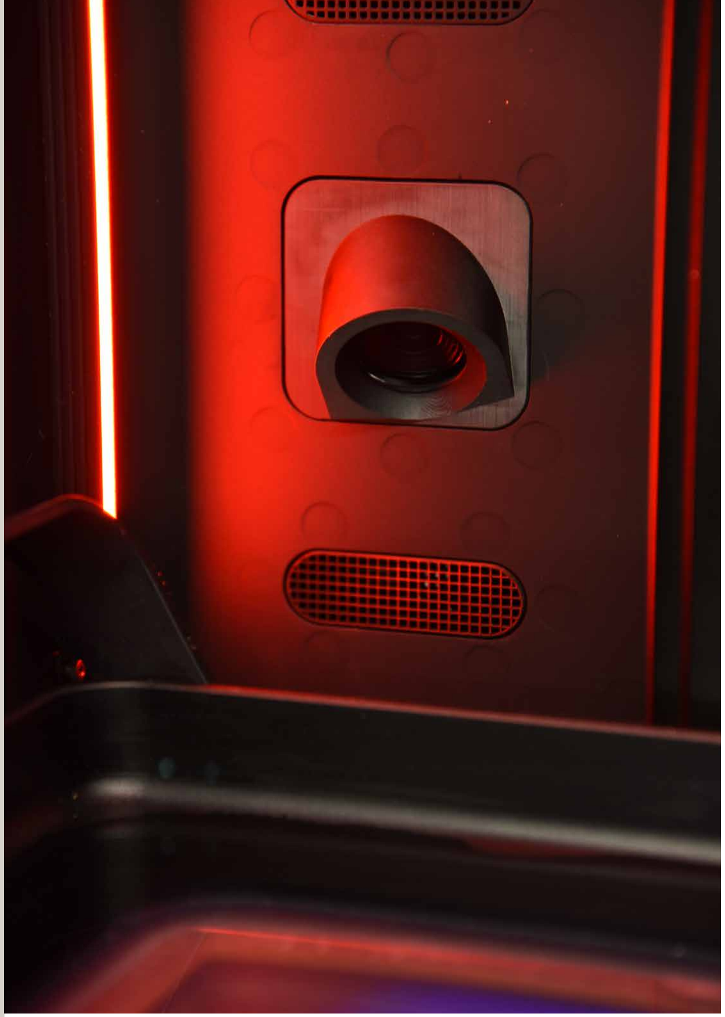

# How to orientate parts for the best results in DLP 3D printing

E-Book



# Great parts start with **proper print preparation.**

Every 3D printing technology is different, and each requires its own print prep considerations to achieve the best success.

When designing parts and preparing prints for the Origin One, or any DLP technology, one important consideration for the best part quality is part orientation. To help you prep better builds we are going to discuss some key orientation considerations and their implementation. These considerations will drive how you choose to orient parts when printing on the DLP-based Origin One 3D printer.

The Origin One printer uses Programmable PhotoPolymerization, or P3™, a form of DLP 3D printing. The P3 process is a highly repeatable and controlled type of 3D printing and incorporates a unique pneumatic separation mechanism. This process produces extremely repeatable parts which exhibit high green strength and high isotropy; the separation mechanism works to minimize adhesion forces during the print process. Together these properties allow for a great deal of flexibility when orienting parts for printing. **Learn more about P3 here.**

While the content of this article is relevant to all DLP processes, it is most accurate for the Origin One and its P3 technology. Non-P3 printers may require additional support or other adjustments to account for the higher separation forces and lower green strength.

# Preventing unvented volumes

P3 is an inverted vat polymerization process also known as bottom-up resin printing and relies heavily on resin flow mechanics during the print process. One of the most important steps in build prep is eliminating or reducing the impact of unvented volumes. So what exactly is an unvented volume? If you have ever placed your finger over the end of a straw and drawn it out of liquid, you have experienced an unvented volume. With the straw sealed off, the liquid is unable to drain from the straw due to the vacuum it would create at the sealed end. With a sealed shape printed via P3, this same phenomenon occurs.

