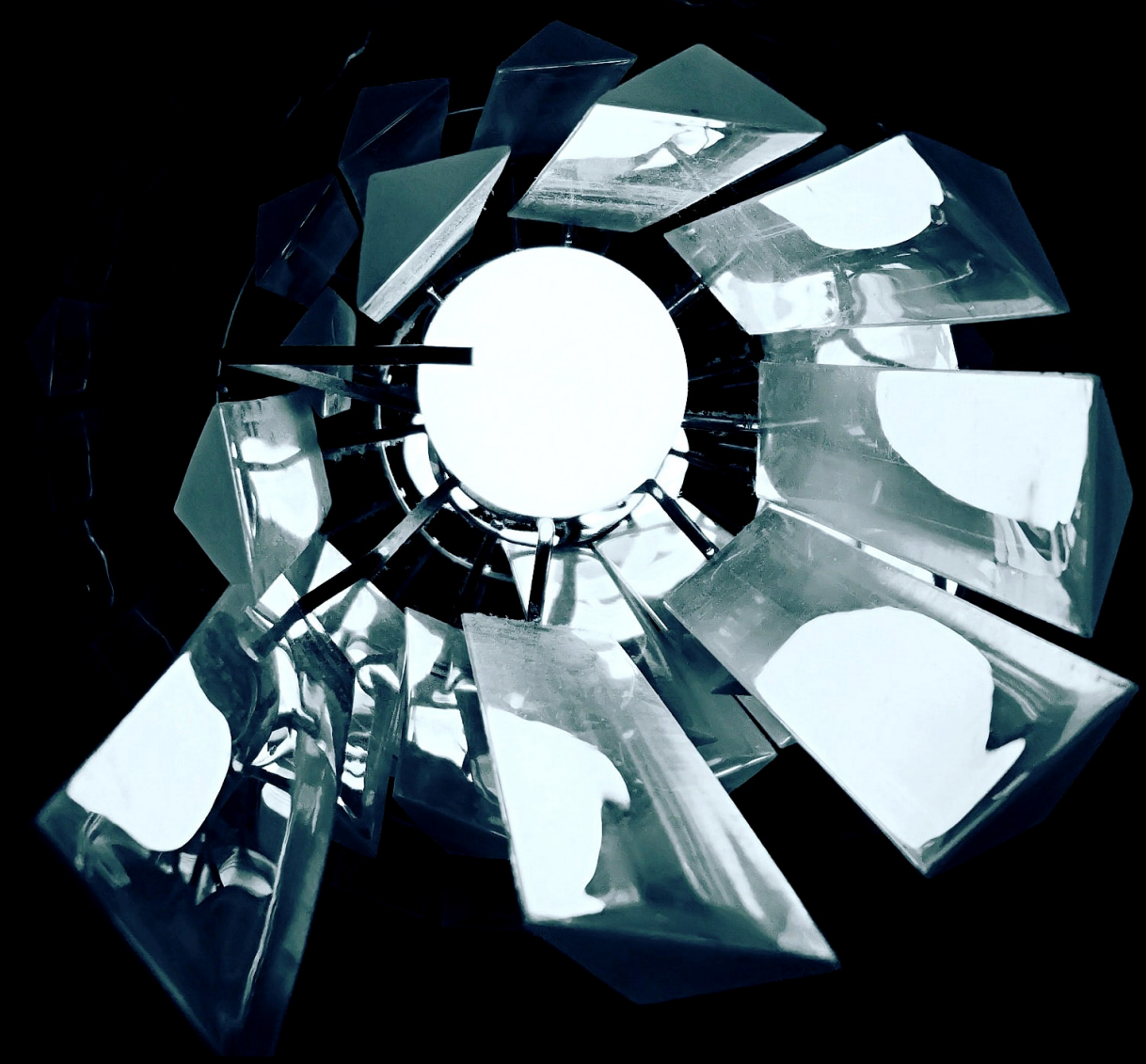

3D Printing Trends 2020

Industry highlights and market trends

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PROTOLABS
Manufacturing. Accelerated.

Thank you for your interest in this trend report by Protolabs. This report was originally published by Hubs, a company acquired by Protolabs in 2021, so you will see references to Hubs listed throughout.

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Executive summary

Looking back on the last decade, the 3D printing landscape has changed drastically. A technology that started as a prototyping solution has gained tremendous momentum for manufacturing end-use parts for industrial applications. 2019 was a landmark year in this evolution.

3D printing is now adopted by the early-majority for serial production.
With ubiquitous applications across multiple industries - including Automotive, Aerospace, Maritime, Medical, Space, Sports, Motorsports, Railway, and Defense - 3D printing is changing new product development and aftermarket supply chains globally.

3D printing entrepreneurship is strong and driven by applications.
A record-high $1.1B+ was raised by 3D printing startups in 3D printing in 2019 alone. Applications of 3D printing are attracting the largest number of investors.

The 3D printing market keeps growing at record speeds.
Top analysts agree that, as adoption steadily increases, the total 3D printing market will continue to double in size approximately every three years, despite current poor returns of publicly traded 3D printing companies.

Professional users are turning to online manufacturing platforms.
The plethora of 3D printing materials and systems make it impossible for companies to invest in in-house capabilities that cover all use-cases. Many professionals choose online manufacturing platforms as the most competitive solution to fulfill their serial 3D printing production needs.

3D printing is only one part of the new digital manufacturing stack.
Joined by other digital manufacturing technologies, such as CNC machining and low-run injection molding, and empowered by digital supply chains and smart factories, 3D printing is forming the new manufacturing landscape.

In the Hubs 3D Printing Trends 2020 report, we take a look back at 2019 to help you better understand what lies ahead. In this report you'll find:

- A timeline with the most influential industrial 3D printing applications of 2019
- An overview of the current size and growth trends of the 3D printing market
- The global distribution of the online 3D printing demand based on transactional data
- A breakdown of the online demand by industry, application, material and process
- Commentary on the role of 3D printing in the greater digital manufacturing landscape
- Interviews with 3D printing subject experts on the state of the industry
- Emerging trends and predictions for 2020 and beyond

3 ×

more professionals are using 3D printing today than 3 years ago

40%

of all online 3D printed parts in 2019 were for serial production

75%

of all online 3D printing orders come from the top three countries: USA, UK and the Netherlands

35%

of total VC funding in 3D printing startups was invested in 2019

24%

is the forecasted average annual growth of the 3D printing market for the next 5 years

Table of contents

Introduction

Methods & approach, and definitions

Methods and approach

Data from five main different sources were collected to produce this report:

- A systematic review of the news reported by the media
- An analysis of the trends in VC funding raised for 3D printing startups
- Market trends through a comparison of market analyst reports
- Transactional data from the Hubs online manufacturing platform
- Informational interviews with leading industry experts

The review of the news provides an overview of the direction of the industry with an emphasis on the progress of large enterprises. These early industrial adopters are at the forefront of the technology and drive cutting-edge innovation and market growth.

Trends in VC funding reveal what direction the industry will take in the near future, as an increased influx of capital into specific areas signals their substantial growth.

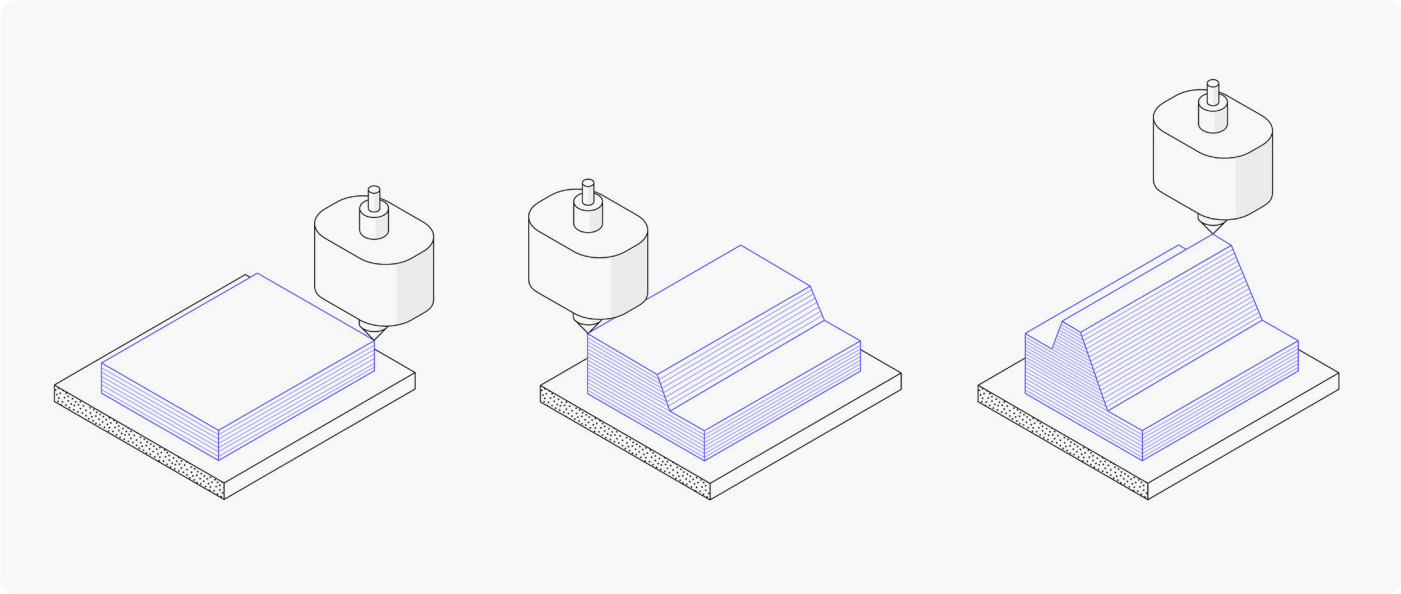
Market analysis gives an overview of the financial forces that drive the growth of 3D printing technologies. By comparing the results of multiple reports —all released in 2019—a more holistic picture of the current state and direction of the market can be drawn.

