

Dimensions Unending

3D printing, a 30-year-old technology, reaches new heights in creating the sublime, and becomes more and more affordable at the same time.

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AS TECHNOLOGY IMPROVES and prices drop, what we think of as everyday desktop printing is beginning to change. We're all familiar with printing ink on paper, but it's possible to get a glimpse of what the future could hold as businesses, schools and libraries in [South Florida](#) increasingly print complex and useful three-dimensional objects with plastic, ceramic, metal and other materials. Some of the capabilities of this emerging technology as it is being used across the region:

- Students at [Florida Gulf Coast University](#) are printing out prosthetic hands for a local elementary school boy.

- A Riviera Beach-based design and manufacturing company, RGF Environmental, has made its own 3D printers to create high-definition parts for air and water purifiers.

- Libraries in Charlotte County are just starting to test out new 3D printers that will be available to the public in the fall.

- And [3D Printing](#) of Florida, a design and print shop in [Naples](#), helps entrepreneurs create just about whatever they can imagine. We purchased a custom designed 7-inch tall print of [Florida Weekly's](#) Paper Boy mascot (\$249.10 including tax) to get a better idea of how the printing process works.



As 3D printing becomes more common both by consumers and businesses, with printers capable of producing a vast array of sizes, shapes and materials, there are also big implications for manufacturers, designers and intellectual property rights issues.

Jimmy Tillman, here with his mom, Tina, is working with [FGCU](#) bioengineering students to help improve and customize a prosthetic hand available for download at [enablingthefuture.org](#). COURTESY PHOTOS

Companies that make things capable of being printed cheaply in 3D may in the next decade start to deal with circumstances similar to what the music industry faced as file-sharing became common on a massive scale, suggested John F. Hornick, a [Washington, D.C.](#)-based intellectual property attorney and author of "3D Printing Will Rock the World."



The hand, printed off one of the university's midline desktop 3D printers, requires some assembly.

While there is little case law regarding 3D printing at this point, he believes it will probably not ultimately be feasible to try to sue everyone who prints out products protected by intellectual property rules. Mr. Hornick quotes MIT professor Neil Gershenfeld who said, "You can't sue the human race." As a

result, he envisions as one possibility something like an "iTunes for things" business model for purchasing files with 3D objects.

"The way the music industry used to police itself was with copyrights," he said. "If they saw that you were downloading music, they might come after

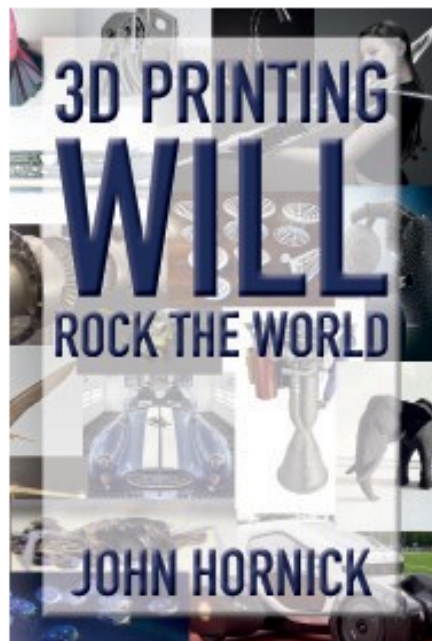
you. But then they started to realize there was so much of it happening and it was so easy that copyright wasn't really adequate any longer to protect artists' rights. So they came up with the iTunes business model which made it cheaper and easy enough to get music that you were unlikely to steal it."

He pointed out that big brand-name companies such as Toshiba and Canon are developing desktop machines, and believes that in the next decade, a variety of 3D printers will be common in homes to print convenient things — whether a small kitchen gadget or a tool for the woodworking shop in your garage. Now, hobbyist desktop printers generally cost anywhere from less than \$500 to \$5,000.



HORNICK

The printers are becoming more common in the business and industrial world as well, with costs that top out at about \$5 million, Mr. Hornick said.