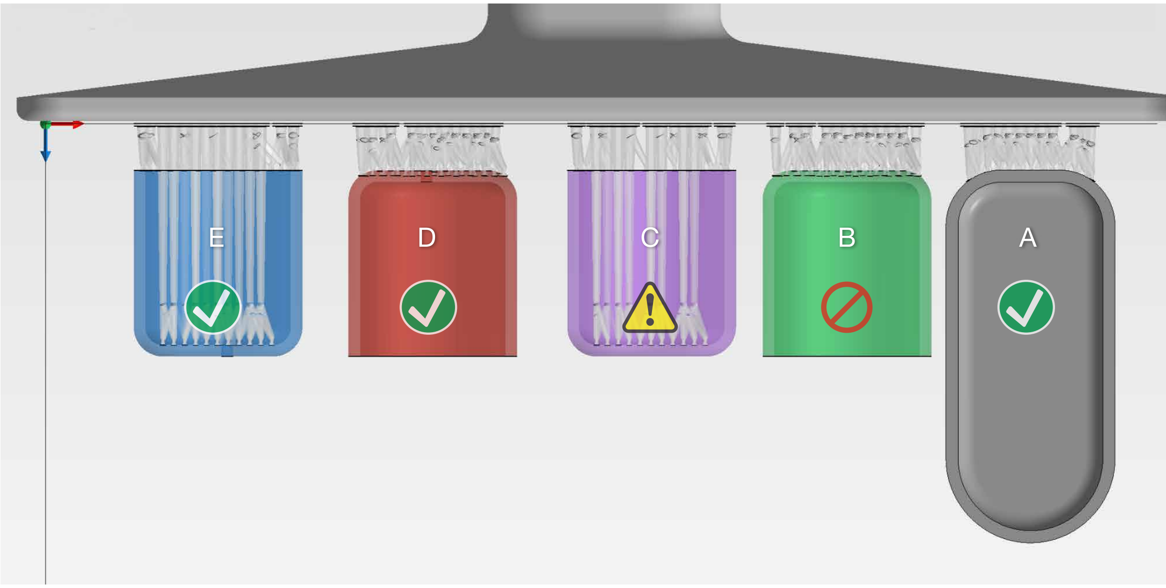
The vacuum inhibits needed resin flow and creates suction forces which may lead to part failures. Unvented volumes can be prevented by designing a small vent hole to break the vacuum in the part, or reorienting the part to avoid the vacuum when the vent hole cannot be accommodated.  Vents should be located such that they are formed as early in the print as possible. Until the vent is formed the volume will remain unvented, by placing the vent early in the print, the volume will be vented for as long as possible.

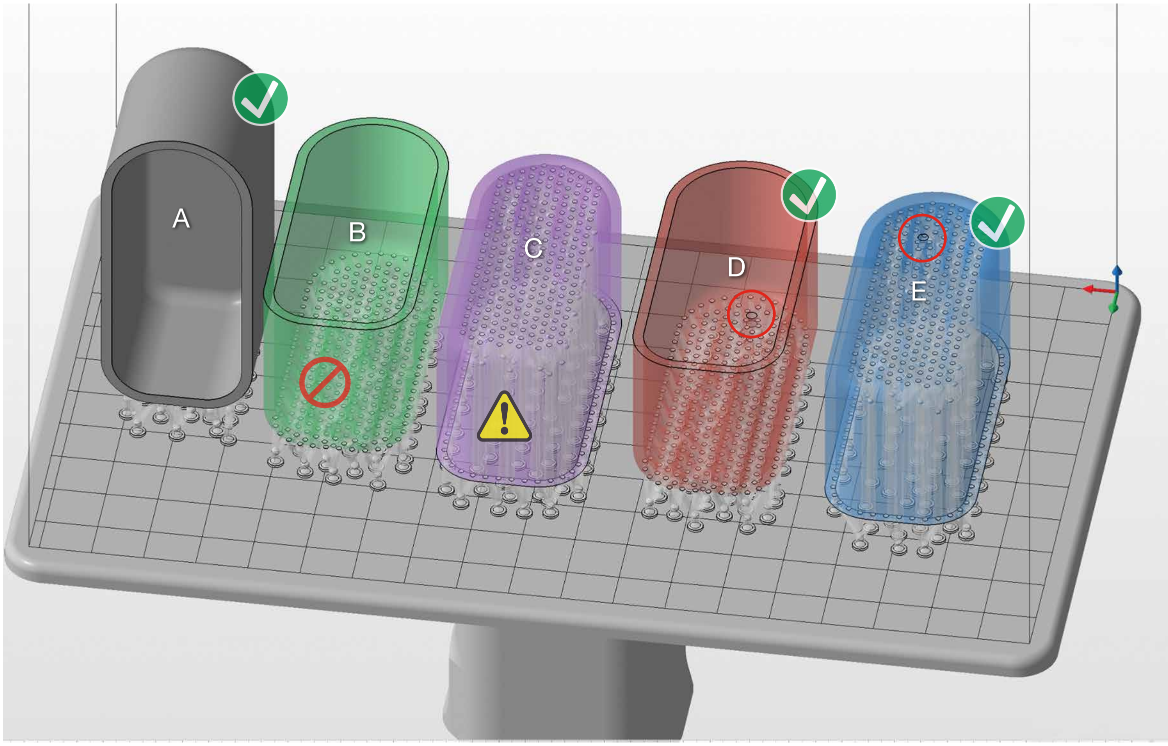
In addition to unvented volumes increasing print failures, it is important to be aware of features that create closed cup shapes that will hold resin. In these situations, a small vent can be added to serve as a resin drain. Similar to the unvented volume causing a vacuum, resin holding can also often be addressed via careful part orientation.

