White Paper

Reshaping production in the Aerospace sector with Roboze 3D printing

Roboze

Introduction to Additive Manufacturing

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Additive manufacturing (AM), known as 3D printing, is the opposite of traditional manufacturing methods. In this technology, instead of subtracting material from a block, the object comes to life by successively depositing layers of material on top of each other until the final part is complete.

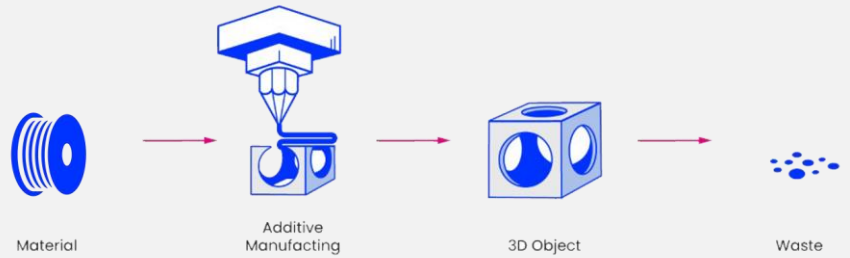
Most of the existing 3D printing solutions on the market today see their maximum expression in the prototyping phase. Obtaining a prototype in a few days allows projects to develop quickly and with reduced costs, as well as enabling more reliable testing by letting operators quickly set up subsequent iterations of the product, while reducing time-to-market.

This method therefore optimises the production process by pushing technicians to design more complex parts and achieve new performances. In this context, the customization of each single piece in low-volume batches is almost at no cost.

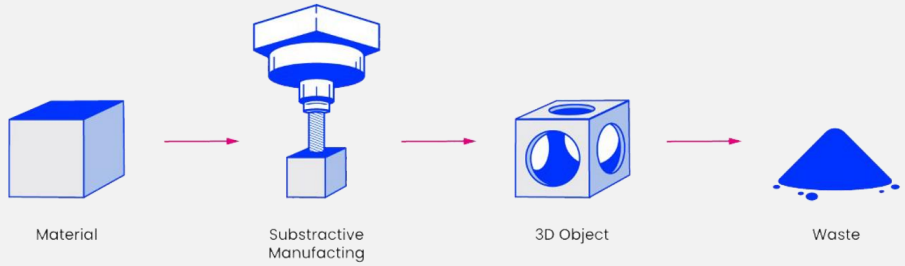
But limiting AM technology to mere rapid prototyping is not enough, it must be allowed to unleash its full potential also in the production of small quantities of customized end-use parts at relatively low costs.

Roboze has created a 3D printing technology ecosystem aimed at expanding the impact of AM on a company's value chain by shifting the focus of technology from rapid prototyping to actual production.

The Production solutions, in fact, finally bring 3D printing on a par with conventional methods such as CNC machining and injection moulding, in terms of consistency, repeatability and process control, integrating perfectly into the production workflow of manufacturing companies and positioning themselves as customized manufacturing solutions.



Additive Manufacturing



Substractive Manufacturing

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Roboze's path for the adoption of AM technology

The innovation process is of fundamental importance for the businesses' growth, increase in performance and sustainability of the competitive advantage. For this reason, choosing to implement 3D printing technology in your processes is not an immediate and simple step, unless you want to use it only for prototyping.

As previously mentioned, the main objective is to shape a new paradigm in digital production through a complete range of advanced 3D printers developed with the collaboration of the best world players, bringing AM closer to the standards of traditional production. To do this, Roboze has created a team of experts able to analyze every single need of your production chain by sharing their know-how and supporting their customers in the digital transformation.

Process analysis and creation of digital twins

The first step, therefore, is a careful analysis of the company from the point of view of the process and products. Once the points for improvement have been identified, we move on to choose those applications that can already quickly return part of the investments in resources, time and machinery. Cost savings during the production phase can be attributed to reduced assembly, shorter supply chains and reduced use of materials.

The process starts from a 3D model, where, thanks to the additive approach, the configuration and equipment costs are irrelevant. The creation of these *digital twins* of real parts allows to gradually create a digital warehouse, resulting in lower logistical cost since there is no longer the need to store physical stocks, thus reducing the need for spot purchases or unnecessary fixed assets in the warehouse.

