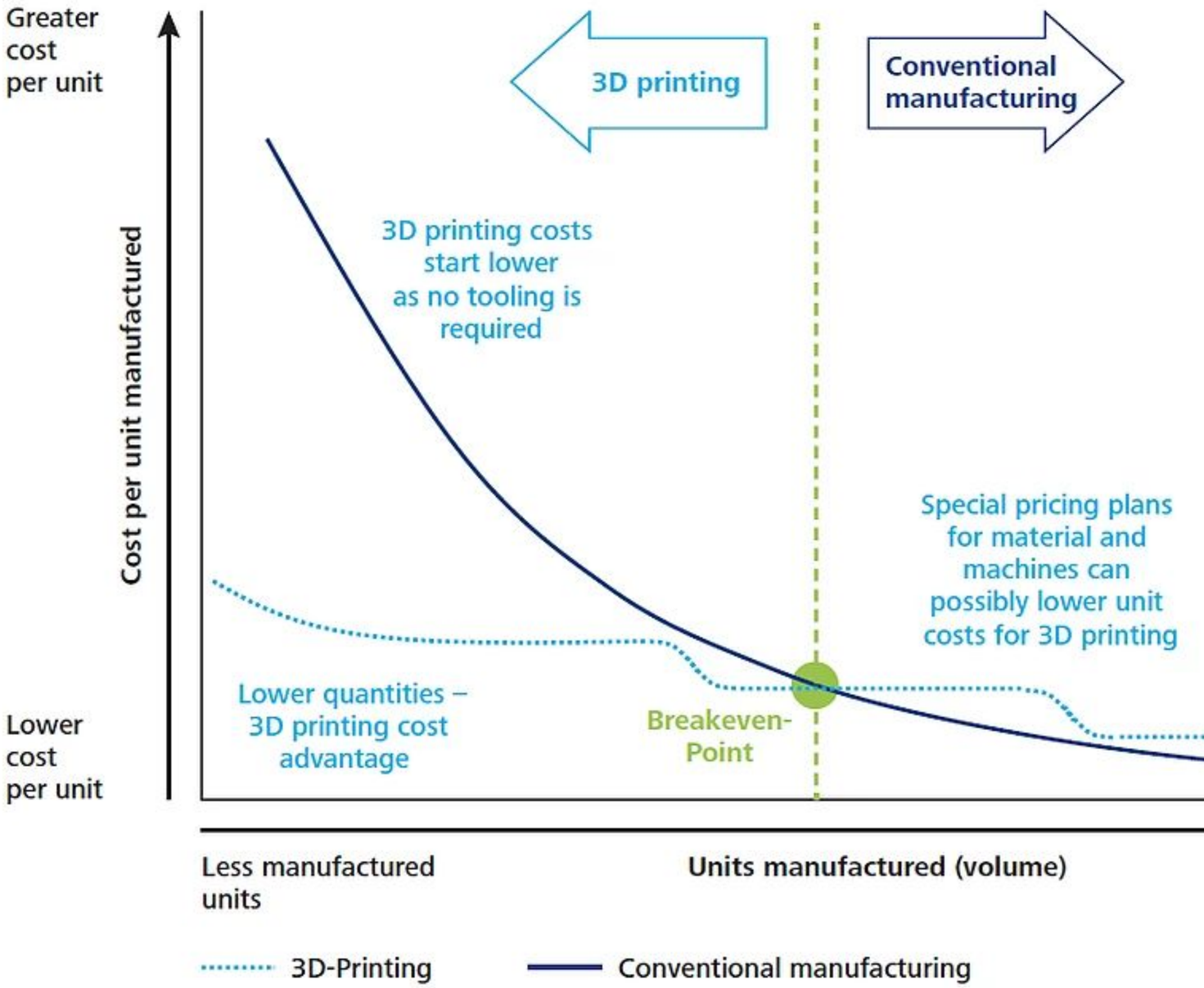


Source: Renishaw

Low Volume Parts

Especially for low volume production 3D printing can be much more economically viable since it is a tool free process.

Often the lead times can also be significantly reduced using metal 3D printing.



Source: Deloitte

Optical connector

Receptacle for a fiber connector that transmits a high power laser beam.

Tooling for feeding system

The tooling conveys and orients components in a vibratory feeding system

Optical connector

The connector is used in the MPRINT metal 3D printer to receive the optical connector that transmits the laser power to the welding optics.

Original motivation for redesign:

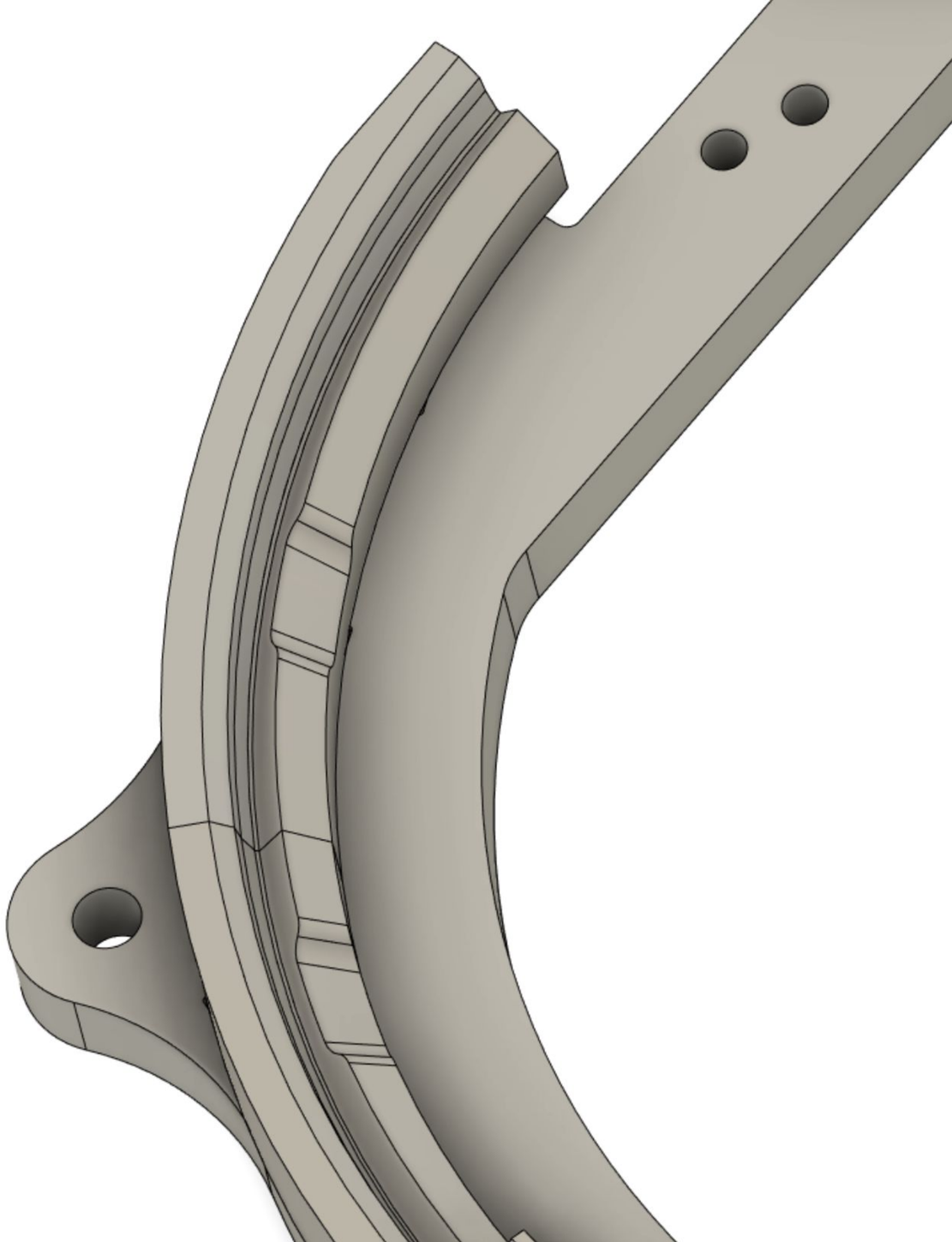
- **Long lead time**
- **high price**

- **Parts with internal channels**
  - assembly has an internal cooling channel
- **Assembly with many parts**
  - 8 parts used in assembly
- **Low part volume**
  - only a small amount of parts is needed
  - parts were needed very quickly

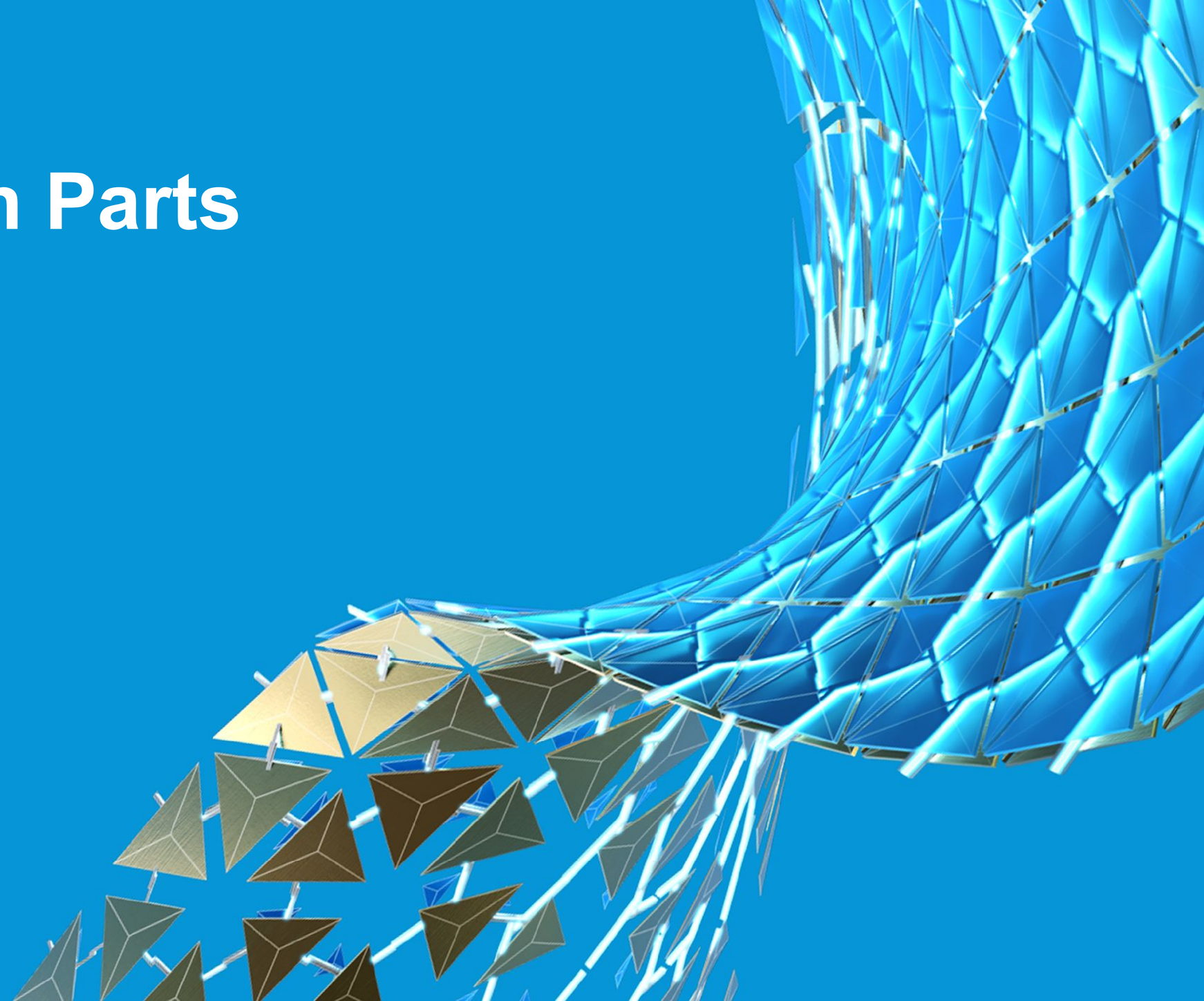
Tooling for feeding system

The tooling is used in feeding systems of the Hoffmann and Stirner GmbH to feed and orient bearing housing components into an assembly machine.

