minsait
by Indra

Advanced manufacturing, beyond Industry 4.0

Agility and efficiency
to speed up Industry 4.0

Executive summary

Advanced Manufacturing brings together all the technologies developed in industrial environments to make manufacturing more agile and efficient. To achieve this, it applies advanced digital technologies to the industrial environment.

Industry 4.0, which consists of the application of digital tools to the industrial value chain to generate impact on business, has evolved and driven the concept of Advanced Manufacturing, facilitating to the maximum its implementation at any stage of the chain.

At Minsait we consider there are six key technologies that are contributing to the emergence of the new Advanced Manufacturing and that are already sufficiently mature to be implemented:

1. Augmented Reality and Virtual Reality
2. UAVs
3. Wearables
4. 3D printing
5. Cobots
6. AGVs

At Minsait we have capabilities and knowledge in Advanced Manufacturing at different levels, complementing our solutions software offering in Industry 4.0 and allowing us to prescribe the best solutions to our clients in their path towards complete digitisation of their enterprises:

- Own Capabilities. At Minsait/Indra we have our own proven proprietary assets in Virtual Reality and Augmented Reality, UAVs and Wearables.

- Partner ecosystem. For some areas we are launching collaborative agreements that allow us to offer our clients an expert point of view and an opportunity to implement several advanced manufacturing technologies, specifically, AGVs and cobots.

- Expert knowledge. We have an expert perspective on 3D printing which helps us to provide support to our potential clients in applying this technology.

01 What is Industry 4.0?

Industry 4.0 consists of applying digital tools throughout the industrial value chain to instigate a profound transformation of its operations and business models.

The so-called fourth industrial revolution is being accelerated by the development of new technologies, increased capacities for date storage and processing and the appearance of new business models.

At global level, it is estimated that the annual economic potential of digitisation up to the year 2025 is in the range of 1.2 to 3.7 billion dollars[1], while at European level it is thought that it will generate around 375-415 billion euros per year in the same period[2], and in Spain the additional gross added value is estimated at up to 120 billion euros[3].

Beyond the quantification of the economic potential, this is a transformation with profound impact at levels of technology, operations and strategy, which will allow companies to occupy new competitive positions and, at country level, strengthen their importance in the worldwide sector (eg the European Commission has set the target for the industry to represent 20% of the EU's GDP in the year 2020, compared with around 15% in 2015).

1 MGI - The Internet of Things: mapping the value beyond the hype (2015)

2 MGI – Digital Europe: pushing the frontier, capturing the benefits (2016)

3 Siemens - Spain 4.0: The challenge off the digital transformation of the economy (2016)

02 What is Advanced Manufacturing?

To understand the concept of Advanced Manufacturing it helps to look back at the third industrial revolution, the so-called Smart Revolution.

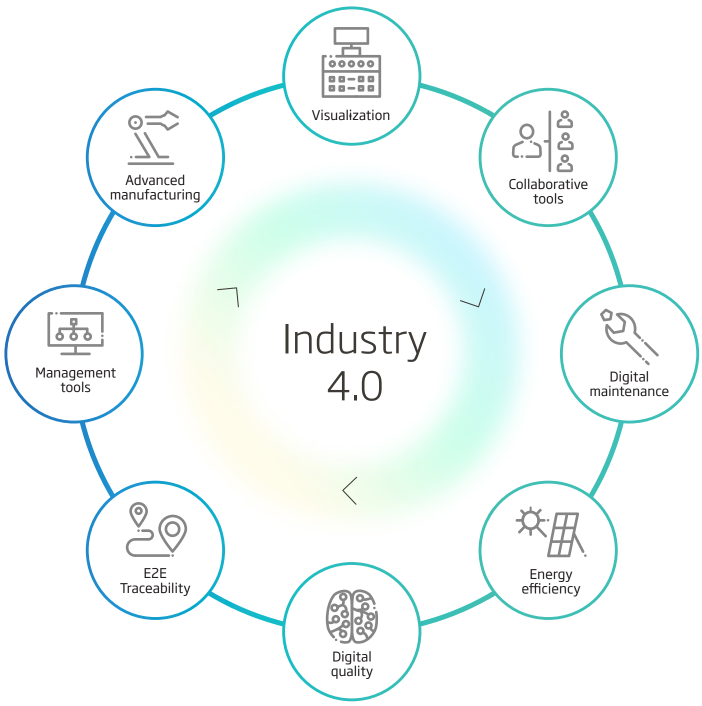
The new forms of communication, the emergence of automation and consolidation of the Information and Communications Technologies (ICT), together with the growing needs for mass production, and sustainability in costs and operations, have stimulated this new industrial paradigm.