Roboze's path for the adoption of AM technology

Roboze has developed a technological ecosystem called Roboze Automate which perfectly meets the needs of innovative manufacturers. The Roboze Automate technology, integrated in the ARGO Production series, was created to accelerate the transition to a new era in customized production of finished parts on demand and just in time by increasing applications in metal replacement as well as the scalability of production around the world.

The 3D Parts network, made up of innovative service providers, highly specialized in engineering, production and post-processing of finished parts and functional components, equipped with the latest Roboze Production system, is the backbone of the distributed production model that Roboze promotes.

Through this network, companies all over the world can rely on the manufacturing as a service model, allowing them to reduce costs and time by shortening the steps in their supply chain and digitalizing their inventory, without the need to implement the technology in house.

Furthermore, in terms of sustainability, this model has several advantages:

- ability to reduce material waste both in the technological process and in warehouses;
- ability to optimize geometries and produce lightweight components, which result in reduced material consumption during production and energy during use;
- reduced transportation, as parts can be produced locally, which can lead to fewer emissions.

The Aerospace sector

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The aviation and space industries are some of the most challenging for manufacturing technologies and materials, due to the incredibly high standards that must be met. For this reason, aerospace companies are notorious for being slow to adopt new technologies, given the high costs and potential for tragedy in case of a failure.

Yet, the adoption of 3D printing solutions has been growing steadily in the last decade, so much so that additive manufacturing is now regarded as a fundamental technology for the future manned exploration of the solar system.

Roboze has developed a set of innovative technologies and materials that allow aerospace companies to take full advantage of 3D printing and manufacture parts that are difficult, if not impossible, with traditional technologies. This in turn allows to truly push the boundaries of what is possible and create a new generation of air and spacecraft that incorporate strength, toughness, and resistance to dangerous environments like low-Earth orbit.

Metal Replacement in extreme environments

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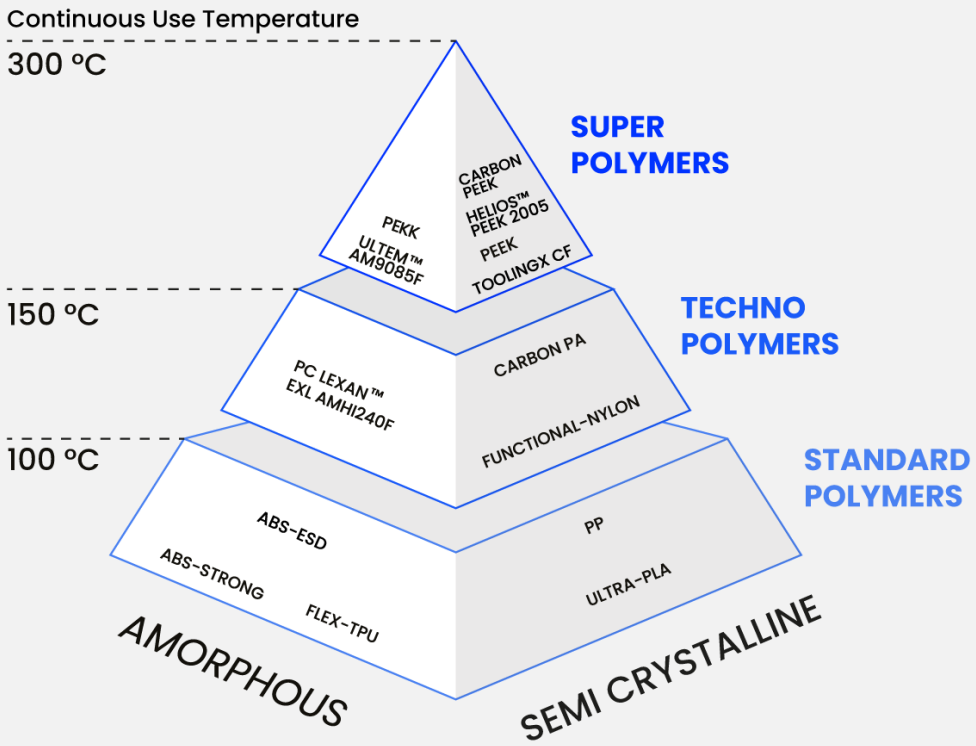
Metals such as Inconel, titanium, steel, and aluminium are heavily used in the aerospace industry because of their strength, rigidity, and high temperature resistance, for example to manufacture turbine blades and rocket combustion chambers.

