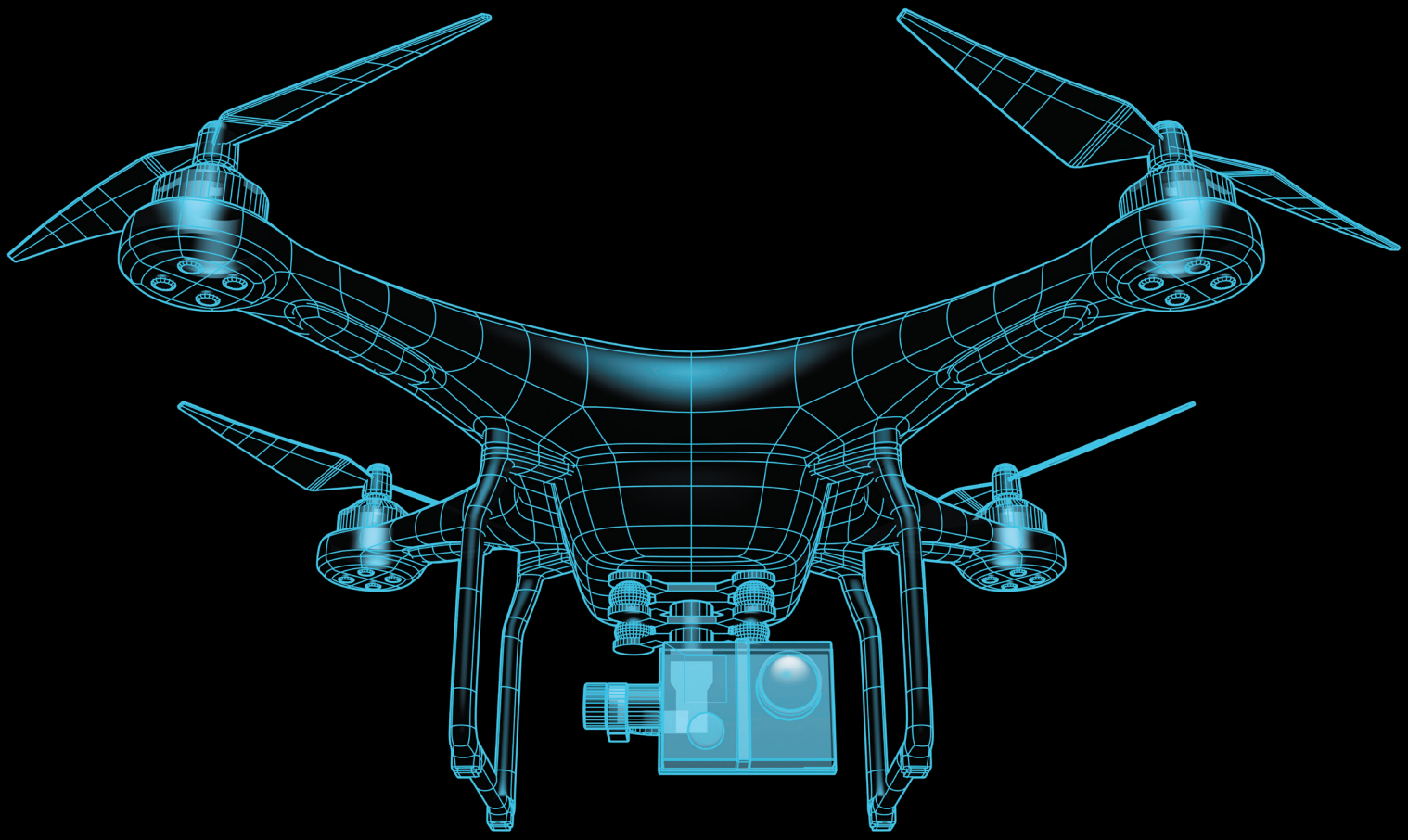
SHAPEWAYS

The Intersection of Drones and Additive Manufacturing

Sleek. Fast. Superior.



This eBook is for designers engaged at the intermediate and advanced 3D printing levels, offering valuable information on drone product development, materials, and technology.