"The technology has been around for over 30 years but I view it as not being a mature industry," he said, with it mostly being used for prototypes and design. "But over the last several years the technology is being used more and more for production parts and so because of that you have an industry that's been around for 30 or so years but it's almost like it's a new industry."

How a basic 3D print job works

To print out an object, computer software slices it up and sends it to the printer to be printed one small layer at a time. And instead of ink onto paper, plastic is fed through a heated nozzle onto a build plate.

John Hornick is a Washington D.C.-based intellectual property rights attorney.

First, you create a 3D design on your computer or download one off the Internet, explained Aaron Blumberg, who helps provide training on how to use 3D printers for The Southwest Florida Library Network.

There are many design programs, such as CAD software, which is what architects use to create blue prints. Tinkercad is a good one for starters, for kids or adults, Mr. Blumberg said. It walks you through the process of making pretty much any object (though the quality of the print can vary widely).

"You're really limited to your imagination, usually," he said.

Or instead of creating your own thingamajig, you could download a file from an open-source 3D library of things such as MakerBot's Thingiverse with designs the company has created.

Then you save your work as an STL file and use the printing software that came with the printer or an open-source software to send it to the printer. You get a print page preview, kind of like with an Adobe or Word document, and at that point you can manipulate the print to some extent, such as sizing or adding scaffolding that pops off when you're done.



"Then once that's taken care of you pretty much hit print," Mr. Blumberg said.

The file goes to the printer, which starts heating up the extruder nozzle. Once heated it grabs the filament from a spool and starts pushing it through onto the build plate a layer at a time. Depending on the quality, size and density,

items could take anywhere from 20 minutes to 36 hours, Mr. Blumberg has found.

At FGCU, printing prosthetics

If the internet is full of 3D toys and trinkets you can download and print for your amusement, there are also greater possibilities emerging. A website called enablingthefuture.org is an open-source site and volunteer network dedicated to making 3D printed prosthetics for children.



FGCU biomedical engineering major Tony Grippo and other students use feedback from Jimmy to improve the printed hand.

It has enabled undergraduate students in Florida Gulf Coast University's bioengineering department to download for free copies of a prosthetic hand, which they custom fit to a patient. Then they can test it out and make modifications such as improving its gripping strength or adding friction between fingers and objects.



North Fort Myers resident Tina Tillman's 8-year-old son, James Tillman IV, or Jimmy, is getting the chance to test out the hand and help the students improve it both for himself and potentially other patients. The Tillmans were referred by their orthopedist to FGCU's Dr. Derek Luca, an assistant professor in bioengineering, and some of his students.

Tony Grippo, a 23-year-old biomedical engineering major who is finishing up his junior year at FGCU, has helped lead the extracurricular project. Jimmy, who was born without a fully formed left hand — his dominant one — controls his new printed one by flexing his wrist muscles to open or close the fingers.



Besides making changes to the hand such as adjusting the placement of the thumb to make it easier to pick things up, Mr. Grippo has also considered changes such as adding Lego bumps to the surface so James can build on it.

"I want it to be not only as good as a hand but I want it to be something he can boast about as well," he said.

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One of the benefits of 3D printing technology is the ability to make tweaks easily and cheaply, or print replacement parts if Jimmy breaks them during an activity such as bike riding or climbing trees — or if he grows an inch and needs a size adjustment.

Mr. Grippo and his classmates used Solidworks software to render the hand, and printed it out on an Ultimaker 2 Extended, one of FGCU's midline desktop 3D printers available to students. It takes about 10 hours to print out.

The hand is an affordable option for Jimmy while he's growing up, Ms. Tillman said. Later he can decide if he'd like a more permanent prosthetic hand or would rather go without one, as he has already been able to do most activities other kids can do without it. It's also less expensive and less bulky than a traditional prosthesis, and it can be worn while swimming.

Jimmy likes working with Mr. Grippo and the other students.