- **High degree of machining**
  - Typically machined on 5-axis machine out of a large tool steel block
- **Assembly with many parts**
  - 2 parts used in assembly
- **Low part volume**
  - only one part required per tooling set

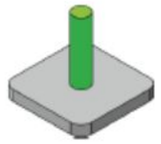


III. Redesign Parts



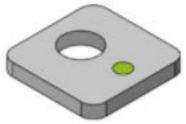
Why redesign at all?

Just like any other manufacturing process there are design guides also for LPBF which you should follow in order to achieve good results. You need to tailor your part for the manufacturing process.



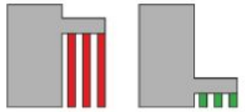
Minimum Pin Diameter / Minimaler Pin Durchmesser

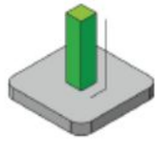
0.5 mm Ø



Minimum Hole Size / Minimale Lochgrösse

0.8 mm Ø

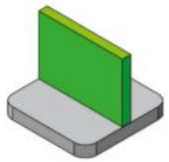




Height:Width (Aspect) Ratio / Höhe:Breite (Seiten-)Verhältnis

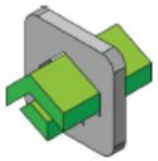
8:1

- 0 to 40 degrees: Need supports
- 40 to 65 degrees: Supports not needed but part may have poor surface on down facing surfaces
- Greater than 65 degrees: Supports not needed; good quality surface finish



Minimum Wall Thickness / Minimale Wandstärke

0.4 mm



Minimum Clearance / Minimaler Zwischenraum

0.3mm

Source: One Click Metal - Design Guide

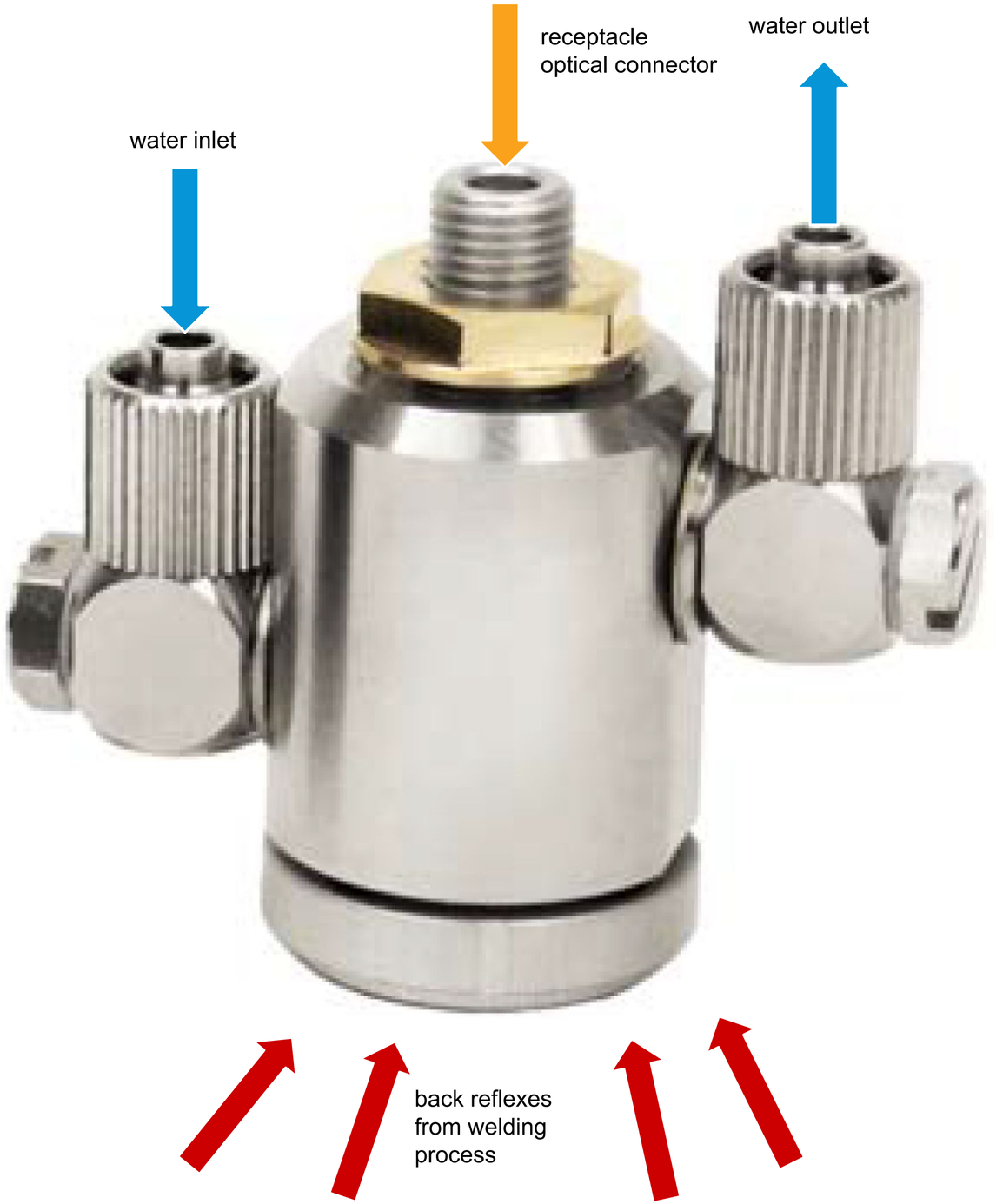
Optical connector

During the welding process laser light is reflected back from the melt pool into the optics. The water cooler around the optical connector prevents cooles away this excess energy.

