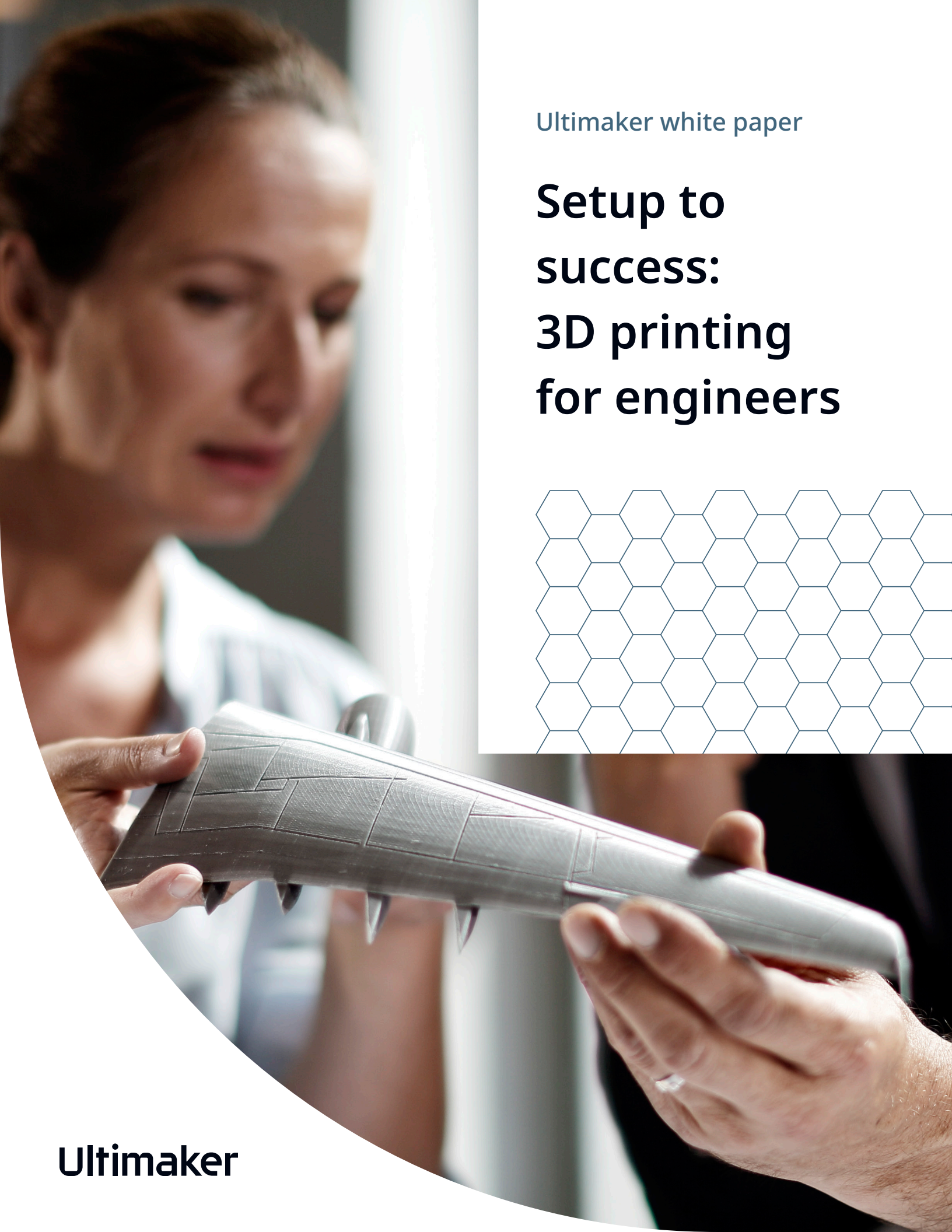
Ultimaker white paper

Setup to success: 3D printing for engineers



Ultimaker

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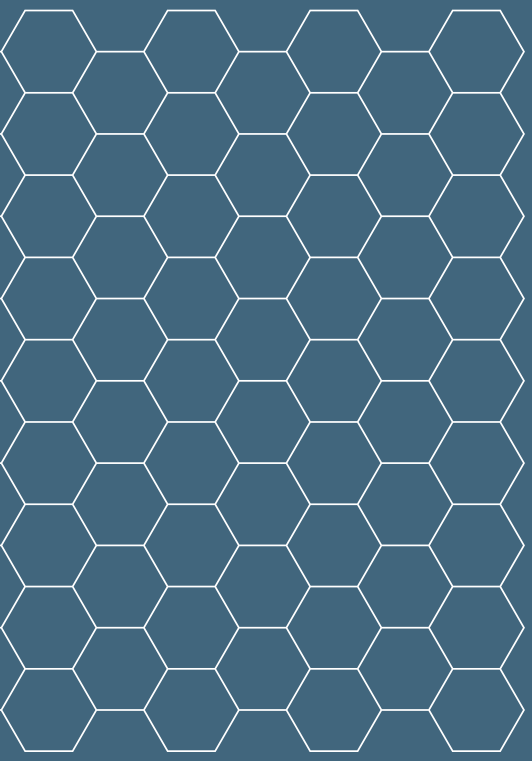

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Introduction

3D printing provides engineers with a better way to prototype ideas and create durable end-use parts that can be ready for visual and functional evaluation in a matter of hours. This eliminates the need for outsourcing and complex production machinery, while allowing you to create more iterations and improve product quality. Once you have finalized your design, 3D printing enables you to print durable, low-volume, and customized parts with minimal tooling costs and lead time.

What you will learn

This guide will help you achieve the benefits of 3D printing as quickly as possible. Using Ultimaker fused filament fabrication (FFF) printers as examples, we will look at:

- How to set up your printer and optimize your workspace
- How to implement a 3D printing workflow
- How to make the most of 3D printing, with application ideas

This guide has been created by Ultimaker's 3D printing experts. It also features examples from real-life engineers, so you can learn from those already using 3D printing to reduce production time and costs.

Setup

To start using your 3D printer as quickly as possible, you should consider a few things in advance. How is it installed? Where will it be located? Who will use it?

Unboxing

Before your 3D printer arrives, visit ultimaker.com for useful resources, or watch one of our videos to help you understand your printer's features and guide you through setup (e.g. the features explained and unboxing videos for the Ultimaker S5).

