DESIGNGUIDE

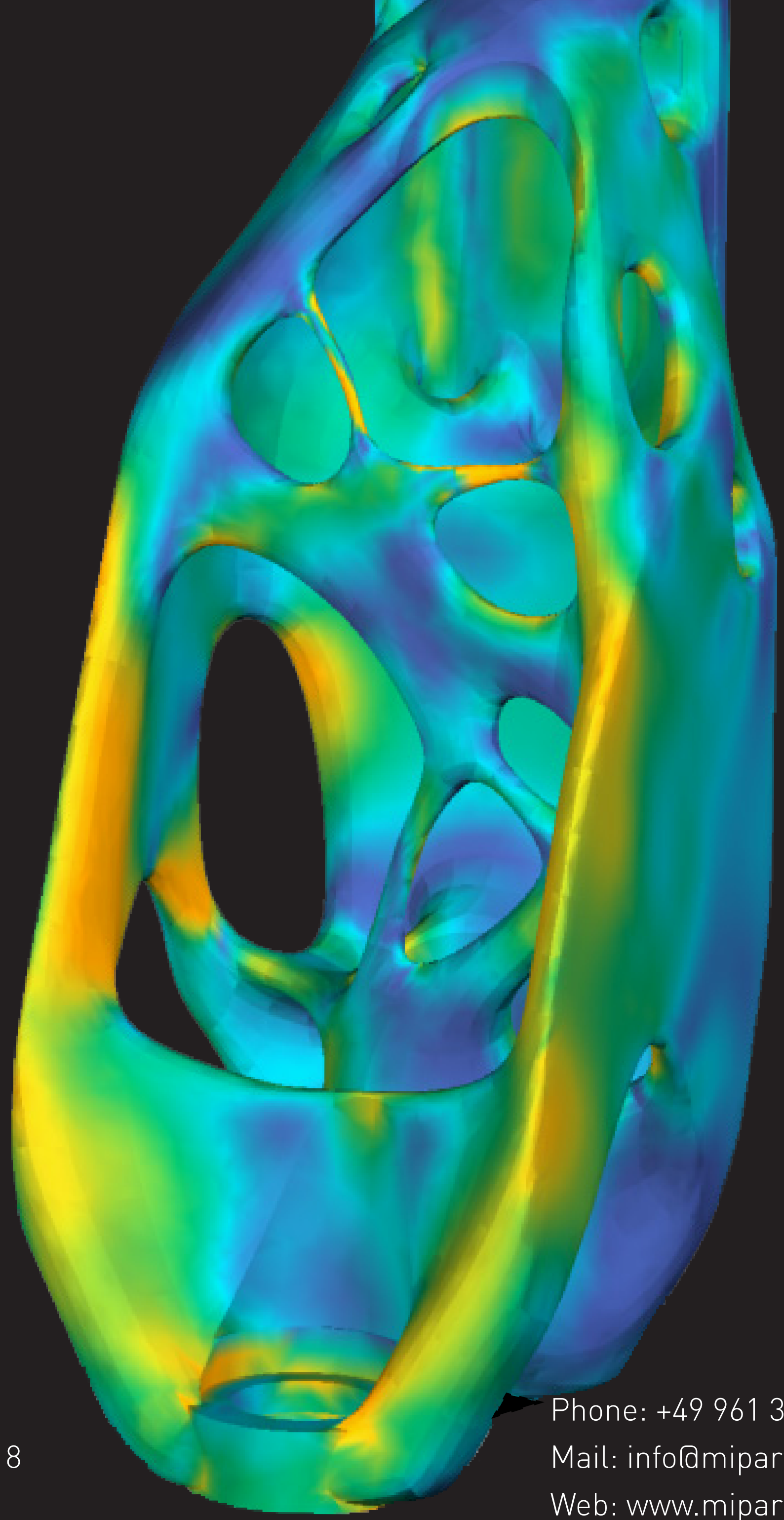
COMPARISON OF PROCESSES

COMPARISON OF MATERIALS

DESIGN GUIDELINES

SURFACE TREATMENT

SURFACE PROPERTIES



mipart
on demand manufacturing

mipart GmbH
Unterer Markt 18
92637 Weiden

Phone: +49 961 388377-0
Mail: info@mipart.com
Web: www.mipart.com

THE PERFECT COMPONENT

3D printing **has a wide variety of applications,** for instance in rapid prototyping or production of small batches. It has become indispensable to numerous**industries,** such as aerospace or the medical industry.

