

## 3D Printing Hooks Users with Prototypes that Bring Designs to Life

**P**rinting, a term generally associated with images on flat surfaces, might soon need to be redefined to include the creation of 3D shapes. In some cases, the fabrication device, or the printer, might be only slightly bigger than a standard fax machine. In other instances, you don't even have to own a machine. You can simply upload a digital model online to a 3D printing service bureau. In a matter of days, a scale model representing your idea — be it a new residential high rise, a pocket-size cell phone charger, or a custom-configured elf warrior from the *World of Warcraft Online* — could be on the way to your doorstep via UPS or FedEx.

Once reserved for the creation of mockups, 3D printing has evolved into an alternative manufacturing discipline for producing parts with complex geometry in smaller volumes. At the same time, a number of technology suppliers are introducing smaller, more affordable desktop models, teasing engineers with the promise of personal prototyping machines. To help you find the right 3D printing technology and service for your business, we speak to the industry leaders, take an account of the latest models entering the market, and outline the pros and cons of certain materials and methods involved.

### New Form of RP

Traditional forms of prototyping — most of which are anything but rapid — involve subtractive methods that create shapes by removing materials, such as hand sculpting, clay modeling, and laser cutting. 3D printing encompasses a new generation of rapid prototyping (RP) technologies, such as fused-deposition modeling (FDM), selective laser sintering (SLS), stereolithography (SLA), and a few others. Emerging over the past two decades with the advance of CAD, they rely on digital models as their guides and have become part of the RP lexicon. Most are considered additive fabrication because they build layers of materials to create solid models rather than cutting materials away.

The definition of *3D printing*, like the technologies it refers to, is still evolving. Some use it loosely to refer to all additive fabrication methods. Others prefer to limit its scope to fabrication methods derived from ink-jet printing, exemplified by the machines from Z Corp. and a few others. Terry Wohlers, the founder of Wohlers Associates and the author of *Wohlers Report 2008: An in-depth global study on the advances in additive fabrication*, defines 3D printing as "a less costly variation of additive fabrication (AF) technology," citing machines from Z Corp., the Dimen-

**Above:** This realistic prototype of a fishing reel from manufacturer Zebco is the result of parts created using an Objet Eden 3D printer and the finish work of Zebco model maker Brad Ruprecht. For more information, see the sidebar on p. 21.



sion series from Stratasys, the PolyJet machines from Objet Geometries, and the lower-cost options from 3D Systems as examples. This article uses Wohlers' definition of the term. In the table provided here, the acronym 3DP is used to identify machines using ink-jet-based methods.

The most commonly used file format for 3D printing is STL, now an available file export option in most architectural and mechanical CAD software. In most cases, the operation to convert a CAD model to STL may be as simple as File / Save As / STL (as is the case with Autodesk Inventor, SolidWorks, Pro/ENGINEER, and Alibre Design). Some programs, such as Autodesk's Revit and 3ds Max, provide additional tools and options to parse or mesh models for the best 3D print results.

## Applications

Because they're comparatively cheaper and faster to produce, 3D-printed prototypes have begun to replace traditional mockups in clay, wood, or foam in various industries. In architecture, 3D-printed models are used not just for design review but also for sales presentations. The ability to print embossed text strings and logos on the model's surface (a feature provided by some service bureaus such as the Colorado-based LGM allows

additional branding opportunities in building models left for display at project sites. Many architectural models consist of sections and parts that are not closed volumes, or solid geometric shapes that can be printed. Architectural firms new to 3D printing should consider working with full-service 3D print shops that offer assistance to help them convert the CAD model into a 3D-printable STL file.

