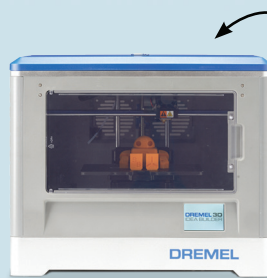


ANNUAL GUIDE TO 3D PRINTING

Make:



DREMEL'S
IDEA
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REVIEWED

26
3D PRINTERS
TESTED!

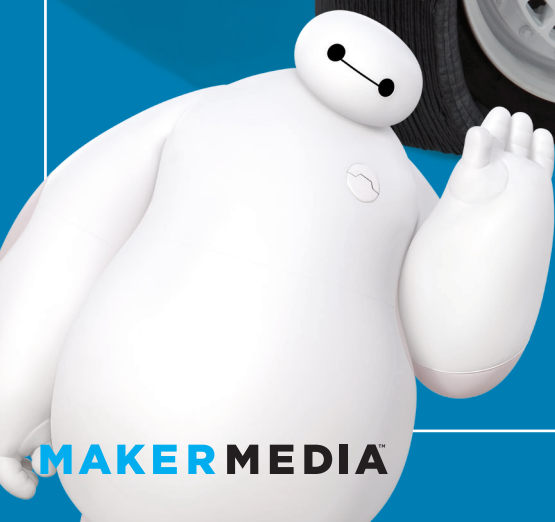
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Full Reviews of our Top 10 Printers

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Behind the
Maker Tech
in Disney's
Big Hero 6

3D PRINT YOUR CAR*

***(YES, REALLY)**

3D EVOLUTION

WRITTEN BY ANNA KAZIUNAS FRANCE

The new printers are much more polished than their predecessors — but are they as consumer-ready as their finish and packaging suggest?

2014 HAS BEEN A FULL-THROTTLE YEAR FOR 3D PRINTING SINCE JANUARY'S CONSUMER ELECTRONICS SHOW (CES) introduced us to dozens of new machines. It's clear that additive fabrication has caught the attention of major brands in all sectors (Adobe, Microsoft, Hasbro, Dremel) and the push for the mainstreaming of this technology has hit a new plateau.

Although there's been a lot of hoopla, most of the changes to actual functionality have been small; with slow and steady improvements being made to existing (and sometimes cloned) hardware,

software, and documentation. Many machines are still in the adolescent stage, but a few have blossomed early, and their polished appearance has begun to attract wider consumer attention.

When unpacking the machines that were tested in our third annual Shootout weekend, I immediately noticed a dramatic, consumer-product-style change in machine packaging and overall fit and finish. Printers once arrived in packing peanuts and were made of laser-cut plywood, now most are shipped with custom foam inserts reminiscent of desktop computer packaging with bodies

made of injection-molded plastic. These machines are slowly evolving, but does their performance meet the expectations set by their consumer-ready facades?

We were keen to find out. The core group of 3D-printing test-team veterans (some of whom have been present at all three Shootouts) began preparing more than a month before our trip to this year's new location at America Makes in Youngstown, Ohio. With the addition of 3D-printing research scientist Andreas Bastain, our test methods advanced from mere visual inspections of Thingiverse objects. We drafted a flexible

evaluation protocol and created parametric models that could be quickly adapted to any unexpected situation. These preparations, combined with the onsite, real-time, data-crunching diligence of Kacie Hultgren (aka Pretty Small Things) has yielded quantified comparison data that we could only dream of previously.

As you read through our reviews, you will see two distinctly different, complementary types of data: the quantified print-quality scores and the qualitative evaluation of our team's personal experience with each machine. As with last year's testing, each machine was run by several different 3DP experts to ensure that personal preferences did not skew the results, and we systematically and anonymously contacted customer support. The materials, host, and slicing software listed on each review are manufacturer recommended, but we verified hardware and software openness by tracking down the source files and their licenses.

We're proud of what we've accomplished during this year's testing, although there's always room for improvement. We used Ultimachine orange PLA as a control variable (the team agreed that it was a solid, widely available choice, representative of what would commonly run through desktop machines), some exceptions had to be made (noted in our print-quality summary) for machines that refused to function or jammed without proprietary filament.

In addition, our fused filament fabrication XY and Z resonance mechanical tests did not yield the granularity they were designed to collect and were downgraded to weighted Pass/Fail scores. Many of our SLA tests proved to be too far too ambitious and were abandoned. That may sound bleak, but it was all part of the plan — as Andreas relates on page 34, these models were *designed* to fail.

Why does all this matter? Because — as Kacie states on page 36 — “consumers want accurate prints at the push of a button” and consumer adoption of 3DP (with lower prices and widespread technological transformations that their adoption could enable) is directly dependent on how we answer two key questions: “What is print quality?” and “What should we expect from our 3D printers?” 🗨️

An Old-Fashioned American Shootout



DURING THE 2013 STATE OF THE UNION ADDRESS, PRESIDENT OBAMA referenced the National Additive Manufacturing Innovation Institute (NAMII) in Youngstown, Ohio as a new program to look at for economic inspiration. A year and a half later, *Make:* chose to conduct its annual 3D-printer tests at their location as a way to help connect a traditional manufacturing community with the Maker Movement.

Located inside a once-shuttered furniture factory, the institute, re-named America Makes in October 2013, honors the city's industrial past while embracing a technological future. Aiming to become a center point of research and development for the rapid-moving world of 3D printing, it teaches its workers to be experts in all areas of additive manufacturing — from desktop to industrial — while offering knowledge and facilities to companies and universities who are looking to bolster their capabilities.

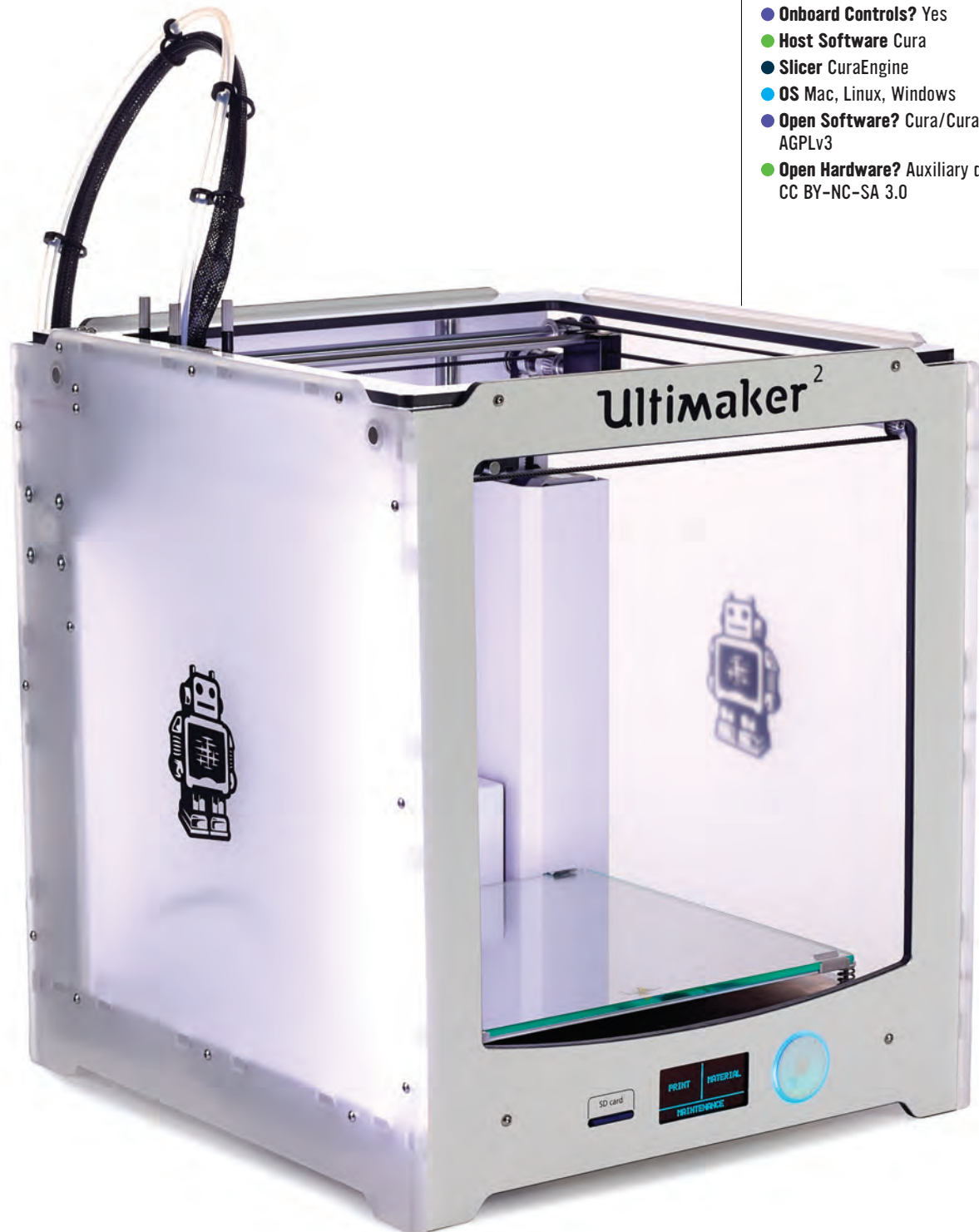
As promised, the venue and its collection of top-level machines, able to turn powdered metal or nylon into anything from rocket nozzles to windmills, is very inspiring. After our weekend of testing, America Makes' founding director Ralph Resnick opened the doors to the public. The look of excitement on the faces of the visitors, many of them hopeful for an economic resurgence in the Steel Valley, made it clear that the program is headed in the right direction.

