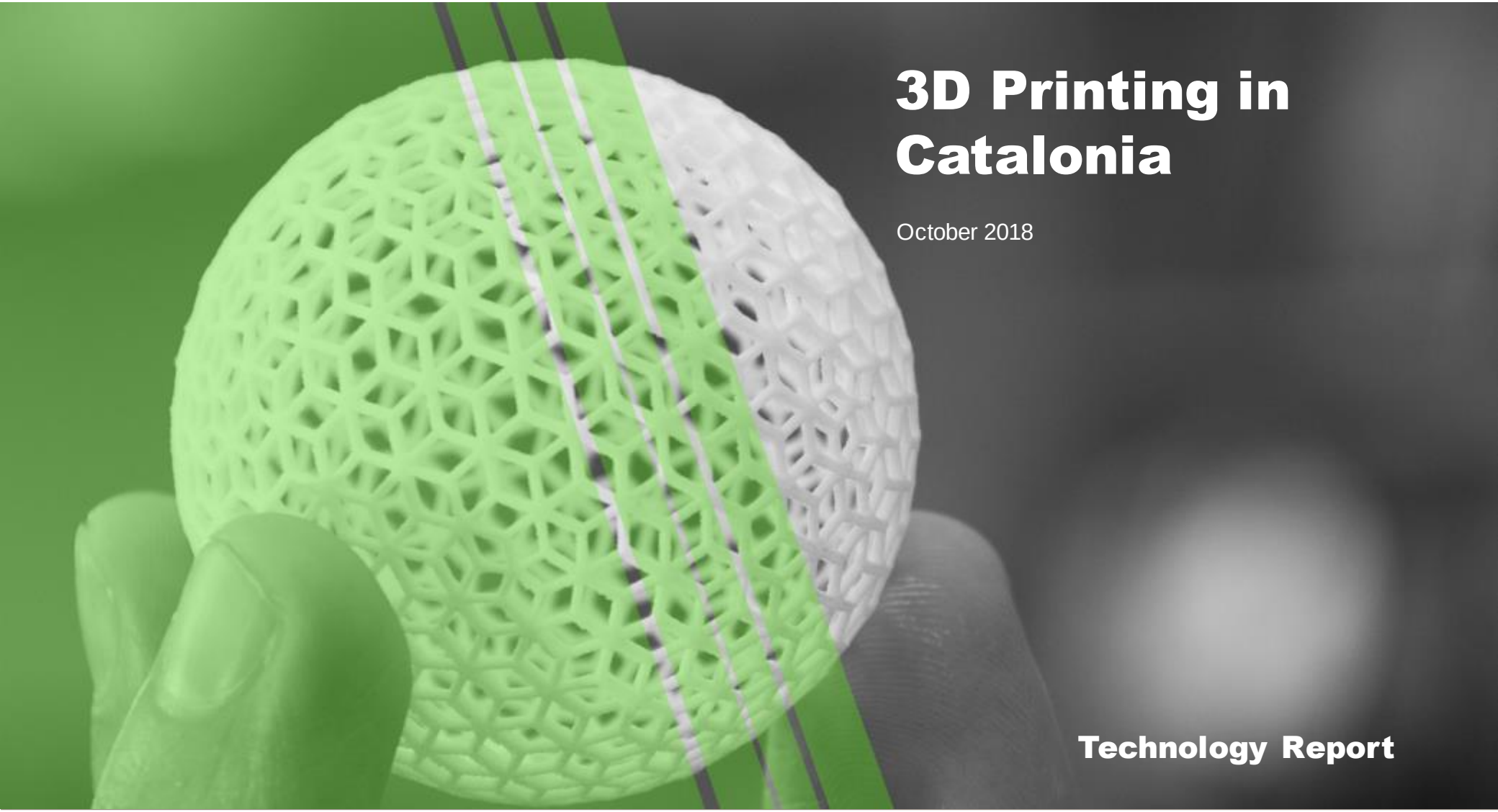


3D Printing in Catalonia

October 2018

Technology Report

Catalonia Trade & Investment

Generalitat de Catalunya
Government of Catalonia

3D Printing in Catalonia: Technology Report

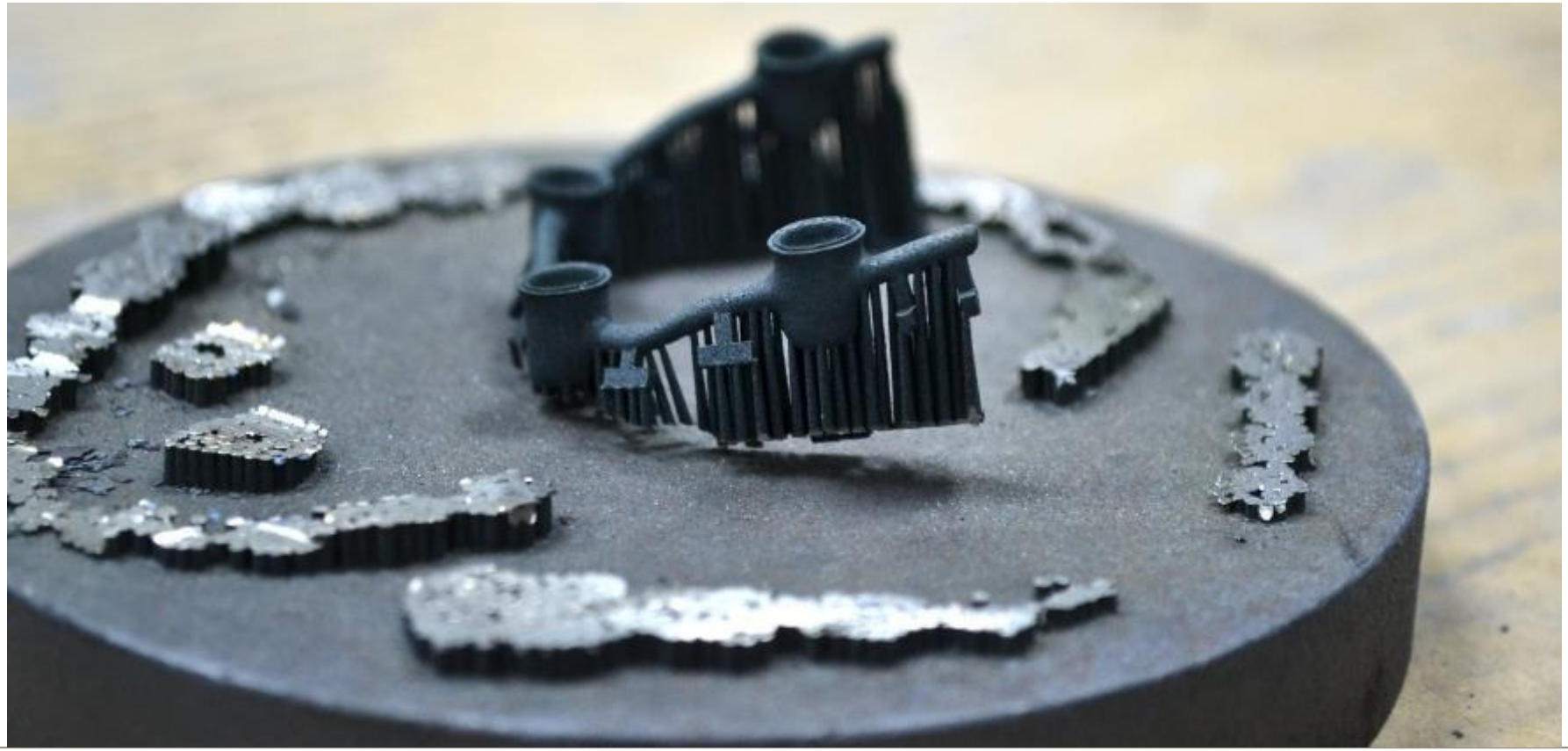
Catalonia Trade & Investment
Government of Catalonia

Elaborated by
Catalonia Trade & Investment. Strategy and Competitive Intelligence Unit
IDOM

Barcelona, october 2018

Contents

1. What Is 3D Printing and How Important Is It?

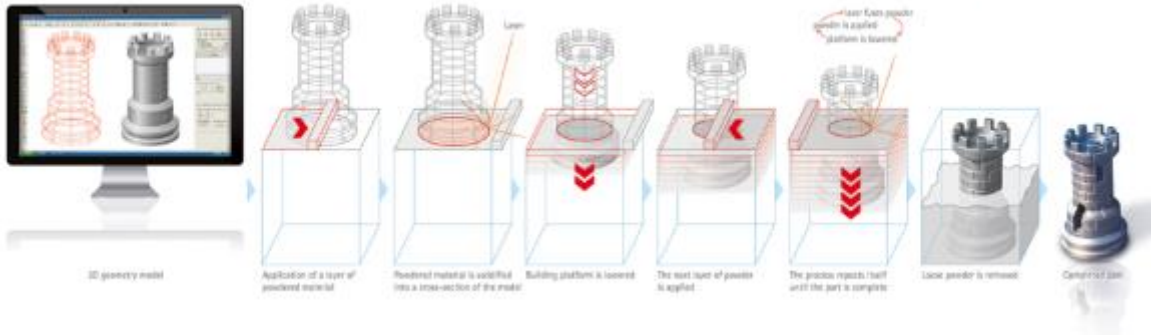


Definition of 3D Printing

3D printing, also known as additive manufacturing, refers to a set of technologies that allow for the **creation of volumetric objects based on digital models**.