## Above and Beyond the Floor Plan

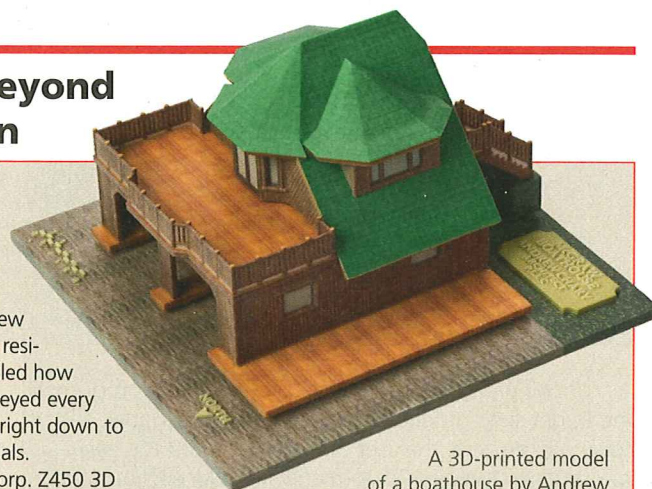
Andrew Chary knew a 3D printer was in his future the minute he saw the intricately detailed models at an ArchiCAD seminar in 2007. The principal of Andrew Chary Architect, a high-end residential home designer, recalled how the 3D-printed models conveyed every aspect of the home design, right down to the brick and roofing materials.

Chary has owned his Z Corp. Z450 3D printer for one year now. The machine generates full-color 3D models of buildings and site plans as large as 8" x 10" x 8". Chary believes the 3D printer pays for itself in the credibility it brings the firm, the increased sales, and more.

Clients love the models, he said. "Holding a model in your hand, there's a light bulb that goes off. It results in intelligent questions and an understanding of the design that is gratifying."

Chary knows that in the world of 3D printing, he's a leader among AEC firms. "We went to a Z Corp. user group meeting and found out we were one of only a few architecture firms using a 3D printer throughout the entire design process," he recalled — for uses including master planning and site adjacency to opening model of a house including windows, furniture, etc. "We even use [the 3D printer] for problem solving, using the model to represent the existing structure and clay to explore possible solutions."

Read the full story at [www.cadalyst.com/3DPapps](http://www.cadalyst.com/3DPapps).



A 3D-printed model of a boathouse by Andrew Chary Architect includes annotations showing direction, scale, and the project name.

## Additive Fabrication at a Glance

Company	Year Founded	Prototyping Methods	Materials Used	Color?	Flexible Materials?	Transparent?	Included Software	Input File Formats
3D Systems	1986	3D printing (3DP), stereolithography, selective laser sintering, selective laser melting	Acrylics, resins, powders, metals	Yes	Yes	Yes	3DManage for preparing build files; 3DPrint for system sequencing and control; LS 3.6 for SLS systems; Alibre Design software (with the V-Flash model); Accelerator for 3D printing	STL, SLC
Desktop Factory	2004 (machine not yet available)	3DP	Composite plastic	No	No	No	System software to receive STL files and to prepare and manage print operation	STL
Objet Geometries	1998	3DP	Resin	No	Yes	Yes	Objet Studio, client-server software for file preparation	STL, SLC
Stratasys (and Dimension)	1989	Fused-deposition modeling	Thermoplastic	Yes	No	Yes	Insight for preparing 3D parts; Control Center for job monitoring; FDM TEAM for managing multiple-user environments	STL
Z Corp.	1994	3DP	Plaster composite, elastomeric materials (rubber-like), direct casting materials	Yes	Yes	Yes	ZEdit and ZEdit Pro for color print preparation; ZPrint for preparing CAD files; Mimics Z for beginners to 3D printing	STL, VRML, PLY



## 3D Model Improves Security at WVU Tech

CAD and design professors Bill Javins and Jim King of the Community and Technical College at West Virginia University Institute of Technology were thrilled when the state capitol police asked them to build a tabletop model of the Charleston campus for security-planning purposes.