Assembly:

- casing
- inner core
- 2 O-rings large
- 2 angled connectors from SMC
- 2 hollow screws for angled connector
- optical connector
- 2 O-rings small
- nut to hold the cooler

→ 12 components



First redesign

The first redesign tried to mimic the original shape an
was only optimized for the printing process however
NOT for any post processing steps.

Issues with component:

- not tool runout for tapping
- only 4 components combined

Videolink: https://youtu.be/tYQJ-yT9sAg

Start from scratch! What are your functions?

ABSORBING LASER LIGHT

The cooler should absorb laser light on its internal surface to dissipate the heat from the connector.

RECEIVE AND OFFER A LIQUID

The liquid needs to be taken in at one point of the assembly and needs to leave it at a different point. These points should point upwards.

FIT INTO SAME ASSEMBLY

The focus laid on the cooler itself so it needed to fit over the original laser receptacle.

TRANSMITTING HEAT TO LIQUID

In order to get rid of the access energy the cooler needs to efficiently transmit the heat to a liquid.

ROUTE LIQUID

The assembly needs to route the liquid between the inlet and outlet

Second redesign

The second redesign was focused on producing the whole cooler as one AM optimized component but it still had some issues

Fixed issues to previous component:

- tool runout for tapping
- 6 components combined
- added additional features to increase laser absorption
- roughly 30% cost saving

Remaining issues with component

- no clamping points for 3 jaw chuck
- not capable to machine on our machines
- only 6 components combined

Videolink: https://youtu.be/J5m6Z4fPNBw

Third redesign

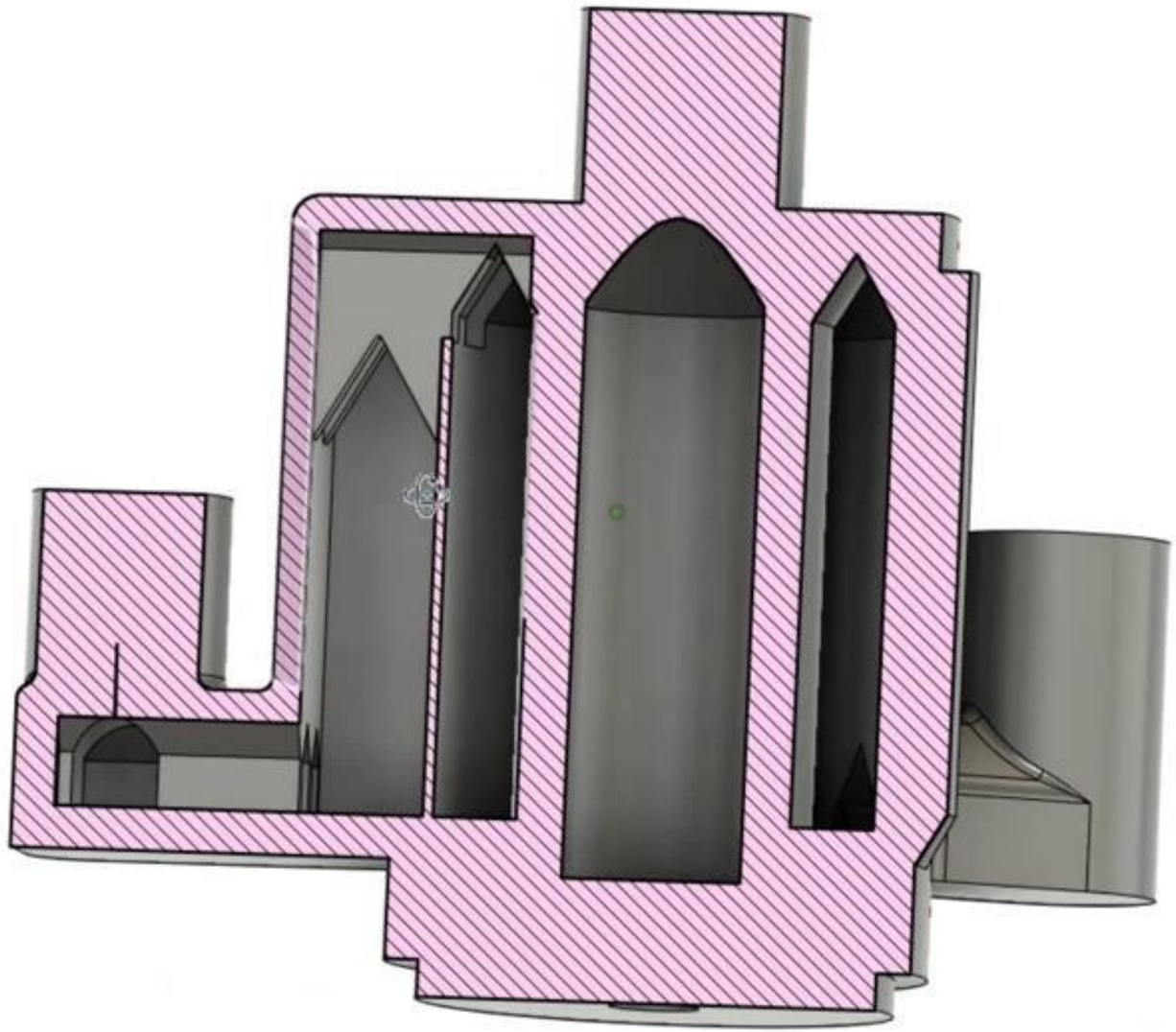
The third redesign is going to incorporate also the optical receptical to

Fixed issues to previous component:

- better cooling
- 12 components combined
- clamping points integrated

Remaining issues with component

- machining still required



Videolink: https://youtu.be/F8hYk1Q9Nag

Tooling for feeding system

The tooling is used in feeding systems of the Hoffmann and Stirner GmbH to feed and orient bearing housing components into an assembly machine.

