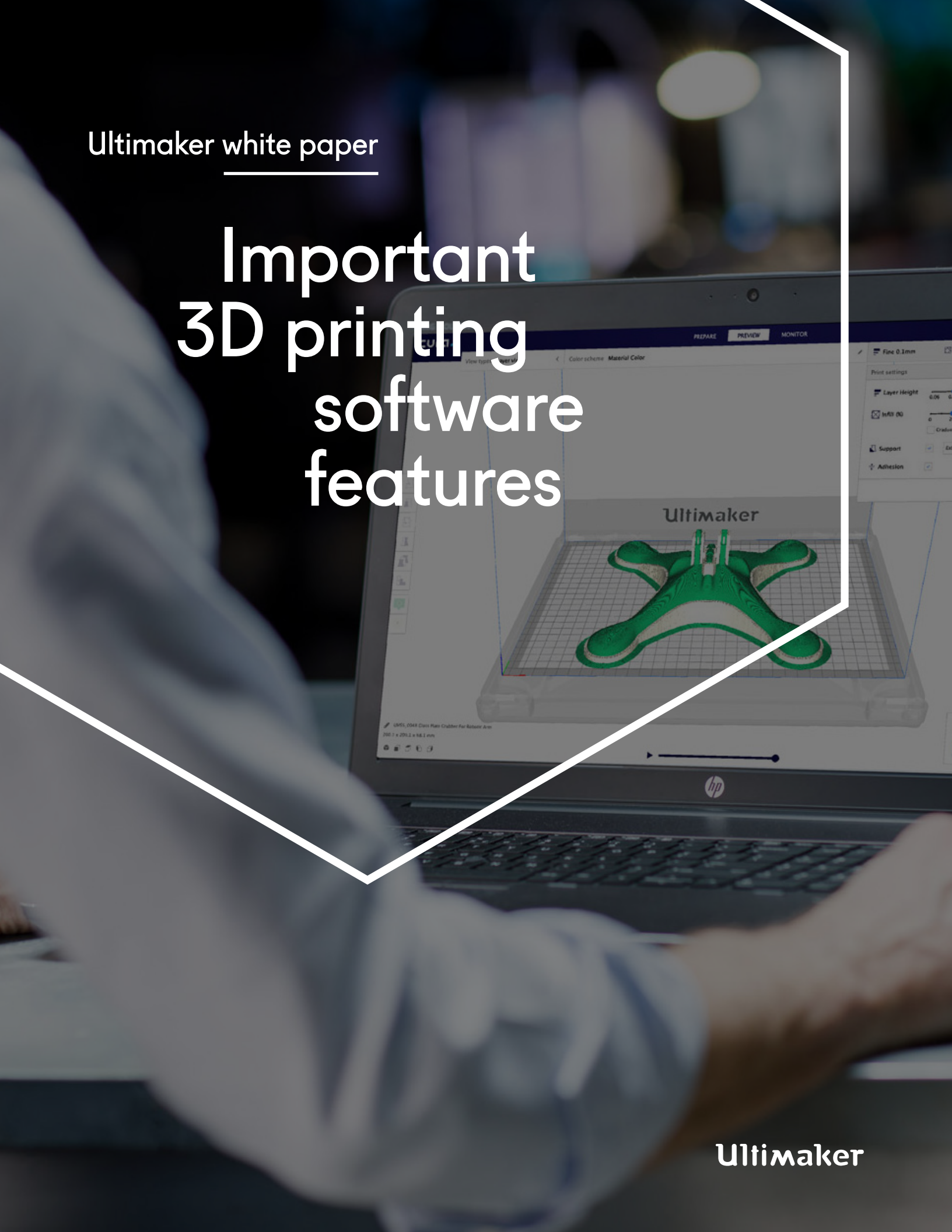
Ultimaker white paper

Important 3D printing software features



Ultimaker

Important 3D printing software features

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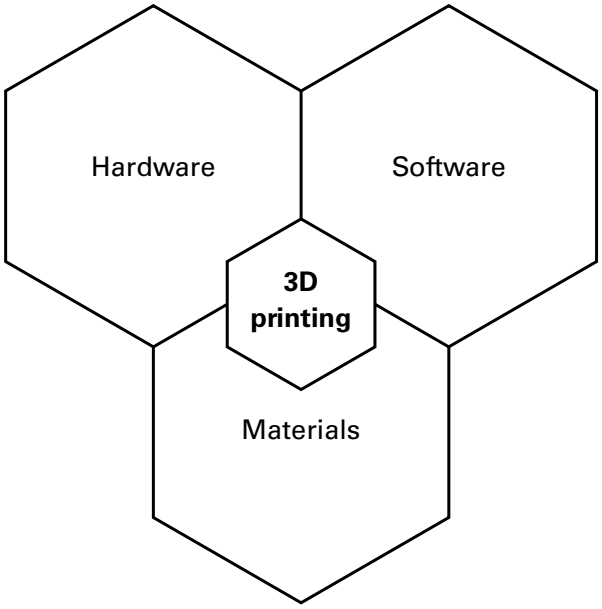
Why software matters

The process of additive manufacturing (or 3D printing) depends on a seamless integration between hardware, software, and materials. Good quality hardware and materials have limited value without advanced, intuitive software to control the process.

Fused Filament Fabrication (or FFF) 3D printing has advanced significantly in the last decade. The most impactful developments have taken place in software, facilitating greater flexibility, accessibility, and performance of the accompanying hardware and materials.



