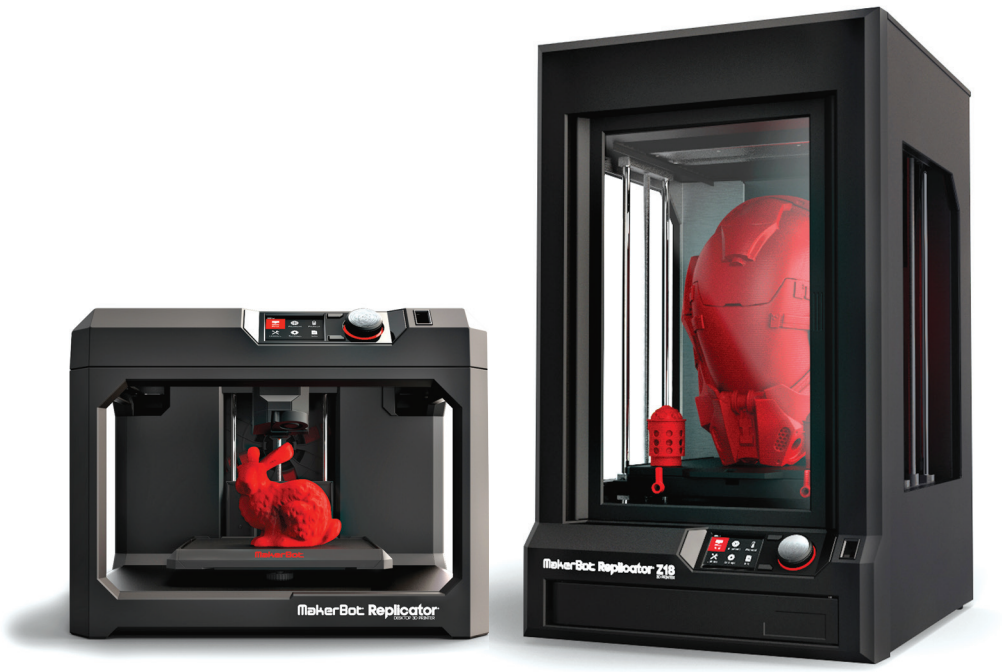

DESKTOP ENGINEERING WITH MAKERBOT ON:

Economics 101: Desktop 3D Printing

Making desktop 3D printers part of the engineering workflow enables real-time prototyping and improved collaboration, helping to streamline design cycles and reduce costs.

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Produced by the editors of Desktop Engineering

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Decades ago, the desktop printer and word processing software untethered office workers from the corporate print shop, enabling them to do more on their own. Similarly, desktop 3D printers are empowering engineers to take rapid prototyping into their own hands, paving the way for new workflows that emphasize creativity while streamlining how design work gets done.

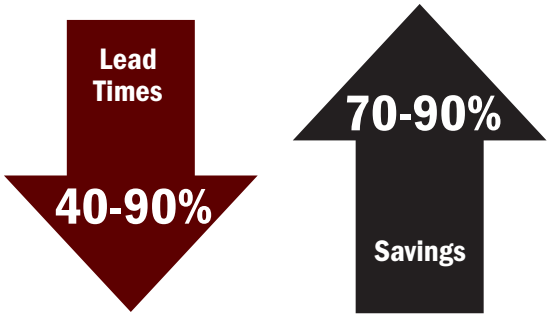
High-end industrial 3D printers have been available for years, but their high cost and need for specialized operations expertise relegated them to service bureaus, either run internally or available from outsourced partners. Because the technology was at arm's length and available at a premium, engineers remained judicious in their use of 3D printing, enlisting it at the end of the design process for validation and testing of physical prototypes, and for production of short-run parts.

While there are well-documented time and cost savings benefits associated with the traditional use case, a new generation of professional-grade, affordable 3D printers presents an opportunity for even greater value. Instead of limiting 3D printing to key intervals in late-stage design, desktop units support a distributed 3D printing model, promoting real-time prototyping and fostering greater design collaboration. In addition, with 3D printing capabilities a desktop or department away, downtime for model turnaround is minimized or eliminated all together. This improves the economics of 3D printing by encouraging more widespread usage and collapsing design cycles, which in turn accelerates a product's time to market.

Companies across industries, from startups to market leaders, are getting onboard and seeing tangible results. By giving engineers access to desktop 3D printers in its Vehicle Design, Infotronics group and other parts of the company, Ford Motor Co. is facilitating early prototyping and doing more iterative design as part of R&D efforts. Likewise, NASA has tapped into desktop 3D printing on a much broader scale for prototyping tasks, including creating an early model of the heat shield used on the Curiosity Mars Rover.