- **High degree of machining**
  - Typically machined on 5-axis machine out of a large tool steel block
- **Assembly with many parts**
  - 2 parts used in assembly
- **Low part volume**
  - only one part required per tooling set

Videolink: https://youtu.be/VzF6o3QUnns

Source: Hoffmann & Stirner GmbH

What are your functions and requirements?

PROVIDE CONVEYING SURFACE

The 3d printed tooling has to provide the same geometrical features to assure propper conveying and sorting of the components

FIT INTO SAME ASSEMBLY

The new tooling components needed to fit into the original assembly.

FASTER LEAD TIME

Lead time was 2-6 weeks. Especially for changes this was a long process.

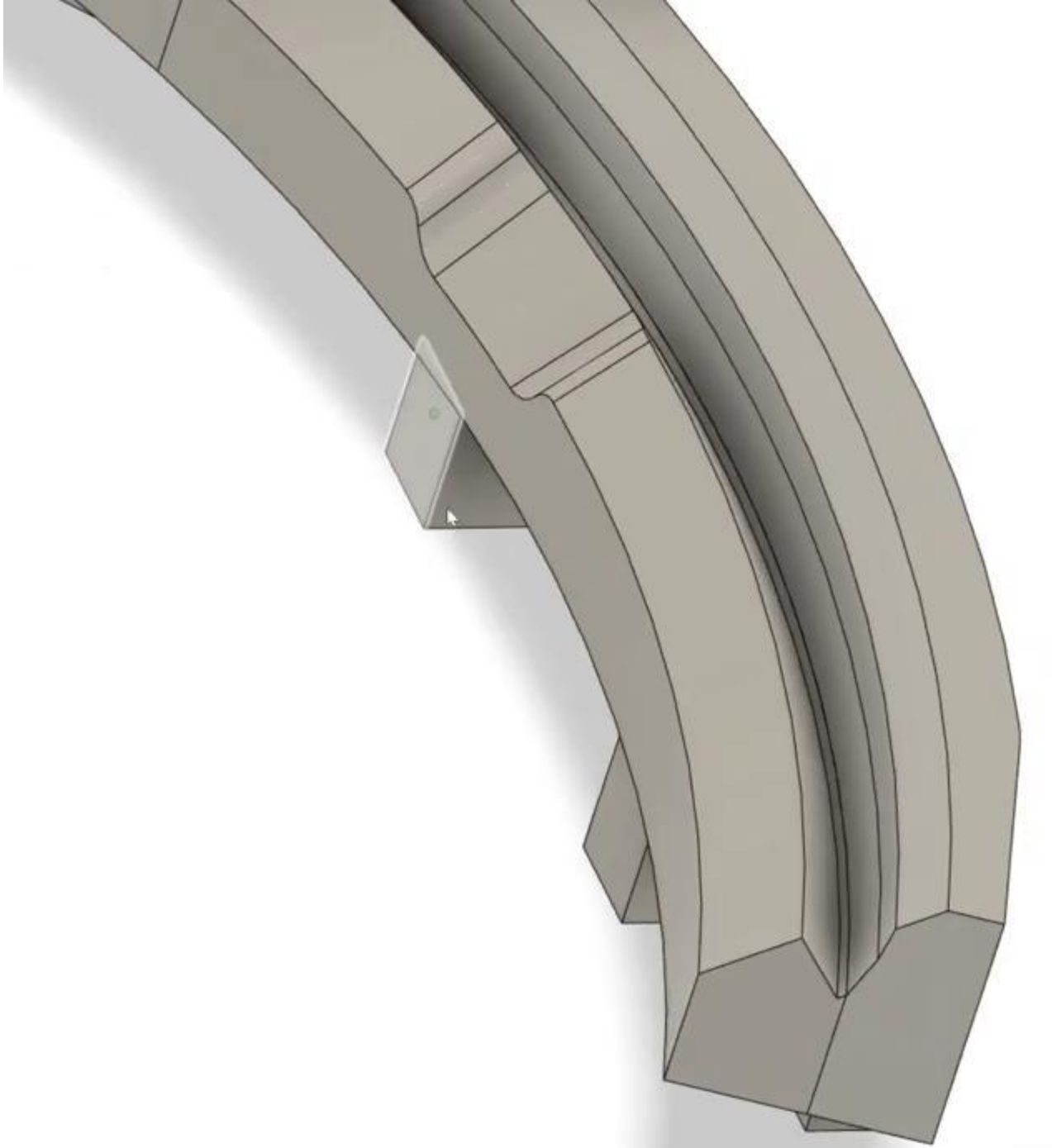
QUICK REDESIGN STEPS

Redesign needed to be quick so all elements of the tooling can be redesigned quickly.

Original Parts

We will focus on the last segment in the tooling since it holds the most potential.