Manufacture is performed by 3D printers that deposit material, generally in layers, and consolidate it using different technologies until the final part is obtained.

General functional principle of laser-sintering



Source: https://www.eos.info/additive_manufacturing/for_technology_interested

There are currently seven categories of additive manufacturing processes

1. Vat Photopolymerization
2. Material Jetting
3. Binder Jetting
4. Material Extrusion
5. Powder Bed Fusion
6. Sheet Lamination
7. Directed Energy Deposition

The Importance of 3D Printing to Industry

Cross-sectoral: this is a technology that can be applied in many industrial sectors, including production (currently limited by production costs and the availability of materials), and prototype and tooling manufacture.

Flexibility: both in terms of series size and the materials used, and even in the ability to adjust manufacturing orders to handle design changes.

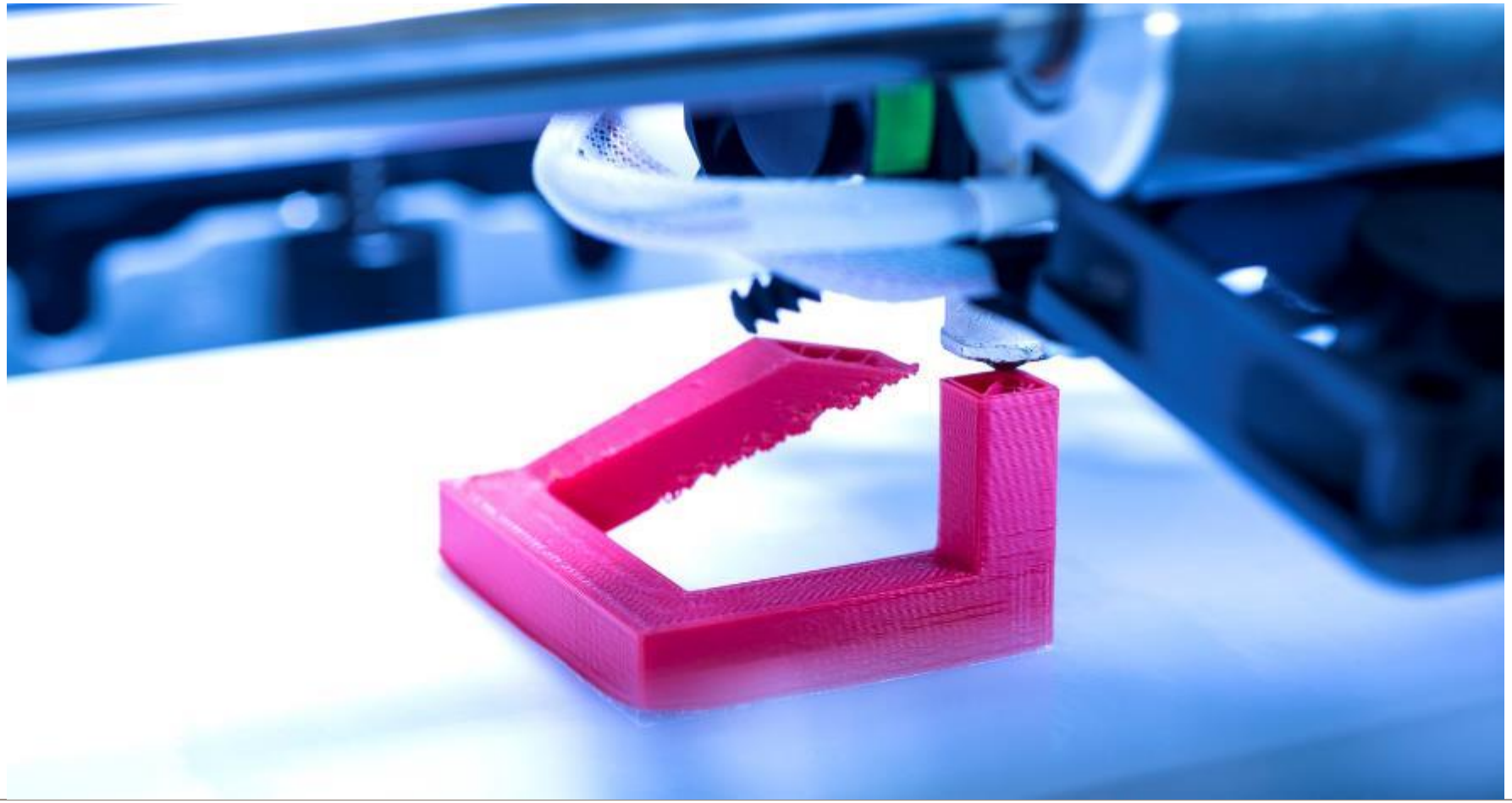
Greater added value: this technology allows for the production of complex three-dimensional geometries that cannot be manufactured using other technologies, and a reduction in the total number of parts. It can also be used with special materials and to manufacture lightweight structures, which makes it very important in an industry seeking to manufacture parts with greater added value.

Kilometre zero manufacturing: the possibility of manufacturing short series of highly user-adapted products means suppliers can compete in terms of quality, innovation and flexibility. When the price is of less relative importance, in-house manufacturing becomes more feasible.

Reducing time-to-market: it means the product design, development and manufacturing processes can be streamlined. This makes it of great interest in industrial sectors where product innovation is constant.

Customization: it means being able to respond to the global trend for greater product customization.

2. Evolution of 3D Printing



Evolution of the 3D Printing Market

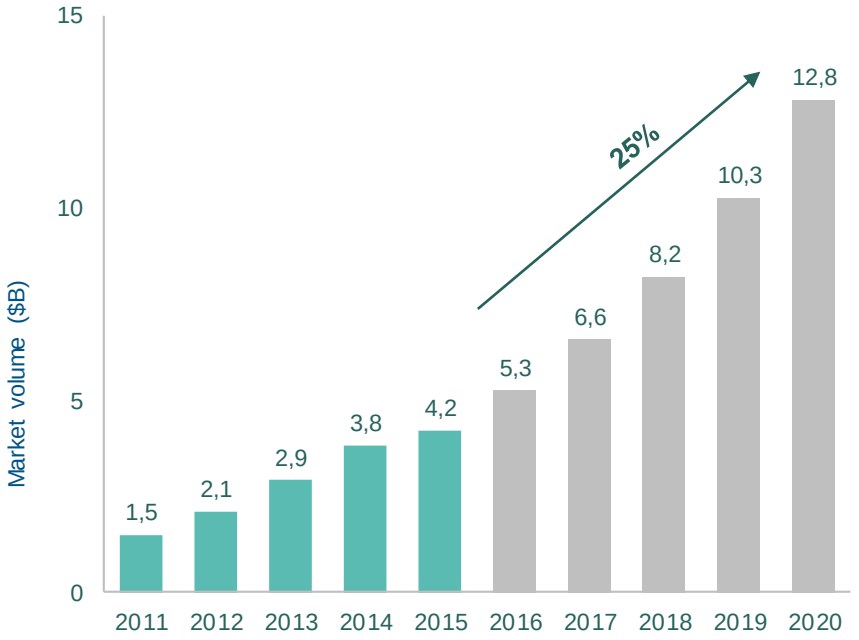
Additive manufacturing technology emerged in the 1980s and **was initially used only for rapid prototyping**.

However, demand for 3D printing systems and related services **increased the market volume of additive manufacturing** from $1.5B in 2011 to $4.2B in 2015. Annual growth of 25% is expected until 2020 (though some experts anticipate annual growth of 40%[1]).

The most optimistic calculations predict **market volume to be anywhere from $12B to $20B by 2020**[1], and to reach $40B by 2025[2].

These experts expect the sector's most seasoned players to grow at a lower rate while new players grow faster and attract new customers through the use of new technologies.