In this context, the term Advanced Manufacturing is becoming established to refer to the use of those innovative technologies that allow efficiency to be increased in key manufacturing processes. Some examples of use cases could be the following:

- Digital design using computing techniques (CAD, CAE, CAM, etc.)
- Automation of key process through advanced robotics
- Process monitoring through control systems (Advanced ICS, MES, etc.)

Currently, the emergence and maturity of multiple enablers and digital technologies that have driven the appearance of Industry 4.0, combined with new business needs (reduced manufacturing and design cycles, product customization and cost control) have made possible the exponential development of Advanced Manufacturing.

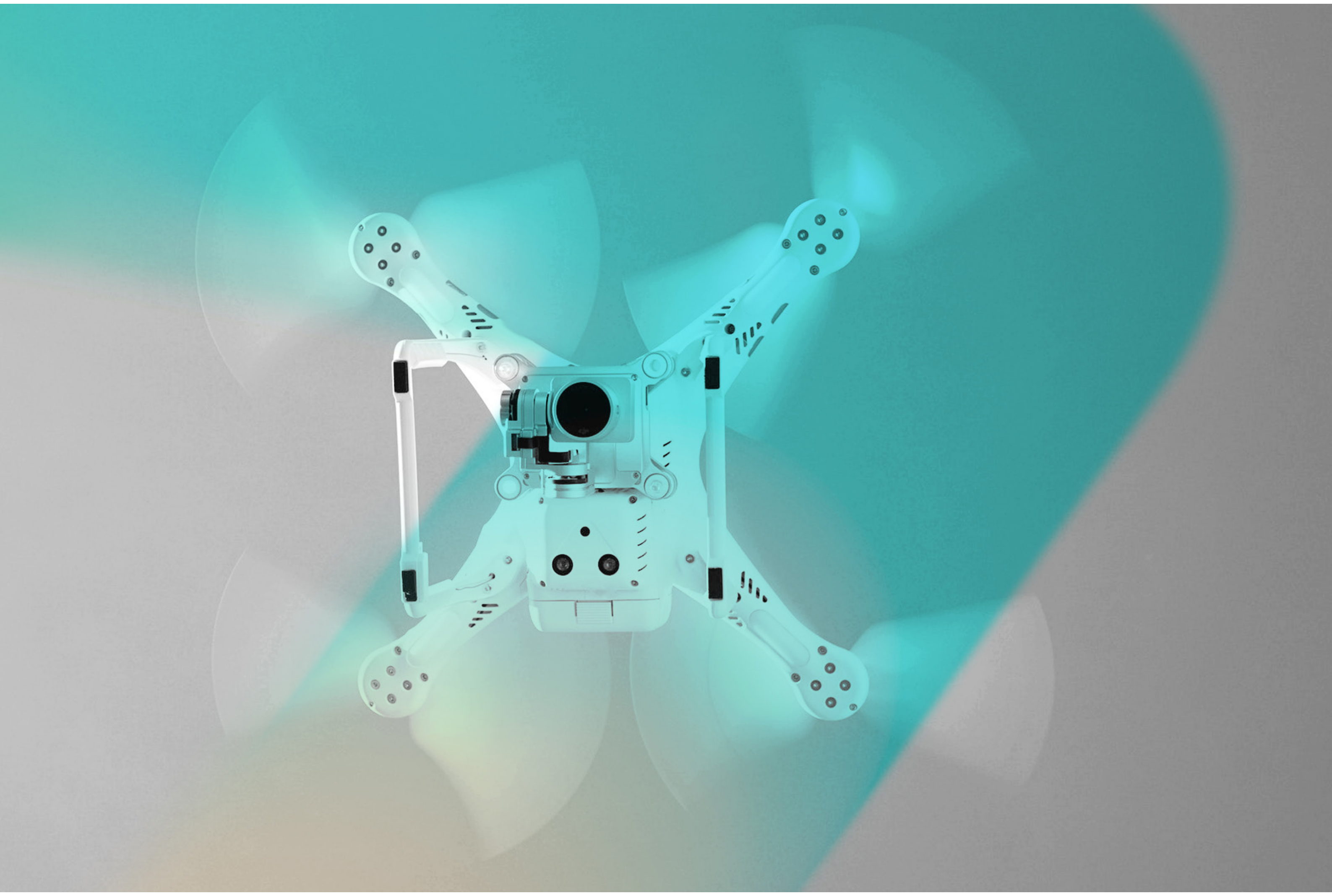
Smart Industry



Under this new Industry 4.0 paradigm, Advanced Manufacturing acquires a new dimension, becoming essential in order to achieve the main objectives of the sector: increase production, reduce manufacturing and operational costs, improve production process flexibility and enable scalability in costs and functionalities.

The reduction in cost and increase in the reliability of the technology has led to a series of digital solutions achieving a higher profile, with direct application in the industrial value chain, used to achieve the objectives mentioned:

- Augmented Reality and Virtual Reality. Vision and mobility technologies to optimise processes in the industrial sphere.
- UAVs or drones. Reusable vehicle without human crew, capable of autonomously maintaining a controlled and sustained level of flight.
- Wearables. Portable devices of very low intrusiveness and completely adapted to labour operations.
- 3D printing or additive manufacturing. Type of manufacturing in which 3-dimensional objects are created through the additive superimposition of consecutive layers of material.
- Cobots. Collaborative and easily programmed robots.
- Autonomous Guided Vehicles (AGVs). Driverless vehicles which arrive at their destination automatically and whose main function is the movement of materials.



03 Augmented Reality and Virtual Reality

La Realidad Aumentada (RA) y la Realidad Virtual (RV) son tecnologías avanzadas de visión que se diferencian entre sí por el grado de inmersión.

Augmented Reality (AR) and Virtual Reality (VR) are advanced vision technologies that differ in their level of immersion. The first of these allows reality to be augmented through the addition of virtual information to the real, physical vision, while the second creates a new appearance of reality allowing the user the sensation of actually being present within it.