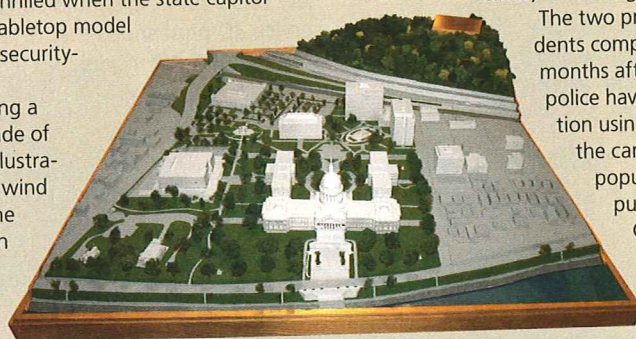
The professors were planning a traditional tabletop model made of foam core, balsa wood, and illustration board when they caught wind of 3D printing technology. One thing led to another, and soon they had a grant to purchase a Dimension 3D printer.

Initially, King and Javins anticipated using the printer to complete the more complicated capitol buildings. "As we got into the process, we found that modeling other

minor details was much faster than making them out of balsa or illustration board, and they looked so much better in many cases," said King.

The two professors and a small team of students completed the final 4' x 4' model six months after the 3D printer arrived. Capitol police have saved hours of event preparation using the model instead of examining the campus on foot. The model is also a popular attraction and is available for public viewing in the state capitol's Center for Culture and History.

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Buildings as well as trees and statues comprise the 3D-printed model of WVU Tech.

For civil projects, 3D printing offers a way to produce the target site's ground conditions as a scale model. To cover a large area, the user may need to print the geospatial data stored in GIS formats in smaller sections and manually assemble them into a single piece; therefore, for such projects, printers with larger build areas offer an advantage. For converting GIS files into 3D printable files, machine maker Z Corp. recommends exporting the file in VRML format.

In mechanical and industrial design, especially in the production of consumer goods, product developers often use 3D-printed prototypes to study the design options available. More recently, because of the increased integration of finite-element analysis (FEA) software in mechanical CAD packages, it has become possible to

output the color-coded analysis results using 3D printers. For these applications, machines with color printing ability should be considered.

For prototyping medical equipment, some manufacturers prefer to create transparent prototypes, even if the shipping product is designed to be manufactured in opaque materials. The transparent prototype allows engineers to examine the liquid flow inside the chambers and, if necessary, correct the geometry before mass production. This practice is especially useful for manufacturing artificial heart valves, automatic glucose delivery devices, and similar products. Manufacturers involved in producing rubber-based products, such as shoes, may prefer machines that can print models in flexible materials, as the texture and tension of the printed prototypes will better mimic the final product.

### Methods

Because SLA employs photocurable resins, machines using this process tend to produce models that are slightly brittle. By contrast, the SLS machines use polymer powders, resulting in models with thermoplastic properties and surfaces with powdery texture. Many consider SLA to be a better process for producing fine, smooth parts with intricate details. But more often, SLA parts need support structures. In some rare cases, the removal of the support structure may leave behind marks that compromise the dimension of the part.

FDM uses rigid ABS plastics, producing parts similar to the thermoplastic SLS parts. Materialise, a Belgium-based prototyping firm, noted, FDM is "less appropriate for parts with living hinges," but "more appropriate for large, flat parts . . . with fewer small details," compared with the SLS process. Stratasy uses eight unique thermoplastics materials in its equipment.

3D printing derived from ink-jet technology uses ink-jet nozzles to create models in layers, with a liquid binder to seal them in place. The process uses a liquid agent instead of a laser, as in SLS. This method is generally considered more affordable and quicker compared with others.

### In this article

#### 3D Systems

[www.3dsystems.com](http://www.3dsystems.com)

#### CADspan

[www.cadspan.com](http://www.cadspan.com)

#### Desktop Factory

[www.desktopfactory.com](http://www.desktopfactory.com)

#### Dimension Printing

[www.dimensionprinting.com](http://www.dimensionprinting.com)

#### LGM

[www.lgmmodel.com](http://www.lgmmodel.com)

#### Materialise

[www.materialise.be](http://www.materialise.be)

#### MIT's Three Dimensional Printing

<http://web.mit.edu/tdp/www>

#### My3DServices.com

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#### Objet Geometries

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#### Shapeways

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#### Xardas

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#### Z Corp.