Yet metals have several downsides that, in contemporary times, are becoming more and more of a hindrance. First is their high density and therefore weight, leading to lower fuel efficiencies and higher operating costs. Second is a low chemical compatibility, which can lead to corrosion and weakening and is problematic when exposed to environments such as that found in low Earth orbit. Finally, metals easily conduct heat and electricity, which is useful in certain situations but can be a hindrance in others, leading to the need for isolation using other materials.

Polymers have revolutionized industries around the world as well as our lives. More and more in recent years, parts that once were the exclusive domain of metals are now being manufactured with plastics thanks to the development of stronger, high temperature “super” polymers. 3D printing further enhances the capabilities of these high-performance polymers thanks to its inherent design freedom.



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Metal Replacement in extreme environments

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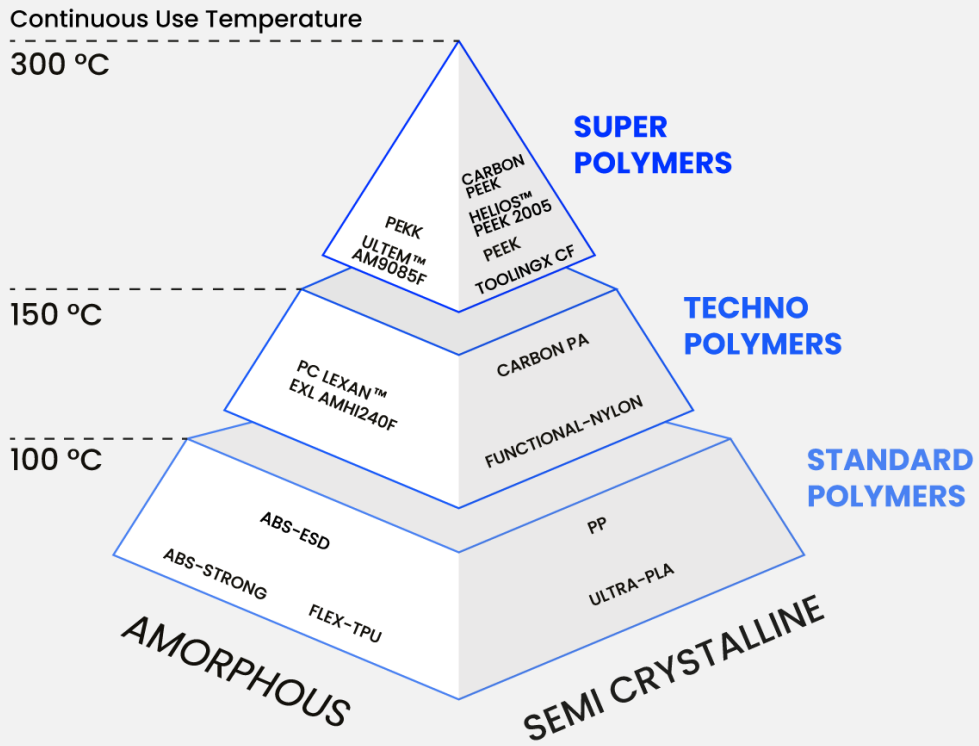
There are hundreds of applications for plastics, but one polymer is more suitable than another for a given application and there are several properties to consider that determine the best possible use. Selecting the type of material based on operating conditions is critical to preventing failures and ensuring the smooth operation of a part. Combining different polymers with 3D printing can make all the difference in the modern competitive landscape.

Roboze offers a wide selection of polymeric materials for 3D printing, ideal for a wide range of applications.

