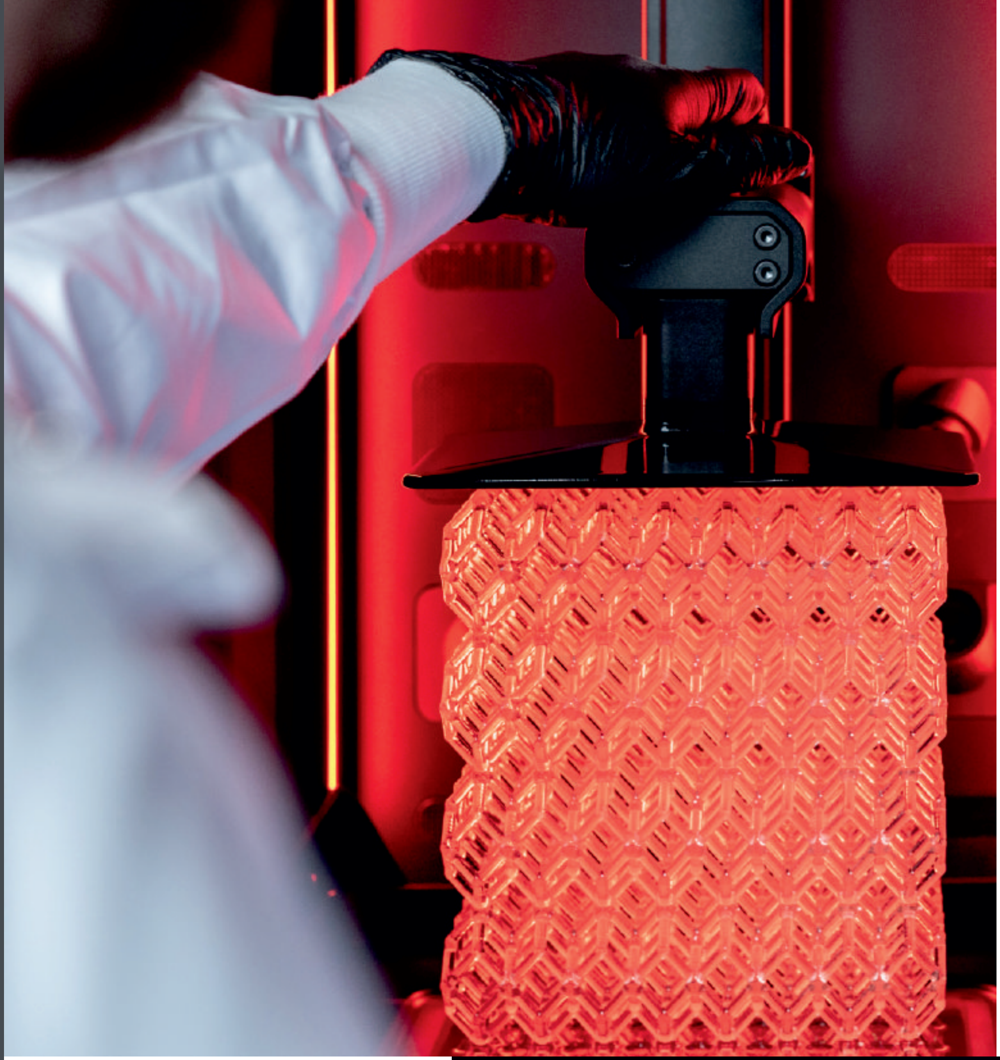

Origin® One

Accuracy, repeatability and isotropy

stratasys

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White Paper

Origin One accuracy, repeatability and isotropy

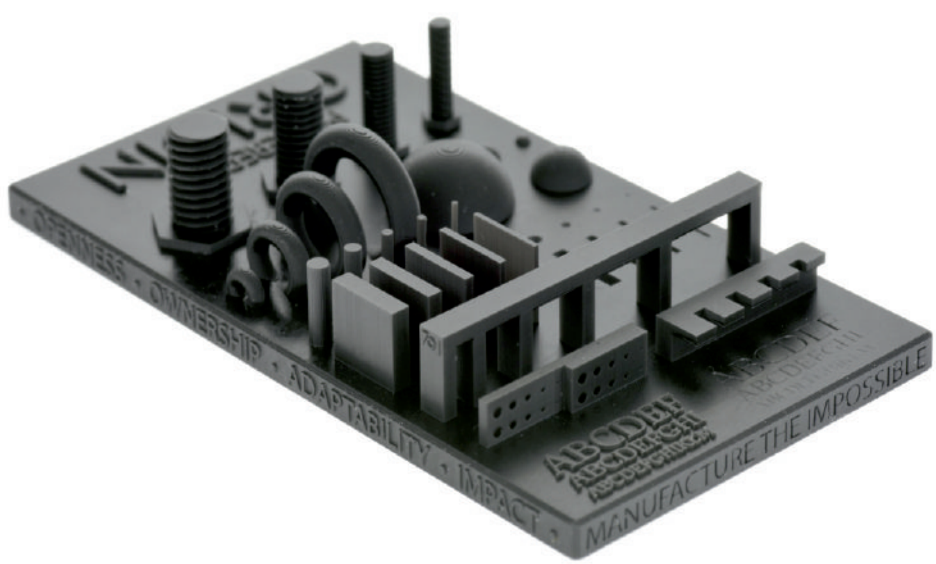
Any additive manufacturing (AM) process deployed for the production of functional and end-use parts must be accurate and repeatable when it comes to the geometric dimensions and material properties of manufactured parts. One method of evaluating the variability of an AM process is to examine the accuracy and precision of part dimensions and mechanical properties, as well as the repeatability of those results on a build-to-build and machine-to-machine basis.

Although dimensional accuracy is critical to any application, an AM process with high repeatability in the geometric dimensions of produced parts can automatically compensate for dimensional inaccuracies through the use of software-centric techniques. Furthermore, a process that produces parts exhibiting a high degree of isotropy provides greater flexibility, ease of use and confidence across various part geometries and build scenarios. In the absence of these key properties, the high degree of unpredictability can present barriers to scaling up manufacturing volumes and operations in many applications. Hence, these aspects are critical factors in developing confidence in any AM process.