Each Ultimaker printer comes with a quick-start guide detailing how to unpack and install the printer and start your first print. The first time you turn your printer on, it will ask you to complete simple setup actions: choose the language, install the build plate and print cores, load material, connect to a network (optional), and check for the latest firmware.

Unboxing the Ultimaker S5 printer

Location

Desktop 3D printers are considered clean and safe for an office environment, depending on the material being printed, and are quiet enough to be placed on a desk. But if a single 3D printer serves multiple users, or you have a multi-3D printer setup, it may be best to create a central 3D printing area.

As Ultimaker 3D printers do not exceed a maximum noise level of 50dB, noise isn't usually a problem when running a single printer. But when running multiple 3D printers it is better to place them in a separate area to reduce overall noise levels.

Ventilation should be considered when using materials with safety requirements, or which produce an unpleasant odor. You could also consider an air management accessory, such as the Ultimaker S5 Air Manager, which removes up to 95% of ultrafine particles (UFPs). Ultimaker provides safety data sheets for every Ultimaker material, so you can identify each materials' safety requirements.

Operation

Ultimaker 3D printers are designed to ensure reliability and maximum uptime, and are certified for safe unattended use. This means that you can leave your printers to run unattended, for maximum efficiency.

Files can be uploaded to the 3D printer via USB or a network connection. With Ultimaker Connect and Ultimaker Cloud, you can start and manage print jobs remotely, access print analytics, and save your print settings to the cloud for remote access.

Personnel

Ultimaker 3D printers are designed to be simple to use, so you're unlikely to need specialist training, or a new team member to use them. You may, however, need a dedicated operator when running more than 10 printers.

