Deloitte.

3D printing is a revolution: just not the revolution you think

Deloitte predicts, in line with the industry consensus, that in 2015 nearly 220,000 3D printers[64] will be sold worldwide, with a dollar value of $1.6 billion,[65] representing 100 percent unit growth and no more than 80 percent growth in dollars[66] versus 2014. But there won't be a 'factory in every home':[67] although 3D printing can be seen as 'the next Industrial Revolution'[68] the real revolution is for the enterprise market, not the consumer.

By 2017, about 70 percent of units will be sold to consumers,[69] and they are likely to be a majority of units in 2015, but almost all of these will be small units with relatively limited capabilities for producing functional parts.[70] Dollar value and usage will be heavily skewed to the enterprise market. Deloitte estimates that enterprise (rather than consumers) will account for just under 90 percent of the value of all 3D printers;[71] over 95 percent of all printed objects by volume; and 99 percent by economic value.

Deloitte also predicts that rapid prototyping and the production of 3D-printed objects that fit into existing manufacturing processes (such as creating a mold, die, cast or tooling that will be used to make final parts) will represent 90 percent of the 3D objects made by enterprises. Although likely to be the fastest-growing component of 3D printing, final-part manufacturing[72] will still represent less than ten percent of 3D objects printed.

The relative insignificance of the consumer 3D printing market is due to several factors. One is the unit price. Home devices for under $1,000 have now been available for eight years; they print fairly small grapefruit-sized objects out of limited-performance materials and with relatively coarse features.

High-end industrial machines are capable of producing finer details, are faster and can print larger objects; but the largest units can cost almost a million dollars, and even smaller machines cost on average hundreds of thousands of dollars each.[73]

But that's only part of the problem holding back the consumer market. In the near term, the less-expensive home devices have some crucial limitations. They can be extremely difficult to calibrate, maintain and use.[74] If the heated bed on which the plastic material is being extruded is even one or two degrees too cold, the object won't form properly; while a degree too hot can cause it to stick to the plate. This deters many consumers from buying a device, and those that do often abandon their machine after producing only a few objects. And this won't be changing soon: according to one forecast, only ten percent of home machines under $1,000 will be 'plug-and-print' by 2016.[75]

3D printers for the home are slow; even objects a few centimeters high can take many hours to print. Printed objects usually require final finishing; materials are expensive at $50 per kilogram or more; the software tools are not easy to learn; and objects tend to be small and have very low-strength properties. The most significant limitation is that most home printers produce objects made from just one or two plastics,[76] and there just aren't that many useful consumer devices made solely out of low-performance plastic.[77]

Many of these limitations will improve over time. Early PCs were hard to use; similar improvements in ease of use are likely for 3D printers.

The most significant limitation is that most home printers produce objects made from just one or two plastics,and there just aren't that many useful consumer devices made solely out of low- performance plastic.

64. Also known as Additive Manufacturing, AM, and/or 3DP. For sake of consistency, we will use the term 3D printing throughout.

65. Gartner Says Worldwide Shipments of 3D Printers to Reach More Than 217,000 in 2015, Gartner, 27 October 2014: http://www.gartner.com/newsroom/id/2887417

66. Deloitte estimate: low cost consumer printers will represent much of the 2015 growth, meaning total dollar growth will be lower than unit growth.

67. What Lies Ahead for 3-D Printing?, Smithsonian, May 2013: http://www.smithsonianmag.com/science-nature/what-lies-ahead-for-3-d-printing-37498558/?no-ist

68. 3D Printing: The Next Industrial Revolution, ExplainingTheFuture.com, as accessed on 9 December 2014: http://www.explainingthefuture.com/3dp_book.html

69. Beyond 2014: Evolving Opportunities in Technology. Wells Fargo, February 2014: https://www.wealthmanagementinsights.com/userdocs/pubs/Beyond_2014_Evolving_Opportunities_in_Technology_ADA.pdf

70. Having an object that looks like an automotive connecting rod but is made of light plastic with the strength of a mediocre child's toy is not the same as having an object with the strength to function as a connecting rod.

