CRP Technology

White Paper

Pioneering the AM Revolution in Aerospace

Achieving manufacturing challenges with Windform®

Windform® PBF composite materials are part of NASA, ESA, JAXA validated products for Space ready parts .
For up-to-date guidance on the realization possibilities we have described some of the major options in this guide.

For furhter information about Windform® Space opportunities, contact the team: **info@crp-group.com**

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Our Company

Welcome to CRP Technology

CRP Technology has successfully integrated engineering development, rapid prototyping and **3D printing processes** together with the **development of innovative composite materials** to create a continuously improving product development system.

The company is one of the main 3D printing companies **headquarted in Italy with partner in United States and branch in UAE.**

It can count on a well equipped production plant including high end, cutting edge sinter stations for additive manufacturing of small/medium/large formats and the most complete quality control chain, thus guaranteeing the respect of high quality standards for finished products, as well as validated parts.

Thanks to the development of Windform® line of high-performance composite materials, CRP Technology partners with the most advanced industry leaders in the world of **Motorsport, Aerospace, Design, Medical and Robotics.**

During the last decades CRP Technology provided **manufacturability and design feedback** for the creation of highly-functional and beautifully finished parts realized in Windform® **which raised performances and opened up new manufacturability scenarios for delicate projects.**

3D printing with Windform® enables the manufacturing of low scale functional parts counting on high quality standards including **high strength and durability.**

CRP Technology continues to foster a new revolution in both **manufacturing and materials development.**

Since 1996, CRP Technology (headquartered in Modena, Italy) has been changing the rules of additive manufacturing.
CRP Technology has been among the first to import AM technology to Europe, and the first to Italy;
its contribution didn't stop here.

Market and context scenario

The revolution among the stars

THE NANOSATELLITES AND MICROSATELLITES SEGMENTS

Additive Manufacturing is evolving very quickly.
It is a disruptive process capable to replace many traditional manufacturing technologies.

It is already powering the development of innovative, lightweight applications, helping product designers and engineers to create highly complex parts faster and more efficiently than before.

When it comes to the cost factor it cancels the tooling needed making it a fast and cut-price solution for small batches, limited editions and products with a constant need of update.
In this scenario, the range of obtainable applications is increasing, and the AM process is gaining momentum in offering even bigger opportunities across industries, unlocking entirely new business models.

Aerospace is one of the most advanced sectors that is experiencing the "Additive" revolution, especially the nanosatellite and microsatellite segments of the satellite launch industry. As matter of fact, in recent years the production and launch of small satellites and cube satellites increased, since they are providing a responsive alternative to larger, more expensive ones.

As demand to access to space grows, engineers are adapting these structures to provide new achievements and goals. Additive manufacturing technologies not only helped this radical change to be fulfilled, but reached new heights with the manufacture of structural components for the new generation of SmallSats using high performance composite materials.

This growth would not have been possible without advances in additive materials. And for this reason the number of materials available for AM has more than doubled in the past five years[1]. Furthermore the rules of manufacturing have been rewritten as the technical capabilities of the polymers met up with the opportunities that 3D printing offers in term of product development and low-volume parts production. High tech materials for professional 3D printing are leading to a new and irreversible development of traditional production schemes, and according to analysts the 3D printing with composite materials will be rapidly reaching a commercial tipping point[2].

[1] According to the 2019 Deloitte Insights Report.
[2] IDTechEx forecast that the market will rise to reach $2bn by 2031.

Nevertheless, it has not been invented a single material that can do everything yet. As additive manufacturing develops fast, there's even more urgent need to understand not only how materials for professional 3D printing work, but also their long term capabilities and properties in the field, in order to provide designers with the right material for any specific application. CRP Technology and CRP USA have built a considerable experience supplying cutting-edge solutions for space industry leaders.

Windform® materials orbiting

Over 25 years ago CRP Technology's R&D brought into market the Windform® range of high tech composite materials being immediately welcomed and adopted by the most demanding industry sectors for their **peculiar benefit of being suitable for the manufacturing of reliable, functional parts not only for prototyping.**

The aerospace industry couldn't fail to notice them, indeed they would have been **tested, approved and used for Space-proof applications.**

Polyamide-based, Glass or Carbon fiber reinforced, Windform® range has been satisfying the demanding needs of the industry, in terms of increased **design flexibility, high-mechanical performances, long lasting durability, lightweight and accuracy in complex parts realization**.
The Windform® family of composite materials has been constantly expanding during the decades, now encompassing the Windform P-LINE for High Speed Sintering and, above all, the **Windform® TOP-LINE[3] specifically developed for Powder Bed Fusion (PBF)[4], Selective Laser Sintering[5] .**

Sitting at the top of the range for Space applications stands Windform® XT 2.0, polyamide-based composite Carbon fiber filled.