"It's very exciting when you're a 7-year old boy and you get to work with these really, really, really big kids, and you get to tell them what to do," Ms. Tillman said. "That's really cool. But he also likes that he's going to be able to help one of his friends."



We sent 3D Printing of Florida in Naples just a few photos and they were able to recreate our mascot, the "Paperboy," using a computer-aided drafting software and 3D printer. At left is Michael Carufe, owner of the shop, who used to be a BMW technician.

3D printing process

The applications of 3D printing are endless. From simple figurines and objects to prosthetic limbs and organs to entire houses. The technology is advancing rapidly. The star is the creation of 3D printed objects is, of course, the 3D printer, but the process begins with an idea and computer software.

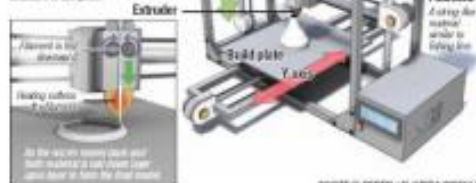
Preparation



Printing

Similar to common office and home printers, the 3D printer's head moves back and forth (X and side-to-side (Y)).

Enter the Z axis (up and down). The 3D print head, called the extruder, pulls in the filament material, heats it and distributes it to the build plate in thin layers measuring about 10 microns. It continues stacking layers until the structure is complete.



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He tells his mom, "I can make it better for someone like me."

While FGCU has long had 3D printing capability, Dr. Lura said, "(O)ur ability for students to have access to it and the cost has gone down substantially in the last few years."

The department plans to add another higher resolution printer soon that will also allow them to print in different plastics. While students enjoy using the printers, attempting to make smaller or intricate parts expose their limitations, a useful learning experience, Dr. Lura said:

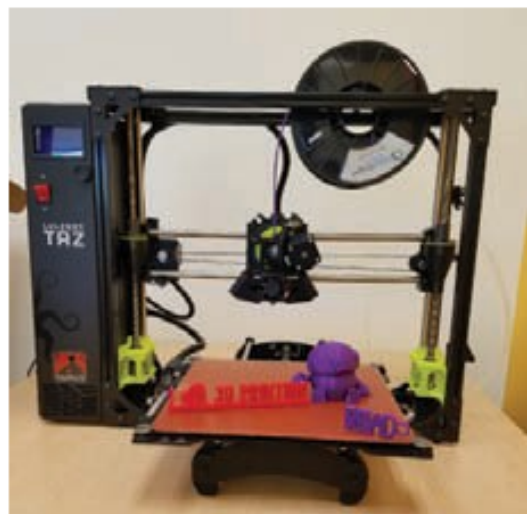
"The initial reaction is always, 'hey, that's really cool.' But then once they use it for a while they get frustrated by the fact that it doesn't work perfectly every time.

"At some point, they start trying to push the limits of what the machines can do and they realize that this, like all things, it's not a miracle magic printing machine. It has its own limitations."

Inside a 3D print shop

In a Naples business district, 3D Printing of Florida is a shop and design studio that prints out all kinds of objects for clients, such as lifelike wedding cake toppers of the bride and groom. Owner Michael Carufe, 32, is a former BMW technician who grew up in Naples.

"I'm an electronic whiz kid, as they say," Mr. Carufe said, someone who has always loved inventing and design. "(3D printing) was just a way to express my thoughts in a real space. It's one thing to draw something and another to make



Some local libraries are just getting started with 3D programs, including the Charlotte County Library System, which recently purchased printers for each of its four branches. COURTESY



Michael Carufe, owner of 3D Printing of Florida, with a miniature he printed of himself.
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There are few limits on forms he can print, he says, for instance a model of a [Tyrannosaurus Rex](#) he's working on for a local school. He is able to print avionics as well as medical products, such as a 3D replica of an MRI that could help doctors better fix a shattered bone. The shop also often combines traditional or CNC machining, such as fabricating soft metal or wood, with 3D printing.

"People always ask me what can we make," he said. "The list is easier to tell you what we can't make. We don't make firearms ... and nothing that can be launched to the moon."

