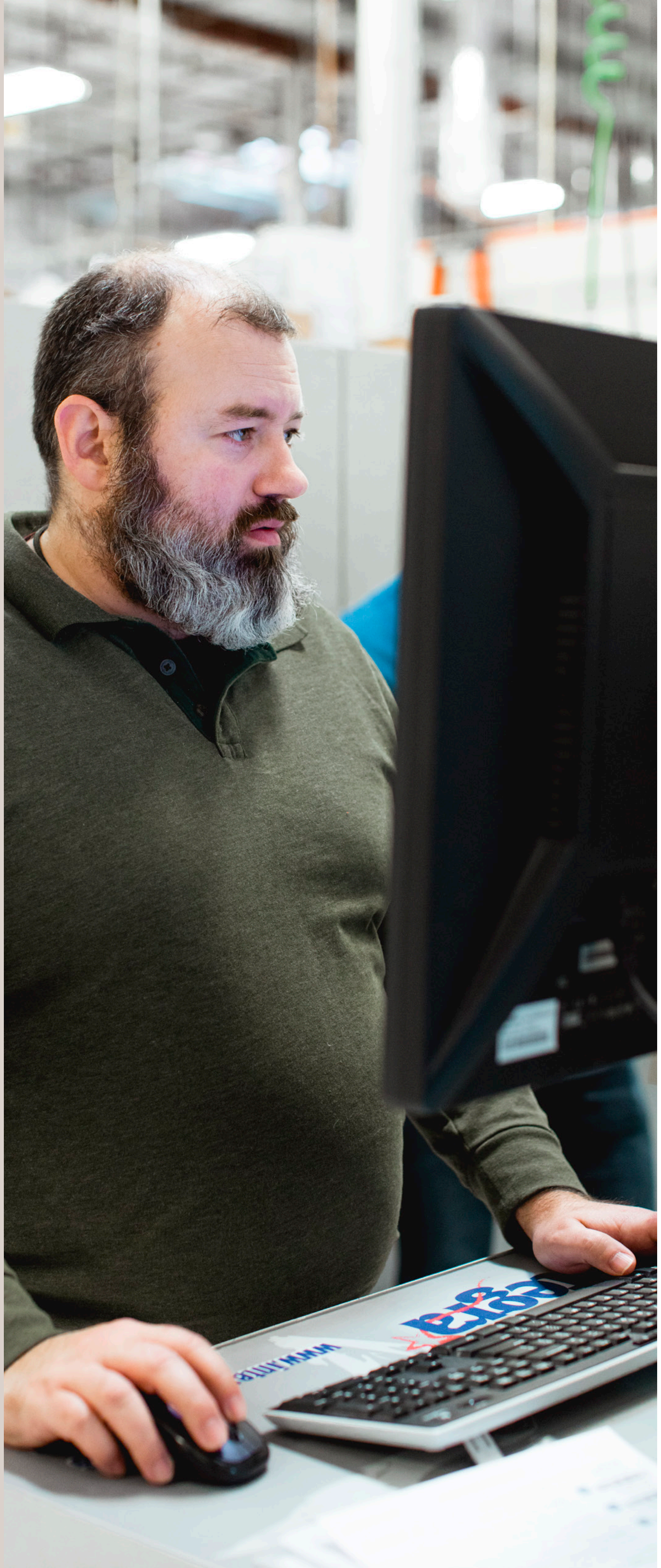
How to Master the Challenge of Large-Scale 3D Printing

E-Book



How to Master the Challenge of Large-Scale 3D Printing

It's a scenario commonly played out in manufacturing: a replacement tooling fixture is needed ASAP to keep production running. Or that prototype has to be in engineering's hands yesterday to maintain the development schedule. If you've been here before, you know 3D printing is the obvious solution because it's faster and cheaper than the standard alternatives. The only problem is, this time, your 3D printer isn't big enough or can't be trusted to handle the size of the parts you need to make.