# Optional
# part orientations

In these images we see the same part in 3 different orientations, for 2 of these orientations, a vented and unvented version is shown.

- Part A has no venting but is oriented in such a way that no resin flow or resin drainage concerns are introduced.
- Part B shows a problematic unvented volume. A vacuum would be created as the part is printed, as discussed this will create resin flow problems and may lead to poor part quality or even failures.
- Part C shows an orientation that will hold a large amount of resin as the bottom surface is formed. In some cases this will just result in resin trapped in the part, in other cases, this can prevent the bottom surface from fully forming.
- Parts D and E show effective venting. In the case of part D, the vent helps prevent the formation of a vacuum as the walls are printed. For part E, the vent is really serving as a drain and will allow the otherwise entrapped resin to drain out.



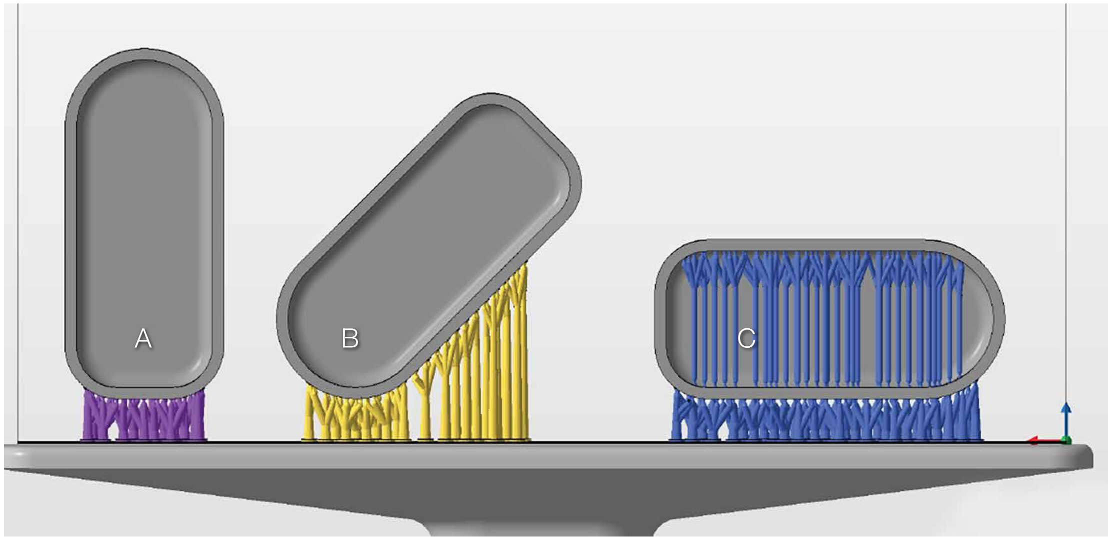



# Minimizing **required supports**

## Orientation will have a direct effect on the quantity and placement of support structures.

Generally, it is desirable to minimize the total support required for a given part. This reduces post-processing time and minimizes material usage. In the image above the same part is shown in 3 different orientations. Supports have been added to illustrate the impact of part orientation.

Orientation A requires only simple supports on its bottom surface, since these supports land on a single flat surface, removal during post-processing will be simple. Orientation B requires minimal support at its lowest surface, however, the unbalanced nature of the part means that additional taller supports are required to ensure reliable printing. Orientation C requires the most base supports and requires internal supports for the large flat surface.




| Orientation | A | B | C |
|---|---|---|---|
| Support volume (ml) | 1.2 | 2.3 | 5.3 |

# Optimizing for **surface finish**


Part orientation will also have implications on the surface finish of the printed parts. Two main mechanisms drive this relationship. The first is geometrically driven while the second is related to witness marks left by supports at their contact points.

