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DIY comes to MANUFACTURING

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DIY manufacturing

"Personal" machine tools and inexpensive CAD let one-man shops straddle the line between traditional manufacturing and more current approaches.

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Resources:

Alibre Inc., *www.alibre.com*

PTC CoCreate, *www.ptc.com*

Sprut Technology, *www.sprutcam.com*

Tormach, *http://www.tormach.com*

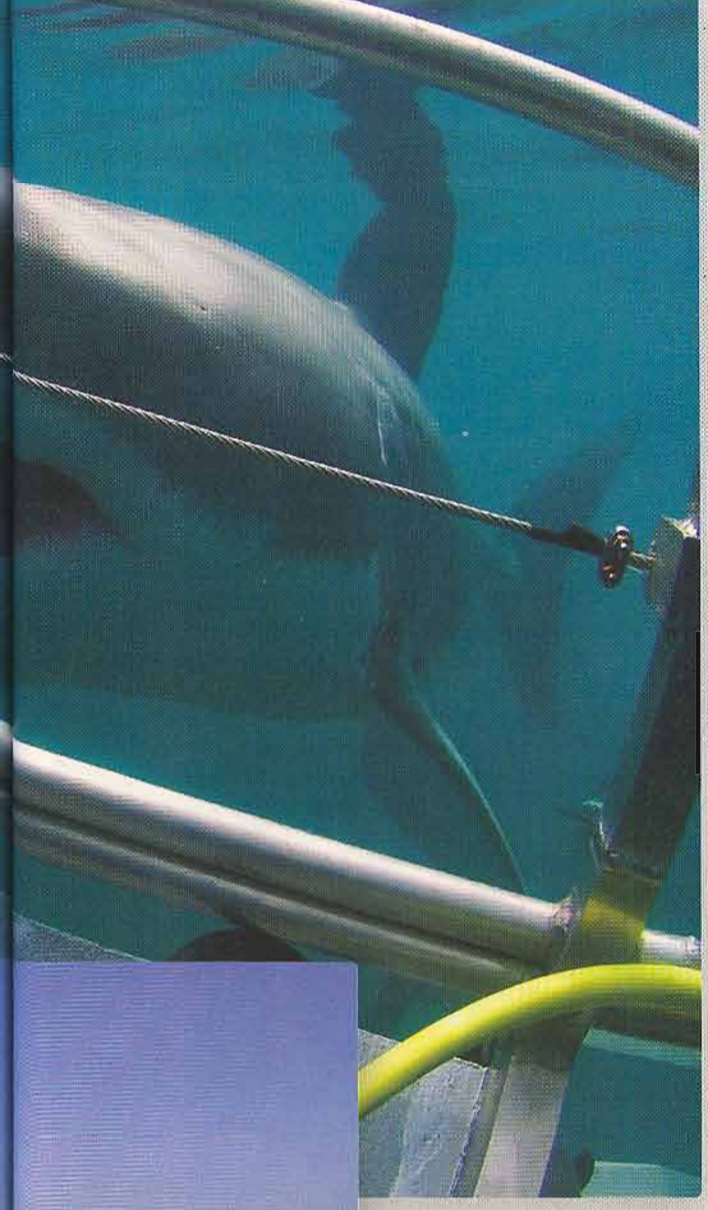
X1 Pallet Systems, *www.x1palletchanger.com*

"Fab it Now," MACHINE DESIGN, (May 22, 2008), *http://tinyurl.com/yke88kl*

"Rapid Prototyping 'On the Cheap,'" MACHINE DESIGN, January 14, 2010, *http://tinyurl.com/ylkdoof*

"Social Networking in Engineering," MACHINE DESIGN, (May 19, 2009), *http://tinyurl.com/nbw54f*

No doubt, trendsetting approaches to so-called personal manufacturing have turned old-school ways upside down by giving almost anyone the means to make stuff. Over the last few years, MACHINE DESIGN has featured articles about several of these approaches. For example, "Fab it Now" (May 22, 2008) discusses the development of a "personal fabricator," an additive machine about the size of a microwave oven that anyone can purchase for a few thousand dollars. The builders used it to 3D print everything from robot parts to small working batteries. And "Rapid Prototyping 'On the Cheap'" (January 14, 2010) talks about how mixing social networking with digital fabrication is a recipe for rapid mass customization. In addition, "Social Networking in Engineering" (May 19, 2009) discusses how social-networking technologies such as blogs, wikis, and RSS feeds are changing



Underwater, the vehicle let researches easily follow great white sharks to study their behavior and habits.

The SOVII for studying great white sharks was designed using the free download of CoCreate Modeling Personal Edition.

how engineers and manufacturers work.

A different "personal-manufacturing" slant comes from machine-tool builders, software developers, and smaller companies that straddle the line between newer ideas and conventional manufacturing. Consider, for example, **Tormach LCC,** Waunakee, Wis., developer of the personal CNC (PCNC) machine tool.