Faster product delivery is just one of the upsides of placing personal 3D printers throughout an engineering department. Being able to generate an immediate 3D model of an emerging concept or a finished design lets project stakeholders collaborate right off the bat. They can identify potential problems and iterate any design changes without having to wait for finished prototypes to come back from the corporate print shop or an outsourced partner.

3D Printing ROI



MakerBot and Stratasys estimate that 3D printing can realize a 40-90% reduction in lead times and a 70-90% cost savings when used in the creation of jigs and fixtures.

A Stratasys survey of over 1,000 3D printer owners quantified the benefits. More than half of survey respondents reported a product launch time improvement of at least 10% or more when using in-house 3D printers, while one-third said they experienced 25% or greater improvement compared to a reliance on a 3D service bureau approach.[1]

There are similar gains to be had reducing

[1] In-house or Outsource? "Six Business Advantages of Owning an in-house 3D printer;" Stratasys; http://goo.gl/THFnRW

design cycle iterations and manufacturing errors simply by using more accessible 3D print capabilities throughout the entire design phase — not just toward the end. Having the visual benefit of a realistic 3D model to showcase a design concept or as a basis for a design review is a far more powerful and effective means of collaborating with design partners and customers compared to working from sketches or 3D virtual models. In addition, an early 3D-printed representation of a part or component provides a much more realistic picture of how something will work in the field, helping team members identify and fix potential problem areas early on when it's easier and far less expensive.

The MakerBot® Replicator® Desktop 3D Printer.
Image courtesy of MakerBot.

Again, these benefits were confirmed by the Stratasys survey. Nearly one-third of respondents reduced the number of iterations in the design cycle by 25% or greater by having ready access to an in-house 3D printer. More than half of the respondents said they were able to minimize the back-and-forth inefficiencies during the design cycle by as much as 10%, according to the survey.

3D printing also facilitates savings by streamlining manufacturing processes. For instance, MakerBot and Stratasys estimate that companies can realize a 40% to 90% reduction in lead times and between a 70% to 90% cost savings when 3D printing is used in the creation of jigs and fixtures.

PERSONAL AND PROFESSIONAL

To make good on this value proposition, a new generation of desktop 3D printers has emerged, incorporating many professional-grade capabilities while still maintaining the ease of use and affordable price point of lower-end 3D printers. While industrial-grade 3D printers offer such functionality as large build volumes, high-resolution print quality, and extensive material choices, they require skilled operators to orchestrate print jobs and significant upkeep to maintain efficiency. Many printers in this class are also cost prohibitive for smaller engineering shops because of the high price tag on the printer unit coupled with on-going expenses related to maintenance, personnel support and specialized materials.

Desktop 3D printers have made significant strides to address these limitations. The latest models are true large-scale 3D printers, like the MakerBot Replicator Z18, for example, which boasts a build volume of 30 cm. long by 30.5 cm wide by 45.7 cm. high (11.8 L x 12 W x 18 H in.) or 2,549 cubic inches, rivaling most commercial 3D printers. Touting Fused Deposition Modeling (FDM) print technology with a 100-micron resolution, the Z18 and others in the personal 3D printer category can easily print complex designs featuring curves and sharp edges, making them a natural real-time prototyping tool to evolve designs from raw ideas to refined concepts.

Along with performance capabilities, material choices have evolved significantly for desktop 3D printers. For its fifth-generation desktop 3D printer lineup, MakerBot is developing PLA Composite Filaments, made with metal, stone and wood, which brings 3D printing closer to the look of a finished product, yet retains the non-toxic and ease-of-use properties of PLA (polylactic acid).

The increase in functionality and material options has not impacted the affordability and accessibility of desktop 3D printers. Many of these offerings tout ease-of-use features that are comparable to professional-grade, office-style printers. In that vein, MakerBot's professional 3D printer lineup has been architected with a swappable Smart Extruder function so the printers can easily be adapted to future 3D printing innovations, and the units are loaded with smart technology for sending alerts and detecting jams, ensuring design teams don't waste time and money on incomplete print runs.

Just as office printers have been adapted for the modern age of mobile, so have many of the newer desktop professional-grade 3D printers. MakerBot Mobile, for instance, lets engineers access their 3D printer from a smartphone, which is helpful for design teams working from the field or at home. Some models even offer extras like on-board cameras that can be used to capture and record finished prints, aiding in collaboration.