It is important to plan the faces which can be used for support connections. As mentioned the contact points of supports will leave small witness marks on the finished part. The marks can be seen on top of the part shown to the left.

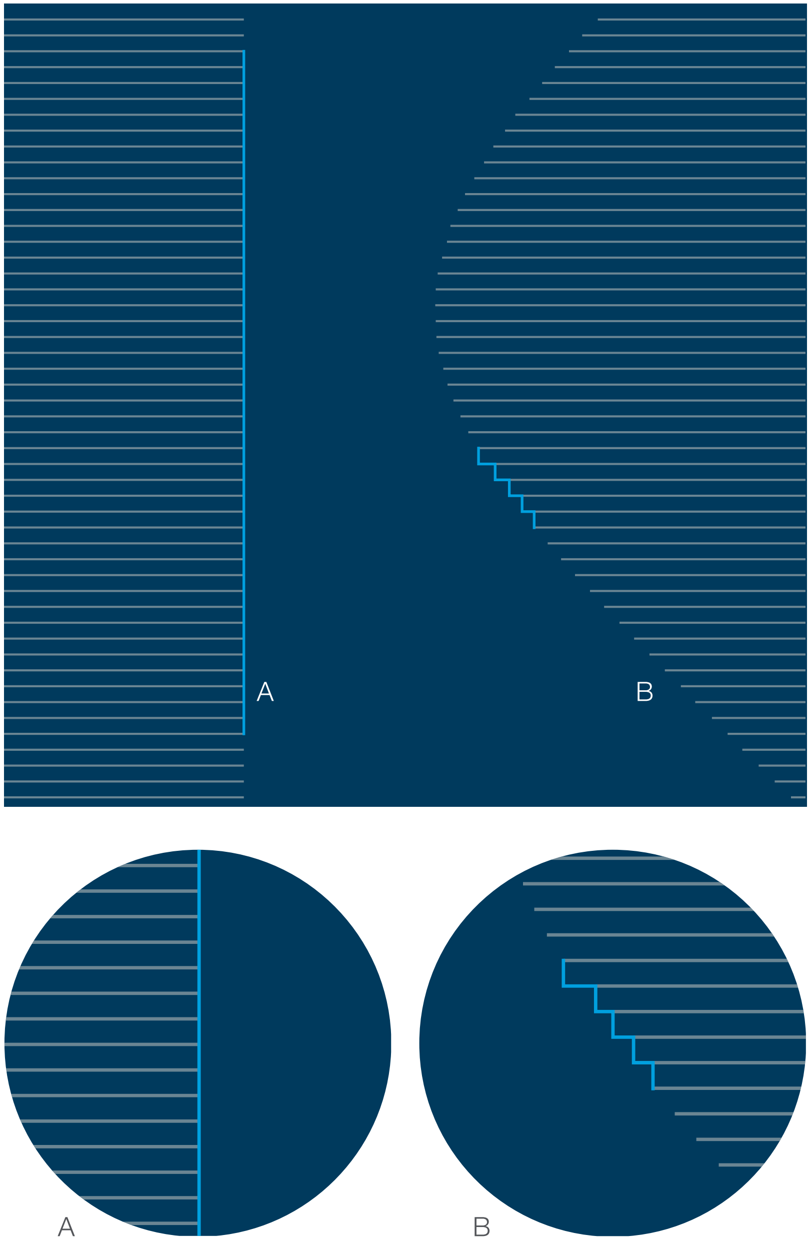
Whenever possible supports should be placed on non-cosmetic surfaces to avoid the need to finish these artifacts. While this is often possible there are cases where placing supports on A-Surfaces is unavoidable. In these situations, it is best to try to minimize the amount of support required. Careful post-processing with files and sandpaper can easily remove these marks and blend the surface to a smooth finish. In situations where supports must be placed on the A-Surface, it is recommended that test articles are produced and post-finished to determine the best strategy.

# Avoiding staircase effect

From a geometric perspective, it is desirable to orient vertical surfaces in the Z direction.

Similarly, horizontal surfaces oriented parallel to the build plate will yield the smoothest possible results. This is a function of the way that the surface is built layer by layer. When surfaces are oriented at an angle, other than perpendicular, they are resolved stepwise as they are built. This phenomenon can be seen in the graphics on the right.