[3] Windform® TOP-LINE is designed to offer customers full range of options, possibilities and features, from excellent thermal properties to resistance to high temperature, from high stiffness and excellent strength to reduced weight, just to name a few.
[4] According to DIN EN ISO/ASTM terminology, PBF comprises two processes: Multi Jet Fusion (MJF) and Selective Laser Sintering (SLS).
[5] It is an additive manufacturing technique that uses a laser as power source to sinter powdered material from a 3D model. This process does not require tooling to manufacture parts. It is ideal to produce tough, functional parts or prototypes, with the possibility to achieve excellent surface finish and fine detailing. The process has been taken to new heights by the use of Windform® materials.

Windform® TOP-LINE. Performances that count

Polyamide-based, Glass or Carbon fiber reinforced, Windform® TOP-LINE provides increased **design flexibility, high-mechanical performances, long lasting durability, lightweight and detailed accuracy in complex parts realization.**

IMPACT RESISTANT
Thanks to the tensile strength (up to 85,25 MPA and elongation at break up to 11,38%)

ELECTRICAL INSULATION
Non-conductive for fitting electronics.
CTI*: 600, maximum test voltage.

*Comparative Tracking Index

HIGH RESISTANCE TO EXTREME TEMPERATURES

OPTIMAL DENSITY WITH A MINIMUM WEIGHT

Sitting at the top of the range for Space applications stands Windform® XT 2.0, polyamide-based composite Carbon fiber filled.

Windform® XT 2.0 key points at a glance

Released in 2015, replacing former Windform® XT, it was introducing new and improved properties, including an +8% increase in tensile strength, +22% in tensile modulus and +46% increase in elongation at break.

Over the years, such enhanced features, combined with the design freedom offered by professional 3D printing, led Windform® XT 2.0 to be efficiently used in many applications for the most advanced sectors[6].

In the aerospace segment specifically, Windform® XT 2.0 has become a successful option in the development of small satellites, as CubeSats and PocketQubes for its resistance to UV, low outgassing and lightweight compared to strength. Such key characteristics allow for the replacement of traditional lightweight material like Aluminium in some applications.
The accomplishing to space requirements is proven by the successful result of NASA, ESA and JAXA outgas testing.

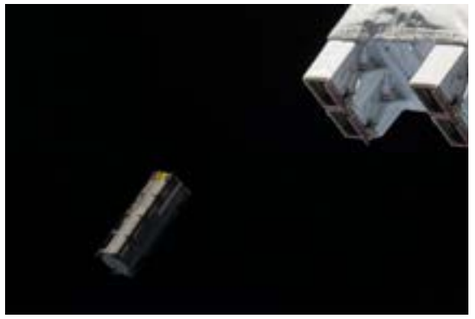
Aerospace and Avionics application spotlight

Since its foundation, CRP USA has pioneered the use of Windform® for space applications under the guidance of Stewart Davis, who has built up a team with considerable specialistic experience for the supply of cutting-edge solutions dedicated to key space industry leaders.

[6] For example Motorsport (alternator covers, end plates and fences for F1 and IndyCar vehicles), Automotive functioning cooling ducts, mirrors, headlight covers), UAS (the arms of Hexadrone's Tundra drone), and more.

TuPOD SMALLSAT
SHORT CONTEXT, BACKGROUND

CRP USA contributed to mark a new milestone in the small satellites arena with TuPOD, the innovative cubesat manufactured via PBF with laser, in Windform® XT 2.0 for the project carried out by GAUSS, Teton Aerospace, Moreheard State University.
The mission marked a new milestone in the small satellite arena: it is the first time that two TubeSats were deployed in Space, using the specifically designed and fully 3D printed TuPOD that functioned both as a satellite as well as a released platform.