The aim of this white paper is to highlight important features that 3D printing software should include in order to achieve the best 3D printing experience. 3D printing software in a professional environment should provide:

- Flexibility for a wide range of workflows
- A reliable process that delivers accurate results with minimal configuration
- An efficient process that optimizes print duration, material use, and part strength
- Support for multi-extrusion printers
- Functional scalability

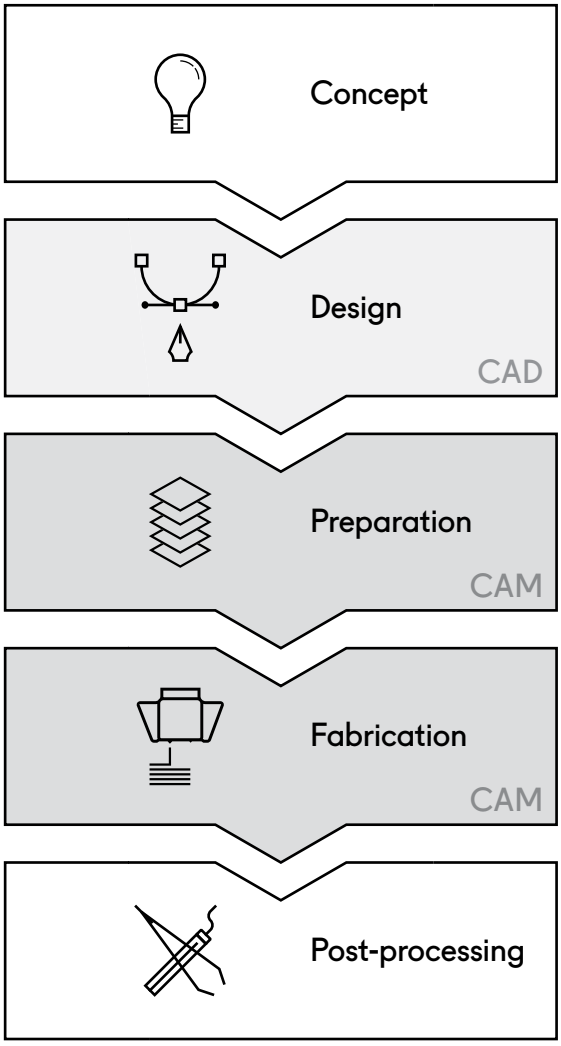
With the rapid adoption of FFF 3D printing to industry, and with the requirements for parts becoming more and more complex, it is more important than ever to choose software that offers a high level of control over the process.

Examining the 3D printing workflow

3D printing includes several steps to get from idea to physical object. A typical workflow features two key phases: CAD and CAM.

CAD (Computer-Aided Design) covers the design of the part, where features, scale, and other factors are decided on. Design is handled by CAD software, such as SolidWorks, Autodesk Inventor, Siemens NX, or others. The end result of this phase is a digital 3D model.

CAM (Computer-Aided Manufacturing) is where the preparation and manufacturing process takes place. The end result of this phase is a physical object, faithful to the digital 3D model from the CAD phase. It is this phase that 3D printing focuses on.



A sketch is created. This refines the initial idea into a workable concept.

A 3D model is created from the concept in CAD software, complete with accurate dimensioning.

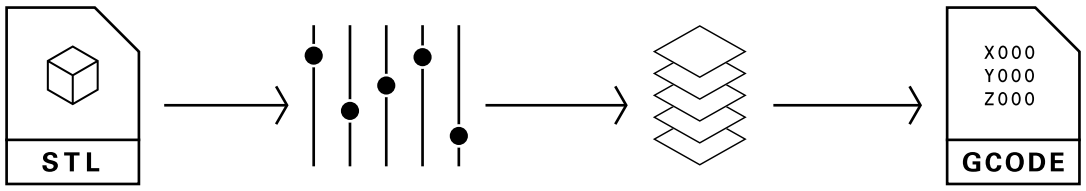
The 3D model is exported and prepared for 3D printing using slicing software.

The output of the slicing software is loaded into the 3D printer. The 3D printer fabricates the part.

Any adhesion or support structures are removed with a knife or pliers. Water-soluble support structures can be removed using regular tap water, leaving an unmarked surface. Surfaces are finished if desired.

The role of software in the 3D printing workflow

No matter which 3D printer you use, an essential step in every 3D printing workflow is preparing a 3D model file for print using *slicing software* (sometimes called a *slicer*). The overarching function of slicing software is to 'slice' a 3D file into thin horizontal layers to make it suitable for the 3D printing process. Besides this function, slicing software can be thought of as a toolkit of features which can perform a complex range of other functions to prepare a 3D model for fabrication. The preparation process includes several phases:



Input file | Configure slice settings | Slice | Output file

Input file. Slicing begins with a 3D model file, such as an STL, OBJ, X3D, or 3MF file. Each of these formats is easily exported from a variety of CAD software packages. Ultimaker Cura is one example of slicing software. It works with all of these formats natively, and also supports plugins that allow users to open industry-standard CAD file formats directly.

Configure slicing settings. The user chooses a set of parameters that controls how the model will be sliced. These user choices will have an impact on the characteristics of the final part, including surface quality, part strength, and print speed.

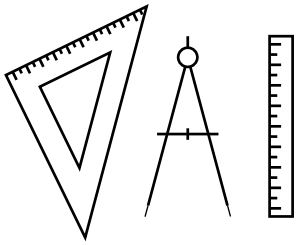
Preconfigured profiles in Ultimaker Cura make configuring slicing settings easier. Quality profiles quickly change a set of parameters for different levels of print quality, such as faster 'draft' prints, or slower, high-resolution prints.

