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3D PRINTING

The Inside Story from the Inside 3D Printing and 3D Printshow Conferences

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3D printing is a technology that could be worth $21 billion by 2020, according to Wohlers Associates, Inc. Last week, in New York, we attended two industry conventions to speak with 3D printing executives and experts about their outlooks on this space. What we found is: 3D printing technology is mature, but a lot of printers are unreliable; materials could be the next big growth area; content could be king; artists are rapidly adopting the technology; manufacturers will have to rethink designs. What surprised us the most was the perception that there aren't that many reliable machines out there. This leads us to believe that any company producing an out-of-the-box, easy-to-use, reliable 3D printer has a definite advantage in a market that has been plagued with problems.

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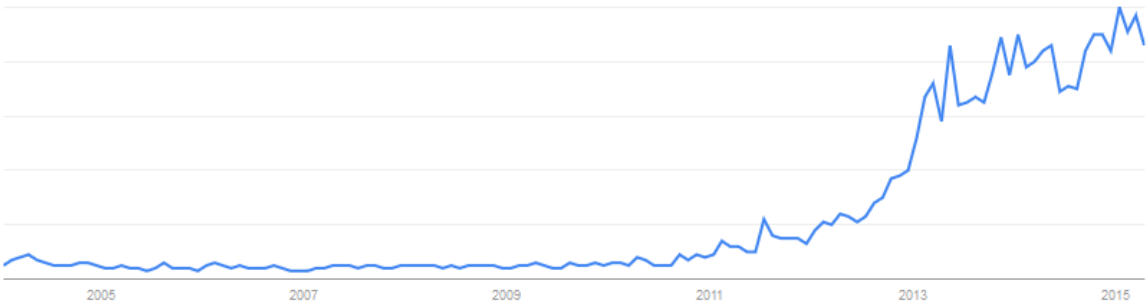
Introduction

Last week in New York City, we attended the Inside 3D Printing and 3D Printshow Conferences. We spent our time wandering both conventions, talking to company executives and industry professionals to consolidate their outlook on the industry. What we uncovered is:

- Hardware for 3D printing plastics is maturing,
- Hardware for 3D printing other materials, especially metals, can still evolve,
- Many companies differentiate themselves beyond hardware,
- Expanding choices of printing materials beyond plastic,
- 3D scanners are more prevalent,
- Artists have immersed themselves into 3D printing,
- Few companies are developing content.

3D printing is real. Inside 3D Printing claimed that almost 11,000 industry professionals and enthusiasts planned to attend the convention and expo. Although 3D Printshow is a smaller gathering of mostly artists and the 3D printing community, the event was well attended on the days we were there. Another data point that could corroborate our opinion is that the number of Google searches for "3D printing" (Exhibit 1) has generally increased with each successive year.

Exhibit 1: Normalized Searches for "3D Printing" Increasing with Time



Source: Google Trends

We Believe 3D Printers will become commoditized

Commoditization is a theme that we have voiced before. The prevalence of 3D printer companies that we saw at the conferences and the number of options in the sub-$500 price range, reinforce our opinion. 3D printers for plastics abound, and few companies rely upon a low-price strategy to survive - we doubt the ones competing on price will be around for many more conferences. Most companies, however, are not relying upon hardware. Some companies offer cloud services to store, share, and collaborate printer files. Others provide services for 3D printing enthusiasts to customize designs and then outsource the printing. Few focus on content, and one doesn't plan to lose its status of offering the largest 3D printer.

Several industry professionals voiced contrary opinions that 3D printers for plastics still need to evolve. Most admitted that the technology has matured, but added that many companies still don't know how to design and ship reliable products. Reliability was the consensus within this dissenting camp and some experts had downright nasty things to say (which we won't repeat) about 3D printers that fall into the "some assembly required" families.[1] Frankly, we were surprised by the number of people who mentioned that all they wanted was a printer that worked consistently. It is a larger problem than we imagined and, to be honest, shocking in a technology that has existed for decades.