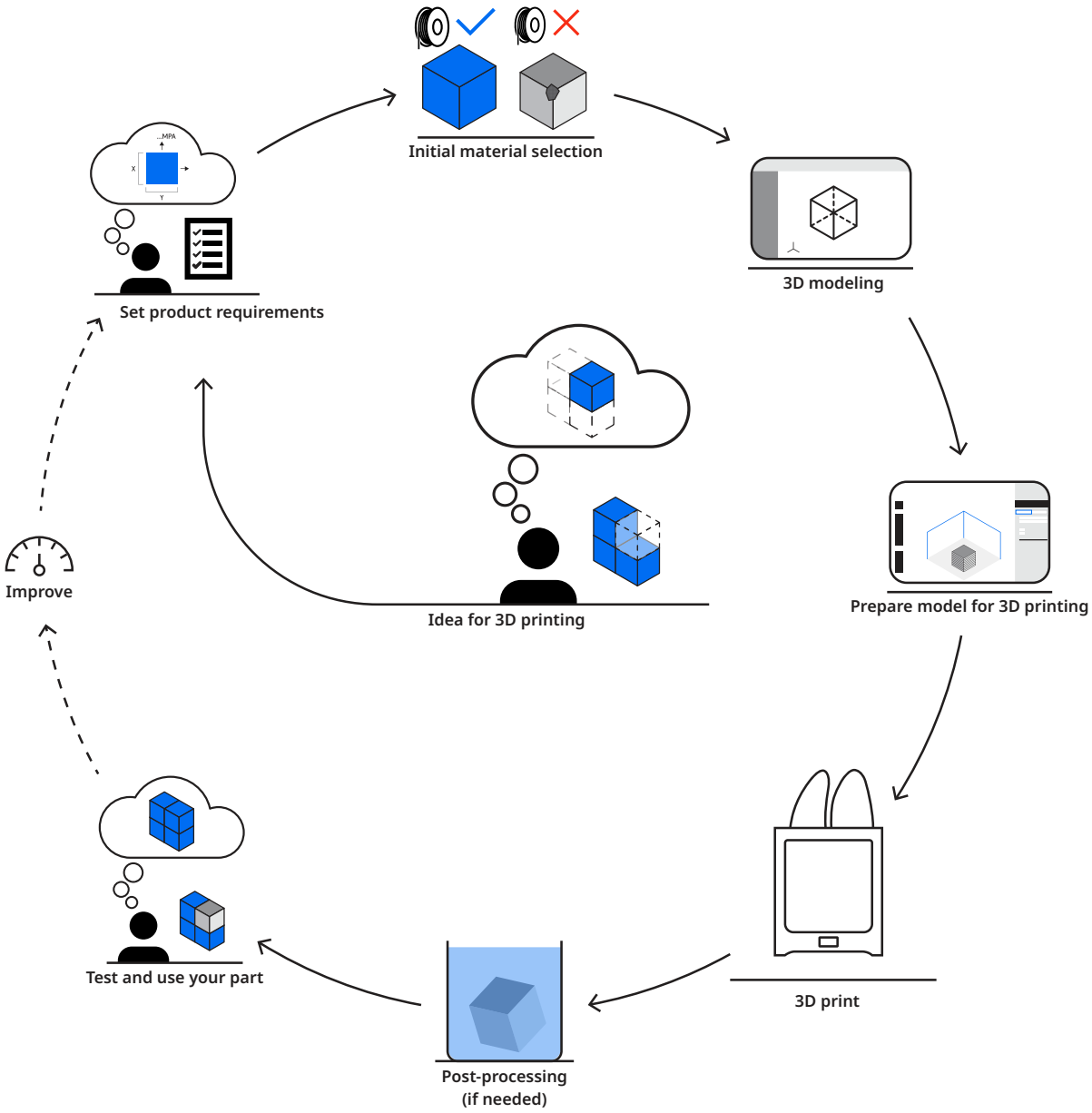
To optimize results, staff should be trained to design for additive manufacturing (DfAM). A good introduction to this concept is our free 'How to design for FFF 3D printing' guide. Your reseller may offer more in-depth training.

Once your team and workspace are ready for 3D printing, it's time to implement a workflow that streamlines production.

Workflow

An efficient workflow will improve the quality of your 3D prints and reduce the time it takes to achieve a return on investment.

To help get you started, we have provided a typical 3D printing workflow below:



Material selection

Material selection is critical to a successful 3D print. Ultimaker 3D printers are optimized to use the Ultimaker range of materials, but can also use third-party materials. Many material manufacturers provide print profiles for their filaments in Ultimaker Cura, for optimal print results.