Stair stepping will be most noticeable for very shallow angles. The part on the left (A) is oriented square to the build direction while the part on the right (B) is oriented at 45° relative to the Z-axis. We can see that both the top and the side surface of the part on the right, experience stepping. Origin One has advanced process software that will help minimize stepping. Generally stepping that does occur is very fine and largely imperceptible to touch however it is visible when viewing finished parts.



# How orientation **impacts print time**

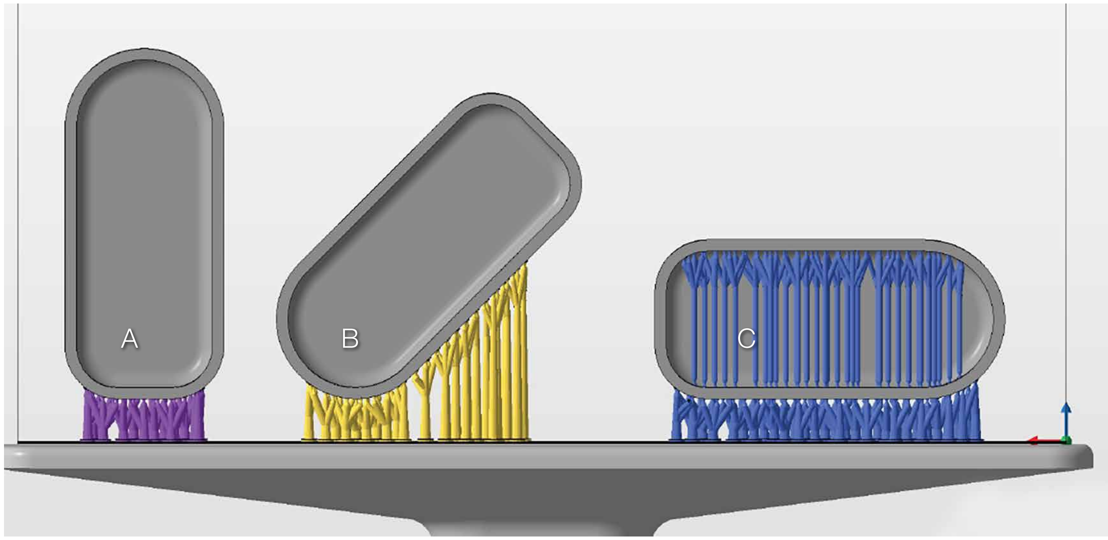
With the P3 process, print time is a function of material selection and overall print Z height. Unlike most other printing processes, the P3 process is insensitive to the amount of part area per layer. This is because, unlike other processes, the entire layer is exposed simultaneously. With the entire layer exposed at one time, there is no toolpathing or tracing required. The overall print height will be a function of any supports and the orientation of the part.

In the image to the right we see the same part in 3 different orientations. Option A will require the least support but is the tallest of the 3 options with an overall height of 72mm. Option B requires only slightly more supports than option A and has an overall height of 64mm. Lastly, option C will require the most support however it has an overall height of only 37mm.

The table shows the relative print times for the 3 orientations using option A as a baseline. We can see that option C is almost 2x the speed of option A while option B offers a modest print speed improvement vs option A.

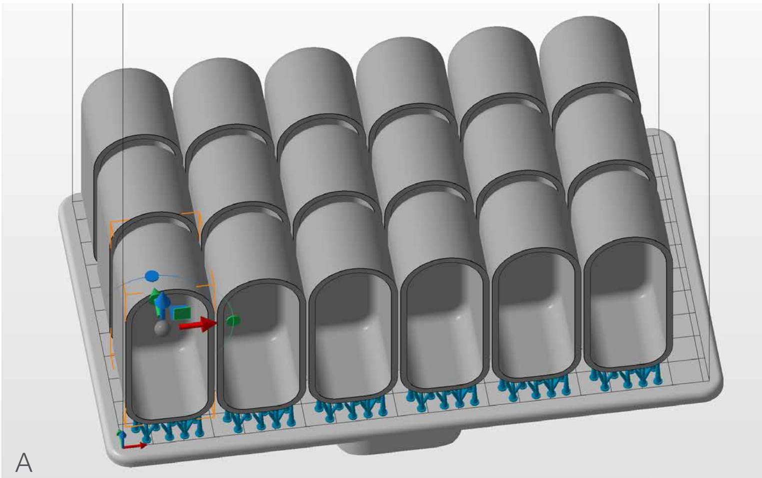
## Orienting for speed will generally be a balance of multiple considerations.