Beyond 3D Printing Plastics

We saw a number of solutions for printing non-plastic materials. Metals are the natural choice for businesses. However, one salesman noted that he constantly encounters resistance from businesses to invest in 3D printers for metals. Cost is one factor (never mind that industrial computer numerical control "CNC" machines can cost millions). But the bigger resistance can come from people who are set in their ways. Their view is that they have no reason to change, and the salesman explained that he'll often take a company's drawings, print the parts, then return them to the company for evaluation. Even after explaining the cost benefits, the salesman stated that resistance often remains. But once a part is accepted within the company and word slowly spreads through the plant, the opportunity opens to win 3D printing business. It's a long sales cycle that requires persistence (and patience from investors).

Manufacturing costs can improve for 3D printers for metals, but the costs won't follow Moore's curve. More powerful lasers are needed to reduce manufacturing time as well as improve resolution on the printed metal parts so that minimal polishing is required on the final product. Other than that, there is not much left to improve manufacturing costs. Little-by-little, costs should fall and approach the cost of the metal itself.

ExOne (NASDAQ:XONE) is taking a different approach to 3D printing for metal. The company specializes in creating sand-based molds for casting iron parts. In traditional sand casting, a mixture of sand and clay is formed into a mold for the part. What ExOne does is create these molds from a printer that layers a binding agent into a bed of sand. One advantage that ExOne's 3D printer offers is the ability to make intricate designs in traditional parts. Think about new, cooling channels that could be embedded into an engine block; something that traditional sand casting may not accomplish. This 3D printing technology opens a new realm for mechanical engineers to design fluid and heat transfers within cast metal parts.

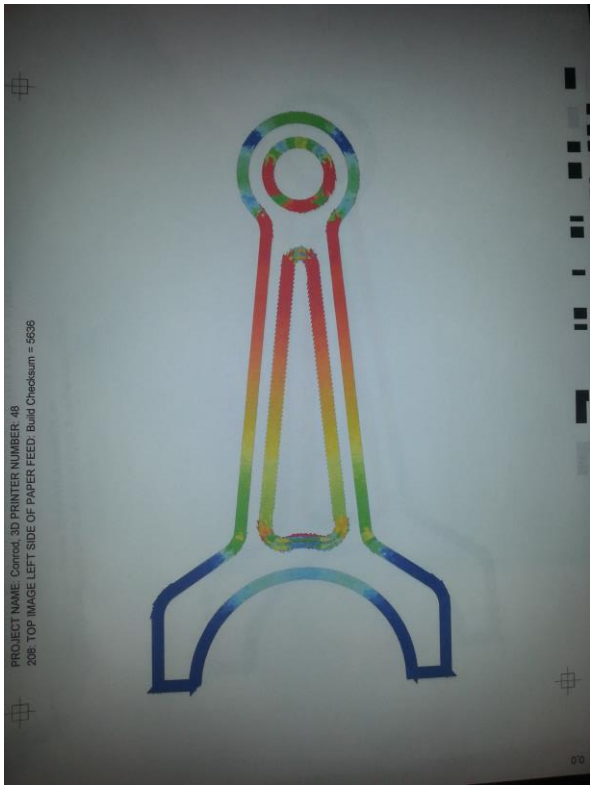
ExOne 3D printed sand cast for iron

[1] Buyers beware of these cheaper, disassembled options because they often come without technical support.

Swappable Zmorph printer heads

Zmorph (private) was one company providing solutions across numerous printing media. The company's differentiator is a platform that has swappable extruders, each of which uses a different material for 3D printing. Of course, the company provides extruders that use plastic as the printing material (including an extruder that prints in dual colours). But the company also sells extruders that print chocolate or cake dough, another that prints ceramic, and a dremmel attachment for any subtractive manufacturing (think of a mini-milling machine).