Sound familiar? It's not an uncommon dilemma for engineers and operations managers who want to use 3D printing to solve everyday design and manufacturing challenges. But the hard reality is that printers capable of accommodating large parts either exceed the budget, aren't sufficiently reliable for manufacturing, or are tied up making other parts with high-performance materials. Some have steep learning curves, which handicaps your operational efficiency when you have to dedicate someone just to run the printer.

What's been lacking is a 3D printer capable of reliably making larger parts that's both easy to use and affordable.

That is, until now. But before we reveal what's behind the curtain, let's look at the facts of 3D printing large parts. Printing them is one thing – doing it successfully is another. What should you consider when making parts up to a meter long? How do you get the best results? Follow along as we share our insights on the challenges and opportunities of 3D printing large parts, and how the right printer can help you do that.

The realities of printing large parts.

Building bigger parts means pushing the boundaries of extruded-plastic 3D printing technology. As part size grows, so do the challenges that must be overcome to achieve good results.

Longer Print Times
There's no getting around this fact. Printing a part 45 inches long with some measurable height is going to take time, considerably more time than you might be used to with smaller printers. Are there ways to speed things up? There are, but in the end, they may add more risk than you're willing to take. We'll get into that in more detail later on.

More Material
It shouldn't be any surprise that printing large parts requires a higher volume of material, so having sufficient material capacity is important. Running out of material before a job is complete requires a pause in printing, which normally shouldn't be a show-stopper when you're prepared for it. It's when you're not prepared (like running out during a middle-of-the-night print job) that the results could be less than desirable. To avoid this problem, you'll need a printer with a generous material capacity that won't interrupt the build.

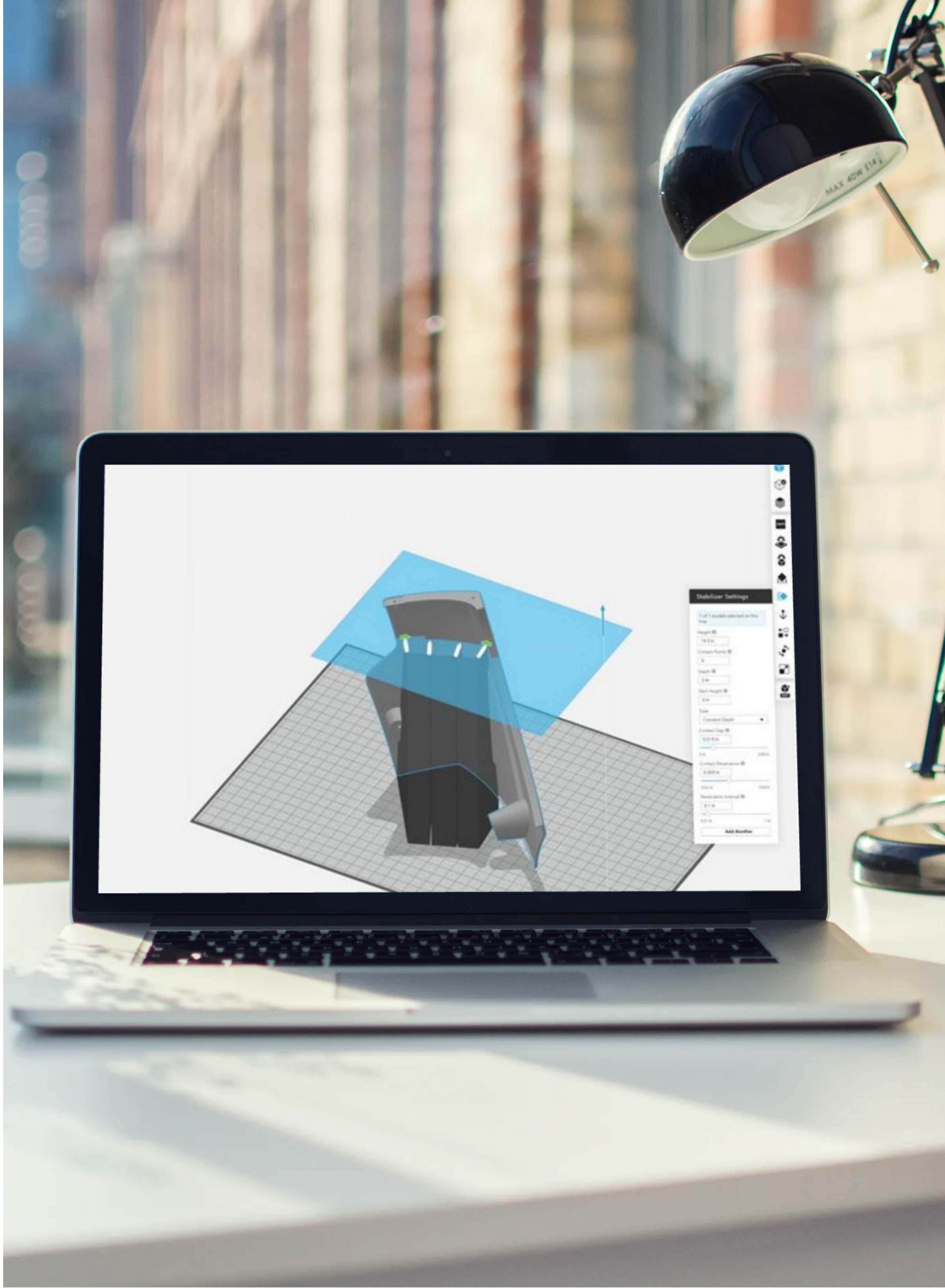
The realities of printing large parts.