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## Desktop Revolution

One recent advance in 3D printing involves the evolution to desktop units. Among the vendors that believe the time is right for desktop RP machines is Objet Geometries, headquartered in Rehovot, Israel. The Objet Alaris30 debuted in October 2008. It measures 32" x 34" x 41" — approximately twice the size of a typical desktop ink-jet printer — weighs 183 lb and has a build area measuring nearly 12" x 8" x 6". The machine is priced at less than \$40,000.

Also in October, 3D Systems announced the return of the V-Flash FTI 230 Desktop Modeler, priced at \$9,900. At this price, the company hopes the machine will appeal not only to engineers and designers but also to hobbyists and students. "This affordable, easy-to-use and office-friendly 3D printer is the first product from 3D Systems based on its new Film Transfer Imaging (FTI) technology platform," the company reported. The machine is designed to operate quietly and plug into a standard electrical outlet.

The V-Flash FTI 230 re-enters the market after an April 2008 introduction led to the discovery of "several technical difficulties that affected the modeler's performance" according to the company, and sales ceased. Julie Graham, 3D Systems communications specialist, explained, "We plan to continue with carefully managed, phased rollout plans through the first quarter of 2009 and, pending the successful outcome of this phase, commence full commercial activities for the V-Flash FTI 230 Desktop Modeler in early 2009." The machine is expected to ship with Alibre Design, a familiar mid-range 3D mechanical CAD product.

Undercutting V-Flash's low price, Desktop Factory is planning to sell its premiere model, the 125ci, for less than \$5,000 sometime this year. Although not yet available, the machine already has garnered headlines: "Printing 3D Gets Practical," hailed *BusinessWeek* (October 6, 2008); "Desktop Factory's Cheapo 3D Printer is Coming," reported the technology blog Engadget ([www.engadget.com](http://www.engadget.com)).

Cathy Lewis, Desktop Factory CEO, admitted, "We're not here to be best in class. We're here to bring awareness and accessibility to the market that we think has been way overpriced and way too complex for way too long."

Desktop Factory's debut machine measures a mere 25" x 20" x 20" and weighs less than 90 lb. But some sacrifices are required for its compact form factor. Its build area is only 5" x 5" x 5". Currently, it prints using only one rigid material. Color, transparent, and flexible options aren't on the menu yet.

## From Prototypes to Functional Parts

In 2005, recognizing the emerging market for printing functional parts, 3D printer developer Stratasys launched a new business unit initially called RedEye RPM and later renamed RedEye On Demand. The new division is a service bureau that produces not just

## Zebco Tackles Prototyping Tasks with Ease

Popular fishing gear manufacturer Zebco has a 50-year reputation for creating innovative products, and it was no stranger to rapid prototyping. But a growing need to produce more reliable and realistic models led the company to explore 3D printing. "Our team was much more limited in our design and engineering capabilities because we hadn't yet found the right rapid prototyping solution," said model maker Brad Ruprecht.

After exploring other alternatives such as stereolithography, Zebco considered Objet's Eden line and was impressed by the resolution quality and smooth surfaces of printed models. The Eden 3D printer was quickly integrated into a range of development applications, including cosmetic samples, form and engineering models, and urethane casting masters. Design changes now are faster and models are more realistic. Replicating carbon-fiber trim, for example, no longer involves the painting and graphic dry transfers that had less-than-authentic results. Now, the design team uses the Objet system to create a compression mold to develop the actual carbon fiber parts, producing a realistic prototype in a few quick steps.