Unmanned aerial vehicles (UAVs) often put aeronautics brilliance on display for all to see in miniature; however, behind the scenes, these industrial devices require highly customized design, planning for transmitters and parts, as well as detailed specifications for payload, camera mounts, and an array of other options.

As both technologies have grown on parallel and often complementary paths, additive manufacturing has made it possible for drone designers on every level to create the UAVs of their dreams. Rapid prototyping allows for accelerated product development with quick turnaround in 3D printed iterations and the ability to customize intensively for any application.

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3D PRINTING AND DRONES: A POWERFUL PAIR

Conveying speed, resistance to impact, and maximum durability, drones already fulfill many duties beyond human capacity, or at least, the ability to perform them efficiently. 3D printing has made an impact in nearly every aspect of aerospace, but is especially powerful as a complementary pairing to drone technology, taking advantage of the power of flight to perform critical tasks.

Quantum-Systems, known for their Trinity F90+ UAVs and the Scorpion UAS, is one of Shapeways' most dynamic customers. Founded in 2015, their journey in designing and manufacturing high-performance drones has included 3D printing with Shapeways since inception. The technology has allowed them to make a series of complex, task-oriented drones that are durable and whittled down to the lightest weight possible for efficiency and speed.

The Munich-based drone manufacturer has proven the point that drone deliveries can be highly advantageous for many applications; for example, they have already made significant strides in transportation of items like lab tests. Rather than navigating through ground traffic, drones take shortcuts afforded by airspace, making deliveries to labs in mere minutes. Quantum-Systems drones are used in professional and government applications for mapping, inspection, surveillance, agriculture, industry, and monitoring.

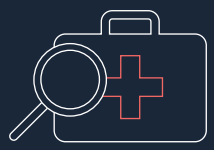
Historically, Quantum-Systems has saved approximately ten weeks time by using 3D printed samples to release their CAD data, making the probability that they would have to perform a second round of corrections quite low. They are often able to skip the first round of samples in CNC machining too by using 3D printed parts.

> "3D printing, besides being super fast and inexpensive, lets us produce nice, modern shapes that always look bionic and are lightweight. That's a good advantage."
>
> - Sebastian Sattler, Team Lead Mechanics, Aerodynamics and Construction at Quantum- Systems.

> "Saved 10 weeks of time by using 3D printing."

FROM DELIVERIES TO DISASTER ZONES: GOING ABOVE AND BEYOND

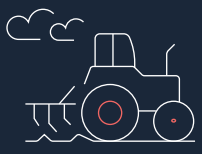
Disaster areas, and search and rescue



Delivery systems

Monitoring and surveying

Farming and wildlife



Lightweight 3D printed drones offer assistance in disaster areas, as well as search and rescue, taking on responsibilities like mapping strategic information and offering live streams. In search and rescue missions, drones apprise teams of aerial details and help them build strategies, along with dropping lifesaving supplies–another critical task important to military applications too.

Consumer deliveries have always been expected in connection with drones, but previously such services have been held back due to restrictions. As the FAA has allowed for new exemptions in the past few years, however, retailers are back to making steady promises and plans for transformative delivery systems.

Drone technology is extremely helpful in many different layers of monitoring and surveying too, whether responsible for securing an area, photographing it, or dropping supplies into a challenging area. Beginning with agricultural and real-estate applications, drones are both nimble and fast, making tracks over large expanses of land in a fraction of the time it would take a human traveling on foot or in a ground vehicle.

Farms now employ drones for streamlining management of their fields and spreading fertilizer over crops, as well as using UAVs to monitor the location, count, and status of animals roaming freely on their property.

Kespry, based in Menlo Park, California, is a long-time Shapeways customer and a drone manufacturer specializing in helping their own clients map out new territories. The Kespry team originally came to Shapeways looking to improve speed in production, delivery to customers, and scale their business.

Shapeways was able to work with them efficiently by 3D printing drones close to their final assembly locations, as well as handling the complexities of meeting all international specifications.

