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Direct Digital Manufacture and the Internet: Let the Games Begin

Everything has to start somewhere, and total direct digital manufacturing—using the Internet as the front end for ordering—seems to be having its start…with gaming.

It is now more than 20 years since 3D pioneer Chuck Hull invented the stereolithography process and started the now billion dollar rapid prototyping industry. Over the following two decades, layer manufacturing processes have evolved from simple prototyping systems into fully validated shop-floor production technologies. Yet over the same 20-year period, we have seen a far more profound technological change in the way we buy products, rather than in the way they are made. The most notable change is the use of the Internet, which has revolutionized the way we find, order, pay for, and even track products for delivery to our homes. Recently, there has been an explosion in the number of interactive web sites that enable us to engage in the actual product design process by allowing us to upload our own images and designs and order customized and personalized products from business cards and coffee cups to T-shirts, shoes and calendars. It was only a matter of time until these two technologies would come together, giving the consumer the ability to not only design over the internet, but also to realize their own 3D products online using direct-digital manufacturing (DDM).

Probably the earliest example of using DDM to enable the manufacture of online content was the launch of www.fabjectory.com by Mike Buckbee in 2006. The Fabjectory business model enables players from Metaverse's online 3D virtual world Second Life to purchase models of individualized avatar characters manufactured using Z Corp. (www.zcorp.com; Burlington, MA) 3D Printing (3DP). Unlike other massively multiplayer online role-playing games, or MMORPGs, the creators of Second Life assigned all intellectual property rights for characters to the game's users, a loophole exploited by Fabjectory, without any infringement of the game's intellectual property.

A similar application of Z Corp.'s 3DP to Fabjectory was launched in December 2007 by FigurePrints (www.figureprints.com). However, the FigurePrints business model is quite different from Fabjectory. FigurePrints is an exclusive licensing partnership between a former Microsoft executive, Ed Fries, and global software house Blizzard entertainment. The FigurePrints Web site allows players of the MMORPG World-of-Warcraft (WoW) to order scale models of their online gaming characters manufactured using 3DP. However, unlike Second Life, where the character IP resides with the designer, all WoW character definitions remain the exclusive intellectual property of Blizzard entertainment, although they are designed online using a suite of "character building tools" by the game's players.

A similar closed-loop rapid manufacturing (RM) fulfillment model to FigurePrints has been developed by the 3D Outlook Corp., where web users are able to select topographic data of the earth's surface using an internet based design tool (www.landprints.com) and use this as the basis for a 3-dimensions color relief map.

A section of online computer games characters created using 3D printing. Image courtesy of Per-Snickety.

Another web-based RM fulfillment business has also been launched in Singapore by Genometri PTE Ltd, a spin-off company from the national university of Singapore. www.jujups.com is a 3D portal that allows web users to design a range of "giftware" products such as photo frames, key fobs and tokens, which are then 3D printed to order. Using a series of simple web-based design tools, users have the ability to select from a pallet of 3D objects, which can be personalized with text, relief objects such as flowers or with photo images uploaded by the user. Unlike other online DDM sites, Genometri has gone one step further and allows the physical part to be manufactured on a 3DP machine closest to the customer. Hence, a Jujups order placed in the UK across the Internet will be printed in the UK for dispatch.

Using this principle of distributed DDM, UK-based Per-Snickety (www.per-snickety.com) has developed a globally distributed 3DP fulfillment service for games companies, whereby the latent capacity of literally hundreds of color 3D Printing machines are networked together to provide a truly global virtual factory. Per-Snickety has already demonstrated the concept with a range of different on-line user design-oriented computer games and MMORPG's. By early 2009 Per-Snickety expects to have developed the capacity to print literally millions of models per annum.

However, globally distributed DDM may be a short-lived phenomenon if home-based additive technologies become a commercial reality. Pasadena-based Desktop Factory (www.desktopfactory.com) is tantalizingly close to launching a sub-$5,000 polymeric based additive technology that will be in offices in 2009 and could be in homes as early as 2010. **tc** tems. More advanced FEA comes in additional modules. The design analysis tools in Rhino range from determining the simple—length, angle, radius, area centroid and moments, volume (centroid and moments), and so on—on up to the more complex—hydrostatics, geometric continuity, deviation, and working surface analysis viewport modes (draft angle, zebra stripe, color-coded feedback, Gaussian and mean, curvatures, and minimum or maximum radius of curvature).