PEEK, Carbon PEEK, Helios™ PEEK 2005 and ULTEM™ AM9085F are the ideal candidates to support metal replacement applications in the aerospace sector thanks to their high strength, toughness, and resistance to chemicals, radiation, and high temperatures.

Obviously, however, the material alone cannot be enough. It is essential to analyse compliance according to qualitative metrics, such as dimensional tolerances or any mechanical specifications. Compliance, along with performance and availability metrics, are among the most important elements considered when designing a production cycle.



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Advantages of Roboze 3D printing solutions

Materials that resist extreme environments

Parts in the aerospace sector are subjected to high stresses, temperatures, and can be attacked by radiation and chemicals, therefore only the highest quality materials can be used. The table below summarises the properties of the main Roboze materials for use in the aerospace sector, showing that they are well up for the challenge of this demanding industry.

Material	PEEK	Carbon PEEK	Helios™ PEEK 2005	ULTEM™ AM9085F
Tensile strength (MPa)	95	139	125	98
Tensile modulus (GPa)	3.5	10.7	8.8	2.9
Heat deflection temperature (°C at 1.82 MPa)	161	249	171	175
UL94	V0			

Roboze manufacturing ecosystem

Roboze has developed and entire ecosystem to support industrial level printing, allowing the manufacturing of the highest quality parts with the most accurate and repeatable systems on the market.

The most distinguishing feature of Roboze printers is the lack of rubber belts to move the extruder. By removing the belts and integrating a direct mechatronic movement system of the X and Y axes (rack-and-pinion), Roboze has brought 3D printers closer to the world of CNC machines, ensuring a positioning accuracy of 10µm and guaranteeing a medium tolerance class in accordance with ISO 27 68 for parts that come out of the printer with no post-processing.

The incredible performance of Roboze printers is a result of various features, including the HVP (high-viscosity polymer) extruder, HT (high-temperature) dryers, heated chamber, and vacuum system.

Advantages of Roboze 3D printing solutions

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They also come with a PLC system. Having industrial electronics on board means relying on components that are certified and tested for hundreds of hours in challenging conditions resulting in a perfectly stable process every time.

The PLC system also allows careful logging of all print settings and the operators that used the machines. This means complete traceability of the printing process, so when a print goes well there is a record of the settings and conditions that enabled that. Of course, the opposite is also true, when a print is not successful, a search into the reasons for this can be easily done.

Aerospace parts have a slow development process and require very high manufacturing standards and materials, which the Roboze printing ecosystem can provide. Manufacturing functional prototypes during the development phase is easily done and greatly helps to speed up the process since design changes are easily implemented and new versions can be quickly manufactured and tested.

At the end of development, functional parts are also printed with ease, especially if some prototypes were manufactured beforehand. Successfully printed parts and print files can be saved to create a digital warehouse of parts that can be printed again in the future, without the need for development or test prints. This all allows novel geometries to be developed and used, increasing part functionality and reducing mass via metal replacement and optimised geometries.

The result is reduced development and manufacturing times, costs, and part weight, the latter being particularly important in the aerospace industry to increase efficiency.

Case study: Carbon PEEK holder for CubeSat payload

Aerospace & Defence

Roboze

University of Colorado Boulder

Application:

CubeSats are a class of small spacecraft that are easy and cheap to manufacture and launch. The price for sending 1 kg of payload with SpaceX Falcon Launcher is $ 2500 so any gram saved is advantageous.

CANVAS is a spacecraft that will be launched in 2023 in a low-Earth orbit to analyse the effects of lightning on the near-Earth space environment.

3 instruments will be housed in the holder, along with the electronics. 3 re-designs were made, the third and final version is shown.

143 g | € 300

Advantages of 3D printing:

- Reduced weight means reduced costs
- Easy implementation of design changes during development
- Complex geometries manufactured easily

Case study: Autoclave cure tool for carbon fiber lamination case in Carbon PEEK & Carbon PA

Metal replacement applications

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Application:

Carbon fibre lamination is a process where carbon fibre sheets impregnated with resin are layered on a mould then cured until they become hard.