Want to try something that's faster than a 3D printer using plastic? Then try Mcor Technologies' (private) 3D paper printer. Literally, you load the printer with the same paper used in your photocopier machine, and Mcor's 3D printer will print the object's layers on successive sheets of paper. Once a layer is done, a thin mesh of glue is deposited on the paper, and then a fresh sheet of paper is laid upon the glue. The printer then prints all the colors on the fresh piece of paper. After stacking up the required number of sheets, the printer cuts away the excess paper surrounding the object. What is left is a dense 3D printed paper object that is harder, less expensive, and faster to make than traditional 3D printers that use plastic filament.



Paper layer from Mcor Technologies' 3D printer

Another material we find exciting for 3D printing is graphite. Think about being able to print something lighter and stronger than aluminum right on your desk. MarkForged (private) demoed their printer and had parts that I couldn't bend. The parts' outer shells were nylon and the interiors were reinforced with carbon fiber, but Kevlar and fiberglass were also possible. The company claims that objects are 20 times stiffer and five times stronger than traditional ABS plastics.

The Industry has its Fill of Filament

We saw six independent filament providers. This was in addition to the 3D printer vendors that sold their own branded filaments. Although we are not suggesting that these independent vendors supplied inferior products, we generally recommend that enthusiasts source their filament from the hardware vendor. The reason for this is that some independent filament suppliers (we're not suggesting the ones at the conferences) may use inferior plastics, which account for the lower prices. However, the inconsistency of such plastics cause the filament to melt at different temperatures, which would likely cause unsatisfactory printing results.

One filament vendor offered a key differentiator: flexible printed plastics. Fenner Drives (private), a manufacturer of conveying and power transmission solutions, presented its NinjaFlex 3D printing filament at Inside 3D Printing. The company had printed: sheets that could be rolled, a giant fly with flappable wings, and all kinds of twisty plastic thingamabobs. Representatives told us that NinjaFlex is popular with artists, especially clothing designers. They added that fashion shows are great marketing tools for exposing the filament's properties to the broader 3D printing community especially engineers.

Fenner Drive's 3D printed NinjaFlex...filament that prints flexible objects

Scanning: A Natural Complement to 3D Printing

Scanning accessories have had an industry presence for some time. But until these conventions, we had never seen a 3D scanner before. These scanners map the surface of an object and translate the map into a 3D printing file. We see the utility in a situation where a legacy part (let's say a carburetor valve) has to be created but no drawings exists to machine it. A 3D scanner could "reverse engineer" the part, and create a 3D printer file so that it could be manufactured.

Matter and Form (private) is a Toronto-based company with a particularly interesting 3D scanning system. The company has a turntable which spins 360

Matter and Form's 3D scanner

degrees, allowing scanners to map the entire surface of the object.This differs from other scanners that we saw, which generally scan an object from a single angle. Matter and Form replicates the entire object and exports the data into a file that can be ported to a 3D printer.

VanGogh Imaging (private) offers full 3D scanning capability. One of the problems with the scanning systems that we saw is they can only scan a surface. Think about your camera when it, let's say, takes a picture of someone wearing a Maple Leafs jersey. When the person faces you, you can tell that they are a Leafs fan. However, you don't know what player's number is on the back of the jersey. Most 3D scanners will extrapolate the information that it can't "see". What VanGogh's systems does is allow for someone to reposition a scanned object to scan these unseen surfaces. The company demoed a 3D scan of a rubber duckie. Once the software identified the object, a company representative flipped the duck upside down to complete the scan of the unmapped surfaces. The software has the intelligence to recognize that the attendant's hand is not part of the image, and removed it from the final image.

One final data point on 3D scanning. In 2014, Intel[2] (NASDAQ:INTC) announced its RealSense family of software and cameras for interaction with computing devices (Dell's Venue 8 7000 series tablets incorporate the technology). One feature that Intel's platform includes is 3D scanning of objects. One application shown in a promotional video shows a woman turning her head as it is scanned, and an image of her face being ported onto a gaming avatar. We can easily see someone (either Intel or a third-party) adapting RealSense technology to facilitate the 3D printing of that avatar and other scanned objects.