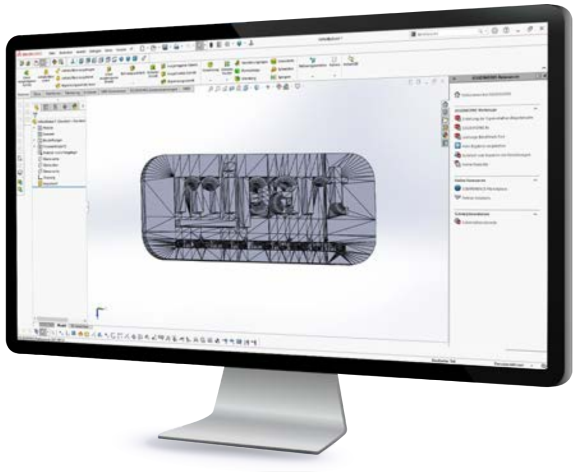
In light of the huge variety of processes and materials that are available, it is important to take the following aspects into account when making your selection to achieve the best result for your component:

- the required **material properties:**
  e.g. rigidity, heat resistance, impact resistance, water absorption, biocompatibility
- the desired **function** of the component or its application:
  e.g. functional integration such as moving assembly groups, interior channels, light-weight construction thanks to lattice structures or infill
- the **appearance:**
  e.g. surface roughness, color, visibly removed support structures
- the possible applications of the **process in question:**
  e.g. component size, tolerance, details of features

STL OR STEP

STL

This file format **only describes the surface of the model using triangles placed next to each other,** i.e. it does not described e.g. a ball but a grid of individual triangles with coordinates.
If it becomes necessary to optimize your model (e.g. the triangulation) to achieve a better printing result, this is not possible.
Conversion to STEP is not straightforward and will lead to a loss of information.



STEP

Unlike .STL, this file format displays the created model as an element. .STEP permits more complex transfer of product data than .STL, e.g. topology. If it becomes necessary to optimize your model (e.g. the triangulation) to achieve a better printing result, this is a simple process.
Conversion of STEP to STL does not lead to loss of information.

WHAT IS THE RECOMMENDED FILE FORMAT

mipart accepts the file formats .STL and .STEP for all 3D printing methods. However, due to the above-mentioned option of retroactive optimization, we recommend the STEP format.

COMPARISON OF METHODS

	FDM (Fused Deposition Modeling)	Polyjet (Material Jetting)	Multi Jet Fusion (Polymer Powder Bed Fusion)
Description of the method	In the FDM method, the filament is unwound from a coil and inserted into a heatable extruder. There it is heated, melted and vertically applied to a build plate under pressure, layer by layer, until the desired object is created.	Polyjet is a portmanteau of "Photopolymer Jetting" and is a combination of conventional ink jet technology, as is used in ink printers, with the use of liquid synthetic resins. During the 3D printing process with Polyjet, liquid photopolymers are applied to a build plate in droplets layer by layer and hardened by UV light.	In the MJF method a print head applies millions of tiny polymer powder particles to a heated powder bed where a binding agent is used to fuse them into the desired component contours. They are then hardened by UV light. After a cooling process, the particles are removed from the powder bed and any adhering powder is removed without residues.
Tolerances	+/- 0.2 mm	+/- 0.1 mm	+/- 0.3 mm
Minimum component size	5 x 5 x 5 mm	5 x 5 x 5 mm	5 x 5 x 5 mm
Maximum component size	406 x 355 x 406 mm	480 x 380 x 190 mm	380 x 284 x 380 mm
Feature details	0.5 - 2.0 mm	0.4 mm	0.5 mm
Materials	ABS-M30 PC-ABS PC FDM Nylon12 FDM Nylon12CF ULTEM 1010 resin ULTEM 9085 resin Antero 800NA	Digital-ABS PLUS Vero Clear Vero (7 colors) Tango Plus	Polyamide PA12
Surface treatment		Light manual surface polishing	Glass bead blasting (standard) Colored black
Surface quality (depending on orientation)	Ra 8.5 / Rz 87	Ra 5.5 / Rz 28	Ra 4 / Rz 24

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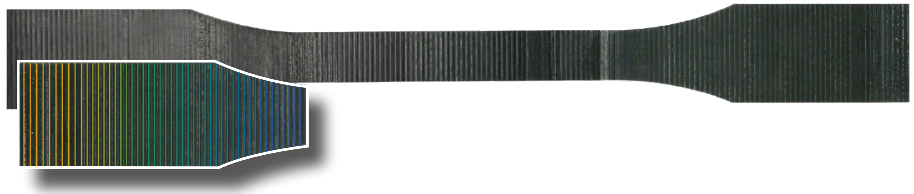
COMPARISON OF METHODS