—Mike Senese

ULTIMAKER 2

Best in Shootout for overall print quality

WRITTEN BY ELI RICHTER Available at [MakerShed](http://MakerShed.com) bit.ly/ultimaker-2-printer



Ultimaker | ultimaker.com

- Price as Tested \$2,499
- Build Volume 230×225×205mm
- Bed Style Heated glass
- Temperature Control Yes
- Materials PLA, ABS (others encouraged)
- Print Untethered? SD card, OctoPrint compatible
- Onboard Controls? Yes
- Host Software Cura
- Slicer CuraEngine
- OS Mac, Linux, Windows
- Open Software? Cura/CuraEngine: AGPLV3
- Open Hardware? Auxiliary design files: CC BY-NC-SA 3.0

ALTHOUGH ULTIMAKER'S SECOND OFFERING RECENTLY CELEBRATED ITS FIRST BIRTHDAY, its performance in our Shootout was head and shoulders above the rest of the FFF machines. This is a great machine for those who want to load a model and print without spending hours setting up and tweaking parameters, but it still gives the advanced user enough control to get even more out of the Ultimaker 2. Ultimaker also maintains its own integrated 3D-printing ecosystem, with an online model library at YouMagine.com and web-based modeling tool UltiShaper 3D.

GREAT OUT OF THE BOX

The Ultimaker 2 ships almost entirely pre-assembled and ready to go. Simply remove the (awesome) glass build plate from its protective bubble wrap, and secure it with the premounted aluminum clips. Snap on the filament holder, power it on, run the leveling procedure, load the filament, and this bot's ready to go. Bed leveling is performed manually using the familiar "paper thickness" ritual, and onboard menus on the OLED screen quickly guide the user through the process. While auto-bed leveling would be a welcome feature, the 3-point system (versus a 4-point system where two knobs must be adjusted in tandem) works very well and the adjustment knobs turn smoothly, making fine-tuning a breeze.

Models are prepared for printing with Cura, Ultimaker's open-source software, and files are written directly to an SD card. Software configuration is simple: Just select your printer from a list of preconfigured options. For those who want to just load a model and print, Cura's default streamlined "Quickpoint" mode displays three basic print quality options: fast, normal, and high quality. More adventurous users can switch the software into "Expert Mode," which opens up a multitude of tweakable settings. Normal mode works great for most prints, but it can be a bit fast for smaller models. Prints are run directly from a computer SD card using the onboard controls.

Using the stock settings, this printer

was at the head of the pack for most of our test prints, notably those that tested the physical stability of the machine. Tests with lower scores, such as the Overhang and Bridging prints, were hurt by the aggressive speeds and could be vastly improved with some minor tweaking.

FEATURE PACKED, OCTOPRINT COMPATIBLE

The Ultimaker 2 has all of the features one should expect of a class-leading printer: a heated glass build platform, illuminated build area, onboard controls, two PLA cooling fans, with a frame that is sturdy and attractive. It's also OctoPrint compatible, so wireless printing (and slicing via Cura) is possible with the user addition and setup of a Raspberry Pi and a wi-fi dongle. Absent from this feature list is an autoleveler and second extruder, which though in development, was not yet available as of press time. If a dual extruder is on your immediate must-have list, then you may want to wait. However, Ultimaker has always included a spot in their extruder carriage for the possible addition of a second one, so upgrades of this machine are feasible.

ONE HAS TO DIG DEEP TO FIND THINGS NOT TO LIKE ABOUT THE ULTIMAKER 2.

NOT QUITE PERFECT, BUT DARNED CLOSE

One has to dig deep to find things not to like about the Ultimaker 2. During the Shootout, we had two thirds of the build area LEDs (I told you, we're digging deep). Feeding material into the extruder can be tricky and the fans on the hot end assembly are a little loud — unfortunate for this otherwise quiet printer. Ultimaker was responsive when we anonymously contacted their support about the faulty LED strips, offering advice to troubleshoot and replacement units.

CONCLUSION

Makers on a tight budget may want to look elsewhere, but few machines can beat the Ultimaker 2's combination of high-quality, hassle-free printing with easy-to-use software and an attractive, compact package. 🍌

PRINT SCORES

● Accuracy	1	2	3	4	5
● Backlash	1	2	3	4	5
● Bridging	1	2	3	4	5
● Overhangs	1	2	3	4	5
● Fine Features	1	2	3	4	5
● Surface Curved	1	2	3	4	5
● Surface General	1	2	3	4	5
● Tolerance	1	2	3	4	5
● XY Resonance	FAIL	PASS			
● Z Resonance	FAIL	PASS			

PRO TIPS

- Reduce printing speed for small parts or tweak settings in Cura to set minimum layer time.
- Use a glue stick to keep large overnight prints adhered to the platform — brims and rafts can be difficult to remove.
- Back filament from hot end manually (heat nozzle, move material, remove tube and trim before executing "change filament procedure") to avoid melted chunks jamming filament feed.

WHY TO BUY

Best in Shootout print quality. Killer heated glass bed is perfect for PLA prints, also works well with ABS, Bridge Nylon, PETT and T-glase. Beginner-friendly software, but also offers complete setting control. Onboard controls allow for fine-tuning of temp and speed settings midprint.

How'd it print?



ELI RICHTER is an engineer by day and maker by night. He is a core member of HackPittsburgh where he manages and maintains their 3D-printer program. Other projects include running HackPittsburgh's PPPRS racing team, Hack to the Future. elijahrichter.wordpress.com

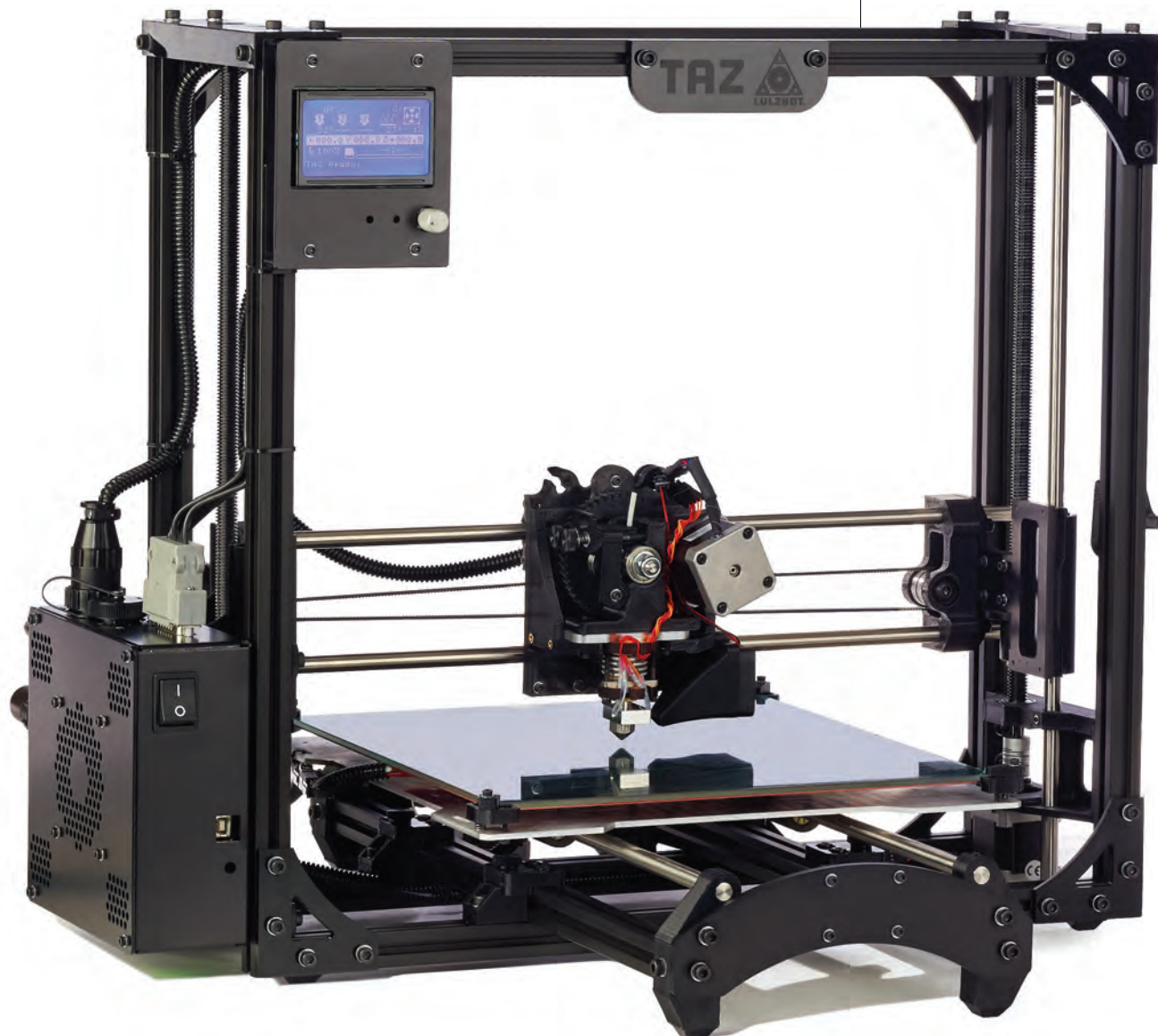
TAZ 4

Thoughtful construction, great prints,
libre hardware

WRITTEN BY MATT STULTZ

TAZ 4 | lulzbot.com

- Price as Tested \$2,195
- Build Volume 298×275×250mm
- Bed Style Heated glass
- Temperature Control? Yes
- Materials ABS, PLA, HIPS, PVA, and wood filaments
- Print Untethered? SD card, OctoPrint compatible
- Onboard controls? Yes
- Host Software Printron
- Slicer Slic3r
- OS Mac, Linux, Windows
- Open Software? Third-party software
- Open Hardware? GPLv3 and CC-BY-SA 4.0



THE LULZBOT TAZ 4 WAS HIGH ON MY LIST OF PRINTERS TO TEST THIS YEAR. I

have always been impressed with the engineering and attention to detail that LulzBot has put into its machines. Having spent some time on the original TAZ during last year's testing, I wanted to see what improvements had been made. I expected a printer that the hackers would love — capable of producing large prints that are perfect for demos and parts. I didn't expect a machine that would print high-quality prints on par with any other machine on the market. I was pleasantly surprised!