Need for Stability

Bigger parts require more stability the taller they get. The printer's natural vibrations translate to the part, affecting these taller areas. If they're not secured they may move out of plane slightly, causing dimensional inaccuracies.

Adding a stabilizer wall to your part is one solution. A stabilizer wall is a separate structure of material built adjacent to the part with intermittent connections to reinforce it and keep it in the proper location. When the part is finished building, the stabilizer wall is removed.

Additional support material can also be used to buttress taller parts and overhung geometries. Although this means increased material and print time, the result is better accuracy. Printers that use breakaway or soluble materials for support structures make it easier to remove them than printers that rely on model material for this purpose. The latter is usually more difficult to remove and may leave surface blemishes. Soluble support is the most effective and time-efficient solution since it also enables complex designs with internal channels and can be removed hands-free in a dissolution bath.



The realities of printing large parts.

Curling and Warping

The tendency of plastic parts to curl during the printing process isn't exclusive to large parts but the problem can be pronounced due to size. The primary cause is the lack of consistent temperature control within the build chamber across the entire build platform.

This same problem can occur on printers that only use a heated build platform rather than a fully heated build chamber. As the height of the part increases during the build, the new material being applied at the top moves farther way from the heated platform, resulting in a temperature difference. This temperature gradient results in portions of the part heating and cooling at different rates, causing it to curl.

Another effective tool for this condition is the stabilizer wall mentioned above. Depending on your part's geometry, this capability is another useful way to preclude warping on very large and/or taller parts.

Now that you're aware of the main challenges associated with printing large parts, let's look at several additional approaches for optimizing print results.

Additional tips for successful large-scale printing.

Beyond addressing the typical hurdles associated with printing big parts, there are other techniques you can use to optimize your results. These added pointers will help you achieve higher-quality parts and get them in your hands sooner rather than later.

Optimizing with orientation.

Orientation describes how the part will be built inside the printer – upright, on its side or at some angle. The choice you make depends on whether you want to optimize the part for strength, speed of build or the quality of the surface finish. And that decision depends on the part's function: concept model, functional prototype, manufacturing tool or end-use part.

In the end, these orientations aren't mutually exclusive. It is possible to achieve a blend of benefits, depending on your part's geometry. But in practical terms, when you're printing large parts, or any size part for that matter, consider your primary objective in light of your constraints. If strength is the priority, orient for that result. If the production schedule is your limiting factor and strength and surface finish are secondary, position the part for maximum print speed.

Orienting for surface quality.