With prices for the starting at just under $3,000 for the MakerBot Replicator, companies are creating new workflows that tap into the distributed desktop 3D printers at regular intervals throughout the design process while leveraging back-room, large-scale 3D printers for later-stage prototypes and limited production runs. The following use cases illustrate how companies are creating new workflows around 3D printers to deliver real value for the business.

ACCELERATE PRODUCT DELIVERY

GE's FirstBuild, an incubator of GE Appliances, has a well-defined mission: Push the envelope on innovation and get products to market fast.

1B | firstbuild

Company: GE's FirstBuild

Use Case: As a product incubator in an established company, GE's FirstBuild needed a process to explore ideas and get product to market quickly. With MakerBot Replicator Desktop 3D Printers, engineers easily iterate designs and make changes, facilitating collaboration and condensing turnaround time.

Because of that mantra, FirstBuild has a radically different way of designing products, and desktop 3D printing is playing a significant role. "The idea is speed," says Rick DeVos, senior consulting engineer with GE's FirstBuild, explaining the incubator's rapid development practices. "We build a concept, test it, try it out, do corrections and are always pushing to go even faster," he said. "We try to go to 3D printers as soon as we can."

Giving engineers and designers direct access to 3D printers means GE's FirstBuild can do quick iterations and make design changes on the fly. "The fact that we have 3D printers on our desks lets us quickly make changes to a part," he says. "Our development cycle time has come way down because of the new technology. We can try something out — see if it fits or works — and it's letting us build things we couldn't have imagined before."

PRODUCT INNOVATION HUB

Orbotix prototypes its smart toys with 3D printers to design more advanced parts. *Image courtesy of Orbotix.*

Hacking is a way of life at Orbotix, a manufacturer of smart toys. Just like its software team is encouraged to experiment with code, its hardware guys quickly iterate and showcase ideas during the early concept phase using MakerBot Replicator Desktop 3D Printers.

Instead of batting around ideas in meetings or holding protracted design reviews, Orbotix engineers now do a quick 3D print to visually communicate the intent of their design concept. "Meetings have gone from a lot of arguing to, 'OK, cool idea. Make it,'" says Ian Bernstein, Orbotix co-founder and CTO. "Being able to quickly iterate on our different thoughts and ideas is important and part of the core values of our company."

Companies: Orbotix, Ringblingz

Use Case: MakerBot desktop 3D printers give teams the creative flexibility to experiment with new designs.

Today, instead of building prototypes of its Sphero robotic ball or other toys with paper clips and various other odds and ends, the Orbotix team is able to go further with designs by 3D printing more advanced parts. "We're doing bigger and better things now," Bernstein says.

Ringblingz, a startup making rings that helped teenagers manage their phones, also used MakerBot 3D printers as a more cost-effective way to do early concepts. Instead of doling out $10,000 to $20,000 to get two or three prototypes from a rapid prototyping service, Ringblingz spent a fraction of that producing 3D prints themselves on a daily basis. After a couple of weeks, the savings more than paid for the printer, according to Bill Phelps, the company's co-founder.

3D printing has also made the design process less combative. "It took away a lot of the arguments," he says. "Before a debate would rage on whether something should be curved or angled and that would mean two different mockups in a prototype shop," Phelps said. "Now the debate stops because you spend a few hours, print one round and one flat and then get back together. It changes the entire conversation and makes everything so much more productive."

CONTINUOUS RAPID PROTOTYPING

The James Webb telescope is part of NASA's biggest science mission ever, so it goes without saying that the telescope's design process needs to go off without a hitch.

While NASA has relied on rapid prototyping for years, a new generation of desktop 3D printers used by its suppliers like Lockheed Martin Advanced

Company: Lockheed Martin Advanced Technology Center

Use Case: Used throughout the design cycle, MakerBot Replicator Desktop 3D Printers are helping to zero in on an optimized telescope design.

Technology Center is allowing to fold rapid prototyping processes into the design cycle. By doing so, NASA can quickly go from conceptual design to CAD model to 3D printed part — a workflow that is enabling it to get to a better telescope design faster.

The addition of 3D printing throughout the design process also means the James Webb telescope team can test its processes and make sure everything is done right the first time — a critical milestone given that the telescope will be operating a million and half kilometers from Earth.

"3D printing is really playing a role here in that it allows us to develop products upfront and find potential mistakes," says Nelson Pedreiro, director of Science and Technology at the Lockheed Martin Advanced Technology Center. "It lets us optimize earlier in the design process."

PARALLEL DESIGN TRACKS

Companies: Kisi, Technotill

Use Case: With desktop 3D printers, companies are able to optimize their hardware designs and produce prototypes for testing.

