After this squirrel-cage exhaust fan was designed, it was downloaded to the FDM Vantage rapid prototyping system from Stratasys, which uses fused deposition modeling (FDM) to create plastic prototypes from ABS or polycarbonate—the material from which bullet-proof glass is made. The prototype components are durable enough to install on working assemblies for functional testing.

Not Just A Prototype

Rapid prototyping machines are capable of producing usable parts. One of these two diverse approaches might be just what you need.

Louise Elliott

Xprime Inc., in Poway, CA, makes and sells Microsoft SQL servers. The company's president, Cary Jardin, a software expert with experience gained at Intel and SCM, uses SolidWorks to design the server faceplates, and then makes rapid prototypes in metal, using a Roland MDX 650 mill with optional rotary axis and VisualMill CAM software. He prefers the Roland DGA mill over plastic-based rapid prototyping (RP) systems because it can work with a broader range of materials. He reports that not only can he prototype his parts in the materials he'll use for the final product, but he can also manufacture small runs directly on the Roland equipment.

Michael Jones, an electromechanical technician with Böwe Bell & Howell in Lincolnwood, IL, makes rapid prototypes on a Stratasys fused deposition modeling (FDM) system. The company won an important contract for high-capacity document scanners in large part by redesigning the system and testing design improvements using rapid prototypes. In addition, although designers have changed a part called a flag on the paper carriage several times, the plastic "flag hold-down" made in lots of 100 on the Stratasys system has never worn out, nor has the design been replaced *(see Figure 1)*.

Michael Huggins, president of Precision CADCAM Systems, Hunt Valley, MD, sells equipment and consults for both Stratasys and Roland DGA RP systems. He finds that among his customers, both systems tend to be used at least as much for rapid manufacturing as for RP. "People want to get product off a machine with the fewest possible setups, while they maintain the highest possible quality for usability," he says. "When someone needs a plastic part, they can go from conceptual design to usable part on a Stratasys system—although the parts tend to be small and may need a little finishing. If someone needs to make a precise part in a hurry, the Roland equipment will do the job."

Although the systems are very different in nature, some companies use both. They use the Stratasys FDM approach to create a prototype from which a mold may be made—if the surfaces can be made smooth enough. And they use the Roland DGA mill to finish the surfaces for that purpose.

FDM uses ABS and other non-toxic plastics that come on spools in thin filaments. These get fed into a liquefier that melts and extrudes the plastic through a fine tip. The machines are very quiet in operation, with very little waste, and can be set up in engineering departments. Depending on the complexity of the design, building a model can be time-consuming, so designers often let the machines run overnight.

Bill Camuel, who heads up training for Stratasys, describes FDM as "a precise hot-glue gun that layers ribbons of material." A design engineer generates an STL file—basically a faceted or tessellated representation of the surface of a design—from his CAD model and brings it into Stratasys's Insight software. That, in turn, "scales the model and slices it in layers that vary from 0.005" to 0.0014", providing cross-sections. Insight then generates extrusion paths, and the extrusion tip follows cross-sections to lay down material. At the end of a section, the *z* axis drops and the machine looks at the next cross-section." Camuel says that this process is the reverse of NC machining "because instead of taking away material, it's putting it in—and instead of starting at the top and drilling down, it starts at the bottom and grows the material up."

In contrast, Roland DGA makes NC mills based on an *x, y* movement the company developed initially to finish musical equipment, and then adapted to CAD plotting and several different kinds of printing *(see Figure 2, below)*. Roland's machines differ from shop-floor mills in that they generally work with less dense materials and have a very easy-to-use software interface.

"The interface is the key," says Gerald Hiller, Roland sales manager. "The software, called Modela Player, lets users with no machining experience program the mill with a wizard-driven four-step process. The software contains a materials library and automatically programs the machine to cut the material selected—but the user needs knowledge to choose the material. People with manufacturing experience often think it's too easy to use. Those people can use the equipment with CAM software, and we resell VisualMill from MecSoft (mecsoft.com) for those users."

Hiller says that Roland mills tend to be used heavily in the packaging industry to model the vacuum for blister packs and clear trays for packaging. Mold makers use the machines to create the positive for a hard tool with a very fine finish. In differentiating the capabilities of "additive" RP and "subtractive" milling, Hiller says that milling systems can't create manifolds with internal definition that are hollow on the inside. But, he adds, "We can guarantee that anything made on our machines will be manufacturable, which the additive processes can't always say."

Xprime's Jardin uses Roland's MDX 650 for higher precision work than is possible with the basic system and software alone. In addition to mill, rotary axis, and VisualMill CAM software, he uses an automatic tool changer supplied by Roland for diamond-coated tools *(see Figure 3)*. "With this equipment, the MDX is very fast. Instead of making deep cuts like a

Figure 2: Here, a mobile phone prototype is milled by the Roland MDX 650 SRP device with the optional 4th rotary axis. A $^{1}/_{8}$-inch flat-end mill is used.

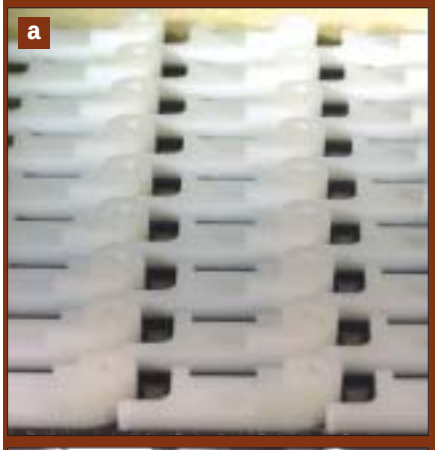


Figure 1a and b: Flag hold-downs were made in lots of 100 on a Stratasys FDM system. Figure 1b shows the flag hold-down in use.