Anticipated evolution of the 3D printing market

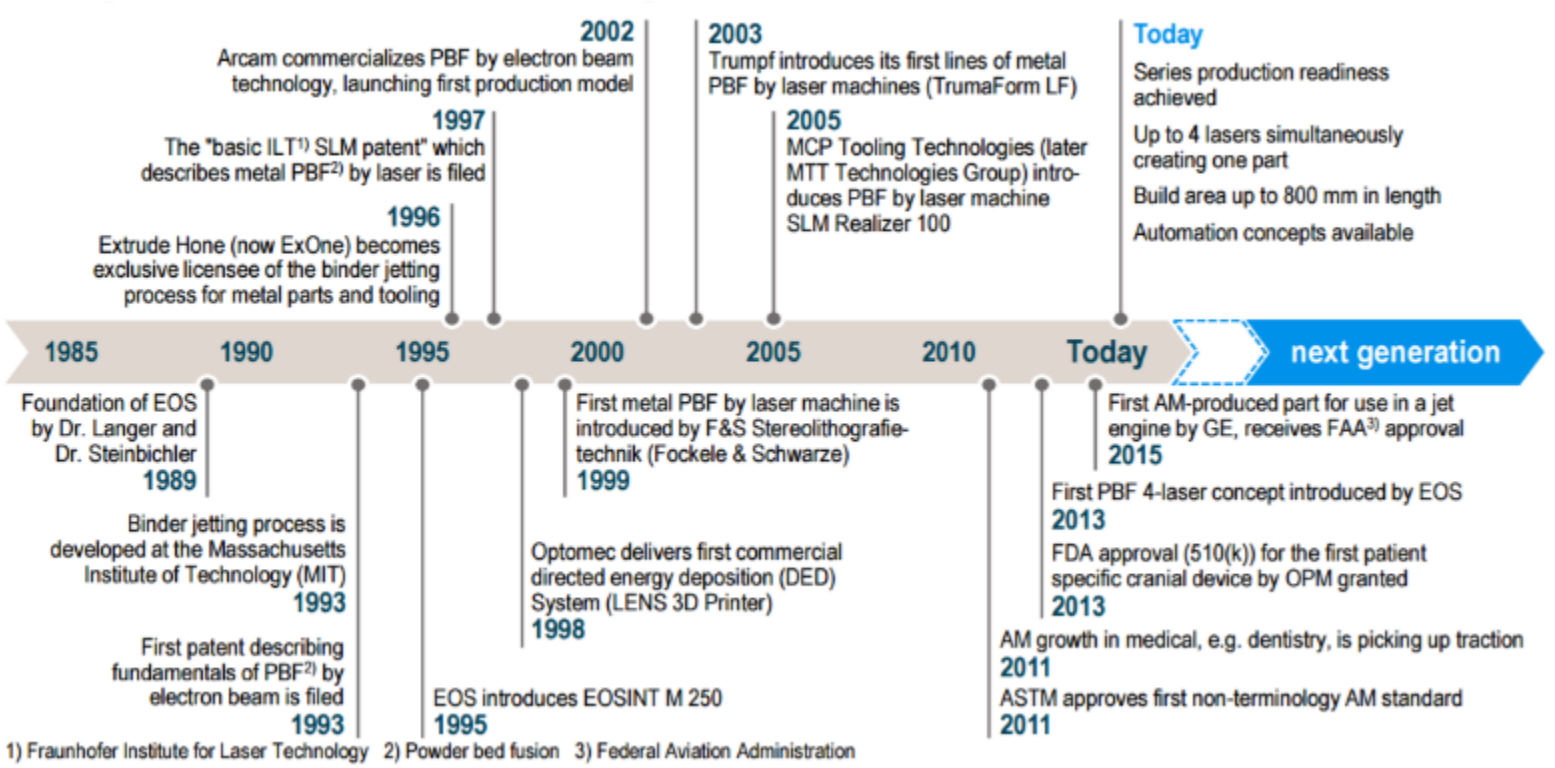


Source: EY (2016): "How Will 3D Printing Make Your Company the Strongest Link in the Value Chain? EY's Global 3D Printing Report 2016"

[1] Roland Berger (2016): "Additive Manufacturing – Next Generation (AMnx)"
[2] IALE Tecnología (2017): "Manufactura aditiva e impresión 3D en 2017. Un vistazo a los desarrollos patentados"; 3D Printing Investing News (2017): "Top 3D Printing Companies"

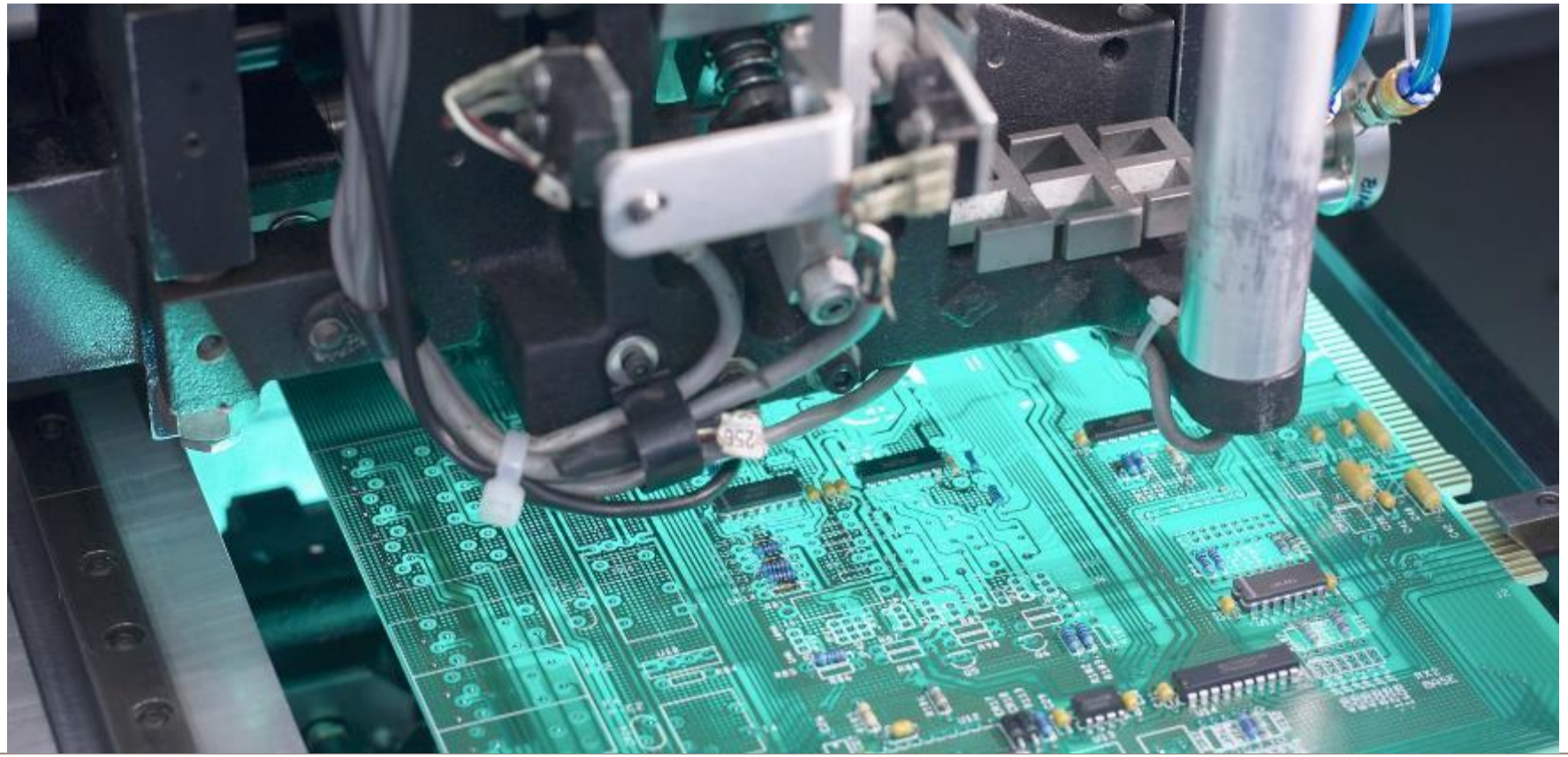
Main Global Milestones in the 3D Printing Industry

3D PRINTING HAS DEVELOPED A GREAT DEAL IN RECENT YEARS. SPECIFICALLY, STARTING IN 2011, THE NUMBER OF PATENT APPLICATIONS SKYROCKETED.