Kisi, a combination of "key" and "easy," is home to a new product that turns a smartphone into a keycard, including a feature that lets users share keys over email. While it's a no-brainer for the company to evolve its mobile app on the fly, it's now able to do similar improvements to its wall-mounted device courtesy of a new design workflow incorporating desktop 3D printers.

Using MakerBot printers, Kisi has been able to evolve its electronics case from a standard rectangle box to a freeform shape, improving the design in real time without having to do expensive rework or changing tooling. The accessibility of the MakerBot 3D printer lets Kisi's design team prototype the hardware rapidly along with the software, making new designs each month.

Moreover, thanks to the advanced print capabilities of the desktop units, Kisi is 3D printing some of the actual components — a more economical alternative to sending components to outsourced partners to be produced and far more efficient than waiting in queue at a service bureau, according to Bernhard Mehl, Kisi's co-founder.

"Having a 3D printer on my desktop allows me instant optimization for the serial production, which I'd never get if I produced it any where else because it would be too expensive to change," Mehl says. "You'd accept a bad design rather than change it. Now users get the best design we can do."

Kisi's new design workflow for its smartphone-enbled key depends on 3D printing. *Image courtesy of Kisi.*

Framework Animation Ltd., a MakerBot reseller in Canada, is doing similar work for an agricultural client. The company created a physical 3D print of its "packer" component of the Technotill Seeding System for testing purposes instead of having to create a one-off

metal part, which costs thousands of dollars and requires a several week turnaround. By using a 3D printer, which makes use of inexpensive plastic, the cost was slashed to hundreds of dollars and the turnaround time reduced to days, said Jason Knott of Framework Animation.

IMPROVED CLIENT COLLABORATION

As a mechanical engineering and product development company, Fringe is all about initiating a collaborative design process with its clients. Yet traditional methods like 2D technical drawings and sketches don't always properly communicate design intent, especially when working with non-engineers or production personnel.

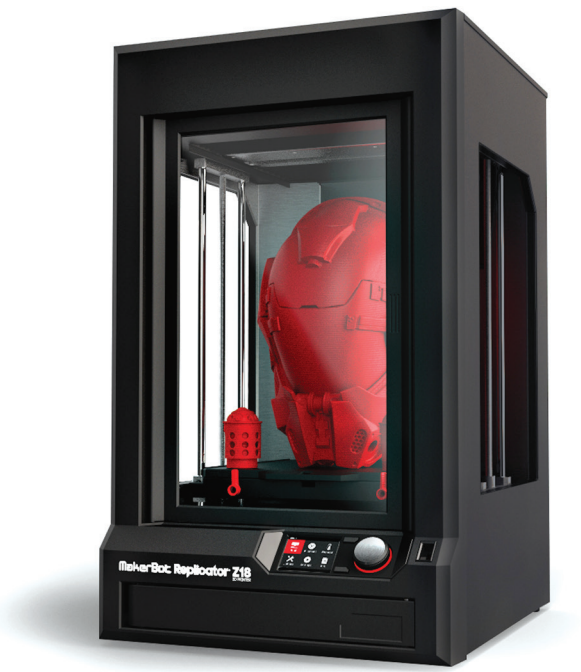
Company: Fringe

Use Case: By quickly outputting 3D models, Fringe is able to communicate design intent more effectively to its clients.

Enter desktop 3D printers which are now being deployed in a "concept sketching" mode to express the direction of product development to clients and to get everyone on the same page. "Traditional design review meetings revolve around a projector view of a 3D model that even for engineers can be difficult to grasp in a one-hour meeting," says John-Karl Boyce, Fringe general manager. "We wanted to give our clients maximum opportunity to give input regardless of their role or background and the easiest way to do that is to present a [3D-printed] model."

In addition to helping communicate design direction, 3D printing is proving to be far less expensive and time consuming compared to producing prototypes using traditional techniques like CNC (computer numerically controlled) machines. "It can be an expensive lesson to run through the entire loop getting a metallic product and then seeing that the assembly doesn't fit against something else," he says. "Production times can be anything from two to eight weeks and this affects development projects badly should the worst happen. Having a 'dummy' version that can be made within days and costs only a few engineering hours is time well spent for our clients."

As these use cases illustrate, companies of all sizes are finding that an investment in desktop 3D printers is money well spent. The cost of desktop 3D printers is quickly offset by the ability to create real-time prototypes at a fraction of the cost. The return on investment is even more apparent when companies factor in the protracted lag times of traditional methods. Distributed desktop 3D printers create product development efficiencies and cycle time reductions that are hard to beat.



The MakerBot Replicator Z18 3D Printer. *Image courtesy of MakerBot.*

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