The analysis of the online transactions of the Hubs platform provides hard data on the way 3D printing is used today by the majority of engineering professionals worldwide.

To gain more profound insights, we interviewed industry experts, who shared with us their opinion on the current key trends of 3D printing and gave their predictions on what to expect moving into the new decade.

DMLS from a Concept Laser machine

Basic definitions and benefits of 3D printing



Professionals use 3D printing for two main purposes:

- A prototyping solution to accelerate product development
- A manufacturing technology for low-run production, and one-off custom parts

Here are the key benefits offered by 3D printing for each use-case:

3D printing for prototyping	Additive Manufacturing for production
Rapid design iterations	Fewer design restrictions
Low-cost, functional prototypes	On-demand production
Widely accessible solution	Mass customization
Effective design communication	Distributed manufacturing

Since 3D printing can manufacture parts without the need for specialized tooling, the startup costs of all AM technologies are relatively low. This makes 3D printing an economically viable solution for prototypes, low-run production, and one-off custom parts. Today, an increasing number of engineering and manufacturing firms are taking advantage of advances in 3D printing technologies to design and manufacture unique parts with improved performance and productions that run at higher volumes —even for serial production.

To refresh and expand your knowledge on the specific benefits, mechanics, and applications of each 3D printing process, follow the links below to our comprehensive guides:

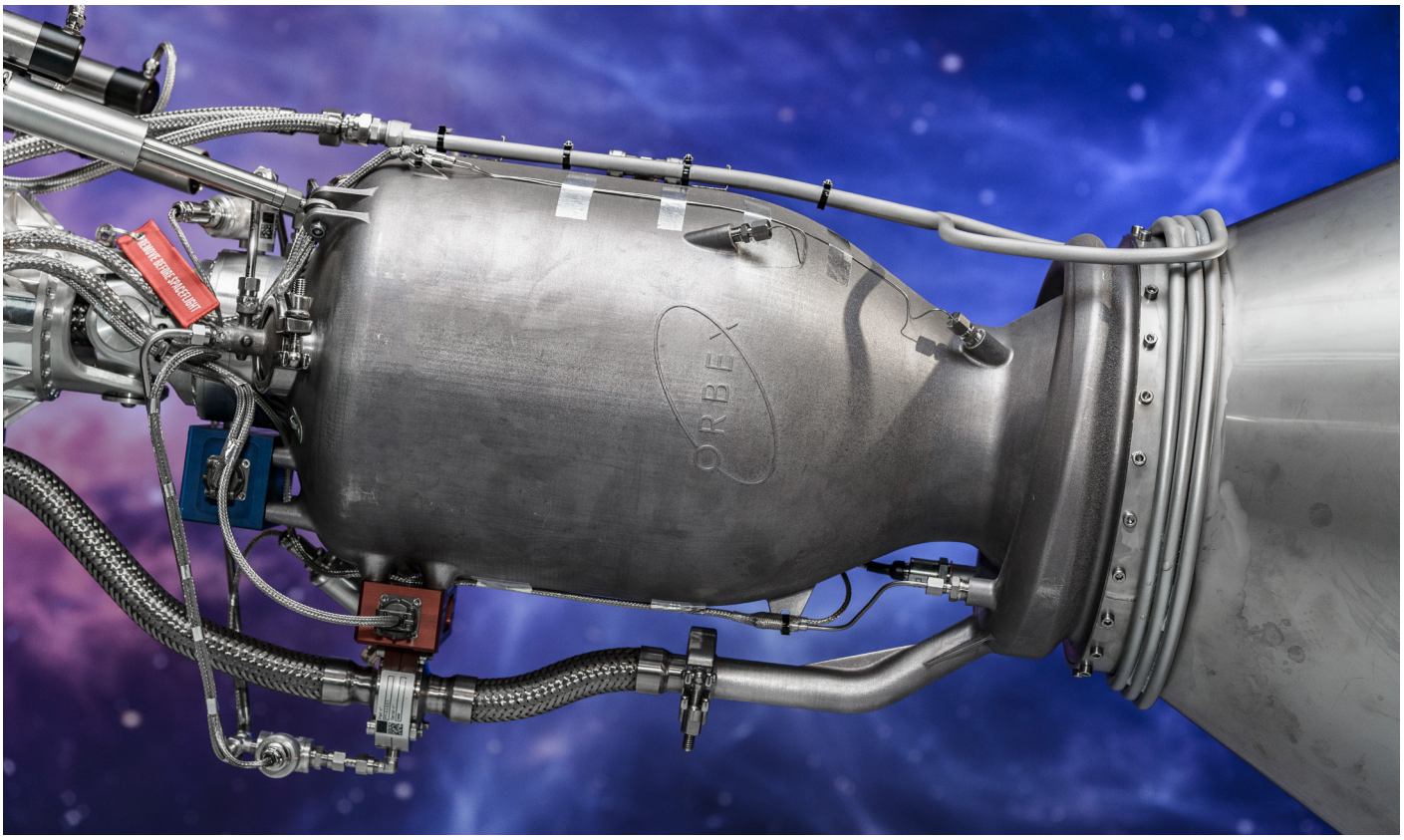
The definitive guide to 3D printing
Metal 3D printing technologies compared
The 3D printing handbook

Market trends

What happened to the 3D printing industry in 2019?

Industry highlights

What happened to the 3D printing industry in 2019?



In 2019, Orbex 3D printed a rocket in a single piece [02]
(Courtesy Orbex)

Quarter 1

Themes:
Industry, Medical

Lima Corporate, the medical device company that commercialized the first 3D printed hip cup implant, announced in January that it will open an on-site metal 3D printing facility at a hospital in New York City. The facility is expected to be in operation by early 2020 and it will be the first of its kind. [01]

Themes:
Applications, Space

The race to space is on for AM.
In February, Orbex [02], Launcher [03], and ESA's ArianeGroup [04] all revealed more information about their progress on producing a 3D printed rocket engine. Thales Alenia Space manufactured an AM titanium pressure vessel for space exploration applications [05]. Later in the year, Relativity Space signed a lease with NASA to set up a robotic micro-factory to produce their rockets that are 95% by mass 3D printed [06] [07].

Themes:
Applications, Automotive, Mobility

In February, Local Motors deployed the first two 3D printed, autonomous shuttles which will be roaming independently in the Sacramento State University campus [08]. Later this year, the company partnered with Airbus to establish a micro-factory that will focus on producing 3D printed solutions for ground and air mobility, for example, urban cargo, and drones [09].

BMW announced in 2019 it aims to produce at least 50,000 components per year using AM
(Courtesy BMW)

Quarter 2

Themes:
Industry, Automotive,
Serial Production

BMW kicked off a project in April targeting the serial production of automotive parts with AM [10]. The company is not the only car manufacturer that sees AM as a serial production tool. In the same month, Audi announced that they are scaling their AM production for polymer components [11]. Later in the year, Volkswagen announced that 10,000 high-quality parts for their EV were produced in just a few weeks using HP's metal binder jetting system. [12]

Themes:
Applications, Industrial Operations

In May, SmileDirectClub announced their plan to 3D print molds for their dental aligners on a massive scale, following the success of Invisalign [13]. Dental is only one of the industries that 3D printing can improve operational efficiencies. Some other examples in 2019 come from the food and beverage industry, with Heineken [14] and Kaspar Schulz [15], the automotive industry, with Volvo Trucks [16], and the textile industry (with Lonati [17]) to name a few.

Themes:
Applications, Aerospace,
Serial Production

In June, Norsk Titanium was recognized as part of Boeing's Material Allowables Program, expanding the collaboration of the two companies for serial produc-tion of structural titanium parts for passenger airplanes [18]. The serial produc-tion of aircraft components was on the rise in 2019. Airbus on-boarded two new suppliers of metal AM parts in its supplier network [19] [20]. Avio Aero, a business of GE Aviation, started the production of a turboprop engine manufactured with AM [21], and other companies like Rolls Royce [22] and Boom Supersonic [23] both made large investments in AM equipment.

Themes:
Applications, Aircraft, Supply Chain

In Q2, Collins Aerospace [24], and Marshall Aerospace [25], as well as British Airways later in the year [26], revealed the expansion of their activities in the field of AM. These firms were added to the long list of Air Carriers and Aircraft Maintenance, Repair, and Operations (MRO) companies that use AM to improve the efficiencies of their supply. This list includes companies such as Air NZ [27], Qatar Airways [28], and Lufthansa Technik [29]. The use of AM in aircraft MRO is only expected to increase as SAE International published in October the first AM specifications for the aerospace industry [30].