“When we started out with Shapeways, it was before we even had our first customer,” said Jordan Croom, Kespry’s previous lead mechanical engineer. “Now we have hundreds of drones going out every quarter, and it’s been a smooth transition to get to that point.”

Affordability and speed play equally important roles in 3D printing drones.

“Leveraging 3D printing and Shapeways allowed us to get things out there faster without paying an exorbitant premium to do it,” said Croom. “And it also allows us to make modifications and improvements to our product without interrupting shipping them out to our customers.”

“We can make a change and incorporate it in production in a few weeks, whereas if we were doing Injection Molding, it would take maybe a couple of months to make that change.”

3D printed covers to protect their drone’s mechanical inner workings were one of the first parts Kespry began manufacturing. 3D printing technology allowed them to make modifications as necessary, and take new, high-quality products to market faster.

3D PRINTING EXPEDITES DRONE PRODUCT DEVELOPMENT

3D printing has evolved into an industry offering much more than the ability to create models or prototypes. The difference between rapid prototyping and 3D printing for drones is that an infinite number of 3D designs and complex geometries can be modeled and printed for product development, and also for functional end-use products used in challenging outdoor climates and scenarios.

Additive manufacturing processes have continued to grow in demand; in fact, recent research shows that 54 percent of engineers reported relying on 3D printing for functional parts. Further, drone technology services are projected to reach $63.6 billion by 2025.

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Drone designers must be prepared to evaluate critical details every step of the way, to include:

1. Intended usage of the technology, level of autonomy, and corresponding structure.
2. Size limitations, per regulations and project requirements.
3. Payload specifications, combining the weight of the drone and its parts, as well as added weight for varying applications, which may require a camera too.
4. Options for maximum maneuverability depending on the structure.
5. Blade structure, length, and efficiency.

Drone engineers use technology like Selective Laser Sintering (SLS), eliminating the need for support structures due to the stabilizing force of unsintered powder during the additive manufacturing process. They create agile aerial tools with adaptable 3D printing materials like Nylon 12 [Versatile Plastic]–moving from identifying product needs to building a prototype and a proof of concept, and testing and validating iterations.

DESIGNING DRONES FOR LOW WEIGHT AND REDUCED PART ASSEMBLY

> “Perfecting our prototypes via 3D printing saves us tens of thousands of dollars in pre-production and testing costs.”
>
> - Sebastian Sattler, Team Lead Mechanics, Aerodynamics and Construction at Quantum- Systems.

Reduction of part weight is key, with every gram making a difference; for example, when Quantum-Systems was optimizing the design of a shield for an antenna mounting on one of their drones, they worked with Shapeways to reduce a 23-gram part by 8 grams, transforming it into a flexible, fully optimized, honeycomb design.

Once product development and testing are complete, a drone manufacturer moves from additive manufacturing to post-processing. Here 3D printing shines with the ability to make one iteration after another, rapidly, and on demand. No lead time or tooling is required.

Sebastian Sattler, Team Lead Mechanics, Aerodynamics and Construction of Quantum-Systems, reports saving up to 50% in time for prototypes, depending on the product;

“Perfecting our prototypes via 3D printing saves us tens of thousands of dollars in pre-production and testing costs.”

At Quantum-Systems, the goal has always been to ensure they optimize each part design with 3D printing, as well as making products with ‘integral functionality,’ reducing assembly while still offering quality and high performance.

ADVANCED MATERIALS AND TECHNOLOGY FOR 3D PRINTING DRONES

3D printing combined with drones equals greater ease, excitement, and freedom for designing new products meant to collect critical data and accelerate workflow–all from the aerial perspective. This is made possible by an ever-expanding range of 3D printing materials and methods.

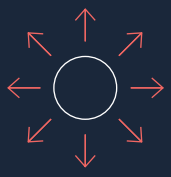
Nylon 12 [Versatile Plastic] with Selective Laser Sintering

Selective Laser Sintering offers high accuracy and good mechanical properties for prototypes.