After laying of the impregnated carbon fibre sheets in the mould, curing is a 2-step process:

1. Hot forming with a Carbon PA mould (up to 1 bar and 80°C)
2. Autoclave cure with a Carbon PEEK mould (up to 7 bar and 180°C)

Carbon PA
Mould

Carbon PEEK
Mould

Advantages of 3D printing:

- Plastic is lighter than metal so moulds are safer to handle
- Internalisation of production leading to time and cost savings
- Different materials for different working conditions

483 g | € 450

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Clamps for the jet engine blade production in Helios™ PEEK 2005

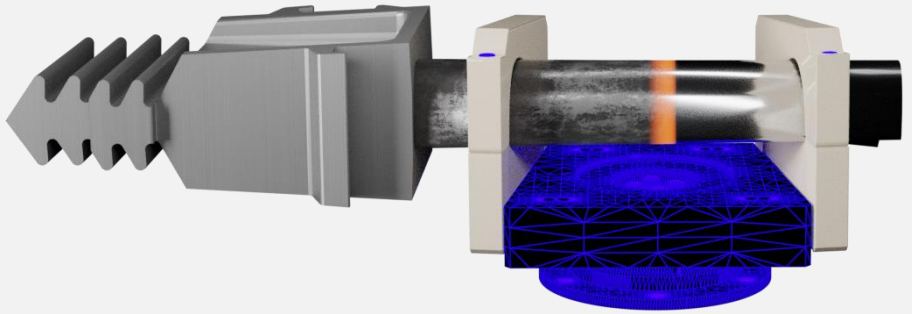
High Performance Tooling

Roboze

Application:

Turbine blades require very smooth surface finishes. Using precise milling and other subtractive manufacturing processes, the blades are held by clamps to provide necessary stiffness and ensure an accurate and repeatable process.

The curved shapes typical of blades require special clamp designs. Using traditional manufacturing results in more material waste and higher costs. 3D Printing has a much higher degree of design freedom, therefore increased geometric complexity has minimal impact on the cost per part.



Advantages of 3D printing:

- Design freedom
- Material can resist vibrations and thermal loads during machining process
- Can print custom production aids in just a few hours

4 h | € 210

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Case study: Busbar support in PEEK for spacecraft

Small production batches

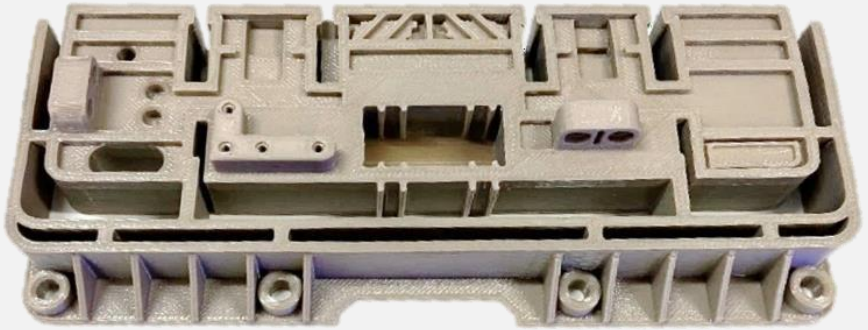
Roboze

Application:

Busbars are systems used to distribute high voltage and current electrical power. These find application in many sectors, including various spacecraft.

Supports hold conductive elements in place, preventing short-circuit. They need to be lightweight and able to resist high temperatures, in case of a short-circuit, as well as preventing the evolution of flame.

Being used in spacecraft, the material also needs to be resistant to the space environment.