The goal of this study was to perform an evaluation of Origin One's Programmable Photopolymerization (P3™) technology in terms of part accuracy and system repeatability of dimensional measurements and mechanical properties across multiple Origin One manufacturing systems and across consecutive production builds.

Test methodology

The test methodology selected for the study examines the variability of an AM process by collecting quantitative measurement data through various mechanical and dimensional tests, and then analyzing the resulting data with statistical techniques. For dimensional accuracy, mean and standard deviations (SD) of geometric dimensions are used as a measure of accuracy and precision, respectively. For mechanical properties, coefficient of variation (CV) is selected as a measure of variability, since mean and SD values are less meaningful when comparing measurements that significantly differ in base values and units. The tests were performed across many consecutive builds on separate Origin One systems, and the sample size for the study consisted of more than a hundred manufactured test specimens.



Mechanical properties

We evaluated tensile modulus, tensile strength and elongation at break of ASTM D638 Type I tensile specimens manufactured in flat (XY) and vertical (ZX) orientations relative to the build platform of the Origin One (see Figures 1 and 2).

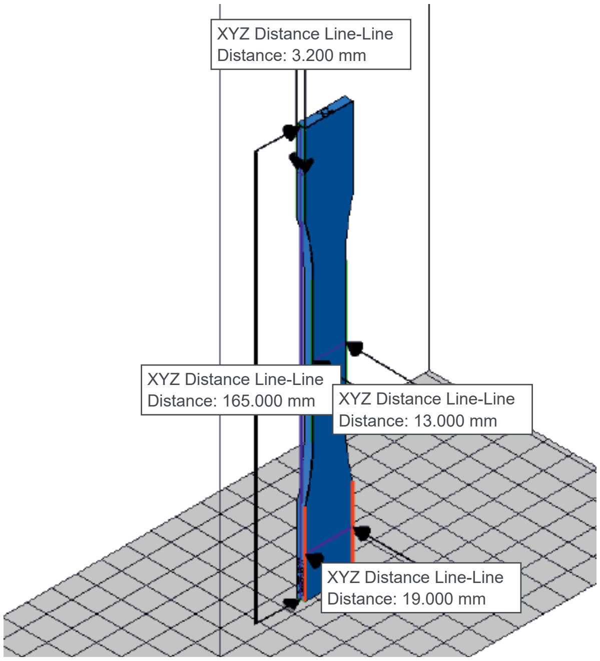


Figure 1: ASTM D638 Type 1 tensile specimen shown in ZX (vertical) orientation with annotated dimensions.