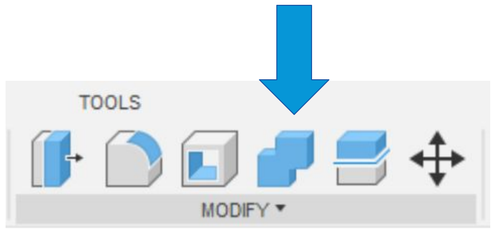
- complicated to machine
- two components
- easy to fit into build envelope

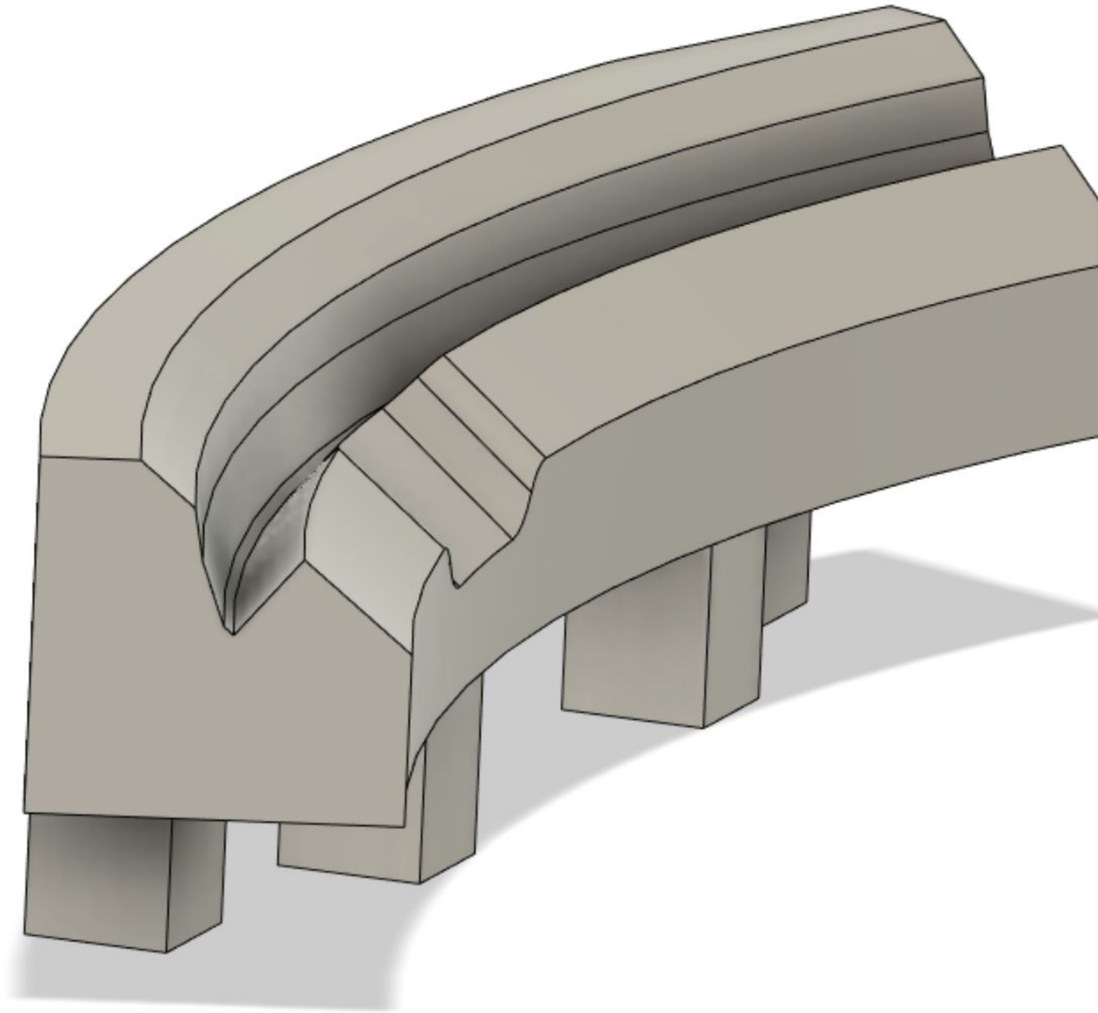


Videolink: https://youtu.be/1S6a9_e1G3w

Combining the parts

Using the combine feature the two parts were combined as the functional surface was only split to allow easy machining





Removing excess geometry

We have to remove excess geometry until you are left with only your functional surfaces.

- removing fixturing studs
- mark connection points for later
- remove bulk geometry

→ We are left with only our conveying surface

Videolink: https://youtu.be/ZS4k5Zxla94

Adding mounting points

Now we have to add new mounting points to the part

- add two studs
- remove any excess geometry
- cleaning up the studs

→ We could say we are done now but there is more

Videolink: https://youtu.be/NNP18uu2MSQ

Adding supports

Now we can add support structures that aid during the printing process and also stiffen up the part

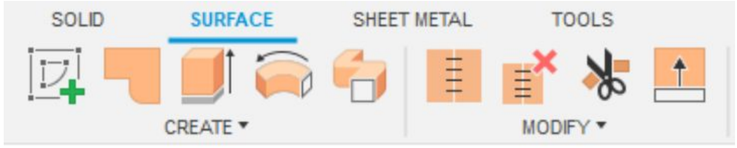
- adding support to upper mounting point
- hollowing support
- rounding of connection point

→ done

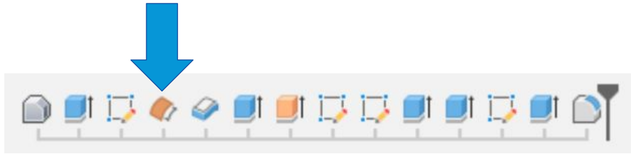
Videolink: https://youtu.be/0lfz9l2EqcA

Other techniques

Sometimes simple push and pull extrusions are not sophisticated enough or the part is too complex. In this case working with surfaces is a good choice