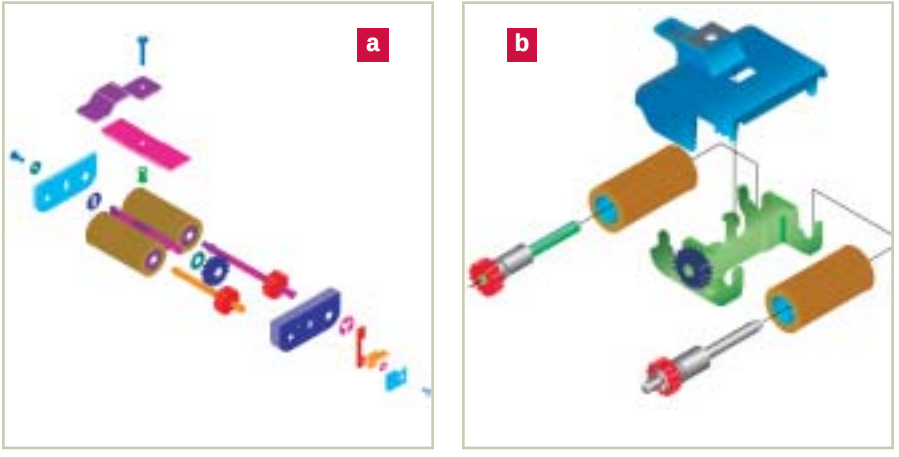
shop-floor mill, it makes small surface cuts, but does them very fast."

Huggins of Precision CADCAM says, "The Roland software is slick. It takes about 20 minutes to learn. I know EDM people who like the finish it makes for plastic molded shapes the electrode burns down inside a mold. They used to use a Fadal machine, but now use a Roland MDX 650." He also demonstrates the Stratasys Dimension system he sells by making parts for people who want to see conceptual models before making a manufacturing mold. "Black & Decker locally had us make two parts to show the system's capabilities."

Design engineers at Böwe Bell & Howell reduced the number of parts in the paper-feed mechanism of its high- speed (250 images per minute) scanner from 26 to 13, creating snap fits that replaced screws and eliminating the need for any manual adjustments to help the scanner handle different paper thicknesses *(see Figure 4)*. Those, and other design changes, won the company a multimillion dollar contract. Michael Jones reports that the installation of working prototype parts made on the company's Stratasys system, and the ability to refine those parts quickly to meet the customer's requirements, made all the difference.

"Before this experience, we would have had to manufacture all the prototypes—which takes so long that we wouldn't have been able to change the design. With RP, we changed the prototypes frequently in order to improve the performance," Jones says. The company did four iterations of the entire assembly and many more iterations of the snap-together parts. "We made the assembly lighter and then tested it to make sure the weight change didn't harm the performance."

Figure 3:
This image shows Roland's Automatic Tool Changer (ATC). Here it has selected a $^{3}/_{8}$-inch ball-nose end mill.



Figures 4a and 4b: Design engineers at Böwe Bell & Howell reduced the number of parts in the paper-feed mechanism of its high-speed scanner from 26 to 13. Fig 4a shows the original assembly; Figure 4b shows the redesigned assembly. According to the company, the installation of working prototype parts made on the company's Stratasys system made all the difference.

Even more important for the scanner and for other product designs, he says, "RP helps to lower the overall cost of manufacturing and makes manufacturing easier. FDM is the best way to go from concept to real parts held in your hand in just hours. We can try out many designs and find the one that works best without spending money on tooling for prototypes or making expensive molds that may not work. If we can test parts quickly, we can make family molds and castings directly from the RPs."

The FDM and Roland milling approaches both work well—as attested by their users. In cases where using both approaches is unnecessary, it appears that the choice of equipment depends upon the nature of the design and surface refinement needed.

COMPANY INFORMATION

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When your rapid prototype is done, is it really finished?

3D PRINTING uses corn starch and sugar to build up a brittle, grainy prototype with noticeable lack of detail and accuracy. The process requires two machines to form the model and remove excess material, as well as a great deal of laborious post-finishing and hand-coating for any kind of durability.

STEREO LITHOGRAPHY is an expensive process which creates prototypes using lasers and proprietary resins. The prototypes often lack detail and include rough banding, the result of the material being applied in distinct steps. The model must be finished by hand or with glass beading, a time-consuming process which alters the final dimensions.

SUBTRACTIVE RAPID PROTOTYPING begins with an inexpensive block of polyurethane, chemical wood or resin. Roland's 3D milling machines quickly and accurately remove material, resulting in a mold or prototype with remarkable detail and accuracy. There is no need for hand work or special treatment. When the device is done, the prototype really is finished.

Subtractive Rapid Prototyping is cutting the time and cost of product development.

MDX-500 ***$19,995 US***
Max. work area: 19.6" x 12.9" x 4.1"

MDX-650 ***$23,995 US***
Max. work area: 25.6" x 17.7" x 6"

Roland's innovative MDX benchtop milling machines are revolutionizing rapid prototyping by offering engineers and designers the opportunity to quickly and inexpensively turn your concepts into three-dimensional prototypes. Costly molds and dies that could take days when outsourced can now be manufactured in hours. Small lot production becomes a practical reality. Powered by AC Servo motors on all three axes, MDX milling machines use Feed Forward Processing technology to mill a variety of materials with speed and precision. Both models come loaded with a variety of safety and performance features and bundled with a suite of powerful software programs. With its optional rotary axis and automatic tool changer, the MDX-650 also offers unattended four-sided machining.

Built with precision. Backed with passion. Roland

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