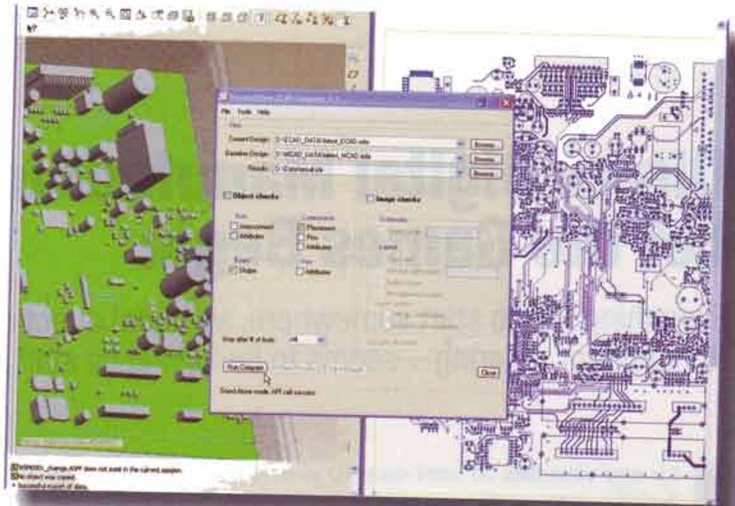
Inventor includes tools that help verify that products can in fact be assembled by letting designers insert and position new components in an assembly and add constraints that define fixed and moving components. Inventor can graphically display mechanical interferences and overlapping material, as well as test for potential collisions between moving parts. Color feedback tells designers when critical design parameters are exceeded, such as length, distance, angle, area, volume, and mass.

Simulation and visualization. Most CAD packages, even at the low end, offer real-time photorendering, animation, videos, flythroughs, and the like. IronCAD, for example, includes ray tracing, shadows, texture/bump/decal mapping, and anti-aliasing for creating photorealistic images. Any number of directional spotlights can also be created. Special visual effects include fog, glow, reflections, transparency, gels, and a range of lighting from direct sunlight to deep shadow.

Manufacturing capability. Autodesk Inventor can generate production-ready drawings for manufacturing and outside suppliers. Designers can pick specific views for a drawing, including front, side, ISO, detail, section, and auxiliary views, as well as overlay drawing views to illustrate various stages of assembly. Inventor also lets designers hide lines at the component level. Inventor will automatically dimension drawings, including isometric view dimensions. For BOMs, Inventor will automatically number items and define materials for virtual components (such as glue and paint). Other documentation produced by Inventor include technical illustrations, process sheets, training materials, parts manuals, assembly instruction sheets, and training videos.

Industry-specific CAD. Many CAD vendors offer various "flavors" of their products. AutoCAD, for example, is the centerpiece to an array of vertical applications from Autodesk. AutoCAD Civil 3D generates surveying, design, analysis, and construction documentation for civil engineers. AutoCAD Electrical includes symbol libraries and workflows suited to electrical engineering and control systems. AutoCAD Mechanical includes standards-based symbol libraries, engineering calculators, and workflows for mechanical engineering. AutoCAD Architecture is for, natch, architects. AutoCAD MEP is for mechanical, electrical, and plumbing businesses, while AutoCAD P&ID is for creating, modifying, and managing piping and instrumentation diagrams. AutoCAD Map 3D combines CAD and geospatial information systems.

Both Dassault's Catia and Siemens PLM's NX have dozens of modules to address specific design tasks and industry design problems—enough to fill a hefty catalog (dead-tree version). Catia modules, to name just a few, cover mechanical part and composite design all the way to manufacturing analysis, electrical harness design to documentation and printed circuit board design, automatic drafting for cast and forged parts to functional tolerancing and annotation review, and shape design and styling to NC machining. Likewise, NX is available for mechanical, package, and electromechanical systems design, and for industrial design and styling. All the modules and products are integrated with the base CAD system and the other product lines of the respective companies.



Pro/Engineer routed systems modules maintain associativity between 2D drawings, 3D models, and Å of circuit boards, as shown here, as well as cabling and piping. A change in the design or routing in one is reflected in all of the associated documenta-tion, such as BOMs and manufacturing work instructions. Photo courtesy of PTC.

Data exchange and file healing. Most CAD systems "play nice" with other systems by supporting most, if not all, major CAD file formats, such as DXF, DRAWING, IGES, JT, STEP, and VRML; STL for supporting 3D digitizing arms, scanners, and printers; and various other industry-standard formats such as PDF and XML. Most CAD systems, through converters, gateways, or simply import/export features directly support third-party CAD systems based on different modeling kernels (such as PTC's Granite, Siemens PLM Software's Parasolid, and Dassault Systèmes ACIS).

The data conversion and import is hardly perfect. Many CAD systems include functions to "heal" such files before a designer works on them.

Speed. Several aspects of a CAD system make it "speedy." According to PTC, these aspects include modeling capabilities, depth of functionality, the allocation of computer memory (especially when displaying designs and building assemblies), the accuracy and breadth of features contained in the modeling kernel, the user interface, and the native data file (size and storage). IronCAD version 10, for example, takes advantage of the latest OpenGL and Direct3D graphics drivers to speed the graphical rendering, 3D rotation, and camera selection of large assemblies. The software can create 2D views from 3D models up to 10 times faster than previous releases.

PDM/PLM. Often, PDM comes as a proprietary add-on to the base system. However, Autodesk Vault, a PDM system, comes with Inventor. Extensive PDM is usually bundled in with the high-end (read expensive) systems, namely PLM, such as Teamcenter from Siemens and Enovia from Dassault. **tc**