Advantages of 3D printing:

- Strong material able to withstand launch
- Custom, low volume geometries simple to produce and with minimal material waste
- Can be used in space: low outgassing, chemical and radiation resistance

24 h | € 922

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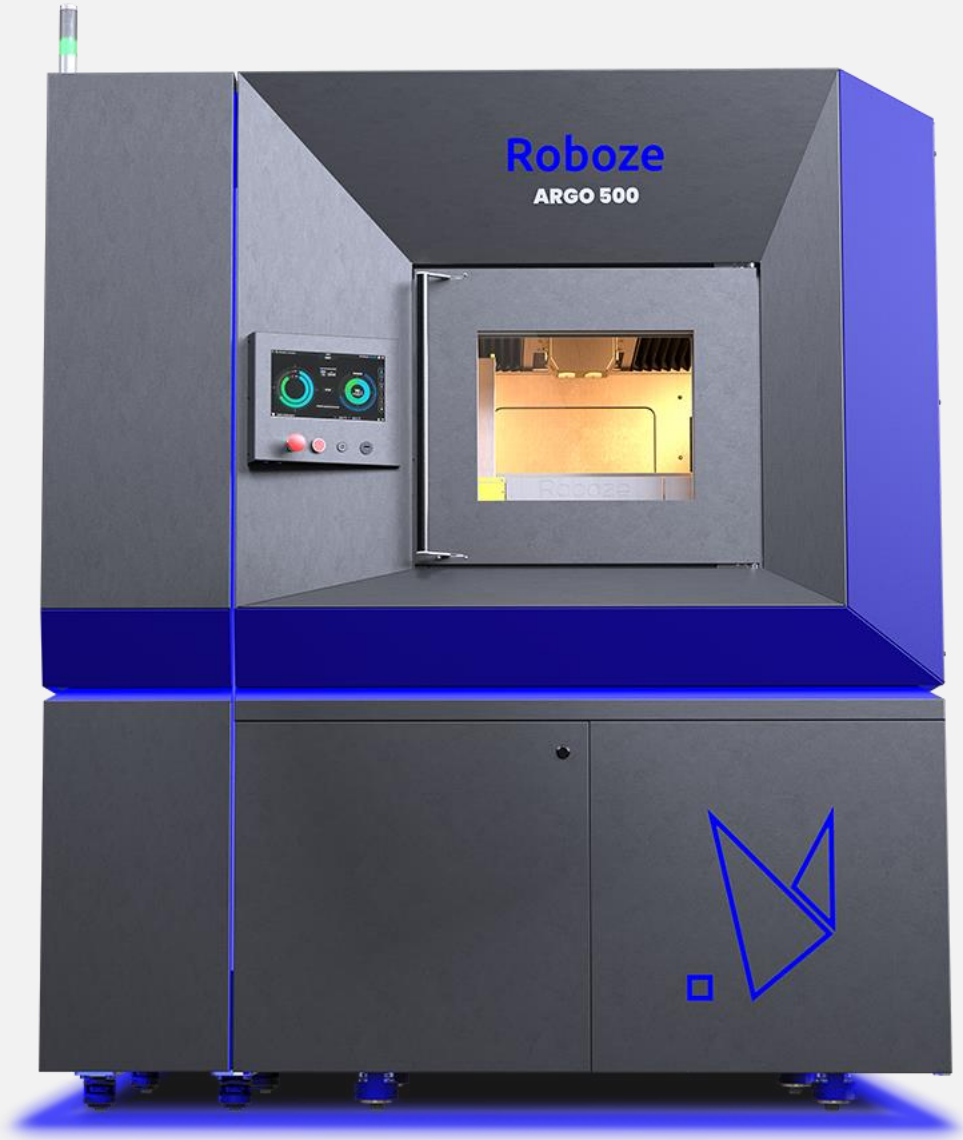
Conclusions

“Techno-polymers such as Polyether Ether ketone (PEEK), combined with a high presence of chopped carbon fibers, open up some interesting horizons for development. Thanks to Roboze technology that enables us to achieve previously unattainable levels of precision in fabrication, we can improve our capacity and speed in developing prototypes.“



Stefano Corvaglia

LEONARDO

Intellectual Property Manager & Head of Research and Development of the Aerostructures Division

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Keep in touch

Many players in the industry have successfully implemented Roboze services and technology and we would love to reach out to you to learn more about your company's digital transition possibilities.

Our consultants will listen to your requests and help you find the right solution for you.

For a personalized consultancy email at
info@ugogo3d.com

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Keep in touch

Roboze SpA - company certified according to
ISO9001:2015 standard / certificate n. 50 100 16683

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