Slice. Based on the user's slicing settings, the software engine will 'slice' the model into thin layers to make it suitable for the 3D printing process. This includes calculating an efficient toolpath, plotting coordinates for the print head to deposit material on the build plate, calculating the motion speed of the extruder and print head, the build emperature, and more.

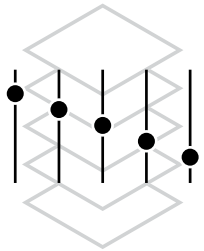
Output file. In most cases, the sliced data is output as a GCODE file – a numerical control language used to control CAM equipment. GCODE is understood by a 3D printer and will allow it to accurately reproduce the digital model as a physical object, in line with the slicing settings specified by the user.

Considerations for preparing a print

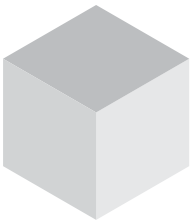
Preparing a part for 3D printing is a balance between material properties and slicing settings. It is up to the user to work with different constraints in order to make the final part true to the design intentions. Some considerations are outlined below:



Geometry



Slicing settings



Final part

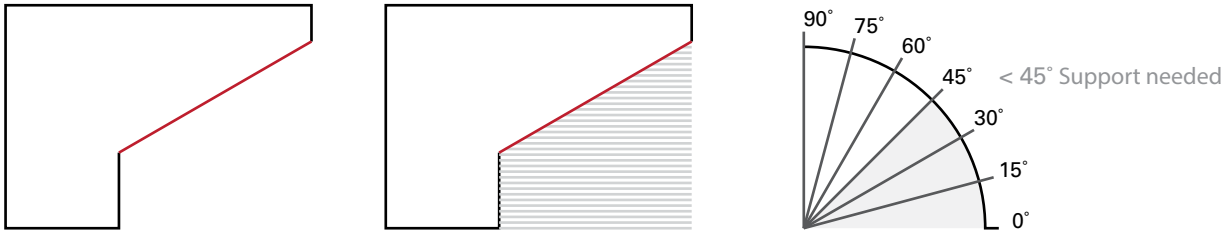
Geometry. Part geometry is decided at the design stage in CAD software. It is beneficial to optimize design for FFF 3D printing. Parts with more complex geometry may need additional 'helpers', such as support material or adhesion structures, which can be generated by slicing software. Helpers accommodate for the limitations of the FFF process, to ensure that the print will be completed successfully.

Material properties. FFF 3D printing materials are typically thermoplastics, each with a range of different properties, such as strength, toughness, and flexibility. It is important for software to include optimizable settings that achieve the best performance from these materials during the 3D printing process. Nozzle temperature, fan speed, print speed, and retraction settings are a few examples of variables that have an impact on the print results when using different materials. Material profiles in Ultimaker Cura include all the ideal print settings for each material in order to minimize common FFF 3D printing issues, such as warping and shrinkage.

Slicing settings. The decisions made during the preparation process will affect the outcome of the part. This is explained in more detail further on.

The impact of slicing settings

Overhangs and support material. FFF 3D printing is a bottom-up process, where each layer will need material underneath it to support it. In some cases, the geometry of a part will draft outwards from the base, or features will overhang at an angle. This means there will be no material underneath certain areas, and support material will be necessary.