Last year, the Renault F1 team announced its partnership with Jabil to produce 3D-printed car parts (Courtesy Renault)

Quarter 3

Themes:
Applications, Motorsports, Product Development

In August, FIA, the governing body of Formula One, used AM to test and issue new regulations for race vehicles for next year's competition [31].
3D printing has become commonplace in motorsport teams in 2019 shown by example from F1 with Renault F1 [32], IndyCar racing with Arrow SPM [33], endurance racing with Toyota Motorsport [34], and even drag racing with Don Schumacher [35].

Themes:
Applications, Sports, Consumer Products

Specialized [36] and fizik [37] both announced in Q3 their plans to use Carbon's 3D printing technology to produce adaptive bike saddles. The sports industry found more applications for resin-based 3D printing. Earlier in the year, New Balance revealed their new sneaker with an insole 3D printed with Formlabs printers [38]. Also, Riddel released American football helmets with customizable padding and an impact-absorbing lattice structure design [39].

Themes:
Applications, Railway, Supply Chain

Obsolete plastic train components were 3D printed, certified and put into operation in UK trains in September [40]. Later in the year, Mobility goes Additive obtained approval to start additively manufacturing a highly-loaded part of the brake unit used in German trains [41].

In Feburary, it was announced the USS Harry S Truman will be the first aircraft carrier to contain a 3D-printed metal part (Courtesy US Navy)

Quarter 4

Theme:
Industry, Sustainability

In October, Made In Space announced that they are sending a plastic recycling system to support the AM facility on the ISS [42]. Sustainability is an important, but often overlooked, topic in AM with initiatives initiated mainly from material companies such as Henkel [43], DSM [44], and 6K [45]. The latter claimed in November they produced the first metal powder for AM from sustainable sources.

Themes:
Applications, Defense, Supply Chain

In December, the US Air Force announced a seven-year $322M agreement with America Makes to advance the adoption of AM [46]. This was one of many activities of armed forces units in the area of 3D printing in 2019. The technology is already integrated into the supply chain of the US Marines [47] and US Army [48] and has been used to produce high-performance parts for the US Air Force [49], the US Navy [50], and the Russian Army [51]. AM will also play an important role in manufacturing five new warships for the Spanish Navy [52].

Themes:
Applications, Maritime

In November, the University of Maine revealed a boat that was fully 3D printed in one piece to demonstrate the capabilities of the technology [53]. In an industrial setting, the use of AM for spare parts and replacement components in the maritime industry is also steadily increasing, with companies like Wilhelmsen [54], Thyssenkrupp [55] and Navantia [52] leading the way.

Startup highlights and VC funding

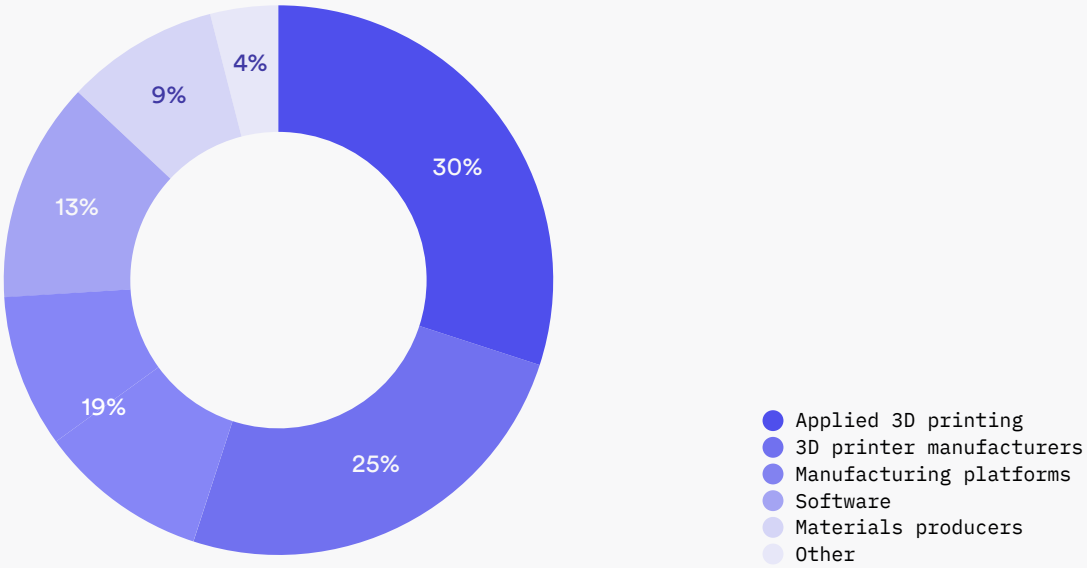
More than $1.1B was raised by 3D printing startups in 2019

Startups with activities in 3D printing raised over $1.1B in 2019 alone [56], with all-time funding exceeding $3.0B [57]. 3D printer manufacturers acquired over two-thirds of the total funding from venture capitalists, with startups working on 3D printing applications, materials, manufacturing services, and software acquiring each 8 to 12% of the remaining funding.

Similar to other industries, VC investment in 3D printing is mainly centralized in the US with companies like Carbon ($2.4B), Desktop Metal ($1.5B), and Formlabs ($1.0B) [56] — all 3D printing system manufacturers headquartered in the US—already acquiring "unicorn" status since 2018.

However, the 3D printing startup scene is changing. Funding is increasing in both China and Europe—from both private investors and EU-lead programs—to promote the competitiveness of the local digital manufacturing economies. We also see an increase in the number of investments in 3D printing applications, especially in the space, and MedTech sectors.

Number of 3D printing investments by category



Q1

Desktop Metal (US)

3D printer manufacturer (metals, composites)
Raised $160M in January (Series E) [58]

Hubs (Netherlands)

Manufacturing platform
Raised $20M in March (Series C) [59]

Mecuris (Germany)

Applied 3D printing (MedTech)
Raised $4M in January (Series A) [60]

Additive Industries (Netherlands)

3D printer manufacturer (metals)
Raised $10M in January [61]

Vader Systems (USA)

3D printer manufacturer (metals)
Acquired by Xerox in February [62]

Markforged (USA)

3D printer manufacturer (metals, composites)
Raised $82M in March (Series D) [63]

BCN3D (Spain)

3D printer manufacturer (polymers)
Raised $3M in March (Seed) [64]

Q2

Fast Radius (USA)

3D printing service provider
Raised $48M in April (Series B) [65]

Dyndrite (USA)

3D printing software
Raised $10M in April (Series A) [66]

Xometry (USA)

Manufacturing platform
Raised $50M in May (Series D) [67]

Carbon (USA)

3D printer manufacturer (polymers)
Raised $260M in June (Series E) [69]

Q3

Fortify (USA)

3D printer manufacturer (composites)
Raised $10M in July (Series A) [69]

Axial3D (UK)

Applied 3D printing (MedTech)
Raised $3M in July (Series A) [70]

Spectroplast (Switzerland)

Material manufacturer (silicone) and manufacturing platform
Raised €1.4M in August (Series A) [71]

Redefine Meat (Israel)

Applied 3D printing (FoodTech)
Raised $6M in August (Series A) [72]

Q4

Relativity Space (USA)

Applied 3D printing (Space)
Raised $140M in October (Series B) [73]

Additive Manufacturing Technologies (UK)

Process automation (post-processing)
Raised $5.2M in October (Series A) [74]

Link3D (USA)

3D printing software
Raised $7M in October (Series A) [75]

Sculpteo (France)

Manufacturing platform
Acquired by BASF in November [76]

Postprocess Technologies (USA)

Process automation (post-processing)
Raised $20M in November (Series B) [77]

Inkbit (USA)