To create the Quantum fishing reel prototype (featured on the cover and on p. 18), Ruprecht first produced the parts on the 3D printer, which required about 8 hours of machine time. Finishing the models required another two days of hand work — one day to sand, prime, paint, and chrome the parts and a second day to assemble. Ruprecht's work results in such realistic models that Zebco sales representatives take them to meetings with retailers when actual manufactured samples are not yet available. "Ninety percent of the time, customers can't tell the difference," he said.

Read the full story at [www.cadalyst.com/3DPapps](http://www.cadalyst.com/3DPapps).



Newcomer Desktop Factory plans a 2009 release for its 125ci 3D printer, priced at less than \$5,000.



## Pay by Piece: The 3D Printer Service Bureau

If the roughly \$20,000–\$75,000 investment needed to own a 3D printer is beyond your budget, you can turn to one of the many 3D printing service bureaus to produce your parts. Most have online query and submission systems that let you obtain a quote for the job you have in mind and remotely upload your file to begin printing. Many offer one-day turnaround. Pricing varies depending on several factors, but the general range is \$15–\$25 per cubic inch of the printed model.

Some 3D printer manufacturers have launched service bureaus of their own, such as Stratasys' RedEye On Demand; other service bureaus operate independently or as an arm of a hardware reseller. Z Corp. partners with Quickparts.com to offer a variety of 3D printing services, including the ZPrints service announced in December, which enables designers and engineers to click a button in AutoCAD 2009, order a 3D model online, and have it printed and shipped to them immediately.

Many CAD files destined for 3D printing are not exactly primed for the process. Because of the limitation of ink-jet nozzle positioning, 3D printing is not

ideal for building certain structures, such as railings or extremely thin walls. As a side business, some 3D printing bureaus offer additional services, such as fine-tuning the CAD files for best results or sanding parts for smoother finishes.

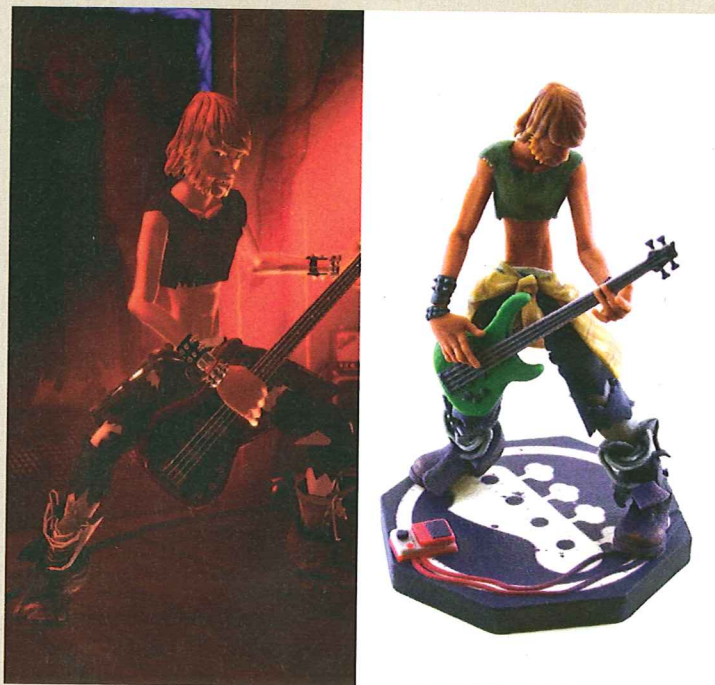
In May 2007, IDEAL, a large-format scanner and printer maker, staked out a position in 3D printing with the launch of My3Dservices.com, a portal described as "File preparation services for 3D printing." The site offers, among other services, 2D-to-3D CAD conversion, conversion of paper drawings and sketches to 3D, 3D file healing, and conversion of building information modeling (BIM) or 3D CAD files to solids model files.