	FDM (Fused Deposition Modeling)	Polyjet (Material Jetting)	Multi Jet Fusion (Polymer Powder Bed Fusion)
Special features	• Large variety of materials, for instance FDM thermoplastics which meet the requirements of firmness, biocompatibility, fire protection or inflammability, smoke and toxicity classes. • Less suitable for moving components or components with complex geometries. • Rougher surface quality due to lower minimum layer thickness compared with other methods and possible effect on appearance due to removed support structures. • Firmness and rigidity can be increased by laminating carbon or glass fibers	• Excellent precision with tight tolerances and high level of detail. • Various material combinations of different plastics possible. • Different Shore values: from firm to rubber-like. • Selection of wide range of colors for multi-color printing with smooth surface. • Transparency, including in color	• High density and low porosity compared to laser-sintered components. • Production of components with isotropic properties and very high levels of detail. • Extremely thin layers with excellent surface quality. • Less suitable for components with large surfaces and flat components. • Build-up without support structures
Conventional applications	• Concept studies • Functional prototypes • Manufacturing tools • End uses	• Manufacturing of smooth, detailed prototypes that show the appearance of the final product • Precise forming tools, jigs, original molds, assembly devices and manufacturing tools • Detailed miniature reproductions of objects, humans and animals • Production of seals directly on the component is possible by adjusting the Shore hardness values • Production of movable components	• Functional prototypes & small series, e.g. snap locks, hinges • Production of complex geometries • Production of complex functional components in low quantities • Low-cost alternative to injection molding

TENSILE

Due to the layered structure, the properties of materials are anisotropic in some methods. Anisotropic means that the material behavior in the build-up direction, that is in the Z axis, differs from the behavior in the X/Y direction.

This phenomenon is particularly important for considering firmness, as the firmness at the layer level (indicated as XZ) is higher than the firmness between layers (ZX). The reason for this is adhesion between layers



MULTI JET FUSION MATERIALS

Plastic	Colors	Characteristics	Tensile strength	Elongation at break	Bending strength	Heat resistance (at 264psi)	Water/moisture absorption
Polyamide PA12	gray	• High robustness • High impact strength • Good sliding properties • High fatigue strength • Ideal for snap-fits • Good chemical resistance	XZ: 48 MPa ZX: 48 MPa	XZ: 20% ZX: 15%	XZ: 70 MPa ZX: 70 MPa	95°C	low

COMPARISON OF FDM MATERIALS

Plastic	Colors	Characteristics	Tensile strength	Elongation at break	Bending strength	Heat resistance (at 264psi)	Water/moisture absorption	Support structure
ABS M30	ivory white black grey red blue	• high accuracy • high durability • high impact resistance • low-cost components with moderate requirements	XZ: 31 MPa ZX: 26 MPa	XZ: 7.0% ZX: 2.0%	XZ: 60 MPa ZX: 48 MPa	96°C	low	soluble
PC-ABS	black	• excellent mechanical properties • high strength and temperature resistance of PC and flexibility of ABS excellent surface structure	41 MPa	6.0%	68 MPa	110°C	low	soluble
PC	white	• excellent dimensional stability • high durability • high rigidity • Highly suitable for producing sturdy components, e.g. long-lived tools	XZ: 40 MPa ZX: 30 MPa	XZ: 4.8% ZX: 2.5%	XZ: 89 MPa ZX: 68 MPa	138°C	very low	separable, soluble
Nylon 12	grey	• High robustness • High impact strength • Good sliding properties • high fatigue strength, making it ideal for snap fits • Good chemical resistance	XZ: 32 MPa ZX: 28 MPa	XZ: 30.0% ZX: 5.4%	XZ: 67 MPa ZX: 61 MPa	97°C	low	soluble
Nylon 12CF	black	• carbon fiber reinforced with very good structural features • high breaking length • high rigidity • ideal for strong, stable and simultaneously light-weight components	XZ: 63.4 MPa ZX: 28.9 MPa	XZ: 1.9% ZX: 1.2%	XZ: 142 MPa ZX: 58 MPa	143°C	low	soluble

