

**Support-Free
Prints On
Origin One
DLP 3D
Printers**



Advantages Of Support-Free Printing

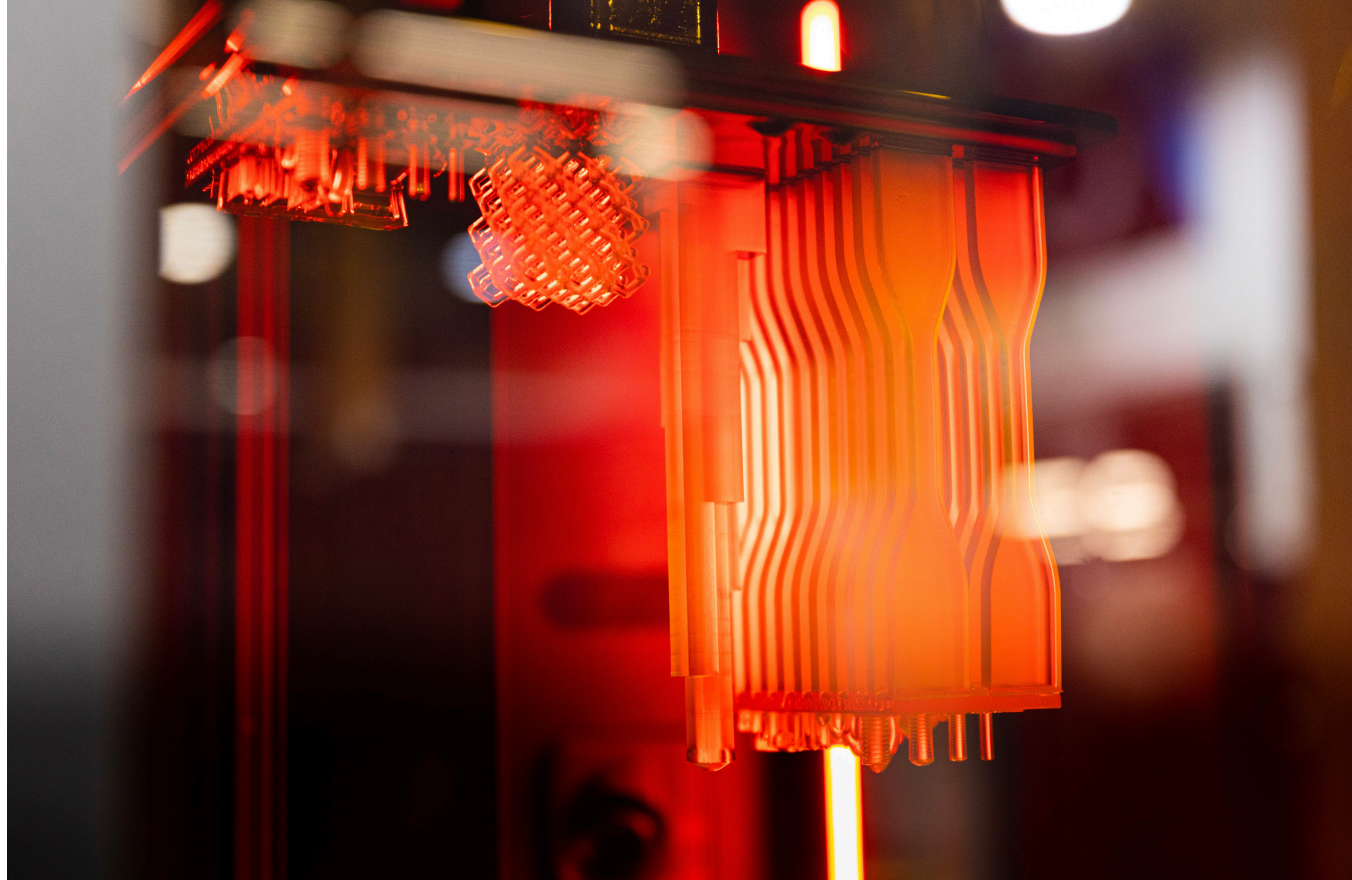
Printing without supports offers a number of advantages in situations where part geometry allows for it. When possible, support-free printing has the opportunity to simplify print preparation, reduce material usage, reduce post processing labor and increase throughput.