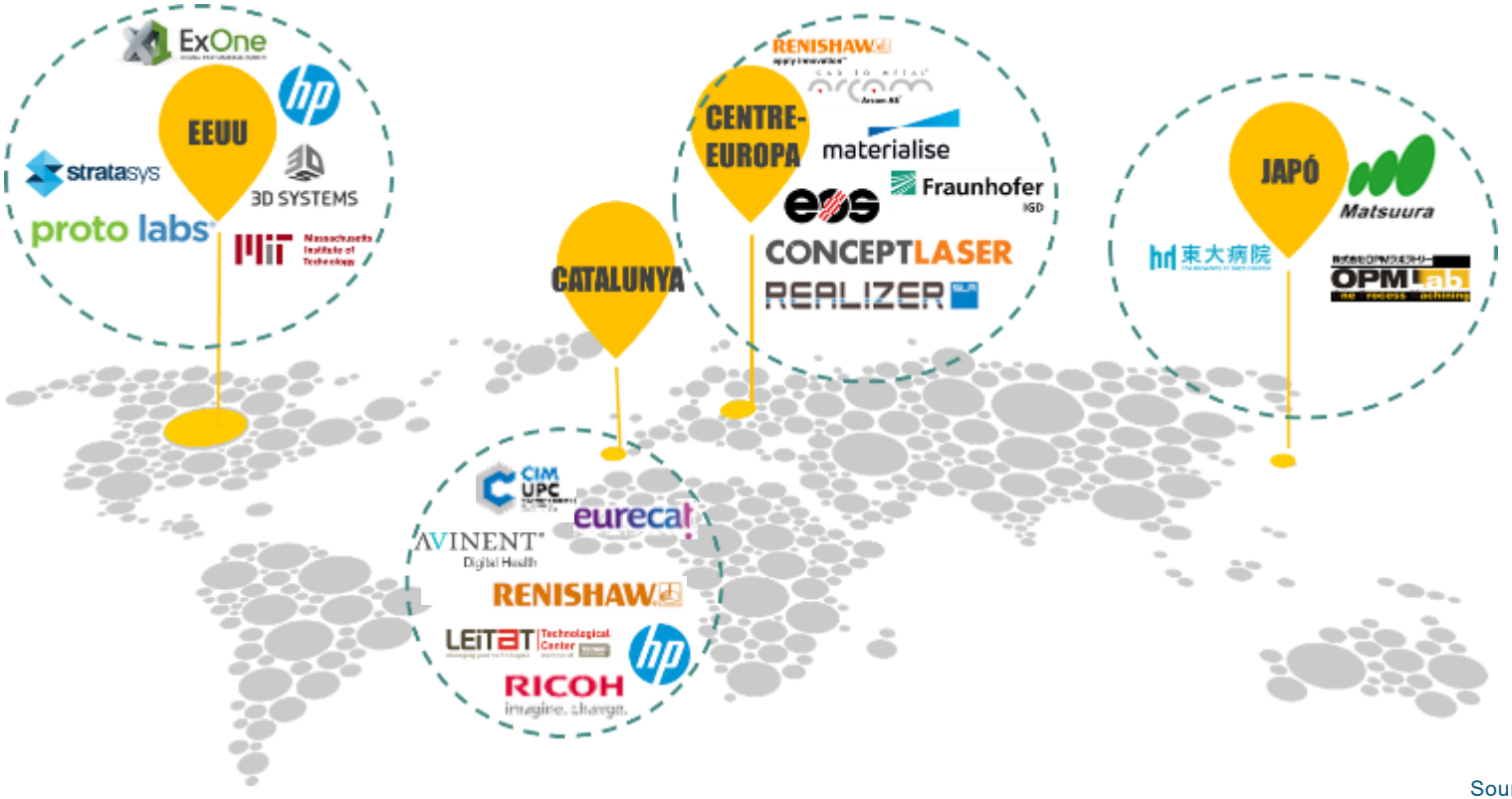
Source: Roland Berger (2016): "Additive Manufacturing– Next Generation (AMnx)"

3. The World's Main Hubs, Players & Investors in the 3D Printing Market



The World's Main Hubs of 3D Printing Development

ALTHOUGH 3D PRINTING DEVELOPMENT IS BECOMING INCREASINGLY MORE WIDESPREAD, IT IS STILL CONCENTRATED IN SPECIFIC GEOGRAPHIC REGIONS.



Source: Authors' own data

Key Players in the 3D Printing Market

Though this company is not strictly dedicated to 3D printing, it may become a market leader with its Multi Jet Fusion technology developed at the company's centre in Sant Cugat del Vallès.

It supplies 3D printing systems with plastics and metals, and is currently the market leader. It also provides consulting and training services for companies that make use of its technologies.

It provides 3D printing services exclusively with metal for the orthopaedic implant and aerospace sectors. Besides machines, it supplies auxiliary equipment, powder material, software, and customer-training services. It holds a portfolio of 200 patents.

It supplies 3D printing exclusively with metals for the medical and dental, aerospace, tool and tooling manufacture, automotive, and jewellery and watchmaking sectors. Its machines can work with different kinds of special metals.

Though it does not work exclusively in 3D printing, the company has a laser additive manufacturing product line. The machines are applicable to different sectors, but specialize in jewellery.

The company was originally dedicated to 3D measurement, but now has a rapid prototyping line for additive manufacturing with metals.

It supplies printers and materials. It is among the companies with the most patents in 3D printing and operates mainly in the medical technologies sector, the automotive industry and products for education.

Supplier of products (printers and printing materials) and services (parts design and manufacture). It works in different sectors (e.g. medical technologies, manufacturing and design) and recently announced its expansion into other sectors (i.e. dental applications, jewellery) for manufacture with plastics and metals.

Company offering 3D-printing-related software and services with a strong focus on the medical technologies sector and a presence in the automotive industry and aeronautics sector, among others. It supplies decision-making software for 3D printing processes.

It supplies printers and printing services with its own proprietary technology developed at MIT to manufacture complex parts with materials for industrial use, such as metals, sand and ceramics.

Company offering 3D printing services and specializing in parts design and the manufacture of prototypes and small series. It boast eight locations on three continents and won Frost and Sullivan's 2017 Manufacturing Leadership Award.

Source: Authors' own data

Main Investors in the 3D Printing Market

Main companies and funds investing in 3D printing

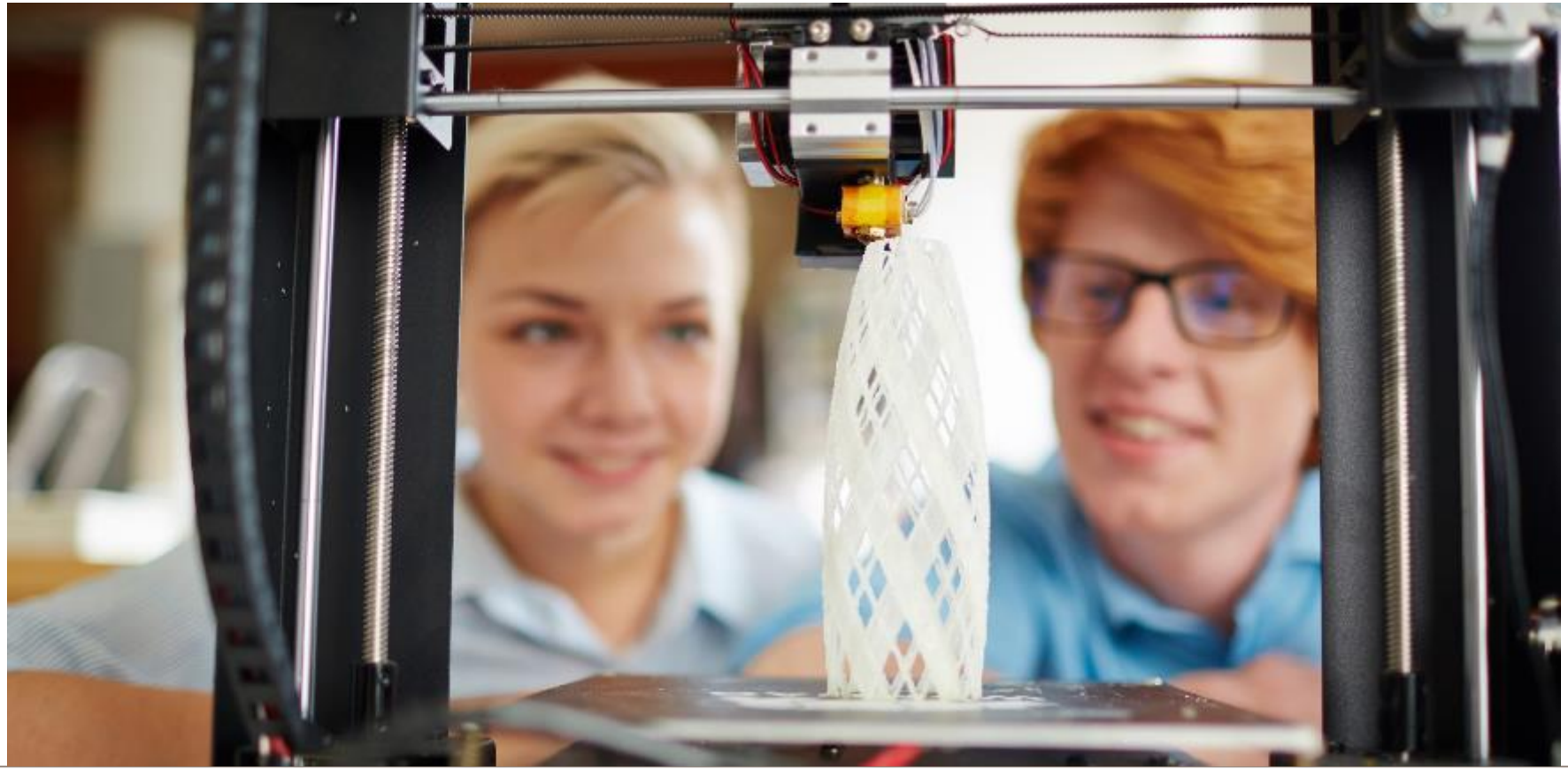
KICKSTARTER
3DSYSTEMS
AUTODESK
GE VENTURES
luxcapital
asimov VENTURES
Index Ventures
GROUPE Gorgé
USV Union Square Ventures
SPARK
HAX
SEQUOIA