COMPARISON OF FDM MATERIALS

Plastic	Colors	Characteristics	Tensile strength	Elongation at break	Bending strength	Heat resistance (at 264psi)	Water/moisture absorption	Support structure
ULTEM 1010 resin	light brown	• Certified for contact with food • (NSF 51 and ISO 10993 / USP Class VI) • high temperature resistance and chemical resistance biocompatible • Suitable for use in autoclaves	XZ: 62 MPa ZX: 42 MPa	XZ: 3.3% ZX: 2.0%	XZ: 144 MPa ZX: 77 MPa	216°C	low	detachable
ULTEM 9085 resin	light brown black	• FST certificate due to high flame, smoke and toxicity values • high thermal and chemical resistance • high breaking length	XZ: 47 MPa ZX: 33 MPa	XZ: 5.8% ZX: 2.2%	XZ: 112 MPa ZX: 68 MPa	153°C	low	detachable
Antero 800NA	brown	• PEKK-based thermoplastic • excellent mechanical properties • high strength • high heat resistance • high wear resistance • light-weight alternative to aluminum and steel • high chemical resistance • fuel resistance • low gas emission • Suitable for aerospace applications	XZ: 93 MPa ZX: 46 MPa	XZ: 6.4% ZX: 1.22%	XZ: 142 MPa ZX: 64 MPa	153°C	very low	detachable

COMPARISON OF POLYJET MATERIALS

Plastic	Colors	Characteristics	Tensile strength	Elongation at break	Bending strength	Heat resistance (at 264psi)	Water/moisture absorption	Shore hardness
Tango Plus		• high oscillation and vibration damping properties • rubber-like, therefore ideal for seals, flexible components and anti-slip surfaces	0.8-1.5 MPa	170-220%	mipart prints with Shore hardness 65	40-45°C	medium	26-28 A-scale
Vero family	black white magenta yellow cyan clear	• high durability • high rigidity • Production of smooth, accurate components for tests, surgical planning or tool making	50-65 MPa	10-25%	75-110 MPa	45-50°C	medium	83-86 D scale
Vero Agilus mixture	black white magenta yellow cyan clear	• Agilus30 is a long-lived, rubber-like photo-polymer • Different Shore hardnesses are achieved by mixing it with Vero • Material combinations in one component possible	Individual choice possible based on material composition the softer, the more transparent				medium	30-100 A-scale
Digital ABS	grey	• high durability • high impact strength • high temperature resistance • excellent surface quality	55-60 MPa	25-40%	65-75 MPa	58-68°C	medium	85-87 D scale

POLYJET MATERIALS,
COMPARISON OF SHORE HARDNESS VALUES

The SHORE hardness is a classification primarily used for elastomers and rubbery-elastic polymers. It is directly related to the penetration depth and therefore indicates the material hardness.

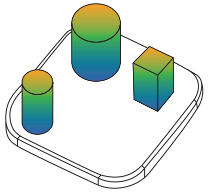
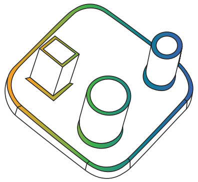
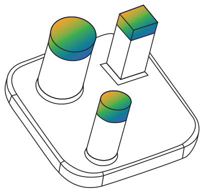
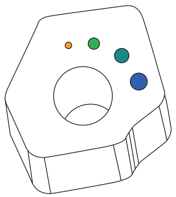
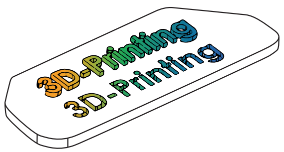
shore hardness A for soft materials like rubber
shore hardness D for hard materials

very soft

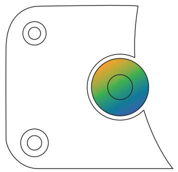
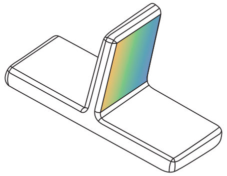
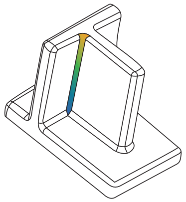
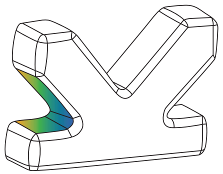
very hard

Shore A	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100					
Shore D						6	7	8	10	12	14	16	18	22	25	29	33	39	46	58	65	72	79	86	93

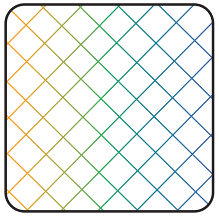
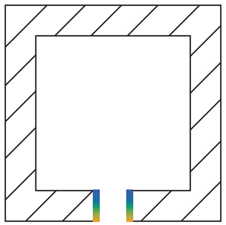
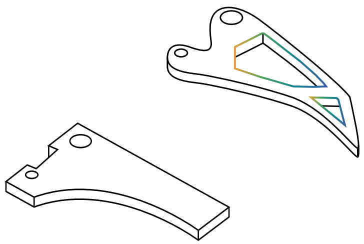
DESIGN GUIDELINES