Support structures can take time and iteration to get just right. By printing parts directly on the build plate, this time can be eliminated from the pre-print and print qualification process. In addition to time required for generation and validation, supports use valuable material. While most support structures typically represent a small fraction of the volume of the finished parts, this volume is not always negligible. For serial production, material saving from the elimination of supports can be a meaningful cost saving.

Most importantly, printing support-free can drastically reduce the post processing labor required. Parts printed on supports need to be removed from these supports during the cleaning process. This step can be time consuming depending on the support styles used. Even for easily-removed supports, this time can add up quickly when printing large production runs. Supports also leave witness marks which may need to be manually finished in the post processing stage.

For low volumes this manual labor may not be significant, but when part counts climb into the 100's and 1000's this labor often becomes the primary driver of part costs. With support-free parts, you are able to eliminate these manual post processing steps, and get the most value out of batch production and post processing. As a result of these time and labor savings, cost can be reduced and throughput can be increased.

Selecting Parts For Support-Free Printing



Not all parts will be suitable for printing with supports.

Generally parts will fall into one of three categories:

1. Suitable for support-free printing without modification
2. Possible to print support-free with minor modification
3. Unsuitable for support-free printing

For support-free printing, there are some fundamental properties a part must have.

- The part needs to feature a flat face which can be placed directly on the build plate.
- The part must not have any islands or otherwise unprintable features, such as long flat overhangs, when this face is placed directly on the build head.

If both of these criteria are satisfied the next step is to check if any unvented volumes are created by this orientation. If a part meets all three criteria it is generally well suited to unsupported printing without modification.

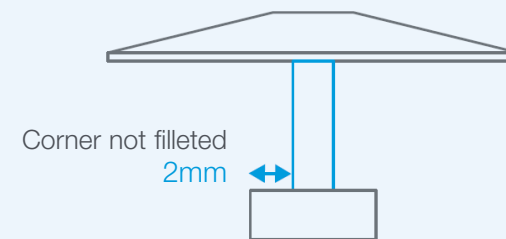
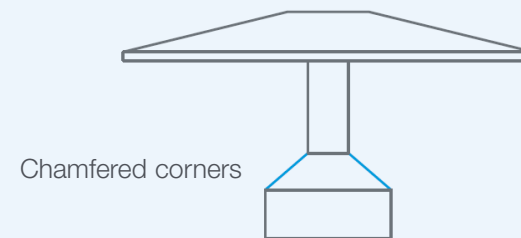
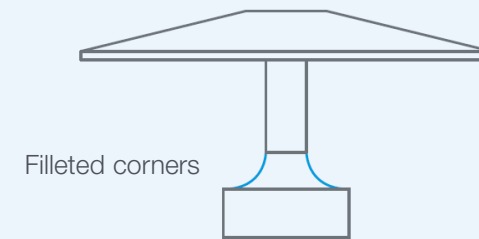
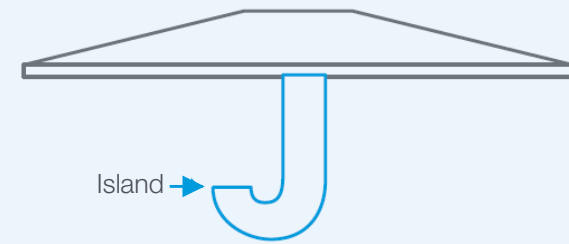
Design Changes To Enable Support-Free Printing