Phil Magenheimer, vice president of IDEAL, pointed out, "Reducing a real-world architectural 3D CAD design of a skyscraper or other large building to the size of a 0.001-scale 3D printed model requires knowledgeable manipulation of the 3D CAD file. . . . My3Dservices.com has experts in 3D CAD who understand file-preparation and -healing services that enable printer-ready 3D files."

With Context's acquisition of IDEAL's scanner distribution division in July 2008, the fate of My3Dservices.com remains

unclear. The site was still active as of January 2009, but no one from IDEAL was available to comment about its future.

Stephanie Wood Design, a United Kingdom-based Z Corp. printer agent, offers both 3D printing and scanning services. The firm uses a Z Corp. Z700 3D scanner to convert physical objects into an STL file, reproducible via 3D printing. "Tabletop parts and components are scanned in our studio," the company explained. "We can come to you for larger and less portable captures subject to project approval."



Customized characters from the video game *Rock Band* are transformed from animated to plastic with the help of a Z Corp. full-color 3D printer.

LGM, a visualization and model making service provider, provides a free, online CAD-to-STL conversion site called CADspan.

"You can use the free version [of CADspan] if you aren't selling the resulting models or deriving commercial benefit from the CADspan service, LGM spells out in its licensing terms. For \$39.95 per month, CADscan Pro, the commercial version, offers one-on-one assistance, batch processing, and other services. If you're a fan of Google SketchUp, you can install CADspan's STL-export plug-in to shrink-wrap a SketchUp model into one continuous, solid mesh ready for 3D printing.

As evidence that 3D printing is reaching

beyond commercial applications, online services such as Shapeways are targeting the consumer. Launched last summer, Shapeways is the first consumer-focused 3D printing production service, as well as a community that provides design support and inspiration, said CEO Peter Weijmarshausen. "Shapeways is making 3D printing easy, fun, and affordable." Shapeways Creator enables users to design unique items based on available templates in a few minutes, without 3D modeling skills or special software installation. Prices start at \$8 per model, including shipping. Using Shapeways Shops, 3D software enthusiasts can sell their designs to others.

Recently, the popularity of 3D virtual worlds such as Linden Lab's Second Life has spawned a number of service bureaus that specialize in 3D printing virtual characters, or avatars. Such is the case with Xardas, which uses a Dimension SST 3D printer to produce characters and objects from virtual environments upon request. Z Corp., through its in-house 3D printing service, will output 6"-tall figures in full color based on the avatars that users create to play the popular video game *Rock Band* — down to intricate details such as chain necklaces and tattoos. (Read the full *Rock Band* case study at [www.cadalyst.com/3DPapps](http://www.cadalyst.com/3DPapps).)



prototypes but also end-use parts. The company has been asked to produce, among other things, a set of air ducts for a light aircraft manufacturer and a series of syringe storage units for a doctor.

These 3D printed parts and products are intended for daily use, not as prototypes. Joe Hiemenz, Stratasys public relations manager, pointed out, "Although *rapid manufacturing* (RM) is the original term, the Society of Mechanical Engineers uses the term *direct digital manufacturing* (DDM)" to describe this application.

For high-volume parts numbering in the thousands, traditional manufacturing methods — tooling, machining, and injection molding — remain the preferred options. But RM can produce certain parts with complex geometry, negative angles, and undercuts that present challenges for traditional methods. Because the typical turnaround time for RM is two to five days, it's ideal for making a few dozen alpha and beta units to test a product's form, fit, and function or a few hundreds parts to launch a new product while waiting for tooling setup.

In April 2006, roughly six months after its launch, RedEye On Demand began offering a flexible, rubber-like photopolymer material known as FullCure Tango. "Tango is expected to be of interest to manufacturers of products with pliable features, such as tires, shoes, gaskets, key-pads, overmolding, and flexible automobile trim components," announced the company.

With the introduction of its Overnight Build service in June 2007, RedEye On Demand began providing next-day shipment for orders placed before 4 A.M. Eastern time. Several months later, in November 2007, RedEye On Demand added Ready Part, a premium service for producing parts with mold-quality smooth finishes. "The Ready Part technology also prepares models and parts for painting, plating, and postfinishing processes," according to the company.