Here are a few of the most popular materials:

- **PLA** offers excellent surface finish and dimensional accuracy, making it ideal for visual prototypes and fit testing. It has limited potential for mechanical parts or high-temperature applications
- **Nylon** offers a high strength-to-weight ratio, flexibility, low friction, and corrosion resistance. Able to withstand significant mechanical stress, Nylon is a great choice for tools, functional prototypes, and end-use parts
- **ABS** is often used to print functional prototypes due to its high strength, durability, and ability to withstand temperatures up to 85 °C

More information on choosing the right material can be found on the Ultimaker website.

3D modeling

When designing for 3D printing, there are seven key considerations based on the geometry and features of your part:

1. **Nozzle size.** Consider the diameter of the nozzle you use. The minimum wall thickness of your part should be equal to or larger than your nozzle's diameter
2. **Bottom layer.** The bottom layer is the foundation of your 3D print. The larger its surface area, the better its adhesion to the printer build plate. Use chamfers instead of fillets for edges that touch the build plate, as rounded corners are more effective than sharp ones
3. **Support material**. Dual extrusion printers can print support material within overhangs or cavities to enable more complex geometries. This does, however, increase print and material costs. Limit the use of support material by creating overhangs with an angle greater than 45-degrees
4. **Small details**. For designs featuring small details, use a smaller nozzle. Ensure that small details have time to cool before the next layer is printed
5. **Tolerances**. Plastic polymers shrink when heated and then cooled. This needs to be considered when designing parts with specific size requirements. With some materials (such as PLA), this is usually unnoticeable, but some filaments may require test printing
6. **Fast printing**. If print speed is important, you can reduce the thickness of the bottom or the walls of your print, or choose a larger nozzle diameter
7. **Modularity**. FFF 3D printers are only able to print parts that fit within their build volume, but this doesn't make them unsuitable for producing large objects. Instead, use a modular design, consisting of multiple components, that can be printed more rapidly

Preparing your 3D model for printing

Once you have a 3D design file, you can transfer it to print preparation software that will turn it into instructions for your 3D printer.

Ultimaker Cura is the most widely used 3D printing software in the world, with millions of users, and is free to download from our website.

In Ultimaker Cura's Recommended mode, printing is as easy as loading your model design, choosing key settings (layer height and infill density), and starting your print. You can also switch to Custom mode and tweak multiple settings for highly customized results.

With Ultimaker Cura you benefit from the open and integrated Ultimaker ecosystem. Here you will find:

- Preconfigured material profiles from leading filament producers, including BASF, Clariant, DSM, DuPont, and Owens Corning
- 'Print from CAD' integration with free plugins for SolidWorks, Autodesk Inventor, and Siemens NX

Extra print profiles and software integration can be downloaded in Ultimaker Cura

Printer operation

When you have prepared your print in Ultimaker Cura, you can save it to USB or print via a network.

Ultimaker Connect is a network print management tool that enables you to queue multiple print jobs, monitor print progress, and track maintenance and printing analytics from your desktop.

This is particularly effective if you have multiple 3D printers. You can create groups of printers for use by different teams, or with a frequently used configuration. Queued print jobs will start automatically when a printer with a matching configuration becomes available.

With the Teams feature in Ultimaker Cloud, your 3D printers are accessible to all team members – regardless of where they are, or the network they're on.

Post-processing

When your print finishes, wait for the build plate to cool, then remove the part. If it sticks, use a spatula to free it from the build plate.

Often, the only post-processing needed is to remove the thin brim added to your print for optimal adhesion. This can be done by hand or with a small modeling or hobby knife.

If you used water-soluble support material such as Ultimaker PVA, you will need to dissolve it before you can use your print. Manually detachable supports, such as Ultimaker Breakaway, can be removed with a pair of pliers.

Once supports are removed, you can start additional post-processing options, such as:

- Sanding, for a smooth surface finish
- Polishing with a plastic polish compound
- Gluing modular parts together using a modeling or industrial adhesive
- Painting your print, using a primer and separate top coat
- Screw threading

Not all post-processing techniques are suitable for all materials, so be sure to research and test your chosen method before trying it on your final part. Follow the manufacturer's guidelines for any off-the-shelf products you use in post-processing.