These visualization technologies are one of the types of electronic device with greatest potential for growth in the coming years. Thus, the associated CAGR between 2016 and 2022 has been quantified at 70%, reaching a market value in 2022 of $152 billion[4].

Within AR and VR, there are different categories depending on the segmentation criterion used. For example, by type of hardware-software components, type of device or support electronic, etc. The most frequently used criterion is based on a technological viewpoint, differentiating between the following types:

AR technologies:

- Based on markers. They use a physical marker (active or passive marker) placed in the real world which is recognised by the device's cameras. At that moment, the application sets the digital experience in motion.
- Without markers. This type does not need markers to launch the digital experience. Instead, recognition is used based on models (heatmap, textures, etc.) or processed images (image patterns, outlines, etc.).

VR technologies:

- Not immersive. Virtual reality is developed using desktop applications in generic devices (PCs, tablets, etc.).
- Partially immersive. Virtual reality is developed using applications that run on high-resolution devices (multiple TVs, high-res projector, etc.).
- Completely immersive. Virtual reality is developed using applications that run on devices attached to the head, usually glasses.

4 Marketsandmarkets: Augmented Reality and Virtual Reality Global Forecast to 2022

Main advantages of AR and VR

Immersion-based vision technologies have a multitude of advantages in comparison with traditional technologies. From the point of view of direct application to the industrial environment, the major advantages are:

- Simple breakdown of integrated components. In assembly tasks, where there are a large number of components, augmented reality makes it possible to break down all components and add key information to simplify the assembly operator's job.
- Integration with other technologies. Vision technologies are easily integrated into other modules such as that of voice recognition. In this way, the combination of technologies makes it possible to increase efficiency in some tasks such as the maintenance of complex machines.
- Delocalized support. The connectivity of these devices allows the virtualization of support tasks by connecting to the operator's in situ vision, centralizing it with the application of advanced support managed from a different location.
- Immersive Training. Virtual reality makes it possible to recreate real situations to train operators performing high-risk work, which requires complex training.

