WHITE PAPER

New levels of speed, quality and affordability bring a new equation to prototyping with additive

3D SYSTEMS
Additive Manufacturing Solutions

The next chapter in additive technology is written by Figure 4 technology – a new manufacturing solution using non-contact membrane DLP (Digital Light Printing), state-of-the-art plastic resins, and a light-based UV curing process that takes minutes versus hours with heat-based curing processes.

The system architecture of Figure 4 enables superior final part and material quality, including improvements to toughness, durability, high temperature deflection and elastomeric properties.

This is possible due to the speed of the non-contact membrane process combined with the low static volume print tray, which allows for more highly reactive material chemistries that might not be achievable with other photopolymer 3D printing methods.

Fastest throughput via technology

Extensive testing* shows the Figure 4 system offers print speeds up to 100mm/hr (Table 1).

These print rates remain constant regardless of how many parts are being built due to the non-contact membrane DLP technology that powers the 3D Systems' Figure 4 platforms.

Taking the fast curing process into consideration, Figure 4 enables a time to first part-in-hand (printed, cured, washed, dried) of 160 minutes (2.67 hours) in draft print mode, or less in standard print mode (Table 2). This is a newly achieved benchmark in the 3D printing industry.

Here it is important to note the critical distinction between throughput and raw print speed. True industrial 3D printing throughput must account for the print process, any required curing time, as well as other post-printing requirements (such as washing or drying).

Only when the part is ready for manufacturing or shipping can it be considered complete. Print technologies that offer fast raw print speeds but require extended cure times can be highly deceptive. A 3D printing process must be looked at holistically to determine the true productivity that is possible.

TABLE 1. PART PRINT SPEEDS ON 2 MATERIALS

SPEED (MM/HR)	DRAFT	STANDARD
Figure 4 TOUGH-GRY 10	103	77
Figure 4 TOUGH-GRY 15	71	41

Figure 4 technology provides breakthrough printer speed at up to 100 mm/hr (Preliminary data. Both Draft and Standard print quality used).

TABLE 2. TIME TO PART-IN-HAND

MATERIAL	TIME TO PART
Figure 4 TOUGH-GRY 10	160 min (2.67 hr)
Figure 4 TOUGH-GRY 15	280 min (4.67 hr)

Time to first part-in-hand, including printing, curing, washing and drying based on test geometry on run on a Figure 4 Standalone using Draft mode (Preliminary data).

*Internal benchmark completed by 3D Systems

Fastest throughput via scalability

Early benchmark testing by 3D Systems shows that within 11 days, eight Figure 4 Standalone printers can turn out 10,000 units of a textured automotive vent. In those same 11 days the injection molding process would still be in the mold design stage.

The CAD-to-production speed of digital molding makes it ideal for Low Rate Initial Production (LRIP) or bridge manufacturing.

Companies can go to market faster, with the option to convert to injection molding to ramp up volume as demand grows.

Figure 4 Standalone is an affordable and versatile solution for low volume production, and fast prototyping in the tens and hundreds of parts per month.

With a compact and easy-to-use design, Figure 4 Standalone delivers ultra-fast speed at an affordable price and low total cost of operation.

Much like digital photography, digital printing, and digital video, digital molding with Figure 4 is the result of combining complementary technologies to achieve a result greater than the sum of its parts. Advances in CAD software, 3D printing technology, materials science, and robotics—along with new tools for digital texturing—come together in the Figure 4 digital molding platform.

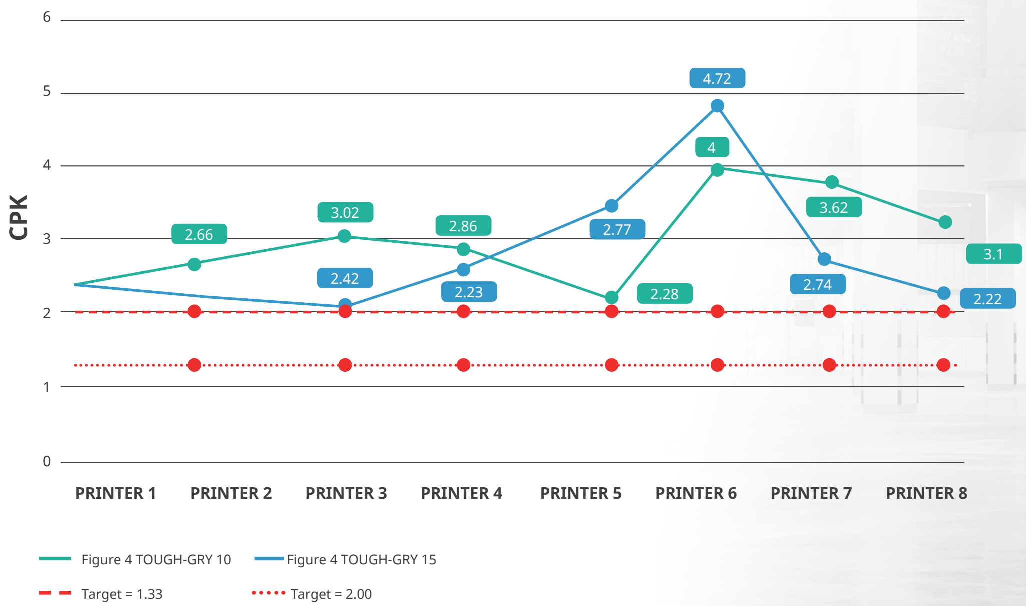
DIGITAL MOLDING:

An alternative to traditional injection molding that enables designs to go straight from CAD to manufacturing without tooling or delay.

FIGURE 4 STANDALONE:

An individual printer targeted at very fast prototyping, low volume production and jewelry casting patterns.

IMAGE 3B. FIGURE 4 SIX SIGMA REPEATABILITY



Results from eightFigure 4 printers with two different materials consistently deliver a Cpk > 2.
This equals 0.002 parts per million are out of spec (Preliminary data).

Fastest throughput, highest accuracy

Figure 4 delivers the fastest DLP 3D printing in the industry with repeatability that is unmatched. Test results show that Figure 4 offers print speeds up to 100 mm/hr—at six sigma repeatability.

The statistical result is stated as Cpk > 2, where Cpk is the process capacity index. A result of 2 or higher is considered a "six sigma" quality process (Image 3A).

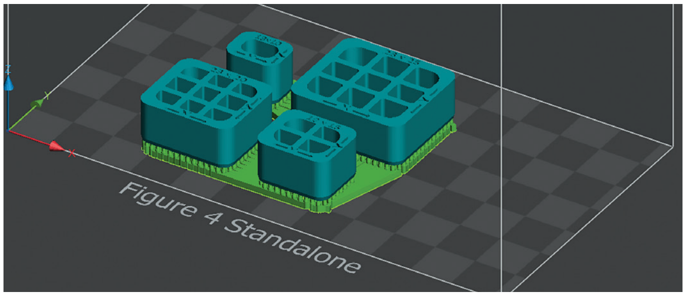
IMAGE 3A. FIGURE 4 SIX SIGMA REPEATABILITY

	FIGURE 4 TOUGH-GRY 10	FIGURE 4 TOUGH-GRY 15	TOLERANCES
C_{PK}	2.46	2.03	+/-100um

Repeatability results from 3 Figure 4 printers consistently deliver a Cpk above the target 2.0.

Cpk is a statistical measure of the ability to produce output within specification limits. Cpk takes into consideration how much natural variation a process experiences relative to the specified limits. Using a standard statistical measurement allows different processes to be compared without ambiguity.

To establish a Cpk value for the Figure 4 3D printing platform (Image 3B), tests were run on eight machines individually. Cpk testing requires running 30 samples. The test part was printed on each Figure 4 printer and measured using micrometers four times; the average was used for the statistical sample.



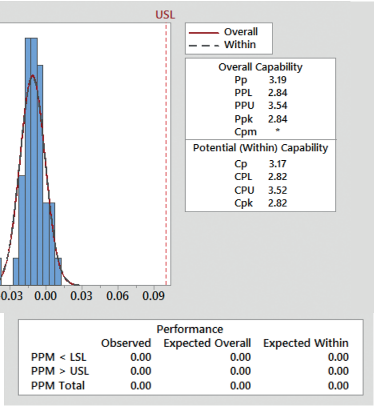
Testing parts on the 3D Sprint build tray set up

IMAGE 4. PRINT BUILD SETUP

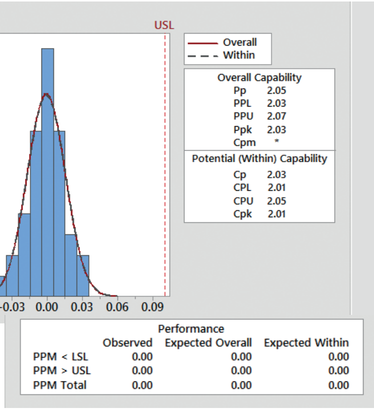
Next the physical model was adjusted, and new objects were printed and measured again. The results for each printer from both runs were given their own results chart. The combined results scored 2 or higher, establishing six sigma quality in the repeatability of the process. Certain individual results scored Cpk = 1.94, which is not a six sigma result, but remains much higher than the other nearest standard of 1.67 for "safety or critical parameter for a new process" (Image 5).