71. It was estimated to be 87 percent of the market in 2013, according to Stifel research report from October 29, 2014. See Roundup Of 3D Printing Market Forecasts And Estimates, 2014, Forbes, 9 August 2014: http://www.forbes.com/sites/louiscolumbus/2014/08/09/roundup-of-3d-printing-market-forecasts-and-estimates-2014/

72. Also known as End Product Production.

73. 3D Printer Price, MCAD, as accessed on 9 December 2014: http://www.mcad.com/3d-printing/3d-printer-price/

74. Home 3D printers take us on a maddening journey into another dimension, ArsTechnica, 28 August 2013: http://arstechnica.com/gadgets/2013/08/home-3d-printers-take-us-on-a-maddening-journey-into-another-dimension/

75. Gartner Says Worldwide Shipments of 3D Printers to Reach More Than 217,000 in 2015, Gartner, 27 October 2014: http://www.gartner.com/newsroom/id/2887417

76. Either ABS or PLA using Fused Deposition Modelling, or FDM. See: Fused deposition modeling, Wikipedia, as accessed on 9 December 2014: http://en.wikipedia.org/wiki/Fused_deposition_modeling

77. Why 3D Printing Is Overhyped (I Should Know, I Do It For a Living), Gizmodo, 17 May 2013: http://gizmodo.com/why-3d-printing-is-overhyped-i-should-know-i-do-it-fo-508176750

Costs for both machines and materials should continue to decline; printing will get faster; and new materials (different kinds of plastics, or maybe even metals) that currently can only be printed by enterprise-grade machines may make it into the home.[78] But this won't happen in the near term. Even by 2020 home 3D printers will likely be more similar to power tools than PCs: 10-20 percent of homes may have one, or want to have one, but they will be far from ubiquitous; and even owning a 3D printer may be like owning a power drill. Unlike a PC, a 3D printer is a device that most are likely to use only rarely, and not daily.

In contrast a cross-industry survey found that in 2013, one in six enterprises in developed countries owned or were planning to acquire a 3D printer.[79] Deloitte's view is that by the end of 2015 the ratio will be one in four, although it will vary considerably by industry.[80]

Given that 3D printers are now widely used by enterprises, varying by vertical (with manufacturing and medical leading the way) why are we predicting that the finished part share of 3D printer output will not be larger in the next year?

First of all, the manufacture of finished parts is limited by the small number of 3D printers that can actually produce metallic components. Although there are some end uses that may need plastic, glass or other substrate objects, metal remains the most useful 3D-printed end material, but only 348 metal printers were sold worldwide in 2013.[81] The installed base at the end of 2014 is likely to be under 1,000 units globally. Even when the right machine is available, and the finished part has suitable materials properties (such as strength and resistance to cracking), 3D printing of these parts seldom makes sense. For the foreseeable future, printing parts will take 10-100 times longer, and cost 10-100 times as much as manufacturing by stamping, casting, or other traditional manufacturing techniques.

In a 2014 survey of industrial manufacturers, 62 percent of respondents were either not implementing 3D printing technology or only experimenting with it. Of those who were actually using 3D printing, two-thirds were using it for prototyping and marketing purposes only; a quarter were using it for a combination of prototyping and production; seven percent were building products that couldn't be made using traditional methods; and only two percent were using their machine only for production of final products or components only (and even then, only for very low volume products).[82]

These trends seem likely to continue in 2015. 3D printing is ideal for prototyping when a fully-functional part is not required. Traditional prototyping requires skilled artisans in machine shops and can take days or even weeks; and each object can cost tens of thousands of dollars – all to create (for example) a plastic rear view mirror housing that a designer looks at and needs to change again.

An enterprise-grade 3D printer can take the CAD (Computer Aided Design) file the designer is using and build, layer by layer, a physical sample in eight hours for a materials cost of $100. The designer can then look at the part, tinker with some aspect in the CAD software model, and print out an iterated version by the next morning.

There will be some highly complex parts that are better made through 3D methods (such as certain aerospace components like turbine blades),[83] or unique situations where there is no room for a machine shop and the nearest parts depot is far away (such as the International Space Station).[84] But for many manufacturers, issues around cost, speed, material availability and consistency of outputs remain barriers to using 3D printers; and "customers have yet to put their full trust into these products."[85]

There is a difference between mass manufacture and producing spare parts. Many enterprises may have a potential need for thousands, or even tens of thousands, of replacement parts, any one of which could be critically important. It is impossible to hold that kind of inventory; and delivery of a part from an overseas manufacturer can take many hours or days, even using air freight. Even when a company that owns a 3D printer can manufacture a part that would normally be ordered from a parts manufacturer or distributor, and that part that meets all the required specifications, there are significant legal questions around intellectual property and manufacturers' warranties.[86]

In the near term however we expect some parts manufacturers to embrace a 3D printing business model, where customers are given the option of downloading an approved file, printing a legal and authenticated part,[87] and installing the part without violating copyright or warranty provisions.