They created and printed Florida Weekly's Paper Boy mascot on a computer system built by Mr. Carufe, which includes virtual reality goggles to help visualize an object in full-life size and fine tune small details. They also have the capability to scan in and print replicas of people or large objects on site like pictures come to life, expressions on faces complete. For now, full-color 3D printing is outsourced and needs to be ordered well in advance. It requires a different printer and material,

made mostly of gypsum powder.

The shop usually turns out two prototypes per week or more, original inventions from local designers or entrepreneurs. One common use of 3D printing is creating models of products to help attract investors, or sometimes the end product itself, whether a fishing lure or your idea for a new ergonomic computer mouse.

3D print manufacturing

Over the last decade, a Riviera Beach-based company that designs and manufactures systems to purify air, water and food, has built its own 3D printers.

RGF Environmental Group Inc. started making the printers over the last decade as a cost-effective way to manufacture intricate shapes for products that, for instance, clean air in a car or a home, or reduce odors and bacteria in water using advanced oxidation systems.

"They're finally getting commercialized to the point where the prices are down and a lot of the companies could afford them, but initially we did it ourselves," said Walter Ellis, executive vice president and general manager. "We're using them every day now. Initially it was just for new product development and design concepts and things like that."

The company now has four printers and their latest, under development, will print with ceramics and metal. They print both for design, to test items, and to create final, patented products.

Mr. Ellis describes the ceramic material as "almost like a very thick toothpaste. It is actually pushed out with a piston down through the nozzle, layer by layer." Then it's air dried and fired off in a kiln.

For metal printing, one method uses a printer that sets down a thin metal layer in powder form, then melts layer after layer over it using a laser.

Designing their own printers also allows them to print larger objects as well as optimize tiny details in high resolution for an optimal look and fit.

"We can do layers now that are one micron thick," Mr. Ellis said. "That took a long time to get."

3D printing coming to local libraries

The Southwest Florida Library Network, a cooperative that provides resources to [Lee, Charlotte, Collier](#), Hendry and Monroe counties, got its first 3D printer in 2014.

Aaron Blumberg helps train members who borrow the printers for use for programming or outreach.

They have three printers, a Maker- Bot, Afinia H800, and a CubePro Trio, a larger, higher-end printer.

"I call MakerBot my workhorse because I can do large quantities on it and I don't usually have to worry about it clogging or something," said Mr. Blumberg, SWFLN's continuing education coordinator.

Fixing a clog can be as simple as popping some parts off and removing plastic to unscrewing the entire extruder, taking plastic out, and reassembling.

"Some of the printers we have there are actually pieces in it that were printed on another 3D printer," Mr. Blumberg said. "So if you have a part broken you actually have the files to print out the parts and fix your printer."

PLA and ABS are the most common types of biodegradable plastic for 3D printing.

"You can get a lot of print jobs out of one spool," Mr. Blumberg said.

MakerBot advertises a 1 kilogram natural colored ABS spool for \$43 which the company says is enough to print 392 chess pieces (12 complete sets but only in one color). Another color spool costs \$48.

Some local libraries are just getting started with 3D programs, including The Charlotte County Library System, which recently purchased printers for each of its four branches.

"We'll be launching the service for the public in September, offering a range of workshops for all ages and the ability for members of the public to reserve the printers in order to work on their own creations," wrote Lanette Hart, libraries and history division manager in Charlotte County.

She added there are volunteer opportunities to assist staff in creating "makerspace labs" where the printers will be used, and to contact your local Charlotte library branch for more information.

Mid-County Regional Library in Charlotte just got a LulzBot TAZ 6 printer set up in the last month.

They've printed a few items like "Rocktopus," a sort of LulzBot mascot that comes with the printer.

"It's definitely pretty cool but it can take a long time (to print) depending on how large your piece is so you wouldn't stand there and watch it the whole time," said Hana Brown, youth services librarian. "...We may use it just to show the kids, the technology is out there, to give them ideas for things they want to create in the future." |