In situations where only a few parts are required, it can be advantageous to print them in a fast orientation. When you have parts with surfaces that are not well suited to sanding or polishing, it may be more important to minimize or otherwise control the number or location of supports. For other situations, a higher packing density may be desirable.

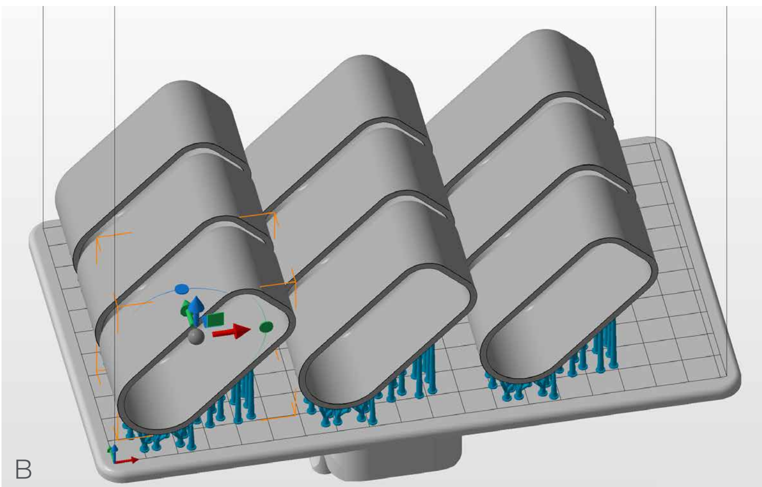



| Orientation | A | B | C |
|---|---|---|---|
| Print time (hrs: min) | 2:46 | 2:26 | 1:24 |

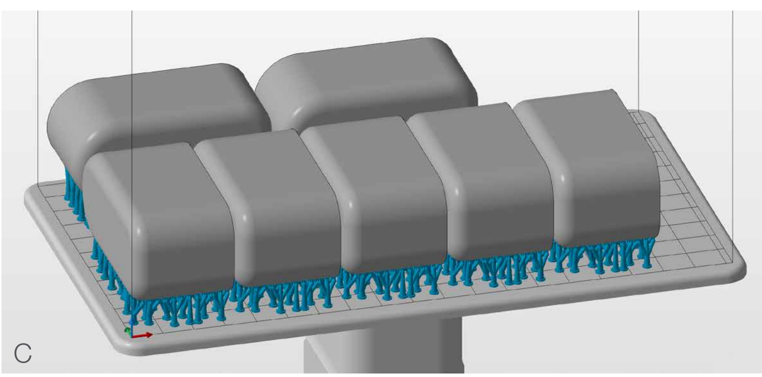
Time approximate for 3843 White



A



B



C

# XY Part Nesting Density

Part nesting density is an important consideration when preparing production print jobs.

As mentioned, the print speed with the P3 process is only sensitive to material selection and layer count. With this in mind, it is desirable to pack parts as densely as possible. For the purpose of this guide we will focus on XY packing. The three images to the left show the maximum density that can be achieved with the 3 part orientations we have used throughout this blog.

| Orientation | A | B | C |
|---|---|---|---|
| Parts per build | 18 | 9 | 7 |

For this example part, we see that orientation A yields substantially more parts per print than the other options. This can be taken one step further. If we consider the part count together with the print time we can start to look at the time per part. Using an 8-hour shift, we can see the per shift throughput for each orientation in the table below.

| Orientation | A | B | C |
|---|---|---|---|
| Time per part (minutes) | 9.25 | 16.22 | 12 |
| Parts per 8hr shift | 54 | 24 | 35 |

As shown in the table, despite the longest time per print, orientation A yields the lowest time per part and the highest throughput per shift. In addition to producing the highest yield, orientation A also results in the least support material used for the easiest post processing.

# Conclusion

## Part orientation is all about balancing multiple considerations.

There are generally many different orientations that will result in a successful print. Exactly how a part should be oriented will be a combination of the part's geometry and the factors discussed. The P3 technology of the Origin One provides immense flexibility to orient parts. Ultimately maximizing throughput can be achieved while maintaining exceptional part quality and consistency. When in doubt, do not be afraid to split test a number of orientations while developing production print files.

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