Source: CB Insights

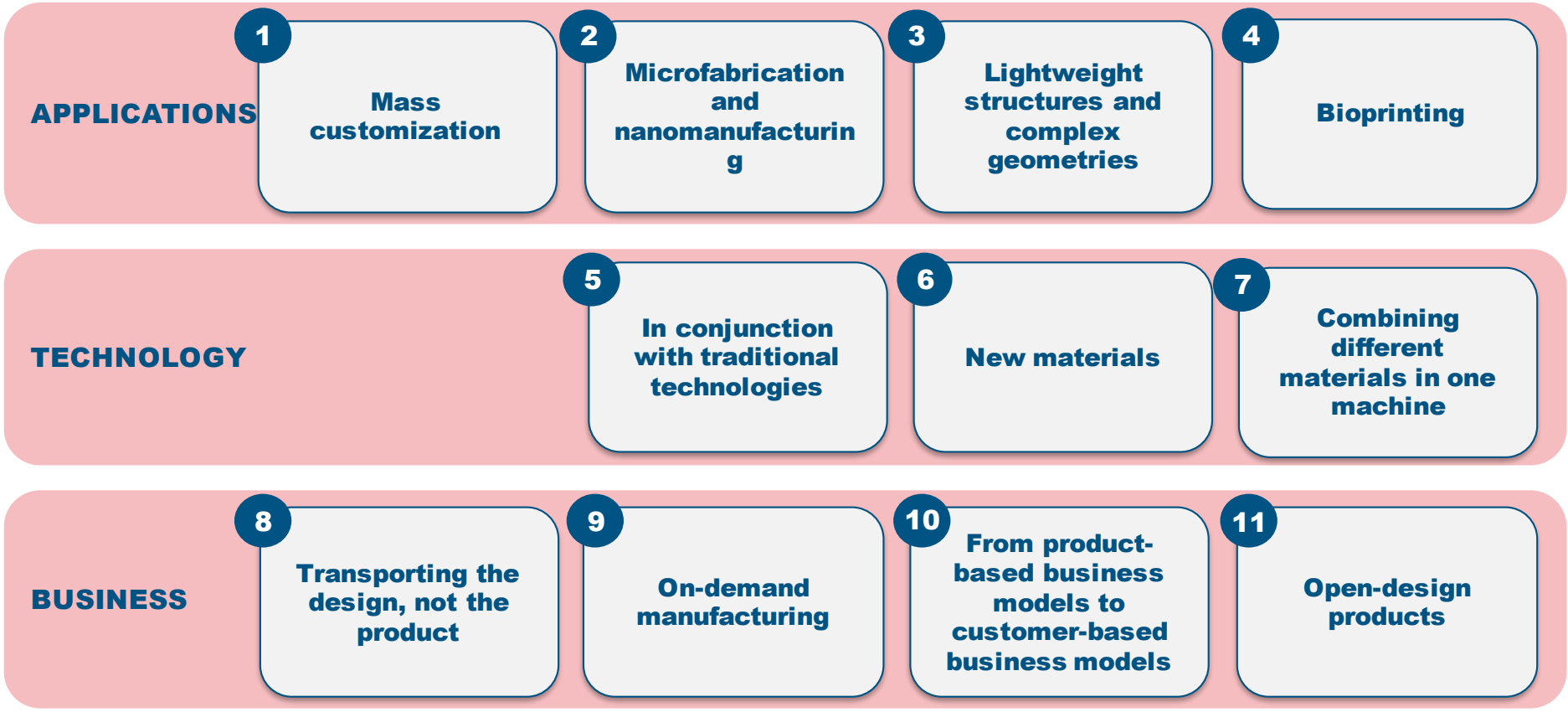
Main countries investing in 3D printing

Source: International Data Corporation

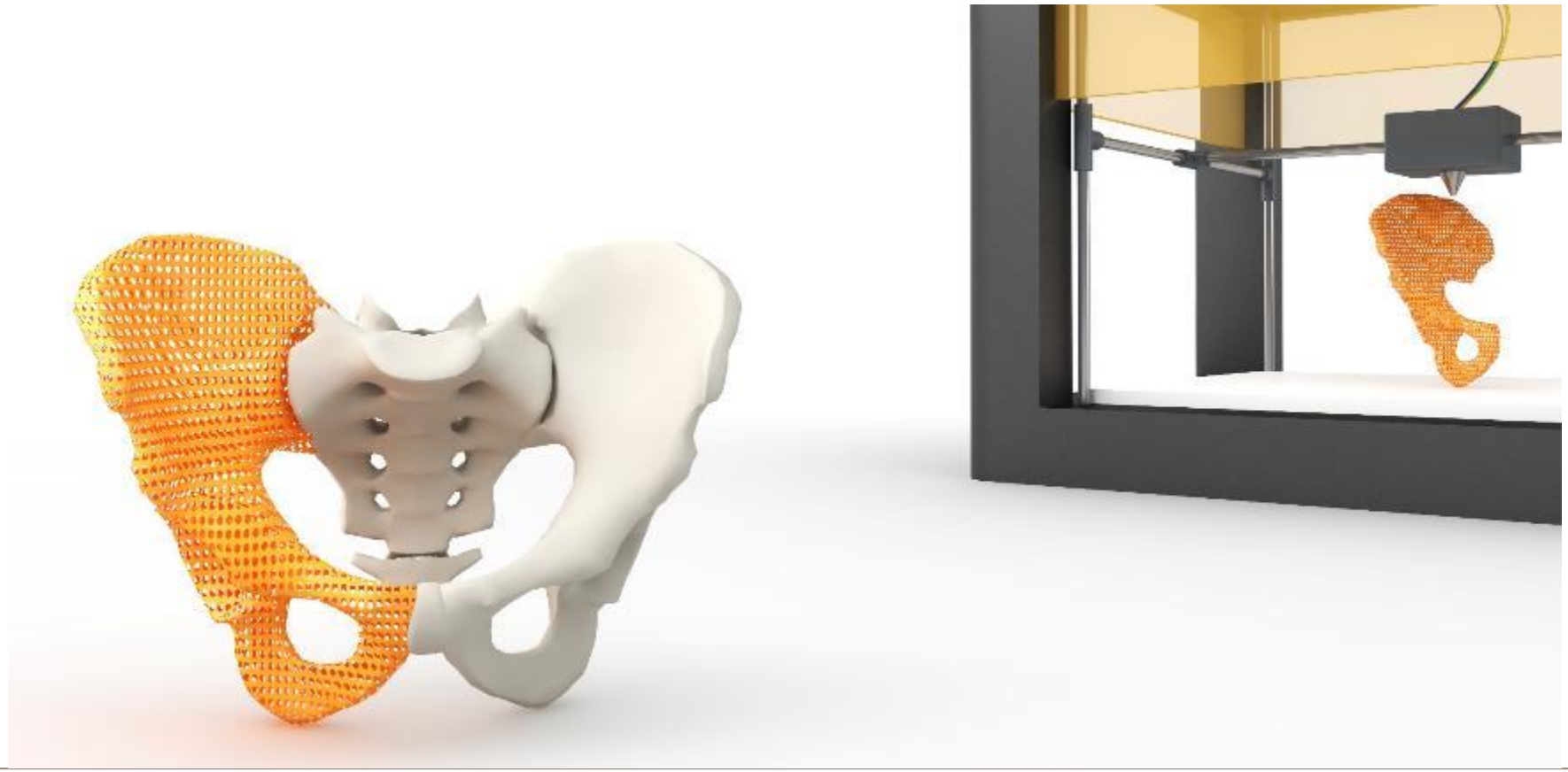
4. Trends in 3D Printing Technology



Trends in 3D Printing



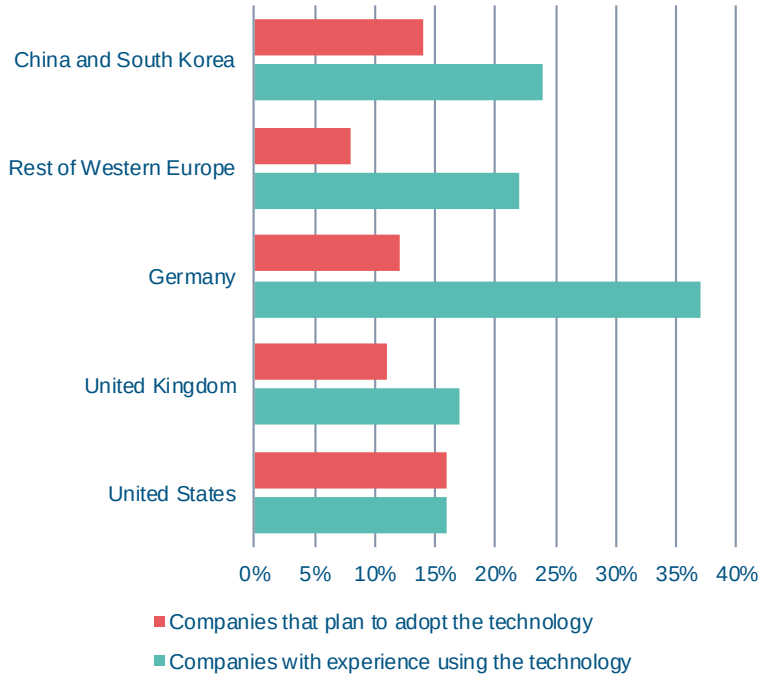
5. Recent and Future Applications by Demand Sectors



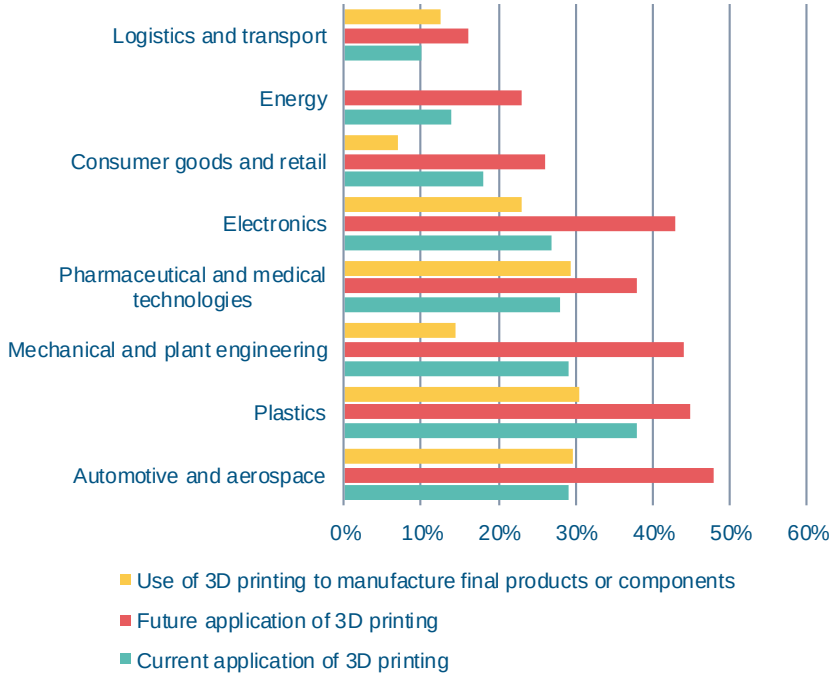
Markets for Application of 3D Printing

THE USE OF 3D PRINTING IS GROWING CONSIDERABLY, NOT JUST IN INTENSITY, BUT ALSO IN THE VARIETY OF APPLICATIONS AND THE GEOGRAPHIC DISPERSION OF MARKETS.

Acceptance of 3D printing in different regions



Current and future application of 3D printing in different sectors



Source: The authors, based on data from EY (2016): "How Will 3D Printing Make Your Company the Strongest Link in the Value Chain? EY's Global 3D Printing Report 2016"

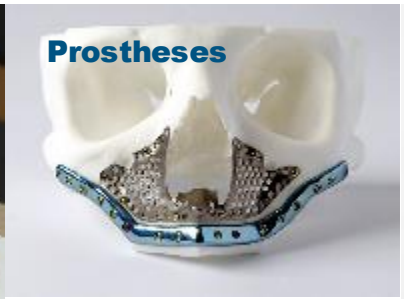
Main Applications of 3D Printing Technology

Current applications → **Future applications**

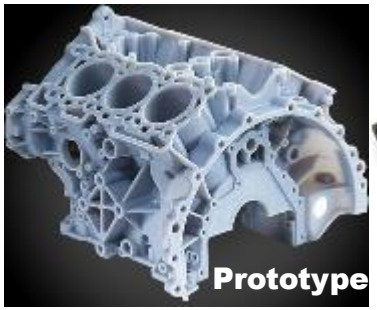
HEALTH

Dental implants

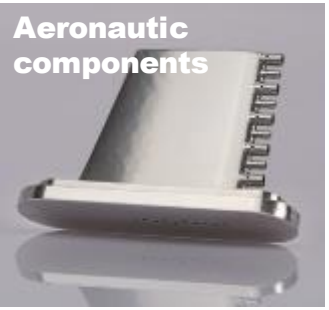