Examples of use – Augmented Reality for maintenance of Thyssenkrupp lifts

Thyssenkrupp, German iron and steel firm, dedicated to steel production and the manufacture and service of steel-based products (lifts, technology, engineering products, automotive industry), has digitised the maintenance process for its lifts division, which provides the company with almost 60% of its overall EBITDA.

For this purpose, it has provided HoloLens augmented reality glasses to more than 24,000 maintenance operators so that they can see and identify maintenance problems, and have hands-free access to expert support information. As well, they have real-time access to all the company's predictive maintenance intelligence on lifts. This allows technicians to analyse the maintenance needs of each lift in real time. The glasses are also used for the training of technicians.

The use of these technologies has enabled ThyssenKrupp to reduce the stoppage times for its lifts by 50%, reduce the number of calls for maintenance to one quarter, increase the lifetime of its lifts, and increase the safety of the operators.

04 UAVs

UAVs (unmanned aerial vehicles) or drones are aircraft without human crew, capable of autonomously maintaining a controlled and sustained level of flight.

As well, a drone has capacity to incorporate different technological modules, eg, flight module, processor, power source (battery), communications, vision, etc.

With mature and proven technology, in the last few years numerous use cases have appeared in all areas (consumer goods, industry, space…) which boost the growth of drones. The size of the market will reach $21 billion in 2022 (CAGR of 20%)[5].

There are different categories to differentiate the types of UAVs. Most importantly, there is a distinction between military and commercial drones. The first of these are characterized by their high flight autonomy, stability and robustness. The second are characterized by their ability to include different modules, adapting to different use cases, and by their light weight (<150 kg).

The UAVs applied to the industrial sphere are commercial drones that may be fixed wing (similar to a scaled-down aircraft) or VTOL (Vertical Take-Off and Landing). In this last group are rotary wing drones, hybrid drones (a mixture of fixed and rotary wings) and nano drones, with rotary wing drones being the most common in industrial environments.

5 Marketsandmarkets: Drones Market Global Forecast to 2022

Main advantages of UAVs

The advantages associated with the use of UAVs are closely related to the use case or specific scenario to which this technology is applied, and can be summed up as follows:

- Capacity for action in areas of high danger. Drones enable access to difficult areas such as electricity grids, power station chimneys, etc.
- Self-guided motion without need for human interaction Drones do not require human intervention for the ongoing management of their trajectories, having the ability to be autonomous in traditional manual tasks.
- Simple integration with other systems. It is easy to add modules, thus improving the drone's capability to integrate in the industrial ecosystem.

Use cases

Drones for the digitisation of inspections at Airbus

Aeronautical manufacturer Airbus is turning to smart industrial drones, data analyses and auto-learning to make aircraft inspections simpler and time-efficient.

The Falcon drones employed are V-shaped octocopters featuring high-resolution cameras (42 megapixels) to capture accurate data. They are also equipped with RealSense cameras giving the UAV "robotic eyes" to avoid colliding into obstacles.

Falcon captures aerial photos in high-quality that are used to create a 3D model of the analyzed airplane. The specifically-designed software used by Airbus analyzes digital images so that inspectors can identify the damage, locate it accurately, and document the sections for a verifiable inspection.