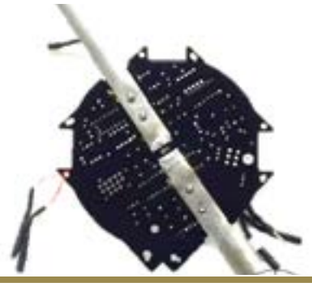


"TuPOD" deployed from the JEM Small Satellite Orbital Deployer (J-SSOD) Credit: JAXA/NASA®

The TuPOD is an innovative system, being at the same time a satellite – a 3U CubeSat – and a deployer platform – carrying inside two even smaller satellites of the size of a can, named TubeSat.

The unique properties of Windform® XT 2.0 material have allowed system optimization that successfully withstood the design requirements due to space limitations and the extreme conditions of the launch.

" Windform® enhances space-applications that require highest fidelity, small sections, and lightweight."



Electronics integration and design. Courtesy of Tetonsys

Special shape for batteries and electronics. Courtesy of Tetonsys

Electronics housing

A major issue addressed with Windform® was the creation of a special shape to house electronics: the problem was the complexity of wiring between multiple boards in such a compact space. Internally, **TuPOD is a smooth cylinder with no cavities** except for a separated section located in the lower part of the cylinder, housing a single board. This contains the PocketQube electronics and it is appropriately **separated from the satellite to avoid any damage** during the TubeSat integration operation.
The single board turned out to be a brilliant dual usage design.
During the course of **TuPOD qualification**, two series of severe environmental testing were performed and, at each stage, **multiple functional testings and deployment testings performed to assure the integrity of structure, electronics and the overall system.**

Users experience

“The TuPOD is a significant undertaking for the international space dissemination and it represents an innovation since its structure has been completely 3D printed”.

This small satellite/deployer is the result of a successful international collaboration. It has been designed, built, tested and integrated by GAUSS Srl in close cooperation with the company TetonAerospace, and it has benefited from the support of Morehead State University which provided environmental testing and initial electronic design, CRP USA which provided the manufacturing of the structure.

Prof. Twiggs, Morehead State University, Co-Founder Teton Aerospace, Founder CubeSat	**“This unique design was only possible with the 3D printing capability and expertise offered by CRP USA and the space qualified Windform® XT 2.0 material. The rapid response, low cost and quality were the key factors in making this a successful mission.”**
Amin Djamshidpour, designer of TuPOD, Co-Founder Tetonsys	**“ Using Windform® XT 2.0 material was one of the best decisions we have made. During the prototyping phase and even the final manufacturing, we got into multiple situations that we needed to drill the part or make small modifications to the 3D printed structure and working with Windform® XT 2.0 gave us the ability to do so.”**

UNIMAGINABLE ACHIEVEMENT IN SPACE APPLICATIONS

Chantal Cappelletti, Project Manager at GAUSS srl: **“Windform® XT 2.0 has passed all the flight qualification tests in complex systems as the International Space Station is. This achievement, unimaginable until recently, opens many perspectives on the possibility of using Windform® materials for space applications.** In particular, GAUSS Srl is more than satisfied with Selective Laser Sintering technique and considers Windform® family of high performance composite materials one of the disruptive revolutions in the small satellites arena. GAUSS is going to use them for new projects”.

Discovery’s Mini-Cubes

CRP USA manufactured several functional prototypes of Discovery PocketQube satellite monitoring water resources for Pennsylvania-based Mini-Cubes LLC.

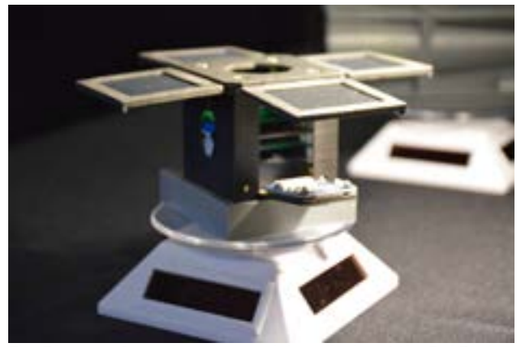
Discovery were the first functional, fully 3D printed, space-ready 1P PocketQube[7] prototypes made using Windform® XT 2.0 Carbon fiber reinforced composite material.

The Technical Problems we faced and our solution.
The challenge was to manufacture **a small satellite which needed to house a lot of possibly conflicting items in a very reduced volume: the PCB’S, a camera for visual observation and the radio system.**

CRP USA’s extensive experience with 3D printing proved to be essential in this mission; Discovery has successfully passed the control and testing criteria against interferences, vibration, thermal excursion.