Offset



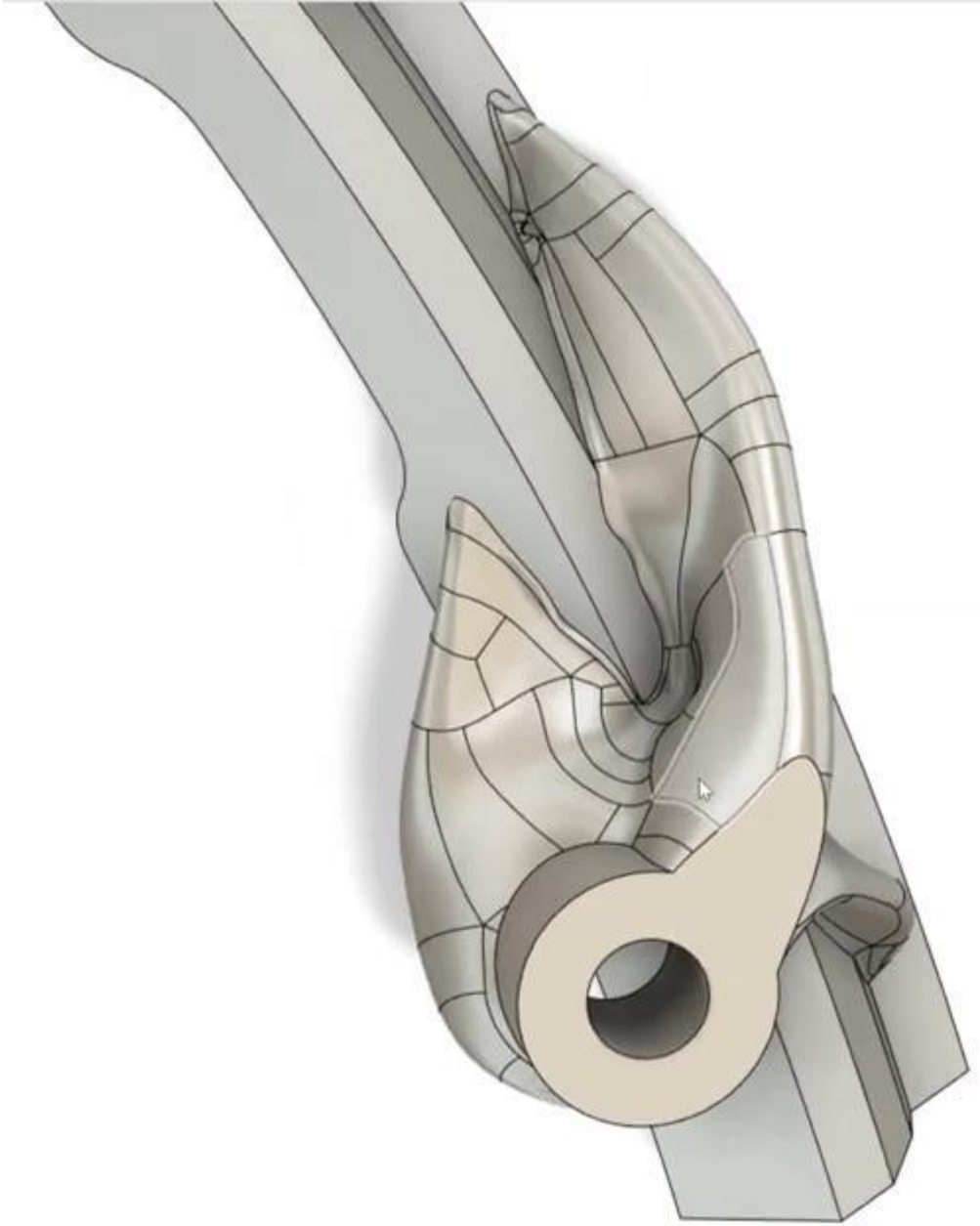
Videolink: https://youtu.be/iKFi-yAULqs

Using generative design

Using generative design can speed up the process for more complicated geometries.

Facts for this component:

- much stiffer part
- only about 7% heavier
- already optimized for printing direction