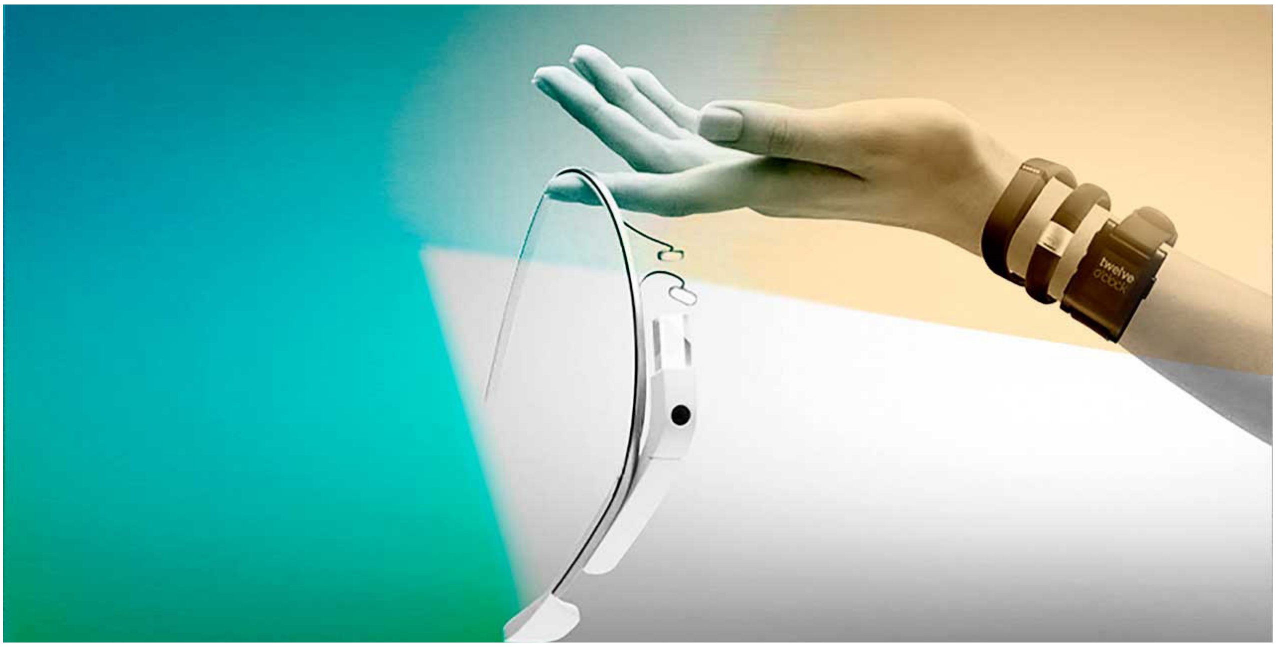
In the past, quality inspections of the Airbus A350 required two operators, who needed two hours just to place the lifting platform. Currently, it only takes 10 minutes for the drone to fly around the entire plane, capturing 150 high definition photos and obtaining the first results of the inspection.

In this way, Airbus has managed to reduce the A330's development timeline, save operator time, improve communications among the different teams and, ultimately, increase aircraft manufacturing productivity.

05 Wearables

Wearables are electronic devices that are worn on some part of the human body and which interact continuously with the user and other devices as part of some specific function.

In recent years this type of devices has spread exponentially, boosting its market due to the decrease in cost and the increase of the useful life of its batteries. The growth trend will continue in the coming years, with its market value rising from $16bn in 2015 to $52bn in 2022 (CAGR of 16%)[6].



The main use of wearables has traditionally been linked to the consumer sector (sports wristbands, smartwatches, etc.), but the use of these devices among workers in the industrial sector has become more frequent.

6 Marketsandmarkets: Wearable Technology Market Global Forecast to 2022

Major advantages of wearables

The main advantage of wearables is that there is no need for conscious interaction, i.e. the person (operator) using a wearable does not need to devote full attention to operating the device, as in the case of smartphones, tablets or PCs.

In the industrial sphere, this advantage implies numerous valuable features associated with two main benefits focused on the operator:

Improved operator efficiency

- Monitoring of the movements in plant or in the logistics chain
- Integration with in-plant operational systems, (eg, production planning and execution system)
- Scalability of functionalities. It is easy to add, integrate or communicate with other modules that provide additional functionality (launching an order and voice recognition, etc.)

Operator safety

- Compatibility with a wide variety of sensors that capture the different physical parameters related to the environment (acceleration, gas level ...) and the operator (physiological data)
- Location of the operator for managing the access to dangerous areas or areas requiring special clearance

Use cases

Wearables for safety in Amey (Ferrovial)

Amey is a service company belonging to the Ferrovial group. In 2017, it commissioned a project to learn how the workday impacted on the physical and health of workers, and provided insight into how the human body responds to the different tasks of the working day.

Amey has deployed wearable technology to track the health and physical well-being of its workers. More specifically, the firm has used smart vests to control different health parameters: heart rate, breathing, steps, posture or stress levels. The main physiological data were correlated with the activities performed by the operators.

Situations were identified in which it was necessary to reinforce safety due to the stress behaviours shown by professionals.