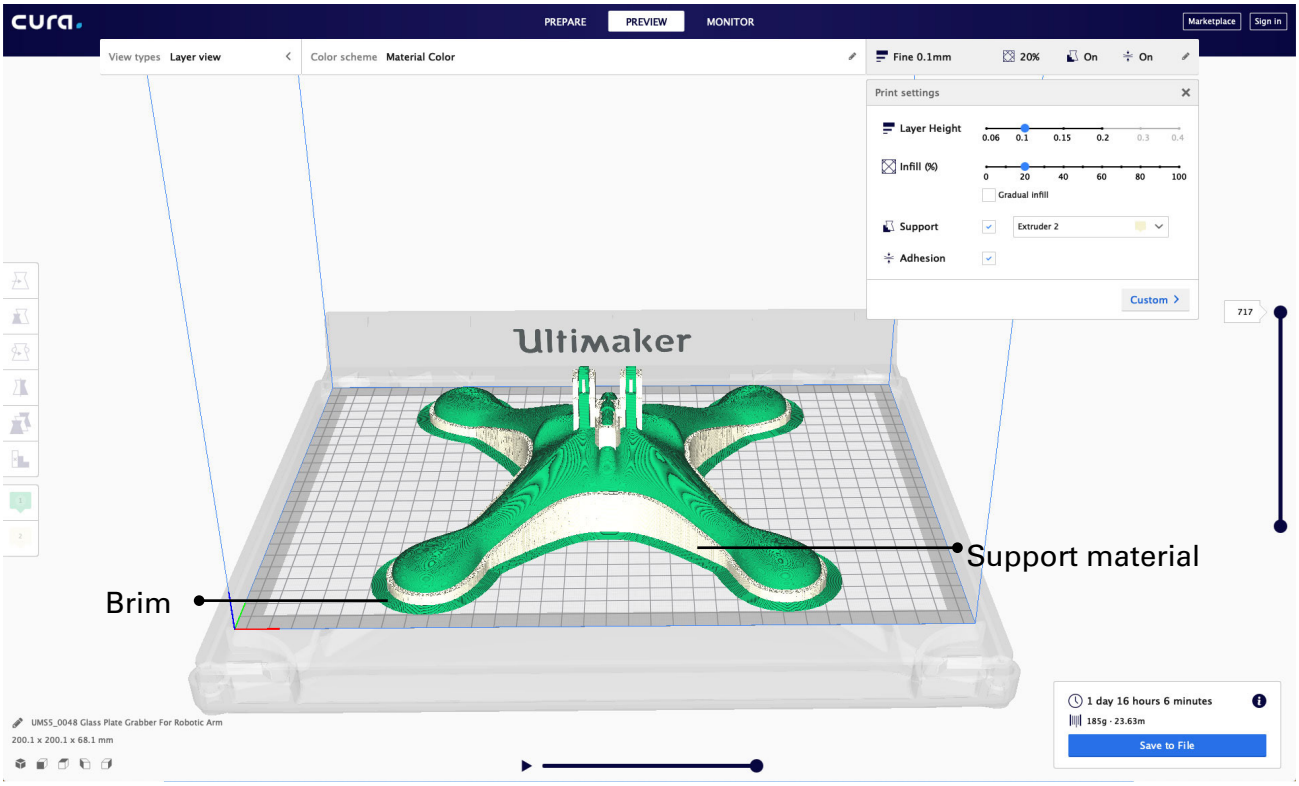
Overhangs and support material

Ultimaker Cura can detect areas which require support material, and automatically generate it where needed. Once the fabrication step is complete, the part can be collected from the printer, and support material removed during post-processing.

Water-soluble support material, such as Ultimaker PVA, will leave an unmarked surface on the final part. Water-soluble material is also able to extend the capabilities of FFF 3D printing, making it possible to fabricate nested or moving parts in a single print. Ultimaker Cura is able to optimize the orientation of a part to efficiently use support structures, so that print time and material costs are kept to a minimum.

Adhesion. A successful 3D print relies on good adhesion to the build plate for the entire print duration. Good slicing software will include various options to ensure the print will adhere well to the build plate. Material profiles in Ultimaker Cura will enable the ideal adhesion method for a given material.

A common adhesion method is a brim. This is a set of extra perimeters that are printed around the first layer of a print, anchoring the part edges in place in order to prevent warping. Using a brim also primes the nozzle before the print begins, so that material flows consistently. A brim can be removed by hand or with a knife during post-processing.



Helper elements ensure the print succeeds

Common preparation options

Object orientation. The orientation of the part on the build plate will influence which parts of the model overhang and can reduce the need for support material. It can also greatly influence the properties of the final part, as well as print duration.

Ultimaker Cura includes functions to duplicate, mirror, scale, or rotate parts, as well as the ability to automatically arrange multiple parts on a build plate, for efficient batch printing.

Compatible plugins can automatically calculate the optimal orientation of a part on the build plate in order to efficiently use support material and optimize the print duration.

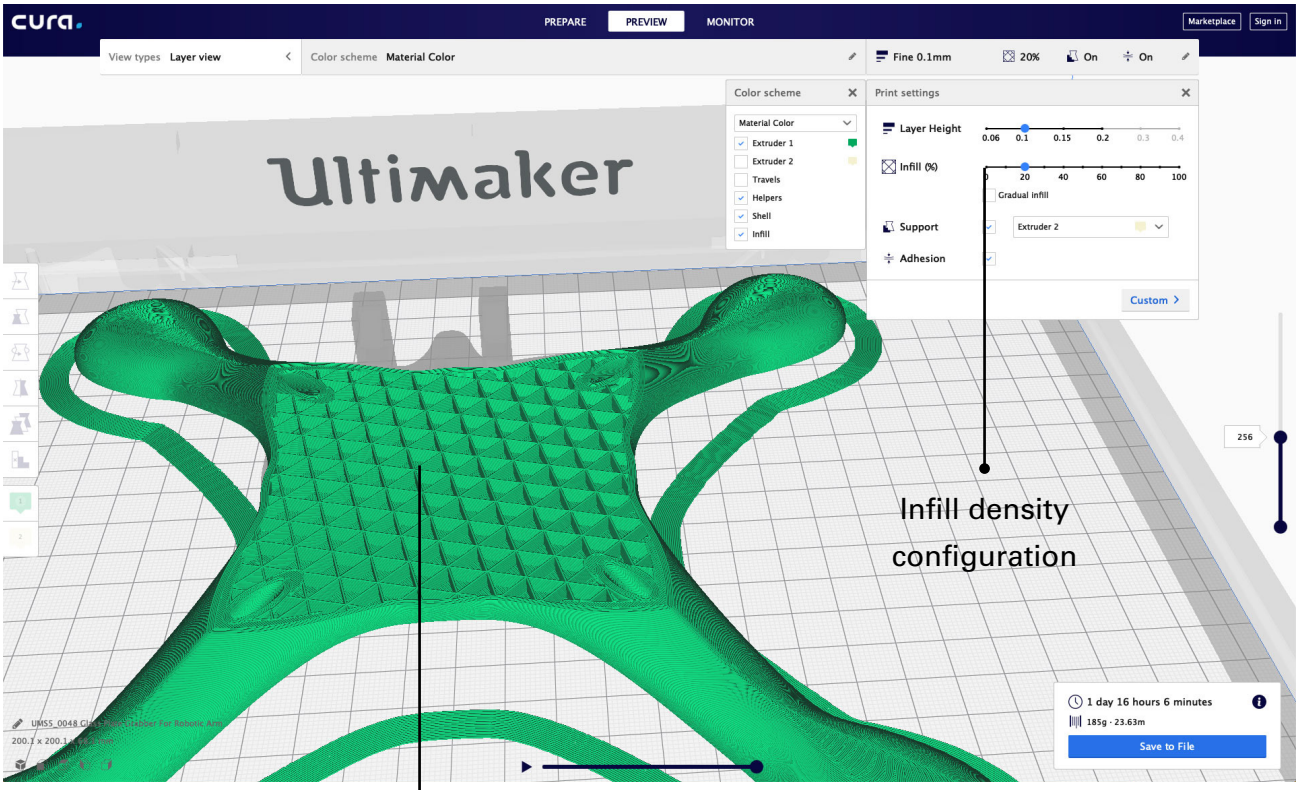
Layer height. The layer height refers to the thickness to which each horizontal layer is sliced, usually a fraction of a millimeter. A thicker layer height will produce quicker prints, but with reduced resolution. A thinner layer height will produce a higher resolution, but will impact the print duration.