Putting the "Art" in "Arts and Science"

Artists have proven themselves as early and enthusiastic adopters of 3D printing. Both conventions had dedicated spaces for art displays (about half the floorspace for Inside 3D Printing and the 3D Printshow had 3 floors of art). We saw flowers, instruments, interactive displays, dresses, hats, and even a flower-decorated 3D printed Camero. These artists stretched our imaginations and impressed us with their technical skill to design such intricate and conscious-stirring masterpieces. They definitely put the "sciences" into "art and sciences," so if you're having problems with your 3D printing models, ask an artist; they could be the best resource for troubleshooting your design.

[2] Intel was not at either conference.

More Government 3D Printing Mandates for Education

China has an ambitious plan for 3D printing within its education system. A Taiwanese CEO, who's company has a 3D printing subsidiary, claims that China has a policy to install 3D printers in over 400,000 primary schools.[i] The deployment could occur over the next two years, and we believe it could be the largest education initiative undertaken to date.

Taiwan has a plan to bring 3D printing to schools. The government plans to outfit six trucks with 3D printing gear in order to bring the technology to almost 500 high schools.[ii]

ExOne, a company we mentioned earlier that makes casts for manufacturing iron parts, also plans to serve the education market. The company plans to offer training for high school and technical college students. The goal is to teach these students the fundamentals about 3D printing for metal technology and expand that training so they can create economic cases for whether or not 3D printers should be used. This is a winning differentiator in our opinion.

MakerBot, part of Stratasys Ltd. (NASDAQ:SSYS), hosted a conference for education where they shared their best practices. Students, it seems, naturally gravitate towards 3D printing because of it's "WOW!" factor. What keeps many engaged is to encourage story telling where a student postulates a theory and discusses the results from testing that theory, regardless of whether or not the experiment was a success. The company emphasized that drafting on paper is an important part of STEAM learning. This legacy method requires much thinking and has heavy mathematical content. But it also makes the transition to 3D design much easier to grasp.

Tinkerine – Focused on the Under-served Education Market

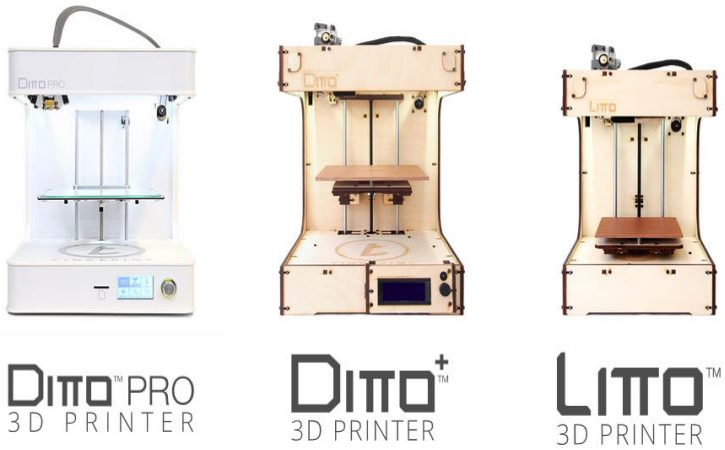
Tinkerine Studios, a Sophic Capital client, is the only public North American pure-play in consumer desktop 3D printing. The company is focusing not only on the consumer desktop space but also on the massively under-served education market - specifically, online learning and training, a market expected to hit $107 billion this year according to market research firm Global Industry Analysts[iii]. In an effort to provide educators, students, consumers, and technicians with the necessary 3D printing tools (printers & STEAM content) and the support that they need in the classroom or workplace, the company launched Tinkerine U on March 12, 2015 following a successful global pilot with educators (Tinkerine U was preceded by an Apple iPad app). **In a world where "content is king" (think television, blogs, streaming music), we believe Tinkerine U has a competitive**

Some of Tinkerine U's STEM Projects on display at the 3D Printshow

advantage with its peer-to-peer Apple iTunes store-like architecture. And as an incentive, most Tinkerine U content is free.

As Tinkerine executes on its pipeline of opportunities, one of the largest education content providers has noticed them. Pearson, a world leader in educational content and technology, selected Tinkerine to present 3D printing on Teachability.com, Pearson's online community of education professionals. We believe this validates that Tinkerine is a contender in the burgeoning Ed Tech markets. You can access the interview here.