How you position the part in relation to its geometry governs its surface quality. Parts made with extrusion printers exhibit fine layer lines that are more or less evident depending on the layer thickness and the shape of the part. On curved surfaces, these layer lines are more pronounced, resulting in a "stair-stepped" look. If your part has curved or angular surfaces, orienting it so those surfaces are built parallel to the Z axis will result in smoother surfaces.

Orienting for strength.

Similar to surface finish, build orientation impacts the strength of a part or particular features. In general, orienting it so that important elements requiring strength or durability are parallel to the build plane and perpendicular to the Z axis produces the best results. This is because extrusion printers produce the greatest strength in this plane.

Orienting for speed.

The part's position in the build chamber affects the amount of support material needed during the build process, which ultimately impacts overall build time. Orienting your part to minimize its Z height requires less support material, resulting in a faster build. We'll cover build speed again in the next section when we consider the possible opportunities and risks associated with shortening the time it takes to complete the part.

This home appliance base prototype measures nearly 600 mm wide by 600 mm deep (23 inches x 23 inches), testament to the F770's large build capacity.

Additional tips for successful large-scale printing.

Optimizing time to part.

There are several approaches you can take to speed up the time it takes to get parts in hand. However, there are tradeoffs and risks associated with some of them, which we'll cover in this section.

Use less infill.

The first technique is to choose a less-dense infill. In extrusion 3D printing, the outer surface of the part is called the "contour." The interior of the part is made up of "infill," which can range from sparse to fully dense.

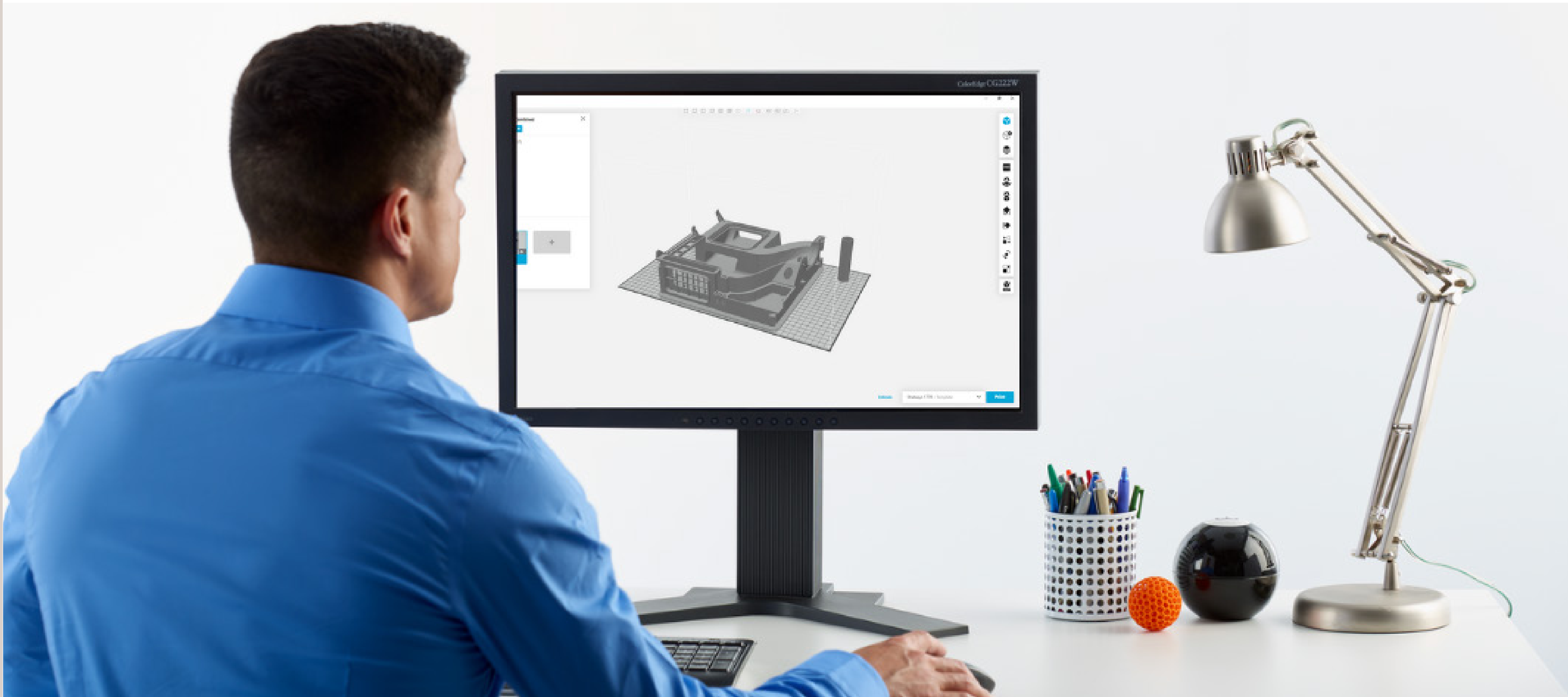
The sparser you can make the infill of your 3D printed part or tool, the faster the build process will be because there is simply less material to lay down. Obviously, if strength is a concern, fill density might have to change. The best solution involves adjusting the density in different areas of the part to suit design needs. 3D printers with this capability let you use full density in areas where it's needed and sparser infill where it is not.