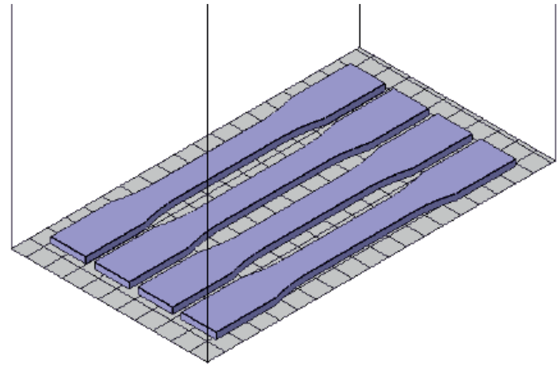


Figure 2: ASTM D638 Type 1 tensile specimen shown in XY (flat) orientation.

The examination of tensile modulus, tensile strength and elongation at break across Origin One's printers using ASTM D638 Type I tensile specimens found low coefficients of variation for all samples tested, as can be seen in Table 1. This indicates that Origin One's technology is highly precise and, consequently, highly predictable. Additionally, analysis of all tensile specimens across orientations, labeled "Overall CV" in the table below, yielded results that were consistent with orientation-specific results, suggesting high isotropy with Origin One's technology.

	Elongation at Break			Tensile Strength			Tensile Modulus		
Orientation	XY	ZX	All	XY	ZX	All	XY	ZX	All
Machine A CV	8.53%	4.77%	7.13%	2.20%	2.54%	3.93%	5.01%	5.47%	6.33%
Machine B CV	10.88%	9.30%	10.03%	2.72%	4.01%	3.97%	3.51%	4.97%	4.46%
Overall CV	9.62%	7.35%	8.65%	3.76%	5.35%	5.35%	4.51%	6.96%	6.40%

Table 1: A table summarizing the calculated coefficients of variation for the various orientations and printers.

Dimensional accuracy

For our evaluation of dimensional accuracy, we measured various dimensions of manufactured accuracy evaluation parts designed specifically for the purpose of this study (see Figures 3 and 4).

Table 2 presents the machine-to-machine results as well as overall results for the dimensional accuracy and repeatability tests, with mean deviations (MD) from nominal dimensions and standard deviations (SD) presented side by side for all dimensional features. The results show that the feature dimensions are both accurate and precise, with all mean and SD values falling within -12 and 43 microns.

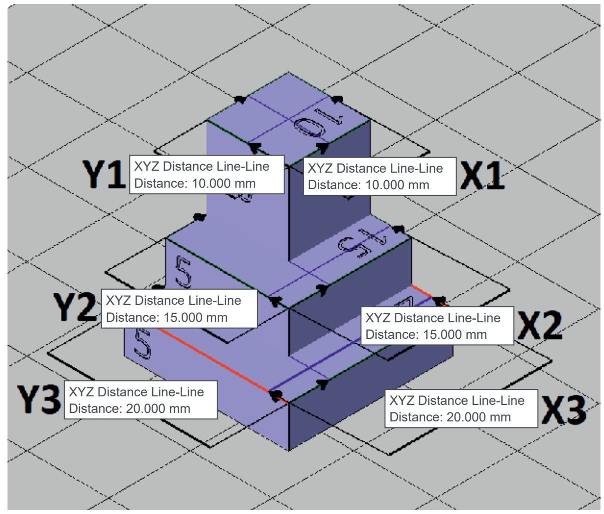


Figure 3: Accuracy evaluation specimen with annotated horizontal dimensions.

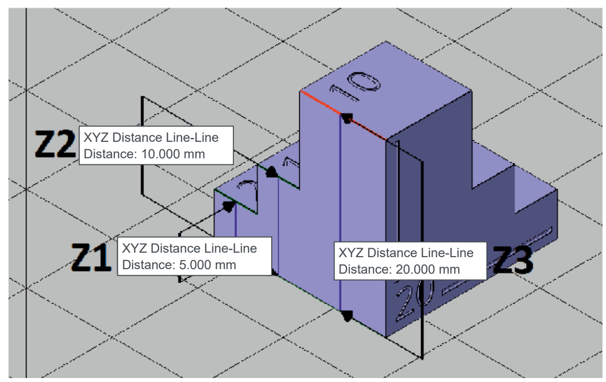


Figure 4: Accuracy evaluation specimen from a different perspective from Figure 3 with annotated vertical dimensions.

