Windform® 3D printed Tundra-M drone

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Windform® 3D Printing materials, which were originally developed for the motorsports industry, are now finding a diverse range of uses outside the race track, e.g. UAS field.
The case study illustrates the manufacture of an unmanned aerial system using Laser Sintering technology and Windform® composite materials.

The project has involved two companies: CRP Technology and Hexadrone. The aim is the construction of Hexadrone's first fully modular and easy-to-use drone for industrial and multi-purpose tasks, made for extreme weather conditions thanks to rugged, waterproof design.
The rapidly swappable arms and three quick release attachments make the Tundra-M extremely flexible to meet the needs of any profession, while making operational conditions easier to maintain.

The Tundra-M is conceived around a multifunction perspective. The Tundra-M can rely on its four quick connect arms as well as its three accessory connections to turn into a formidably effective and very pliable work tool. This makes the Tundra-M suitable for plenty of different flight scenarios as well as plenty of professional uses.
The body as well as the main parts have been conceived with the composite polyamide based material carbon filled Windform® SP and Windform® XT 2.0. Those two materials are shaped into pieces using the selective laser sintering 3D printing technology.
The four arms supporting the body frame of the Tundra were 3D printed using Windform® XT 2.0 composite material.
The rest of the components were developed with the Windform® SP composite material.

Windform® family of high performance composite materials was created by CRP Technology, 3D printing service provider specialized in advanced 3D printing and additive manufacturing solutions.

The collaboration with CRP Technology

Understanding the limitations with traditional manufacturing technologies, the opportunity to develop a unique drone based on the use of Additive Manufacturing (AM) technologies was identified. Additive Manufacturing technologies in UAS applications has presented both opportunity and challenges to engineers in the field. The ability to produce parts and components using Additive Manufacturing technologies hold promise in both metals and plastics. Whereas, traditional Subtractive Manufacturing technologies can be restrictive in design development and material selection.

Hexadrone has requested CRP to devise the functional prototype of the Tundra-M, Hexadrone's very first mass-produced drone.
Hexadrone CEO Alexandre Labesse commented, "We have engineered our drone by means of a cautious, multifaceted, and collaborative based approach with the involvement of broad-based stakeholders.
In the course of two years of consulting, research and development we have gathered all the advice and customers' testimonials useful to its design and which finally helped us in the process of devising an ideal UAV solution".

Additive Manufacturing technology is often faster than designing and producing a tool for traditional manufacturing technologies. Furthermore, 3D printing has given engineers more flexibility in the timeline to make design improvements and being able to think outside of limitations caused by traditional tooling. This choice made it possible to substantially reduce the costs and has been very convenient in terms of timing when compared to traditional production methods. The unique properties of AM Windform® XT 2.0 and Windform® SP composite materials have allowed system optimization that successfully withstands the design requirements due to space limitations and the extreme conditions during flights.

Hexadrone moved to SLS technology in collaboration with CRP Technology in order to accelerate iteration generation, improve manufacturing time and facilitate series production.
"The Windform® selective laser sintering technology – Alexandre Labesse added - allowed us to easily prototype key components of our product, to outcompete the plastic injection molding process in terms of deadlines, cost, and to test our prototype in real life conditions with almost the same mechanical characteristic".
The project we have designed with these two materials, the Windform® SP and the Windform® XT 2.0 from CRP Technology, lies in the conception of different frame parts, junction parts, a quick release patented system as well as the components forming our patented carbon-made arm system.
This 3D printing time/cost saving technology helped us a lot and now allows us to calmly approach the mass production phase".

The requirements were fast iteration process, best ratio between structural strength and weight, acceptable consistent result and opportunity to combine multiple functionalities from one unique part.
CRP Technology provided fast response time to new requirements, very good cooperation with Hexadrone and CAD designer and best output quality with unique proprietary process.

Alexandre Labesse stated, "Regarding the most innovative aspect of Laser Sintering technology with Windform® materials, lies in the possibility to prototype with all the pros of the plastic injection process without the cons this method entails in terms of cost and deadlines. Furthermore, Windform® provides us with a close enough material in terms of properties (eg, density, colour, tensile strength, modulus, elongation at break etc)"

Evaluation criteria / critical problems overcome through SLS technology and Windform materials

The main stress/efforts involved in the application were:

- Compressive stress
- Tensile stress
- Vibrations
- Traction stress

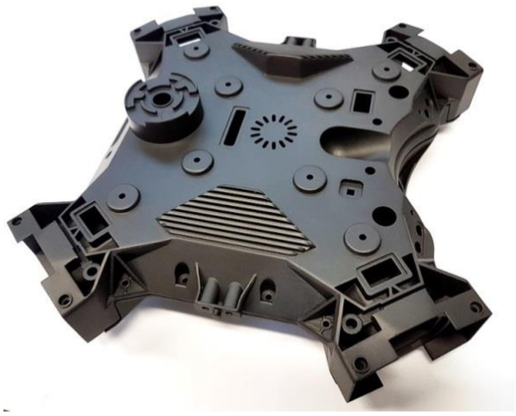
The critical problem of this application resides in a lack of precision resulting in a scale gain. This gain lies between 0.15 and 0.20 millimeters. If not anticipated, this gain can compromise the assembling of the different parts as trying to fit them together.

Tundra-M drone: parts in Windform composite materials

The most interesting parts that have been made using the Windform® SP and the Windform® XT 2.0 are:

- **The body frame** which is composed of the main frame plus a removable top lid. This component contains the brain of the Tundra-M (the main circuit boards as well as the cooling system).
  CEO Hexadrone Alexandre Labesse, "To devise this component, we were in need of a water-resistant, durable and sturdy material. Moreover, this sturdy frame comes with an emergency parachute, four removable and scalable arms, two batteries as well as three easily interfaceable accessories.