Ultimaker Cura includes an adaptive layers feature, which will analyze the shape of the part and optimize the layer height so that there is less of a compromise between layer resolution and print time.

Wall thickness. A thicker outer wall of a 3D object will make a stronger part, but will have an impact on the print duration, as the printer will take time to print more walls.

Infill density. Infill density will print internal structures inside the part to give it additional strength, and can also act as support for parts with flat top surfaces.

0% infill will print a completely hollow model, which will print quicker than a solid model, but will have reduced strength and impact resistance. 100% infill will print a completely solid model, with increased strength and toughness, but will take longer to print.



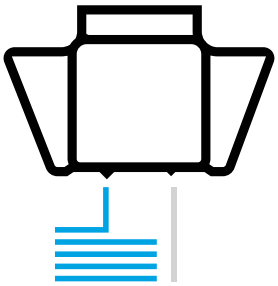
Infill density configuration

20% infill density

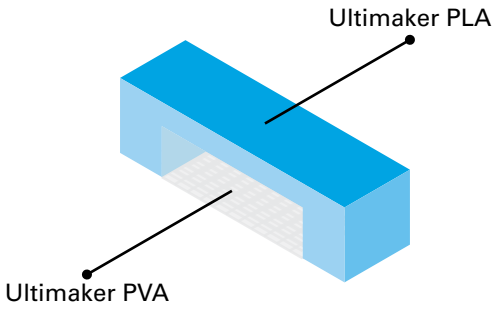
The advantages of dual extrusion

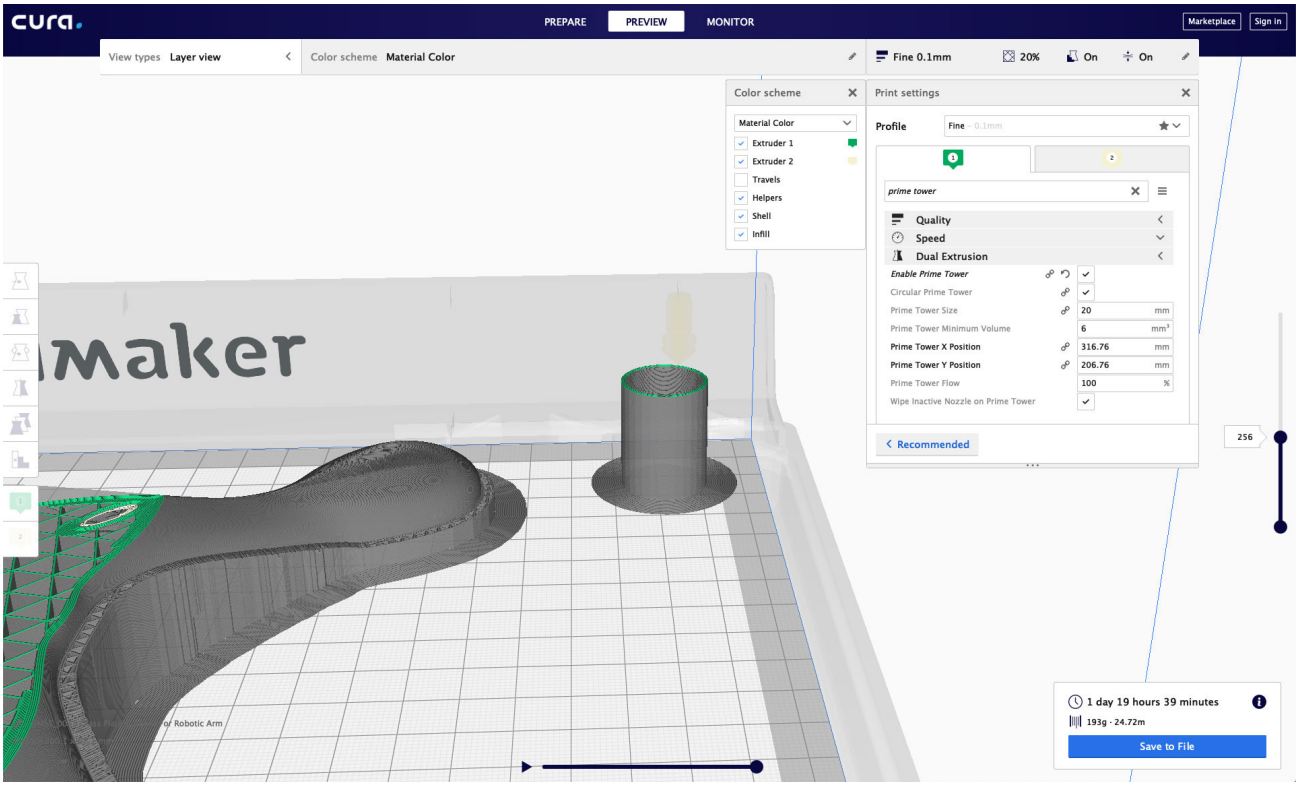
Dual extrusion means that a printer can process two materials together in a single print.