MINOR ASSEMBLY, FOOLPROOF CONNECTORS

Unpacking the TAZ 4, you will find the printer mostly assembled but with a few of the parts packed separately for easy shipment. You will also find a quick-setup guide, a larger manual, a spool of filament, and an excellent toolkit. Assembly is a snap — the TAZ 4 uses high-quality connectors that make the wiring foolproof. Most of the parts can be assembled by hand, but the few that can't are easily completed with the included toolkit. With the help of the quick-start guide, you will be up and running with your first prints in about an hour.

BY ENGINEERS, FOR ENGINEERS

In a field of printers that are starting to spend a serious amount of effort on their design aesthetics, the LulzBot TAZ 4 isn't going to be winning any beauty pageants — it's been designed by engineers for engineers. The creators took time to not only figure out how to do the things they wanted but how to do them the best way. The spool holder is hinged to hide away during transportation or storage, but swivels down and locks in place for use. The filament guide snaps onto its holder and can adjust with the movements of the machine. In most printers we find that

screw holes are either tapped directly into the plastic or have nuts on the backside to hold the bolts in place. The TAZ uses press-fit brass threaded inserts that ensure all connections stay rock solid. Instead of using the standard steel roller bearings for linear motion, the TAZ uses igus polymer bushings. These bushings run quieter and without lubrication, resulting in zero maintenance and a longer lifespan.

KEEPING IT OPEN SOURCE

As more printers hit the market as closed-source projects, LulzBot has continued its commitment to manufacturing a fully open-source printer. All of the files — their source files, schematics, and code — are available for you to fix, build, and redesign any portion of the machine. They also support a large number of the slicing and control software options that are available for the OS printers. LulzBot's site includes config files for the popular open-source Slic3r engine tuned for numerous materials, making it simple to start printing in ABS, PLA, NinjaFlex, and others.

Even the printed manual that comes with the TAZ is open source. If you get nothing else out of this review, download (bit.ly/taz-manual) and take a look. Many sections are nonprinter specific and are perfect for anyone interested in 3D printing. If you use Slic3r this is a must-read!

CONCLUSION

So who is the TAZ 4 a perfect printer for? While I'm hesitant to say this is a printer for a first-time printer owner, the quick-start guide and manual make it easy for anyone to get this machine up and running. Makers, hackers, engineers, and artists will feel right at home with this machine. The large, heated glass build platform, ability to print untethered, and ease of modification will give them everything they are looking for. Sometimes it's best to spend your time on engineering rather than good looks. 🍷

SOMETIMES
IT'S BEST TO
SPEND YOUR TIME
ON ENGINEERING
RATHER THAN
GOOD LOOKS.

PRINT SCORES

● Accuracy	1 2 3 4 5
● Backlash	1 2 3 4 5
● Bridging	1 2 3 4 5
● Overhangs	1 2 3 4 5
● Fine Features	1 2 3 4 5
● Surface Curved	1 2 3 4 5
● Surface General	1 2 3
● Tolerance	1 2 3 4 5
● XY Resonance	FAIL PASS
● Z Resonance	FAIL PASS

PRO TIPS

- The quick-fit extruder makes upgrades a snap. LulzBot already makes a flexible filament extruder and promises a dual extruder upgrade soon.
- Even if the TAZ isn't for you, download the manual at bit.ly/taz-manual, it's packed with info on Slic3r and 3DP tips.
- Download the Slic3r config files from LulzBot's site to get printing in a wide variety of materials quickly.

WHY TO BUY

Large print area with a heated glass bed makes print removal easy and supports most materials. It's totally open source, extremely well engineered, has a quick-exchange extruder system, an amazing manual, and a top-quality toolkit. It produces excellent prints in a wide variety of materials and has an extruder upgrade made for flexible filaments.

How'd it print?



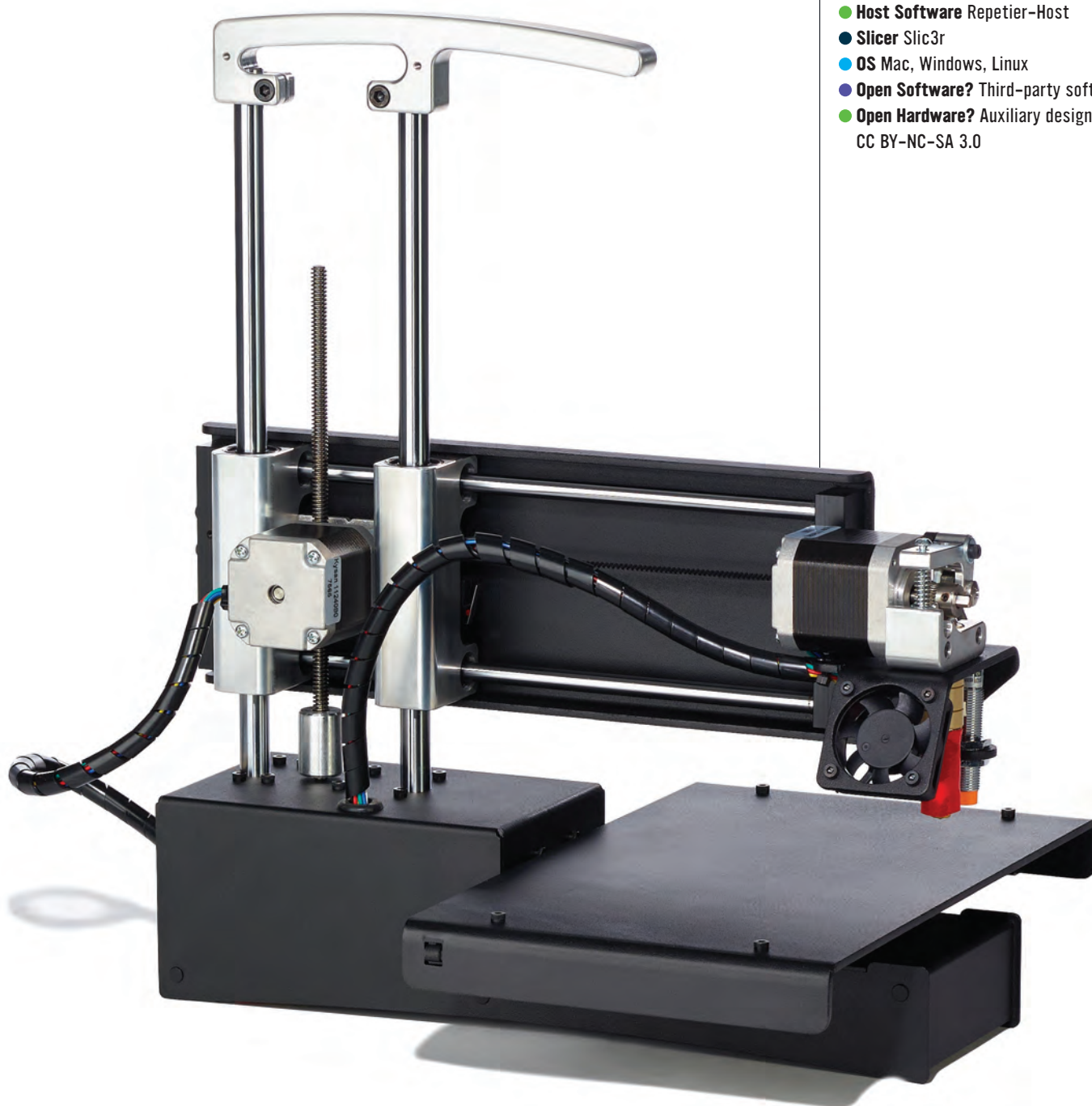
MATT STULTZ is a community organizer and founder of both 3D Printing Providence and HackPittsburgh. He's a professional software developer, which helps fuel his passion for being a maker! 3DPPVD.org

PRINTRBOT SIMPLE METAL

Last year's portable "best value" returns with some serious upgrades

WRITTEN BY LUIS RODRIGUEZ

Available at [Maker Shed](https://www.makershed.com) bit.ly/printrbot-metal



Printrbot Simple Metal | [printrbot.com](https://www.printrbot.com)

- **Price as Tested** \$599 (plus \$39 for metal handle)
- **Build Volume** 150×150×150mm
- **Bed Style** Unheated steel (heated upgrade available)
- **Temperature Control** Yes
- **Materials** PLA (ABS if heated bed)
- **Print Untethered?** MicroSD, OctoPrint compatible
- **Onboard Controls?** No, but LCD add-on available
- **Host Software** Repetier-Host
- **Slicer** Slic3r
- **OS** Mac, Windows, Linux
- **Open Software?** Third-party software
- **Open Hardware?** Auxiliary design files: CC BY-NC-SA 3.0

THE ALL-METAL CONSTRUCTION OF THE PRINTRBOT

SIMPLE METAL feels more like a professional power tool than an entry-level 3D printer. The weight of this small, portable printer gives it a real sense of quality, and the inclusion of a now-standard auto-leveling bed makes it a real step up from its wooden predecessors. This printer is packed with features and rivals machines costing much more.

SAME GREAT VALUE, NOW ALL METAL

Upgrades from the original Simple (still sold as an upgraded “Maker’s Kit”) include a larger build platform that measures a healthy 150×150×150mm, a powder-coated steel frame, thicker polished guide rods, large linear bearings that are seated in machined aluminum carriage, and an all-aluminum, direct-drive extruder that includes a UBIS hot end with interchangeable tips. Our assembled review unit also came with an aluminum handle (\$39 upgrade) with an integrated printed spool holder (free).

MANY OPTIONAL UPGRADES AVAILABLE

With the healthy-sized bed you can print many substantially sized items in PLA and nylon on the unheated surface. ABS is supported if you add the optional heated bed upgrade. In fact, the heated bed upgrade (\$99) and the interchangeable tips (ranging from 0.25 to 0.75mm for \$8 each) allow you to experiment with just about any material. You can print tethered via Repetier-Host, untethered via onboard microSD card, or add onboard controls with the Printrbot LCD control kit accessory (\$65). Don’t forget to print the fan shroud upgrade, it enabled our test unit to attain perfect scores on the Bridging and Overhang tests.