*Internal benchmark completed by 3D Systems

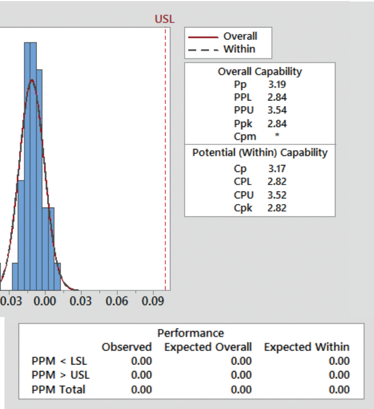
IMAGE 5. PROCESS CAPABILITY RESULTS



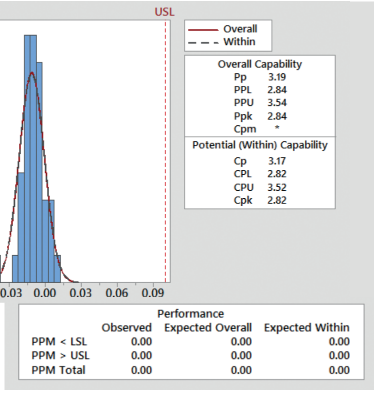
003: Printer 1 Stats (5-prints)



004: Printer 2 Stats (5-prints)



005: Printer 3 Stats (5-prints)



006: Printer 4 Stats (5-prints)

Designed to fit your production needs

An integral part of the solution is the 3D Sprint® additive manufacturing software which supports the preparation and optimization of CAD data and then manages the additive manufacturing process on Figure 4 3D printers.

With a broad set of additive manufacturing preparation, editing and management tools, 3D Sprint enables a significantly decreased cost of ownership of Figure 4 by reducing the need for software seats by third party vendors. 3D Sprint's single user interface delivers the tools needed to go from design to 3D print.

With standard 3D data translators provided, import and repair of 3D meshes is enabled. Access to a wide range of 3D editing tools supports immediate printability analysis, and takes advantage of the built-in, intelligent software to optimize part placement and supports for your 3D printer.

3D Sprint's management and monitoring tools allow engineers to accurately estimate print time and optimize material levels and usage both before and during the print operation.

Management of print queues, job priorities, and monitoring of printers enables immediate understanding of all print jobs, helping to reduce total cost of operations.

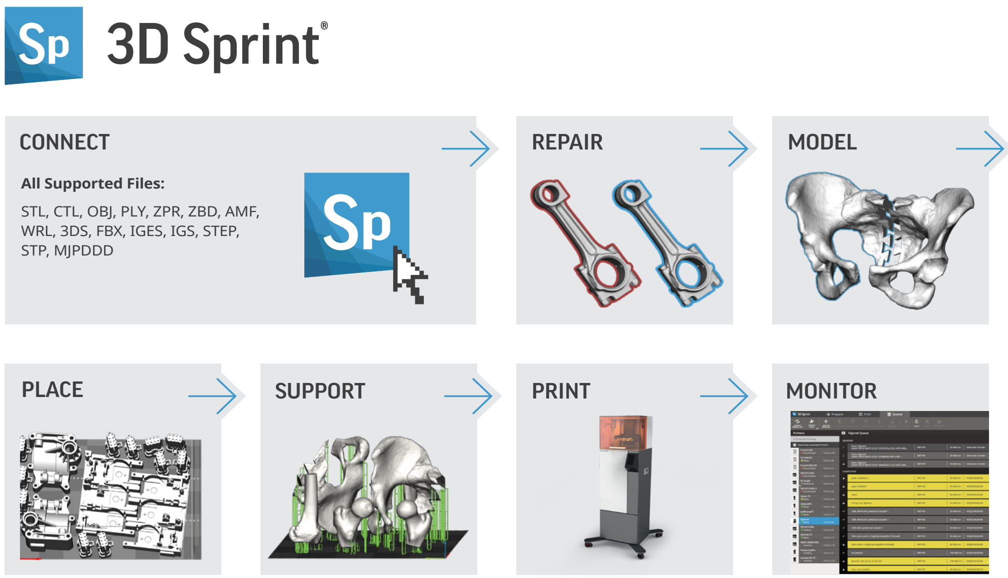


Figure 4 Standalone

Ultra-fast and affordable for rapid, same-day prototyping

With fast part throughput, repeatability and accuracy, Figure 4 Standalone sets a new benchmark for rapid prototyping. Parts can be designed and printed in the same day, allowing for fast design iteration and verification, and same day shipping.

AFFORDABILITY
Industrial-grade durability at an affordable price

VERSATILITY
Performance from a wide variety of materials

SPEED
Fast throughput speed for accelerated "parts in hand" delivery

LOW TOTAL COST OF OPERATION
Cost efficient and productive

What's Next?

Interested in Learning More About Figure 4 Standalone?

Talk to an expert about which material and solutions would work for you

Get in Touch

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