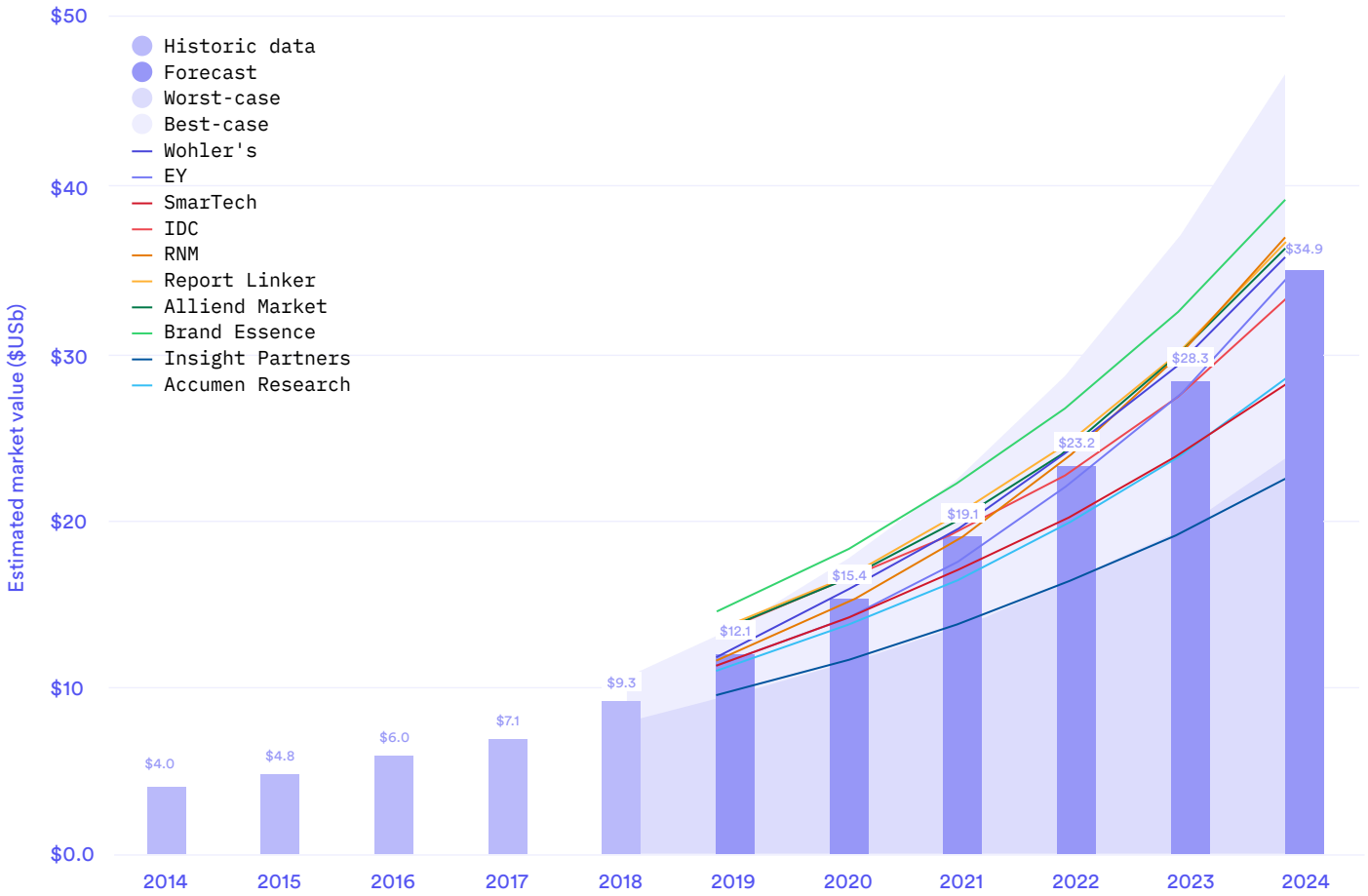
3D printer manufacturer (polymers)
Raised $12M in November [78]

HeyGears Technology (China)

3D printer manufacturer (metals) and manufacturing platform
Raised $60M in December (Series B) [79]

Market trends and sentiment

3D Printing market forecast



Footnote:

* The historic market size was calculated by averaging the market size reported by Wohler's associates [80], EY [81], and SmarTech [82].

** The forecasted market size in the media market size reported by all market analysts.

*** The worst-case and best-case scenarios were calculated starting at ±15% of the market size in 2018 and by applying 20% and 28% CAGR respectively.

The graph above summarizes data reported by ten reputable market analysts who evaluated the additive manufacturing market segment in 2019. It was constructed based on publicly available information and it provides the best estimate of the current size and future potential of the global 3D printing market by combining data from different sources.

In 2019, the global 3D printing market was estimated at $12.1B on average (or at a range between $9.9B and $15.0B by different analysts), seeing a 25% year-over-year growth since 2014. This includes revenue from 3D printing systems, software, materials, and services, but excludes internal corporate investments in AM technologies.

For the following five years, analysts expect the market to grow on average at 24% CAGR, reaching $35.0B by 2024 and doubling in size approximately every three years. However, external variable factors could lead to growth as low as 20% or as high as 28%, resulting in a market size below $24.0B or above $45.0B in 2024. Such variables include factors internal to the 3D printing industry, such as the rate of adoption for serial production, developments in materials and systems, and reduction in total costs. They also include external factors, such as customer demands and the greater economic climate.

The promoters of growth

"The adoption of 3D printing by professionals tripled over the past 3 years."

In 2019, two large market research studies by EY [81] and Ultimaker [83] were published. Both studies surveyed a large sample of industrial companies—both current users and non-users of 3D printing—to assess their sentiment towards the technology. Both surveys found evidence that supports the accelerated adoption rate of 3D printing by industrial users, but also found a lot of room for growth, which will likely have a very positive effect on the growth of the 3D printing market in the coming years.

For example, EY reported that out of 900 companies, 65% are already applying 3D printing and 18% are considering its application in the near future (from 24% and 12% respectively in 2016). Ultimaker paints a slightly different picture. Their survey found out of 2,500+ companies, 67% of the respondents were aware of the terms '3D printing' or 'Additive Manufacturing', but only 35% are applying it—which is still a significant increase from 10% in 2014.

More importantly, EY's study found that 18% of the respondents already use AM for serial production. This means that 3D printing has "crossed the chasm" of adoption, which lies at the 16% mark, according to the technology adoption life cycle model [84]. At this rate, the use of AM for manufacturing end-use parts is expected to be adopted by the early majority (that is 50% of all companies) by 2022, signifying a significant increase in production volumes and hence market size.

The critics

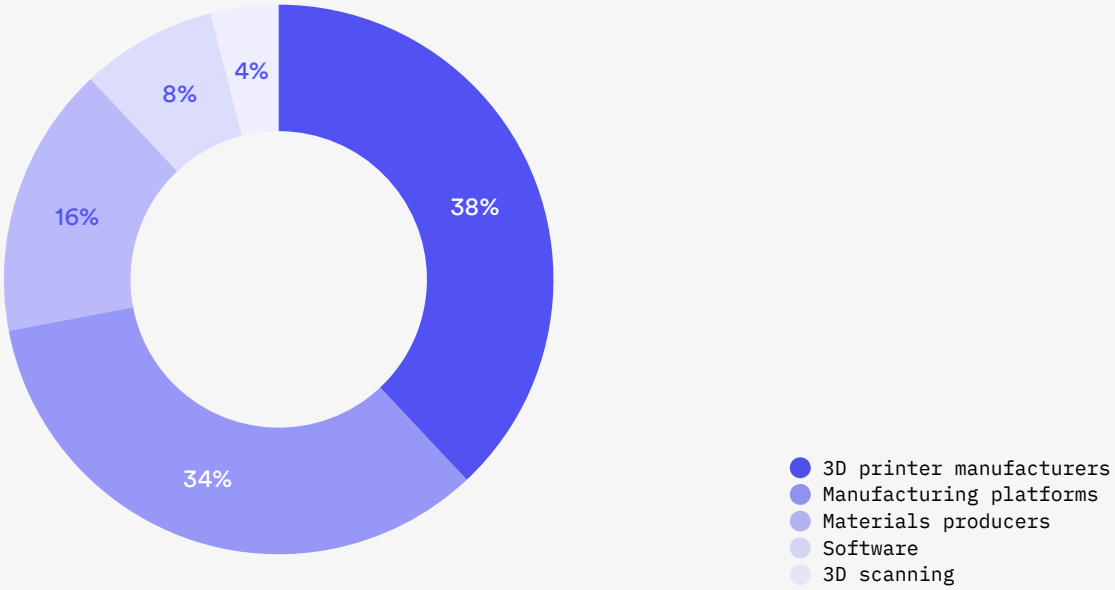
However, the growth of the 3D printing market hasn't happened without some hiccups. For example, the latest Wohler's report found that desktop 3D printing systems saw a significant decline in annual growth in 2018, as well as several complete shutdowns [80]. This signifies that the consumer sector is not a suitable target market for the technology.

The metal 3D printing market—a segment that has been growing at a rate of over 40% year-over-year for the past five years, driving the whole growth of the market [80] — may also start slowing down. In a recent study by Roland Berger, the consultants of the firm identified that many metal AM users are currently having problems reaching full utilization of their machines [85]. That was attributed to the increased number of suppliers of commodity components, which surpasses the current demand. The strict and currently often unclear process qualification requirements for specialized applications may also have had an influence.

The poor performance of the 3D printing stocks is another worrisome indicator. In the past four years, out of the top five US stocks related to 3D printing, only two (the service providers, Materialise and Proto Labs) have managed to beat the market [86] [87]. However, market commentators note that PRNT, the ETF which is designed to track the price movements of stocks of companies involved in the 3D printing industry, can make a comeback in the near future [88] [89].

Service providers and online manufacturing

Market share of global AM players



Source: EY [81]

We have identified that the AM service provider sector is one of the fastest-growing sectors within the 3D printing industry. Its growth is even impacting the manufacturing industry in less obvious ways. For example, forging and casting manufacturers with activities in the aerospace industry are reluctant to expand their capacity, even when demand increases, because they see AM as a replacement technology and they don't want to be faced with unused capacity [90].