Dual extrusion enables a different support material to be used from the build material (the material that the part is printed with). Alternatively, the build material can be two different colors of the same material for varied aesthetic characteristics, or two different materials for varied properties.



To prevent material cross-contamination during a print, Ultimaker Cura includes a prime tower feature for dual-extrusion prints. When enabled, a prime tower will be printed next to the part, and will prime each nozzle before a nozzle switch takes place. The user is able to control the position and size of the prime tower for the best performance.





User experience

More advanced software is able to perform more advanced tasks. However, the more complex the software, the steeper the learning curve tends to be.

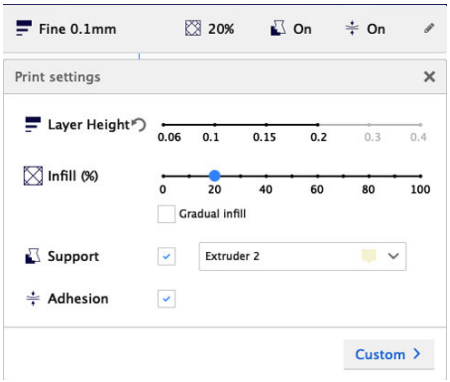
Having the right slicing features, an intuitive and straightforward interface, and a good amount of user control are key factors for a hassle-free 3D printing experience. An overly complex interface is likely to intimidate or frustrate users. On the other hand, a lack of in-depth settings prevents advanced users getting the depth of control they need to meet professional demands.

The user experience (known as the UX) refers to the process of enhancing user satisfaction with a product by improving the usability and accessibility in the interaction with the software.

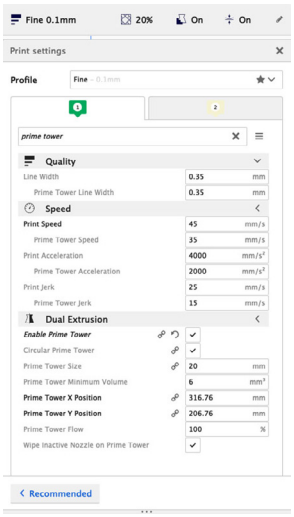
A well-thought-out user interface doesn't just look appealing – it has a consistent, logical flow for the function it achieves, and gives a good balance of automation and control. It makes complex settings accessible to first-time and advanced users.
Some considerations are outlined below:

User modes. Different user modes give different levels of accessibility to users of different levels.

Ultimaker Cura includes a recommended mode with commonly used settings, and custom mode, which includes over 400 configurable settings, to balance accessibility and control.

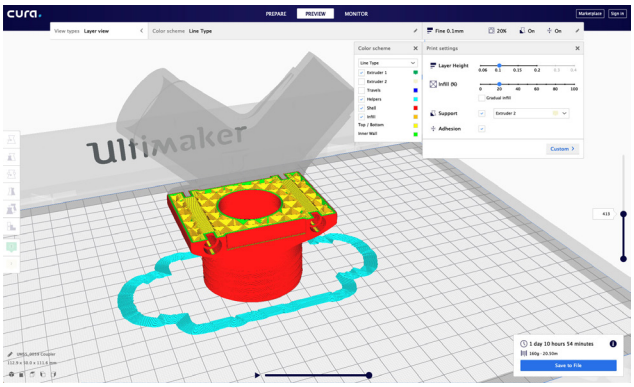


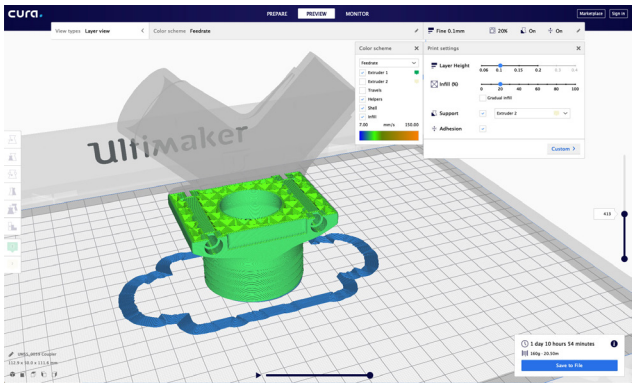
Recommended mode includes settings that are commonly changed

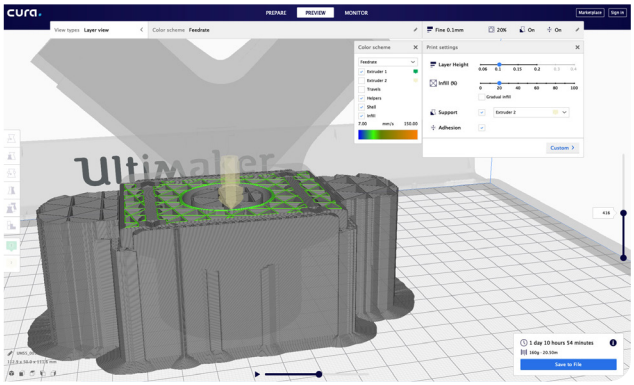


Custom mode allows the user to configure all 400 settings to their requirements

Graphical user interface. A graphical user interface takes the guesswork out of print preparation. The interface of Ultimaker Cura reflects the interface of CAD software: the part is prepared in a 3D environment, the object can be orbited around, and hotkeys are used to quickly change manipulation tools.