Additional tips for successful large-scale printing.

Use a thicker slice height.
The second method involves using a thicker slice height, which refers to the thickness of the extruded layer. Applying more material per layer decreases build time. Layer lines will be more apparent as layer thickness increases but this may not matter if surface finish or fine details are not important.

Use multiple slice heights – for speed and aesthetics.
On the other hand, if both speed and aesthetics are important, using a combined slice height offers a best-of-both-worlds scenario. This entails using thicker layers on vertical surfaces, where layer lines are least noticeable, which increases throughput. On sloped surfaces or where more detail is needed, a finer slice is used to reduce stair-stepping and increase visual quality.

Minimize part height.
Third, as mentioned in the previous section, you can orient the part to minimize its height and/or reduce the number of unsupported or overhanging features. This results in less support material needed to prop up these features, reducing build time.



Additional tips for successful large-scale printing.

Hand vs. tank removal of support.
Soluble support material is a very effective tool that enables printing complex designs with internal channels, provided your 3D printer has this capability. But where the support is fully accessible, it can be removed by hand much faster than immersing the part in the dissolution bath.

This process can also be accelerated by the addition of perforation layers – layers of model material added between sections of support material. Perforation layers are usually employed when 3D printing with breakaway (non-soluble) support materials to make removal easier. However, they can also be used with soluble support, usually where large blocks of the material are used, speeding its removal time. While this process doesn't accelerate the print process, it can reduce the total time it takes to get parts in-hand.

Additional tips for successful large-scale printing.

Changing the default settings – balancing risk and reward.

Most 3D printers offer default settings designed to provide acceptable results for general purpose applications. However, the ability to change them may be available depending on your printer configuration. They include toolpath width, number of standard contours, support style, and slice heights, among others. Under the right circumstances, these adjustments can shave time off the build process. However, this benefit also comes with potential liabilities.