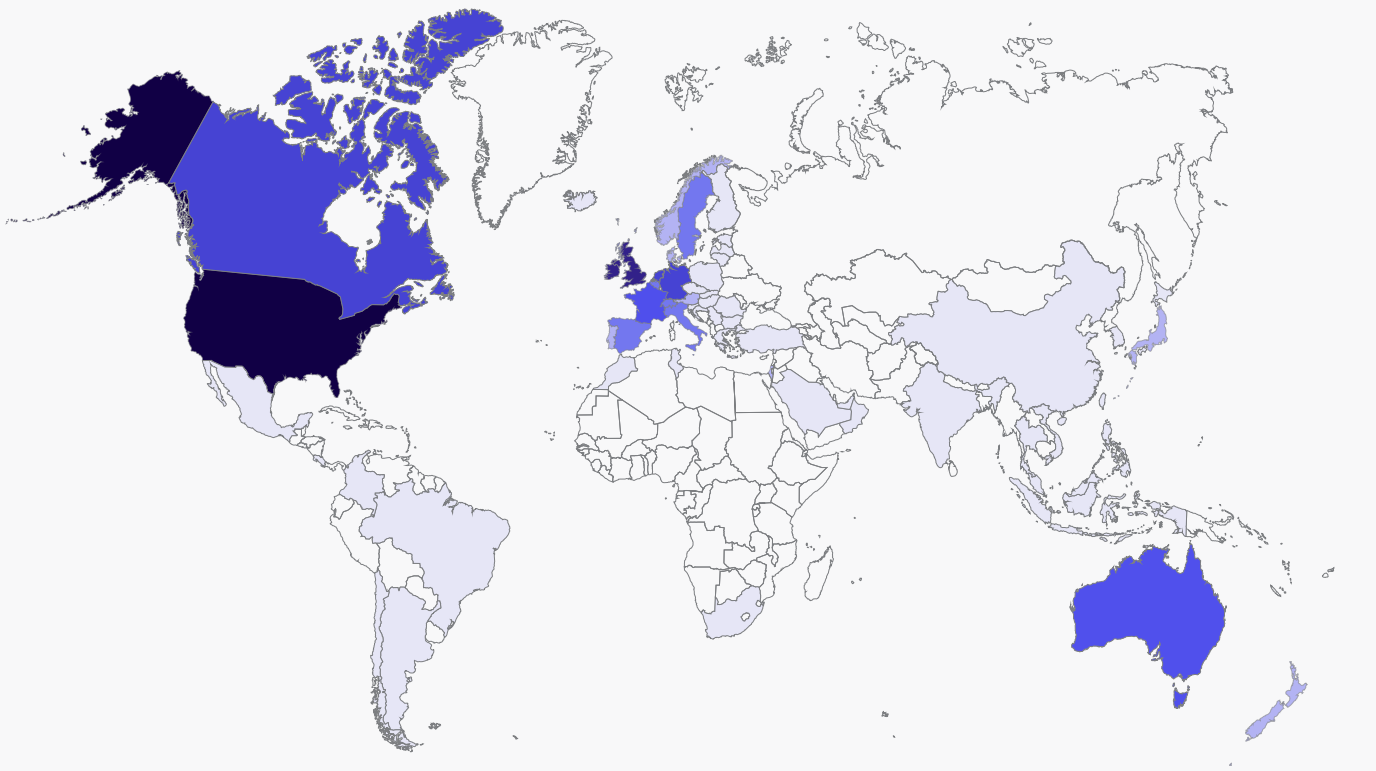
The size of this segment is estimated by market analysts to be approximately 34% of the total. Based on research by Hubs, at least 35-45% of this share can be attributed to "online manufacturing". The term "online manufacturing" or "Manufacturing-as-a-Service" refers to online platforms that automate the procurement and sourcing process in the manufacturing industry [91]. It is the opposite to "offline" manufacturing where most operations on the supply chain (inquiry, price negotiation, etc.) are performed manually.

The next sections analyze transactional data collected through the Hubs platform to create a snapshot of the global distribution of 3D printing demand by professional users today.

Global online 3D printing demand

Geographic distribution

Online 3D printing demand by country



Source: Hubs

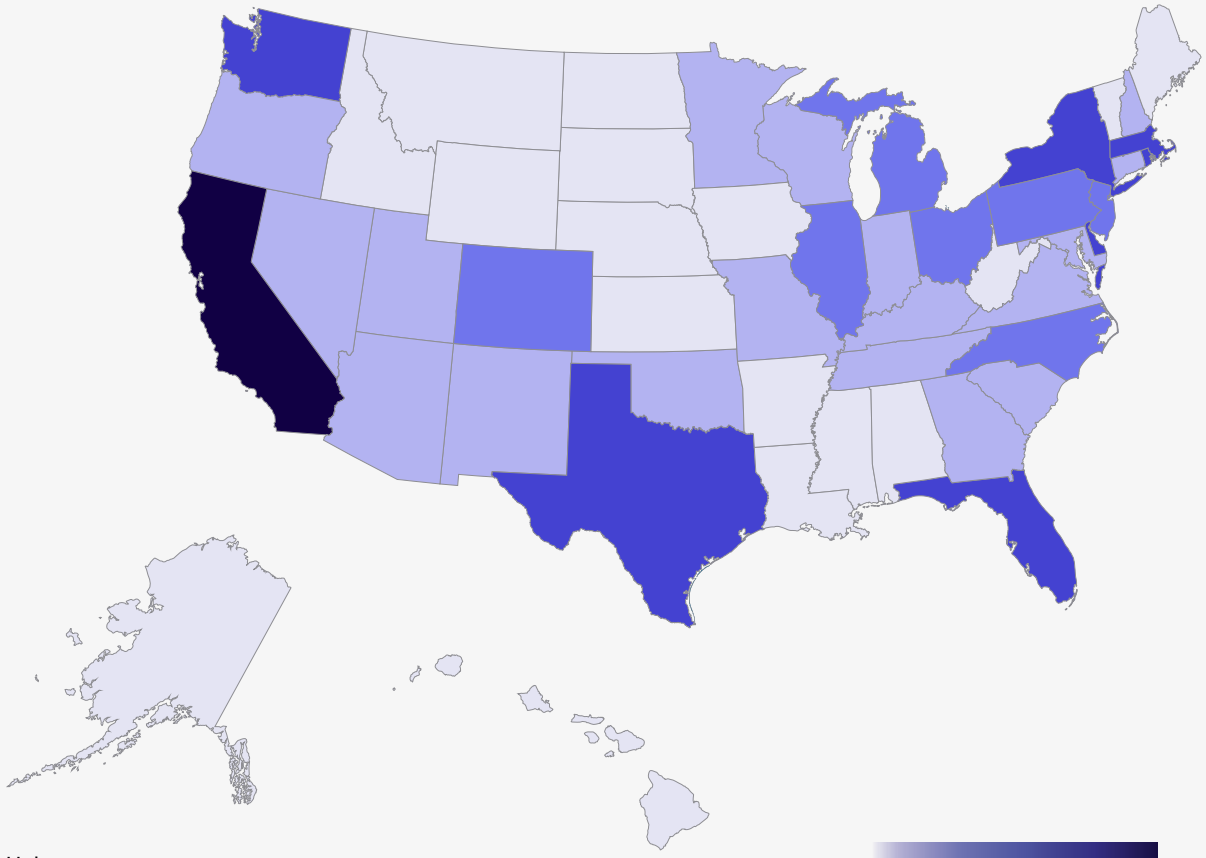
13,558 — 258,484,531

This map gives an overview of the global distribution of online 3D printing demand based on transactional data from the Hubs platform. It graphically represents the location of customers who collectively ordered more than 550,000+ 3D printed parts in 2019.

North America and Europe are the clear leaders in online 3D printing, representing together more than 95% of the global demand. The US alone amounts to nearly 50% of the worldwide demand for 3D printed parts.

Compared to 2018, the total value of 3D printed parts increased by up to 300%, while the number of parts printed did not increase at a similar rate. This is a clear indicator that online 3D printing has moved away from the low-value consumer market and has been integrated into the workflows of professional users who have higher demands in terms of performance and quality, and are willing to pay the higher price tag.

Online 3D printing demand by US state



Source: Hubs

13,558 — 97,645,192

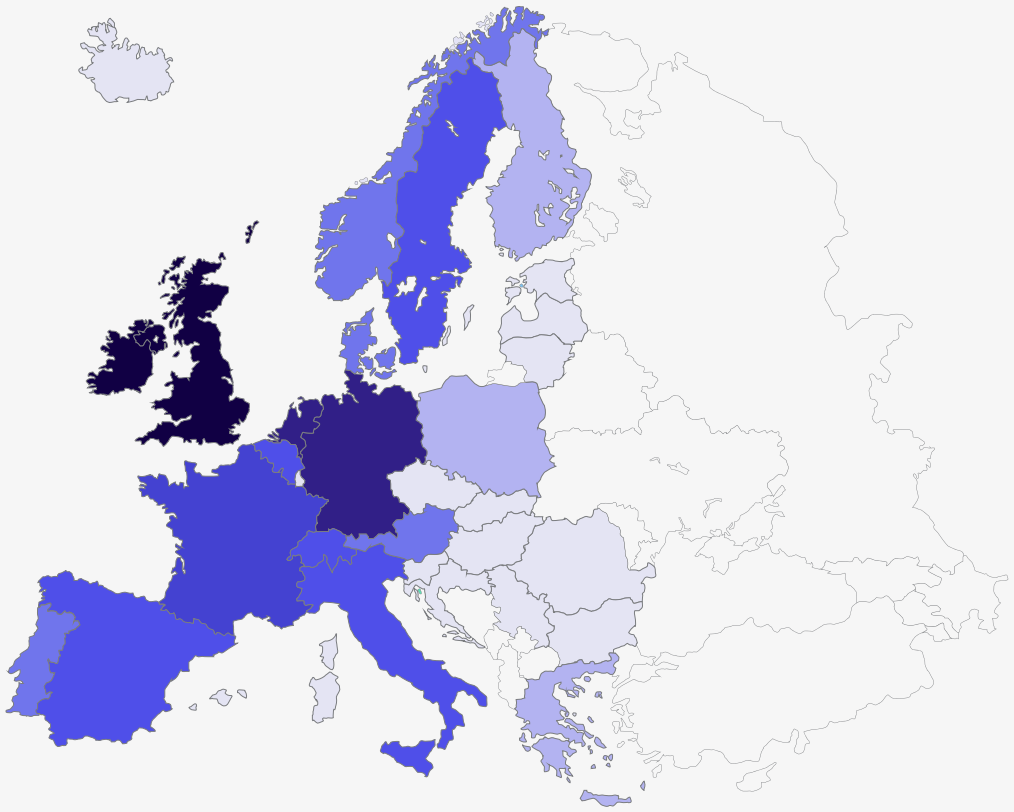
"The total value of 3D printed parts tripled in 2019 compared to year."