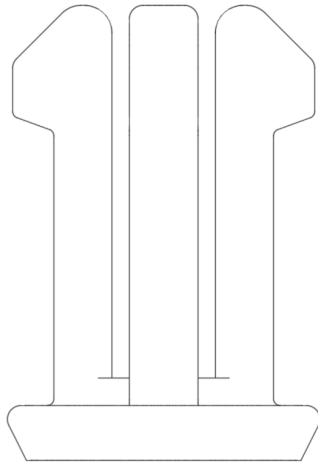
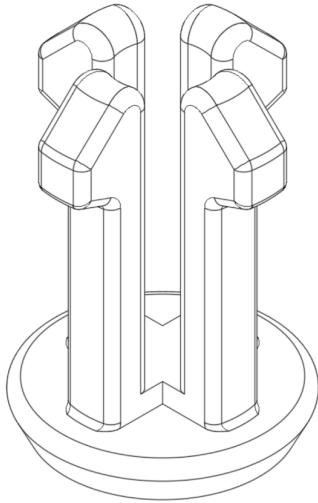
Many parts will fall into the second category, printable support-free with minor modification.

These parts generally will pass at least 1 or 2 of the criteria previously mentioned. Parts lacking a flat surface but passing the other checks can be adapted by adding a relatively small flat surface, provided the end use application allows for this.

In the case of parts with unvented volumes it is necessary to add a venting feature to the part. Overhangs can be addressed by adding a transition feature, such as a fillet or chamfer, or angling the overhang if the situation allows for either.

Parts with islands or that are not able to be modified will generally fall into the category of not being suitable for support-free printing. In these situations the modifications required would offset the advantages of printing the part without supports.



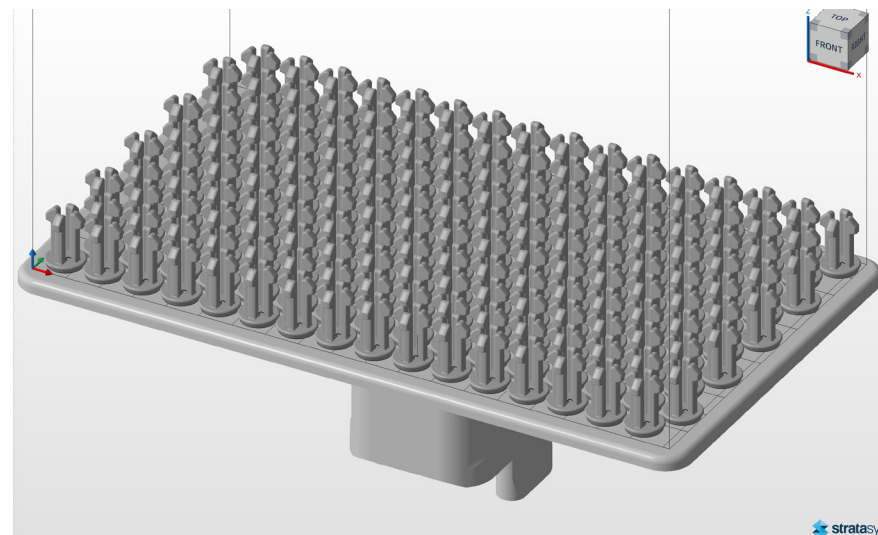


Examples Of Suitable Support-Free Parts

Unmodified Press Rivet

The 4 leg snap rivet shown to the left is a great example of a part well suited to support-free printing without modification.

The base of the rivet has a flat surface with an area very close to the maximum cross section of the part. This high contact area will help ensure the most reliable possible printing. Looking closer we can also see that the bottom of the teeth have a roughly 15° angle. This angle means that the overhang feature will be no problem for Origin One to accurately and reliably produce. In this case the overhang is short enough that a flat surface would also be printable. Unsupported overhangs should always be test printed to verify satisfactory results prior to entering production.