Some of the situations included driving vehicles in reverse, tasks in irregular surfaces, or driving in heavy traffic. Following the study, are being integrated cameras in and vehicles to strengthen the safety in this kind of manoeuvres.

Since the introduction of wearables, Amey has seen a fall in the amount of sick leave taken by its operators, has reduced stress levels under critical situations and has ultimately increased user safety.

06 3D printing

3D printing or additive manufacturing is a manufacturing technique that creates three-dimensional objects based on the adding of consecutive layers of material, using a 3D CAD model.

In terms of materials, most applications are based on polymers, fewer are based on metals (cladding, powder metallurgy) and some specific applications with building materials.

Initially, 3D printing only referred to a process that deposited binder material on a powder bed by means of layer-by-layer print heads, hence the use of the term printing.

Currently, it is used as a term that covers a series of different additive manufacturing techniques (the most popular is extrusion printing). Other common techniques are:

- Binder injection
- Direct energy deposition
- Extrusion of material
- Injection of material
- Powder bed fusion
- Lamination of layers
- Polymerization in tub

Extrusion 3D printer

Industrial jet binding printerand detailed agent

It is estimated that by the end of 2021 the additive manufacturing market will reach $11bn, $6bn by the end of 2017, starting from about $4bn in 2015[7].

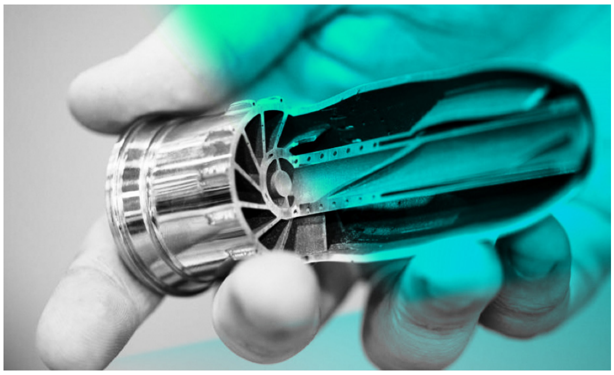
7 Marketsandmarkets: 3D Printing Technology Market Global Forecast to 2022

Main advantages of 3D printing

The main advantage of 3D printing is the flexibility to design the geometry of parts and the possibility of manufacturing without tools, which means that this production is completely flexible, as it is capable of varying geometries, references, combinations of these, etc. from one batch to the next.

The flexibility to generate geometries which could not be obtained using the previous manufacturing methods is one of the characteristics that has allowed additive manufacturing to enter the industrial world. Applications include the manufacture of blades and injectors for gas turbines, for power generation and aviation engines (GE, Safran), which benefit from the ability to manufacture much more complicated designs for the internal cooling channels and fuel and oxidizer transport conduits. As well, in the medical sector, very promising applications have been found in prostheses and implants that are completely adapted to the bone and muscle geometry of patients. Customised manufacturing tools and aids are also widely used.

As well, the flexibility in manufacturing (without tools, and with the ability to change between one batch and the next) has generated a new business model in which buyers can upload a 3D model to a manufacturers' marketplace, specify materials and other conditions of manufacturing and delivery, and a pool of manufacturers with "farms" of 3D printers can give a quick quote for the manufacture of the parts uploaded to the marketplace. All of this is facilitated by the standardization of 3D models, speed in preparing the manufacture in the printers, etc.



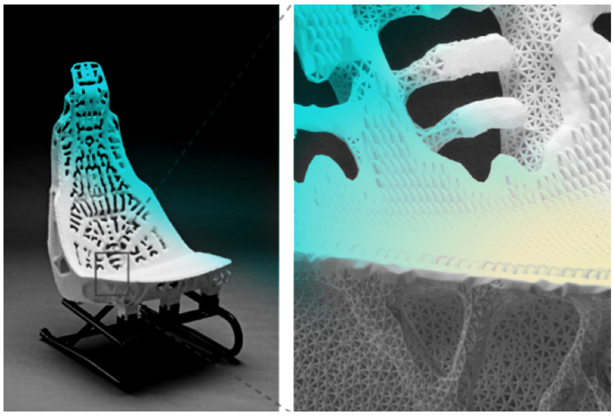
Cut into a turbine injector made with 3D printing (GE) and an example of a bone implant made with 3D printing

Example of use

Design of a light car seat

Toyota and Materialise worked together to design and print a car seat which was as light as possible and they ended up concluding that 3D printing was the technology that was going to give the best result.