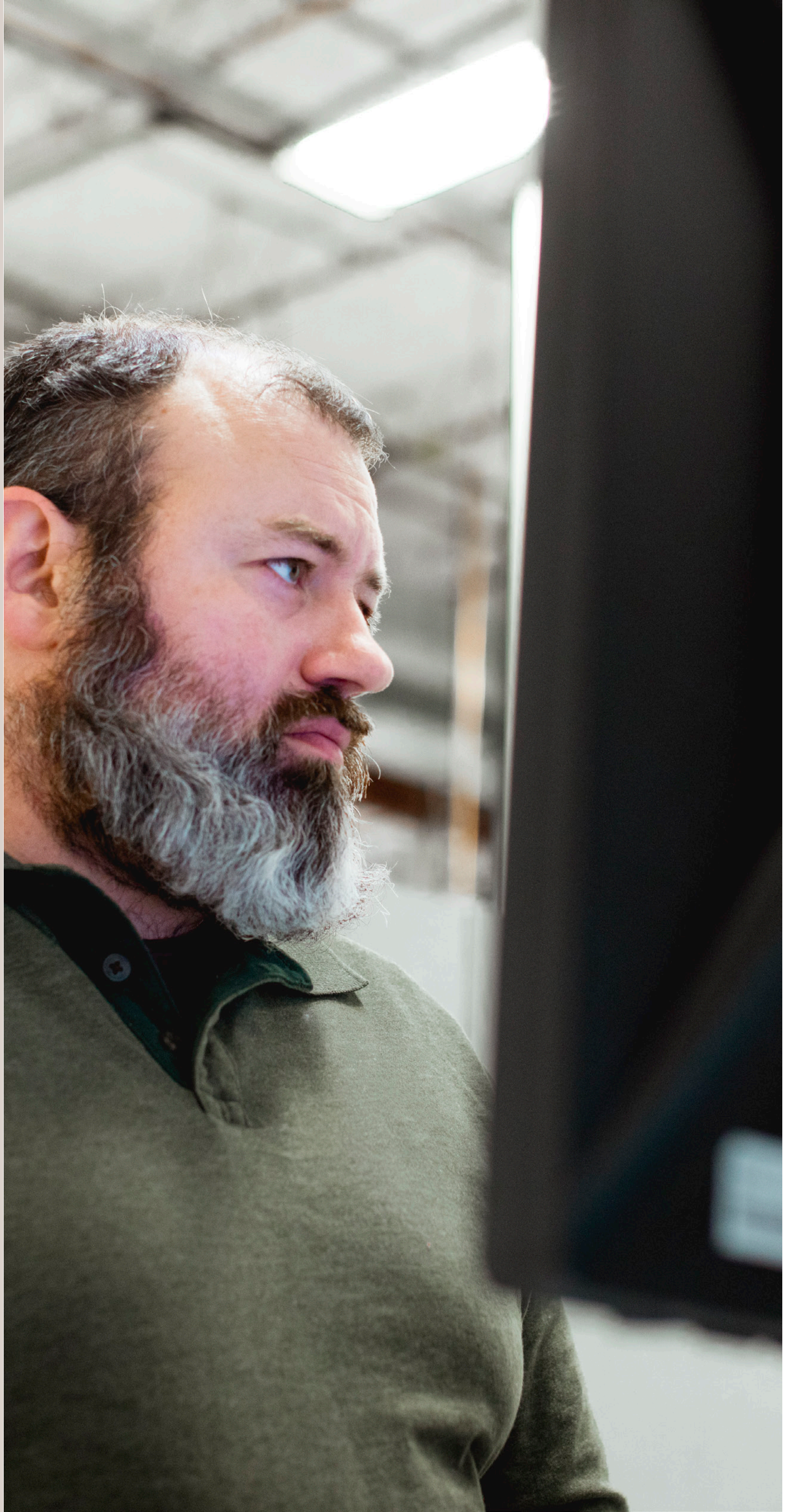
For example, building large parts can take considerable time and depending on your printer's reliability, the risk of a problem occurring rises with print duration. Also, Stratasys engineers found that adjusting build parameters on large-part builds only saved as little as 5% of the overall print time on average. If you decide to change settings, you need to ask yourself if the risk is worth the reward. Would saving four hours on an 80-hour build be worth it? It might be – but if a failure occurred at hour 75, you've just lost three days of print time – and possibly missed your production deadline. Consideration of how much schedule flexibility you have is important.

In contrast, a scenario where adjustments may be advantageous includes production builds, where you need to print multiples of larger parts. Taking the time to adjust file settings and then doing a test print to verify success may be worthwhile. Even if it saves just a little time on each build, the cumulative effect over multiple builds could be very beneficial.

The bottom line here is that large-format printing is doable, provided you know what you're up against. Since no one can alter physics, the realities of extruding hot thermoplastic to build things need to be dealt with, and that can be easy or difficult. But the right printer not only makes things easier, it lets you achieve impressive results in both the size and quality of your printed parts. So let's introduce you to the 3D printer that's just right for the job.