IMPROVED DOCUMENTATION, GREAT SUPPORT

The Simple’s setup documentation is professional and thorough. Due to the amount of information presented, it can feel a bit overwhelming, but it’s a fantastic reference when needed. Printrbot also has a robust help site (help.printrbot.com) and

THIS PRINTER IS PACKED WITH FEATURES AND RIVALS MACHINES COSTING MUCH MORE.

community forum (printrbottalk.com), and it’s common to see the Printrbot’s founder, Brook Drumm, answering questions directly. That’s a nice customer service touch. There’s also a great education section for teachers and students (learn.printrbot.com).

A FEW MINOR ISSUES

The Simple Metal is pretty great, but it’s not perfect. The initial adjustment of the auto-level probe is a tad cumbersome. It takes a bit of double-hand holding to adjust the probe while fighting the tension on the wiring in the close quarters around the adjustment nuts. The inclusion of a laser-cut wrench helps, and is a nice, sentimental reminder of Printrbot’s beginnings. In addition, it can be hard to tell if the printer is turned on until you notice the glow from underneath the machine. This was not immediately apparent in a well-lit room. We also had a serious nozzle clog issue during an 8-hour overnight print that resulted in the filament forcing its way out of the extruder in a bizarrely perfect, spring-like coil.

Although it’s a common open-source toolchain issue not directly related to Printrbot, it can be a frustrating experience for a first-time user to walk through Slic3r’s multiple setup screens and dialog boxes. I’d like to see Cura formally recommended as another open-source option, as the Printrbot community already recommends it. I also was not impressed with the “write to SD” function of Repetier-Host; I took the microSD card out and loaded it into the computer to transfer the file manually, although it’s a bit hard to access.

CONCLUSION

This printer is a joy and doesn’t feel like an entry-level machine at all. I recommend this printer daily to visitors to Science City, explaining it has many features of higher-priced printers (plus some they don’t offer). This resonates with educators and budget-conscious parents. It’s also perfect for my friends at the local hackerspace, many of whom have spent quite a bit more on machines that don’t have the print quality or the fit and finish of the Simple Metal. 🍌

PRINT SCORES

● Accuracy	1	2	3	4	5
● Backlash	1	2	3	4	5
● Bridging	1	2	3	4	5
● Overhangs	1	2	3	4	5
● Fine Features	1	2	3	4	5
● Surface Curved	2	3	4	5	
● Surface General	1	2	3	4	5
● Tolerance	1	2	3	4	5
● XY Resonance	FAIL	PASS			
● Z Resonance	FAIL	PASS			

PRO TIPS

- During Slic3r setup, measure your filament diameter. Add 0.1mm to avoid a known bug and perfectly adjust your extrusion.
- Print the fan shroud from printrbot.com/project/simple-metal, it will greatly improve every print thereafter.
- Avoid Repetier-Host’s “write to SD” — manually transfer files to SD from your computer’s SD reader.

WHY TO BUY

It’s feature-packed, portable, and solidly built. With its high print scores and many available upgrades, the Simple Metal is a great value for beginners and experts alike.

How’d it print?

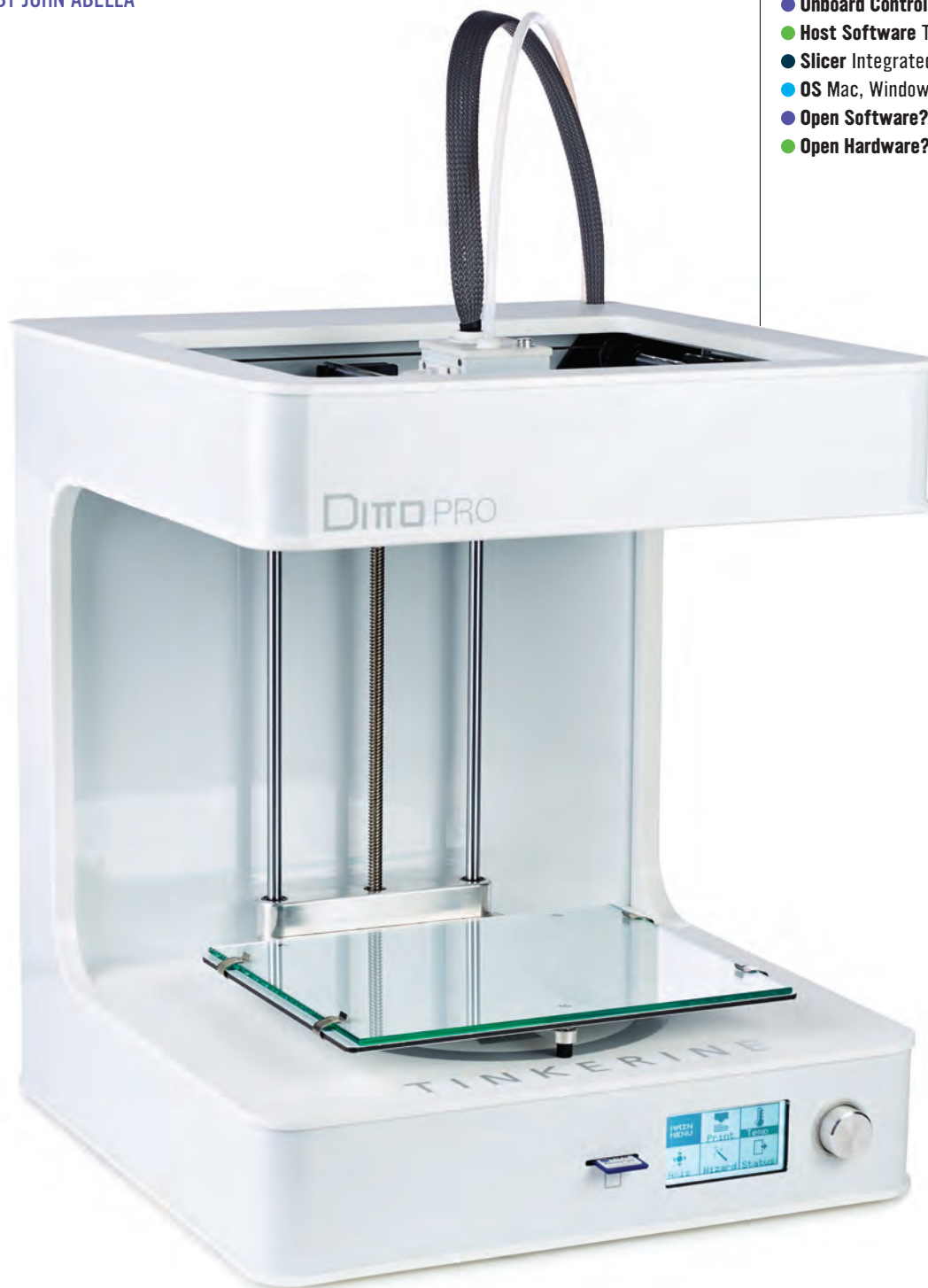


LUIS RODRIGUEZ is the lead organizer for Maker Faire Kansas City and has been 3D printing since 2009, when he got his first MakerBot Cupcake. Luis works at Science City, where he manages the Maker Studio and Spark!Lab. unionstation.org/sciencecity

DITTO PRO

Easy for beginners. Plus, attractive, affordable, and tinkerer-friendly.

WRITTEN BY JOHN ABELLA



DITTO PRO | tinkerine.com

- Price as Tested \$1,899
- Build Volume 220×165×220mm
- Bed Style Unheated glass
- Temperature Control Yes
- Materials PLA
- Print Untethered? SD card, OctoPrint compatible
- Onboard Controls? Yes
- Host Software Tinkerine Suite
- Slicer Integrated CuraEngine
- OS Mac, Windows
- Open Software? No
- Open Hardware? No

BACK FOR A SECOND YEAR, VANCOUVER'S TINKERINE STUDIOS HAS ADDED

a shiny new printer to their lineup, the Ditto Pro. We put the bright white machine through its paces and found that there's a lot to like.

UNIQUE OPEN C FRAME

Keeping with the open design of their previous Ditto and Litto models, the new Pro has a very accessible "open C frame" build area. It's great for demonstrations, as onlookers can easily see how it works. Fashioned from white Dibond panels, it features bright LED lighting and a built-in graphical LCD screen with an SD card slot. The extruder hot end is well designed, and the filament loading and changing was easy following the on-screen prompts.

The Ditto Pro is one of the few systems where the filament spool is kept within the confines of the printer. It's a small detail, but a game changer when you're pressed for space.

FOURTH HIGHEST IN OVERALL PRINT QUALITY

This machine scored the fourth highest overall print quality in our tests, with especially impressive performance in the Overhang and Surface Finish tests. The Ditto Pro's build area of 215×160×205mm falls just below average size, and it comes equipped with a removable, unheated, glass build plate, making this machine PLA only. Leveling the build plate was easy using the on-screen direction and the three-point adjustment knobs, but our testers had problems with print adhesion until we began using glue sticks.

INTUITIVE BESPOKE SOFTWARE

Tinkerine supplies their own bespoke software for their printers, known as Tinkerine Suite. It provides a user-friendly interface while tucking away the more technical details, and uses Ultimaker's open-source Cura engine under the hood. Many of our testers found the software to be intuitive and easy to use. There's no provision for manually controlling the printer from the

software, but it's an available option in the LCD menus.

LACKING DETAILED DOCUMENTATION

One of the biggest improvements across the field of tested printers this year has been in the area of documentation; unfortunately this has not been the case for the Ditto Pro. The primary machine documentation for this model was a nicely designed, but extremely brief, quick-start guide and an 18-page Tinkerine Suite software bound 50-100 page guides, supplying so little in the way of documentation is a significant shortcoming.

The FAQ section on the Tinkerine website covers some topics such as print adhesion, but it doesn't offer concrete direction, instead suggesting only that something may be needed. Similarly, the FAQ suggests that in certain circumstances the stepper driver voltage may need to be tuned, but offers no direction about what the process entails or how to go about it.

CONTROL ISSUES

Throughout the course of our testing, the Ditto Pro performed extremely well, and did not experience any jams or clogs. However, testers consistently reported that the LCD control panel knob was way too sensitive, often making it hard to select the correct item from the menu. This ranged from a nuisance to borderline unusable throughout the weekend and was a source of frustration for many testers.