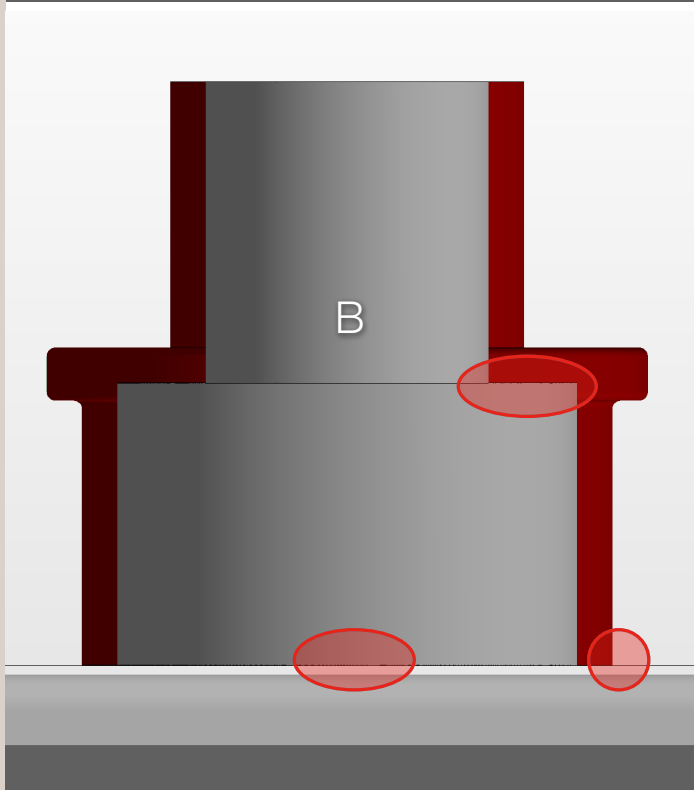
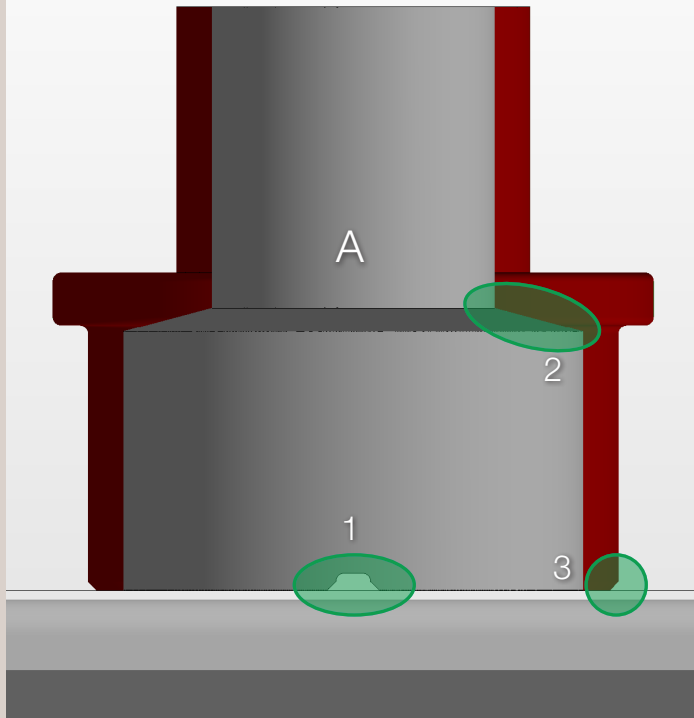
Minor Adaptations To A Hose Adapter For Support-Free Printing

The hose adapter shown here is a good example of a category 2 part. As designed it is not ready for support-free printing but with minor modifications it is a very good candidate. This part is a hose adapter to allow for a step down in hose size. The initial design is shown on the bottom and the revised design is shown on the top. In this case the initial part is not suitable for support-free printing. As designed the part presents a large overhang. In addition to the large overhang, the part creates an unvented volume when printed directly on the build plate.