Using topology optimization algorithms, a seat was designed with areas of different densities, mesh structures and other patterns for support and an external geometry with "interfaces" with the driver and the anchoring structure. The final result was printed in 3D, giving a final weight of 7 kg (traditional seats weigh considerably more than 15 kg) and also improving the ventilation capacity of the seat.



Details of Toyota's new seat design

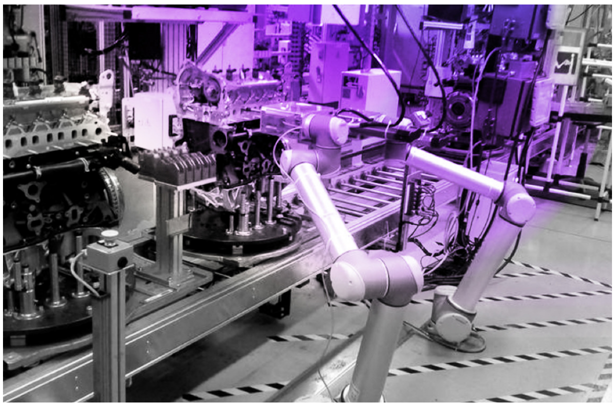
07 Cobots

Cobots are robots that have two main characteristics compared with the “classic” robots.

- They can work side-by-side with people thanks to new, much more robust safety systems (due to the technological improvements that have enabled faster, more reliable and cheaper systems for detection of collisions)
- The programming method is much more intuitive, flexible and simple, allowing people without training to programme the tasks of the robot

Cobots were first conceived as part of a General Motors initiative in 1994 that intended robots to be safe enough to physically interact with operators in a shared environment.

By the end of 2017, the worldwide robot fleet is expected to reach a total of almost 2,000,000, up 66% since 2013, when there were just over 1,200,000 installed. This great growth has been mainly due to the reduction of costs per robot (A -25% fall since 2014 and an expected additional -22% fall by 2025)[8].



Cobots bolting engine blocks in a Renault factory

Operator programming a cobot on wheels for line discharge

Major advantages of Cobots

The main advantage of Cobots is the possibility of working side by side with people without the need for protective barriers.

This has made possible the emergence of new ways of working and has allowed the application of robots to new areas in which had not developed before due to space and safety restrictions.

Among the new ways of working are cases in which the robot interacts actively with the operator, either operating as an intelligent tool, performing the dangerous parts of the process, automating repetitive tasks within jobs that have a lot of variability, and so on.

8 Marketsandmarkets: Collaborative Robot Market Global Forecast to 2022

These advantages give rise to the main impacts of incorporating cobots into the productive processes

- Automation of non-ergonomic / repetitive tasks
- Improvement in assembly times
- Greater flexibility of automation for changing environments
- Automation in restricted areas (mainly due to lack of space)

Example of use - Volkswagen engine assembly plant

Volkswagen has installed a cobot unit in one of its engine plants in Salzgitter to perform the insertion of spark plugs. Previously, the operators had to insert the spark plugs in a stooped position in the barely-visible holes of the cylinder heads. Now, the cobot puts the spark plugs in places and the operators only need to tighten them and insulate the cylinder head.