### Office and Earth Friendly

Objet Geometries describes its new Alaris30 as being "ideally suited for an office environment." Dimension, a division of Stratasys, usually describes its product line as "a fast, office-friendly, low-cost alternative."

The ubiquitous term *office friendly* indicates the RP machine developers' recognition that standard RP materials require careful handling. Many

companies now strive — especially in designing desktop machines — to minimize or prevent user exposure to toxins and heat. They also have introduced disposable, recyclable materials.

"All current Stratasys systems use thermoplastic materials," explained Hiemenz, so printed parts can be recycled by industrial recycling firms that process plastic scrap. "Compared with subtractive manufacturing, such as machining, the additive RP process uses, for the most part, just the volume of materials needed to form the shape, so you have virtually no waste," Hiemenz added.

Joe Tiltlow, director of product management at Z Corp., said, "Beginning with the Z450, down to the latest ZPrinter 650, we use a technology that automatically recaptures the unused powder. Ninety-nine percent of that unused powder gets put back into the machine for future builds. That's a tremendous cost savings for the user. Several years ago, we used heaters to cure the parts. We realized the noise and the heat weren't suitable for office environment, so we've moved away from it. Our current technology uses heat only near the end of the build cycle."

### Workhorses and Ponies

"Using additive fabrication machines to create end-use parts requires high performance, meaning larger build

## 3D-Printed Bike Rack Hits Streets of NYC

Francis Bitonti, principal with the design firm FADarchitecture, used 3D printing to create what he calls an alien-looking bike rack for a contest sponsored by the New York City Department of Transportation. The contest aimed to raise the profile of cycling in the city and address riders' concerns about bike security.

The rack design is based on modular pieces and freeform geometry. "A lot of what I do comes out of writing small computer programs that generate forms," Bitonti said. "This form is disconnected but continuous at the same time, operating as a modular system that produces many variations."

Bitonti had planned to mill the rack, but the design would have required 200 parts. "It would have been nearly impossible to fabricate with traditional milling. 3D printing was the most cost-efficient and precise way to manufacture these parts," he said. He called on RedEye On Demand, a business unit of 3D printer manufacturer Stratasys, which printed the components using FDM (fused-deposition modeling). Only 18 parts were needed, and the 3D printer tackled the large build with ease, creating components from a glossy plastic. Parts were painted an automotive deep red-orange.

Two finished models were created. One is in use on the streets of New York. The other is on display at the Cooper-Hewitt National Design Museum.

Read the full story at [www.cadalyst.com/3DPapps](http://www.cadalyst.com/3DPapps).



Francis Bitonti's 3D-printed bike rack is in use on the streets of New York City.



## From Concept to Production Mold Master in 24 Hours

Precision CAD/CAM Systems (PCS), a 3D printing reseller and parts service provider, used 3D printing to create prototypes of an Indiana Jones action figure so quickly and accurately that the design went directly from concept development to final market production. Toy company officials reviewed the prototypes and immediately approved the design.

The printer was a 3D Systems ProJet HD 3000 3D Production System, which builds ready-to-use models in high and ultrahigh definition. PCS built and shipped the Indiana Jones prototype within 24 hours. "[The client] couldn't believe how good it was in standard [high-definition] mode," said PCS president Michael Huggins.

The toy company's production manager commented, "It feels like you're looking at Indiana Jones. It's the spitting image of him. You can see his personality. The models looked so good that we used them as the master mold for production. It expedited the approval process."

Huggins added, "The technology is here. Give me the [design] files and pretend this machine is sitting in your office — you'll have the models in 24 hours." Read the full story at [www.cadalyst.com/3DPapps](http://www.cadalyst.com/3DPapps).



Precision CAD/CAM Systems built and shipped this Indiana Jones toy prototype in 24 hours. Toy company officials immediately approved the design.