Machine tools get personal

"Crowd sourcing and social networking include lots of discussion forums and groups that are doing interest-

Modeling a sub for viewing great white sharks

Engineers in a project for studying great white sharks used the free download version of CoCreate Modeling Personal Edition to design a submersible vehicle for viewing the animals up close. Previously, researchers had to rely on sharks approaching their diving cages voluntarily. But once the shark's interest faded and it disappeared into the sea depths, the observational dive was over.

So Peter Arnold of **SharkProject** developed the new Shark Observation Vehicle II (SOVII). The team only had nine months for design, development, manufacturing, and testing. "All the components and instruments of SOVII had to be redeveloped from scratch because everything had to be pressurized and saltwater resistant," says Arnold. "Designs like this are most easily done using explicit modeling. I had no time to plan ahead or give thought to parameters and boundary conditions."

The SOVII is 4.5-m long, 1.6-m wide, and 1.6-m high, with an open aluminum-frame construction. It was designed for long dives and full-day operations with a maximum depth of 70 m and an operating depth for shark observation of 5 to 30 m. The vehicle provides sufficient space and protection for two people, while being agile enough to follow sharks.

Interestingly, the engine is a common outboard motor for inflatable boats. For underwater use, it must respond to constantly changing pressures in different water depths. Arnold designed an automatic air control, which measures the external pressure so enough pressure builds up in the engine to prohibit water from entering the motor.

"I clarified this and a number of other development issues through trial and error, says Arnold." The explicit modeler made it easy to try out new ideas for review and just keep discarding them until I found the right solution. I had to repeatedly rebuild individual components and derive the drawings. Optimizing the weight of the boat was a bit scary because I had no experience in how heavy a sub should be."

The team first tested the sub in the plunge pool of the **European Astronaut Centre of the European Space Agency** in Cologne, Germany. The good news: SOVII was not too heavy. The bad news: it was too light. "CoCreate made it simple to make the necessary weight changes, which let us meet our deadline," says Arnold.

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http://tinyurl.com/27pva3s

ing things with technology," says Greg Jackson, president of Tormach. "Really, though, these individuals are mostly just having fun screwing around with cool stuff."

Another tack comes from countless "little guys," usually with part-time jobs, who are invisibly weaving themselves into mainstream business-to-business interactions, often by cutting parts for their interest group or community, says Jackson. "For instance, a guy might be a hobbyist or an enthusiast of vintage **Triumph** motorcycles," he says. "But components for them are no longer available. So he sets up shop in a garage to cut motorcycle parts and then starts selling them to others in his interest group."

A machine tool with a smaller footprint, the personal CNC targets one-man shops, says Jackson. "One person acts as a vertically integrated company — he's a machinist, but he is also the programmer, designer, accountant, and salesman. The shops fill niche or boutique markets and usually perform what is called 'small-batch manufacturing' of one to 50 parts."

Because the machines are smaller and weigh less, PCNCs are less rigid than traditional machine tools. "However, this is not typically a factor for a lower-power spindle," says Jackson. "First, one-man shops usually cut smaller parts — you can hold one in the palm of your hand. The smaller machines cut parts such as this as accurately as traditional large, general-purpose machine tools, capable of holding tolerances of 0.001 in. And although users must cut parts more slowly, at the end of the day it doesn't matter. For instance, consider the traditional approach of making a one-off part. The user would probably go to a big machine shop that would take perhaps 8 hours to design and lay out the part, proof the program, and bolt everything down. It then takes 5 minutes to cut the part. A small guy with a PCNC would also take 8 hours, plus maybe 15 minutes to cut the part. The difference is negligible."

What small shops need is a lot of capability, adds Jackson. "To this end, we provide enough attachments for the PCNC that, in-house, we informally call it 'the Swiss-Army knife' machine," he says. One option, for example, provides part inspection and reverse engineering. The unit comprises a low-cost USB microscope that creates video images and mounts where the cutting tool normally attaches. The CNC system moves the camera to the part, takes a series of pictures, and then stitches them together, creating an image equivalent to that of a 200-Mbyte camera. The system uses a Google Maps-like principle of connecting many images together to create a larger, more-complete picture.

And for those who want to make a product but lack CNC skills, the company lists helpful manufacturing consultants on its Web site — either machinists or manufacturing engineers who have no direct relationship with Tormach. The consultants do own at least one PCNC and use it regularly in a professional capacity. "They help less-experienced shops bootstrap themselves," say Jackson. "For example, if you are just starting up and don't yet know how to use CAM software, a small project might consist of getting G & M code based on your drawing. This is a way for you to start cutting parts quickly."