Simulation tools, such as layer view, enable the color scheme of the model to change. This visually represents the layer thickness or print line type.

Ultimaker Cura's layer view can visually represent the 'printing strategy'. The user is able to scroll through and inspect each layer, providing assurance that the printing strategy will achieve the best print results in an efficient timeframe.

Preconfigured profiles. Ultimaker Cura includes preconfigured profiles for Ultimaker 3D printers and Ultimaker materials. Each profile is configured and tested by engineers at Ultimaker. Selecting a profile will automatically configure the optimal settings immediately. Using profiles gives users a good balance of accessibility and control, while avoiding time-consuming experimentation and labor-intensive configuration. If desired, changes can be made to these profiles to meet individual needs.

Network connectivity. The latest generation of Ultimaker 3D printers feature wireless network connectivity out of the box. This means that Ultimaker Cura is able to detect available printers on a local network, and synchronize the printer's material and print core configuration with the software, to reduce the number of manual user steps.

In addition, print jobs can be sent from Ultimaker Cura over the wireless network, eliminating the need for the use of peripherals such as USB sticks and SD cards.

Network-enabled Ultimaker 3D printers include a webcam for remote monitoring. With this, the printer can be placed in a remote location, and print job progress monitored through Ultimaker Cura or Cura Connect.

Multiple printer management. Cura Connect enables centralized control of a group of network-enabled Ultimaker printers, and works seamlessly with Ultimaker Cura.

Using Cura Connect, the user slices a print job for a printer, which is placed in a queue. Each job will then be automatically delegated to an available printer with matching material and print core configurations.

Not only does this reduce manual steps from the workflow, but it also keeps all available printers occupied for maximum uptime, as an ideal solution for professional users who want to scale their processes and use multiple printers to meet demand.

Learn more about Cura Connect

Ultimaker Cloud

Ultimaker Cloud is an expanding platform of cloud-based tools that adds extra flexibility to different workflows. With an Ultimaker account, users have access to extended features that personalize and enhance the user experience.

Marketplace. Installing extensions to Ultimaker Cura is seamless and automatic using the Marketplace. Content is user-submitted and curated by Ultimaker. Marketplace content falls into two categories:

Plugins. Plugins are used to enable custom features for different workflows. An example application is a type of plugin that pushes CAD data directly into Ultimaker Cura from software such as SolidWorks, AutoCAD, or Siemens NX. This streamlines a typical design-to-fabrication workflow, reducing the need for exchange format files between different software applications. Users can feedback on their experience of plugins by adding ratings, so that the highest-rated plugin content is most prominent in the Marketplace.

Third-party print profiles. Material manufacturers can develop preconfigured print profiles for third-party materials that are optimized for Ultimaker software and hardware. By using these, Ultimaker account holders can achieve reliable print results quickly and easily without a lengthy 'trial and error' process for advanced materials. By submitting material profiles to the Marketplace, material suppliers also have an opportunity to expose their branded materials to the Ultimaker Cura's professional user base, to encourage material sales.

Remote printing. Users can prepare prints and submit them from outside a local network, using an Ultimaker account as an intermediary. This is useful if a network-enabled Ultimaker printer is in a remote location, such as a home office, or off-campus location.

Cloud backups. Users can backup profiles and settings from an Ultimaker Cura session, so that the preferred settings can be accessed from multiple locations, or on different operating systems. This removes the need to set up software from scratch on a different system.

The development cycle

Regular software updates ensure continuous improvement, introducing new features that are relevant to rapidly-changing demands. Compare this to software that is released annually – bugs will not be addressed for an entire year. A stable version of Ultimaker Cura is released every few months for Windows, MacOS, and Linux platforms. As open source software, the application and source code are available for free, and development is completely transparent, making it possible for anyone to take and alter the source code as they see fit. If useful new features are contributed by the community, these can be curated by the core development team and integrated into the next public release.

Integrated development

Hardware, software, and materials that are developed alongside each other offer advantages over separate third-party products. Consider a combination of hardware, software, and materials from different vendors: each will require manual configuration and a degree of experimentation to get reliable results, with a multitude of variables to account for.

Integrated development offers the end-user a well-tested combination of hardware, software and materials. The software is compatible with the hardware and materials as soon as they become available, and are able to produce reliable results immediately with minimal configuration. Ultimaker products are designed and tested to work seamlessly with each other, for maximum reliability and uptime.

Security and code signing

Code signing certificates allow developers to add a layer of assurance that tells users that their software can be trusted and does not come from a malicious source.

Running an application with unsigned, uncertified code poses a significant security risk on a business network, as malicious code can compromise network security. Besides these risks, running unsigned or uncertified code creates several extra steps, as attempting to open an uncertified application will issue a warning from the operating system, and in some cases prevent the application from starting unless it is enabled by an administrator.

Ultimaker Cura has been certified for Windows and MacOS platforms. This certificate verifies to the developer of the operating system (i.e. Microsoft or Apple) that the application comes from Ultimaker. Each release of Ultimaker Cura is also digitally signed for Windows and Linux platforms. This verifies that each release comes from Ultimaker, and does not contain any malicious code.