Three minor modifications have been made to part A in order to make it well suited to printing without supports.

1. First, vent holes were added at the bottom to address the unvented volume. Since the adapter is intended to fit inside a hose, these vents have no detrimental impact on the function of the part.
2. The large internal overhang has been updated to feature a 15° angle. This angle allows the downfacing surface to print free of supports.
3. Lastly a small, 0.5mm, chamfer was added to the outside edge of the part where it contacts the build plate. This chamfer is not strictly required but will help make part removal easier than if the edge were left square.

This part also presents a good example of how the contact area does not always need to be nearly the same as the maximum cross sectional area for a given section. In this case the flange feature has a good deal more area than the plate connection section. Here the distribution of the contact is more important than the total area. Since the contact occurs around the full perimeter of a large diameter, the fixation of the part will be very stable. This stability combined with the low separation forces of P3 combine to create a favorable condition for reliable printing.



Orientating Parts For Printing Without Supports

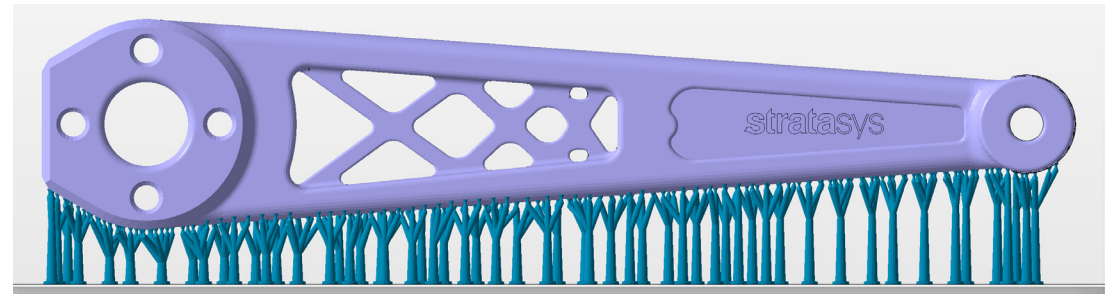
The robot leg shown to the right is a good example of a part that can be printed without supports, without modification.

The stiffening feature inside the pocket is made of up beams placed at an angle rather than horizontal, allowing for these features to be self supporting. The part also features a flat surface that can be placed directly on the build platform. This small design element is the result of processed based thinking. While typically a round boss may be used if the part were to be machine or molded, the flat surface does not have any functional detriment but does serve to enable placement on the plate. Lastly this flat surface features a small chamfer to ease removal of the part from the build plate.



While the part can be printed support-free, there may be situations where a supported approach would be preferred.

For this part the support-free orientation is very tall resulting in a relatively long print time. During development and prototyping it may be preferred to print this part on its side using supports as shown here. The shorter print time may allow faster iteration of the design.