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- (1) **Timing:** The Contest begins on September 15, 2008 and ends on February 28, 2009. Entries must be received no later than 11:59 pm Pacific Time on February 28, 2009.
- (2) **Eligibility:** Contest is open to all individuals age 18 years or older who are residents of the United States. Employees and the immediate families of Questex Media and/or Hewlett-Packard and/or Intel are not eligible to enter. All federal, state, provincial and local laws and regulations apply. Void where prohibited.
- (3) **Categories & Judging:** Each entry must meet the requirements, as specified below in section 4. Any non-conforming entries will be disqualified. Altered, defaced, mutilated, illegible or incomplete. Entry Forms are not eligible and will result in disqualification of entry. After each entry is screened for compliance with the entry requirements, it will be judged by Sponsors. The judges' decisions are final and binding. The entries shall be judged based on the following information: (a) What were your Objectives; (b) What were your Challenges; (c) How do Hewlett-Packard Workstations with Intel Quad-Core technology help you overcome your challenges; and (d) What benefits did you/your company realize? Please quantify your answer with examples from any of the following: (e) number of workgroups involved; (f) number of man hours saved off a development cycle, decision process, etc.; (g) number of revisions you reduced; (h) number of people communicated to; (i) estimated cost savings; and (j) Hewlett-Packard Workstation product number.





Z Corp.'s ZPrinter 650 has five print heads that produce two to four layers per minute in full-spectrum, 24-bit color.

envelope, higher throughput, speed, accuracy, and greater material strength," explained Hiemenz. These requirements can be met only by the larger 3D printers.

"On the other end of the spectrum, there's also a trend to drive the price and footprint down for conceptual modeling," added Hiemenz. He predicts that soon 3D printing will no longer be a workgroup function but a feature available to individual design engineers, allowing them to create prototypes on the fly. If Hiemenz is correct, expect to see a divergence: the rise of larger, faster production workhorses devoted to rapid manufacturing of end-use parts and a proliferation of smaller, affordable, even personal machines for printing prototypes. ◀

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## ADVERTISEMENT



HP Workstations are fully tested and certified for many CAD and CAE applications, the xw6600 system featured here is an ideal system for those who need an HP Quad Core Xeon workstation, and can easily be upgraded by adding a second Quad Core processor.

(4) **How To Enter:** Only stories based on a Hewlett-Packard Workstation with Intel Quad-Core technology are eligible. Application entry forms are exclusively available at [www.cadalyst.com/workingdifferently](http://www.cadalyst.com/workingdifferently). Complete the entry form online in its entirety. By submitting an entry you warrant that you are authorized to submit the information on the Contest form and that the Contest form does not contain information considered by your place of business or any other third party to be confidential. Any entry not complying with the above entry requirements will not be eligible for any prize. One entry per person. In all cases, entries become the property of Sponsors. Entries will not be acknowledged or returned. Questex Media accepts no responsibility for entries that are lost or damaged in transit.

(5) **Prizes:** One (1) winner will be selected. The winner will receive one (1) Hewlett-Packard xw6600 Workstation with a Quad-Core Intel processor 5420 2.5 GHz with 2x6MB L2 cache and 133 MHz front side bus. Included is an NVIDIA Quadro FX1700 Graphics card (512MB), 4 GB 667 MHz DDR2 SDRAM, 250 GB 7200 rpm SATA NCQ hard drive, a 16x DVD+-RW, 80% efficient power supply 3/3/3 warranty and a Hewlett-Packard LP2475w 24-inch Widescreen LCD Monitor. Total prize value is approximately US\$3,100. Because this is a contest of skill, winning is dependent upon the quality of entries received. No alternative prize, cash or other substitution is allowed except by Questex Media in the event of prize unavailability. Prizes are non-assignable/nontransferable. All federal, state, provincial and local taxes are the sole responsibility of the winner.