Prostheses



MANUFACTURING



Functional parts



FOOD

Main Applications of 3D Printing Technology

Current applications → **Future applications**

CONSTRUCTION


Prefab concrete


Prefabricated infrastructure


Ceramic parts with complex geometries

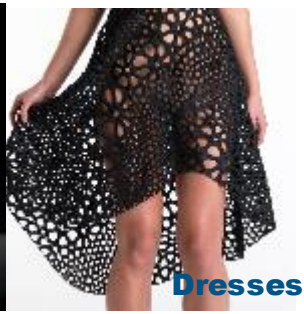

Prefab houses

FASHION


Handbags


Custom-made eyewear


Customized technical footwear


Dresses

HOME AND GIFTS


Decoration


Toys (customized)


Jewellery


Lighting

6. The 3D Printing Ecosystem in Catalonia

3D Printing in Catalonia: Main Mapping Conclusions

90 companies offering 3D Printing solutions have been detected

239M€ turnover related to 3D Printing

1,118 employees work in 3D Printing

Classification of companies considered:
- Solution providers (printers producers and materials)
- Service providers (3D Printing Bureau)
- Integrators

3D Printing in Catalonia

This ecosystem is composed either by start-ups and consolidated companies:

47.7% of companies are less than 10 years old

90% are SMEs

26.6% of companies have a turnover higher than a €1M

Highly internationalized sector:

7.7% of companies have subsidiaries abroad

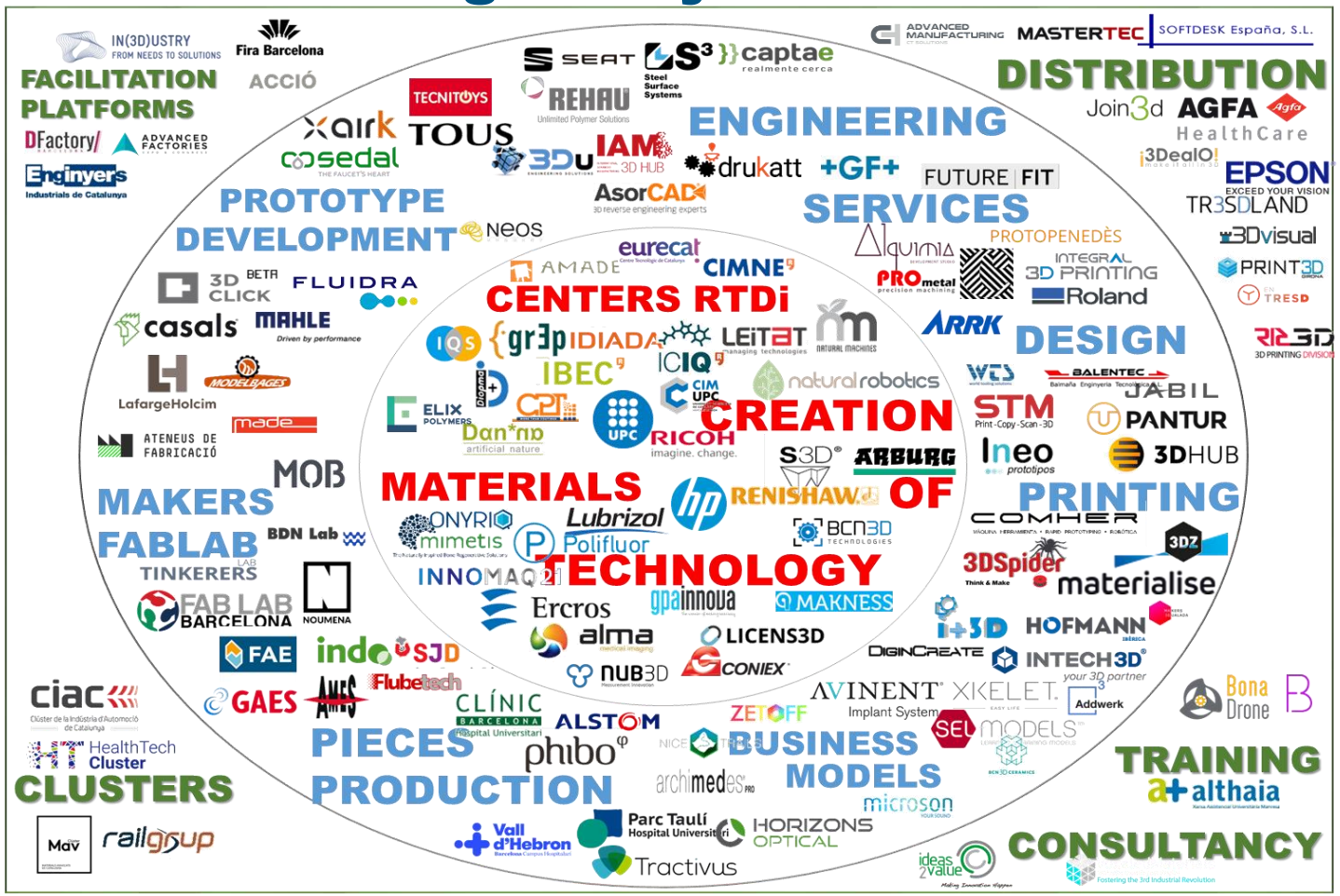
25.5% of companies are exporters

Source: authors' own following Orbis, ACCIÓ *and Catalonia Start-up Hub* Directories. For company turnover and employee data, estimates were made based on company business lines.

ACCIÓ Generalitat de Catalunya

The 3D Printing Ecosystem in Catalonia

Partial illustrational table



SECTORS OF APPLICATION

- Automotive and Motorcycle
- Machinery and Equipment
- Metal and Metallurgy
- Health and Medical Equipment
- Pharmaceutics
- Construction
- Food and Gourmet Products
- Circular Economy
- Fashion and Textile
- Habitat and Furniture

Note: *The use of these trademarks is for informative purposes only. Trademarks mentioned in this document are the registered trademarks of the companies to which they belong and are not owned by ACCIÓ. This is a partial illustrative representation of companies that formpart of the Blockchain ecosystemin Catalonia; however, there may exist other companies that have not been included in the study.*

Source: ACCIÓ & Barcelona-Catalonia Startup Hub

TECNIO Centres Specializing in 3D Printing

Eurecat is the largest technology centre in Catalonia. It was created when several technology centres merged and therefore benefits from more than 450 professionals with a wide range of expertise in industry and the digital world. It generates annual turnover of €36M. Eurecat's knowledge and technology working line in the area of additive manufacturing is under development: 3D functional printing, structural printing, multiprocess 3D printing, etc.

It is a technology centre recognized by the Catalan government. Its mission is to work with companies and other organizations to guarantee economic, social and sustainable development through its R&D projects based on innovative technological processes and creativity. LEITAT has an area of expertise in 3D printing applied to advanced manufacturing with rapid and additive manufacturing.

IQS has an established background in basic and applied research, technological development, tech transfer and the use of knowledge in the industrial context. Iqs Tech Transfer boasts a research line in new manufacturing technologies (additive manufacturing).

The Thermal Spray Centre is a Universitat de Barcelona research centre with more than 25 years of experience in the field of surface engineering. Its main objective is to contribute solutions in the field of materials engineering in new processes and products. The centre works in the area of additive manufacturing using cold spray technology on applications in the industrial and biomedical sectors.

The aim of CIMNE is the development of numerical methods and computational techniques to advance knowledge and technology in applied engineering and sciences. The final objective of the CIMNE is to become an international reference center and leader in computational mechanics.
The center develops and uses additive printing technology in several lines of research.

Other Centres Specializing in 3D Printing

FUNDACIÓcim UPC BARCELONATECH

This centre forms part of Universitat Politècnica de Catalunya - Barcelona Tech (UPC), whose institutional mission is to transfer engineering and technology management knowledge to companies and professionals seeking to expand Catalonia's industrial options by creating, improving and promoting products and manufacturing processes.

In 3D printing, one of its specialized fields, it provides services to companies and develops its own technology and machines.

IBEC

Institute for Bioengineering of Catalonia

IBEC combines research on the frontiers of knowledge with specific transfer goals for producing new technologies that can be applied in the health and life sciences.

IBEC's working lines include bioprinting, a technology that promises to open new pathways in the field of tissue and organ regeneration.

7. Examples of Demand for 3D Printing in Catalonia

Examples of Demand for 3D Printing in Catalonia (I)

LafargeHolcim

Prefab building materials

Lafarge participates in the 3D Cons project, whose goal is to develop new 3D printing systems for structural rehabilitation by means of direct printing and manufacturing of custom-made prefab elements (with no need for moulds or form work).

BASÍLICA DE LA SAGRADA FAMÍLIA

3D printing and Modernism

The use of 3D printing has made it possible to speed up construction work on the Sagrada Família. The technology helps technicians visualize Gaudí's models as prototypes using SLA 3D printers.

Sant Joan de Déu

HOSPITAL MATERNO-INFANTIL UNIVERSITAT DE BARCELONA

FUNDACIÓcim BARCELONATECH

Testing surgical operations

The CIM Foundation is working with Hospital Sant Joan de Déu to use 3D printers to create exact reconstructions of tumours as a way of increasing the odds of surgical success. The CT scan and ultrasound data of a child with a tumour were used to create a 3D reconstruction of the tumour and affected arteries and organs. Two different materials were used to create the tumour: a hard plastic to represent the untouchable parts and a soft resin to represent the texture of the tumour.

Examples of Demand for 3D Printing in Catalonia (II)

phibo

Manufacture of medical devices
PHIBO uses 3D printing to manufacture dental parts and screws for dental implants.

MODELBAGES

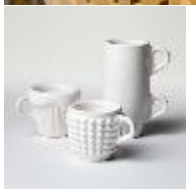
Rapid prototyping
Modelbages develops the design and manufacture of different prototypes and sample parts from 3D printing with PLA.

TOUS
jewelers since 1920

Jewellery prototyping and manufacture
As a pioneer in the use of 3D printing in jewellery, Tous initially used the technique to manufacture prototypes and later for product manufacturing.

CUNICODE | DESIGN FOR 3D PRINTING | MAKE THINGS DIFFERENT

Manufacture of design products
Cunicode is dedicated to the design and manufacture of 3D printing products. It manufactures a wide range of objects, including lighting, jewellery and decorative items. It also works on custom projects.



Iaac
Institut d'arquitectura avançada de Catalunya

3D printing infrastructure
The Institut d'Arquitectura Avançada de Catalunya developed a bridge manufactured entirely with 3D printing. It is installed in Alcobendas.

Examples of Demand for 3D Printing in Catalonia (III)

Parts optimization using 3D printing

Alstom's aim was **to improve the design of an existing part of its Metro units using additive manufacturing**. The study began with an analysis of the part, which showed that this very static part was operating well below its capacity. Optimization then began, including an analysis of where material was actually required in the new part design. The design was gradually fine-tuned until the most suitable solution was found in terms of the external topology.