More than 260,000 parts were 3D printed in the USA through the Hubs online manufacturing platform in 2019. The map shows the distribution of 3D printing demand by state based on the customer's location.

California extended its lead as the state with the highest 3D printing demand in 2019. More than 22% of the total parts produced in the US were shipped to customers based in this state—from 21% in 2018. The strong hardware and tech scenes of Silicon Valley, Los Angeles and San Diego are a substantial driver of this trend.

New York, Texas, and Massachusetts followed at 7%, 6%, and 5% respectively. These are also states that house companies with a strong focus on innovation and technology.

Online 3D printing demand by European country



Source: Hubs

13,558 — 97,645,192

"The demand for 3D printing in Europe remains strong, with the UK leading."

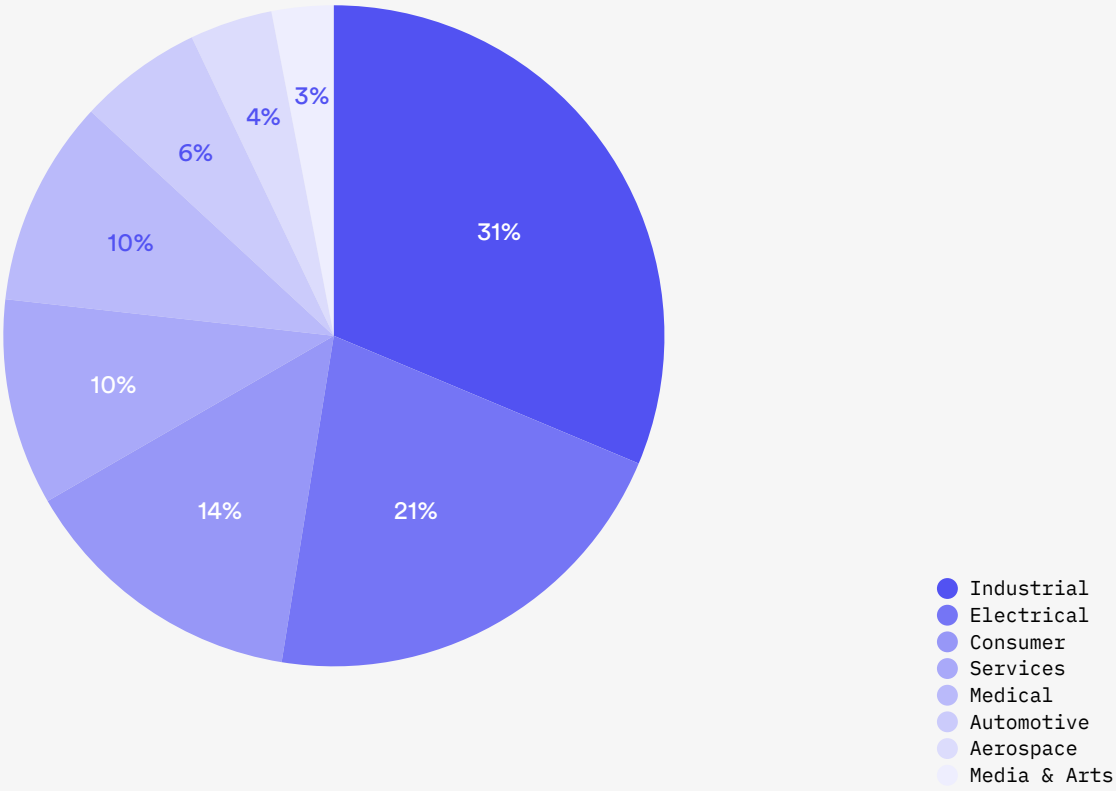
More than 230,000 parts were 3D printed for European customers through the Hubs platform in 2019, which is only 30,000 short compared to the US. The map shows the countries with the highest demand.

The UK led the way in online 3D printing with almost 100,000 parts 3D printed in 2019 and delivered to 7,000+ customers—that is 44% of the total demand in Europe, surpassing even the state of California. The Netherlands came second and Germany close third with 30,000+ parts, while France followed with 15,000+ parts.

The European online 3D printing demand follows similar patterns to the demand in the US. It's driven by countries with a strong focus on technological innovation, hardware and manufacturing.

Breakdown by industry and application

Online 3D printing demand by industry



Source: Hubs

The graph shows the distribution of online 3D printing demand by industry based on a representative sample of professional users. [92] Over 65% of the demand comes from professional users working in the development of Industrial, Electrical or Consumer Goods. On the other hand, professionals in the Aerospace, Automotive, and Medical industries prefer to produce parts in-house or outsource using traditional "offline" supply chains.

To gain a deeper understanding of how professional users are taking advantage of 3D printing, we tracked the number of parts they included in each order. The main assumption here is that the majority of orders with a lower number of parts are primarily used for prototyping purposes, while the majority of orders with a higher number of parts are intended for end-use applications. A reasonable threshold that describes correctly 90% of all cases for this segmentation was found to be at 20 parts per order.

"Small-to-medium production corresponds to 70% of the total 3D printing demand."

It was found that the overwhelming majority of all orders (more than 80%) included less than 20 parts. This data shows that prototyping is still the primary use of 3D printing. However, the remaining 20% of orders correspond to more than 70% of the total number of parts that were 3D printed in 2019, showing that the production of 3D printed parts for end-use applications through small-to-medium production runs is a significant share of the online 3D printing demand.

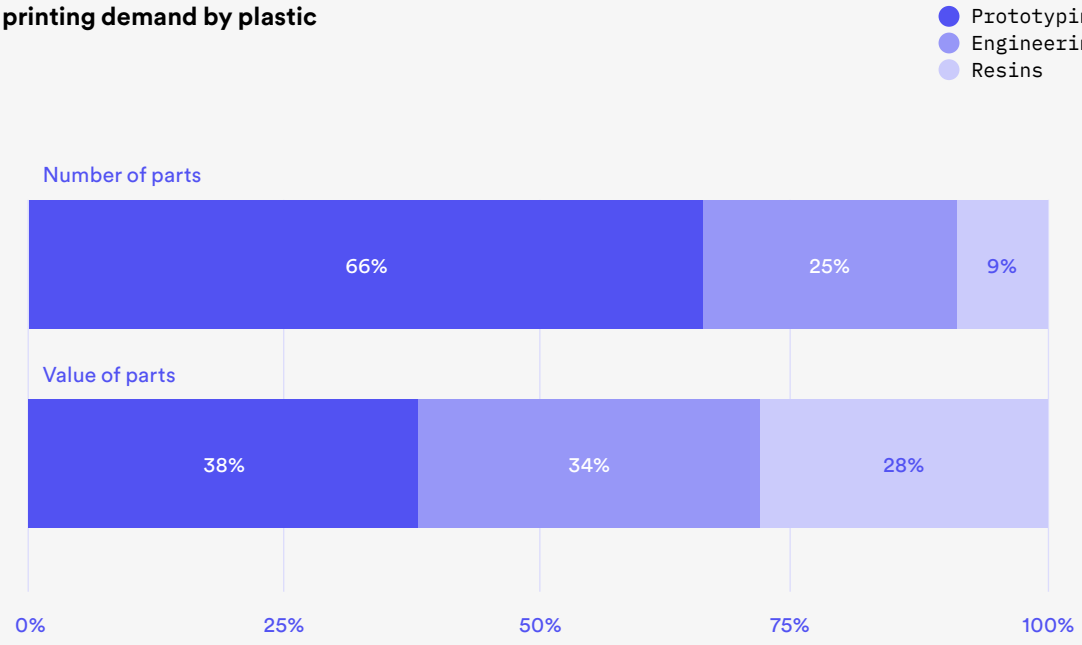
Breakdown by materials and processes

The following graphs breakdown the online 3D printing demand by material and by 3D printing process. In terms of volume, parts produced from prototyping plastics with extrusion-based 3D printers (FDM / FFF) corresponds to approximately two thirds of the total demand, while the demand for metal parts is almost 100 times smaller than that for plastic parts.