  The Windform® composite material used for the body frame is Windform® SP due to its mechanical and thermal properties.




Tundra 3D printed body frame in Windform® SP

- **The arms** which are composed of motor supports plus the removable arms plus its interlock base which allows the user to easily tighten the four arms with the support of a patented "tension ring": This stiff system allows the user to connect and disconnect the interchangeable arms on a discretionary basis.
  CEO Hexadrone Alexandre Labesse, "Our patented technology offers a reliable and sturdy connection while being a waterproof solution in case of inclemency. This interlocking connection is also able to handle the stress due to leverage forces. Those leverage forces are primarily generated through the components at the end applying a constant force through masses".

  The Windform® composite material used for the arms is Windform® XT 2.0


Tundra 3D printed arms in Windform® XT 2.0

SLS technique and Windform® composite materials: the pros by Hexadrone

The performance of this application as to what it allowed Hexadrone to create in terms of mechanical parts was essential due to its intrinsic material qualities. Therefore, the quality of this component had a great incidence over a number of key factors:

- Flight tests, which, thanks to the Windform® SP and Windform® XT 2.0 are run in real-world service test conditions. This application allowed the completion of successful flight tests for the Tundra-M.
- The flexibility of the Windform® material and its compatibility with many different applications makes it an ideal candidate for demanding applications.

Furthermore, thanks to Windform® SP and Windform® XT 2.0, Hexadrone benefited from the plastic-like materials' properties without the common drawbacks. The drawbacks of plastic injection molding, mainly its cost and its time consumption, make it unfit for prototyping.

What prompted Hexadrone to focus their intention on the Windform® technology from CRP was:

- The possibility to have access to printed parts within very short deadlines at a very cost-effective price.
- **Windform® family of composite materials can compete with the injected plastic in terms of** tensile strength, stiffness, tensile modulus, elongation at break, shear strength, flexural strength, flexural modulus, traction stress vibrations, resistivity as well as density and its low moisture absorption rate.
- The price which makes Windform® technology a highly profitable solution for prototyping purposes.
- The fact this method produces zero undercut as well as zero flaws which is also a good point for prototyping jobs. (Flaws are often noticeable on industrial pieces which were produced using the plastic injection method).
- Windform® material density which induces a low mass making Windform an ideal component for the prototyping of UAVs and the completion of their flying tests.
  This allowed Hexadrone engineer to have an acute in-flight first impression as to the behavioral characteristics of the different parts processed with Windform® carbon fiber reinforced composite materials.

SLS technique and Windform® composite materials: the advantages by Hexadrone

The advantages obtained by Hexadrone with the technology and Windform® family of composite materials are:

- Windform density, which makes it lightweight material suitable for UAV prototyping phases and testing phases.
- The price, which makes it a smarter solution than plastic injection if you are to run through iterations. Plastic injection is considered financially too risky if you

were to notice design flaws (In case of design flaws, the mold become obsolete and then you can't make it profitable for the company).

- The neutral color and texture suitable for prototypes.
- The thermal properties suitable for UAV prototypes.
- The mechanical properties making it a very competitive material similar to injected plastic, in terms of the various stress an UAV has to face while flying.
- The electrical properties suitable for the prototyping of functional parts which are to be mounted in an electrical environment.
- The moisture resistance thanks to its low absorption rate suitable for the Tundra-M, an UAVs vowed to extreme weather.

SLS technique and Windform® composite materials: the tests carried out by Hexadrone

The tests Hexadrone carried out on the prototype they designed using Windform® reside in:

- **The assembly / disassembly tests** of the different parts to road test their structure as well as the fatigue resistance of this new materials.
- **Landing tests**, folding and unfolding the landing foot structure of the Tundra-M drone whose different structures were made in Windform® SP and which support the full weight of the Tundra-M. On top of the weight of the device those small parts also have to handle the stresses due to the folding/unfolding of the landing system.
- **Flight tests**, to determine whether the mounted parts can handle the different strains encountered throughout the many different flight scenarios.

Tundra 3D printed functional prototype at CES 2018

About Windform® composite materials (carbon fiber reinforced)

Windform® XT 2.0 and Windform® SP are the LS polyamide-based carbon fiber reinforced Windform® materials within Windform® family of high-performance composite materials.

Windform® XT 2.0 is the ground breaking carbon fiber reinforced composite 3D printing material known for its mechanical properties. It is particularly suitable in demanding applications such as motorsports, aerospace, and UAV sectors.
Windform® XT 2.0 is an innovative material which replaces the previous formula of Windform® XT in the Windform® family of materials. Windform® XT 2.0 features improvements in mechanical properties including +8% increase in tensile strength, +22% in tensile modulus, and a +46% increase in elongation at break. The material allows for the creation of accurate, reliable, and durable prototypes and is perfect for functional applications.

Windform® SP has excellent mechanical properties similar to Windform® XT 2.0, with the addition of increased resistance to shock, vibrations, and deformation. The material also shows increases in impact strength and elongation at break, as well as excellent thermal properties and resistance to high temperatures.
Windform® SP has waterproof properties, and it is resistant to absorption of liquids and moisture.
It is suitable for dyno testing and on track testing, for applications requiring resistance to impact, vibration, deformation, and high temperatures.
Windform® SP is the material of choice for functional applications in Motorsports, Automotive (under the hood components such as intake manifolds), Aerospace and UAVs.