CONCLUSION

The Ditto Pro is a great-looking machine with print performance to match. It scored as well as some of the best printers we tested, while far less expensive than most of them. If the documentation were improved significantly, we believe that the combination of good design and easy to use software would make it ideal for new users. As it stands, the Ditto Pro is probably best for the user willing to get a little more involved in the care and feeding of the system — a tinkerer, and maybe that's the point. 🍌

WE PUT THE BRIGHT WHITE MACHINE THROUGH ITS PACES AND FOUND THAT THERE'S A LOT TO LIKE.

PRINT SCORES

● Accuracy	1	2	3	4	5
● Backlash	1	2	3	4	5
● Bridging	1	2	3	4	5
● Overhangs	1	2	3	4	5
● Fine Features	1	2	3	4	5
● Surface Curved	1	2	3	4	5
● Surface General	1	2	3	4	5
● Tolerance	1	2	3	4	5
● XY Resonance	FAIL	PASS			
● Z Resonance	FAIL	PASS			

PRO TIPS

To get your prints to stick to the platform, cover it with blue tape or use a glue stick.

WHY TO BUY

Simplified software (but configurable settings) that produces great prints with nice Surface Finish and solid Overhangs. The Ditto Pro takes G-code, so you can use whatever slicer you like.

How'd it print?



JOHN ABELLA is a maker of things, obsessive hobbyist, 3D printing and CNC enthusiast. Maker Faire New York 3D Printer Village wrangler and lead instructor at BotBuilder.net. John has written for all three Make: 3D printer guides.

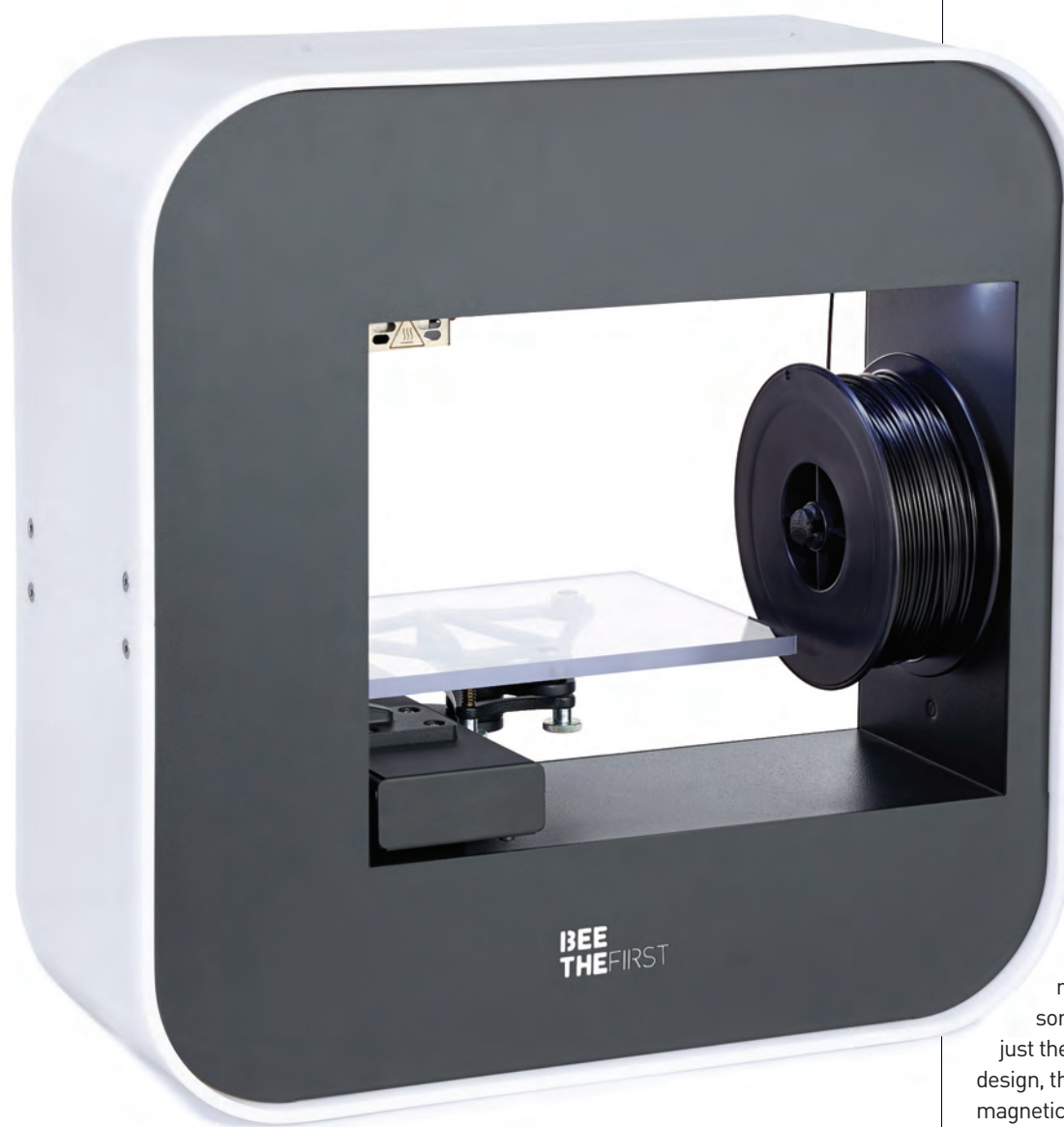
BEE THE FIRST

Smartly designed consumer-grade hardware, with a little something extra

WRITTEN BY CHRIS YOHE & ANNA KAZIUNAS FRANCE

BeeTheFirst | beeverycreative.com

- Price as Tested \$2,172
- Build Volume 190x135x125mm
- Bed Style Unheated acrylic
- Temperature Control No
- Materials BeeTheFirst PLA only
- Print Untethered? Unplug USB, wi-fi via BeeConnect
- Onboard Controls? No
- Host Software BeeSoft
- Slicer Integrated CuraEngine
- OS Mac, Windows, Linux
- Open Software? BeeSoft GPL v2.0, BeeTheFirst firmware GPL v3.0
- Open Hardware? No



LOOKING FOR A TRULY CONSUMER-GRADE PRINTER THAT INTEGRATES LOOKS AND PORTABILITY WITH SMART DESIGN?

You'll find it in BeeTheFirst. Portugal's BeeVery-Creative provides a fantastic out-of-the-box experience that allows anyone to painlessly enter the world of desktop 3D printing. Neophytes will be up and running quickly and this portable, polished machine is sure to look great on any desktop or coffee table, but even seasoned veterans will find some interesting software Easter eggs if they peek below the shiny surface.

BEAUTY AND BRAINS

Upon unboxing, it's immediately clear that this is something new. But it's not just the hip, modern, minimalist design, the clever built-in handle, or magnetically removable build plate that piqued our interest — we were impressed by the forward-thinking industrial and user-experience design.

Brian Kaldorf

OCCAM'S RAZOR

It's refreshing to see a machine that's been designed from the ground up with equal focus on aesthetics, ergonomics, user experience, and functionality. BeeTheFirst also defies the current trend of adding fancy extruder sensors and auto-levelers to solve common printer problems, instead applying the tenet of Occam's razor: Good design solves problems in the simplest way possible, instead of cramming in more tech.

The cleverly integrated, magnetic/kinematically coupled bed with large accessible knobs is hands down the easiest we have ever leveled. The thick acrylic build platform sits upon a sturdy metal arm, which unlike the flimsy plastic parts present on many desktop machines, will never warp or twist. We popped it off and on dozens of times throughout our testing without the need to re-level.

CLEAR BEGINNER DOCUMENTATION

The user guide is well written, brief, and surprisingly informative. It gives a concise breakdown of the machine and clearly sets new-user expectations. There are also numerous troubleshooting videos on BeeVeryCreative's site, including how to take apart the case (it's easier than it looks) to clear a jammed extruder.

MATERIALS MATTER

Another interesting design feature is the tiny, magnetically attached internal spool that holds proprietary (but unchipped) filament. Like Afinia, BeeVeryCreative seeks to eliminate nozzle jamming by operating at higher temperatures of about 220°C. We fed ours non-OEM orange Ultimachine which produced part of a very stringy print before jamming completely. BeeVeryCreative materials have been limited to eight colors of PLA, but recent software update options reveal that more are on the way soon.

STRAIGHTFORWARD SOFTWARE, NO ADVANCED SETTINGS

When it comes to printing, they couldn't have made it simpler. The custom BeeSoft host software has all of the standard placement, scaling, and rotation options, but the print dialog deliberately restricts layer height and infill to a few simple choices in order to streamline the experience. BeeSoft is in active development and provides both regular and beta releases frequently. Since the Shootout, the low (0.3mm) and high (0.1mm) slicing options have been expanded to include a 0.05mm setting and additional infill density options, plus the ability to print untethered after kicking off a print via USB.

Shootout prints run at 0.1mm ranked within the top third of printers tested. This machine also had very little Backlash, but had some trouble with Fine Features and scored poorly on the Tolerance test.

EASTER EGGS!

Hardcore enthusiasts don't despair! While not advertised, there are plenty of software hacking opportunities under the hood. Here's where it gets interesting: BeeSoft's interface is derived from ReplicatorG and slices with CuraEngine. Both BeeSoft and the BeeTheFirst firmware are completely open-source and GPL-licensed: point your browser to github.com/beeverycreative and clone away!

They've also forked OctoPrint and created their own BeeTF variant of OctoPi that works with the BeeTF's speedy R2C2 printer controller (ARM 32bits running at 100MHz) over USB native. They plan to offer their own BeeConnect Raspberry Pi kit, followed by assembled versions and mobile apps.

CONCLUSION

With hand-holding for beginners and a GitHub repo full of open-source software for advanced users, BeeTheFirst has something for everyone. 🍯

WITH HAND-HOLDING FOR BEGINNERS AND A GITHUB REPO FULL OF OPEN-SOURCE SOFTWARE FOR ADVANCED USERS, BEETHEFIRST HAS SOMETHING FOR EVERYONE.