Just to mention a few tests ran by Mini-Cubes LLC:

- load to over 20 Kg.
- Vibration to NASA GEVS-7000 specifications, subjected to a near vacuum to simulate the conditions in Earth orbit.
- Thermal +50c ÷ -40c.

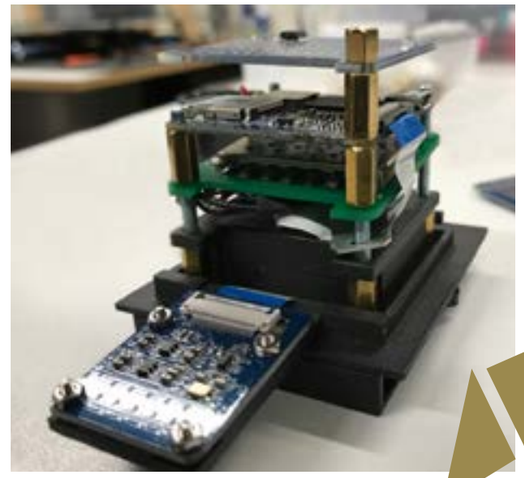


The Discovery 1a engineering model on display at the 3rd PocketQube workshop in Glasgow, Scotland. Courtesy of Mini-Cubes

Client credits

Joe Latrell, CEO of Mini-Cubes: “We knew we wanted to use additive manufacturing for Discovery but **understood that it would be hard to find a 3D printing composite material that would work in the harsh environment of space.**
The combination of strength and ease of use made the Windform® XT 2.0 a natural choice for us.”

Once again Windform® XT 2.0 – used in combination with the PBF process – was integral to the development of the Discovery PocketQube.
It enabled Mini-Cubes to iterate prototypes quickly, test them and tweak their design without drastically increasing project time and costs.



The internal operatonal electronics of the Discovery 1a engineering model. Courtesy of Mini-Cubes

While CRP USA committed to creating the Mini-Cubes’ 1P PocketQubes Discovery, in Europe CRP Technology was undertaking to manufacture the deployer for this type of device under the behalf of Alba Orbital. (See next page AlbaPodv2 deployer).
Find out more

[7]PocketQube is a type of miniaturized satellite for space research, with a mass of no more than 250 grams and a size of 5 cm cubed (one eighth the volume of a CubeSat). The original idea came from Professor Robert J. Twiggs from Morehead State University (MSU). The firsts dated back 2009.

AlbaPod$_{v2}$ deployer

Pocket Satellite Deployer

AlbaPod V2 is the updated version of Alba Orbital's deployer. Currently it is the only operational, flight proven 6P PocketQube Deployer on the market, fully 3D printed. Albapod V2 is the result of the fruitful partnership with the Glasgow-based Alba Orbital

The Technical Problems we faced

Not only did the full assembly need to function correctly to facilitate the deployment of the satellites inside, but it had also to contain the satellites in the event of catastrophic failure of a payload. As a matter of fact, during the launch, anything breaking free could fatally damage other payloads, or the launch vehicle itself.

"The mechanical performance of the 3D printed part was critical. These were tested thoroughly with free masses on vibration tables at extremely high loading and the shell held up phenomenally."

Client credits

"The most innovative aspect of the project was the sheer number of components we switched over to Windform® XT 2.0, not only the shell, but also the moving ejection mechanism and door assembly were redesigned for manufacturing in Windform®. The material allowed us the option to design parts that cannot be manufactured with traditional techniques due to thin sections and extremely complex geometry. These parts were manufactured and delivered in a fraction of the time for a traditional supply chain."

" The **weight has been improved** *as well: AlbaPod V2 has a mass of <500g,* **60% less than the original AlbaPod v1 ".**

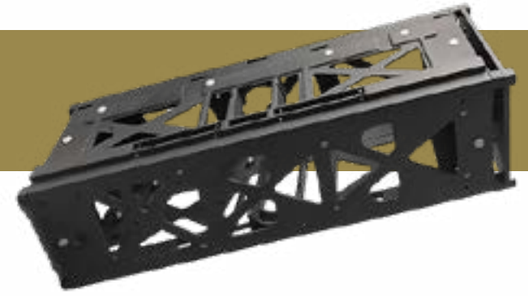
"Windform XT 2.0's toughness and strength made it the perfect choice for the manufacturing of the case".