In the long term 3D printing will be used increasingly for making finished goods. Already its use for this purpose appears to be growing faster than the 3D printing market generally.

Even here, adoption may take longer than some of the more optimistic expectations. For example the automobile industry is often cited as an early adopter of 3D printing technology: in 1988 Ford bought the first 3D printer ever made,[88] and the auto industry is the single largest buyer of 3D printers, with over 40 percent share.[89] Virtually all global auto manufacturers and many parts makers[90] have purchased one or more 3D printers; but over 90 percent of them are used for prototyping of non-functional parts, and only about ten percent are used to make functional prototypes or casts or molds to help in conventional manufacturing. As of January 2015, the major North American auto manufacturers and parts makers are not using 3D printing for the direct manufacture of even a single final part for a production vehicle, and are not planning to do so in the next two years.[91]

78. This may be decades away or even further: metal printers emit unsafe fumes and run at dangerously high temperatures.

79. 3D Printing: The Hype, Reality and Opportunities — Today, Gartner, 8 October 2013: http://www.gartner.com/it/content/2589000/2589023/october_1_3d_printing.pbasiliere.pdf?userId=13498280

80. Manufacturing or retailing are likely to be higher than average, while it is difficult to imagine what a bank or software company would need a 3D printer for.

81. The Golden Age of 3D Metal Printing: 75.8 % Growth, 3D Printing.com, 22 May 2014: http://3dprinting.com/materials/metal/golden-age-3d-metal-printing-75-8-growth/

82. 3D printing and the new shape of industrial manufacturing, The Manufacturing Institute, June 2014: http://www.themanufacturinginstitute.org/~/media/2D80B8EDCCB648BCB4B53BBAB26BED4B/3D_Printing.pdf

83. Advanced manufacturing is reinventing the way we work, GE, as accessed on 9 December 2014: http://www.ge.com/stories/advanced-manufacturing

84. SpaceX rocket carries the first ever zero-g 3D printer to the Space Station, ExtremeTech, 22 September 2014: http://www.extremetech.com/extreme/190629-spacex-rocket-launches-to-the-space-station-carrying-the-first-ever-zero-g-3d-printer. It is important to note that due to the danger, size and weight of a 3D printer that can make metal parts, the ISS printer is plastic only. In NASA's words: the 3D printer being used in October 2014 is only "the first step towards establishing an on-demand machine shop in space." See: 3D Printing In Zero-G Technology Demonstration (3D Printing In Zero-G), NASA, 25 November 2014: http://www.nasa.gov/mission_pages/station/research/experiments/1115.html; NASA is 3D printing objects in space, Engadget, 25 November 2014: http://www.engadget.com/2014/11/25/nasa-is-3d-printing-in-space/?ncid=rss_truncated

85. 3D Printing: Cutting through the hype, LinkedIn, 21 June 2014: https://www.linkedin.com/pulse/article/20140721200509-22092049-3d-printing-cutting-through-the-hype?trk=prof-post

86. The lead author on this Prediction was a speaker at the Interlog 2013 conference on spare parts in San Diego. In a room of large enterprise users, about 30 had metal 3D printers, none of whom of had yet used the machine (or at least admitted to using the machine) to manufacture one spare part. See: How 3D-printed Spare Parts Could Save Manufacturers from any Production Interruptions, Interlog, as accessed on 9 December 2014: http://interlog.wbresearch.com/interlog-3d-printing-ml [Registration required.]

87. There is an entire fascinating area around watermarking (or otherwise identifying) a specific 3D-printed object. See: Secretly Tag 3-D-Printed Objects With InfraStructs, IEEE Spectrum, 20 August 2013: http://spectrum.ieee.org/video/consumer-electronics/gadgets/secretly-tag-3dprinted-objects-with-infrastructs

88. Ford's 3D-printed auto parts save millions, boost quality, Ford, 12 December 2013: https://media.ford.com/content/fordmedia/fna/us/en/news/2013/12/12/ford_s-3d-printed-auto-parts-save-millions--boost-quality.html

89. 3D Printing Market Analysis By Application (Automotive, Aerospace, Aerospace, Medical), By Raw Material (Polymers, Metals, Ceramic) And Segment Forecasts To 2020, Grand View Research, December 2013: http://www.grandviewresearch.com/industry-analysis/3d-printing-industry-analysis

90. The auto companies themselves only produce about 20-30 percent of parts in any given vehicle. The parts makers of various levels in the supply chain produce the remainder.