The opportunities of large-scale printing with the F770.

3D printing large parts on a reliable scale is no longer the exclusive realm of high-end, premium systems. The Stratasys F770™ 3D printer offers over 13 cubic feet of build volume and the ability to print parts up to 46 inches long. But there's more than just size here. Several key features offer valuable benefits that address the challenges raised earlier.



The opportunities of large-scale printing with the F770.

Generous Build Capacity

You don't need to worry about running out of material if you have a full material load. F770 material cartons provide 200 cubic inches of material, giving you up to 140 hours of continuous print time.

Soluble Support Material

An effective soluble support material means your large parts can be as detailed and intricate as they need to be. It lets you print the part you want and doesn't limit you to the part you can because of a less-capable printer.

GrabCAD Print™ and Insight™ Software

Good software gives you the tools you need to get the results you want. Print large parts with an effective blend of speed and favorable aesthetics using adaptive slice that automatically adjusts the layer thickness to optimize throughput and visual appearance. Dial in the right amount of infill where you need it to balance part strength and build time as well as material use. Easily create stability walls to ensure accurate parts. Incorporate perforation layers in your support structures for faster hand removal and quicker time-to-part.

Three Layer Thicknesses

Leverage the flexibility to tailor big parts for speed or detail with multiple layer thickness options. Or, rely on the adaptive slice capability for an optimized blend of both.

Fully Heated Build Chamber

An enclosed build oven and time-tested FDM® technology ensure a uniform temperature profile throughout the build volume. You'll build large parts that won't warp and curl, so what you model in CAD is what comes out of the printer.

The opportunities of large-scale printing with the F770.

When it comes to applications, the F770's value cuts across multiple industries including automotive, aerospace, heavy industry and agriculture, to name a few. Prototyping body panels is just one example of a typical use case for autos and recreational vehicles. Similarly, aircraft cabin and seat components can be mocked up with greater efficiency than traditional prototyping methods. Consumer goods manufacturers like those who make water softeners and other appliances can also benefit from the capacity of large-format 3D printers based on the size of their products.

Tooling is a particularly favorable application in many of these industries. Typically large and heavy, these tools can be made lighter by replacing metal with plastic under the right circumstances. 3D printed tools can also be easily customized and made more ergonomic for worker comfort and safety.

It's not that you can't achieve these objectives with smaller 3D printers. You'll just have to make the parts in sections and fasten the pieces together, provided your printer is sufficiently accurate to achieve that. All of this requires more up-front design time and post-print processing. It's precious time most manufacturers are hard-pressed to spend.

Instead, the F770 offers the opportunity to avoid that time and effort. It precludes having to stay with the slower, more expensive status quo of machining large prototypes and tooling fixtures or piecing parts together with smaller printers. Virtually any manufacturer that deals with larger tools and components can benefit from the F770's capabilities.

This painted 3D printed car fender illustrates just one of the many large-part applications served by the F770.

Time for big decisions.

If you or your team already has experience with reliable 3D printing, you understand the positive impact it can have on your production schedule and your budget. Now ask yourself this: what if you could 3D print even larger items than you're making now – what opportunities would that open for you?

And what if you haven't adopted 3D printing yet? You simply need to determine if making large tools and prototypes in less than half the time it currently takes you, at a lower cost, is worth it. There's plenty of readily available evidence that supports 3D printing's value as a time and cost-saving supplement to existing manufacturing approaches. If the price tag of current large-format 3D printers has kept you from joining the additive manufacturing party, consider the F770 your open invitation.

Time for big decisions.

Reliable, large-scale 3D printing is the F770's primary mission. And it's designed to do that so virtually anyone can initiate the print job – and then get back to their real job. Combined with its affordable price, it makes reliable large-format 3D printing, and the time and cost savings it embodies, much more accessible.

Find out how the F770 can scale up your operation. To learn more, **contact us** today.

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