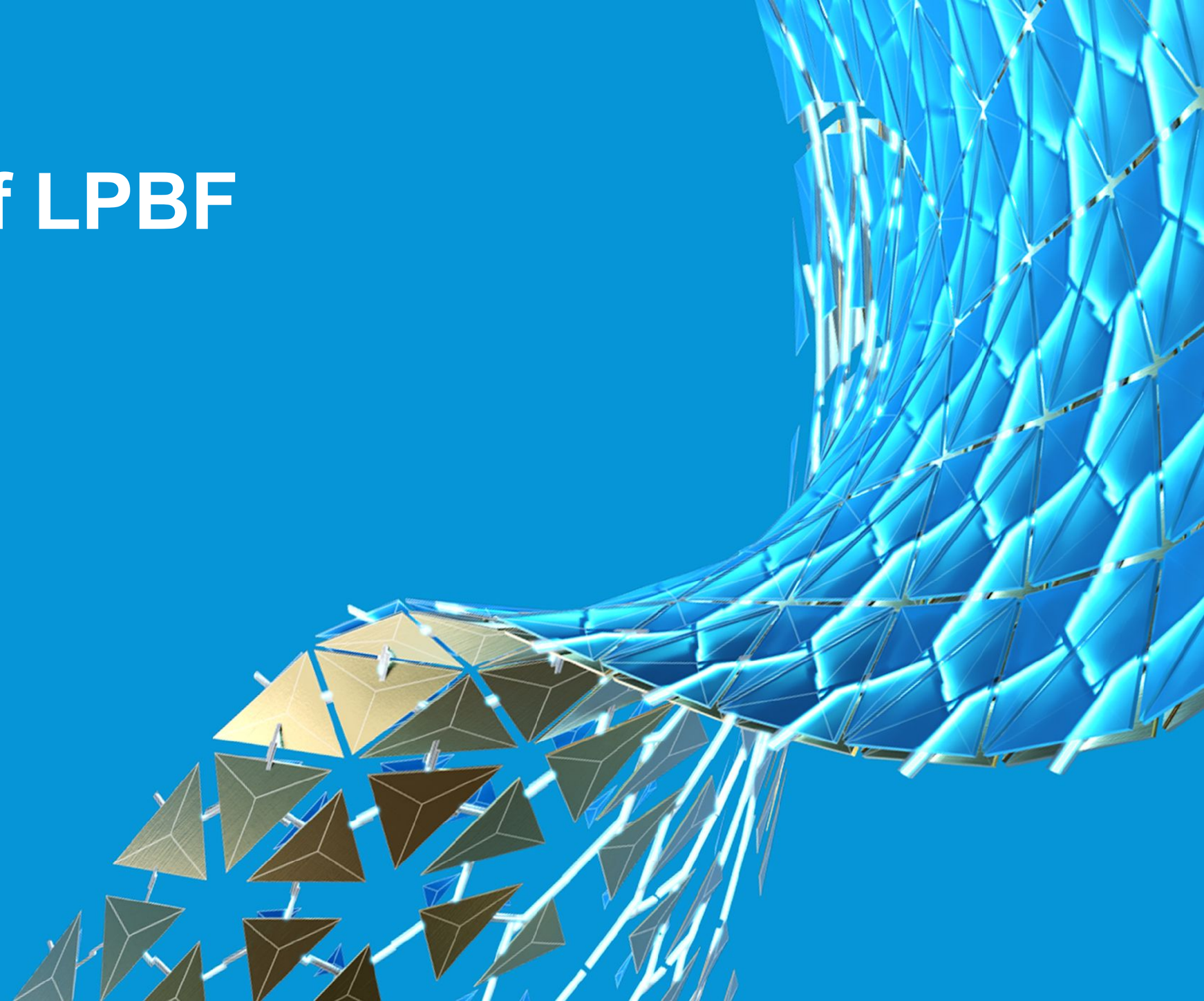
Videolink: https://youtu.be/cRdI4OQwK3A

Results using AM:

Facts for this component:

- drop in replacement for original part
- significantly shorter lead time (4 days)
- cost saving about 50% compared to machining
- more flexibility in surface design for future parts

IV. Limits Of LPBF



KNOWING THE LIMITS

PART QUANTITY

L-PBF is good for single part to medium lot production. (~10k parts per year). However it has not YET reached capabilities of mass production.

PART VOLUME

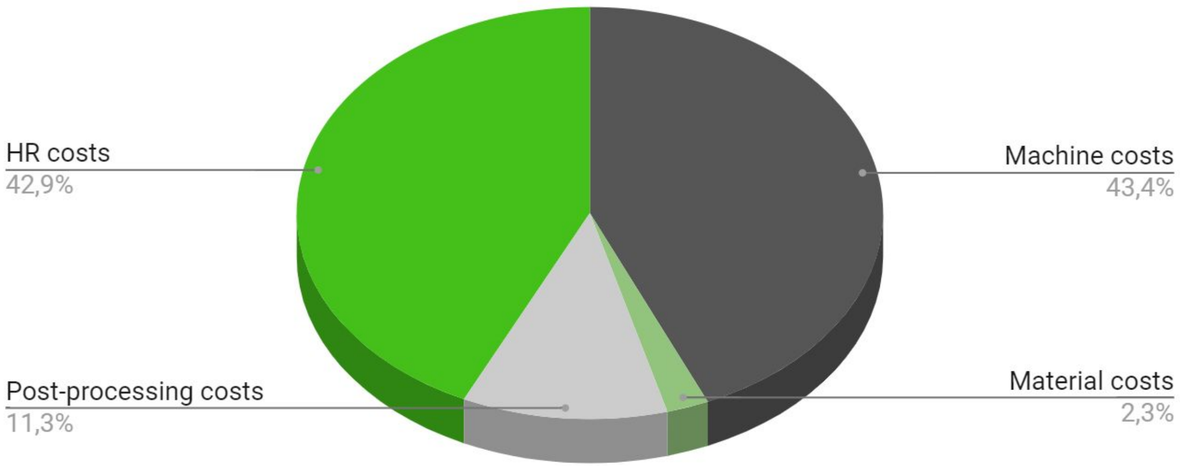
The larger you part the longer the buildjob and the more likely it is the build will fail. Also the larger the part the larger the machine. The welding process is much harder to controll in a larger machine.

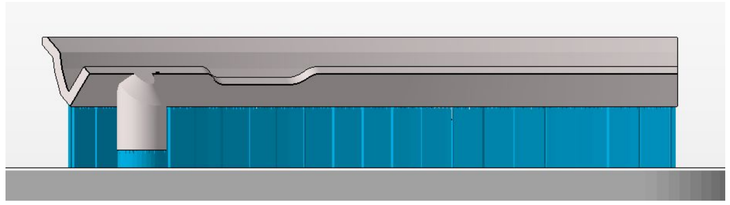
OVERHANGS

While it is said that you get “complexity for free” this only accounts for certain complexity. There are still limitations regarding overhangs which need supports.

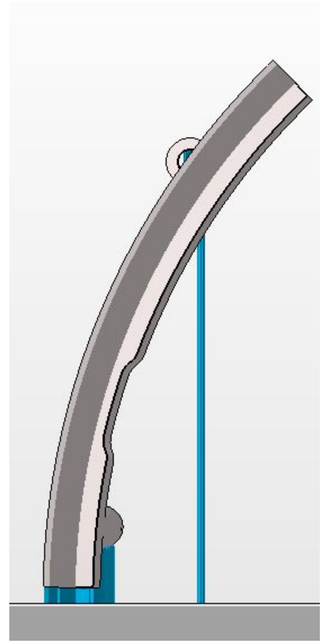
PROCESS CHAIN

The printing of the part is only one step in the process chain and also only accounts for a part of the cost.





12h



17h

Cost of tooling part

In case of the tooling not even half of the cost is caused by the printing itself. This example was calculated ONLY printing one part on the build plate. The cost per part is lower when you fit more parts in to one build job.

Part orientation

- printing your part flat saves printing time
- printing it standing up saves time during post processing
- balance between cost of printing and cost of support removal

Thank you