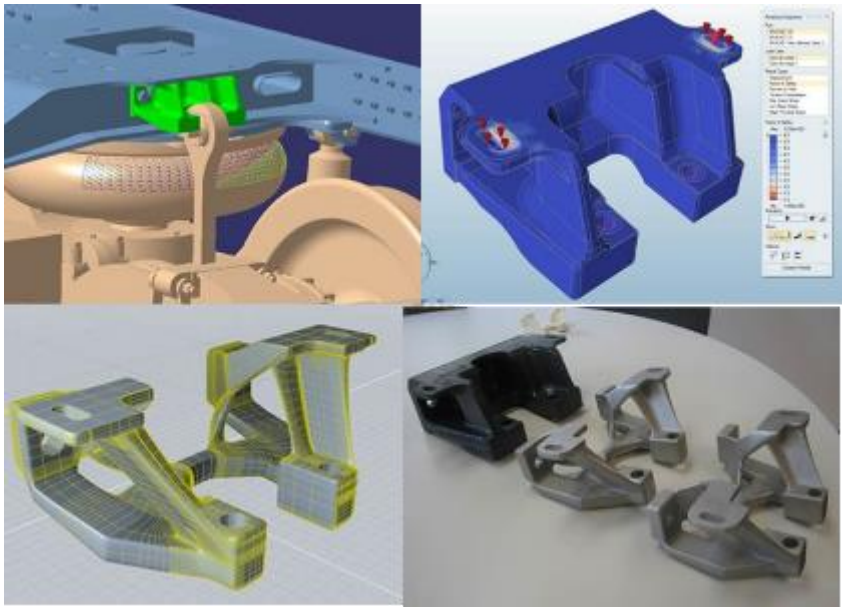
Calculated results on the final part showed that it performed as desired based on the component's mechanical requirements.

This new design is manufactured in stainless steel in collaboration with LEITAT using additive manufacturing and selective laser sintering technology.

The study results were completely satisfactory:

- 66% reduction in mass.
- discovery of new industrial processes.
- first organic designs and topology optimization.

Furthermore, also in collaboration with LEITAT, a second optimization was performed using a different methodological approach that involved replacing the material inside the design with reticular structures.



Examples of Demand for 3D Printing in Catalonia (IV)

Manufacture of highly customized products

For AVINENT Implant Systems, **product customization is a critical matter**, especially in its line of prostheses for maxillofacial reconstruction.

Based on a 2D medical image, AVINENT professionals use latest-generation CAD/CAM tools to build a 3D image of the bone tissue to be repaired. Then they design a comprehensive solution that includes the prosthesis (which provides the patient with functionality and aesthetic improvements) and surgical guides that help ensure the operation is successful.

In this process, additive manufacturing is a very powerful technology because it can be used to manufacture unique, totally customized parts in a wide range of materials, such as resins and polyamides (for pre-surgical models) and titanium (for prostheses).

AVINENT Implant Systems can develop customized solutions in three days, which means patients are treated without delay.

AVINENT Implant System

Examples of Demand for 3D Printing in Catalonia (V)

The printer that prints itself

HP Inc. developed a new additive manufacturing technology at its development centre in Sant Cugat del Vallès: HP 3D Multi Jet Fusion.

This **technology helps reduce the cost of manufacturing small and medium-sized series** because there is no need to build moulds. It also **reduces the time to market** because a 3D design can go directly to production with no need for a complex industrialization process.

HP therefore decided to **use its own technology to manufacture approximately 50% of the plastic parts in the HP 3D Multi Jet Fusion printer,** which gave it the following advantages:

- **More economical:** producing parts with the company's own technology was economically more favourable than doing it using traditional technologies.
- **Shorter development times:** using additive manufacturing made it possible to work on the optimization of parts design almost up to time of market launch of the printer because it was not necessary to spend time building moulds or dies.

Examples of Demand for 3D Printing in Catalonia (VI)

The optical firm **Indo and Eurecat** created **customized eyewear with 3D printing** using a technique that will change the production processes of the ophthalmic industry. This technology determines the shape and ensures the frame and lenses fit perfectly on each face.

The **Optician2020 project**, which was carried out in collaboration between Eurecat and Indo, an established lens company operating in Sant Cugat del Vallès, resulted in a product that bears in mind weight, as well as visual comfort and convenience. The product they designed with 3D printers studies the anatomical features of each face and each customer's aesthetic preferences to create comfortable glasses.

How does it work?

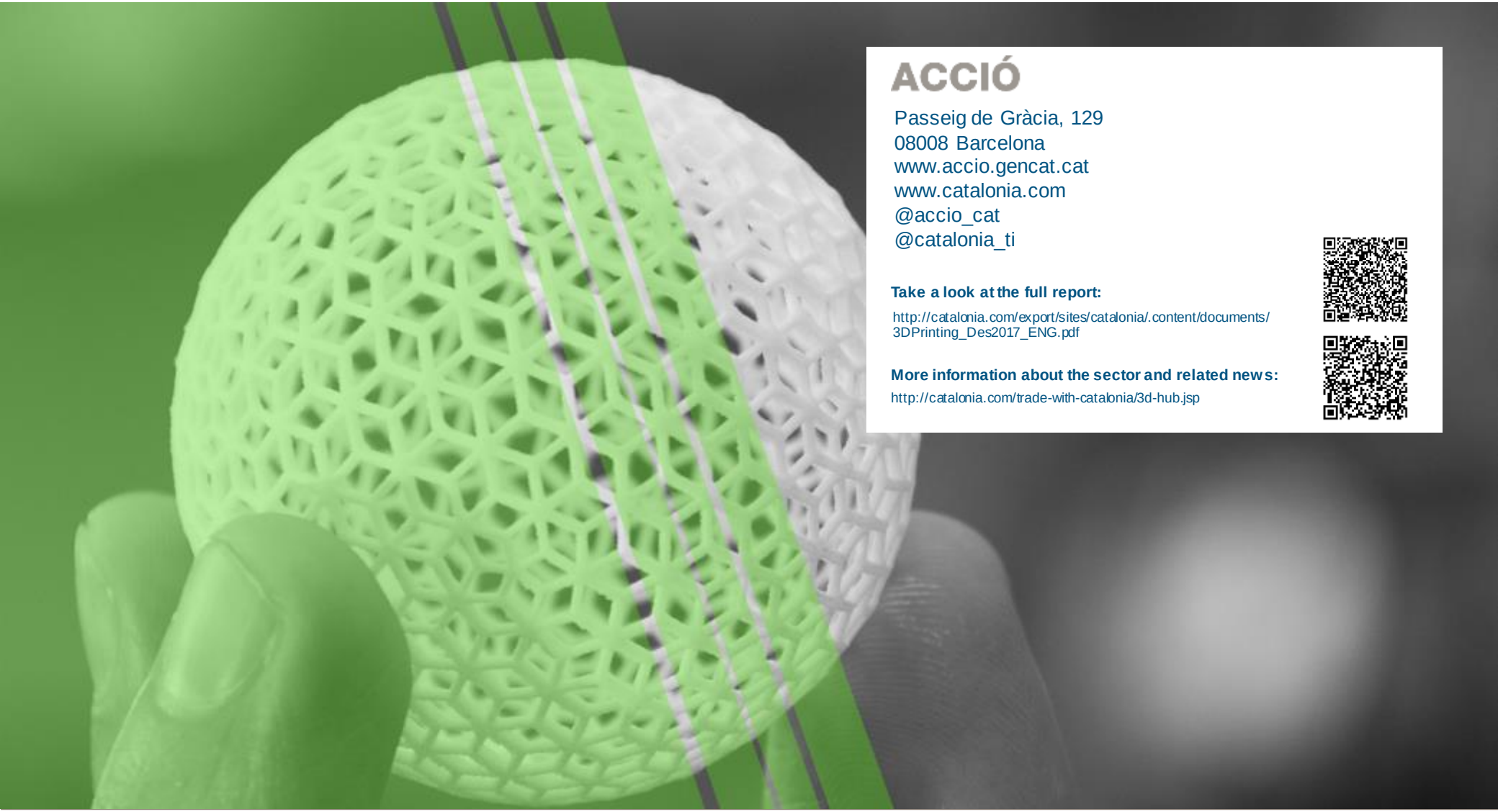
The program scans the shape of the user's face, size of the eyes, tip of the nose, bone structure and even the shape of the pupils to chart that person's true dimensions. Then the user's visual behaviour is studied, given that some people move their eyes to focus while others move their head. This affects the focal point of the lens, which is why it must be considered when designing frames and lenses.

Once all the three-dimensional anatomical information is compiled, users can add their own aesthetic preferences and, in only a few minutes, can perform a virtual review (from all angles and in any colour and material available) of how the glasses will look on their face. Then it's just a question of printing the glasses. The order is sent to the closest associated factory with a 3D printer and the glasses can be ready at the optician's in just a few days.

indo
your eyes, our world

eurecat
Centre Tecnològic de Catalunya

tecnio catalonia
ACCIÓ
Generalitat de Catalunya



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Take a look at the full report:

http://catalonia.com/export/sites/catalonia/.content/documents/3DPrinting_Des2017_ENG.pdf

More information about the sector and related news:

http://catalonia.com/trade-with-catalonia/3d-hub.jsp

Catalonia Trade & Investment

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