When we breakdown the demand in terms of value-added, we're looking at a different picture. Prototyping plastics still captures the largest market share, but engineering plastics and resins follow very closely behind. The share of metal 3D printing has also increased considerably, as the average order value for metal parts is 10 times higher than that of plastics.

In terms of 3D printing processes, FDM / FFF is the clear leader in both the total number of parts and the total value. This can be attributed to the proliferation and low-cost of those systems, as well as their low barrier-to-entry from a Design for Additive Manufacturing (DfAM) perspective.

Online 3D printing demand by plastic



Footnote:
* Prototyping plastics: PLA, ABS, PETG
Engineering plastics: Nylon, TPU, ASA, PEI
Resins: Standard resins, Engineering resins
Metals: Stainless steel, Aluminum

Source: Hubs

Beyond 3D printing

How 3D printing fits into the greater manufacturing landscape

Beyond 3D printing

"3D printing is only a fraction of the total value-added by online manufacturing."

Let's take a step back at this point to assess the position of 3D printing in the greater manufacturing landscape, by comparing the total number of orders and the total value of the parts produced in 2019 through 3D printing versus CNC machining, another widely used digital manufacturing technology. Even though more 3D printing orders were placed, its total value was approximately lower than that of CNC machining.

If other technologies, available through the Hubs online manufacturing platform, are taken into account, such as injection molding and sheet metal fabrication, then the share of 3D printing is even smaller.

For example, the total contract manufacturing market surpassed $175B in 2019 [93], while the share of 3D printing service providers was estimated at approximately $4B or about 2% of the total [81].

These observations bring up an important point: 3D printing is the newest—and thus, the most interesting and covered in the media—digital manufacturing process. However, it's only one of the many enabling technologies that empower the digital transformation that is currently taking place in the manufacturing industry.

Online 3D printing demand

The pillars of the new digital manufacturing stack

There are three main pillars that enable this new digital manufacturing landscape: new technologies, online supply chains, and smart factories.

Digital manufacturing technologies, like 3D printing, and CNC machining, make it possible to produce parts directly from a CAD file, closely connecting the digital realm to the physical world. Their common denominator is the need for no tooling (or rapidly manufactured tooling), reducing the lead times drastically and the economic barrier to manufacturing. Even manufacturing technologies like injection molding are turning digital, as inexpensive molds can be manufactured quickly using 3D printing or CNC machining. Digital manufacturing technologies radically change the way companies think about manufacturing. These technologies allow them to quickly start, stop, or scale production whenever they need to respond to fluctuations in the demand for their products.

Manufacturing companies responded to the proliferation of digital technologies by turning their production lines into **smart factories**. All aspects of manufacturing operations are measured in real-time, the collected data are analyzed online, and production is controlled remotely using robotics and automation. Also, digital twins of the manufacturing systems are used to simulate the process and predict their performance. These optimized workflows reduce waste and lead time. They also help achieve higher efficiencies and competitiveness, and ultimately better products at a lower cost.

The end-users of the manufacturing supply chain are the engineering companies who develop and design the products. What impacts their operations the greatest in this digital transformation is the emergence of **online supply chains**. More specifically, online manufacturing platforms, like Hubs, give access to engineers worldwide to the available capacity of manufacturers in their network, lowering the barrier to entry and expediting hardware development cycles. Online manufacturing platforms offer three major benefits that impact both engineering and manufacturing companies:

Online manufacturing automates and expedites the order placement process. Online manufacturing platforms develop algorithms that automate the assessment of whether a part can be manufactured, by what process and at which price. These manufacturability algorithms have been described as having the same potential strategic importance to Google's search algorithm [94]. This is because they have shrunk into a matter of minutes a manual process that would have traditionally taken days to complete.

Online manufacturing provides price transparency to a previously closed marketplace. Quotes for certain parts can vary by as much as 300% across different suppliers, forcing purchasing managers to spend a lot of time comparing prices and quality. By providing instant quotes generated by AI engines that draw information by a large set of previous orders, online manufacturing platforms are becoming the equivalent to the stock market of manufacturing. This will foster greater speed and efficiency, but will also allow manufacturing companies to gauge effectively whether their offering is competitive.

Online manufacturing reshapes the global manufacturing landscape. Distributed manufacturing has always been appealing, as proximity means speed and reduced transportation costs. However, economies of scale and the high equipment cost resulted in the centralization of manufacturing in certain locations—usually in Asian countries. Online manufacturing platforms are changing this status quo. By increasing the usage of installed manufacturing systems, the return on investment for manufacturers is also higher. Making the establishment of digital manufacturing companies that serve their local markets economically viable[91]. The result for the end-user and the engineering companies, is the creation of more flexible, efficient, responsive, and distributed manufacturing supply chains, reducing their overhead costs and allowing them to innovate faster.

To learn more about how online manufacturing platforms are helping engineering companies worldwide to bring their products to market faster in practice, explore our case studies.

Industry expert interviews

Interview with Emilio Juárez, EMEA Head of 3D Printing Sales, HP

HP is striving to pave the way for industrial development, launching into the additive manufacturing industry back in 2015 with the release of their Multi Jet Fusion and building on that success with the HP Metal Jet in 2018. To learn more about the current state of 3D printing and its future, we spoke to Emilio Juárez, EMEA Head of 3D Printing Sales at HP.

"The interest in Additive Manufacturing has been present in the industry for a long time, but there were too many limitations that prevented adoption like speed, part quality, and cost," stresses Emilio. Now, new technologies are closing this gap and becoming a potential alternative to traditional manufacturing processes.

"With the introduction of MJF 3 years ago, we increased production capacity and lowered cost per part to unprecedented levels," adds Emilio, "and last year, we focused on taking repeatability to unknown heights." After eliminating the need to quality check each 3D printed part, HP's current focus is on automating processes.

This focus on automation feeds into HP's long term aim. "We intend to provide a valid alternative for producing not only very sophisticated, high value parts, but also everyday parts," shares Emilio, "so the reason for using AM doesn't come exclusively from the need to produce complex geometries or custom parts at a high volume." Emilio notes some AM operations have scaled up to factory dimension producing millions of parts, and he's already seeing the high demand for AM metal application.

"AM drivers today are mainly lower cost for shorter runs, personalization and functionality optimization," explains Emilio. "The first two are obvious, but the third one is becoming increasingly relevant. We see everyday examples of products that deliver better performance because they've been designed to benefit from the freedom 3D printing allows."

"Looking forward to 2020, I believe we'll start seeing breakthrough applications in which AM will replace traditional manufacturing methods," he claims. As manufacturers start to gain confidence in AM, new players enter this space, attracted by the rising opportunity. Emilio also predicts significant growth in online, on-demand manufacturing services thanks to the greater dependability coming from further certifications and production repeatability.

As a final thought, Emilio points out what he believes is one of the most important inhibitors for AM adoption: not enough attention is given to how manufacturing companies will manage internal changes, sparked by AM, in their product development process and supply chain. "In my view, this can only be overcome by training and consultancy," emphasizes Emilio, "which could fully unleash AM potential in the industry."

Interview with Max Lobovsky, Co-founder and CEO, Formlabs

formlabs

Formlabs is an ambitious company, expanding access to digital fabrication to empower anybody to make anything. As the professional printer of choice for engineers, manufacturers and designers, Formlabs continues to push boundaries by developing its own suite of high-performance materials and best-in-class 3D printing software. We got the chance to speak to Max Lobovsky, Co-founder and CEO at Formlabs, to get his take on the industry.

For Max, there are three main factors behind Additive Manufacturing today. The first is the accessibility of printers: “We are now seeing industrial-level systems for less than $10k that require minimal training and maintenance,” shares Max, “This has made it easier than ever to get started with 3D printing.” The steady progress in capabilities accessible to 3D printers is also a driver, with today’s printers providing a better surface finish, finer part detail, and larger build size. “Combining that with an expanded array of materials means 3D printing can be applied to many more applications,” adds Max.

Lastly, Max also put the adoption of 3D printing down to increased knowledge in the workforce. “Today, I would estimate that more than half of the mechanical engineers graduating from university have used a 3D printer,” claims Max, “10 years ago, it would have been a small fraction of that. Waves of hype in 3D printing, even if they have been misguided, have also helped to raise awareness.” According to Max, lower costs, faster cycle times, and overall accessibility are the reasons why customers are adopting 3D printing over machining and injection molding.

In 2019, the developments in new hardware and materials have been a highlight for Max, especially when they’ve made new user applications possible. “For example, developing Low Force Stereolithography (LFS) is opening up new possibilities of further innovative materials for our system and expanding potential use cases,” explains Max, “Also, scaling the printer footprint with the Form 3L is allowing companies like New Balance to rethink their approach from design to manufacturing.”

Outside of AM, the most exciting area of innovation for Max is the increased digitization in manufacturing, which continues to provide opportunities for cost saving, customization of products, and faster new product introduction.

For 2020, Max believes we’ll see a continued trend of many more powerful AM capabilities becoming available in significantly more accessible systems. He forecasts, “Large format SLA and SLS will go from being niche, >$100,000 type systems to systems found in thousands of shops around the world.”