The PCNC 770 milling machine features a 10,000-rpm spindle, 130-ipm maximum feedrate, and a cast-iron construction. Shipping dimensions are 42 × 45 × 49 in.

The Tormach CNC Scanner takes a series of photographs where CNC motion automatically positions the camera for each photo. The associated software then assembles a dimensionally scaled photomosaic by stitching photographs together to build a larger image.

Fitting right in with the low-cost PCNCs (a basic milling machine is around $6,000) is low-cost CAD software such as Alibre and CAM tools like SprutCAM from Russia, says Jackson. "SprutCAM includes a wide variety of machining strategies for better finishes, faster cutting, and higher accuracy" he says. "It costs around $1,000 and is comparable to programs that generally cost $5,000." A basic Alibre package costs under $100 and there are no maintenance fees.

Software helps democratize design

According to Max Freeman, vice president of marketing at **Alibre,** Richardson, Tex., its CAD software targets "midnight engineers" — individuals in the new economy trying to start up their own businesses. "Inexpensive programs such as ours facilitate the democratization, if you will, of technology," he says.

The basic version of the 3D CAD software costs $97. "Previously, our software ranged between $1,000 to

$2,000," says Freeman. "Our intent was to open the door for hobbyists and home guys who couldn't afford higher-end packages. To an extent, this approach was successful, but at that price we still didn't really grab them. The $97 version, though, our bread-and-butter software, has had a great response. We also provide CAM software for about $4,000, much less expensive than the mainstream-system costs of $10,000 to $30,000."

Alibre users make everything from simple trinkets to full assemblies with 3,000 parts, says Freeman. "For example, a retired Air Force officer designs wheelchair systems in 3D CAD that let disabled vets get into a good-looking hot rod and drive it instead of grandma's van," he says. "Another guy designs special brackets for car seat belts so short people don't get choked by the belt. Yet another individual makes aluminum yo-yos, which, believe it or not, are hot among a certain global young set. All of these individuals make a living manufacturing something."

The X1Palletchanger lets operators load and reload a machine tool in less than 30 sec. In an unloading cycle, the operator unlocks the clamps, grasps the handles, and removes the platen. Loading is a matter of positioning the platen loaded with new work, placing it on the locators, and locking the clamps.

Another CAD package playing into the mix is Co-Create Modeling Personal Edition, a free download from **PTC Corp.**, Needham, Mass. (*www.ptc.com/go/modelingpe*). "As an explicit modeler, it's one of the easiest ways to learn 3D CAD," says Geoff Hedges, marketing director, PTC. "Users don't need to worry about the traditional complexities of other CAD tools, like understanding parameters, constraint mechanisms, or history trees. They just push and pull the geometry to quickly and easily create their first 3D designs."

According to Hedges, users design everything from a computer mouse to a home. "The only real limitation is you can only create models with 60 individual parts," he says. "But for hobbyists and small shops, that is plenty good enough for their assemblies."

The company currently has over 175,000 registered users, which shows that lots of individuals are interested in 3D CAD, says Hedges. "To keep track of who is using the software and how often, rather than just seeing a wave of people downloading the product and never using it, the software includes a mechanism that checks a central server when the program is opened. This process is transparent to the end user. Over 1.5 million product-starts shows the growing interest in using free or inexpensive software in design and manufacturing," he says. **MD**

A fast part loader

A turning and milling shop owner used Alibre to design an innovative pallet or parts loader for machine tools. **X1 Pallet Systems,** Burbank, Calif., also uses the software in the design and machining of aerospace and military components and industrial actuating systems.

"One of my jobs is to increase production, without disrupting it and costing a lot of money," says Michael A. Near, owner of the company. "I noticed that one of our three-axis NC machines was taking 12 minutes to machine a part, but the total cycle time was 16.5 minutes because it took so long to unload the finished part and insert and align the next part for machining. Four and a half minutes seemed way too long. So I developed a fast parts-loader that reduced the reload time to less than 30 seconds."

The loader comprises a two-part fixture, says Near. "The base attaches to the NC machine. A pallet containing parts for machining attaches to the base quickly using locating pins and swing clamps. I made two pallets, one for use on the machine tool and the other offline so the operator can unload finished parts and load new parts while the machine is running.

The X1Palletchanger is relatively inexpensive, under $5,000, says Near. "In our shop, it paid for itself in less than two months. The loader works on almost any vertical spindle NC milling or drilling machine. This is how shops can thrive — by doing things the smart way."

Near also says larger shops can download the 3D data to a smaller machine tool like the Tormach and not tie-up a $400,000 machine to make two parts. "The $10,000 machine is ready to go and lets shops make a few parts and see whether they work together. Then they can commit the process to larger equipment. This approach is fairly new in the industry. Years ago, when you wanted a part cut, you took the blueprints to a shop and then basically just waited three to six months. Only then could you see if they would fit."