		FDM (Fused Deposition Modeling)	Polyjet	Multi Jet Fusion
Individual elements		Smallest element size 2.8 mm	Smallest element size 0.5 mm (1.5 mm if a function is assigned to the element)	Smallest element size 0.7 mm
Minimum radil		0,5 mm	0,1 mm	0,2 mm
Tolerances		+/- 0.15% (with a bottom limit value of +/-0.2 mm)	+/- 0.1% (with a bottom limit value of +/-0.1 mm)	+/- 0.3% (with a bottom limit value of +/-0.3 mm)
Holes		>1,5 mm	>0,5 mm	>1,5 mm
Feature details (e.g. labeling)		engraved (min.): Line thickness 1.5 mm / depth 0.5 mm embossed (min.): Line thickness 2.0 mm / depth 0.5 mm	min. 0.4 mm in height and depth	min. 0.5 mm in height and depth

DESIGN GUIDELINES

		FDM (Fused Deposition Modeling)	Polyjet	Multi Jet Fusion
Moving parts		>0.4 mm radial Not possible with ULTEM and ANTERO, as breakaway support is required.	>0,2 mm	>0,2 mm
Unsupported wall thickness		0,8 mm	1 mm	0,6 mm
Supported wall thickness		0,8 mm	0,5 mm	0,6 mm
Overhangs		No less than 45° to avoid support. Support structures are removed after completion, but de-crease the surface quality in this area.	Overhangs are generally always supported. Support structures are removed after completion, but decrease the surface quality in this area.	All overhangs can be created without a support.

DESIGN GUIDELINES

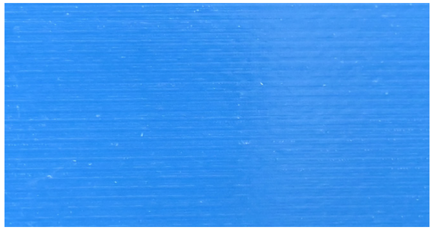
		FDM (Fused Deposition Modeling)	Polyjet	Multi Jet Fusion
Defined wall thickness/infill		Filling with lattice and honeycomb structures possible. It is possible to reduce weight and production cost by indicating the outer wall thickness and the volume by percent in the component. Savings must be weighed against rigidity.	Hollow spaces are filled with water-soluble support material.	For solid components with a large volume and exposure area per layer, it is advisable to make the components hollow. This not only reduces weight but also prevents thermal distortion.
Powder removal			If components are printed as hollow pieces it is important to include a hole somewhere. Depending on the component size, this hole should have a diameter of at least 4-5 mm. This hole is used to fully remove the water-soluble support in order to remove the component support structure.	To benefit from the weight reduction advantage, integrate powder removal holes in your design. **1 x 8 mm Ø** or **2 x 4 mm Ø** If the component is to be closed a suitable conical plug must be ordered separately.
Topology optimization		Systematic structural analysis and structural optimization can lower your manufacturing costs while simultaneously ensuring the function and quality of your products. Note anisotropic characteristics of the material.	Systematic structural analysis and structural optimization can lower your manufacturing costs while simultaneously ensuring the function and quality of your products.	Systematic structural analysis and structural optimization can lower your manufacturing costs while simultaneously ensuring the function and quality of your products.

OBERFLÄCHENBESCHAFFENHEIT

FDM (Fused Deposition Modeling)

Untreated components have a rough surface that shows the printing tracks. Due to the printing method, the material inclusion is visible in a kind of frame on the top and bottom. If the surface angle is flatter, a step effect can occur.

With the exception of Ultem, Antero and PC, all materials are suitable for use of a water-soluble support structure that leaves no residues. With Ultem, Antero and PC, material is broken away, which may leave visible breakaway areas.



Polyjet (Material Jetting)

Untreated components have a fine, smooth surface. Printing tracks are visible when looking closely. As the components are completely surrounded by a support structure, no outer frame is visible.

Support structures are removed in a bath of soapy water and do not leave residues.

We recommend polishing to achieve an ever finer surface effect and more realistic appearance. To request this, please contact our customer service.

Should you want partial matting of the smooth, partially glossy surface, we recommend glass bead blasting.

Multi Jet Fusion (Polymer Powder Bed Fusion)

Components made by Multi Jet Fusion are characterized by a continuous, uniform and fine surface without visible layers. Untreated components are stone-gray.

Multi Jet Fusion components are blasted after printing and can be dyed black on request.