Technical support

Ultimaker Cura includes built-in tooltips to assist with features that may require in-depth technical knowledge. Ultimaker.com features a wealth of up-to-date resources explaining how to get the most out of 3D printing. Online resources, such as screencasts, are readily available, and walk users through how to use the software. The Ultimaker online community of 3D printing experts share information and tips on an active online forum.

For developers, a dedicated resource base aimed at maintenance, troubleshooting, and plugin development is available on GitHub, where the source code for Ultimaker Cura is hosted.

Ultimaker product experts and Ultimaker's service partner network offer dedicated training on how to use the hardware, software, and material products together effectively.

Conclusion

A company that is considering desktop FFF 3D printers in-house should be well equipped with the necessary information and tools.

This white paper provides a brief glimpse into important features that a slicing software should have, and what it is capable of. With software, hardware, and materials working together effectively, users can ramp up the quality of each area and streamline processes efficiently.

Download Ultimaker Cura
Ultimaker Cura is available completely free of charge. Download it today and take control of your 3D printing processes.

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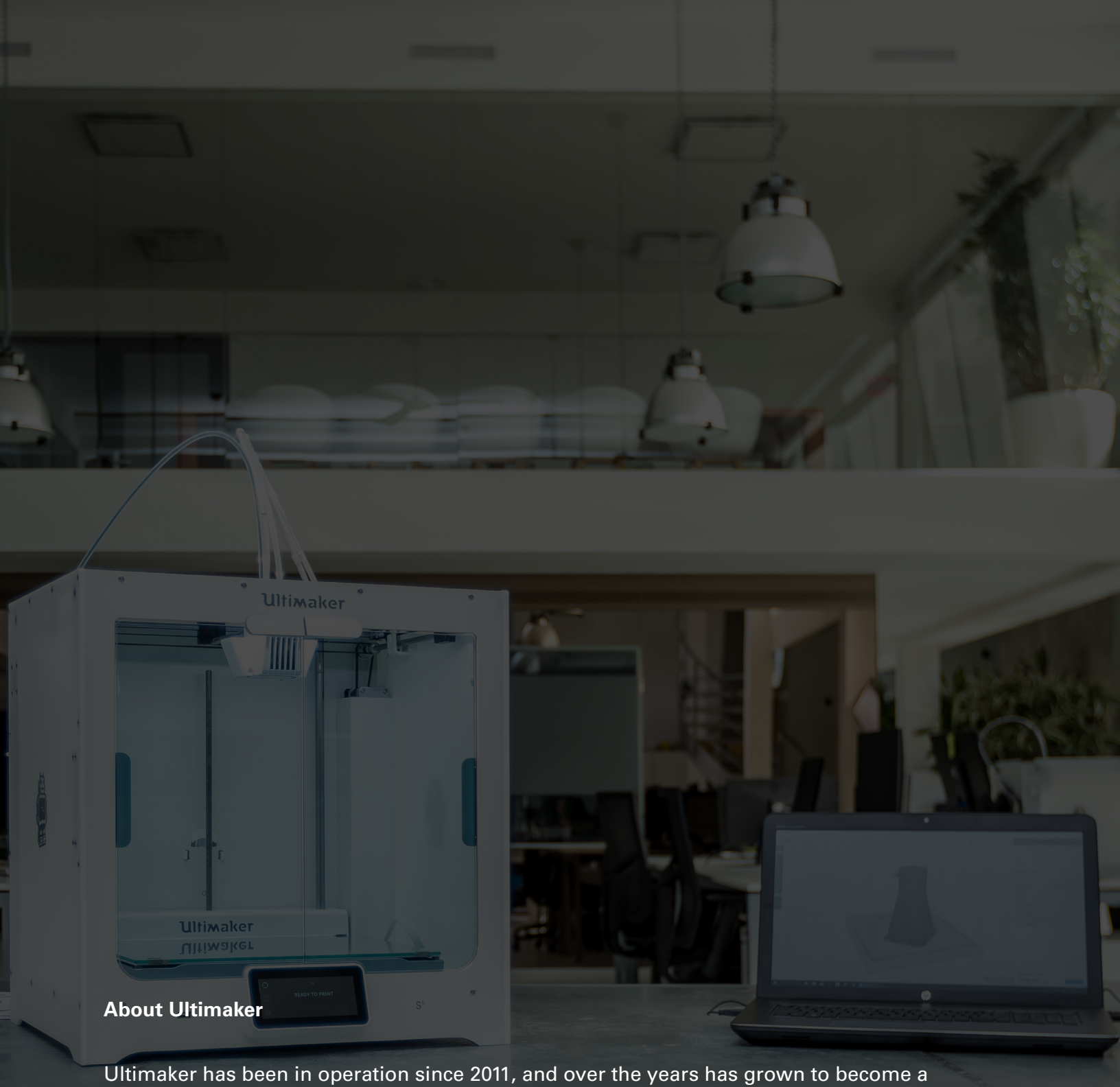
Learn more from industry leaders and experts, and compare the specs of our 3D printers, on the Ultimaker website.

Read more 3D printing resources

Compare Ultimaker 3D printers



About Ultimaker

Ultimaker has been in operation since 2011, and over the years has grown to become a market-leader; creating powerful, professional, and accessible desktop 3D printers with offices in the Netherlands, New York, Boston, and Singapore plus production facilities in Europe and the US. Ultimaker's team of over 300 employees continually strives to offer the highest-quality 3D printers, software, and materials on the market to accelerate the world's transition to local digital manufacturing.

General inquiries: info@ultimaker.com
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