91. We are indebted to Dr. Peter Frise for these insights. He is a Professor at the University of Windsor, consultant to many of the leading manufacturers and ODMs, and CEO of AUTO21, Canada's national automotive research program.

The medical vertical is about 15 percent of the 3D printer market, and is often discussed as one of the bigger markets for finished part manufacture. Although 3D-printed hips and skulls are getting the most press, the less-glamorous use cases are almost certainly the main drivers of medical 3D printed devices, both in volume of parts and in value. The audiology and dental markets are often cited as examples where 3D printing is ubiquitous: "Virtually all hearing aid shells and dental copings are made using 3D printing."

That is true for the hearing aid market: there are likely to be over 15 million 3D printed hearing aids in circulation today.[92] But although 3D printing is used for some part of the coping manufacture process, in many cases only 15-20 percent of all finished part copings are made exclusively with a 3D printer.[93] Equally, while 3D printers are used occasionally for making temporary teeth, almost all permanent teeth continue to be milled: it's faster, cheaper, and produces better quality objects.

92. 3D Printing Revolutionizes the Hearing Aid Business, Forbes, 15 October 2013: http://www.forbes.com/sites/stevebanker/2013/10/15/3d-printing-revolutionizes-the-hearing-aid-business/ It was ten million units as of October 2013, and 15 million seems a reasonable assumption for January 2015.

93. Interview with European company in the 3D medical printing business.

94. This Year Educational 3D Printing Contracts Averaged almost $32,000, 3D Printing Industry, 21 October 2014: http://3dprintingindustry.com/2014/10/21/education-al-3d-printing-onvia/

95. 3D Printing: Cutting through the hype, LinkedIn, 21 July 2014: https://www.linkedin.com/pulse/article/20140721200509-22092049-3d-printing-cutting-through-the-hype?trk=prof-post

Bottom Line

Although 3D printers are unlikely to be the 'factory in every home', they may become the factory in every school. Learning how to use 3D printers (and the software tools needed to operate them) will be like learning woodworking or metalworking for past generations of students: enormously useful for those who will end up using 3D printers in their jobs, and still a positive learning experience for the rest. It is still early days, but one study found that hundreds of US primary and secondary schools are already including 3D printers in their annual budgets.[94]

Outside of schools, and for the near term, 3D printing technology may be used best as only part of the manufacturing process: 3D printing dovetails well with many existing production techniques. New technologies that work with existing processes are almost always adopted more rapidly than those that require entirely new ways of doing things.

By lowering the cost and dramatically accelerating the time-to-market for both prototypes and tooling, 3D printing solves particular pain points in some manufacturing chains, and levels the playing field between large manufacturers and the start-up in the garage, just as PC technology narrowed the gap between the mainframe computer makers and the kids in the Silicon Valley garage. Large jewelers used to be the only ones who could maintain in inventory hundreds of mocked-up rings in all the various sizes needed: now small ateliers can produce customized samples at low cost and within hours.

3D printers are used widely in rapid prototyping of mainly non-functional components, but this usage is unlikely to result in material cost savings for the R&D process. Although building traditional prototypes is usually more expensive than using a 3D printer, prototyping is typically only a small fraction of overall R&D costs. The speed and low cost of iteration means that more versions of a given part will be tried; outcomes and timelines will be improved, but dollars won't be saved.

In addition, 3D printing makes the supply chain more flexible and agile. Product life cycles are shortening, which puts a premium on speed to market. Since the initial costs can be lower than those of traditional manufacturing, 3D printing can offer competitive per-unit costs at levels below the scale required by traditional manufacturing.[95]

Deloitte Predictions normally looks at only the next 12-18 months. At the furthest limit of that time frame, there are likely to be new multi-material 3D printers from major manufacturers, targeted at the enterprise market and not the consumer. Full details of these devices are unavailable yet, but they are likely to increase the market for finished parts, due to multi-materials capacity, higher speeds and greater precision.

Although 3D printers are unlikely to be the 'factory in every home', they may become the factory in every school.

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