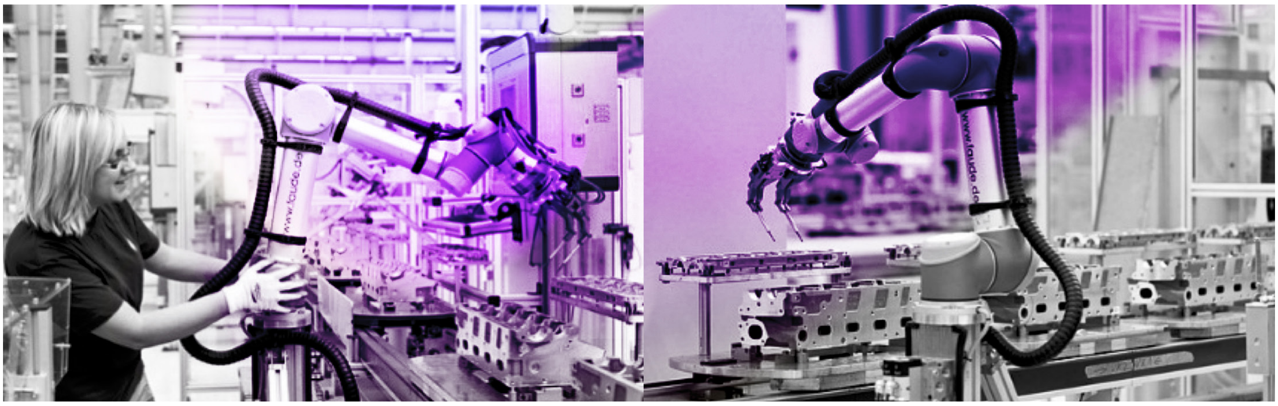
Thanks to the help of the cobot, work injuries have been reduced by avoiding the poor posture of the operators and improving the quality of the operation through automation.

AGVs

Automatic Guided Vehicles are driverless vehicles that are guided to their destination automatically and whose main function is the movement of materials (from / to: warehouses, production areas, goods shipping/receiving areas) in factory interiors and in some outside areas.

The growth of the market for AGVs in recent years has been due to cheaper and improved technologies (batteries, electronics, processing capacity, new / better sensors for guidance - Lidars, etc.) which have made it possible to simultaneously reduce costs and add new functionalities to classic AGVs (large guided cars designed to move heavy loads on fixed and repetitive paths).

The market is expected to grow by 9% per annum (CAGR) from 2017 to 2022.



Cobot in VW engine assembly line

Main advantages of AGVs

The main advantage of an AGV is that there is no need for an operator to perform the driving tasks.

As well, with the aforementioned advancement in technologies, an AGV or an AGV system also has other functionalities that can give rise to some very attractive business cases:

- Higher flexibility to change routes (improvement of flexible guidance technologies – laser, optical - against traditional technologies– wire guidance)
- Real-time optimisation of internal logistics routes
- Automatic loading and unloading of materials
- Picking assistance
- Connection with ERPs, SGAs and other company/software/plant/warehouse/flow management applications

Kuka AGV cobot

Use example - Amazon warehouse robots

In 2016 Amazon increased the number of robots in its processing centres by 50%, up to a total of 45,000, working together with 230,000 people (data from early 2017).

Amazon has automated its warehouses with robotic AGVs that are in charge of the movement and shelf positioning of the products. This change in technology has meant that the pick and pack is performed goods-to-person instead of person-to-goods. These AGVs serve as a mobile and automatic goods warehouse, so workers can avoid having to move to the place of storage of the orders under preparation. They also improve warehouse space efficiency because wide corridors for forklifts are no longer needed.

AGVs are connected to the warehousing ordering and management system and operate autonomously, reducing the picking time, minimising the errors produced when doing this task manually and, ultimately, reducing the overall lead time of Amazon's products.

VGAs de Amazon

08 Minsait and the Advanced Manufacturing

At Minsait we have capabilities and knowledge in Advanced Manufacturing at different levels, complementing our solutions software offering in Industry 4.0 and allowing us to prescribe the best solutions to our clients in their path towards complete digitisation of their enterprises.

Own Capabilities

Minsait/Indra has its proprietary and tested assets in :

Virtual reality

- Simulation environments
- Training and serious games
- Immersive reality with glasses

Augmented reality

- Mobile devices: smartphone and tablets
- Specialised devices: glasses

UAVs

- Military
- Commercial drone manufacturing centre
- Commercial uses such as communications platforms

Wearables

- Monitoring of physiological parameters
- Geolocation

Partner ecosystem

In some advanced manufacturing areas, we are developing a partner ecosystem that will provide our clients with an expert viewpoint and an opportunity to implement advanced manufacturing technologies within the Industry 4.0 offering:

- Automatic Guided Vehicles
- Collaborative robots

Expert knowledge

We have expert 3D printing knowledge to help support our potential clients in the application of 3D printing in their business.

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Minsait is the Indra business unit that responds to the challenges which digital transformation poses for companies and institutions.
Indra is one of the leading global consulting and technology companies and the technology partner for the key businesses of its clients around the world.

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