

Low-Cost Rapid Prototyping (MCAD Modeling Column)

These affordable machines can make whatever you want.

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By: [Mike Hudspeth, IDSA](#)
Cadalyst



A blue sidebar titled "In this article" with a grid of icons. It lists several companies and their websites: Desktop Factory (www.desktopfactory.com), Evil Mad Scientist Laboratories (www.evilmadscientist.com), Fab@Home (www.fabathome.org), Roland DG (www.rolanddg.com), Stratasys (www.stratasys.com), and Z Corp (www.zcorp.com).

You've been designing your heart out, and now you think you've got everything to the point where you feel physical prototypes are necessary. You have several choices to make. In the good ol' days, you would need to make fully detailed drawings and send them out to a machine shop to produce models. It took weeks to get them back only to find that changes needed to be made. It would take several iterations before you could gain enough confidence to sign off on the design and begin preliminary tooling. Then you had to have enough prototypes for testing. The tooling would give you that ability, but by then if changes needed to be made, it was both hideously expensive and time consuming. Funny how those days don't sound so good anymore. But nowadays things are different — and better.

In this article

We can do it. We have the technology. We can make prototyping better than it was — and it won't cost six million dollars, either. Nowadays, we can opt for a rapid prototype.

What is that? Well, where have you been? Rapid prototyping (RP) is only one of the most exciting technologies to roll out of the twentieth century! Think of an early stage of *Star Trek's* replicator device. It's a machine that makes whatever you want it to — without the need for expensive tooling.

The Technology Within

To be sure, different machines use different technologies. Most of them start out with the venerable stereolithography (STL) file. This is a file that allows the RP machine to slice your computer model into thin layers — some thinner than .005 inches — and enables the machine to build and stack each layer one upon another until the whole part is finished. This process is known as an additive process. It adds material to make the parts.

Another technology is stereolithography, which relies on photocuring resins with lasers. Some machines use powders that are sintered together with light or electricity. Others use fine plastic strands that feed through a heated head. Others are available as well, but I'll confine my discussion to these for the time being.

One thing that has been common among all RP machines is their high cost (some have been several hundred thousand dollars). Other common traits are expensive materials and controlled working environments. Historically, these things have made RP the niche business of specialist vendors, but times are a-changing. Prices are coming down. During the past few years, a quiet revolution has been taking place that is sure to have wide-ranging effects for everybody.

Desktop 3D printers now are in the \$30,000 and below range. What's the difference between these and regular RP machines? The 3D printers generally don't need controlled environments. The materials aren't as expensive — although I might get some argument there. Unfortunately, the parts they produce haven't been as high resolution as those made by higher-priced machines, and the surface finish hasn't been quite as good. But for a fraction of what you'd pay for a full-fledged RP machine, you can get physical models of your designs. And if you do a lot of RP, it doesn't take long to justify buying your own machine. Let's look at a few of these machines.

The Players

Obviously, I can't cover all of the low-cost RP machines that are available, but I will hit on the highlights. First up, and probably most expensive, is Stratasy. Stratasy (\$30,000, **figure 1**) is continually lowering the price for professional RP. Although several technologies are available, the one Stratasy uses is fused-deposition modeling (FDM). It uses filaments of engineering plastics that pass through a heated head to draw each layer. The resolution is usually limited to ± 0.05 , so if you design with smooth curves, you'll end up with the infamous stairstepping you find in

most RP technologies. The model also will have a fairly porous texture because of the fusing of the filaments, but you can seal it with a solvent.



Figure 2. Z Corp. has the unique capability of modeling in whatever combination of colors you want.

Z Corp. (approximately \$25,000) entered the low-cost RP market a few years back and has done quite well. It has a unique claim to fame that anyone can appreciate: Its machines can print in multiple colors on the same RP model (**figure 2**). This capability lets you model in graphics or show such things as overmolding. A lot of companies use the technology to quickly visualize device designs without having to paint the models. They build their models with a powder held together with a binder agent and an infiltrant, and that's primarily why it can handle the color. The print heads are very much like those in your ink-jet printer.



Figure 1. By tracing each layer of your computer model, you can create marvelous physical models that you can hold in your hand.

This technology is very cool. The resolution is fair, but the texture is granular.

A new company on the block is trying to position itself to mainstream RP. It is Desktop Factory (\$4,995, **figure 3**). Its machine is one of the smallest I have seen (a cube of approximately two feet). It won't make the largest of parts in one piece, but it can create models as large as 5 cubic inches. Its resolution tops out at .010-inch layers, so it's also not going to make extremely small parts. What's it good for, then? As the technology improves, so will the resolution and the price. Desktop Factory says that when it gets fully up and running in production, its price might fall to roughly \$1,000. At that point, I know I'm going to buy one. And why would anyone want one of these things for their home? Why, to print off whatever your little heart desires, of course! The Internet hosts many free or low-cost 3D model libraries. Imagine downloading a model and printing out a model kit or maybe that pesky battery door that you lost off the TV remote. What a blast this technology would be!



Figure 3. The Desktop Factory's low price (and future lower price) has the potential of bringing RP technology into the home.

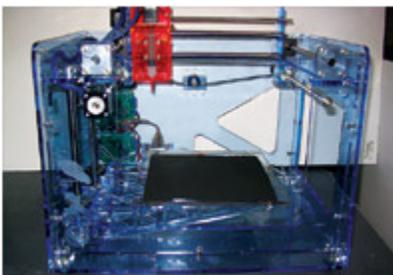


Figure 4. If you want to go all DIY, you can download plans and parts lists for the Fab@Home Fabber and build your own RP machine.

For the adventurous DIYers among us, the Fab@Home Fabber (\$2,400, **figure 4**) is an open-source project to supply all the materials needed for anyone who wants to build an RP machine. It's an ambitious project, but Fab@Home is doing it. As you might expect, the resolution isn't going to be great, but Fab@Home has an advantage most of the others companies don't — they can use all sorts of common materials. Some people make their models out of chocolate, for crying out loud! If you've got the bucks and a mechanical bent, why not give this thing a try? I'd bet you'd be the first kid on your block to have one.

Another technology to look at is subtractive rapid prototyping. The aforementioned units are classified as additive because they add each layer to build the model. A subtractive prototyper essentially is a computer numerical controlled (CNC) mill. Several are available on the market. Roland makes some very good machines that range in price from \$2,995 to \$4,995. The upside is definitely the surface finish and resolution. These machines probably are the best of the bunch. The downside to subtractive technologies is that either you design parts that can be cut all at once or you're going to have to perform multiple setups.

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Sound Off!

The Ever-Growing Game

Other units besides what I've mentioned are available. One even models in sugar (diabetics beware!). What are people doing with them? Doctors are using RP to build bones for prosthetics that fit better than ever. And chefs are using RP to make wonderful decorations and food combinations never before possible.

You could do what I want to do — design and build your own plastic model kits. In effect, low-cost RP technology has many uses. You're limited only by your imagination.