Alba Orbital team
Find out more

NEW LAUNCH IN Q4 2021

One AlbaPod V2 was launched into orbit in late 2019, and on March 2020 it celebrated the 100th day on orbit. Other launches are expected soon: indeed, Alba Orbital recently announced the launch of sixteen PocketQube satellites via SpaceX Falcon 9 in Q4 2021, as the largest PocketQube deployment in history to date.

The first of the two fully loaded AlbaPod 2.0 being attached to the kick stage of Rocket Labs Electron rockets for launch. Courtesy of Alba Orbital



[8] OGMS-SA has two deployed solar panels connected to a power supply distribution in charge to control the batteries and provide the power buses to the satellite. It is a technical demonstrator for a space cavity ring down spectrometer (CRDS).

OGMS-SA 3U CubeSat
Goals and background

CRP Technology collaborated with the Laboratoire InterUniversitaire des Système Atmosphérique (LISA) of Université Paris-est Creteil (UPEC) on the construction of a 3U technological demonstrator CubeSat called OGMS-SA[8].
The goal of the project was to develop a demonstrator flight-ready in Low Earth Orbit.

THE ENVIRONMENTAL PROBLEMS FACED

The mechanical structure had to survive vibration tests **(to endure the launch) and thermal-vacuum tests. It had also to withstand outgassing requirements.**

The demonstrator was designed taking into account all of these constraints, and CRP Technology's consultancy was crucial to achieve LISA's aims.

CubeSat Structure is critical as it has to fulfill the launch-pad (P-Pod) requirements in terms of **dimension, flatness and roughness, but also for outgassing, UV resistance, thermal variation, and general space constraints.**

ADOPTED SOLUTION IN CUSTOMER'S WORD

"Thanks to CRP Technology's Windform® XT 2.0 we obtained very important **key advantages such as mass reduction, component integration, outgassing control, and low surface roughness**.

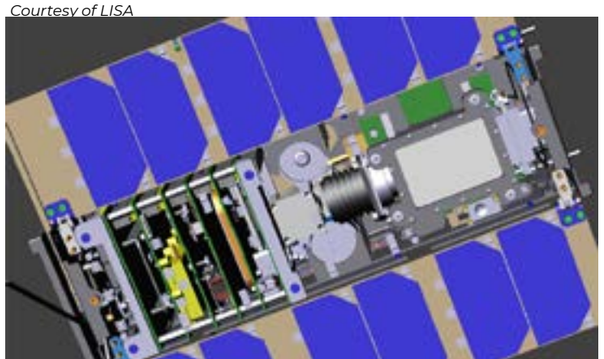
We are more than satisfied with PBF / laser sintering technique and consider **Windform® XT 2.0 one of the disruptive revolutions in the small satellites arena. We do hope to use additive manufacturing intensively in space applications."**

"Using such a 3D printing process and Windform® XT 2.0 we knew for sure we would have been able to design the structure exactly the way we needed it."
LISA Team.

Find out more

Antenna frame integrated in the 3D printed structure. Courtesy of LISA

3U CubeSat internal view. Courtesy of LISA



Wind tunnel model for Leonardo AW609, a revolution in aircraft performance

The AW609 combines the speed, range and altitude of a fixed-wing turboprop airplane and the vertical take-off and landing versatility of an helicopter along with the comfort of a pressurized cabin in which you can fly above bad weather.

The challenge was the realization of the prototype in 1:8:5 scale for AW609 Tiltrotor to be used for the wind tunnel testing.

TARGETS AND TECHNICAL DIFFICULTIES

The overall size of the prototype was a big issue that CRP Technology's technical team had to sort out: some components were larger than the construction volume of the 3D printing machines.

From the beginning it was clear that it was necessary to manufacture separately the various single parts, while ensuring the highest level of reliability, that such a demanding avionic application require.

The long experience and deep knowledge in 3D printing processes of CRP Technology's engineers accomplished the task after a deep project analysis, which led to the realization of the most suitable manufacturing process adequate to such complex project.
The goal was reached without any delay or issue during the printing phase.

From the beginning CRP Technology's team worked with the client's engineering team focusing on the design of the components, with the correct split of the parts taking into consideration the adverse operating conditions such as high winds and the stress that the components would have to sustain.