Interview with Jon Bruner, Head of Enterprise Strategy, Carbon

Carbon

Carbon's aim is to reinvent how polymer products are designed, engineered, manufactured and delivered towards a digital and sustainable future. Jon Bruner, Head of Enterprise Strategy at Carbon, shared his insights and the latest trends in the additive manufacturing industry.

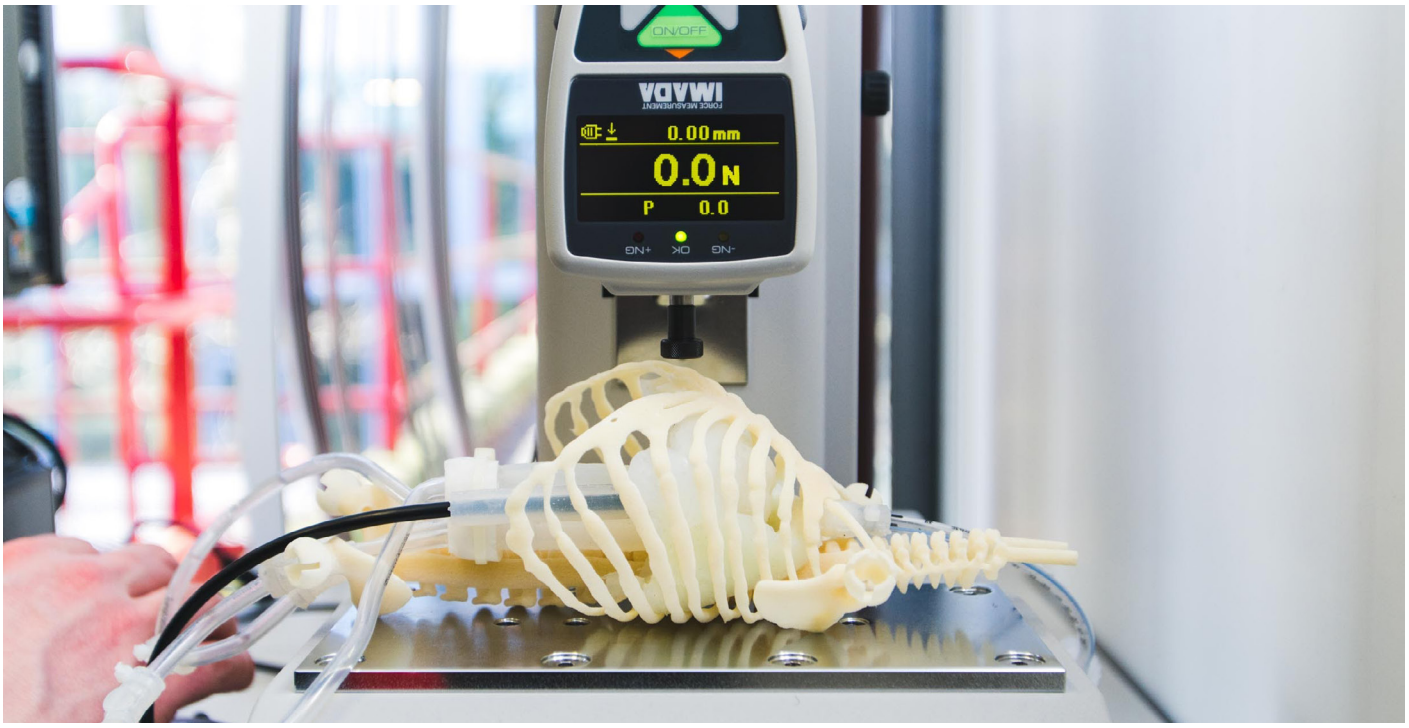
For Jon, the business case for 3D printing is becoming more robust. "As more evidence demonstrates the value of 3D printing, it becomes easier for business leaders to justify investments in 3D printers and to drive the development of 3D-printed products." A decade ago, polymer 3D printing was only suitable for light prototyping. Now it can replace high-impact injection molded parts - and sometimes even machined aluminum - in end use applications. "With every new application, 3D printing needs to prove itself against a different legacy-manufacturing niche," remarks Jon, "and every time that happens, the market grows."

Managers have also become more experienced with the implementation of 3D printing, according to Jon. "They've figured out how to organize their product development processes, build expertise, and work with new supply chains. This is foundational knowledge which will drive the growth of AM for years to come."

But overall, what excites Jon the most in AM is the convergence of design and manufacturing. Historically, those functions have been largely separate: designers and engineers design a product, manufacturers figure out how to make it, and the two sides fight throughout the product development cycle. "3D printing brings those disciplines together," claims Jon, "when a product is 3D printed, it's easy for its designer to take production into consideration from the beginning, by prototyping on the very same platform that will be used for production. Likewise, 3D printing transforms manufacturing managers from churning out parts into core leaders in their businesses."

In 2019, two end-use 3D printed products really stood out to Jon: Riddell's Diamond football helmet and the S-Works Power Saddle from Specialized, which use elastomeric lattices to deliver exactly the required performance in every centimeter of the product. This coming year, he's looking forward to the introduction of more products with "impossible geometries" that can only be made on 3D printers. "We've already seen this with lattices designed by early adopters," remarks Jon, "but as mainstream mechanical designers become more familiar with the promise of part consolidation and 3D printed functional assemblies, those will become more common."

Jon also predicts that 2020 is the year customized consumer earbuds will take off. "Mass customization has been slow to arrive," shares Jon, "largely because the easy-to-print products haven't always been the products where customization is valuable." With customized earbuds, such as those by MyFit Solutions, Jon sees a clear overlap between "possible to manufacture" and "valuable in the marketplace".



Interview with Dr. Cora Lüders-Theuerkauf, MGA Medical, a division of Mobility goes Additive

The MGA Medical network aims to raise people's full awareness on the potential of additive manufacturing in the medical industry, particularly medical devices. We spoke to the organization's network manager, Dr. Cora Lüders-Theuerkauf, whose previous research focused on the engineering of heart valve prostheses at the Deutsches Herzzentrum Berlin, to discover how she sees the state of the AM industry.

Cora believes that 3D printing's on-demand nature, with shorter lead times and the level of customization inherent to the technology, is clearly the reason for its fast adoption. And thanks to the growing knowledge around industrial 3D printing and concrete use cases, the manufacturing process is becoming more widely accepted in businesses.

"Trends like digitization and sustainability are also at the top of everybody's mind," remarks Cora, "which are further promoting the development of AM.

In medicine, 3D printed anatomical models, customized to the patient, are increasingly used for surgery preparation to lower the risk for the patient, reduce operating time, and overall improve the quality of care." For the medical sector, Cora notes, the real advantage of AM is the ability to mass produce customized parts for medical instruments and devices or implants.

Looking at the past year overall, 2019 was an exciting year for materials in medicine. "There were a few cases which were thrilling to see, like bionic eyes and organs, such as the heart and skin, which can currently only be found in the R&D department," shares Cora. The innovations in AM really come from various materials, processes or technologies developing at the same time, like 3D-concrete printing paired with the ability to 3D print large parts for a construction project. This is why Cora regards accessible databases registering all certified products and details on the manufacturing process, such as TÜV Süd Product Service GmbH, so highly. This knowledge sharing can support the reproduction of AM parts, and ultimately innovation.

However, for AM to really take off, Cora sees the need for updated and regulated certifications in the industry. "Looking at current studies, investments in AM are stagnating," she explains, "this is because AM applications with clear business cases are still lacking or are limited by certification restrictions."

Cora considers that AM has reached a level of maturity where it will move away from small scale production but towards industrial manufacturing. Meaning aspects like a greater material portfolio and certification standards now need to develop. "This is where the MGA Network is seeking to close the gap, in both the mobility and medical industry, by modernizing old standards and developing new guidelines."

Predictions for 2020

AM will replace traditional manufacturing methods

"I believe we will start to see breakthrough applications in which AM will replace traditional manufacturing methods. Also, online manufacturing will experience a significant growth grounded on greater dependability coming from further certifications and production repeatability that will allow more on-demand distributed manufacturing services."

- Emilio Juárez, EMEA Head of 3D Printing Sales, HP

More powerful AM capabilities

"I think we will see a continued trend of many more powerful AM capabilities becoming available in significantly more accessible systems. Large format SLA and SLS will go from being niche, >$100,000 type systems to systems found in thousands of shops around the world."

- Max Lobovsky, Co-founder and CEO, Formlabs

"Impossible geometries"

"I think we'll see the introduction of more products with "impossible geometries" that can only be made on 3D printers. We've already seen this with lattices designed by early adopters, but as mainstream mechanical designers become more familiar with the promise of part consolidation and 3D printed functional assemblies, those will become more common."

- Jon Bruner, Head of Enterprise Strategy, Carbon

Localized, on-demand & free of design constraints

"2020 marks a new decade in which manufacturing will become more localized, on-demand and freed of design constraints. 3D printing is a key driver of this change."

- Bram de Zwart, Co-founder and CEO, Hubs

About this report

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About Hubs
Hubs is an online manufacturing platform that provides engineers with on-demand access to a global network of manufacturing partners. Users can easily upload their design, instantly receive a quote, and start production at the click of a button.

Founded in Amsterdam in 2013, Hubs has raised over US$30 million and produced more than 4 million parts, using various manufacturing technologies, including CNC machining, 3D printing, injection molding and sheet metal fabrication.

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