PRINT SCORES

● Accuracy	1	2	3	4	5
● Backlash	1	2	3	4	5
● Bridging	1	2	3	4	5
● Overhangs	1	2	3	4	5
● Fine Features	1	2	3	4	5
● Surface Curved	1	2	3	4	5
● Surface General	1	2	3	4	5
● Tolerance	1	2	3	4	5
● XY Resonance	FAIL	PASS			
● Z Resonance	FAIL	PASS			

PRO TIPS

- The BeeConnect software is continually updated and released in two parallel versions, one production, one beta. Check out the beta for the newest features.
- BeeTheFirst can print with Afinia's new PLA (green worked well for us)
- Want to print wirelessly? Grab a Raspberry Pi and check out "BeeConnect": github.com/beeverycreative

WHY TO BUY

An easy-to-use, attractive, portable machine with stripped-down, custom open-source software. Uses smart hardware design (instead of sensors) to make bed leveling easy.

How'd it print?



CHRIS YOHE Software developer by day, hardware hacker by night, Chris is a man of many gadgets. A member of HackPittsburgh, he is an avid 3D printing enthusiast and like many others is amassing a slowly growing army of manufacturing minions. From rugby, to tailgating, to 3D printing he's always looking for an excuse to make the world a better, or at least more interesting, place.

AFINIA H480

WRITTEN BY JOSH AJIMA

Excellent out-of-the-box experience, great for educators



AFINIA H480 | Afinia.com

- Price as Tested \$1,299
- Build Volume 140×140×135mm
- Bed Style Heated perf board
- Temperature Control? No
- Materials Afinia PLA, ABS
- Print Untethered? Unplug USB
- Onboard controls? No
- Software Afinia 3D
- Slicer Afinia 3D
- OS Mac, Windows
- Open Software? No
- Open Hardware? No

Available at MakerShed bit.ly/Alfinia-H480

AFINIA CONTINUES TO LIVE UP TO ITS “EASY TO USE” REPUTATION WITH THEIR UPDATED H-SERIES PRINTER. The H480 printer may appear identical to the previous model, but it now includes automatic platform leveling and nozzle height detection.

AUTOMATIC CALIBRATION

Leveling a print bed and setting the extruder height are two of the biggest challenges for beginners. The Afinia H480 uses a magnetically attached sensor to perform automatic platform level calibration. A sensor attached to the extruder probes the bed at 9 different points and a separate sensor determines the correct nozzle height. Even experienced users may be surprised at how reliable prints are when these important calibration steps are automated.

SIMPLE SETUP, GREAT PRINT SURFACES

The Afinia software is easy to use, providing all the essentials for slicing and printer control in an uncluttered interface. The software defaults create rafts and supports which, combined with the heated bed, gives great print results, although the built-in slicer didn't fare well with very small positive Fine Features or Bridging. It excels at producing high-quality Surface Finish and did well with the articulated robot Toler-

ances. Other printers may have flashier interfaces or larger build volumes, but the Afinia's Surface Finish and ease of use keeps it in the top 10.

NOW WITH (PROPRIETARY) PLA

The Afinia (and its Up brethren) lack user-controlled temperature settings and print ABS at a much higher temp (260°) than other printers. This requires Afinia-produced high-temperature filament to perform properly. Afinia has also begun to produce its own brand of specially formulated PLA, but color selection is (at press time) limited. It's not recommended to use non-Afinia/Up filaments with this machine.

NOT FOR TINKERERS

The same features that make the H-Series a top “Just Hit Print” choice will steer hardware hackers away. The closed design means that there are limited options to tweak or tinker with the machine. The Afinia software only allows limited choices for layer height, temperature and percent infill.

CONCLUSION

Overall, the updated Afinia H480 offers a reliable print experience that should appeal to the growing ranks of new 3D printer users. 🍌

PRINT SCORES

● Accuracy	1	2	3	4	5
● Backlash	1	2	3	4	5
● Bridging	1	2	3	4	5
● Overhangs	1	2	3	4	5
● Fine Features	1	2	3	4	5
● Surface Curved	1	2	3	4	5
● Surface General	1	2	3	4	5
● Tolerance	1	2	3	4	5
● XY Resonance	FAIL	PASS			
● Z Resonance	FAIL	PASS			

PRO TIPS

- Load models and configure settings while preheating to save time.
- Use BuildTak to eliminate perforated print bottoms.
- You can't turn off support completely, but you can minimize the support angle to 10° to eliminate most support structures. Use “Print Setup” menu (3D Print menu > setup)

WHY TO BUY

Great surface finish with “fine” print settings. Automatic platform leveling and nozzle height detection remove beginner frustration. Good for educators, as reliable design and easy-to-use software mean successful prints with less training and support issues. Includes a 1-year manufacturer's warranty, with an optional 1-year extension. Includes accessories kit.

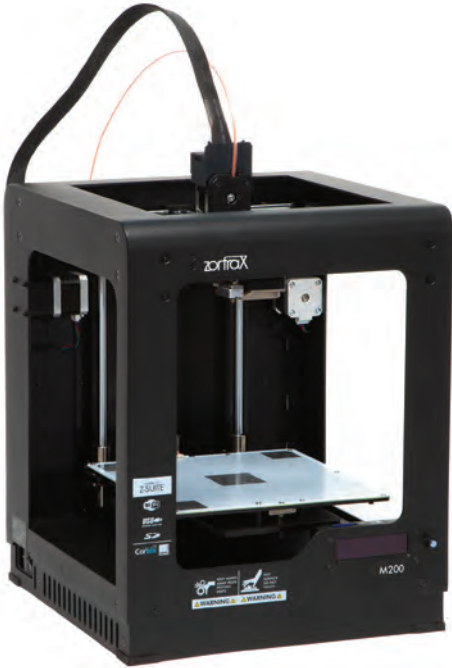
How'd it print?



JOSH AJIMA is a high school technology resource teacher and a K12 makerspace and 3D printing advocate. He created the Makerspace Starter Kit, runs a STEM camp makerspace, and sponsors a 3D printing club. designmaketeach.com

ZORTRAX M200

Unique case and lots of extras WRITTEN BY NICK PARKS



ZORTRAX M200 | zortrax.com

- Price as Tested \$1,990
- Build Volume 200×200×185mm
- Bed Style Heated perf board
- Temperature Control? No
- Materials ABS
- Print Untethered? SD card
- Onboard controls? Yes
- Host Software Z-Suite
- Slicer Z-Suite
- OS Mac, Windows
- Open Software? No
- Open Hardware? No

THE ZORTRAX M200 COMBINES SUPERB PRINT QUALITY WITH A LARGE BUILD VOLUME, a built-in screen and SD card reader for untethered printing, and requires almost no maintenance. This machine comes with a large variety of useful extras including a complete hot end, two extra nozzles, and a toolkit that includes everything required for maintaining the machine.

ALL-ALUMINUM EXTERIOR, UNIQUE 8-ROD GANTRY

The build quality of this machine is absolutely amazing. The M200 is made entirely of aluminum, which allows the machine to be both light and rigid. It also has a unique gantry setup that uses four X-axis and four Y-axis rods, which also increases the machine's rigidity.

The Zortrax doesn't have auto leveling, instead the bed is equipped with five conductive squares that the M200 uses to level the bed and calibrate the nozzle height, prompting the user to either tighten or loosen the bed-leveling adjustment knobs. These features, coupled with the perforated board, allow the prints to maintain strong adhesion to the bed while printing.

NO TEMP CONTROL, ABS ONLY

The Zortrax software does not allow for user temperature control and is built for printing in ABS only. I've always found ABS to be smelly, warp-prone, and generally difficult to work with, but the M200 does a great job of preventing warping by using a perforated bed and raft system that holds the prints down tight.

Zortrax makes two lines of filament, Z-ABS and Z-ULTRAT, both of which are formulated to work well on the M200. The Z-ABS is just standard ABS filament that works well and costs only \$20. The Z-ULTRAT has a high hardness and low elasticity level of deformation, but costs \$50. We ran the test prints in Ultimachine ABS, which yielded beautiful prints, but I found that support material wasn't as easy to remove as it was when using the filaments designed for the machine.

CONCLUSION

I recommend the Zortrax M200 to anyone looking for a machine that can print large, precise, and durable prints without requiring a lot of time to fiddle with settings or breaking the bank. 🚫

PRINT SCORES

● Accuracy	1	2	3	4	5
● Backlash	1	2	3	4	5
● Bridging	1	2	3	4	5
● Overhangs	1	2	3	4	5
● Fine Features	1	2	3	4	5
● Surface Curved	1	2	3	4	5
● Surface General	1	2	3	4	5
● Tolerance	1	2	3	4	5
● XY Resonance	FAIL	PASS			
● Z Resonance	FAIL	PASS			

PRO TIPS

● Zortrax owners get reduced prices on filament, lowering each 1Kg spool of standard filament to \$19.99.

WHY TO BUY

Auto calibration, easy-to-use software. Great for workplaces where quality, reliability, and ease of use are highly important. An excellent choice for people who need the durability of ABS without all of the warping and frustration.

How'd it print?



NICK PARKS is an engineering intern at *Make: Labs* and is studying mechanical engineering at Santa Rosa Junior College. He likes to build and take apart things to make products better or create something new. He enjoys working at *Make: magazine* and likes to help other people build projects of their own.

REPLICATOR 5TH GENERATION

“Feature-packed” is putting it mildly

WRITTEN BY JOHN ABELLA



REPLICATOR | makerbot.com

- Price as Tested \$2,899
- Build Volume 252×199×150mm
- Bed Style Unheated plastic
- Temperature Control? Yes
- Materials MakerBot PLA
- Print Untethered? USB Stick, wi-fi / networked app
- Onboard controls? Yes
- Host Software MakerBot Desktop
- Slicer MakerBot Slicer
- OS Mac, Windows, Linux
- Open Software? No
- Open Hardware? No

Available at [MakerShed](http://MakerShed.com) bit.ly/Replicator-5th

IT'S IMMEDIATELY OBVIOUS UPON UNPACKING THE MAKERBOT REPLICATOR

that substantial engineering resources went into this fifth-generation machine's consumer-focused hardware and software. It sports a large, bright, color LCD interface, mobile or PC app-controlled LAN / wi-fi printing, an internal print-watching camera and a magnetically attached, sensor-packed Smart Extruder. The onboard LCD interface was by far the most complex of all systems we tested. While printing, you can scroll through system status to see print progress, slicer settings used, a rendering of the finished piece, and even snap photos.