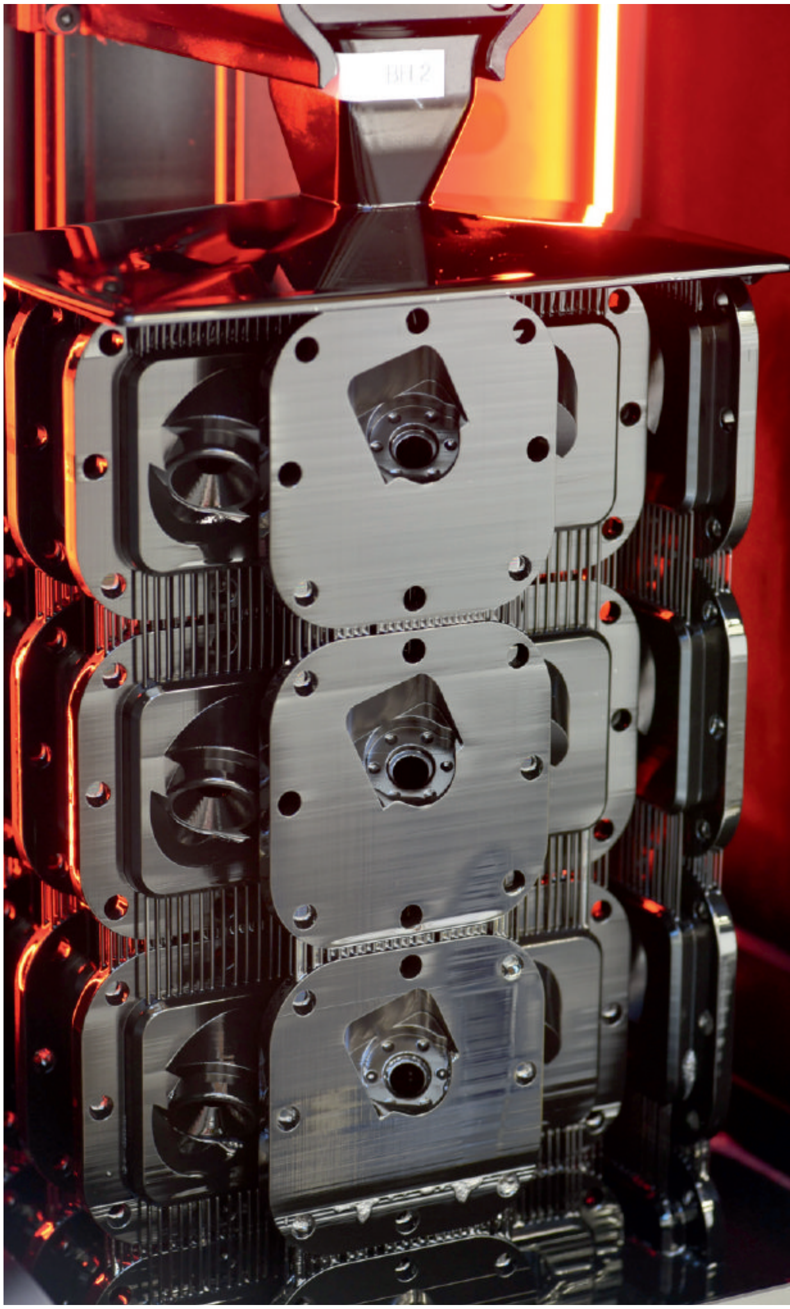
(All values are in mm)		Positive Features X-axis			Y-axis			Z-axis		
		X1	X2	X3	Y1	Y2	Y3	Z1	Z2	Z3
Nominal		10	15	20	10	15	20	5	10	20
Machine A	MD	0.027	0.009	0.012	0.010	-0.006	0.000	0.012	0.038	-0.012
	SD	0.010	0.022	0.017	0.014	0.021	0.017	0.024	0.025	0.026
Machine B	MD	0.005	0.017	0.016	0.016	0.028	0.028	0.006	0.043	-0.001
	SD	0.012	0.013	0.015	0.014	0.020	0.011	0.037	0.042	0.043
Overall	MD	0.016	0.013	0.014	0.013	0.011	0.014	0.009	0.041	-0.007
	SD	0.016	0.018	0.016	0.014	0.026	0.020	0.031	0.034	0.036

Table 2: Mean deviations (MD) from nominal and standard deviations (SD) of measurements from the dimensional accuracy test.

An accurate, production-grade AM solution

The Origin One is a transformative 3D printer enabling mass production of functional and end-use parts in a diverse range of high-performance materials. It empowers manufacturers with industry-leading accuracy, consistency, detail and throughput, allowing them to take on the most demanding production applications in manufacturing.

The results of the study confirm that the Origin One, powered by its cutting-edge P3 technology, achieves best-in-class dimensional accuracy, consistency of mechanical properties and part isotropy. The high degree of repeatability demonstrated across many manufacturing builds and different machines inspires confidence and fulfills a mission-critical requirement present in any high-volume additive manufacturing application.



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