Removing PVA (left) and Breakaway (right) support material

Application ideas

3D printing gives engineers a powerful competitive edge – avoiding outsourcing, and speeding up product development cycles. With Ultimaker's versatile and reliable 3D printing solutions, you can create highly accurate functional prototypes and manufacturing aids, or small batches of your first run.

But how do you ensure that you are maximizing your return on investment? This list of application ideas will help you make the most of your 3D printer.

Prototyping

Fit testing and functional prototyping are often the reasons that engineers start 3D printing. Because prototypes are ready in a matter of hours, you can evaluate and iterate designs quicker than with any other production method.

Tip: Choosing the right material is critical to successful prototyping. For example, PLA provides dimensional accuracy for fit testing, Nylon offers low friction and high impact strength for mechanical parts, and CPE+ can withstand temperatures up to 100 °C.

Low-volume production

Use 3D printing to create custom one-offs with no cost penalty, replacement parts only when needed, or for small production runs. Get your product to market quickly by turning your final prototype into your first production run, on the same day.
Tip: One print job doesn't have to mean one printed part. Print batches of smaller parts by loading multiple models or right-clicking your model in Ultimaker Cura and selecting 'Multiply Selected Model'.

Manufacturing aids

Streamline production with 3D printed tools, jigs, and fixtures. This is ideal for keeping a just-in-time inventory, and enables you to improve tools within hours of receiving feedback from technicians.
Tip: Create more effective tooling with modular design. Need to prevent a tool from scratching surfaces? Add a layer of semi-flexible TPU 95A material. Does one part of the tool wear down? Design it as a replaceable segment.

Case study: Sylatech

Sylatech uses Ultimaker 3D printing technology to prototype sample parts for its customers, allowing them to test their designs without having to invest in tooling ahead of investment casting. This yields significant time and cost savings, as fewer tooling modifications are necessary.

"With the Ultimaker, we can use a 3D printed model for the creation of sample parts directly in our foundry process, without having to invest in tooling to create wax patterns. Through 3D printing we can significantly speed up our sampling process – clients can now get a prototype metal part in just seven days!"

Gordon Gunn, Director of Marketing at Sylatech

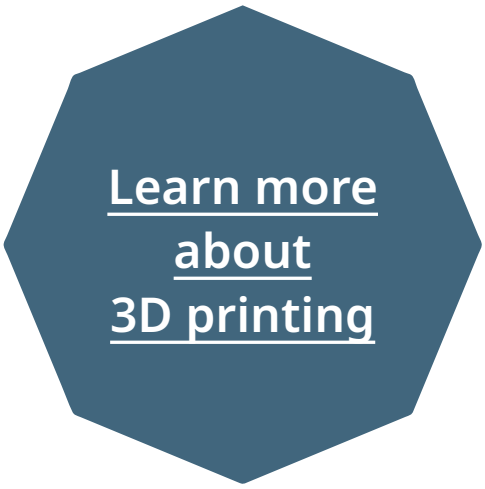
Traditionally, design engineers were unable to fully test design functionality without investing in tooling for casting. Tooling typically takes 3-4 weeks and is a costly process. About 30% of tools would require alteration due to customer design modifications, increasing costs.

For the investment casting of a propellor, Sylatech was able to achieve considerable cost and time savings compared to tooling, as 3D printing typically eliminates or reduces tool modifications. Only when the customer is ready to produce a production volume, is investing in tooling necessary.

	Traditional tooling	**Ultimaker 3D printers**
Cost	$21,500	$850
Time	4 weeks	5 days

Take the next step to success

Build your 3D printing knowledge with industry leaders and experts, or request a quote, on the Ultimaker website.



About Ultimaker

Since 2011, Ultimaker has built an open and easy-to-use solution of 3D printers, software, and materials that enables professional designers and engineers to innovate every day. Today, Ultimaker is the market leader in desktop 3D printing. From offices in the Netherlands, New York, Boston, and Singapore – plus production facilities in Europe and the US – its global team of over 400 employees work together to accelerate the world's transition to local, digital manufacturing.

ultimaker.com

General inquiries: info@ultimaker.com
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