INTEGRATED 3DP ECOSYSTEM

The MakerBot Desktop software is easy to use and certainly the most comprehensive of all packages tested. In addition to allowing the user to prepare and print files, it has extensive integration with Thingiverse and MakerBot Digital Store. After login, designs the user has “liked” on Thingiverse or models purchased from the Digital Store are automatically populated in the software, allowing (almost) one-click printability.

SURFACE FINISH NEEDS WORK

The new Replicator's print quality was at the higher end, especially on the Overhangs, Tolerance, and Backlash. However, it

was near the bottom of the pack in our Fine Features testing. Testers also commented that the Surface Finish was a step down from the Replicator 2.

NOISY

Within the first few minutes of using the new Replicator we noticed that it's not a quiet machine. As testers came over to watch it in action, the first thing mentioned was always the noise; the Z-axis movements sounded particularly pained.

RAZORS VERSUS BLADES

Use of non-OEM filament on the 5th generation Replicator is aggressively discouraged through the inclusion of an internally mounted, unusually sized filament spool and will void the 6-month machine warranty. We voided ours with Ultimachine, and it printed without issue. While we didn't experience problems with the Smart Extruder, it's worth noting that it's not user-serviceable. When jams occur after the 90-day extruder warranty period expires, a \$175 replacement must be purchased.

CONCLUSION

Out of all the machines tested, the fifth-generation Replicator is the closest to a networked appliance. We just wish there was more for the maker in this 'bot. 🤖

PRINT SCORES

● Accuracy	1 2 3 4 5
● Backlash	1 2 3 4 5
● Bridging	1 2 3 4 5
● Overhangs	1 2 3 4 5
● Fine Features	1 2 3 4 5
● Surface Curved	1 2 3 4 5
● Surface General	1 2 3 4 5
● Tolerance	1 2 3 4 5
● XY Resonance	FAIL PASS
● Z Resonance	FAIL PASS

PRO TIPS

- Have piles of non-MakerBot PLA on standard spools? Use a lazy Susan for filament management.
- The software does not warn or prevent trying to print something larger than the build area of the system.

WHY TO BUY

Ideal for someone who doesn't want to get under the hood but wants a networked, app-integrated machine with all the bells and whistles and is willing to pay (and keep paying) a premium for it.

How'd it print?



JOHN ABELLA is a maker of things, obsessive hobbyist, 3D printing and CNC enthusiast. Maker Faire New York 3D Printer Village wrangler and lead instructor at BotBuider.net. John has written for all three Make: 3D printer guides.

DELTAMAKER

WRITTEN BY ANNA KAZIUNAS FRANCE

Simplify your workflow with this minimalistic deltabot



DeltaMaker | DeltaMaker.com

- Price as Tested \$2,399
- Build Volume 260mm Z, 240mm wide hexagonal platform
- Bed Style Unheated acrylic
- Temperature Control? Yes
- Materials PLA
- Print Untethered? Preconfigured OctoPrint
- Onboard Controls? No
- Host Software OctoPrint
- Slicer CuraEngine
- OS Mac, Windows, Linux
- Open Software? Third-party software
- Open Hardware? No

EVERYTHING ABOUT THE DELTAMAKER EXPERIENCE IS MINIMALISTIC AND SEAMLESS. With a Raspberry Pi tucked out of sight inside the base of its sleek silver frame, this wirelessly OctoPrint-controlled 'bot arrives completely assembled with onboard CuraEngine slicing. While not a new OctoPrint feature, this is the first commercial machine I've seen with it enabled (Type A ships without onboard slicing). I'm flabbergasted that other vendors haven't adopted it.

STREAMLINED SETUP

Setup consists of removing the machine from the securely packed box, placing the removable, magnetically attached acrylic build plate on the frame, and plugging it in. Skim the setup guide for the OctoPrint login info, autolevel, load filament, and start printing from the browser of any device.

PROPERLY PRECONFIGURED ONBOARD SLICING

The built-in slicing configuration is conservatively configured to ensure success. It's super easy and works quite well, as long as the model has been properly oriented before uploading. It's refreshing that, unlike many other vendors utilizing free software toolchains, DeltaMaker took the time to properly preconfigure their slicing

settings. The result is that their spartan approach makes the machine layer almost invisible, allowing OctoPrint to take center stage. Like any advanced digital fabrication tool – the hardware just works – and user energy is spent in software tweaking parameters, not mechanical fussing.

DOCUMENTATION DEFICIENCY, XY VIBRATION

One area where DeltaMaker's minimalist approach breaks down is the complete lack of readily available, online documentation. This austerity stands out in sharp contrast to the other machines tested. A second detraction is that the hollow-ball connector rod ends that join the arms to the extruder-mounted effector platform seem to rattle a bit. It's not particularly loud, especially when compared to Cartesian printers, but it appears to have produced resonance in the XY plane, failing our XY Resonance test.

CONCLUSION

While the DeltaMaker had miserable ratings for Retraction and Overhang, it earned top scores for Accuracy, Bridging, Backlash, Tolerance, and Z mechanical. It also produced a nicely surfaced, completely articulated robot, tying with the Zortrax for the fourth highest overall print-quality score. 🍷

PRINT SCORES

● Accuracy	1	2	3	4	5
● Backlash	1	2	3	4	5
● Bridging	1	2	3	4	5
● Overhangs	1	2	3	4	5
● Fine Features	1	2	3	4	5
● Surface Curved	1	2	3	4	5
● Surface General	1	2	3	4	5
● Tolerance	1	2	3	4	5
● XY Resonance	FAIL	PASS			
● Z Resonance	FAIL	PASS			

PRO TIPS

- Although currently without a heated-bed option, the Azteeg X3 controller used makes future upgrades possible.
- The Marlin firmware is slicer agnostic and both KISSlicer and Slic3r are viable options, but just use Cura. For more complex slicing needs, switch to the desktop version and upload your G-code via the browser.

WHY TO BUY

This delta robot-style machine looks and operates very differently than the boxy, Cartesian printers. It has a tall Z build area and ships with preconfigured OctoPrint with wi-fi enabled CuraEngine slicing out of the box.

How'd it print?



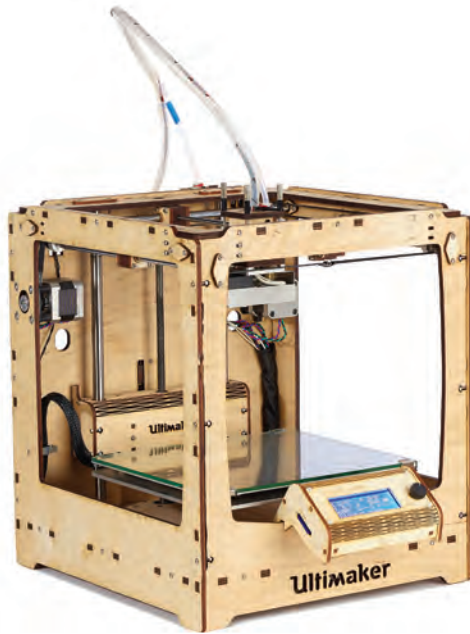
ANNA KAZIUNAS FRANCE is *Make* magazine's Digital Fabrication Editor. She's also Dean of the global Fab Academy program, co-author of *Getting Started with MakerBot*, compiled *Make: 3D Printing* and has organized and

directed the 3D Printer Shootout for the past two years. kaziunas.com

ULTIMAKER ORIGINAL+

Same great kit, now with a heated glass bed

WRITTEN BY YVES SINNER & NICK PARKS



Ultimaker Original+ | ultimaker.com

- Price as Tested \$1,600 (kit)
- Build Volume 210×210×205mm
- Bed Style Heated glass
- Temperature Control? Yes
- Materials PLA, ABS (others encouraged)
- Print Untethered? SD card, OctoPrint compatible
- Onboard Controls? Yes
- Host Software Cura
- Slicer CuraEngine
- OS Mac, Windows, Linux
- Open Software? Cura/CuraEngine: AGPLv3
- Open Hardware? Auxiliary files: CC BY-NC 3.0

RELEASED JUST OVER THREE YEARS AGO, THE ULTIMAKER ORIGINAL KIT JUST KEEPS GETTING BETTER.

The Original+ has a slew of enhancements that include a heated glass bed (upgrade kit available), an improved Z-axis, new electronics, and Ultimaccontroller onboard controls with SD card are now included.

BUT THAT'S NOT ALL ...

Another welcomed improvement is the move to a 3-point bed leveling system, which is much easier and quicker than the previous 4-point bed adjustment system. Additionally, there have also been changes to the extruder. The polypropylene fan duct has been replaced with a sturdy metal one and new plastic spacers and clips are used in the assembly of the hot end. Our test machine was fully assembled (and a prototype, which may have hurt XY, Z scores) but judging from our personal kit build experiences, this redesigned extruder will be significantly easier to build.

PERIODIC MAINTENANCE

The overnight prints on this machine

performed extremely well and reliable.

One thing we did notice was that one of the nuts was a little loose when we came in the next morning. Experience using other Ultimaker Originals for the last two years has shown that it's important to tighten all of the nuts every three to six months.

LET THERE BE LEDS?

The only thing that this machine might be missing is a lighted build platform. That is one of the many things that the Ultimaker 2 did extremely well, and it seemed to be a big hit. I imagine that Ultimaker will eventually release a lighting kit or, perhaps, *Make: Projects* will come up with a clever tutorial on how to light up this machine.

CONCLUSION

This printer packs a huge value. It puts a huge build volume, refined quality, reliability, and incredible speeds into a continually upgradable, well-supported machine. It may not be as sleek as the Ultimaker 2, but at nearly half the price (\$1,600) it's a great bargain. With its low maintenance and high performance, this hackable machine is great for any maker. 🚫

PRINT SCORES

● Accuracy	1	2	3	4	5
● Backlash	1	2	3	4	5
● Bridging	1	2	3	4	5
● Overhangs	1	2	3	4	5
● Fine Features	1	2	3	4	5
● Surface Curved	1	2	3	4	5
● Surface General	1	2	3	4	5
● Tolerance	1	2	3	4	5
● XY Resonance	FAIL	PASS			
● Z Resonance	FAIL	Pass			

PRO TIPS

Regularly retighten nuts on the sliding blocks and the extruder, they tend to loosen.