Wind tunnel mockup capable of simulating different configuration of flight modes

AW609 wind tunnel model, final result.
Courtesy of LEONARDO HD

ADOPTED SOLUTION – MATERIALS BEARING HIGH HEAT DEFLECTION -

We had to use a material able to withstand a series of dedicated low speed wind tunnel tests and Windform® XT 2.0 resulted immediately as the perfect option because of its:

- **high heat deflection (HDT = 173.40 °C; test method= ISO 75-2 TYPE A),**
- **superior stiffness,**
- **first-rate detail reproduction capability.**

The CAD cut[9] was realized with a special technique able to maximize the contact surface where the structural adhesive would be applied, **thus having a great resistance to any kind of stress even with very large parts having low thickness.**

During Wind tunnel tests the unique technical characteristics of Windform® XT 2.0 remained absolutely intact.

FURTHER ACHIEVEMENTS

Lead Time

The manufacturing time of each single part was really short: one day for the setting up of the 3D printing machine and 4 days to manufacture all the components.
- Different confidential efficiencies capabilities, allowed to minimize the normal tolerances of the technology, and eradicate any potential problem of deformation or out of tolerance issue.

Surface finishing.

Directly applied on the rig assembly, the finishing process enabled the optimization of the small imperfections eventually derived from the union of the single components. In this case, too, the patented techniques validated by CRP Technology allowed to execute this step in a very short time.
The surface of whole model was flatten in an efficient way and subject to a liquid treatment with the double function of making the surface waterproof and ready to be painted without any problem.
Find out more

[9] Identifying the parts to split was an operation undertaken with the CAD, evaluating the functional measures of the working volume but also the possibility to optimize such volume and minimize the production time and costs.

1:6 model for NASA wind tunnel
SHORT CONTEXT, BACKGROUND

CRP USA also contributed to demonstrate the effectiveness of additive manufacturing and use of Windform® as a structural material **for avionics applications: on behalf of Leonardo HD** and under the control of ATI Co. - Newport News (the model supplier), CRP USA manufactured via PBF and Windform® XT 2.0, the external fuselage and additional components for a 1:6 model for high speed tests at NASA Ames Unitary Plan 11 by 11 foot transonic wind tunnel.

Model installed in the 11' x 11' test section at NASA Ames. Courtesy of LEONARDO HD

WINDFORM® SPACE-PROOF MATERIALS
THE RANGE AT A GLANCE

Windform® TOP-LINE family of high-performance composite materials have passed NASA, JAXA and European Space Agency (ESA) outgassing screening, suitable for aerospace applications:

- Windform® XT 2.0, Windform® SP carbon-composite materials; Windform® LX 3.0, Windform® GT glass-composite materials: tested in accordance to ASTM E-595-07 standard
- Windform® XT 2.0 carbon-composite material: passed ESA screening outgassing tests in accordance to ESA TEC-QTE 7171 (based on ECSS-Q-ST-70-02C);
  K-rated according to Japan Aerospace Exploration Agency (JAXA) outgassing test.

In addition:

- Windform® FR1 flame retardant carbon filled material: rated V-0 according to Flammability UL 94; passed the FAR 25.853 flammability tests and 45° Bunsen burner test.
- Windform® XT 2.0, Windform® SP, Windform® GT, and Windform® LX 3.0: passed flammability tests UL 94 and successfully obtained HB classification.
- Windform® LX 3.0 and Windform® SP: subjected to vacuum ultraviolet (VUV) testing without showing degradation.

Around The World

Our focus is supporting companies, engaged in the industrial design of challenging sectors, with innovative manufacturing technologies and materials. **From Modena, in the heart of the Italian Motor Valley, to United States and UAE, pushing limits of innovation in the most demanding sectors.**

Each CRP branch focuses on the specific marketplace **to help industrial and product design companies** in achieving the consultancy and support required in the last phase of protoyping and engineering.

ITALIAN MOTOR VALLEY

HEART OF NASCAR

DUBAI

25 years of Proven Expertise

In the R&D and development stage our long lasting expertise makes the difference to assure that the future product is aptly detailed for small series, limited editions or mass production. Mechanical calculations and other deep analyses are realized with our customer to meet functional requirements. We provide for the most realistic analysis of final product performances and usability.

CRP Technology srl

CRP Technlogy has been committed for 25 years to the development and realization of high end materials for AM and to the manufacture of solutions via professional 3D printing technology.

Detailed Aerospace Applications

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