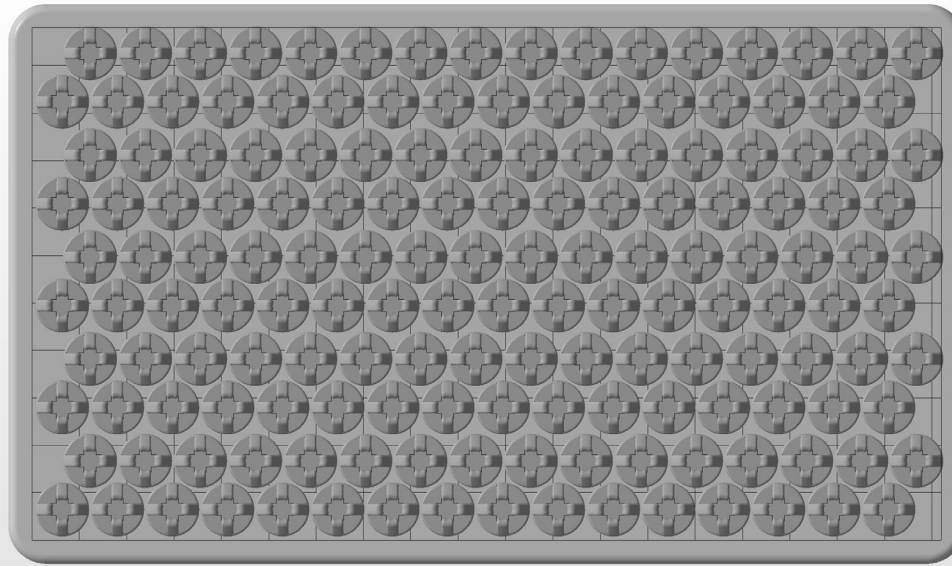


Once iteration is completed the vertical and support-free orientation would be preferred.

The vertical orientation allows for a higher throughput due to its advantageous packing ability, further material and labor savings are able to be realized via the elimination of supports. This kind of orientation change can be made with minimal concern due to the high isotropy of the P3 process.



Cost Savings For Press Rivets



The real benefits of support-free printing are realized when producing production runs of parts.

The press rivet we examined earlier is a great part for a deep dive illustrating the advantages of support-free printing.

By packing the parts in offset rows it is possible to fit 160 of the snap rivets on the build plate. These parts are roughly 17mm tall which yields a print time of approximately 30 minutes, depending on the material used. This means that over 2,500 parts could be produced in a single 8 hour shift, or over 50,000 parts per month. At these throughputs it is critical to minimize per part post processing labor.

After printing, parts must go through a post processing step before being finished and ready for use. This process starts by removing the parts from the build head. Subsequently

any supports are removed and the parts are washed in a series of cleaning baths. After washing and drying, the parts are then post-cured to achieve their final material properties. After curing, any support marks left on the parts are removed via hand work typically consisting of sanding and or filing.

Most of the post processing steps are completed with batches of parts rather than on a per part basis. The final stage of support removal and support mark removal is a per-part process. With high part count builds this per-part labor and the associated cost can add up quickly. The table below shows the total handling time and cost that would be required for support mark removal assuming that the technician spends 20 seconds working on each part.

Labor time per part 20s

Parts per day 2500

Labor per day 13.9hrs

Labor cost per part \$0.14

Labor cost per day \$347
@\$25 per hour



As we can see, even at a reasonable per part time of only 20 seconds, the total post processing labor would be almost 150% of a standard shift.

If supports were required for this part, available technician time would become the binding constraint preventing maximum possible throughput. By printing these parts support-free, throughput is unconstrained and technicians are free to focus on other activities. perimeter of a large diameter, the fixation of the part will be very stable. This stability combined with the low separation forces of P3 combine to create a favorable condition for reliable printing.

Conclusion

Support-free printing is one of many powerful capabilities enabled by the Origin One. As we have seen, support-free printing can offer a number of substantial advantages in production applications. To maximize the potential of support-free printing it is important to have a good understanding of the constraints, and a strong dialogue between the printing and design teams.

Many parts will not be suitable for support-free printing as they are designed. Many of these parts may be adaptable to make them well suited. In these instances it is critical that the part designers are involved in the design revision process. This serves two important functions. Firstly, involving the part designers ensures that no design intent is violated and further that the adaptations do not compromise the function of the part. Secondly, by involving the designers and discussing the constraints with them, a learning process is started. As designers grow accustomed to the constraints of support-free printing, they will learn to design with them in mind. With consideration for printing early in the design process, more parts can be well suited for support-free printing. This will reduce design adjustment time and increase overall throughput and efficiency.

While many advantages do exist for support-free printing, it is not the right solution for all situations. It is important to have many workflows for printing parts with varying geometries. In many situations the compromise required for support-free printing would not be practical. In these cases it is best to develop a refined support structure which minimizes material consumption, support removal, and finishing time, rather than trying to force the parts into a form which can be printed support-free.



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