WHY TO BUY

Continually upgradable, extremely fast and reliable printing, excellent hackability, great surface finish, large build area, heated glass, low maintenance.

How'd it print?



YVES SINNER is a Luxembourg/Europe-based blogger, 3D-printing enthusiast, innovation expert, and start-up advisor. You can follow him and his brother Michel on 3Dprintingforbeginners.com.



NICK PARKS is an engineering intern at *Make: Labs* and is studying mechanical engineering at Santa Rosa Junior College.

THE STANDOUTS

We've run all the tests and based on our experiences we can confidently say that these machines are all top performers. Each has things that make it great, but a few have some restrictions and limitations. Based on our team's extensive 3DP experience, we know that the value of a machine is determined by a combination of price, quality, functionality, and cost of ownership. **WHICH ONE IS RIGHT FOR YOU?**

BADGES



Turnkey = Easy, fast out-of-the-box experience

Portable = Compact, has handle, will travel

Smart Design = Simplified, fresh take on hardware and/or software

Open Source = Company has released their code, original file formats, and placed their designs under an open license for your hacking pleasure

Software Agnostic = Slicer and control software choices available

Bells & Whistles = Extra features that most machines don't have



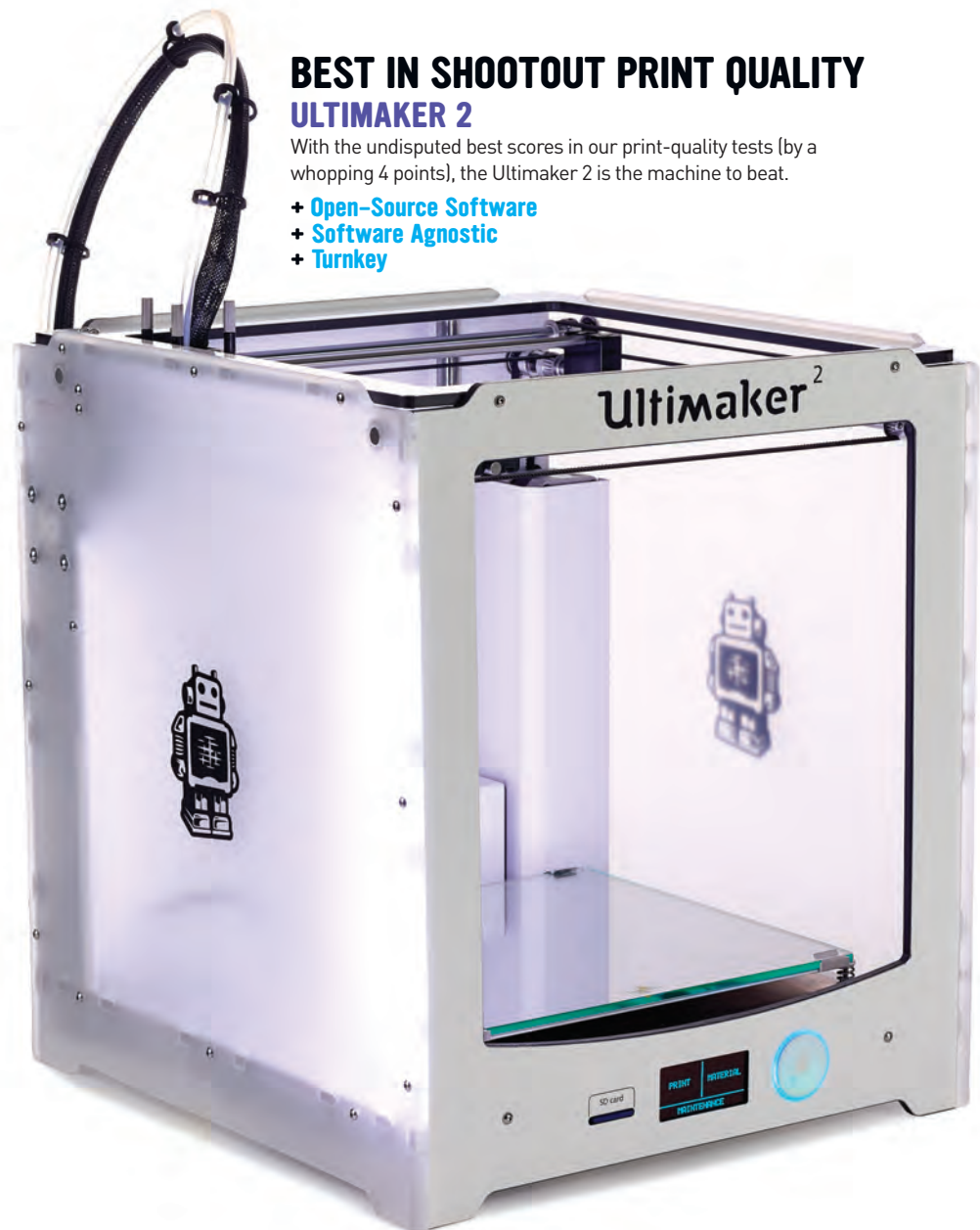
Hidden Costs = Proprietary consumables

Limitations = Limited software settings, no user temperature control, or intentionally restrictive warranty regarding materials

BEST IN SHOOTOUT PRINT QUALITY ULTIMAKER 2

With the undisputed best scores in our print-quality tests (by a whopping 4 points), the Ultimaker 2 is the machine to beat.

- + Open-Source Software
- + Software Agnostic
- + Turnkey

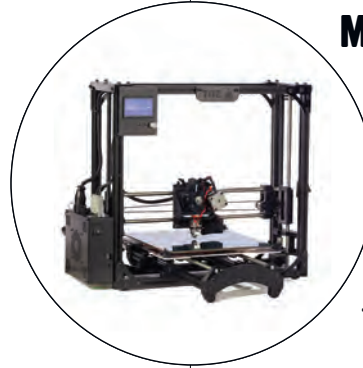




THIN WALLET WIN
PRINTBOT SIMPLE METAL

At \$599, the Printbot Simple Metal is affordable, auto-leveling, AND tied for second for print quality.

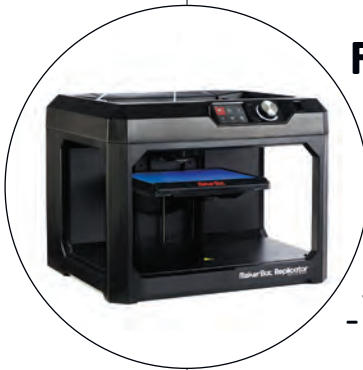
- + Software Agnostic
- + Bells & Whistles
- + Portable



MOST MAKER MACHINE
LULZBOT TAZ 4

Everything a maker wants. Open-source underpinnings, big heated-glass build volume, high-temperature and multi-material capable with the custom Flexystruder. Plus, the excellent print quality and the detailed documentation needed to level up.

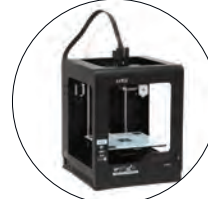
- + Software Agnostic
- + Open-Source Hardware



FEATURE PACKED
REPLICATOR 5TH GENERATION

MakerBot's updated flagship machine is full of shiny new tech, but it comes with a hefty price tag, hidden costs, and warranty-voiding materials limitations.

- + Bells & Whistles
- + Turnkey
- Hidden Costs
- Limitations

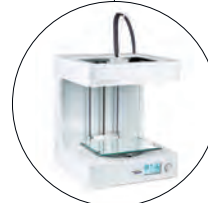


HAPPY MEDIUMS

Not quite top of the charts, but high-quality prints, a large build volume, and below-average price make these machines solid choices.

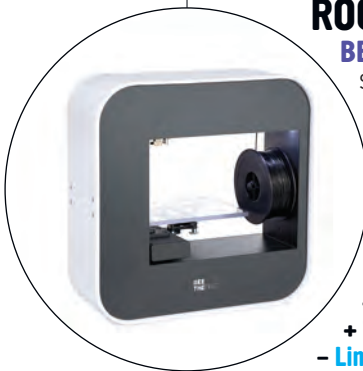
ZORTRAX

- + Turnkey
- Limitations



DITTO PRO

- + Turnkey



ROOKIE OF THE YEAR
BEEHETFIRST

Something new! An easy-to-use, attractive, portable machine with stripped-down, custom open-source software that uses smart hardware design (instead of sensors) to make bed leveling easy.

- + Smart Design: Hardware
- + Open-Source Software
- + Portable
- + Turnkey
- Limitations
- Hidden Costs



SMART SOFTWARE INTEGRATION
DELTAMAKER

The seamless integration of Octo-Print with preconfigured onboard Cura slicing is the first we've seen in a commercial machine out of the box, and something we'd like to see other vendors adopt and attribute.

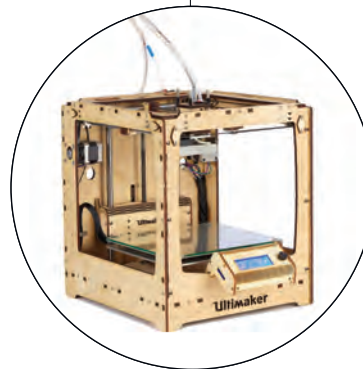
- + Software Agnostic
- + Turnkey
- + Smart Design: Software Workflow & Integration



RELIABLE PERFORMER
AFINIA

A solid bet for the third year running. It's small build area and software and materials limitations mean that it's not for everyone, but it's ease of use and continual upgrades make it shine.

- + Bells & Whistles
- + Turnkey
- Hidden costs
- Limitations



MOST UPGRADABLE
ULTIMAKER ORIGINAL+

With continual support and available upgrades from Ultimaker, this beloved classic just keeps getting better.

- + Open-Source (Custom) Software
- + Software Agnostic