What differentiates Tinkerine 3D printers? Reliability. Tinkerine's hardware is solid – its Ditto™Pro, the third generation printer, received high praise from *MAKE:* magazine[iv], the leading 3D printing publication. Tinkerine is developing educational content to reduce teacher reluctance toward implementing 3D printers within the classroom. And at both 3D printing conferences, "out-of-the-box" reliability was often cited as a differentiator amongst the service providers we polled.



NASA's Jet Propulsion Laboratory (JPL) is also a customer. NASA has been involved in additive manufacturing since the 1990s and has experimented with metals and plastics.[v] NASA has a plan to push desktop 3D printing since the technology facilitates problem solving and innovation at lower costs. Tinkerine has sold small quantities into JPL, and NASA JPL has showcased the Ditto™Pro at its events.

"A successful prototype. Valued the entire experience."

Gabriel Rangel
NASA JPL

Tinkerine has recently announced two new distribution deals in the last month to expand the Company's sales reach into new regions globally. The first was with PRECISE Group, a UAE-based 3D printing distributor that has 100 retail stores with another 60 locations poised to open. The second distributor is DTSL Group, a Hong-Kong 3D printer provider focused on Greater China's education technology market. Both distributors should expand Tinkerine's reach into the ed tech space by providing educators with the company's reliable hardware, training, and content.

Industry M&A and Investment Continues

Both the ed tech and 3D printing industries continue to consolidate. Pluralsight (private), an online training service company, is purchasing content. On On January 26, 2015, the company acquired Code School (private), which provides content and instructional courses for app developers, for $36 million[vi]. This followed a $75 million acquisition of Smarterer (private) and $45 million spent to buy Digital-Tutors (private), both companies create content.

3D Systems (NYSE:DDD) announced that it would purchase Easyway Design and Manufacture Co. (private) in China[vii]. Terms of the deal weren't disclosed, but a Company official stated that, "Easyway represents the cornerstone of our expansion plans for China."

Groupe Gorgé (FRA:2G3) bought INITIAL (private), a leading independent French manufacturer of 3D printed, and NORGE Systems (private), an English start-up that designs 3D printers.

Ed tech M&A was not left behind. On April 9, 2015, LinkedIn (NYSE:LNKD) bought online training company Lynda.com (private) for $1.5 billion[viii]. LinkedIn's CEO Jeff Weiner stated, *"Both companies seek to help professionals be better at what they do…lynda.com's extensive library of premium video content helps empower people to develop the skills needed to accelerate their careers."*[ix] As we noted in our first 3D printing report, 3D PRINTING – The Education Sector is on the Cusp of Adoption, content is king. And judging by this transaction, it appears as though LinkedIn would agree.

Autodesk's (NASDAQ:ADSK) Spark Investment Fund made a $10 million investment in Carbon3D (private). Carbon3D developed a new 3D printing process called "continuous liquid interface production" that it claims can 3D print objects 25 to 100 times faster than traditional methods. Rather than print successive 2D layers, Carbon3D's process grows objects. We believe this could revolutionize manufacturing especially in high-volume, low-cost production.

Conclusion

3D printing clearly has evolved beyond making plastic trinkets for fun. Manufacturers are adopting the technology, albeit slowly for printing metal parts. Printing plastic is legacy technology although several people are concerned about the reliability of some vendors. Scanning appears to be a complementary technology that enthusiasts are adopting. And, content is clearly a differentiator, especially in the education sector.

Acronyms Used in this Report

3D	three dimensional
CNC	computer numerical control
JPL	Jet Propulsion Laboratory
STEM	science, technology, engineering, math

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[iii] *Global E-Learning Market to Reach US$107 Billion by 2015, According to New Report by Global Industry Analysts, Inc.*, PRWeb, February 15, 2015

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[v] *3-D Printing*

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[viii] *LinkedIn to Acquire lynda.com*, LinkedIn, April 9, 2015

[ix] Ibid.

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