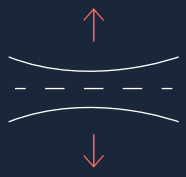
Nylon 12 [Versatile Plastic] is extremely popular because it is strong, yet flexible too. High ductility translates to stronger, thicker parts 3D printed with greater rigidity, while thinner parts result in more elasticity. SLS 3D printing allows for parts to be manufactured on a large scale and does not require supports, offering much greater latitude in 3D modeling.

Without support structures, the potential for damaging parts after 3D printing is eliminated. Extra powder can be used in following productions too, mixed with virgin powder at a 50/50 minimum. Some parts may be 3D printed with 100% virgin powder for even higher quality.

High accuracy



Strength



Flexibility

Variety of colors and finishes

Large-scale manufacturing

No shrinkage or warping

Precision in parts

Strength

Surface quality

Advanced standalone cooling

Printing interlocking parts in one piece

Recycling materials

MJF PA12 with Multi Jet Fusion Technology

Materials like Multi Jet Fusion Plastic PA12 are used for rapid prototyping and 3D printed functional products due to high strength and accuracy.

Multi Jet Fusion technology is extremely well-adapted for drone prototyping due to precision in parts, as well as the excellence offered in surface quality and texture. MJF, a powder-based technology, relies on an inkjet array moving back and forth to release fusing and detailing agents, instead of laser heat. Parts 3D printed via MJF are uniformly strong due to evenly dispersed temperatures, with greater strength due to deep absorption of thermal energy during manufacturing. Large builds are also possible using MJF, with the ability to print many parts at once.

MJF technology is unique in its advanced standalone cooling that prevents warping, shrinking, and failure in parts. Materials can be recycled too after the process, with the mix ratio for MJF typically found to be 80% re-used powder and 20% virgin.

Resin-Based Materials with Stereolithography

For prototypes that require finer details, designers turn to Stereolithography (SLA) with materials like:

- Accura 60
- Accura Xtreme
- Accura Xtreme White 200

SLA 3D printing offers excellent mechanical qualities, smooth surface finishes for prototyping and end parts, and master patterns for industrial molds. Famous for accuracy and precision, SLA 3D printing offers strong adhesion between layers, resulting in good structural integrity for parts.

Smooth surface

Accuracy and precision

Strong adhesion between layers

Strength and durability

Efficient process

Lightweight

Accuracy of details

Heavy customization

Low batch production

Aluminum with Selective Laser Melting Technology

Aluminum (alloy AlSi10Mg, 10% Silicon 0.5% Mg) is favored for high-performance parts required for aircraft like drones due to incredible strength and durability. Even better, Aluminum is lightweight enough to allow for maximum flying speed in UAVs. This alloy offers good resistance to corrosion, temperature, and high pressure, and is suitable for products like drones requiring toughness and accuracy. Other material properties include good strength to mass ratio and low density.

Aluminum is 3D printed with Selective Laser Melting (SLM), known for its ability to manufacture strong metal parts rapidly, and without tooling. SLM 3D printing allows for heavy customization and maximized performance in functional parts. Shapeways recommends SLM 3D printing technology to customers seeking low-batch production of specialized metal parts with detailed designs.

ENSURING QUALITY WITH POST-PROCESSING FOR DRONE TECHNOLOGY

Post-processing is centered around the routine and the required, from removing supports to cleaning. These steps may heavily impact the finished product, improving the integrity or enhancing the appearance of 3D printed drone parts.

Various types of finishing are included:

Dyeing	Available with Nylon 12 [Versatile Plastic], parts can be dyed in a variety of colors. Benefits of dyeing include comprehensive coverage of color, as well as offering the ability to delineate one system or feature from another, with sensors serving as a great example.
Premium Finishes and Polishing	3D printed material finishes for drones range from natural to premium, spanning basic rough textures to smooth scratch-resistant surfaces meant for high-end products.
Vapor Smoothing	This physio-chemical process smooths visible lines and protects the quality of 3D printed drone parts. Internal cavities can be smoothed too, resulting in watertight parts with all their mass intact.

The goal is to complete all post-processing steps without compromising or damaging drone parts.

"Post-processing is an integral part of the production process for every material associated with 3D printed drones," said Zach Dillon, User Application Lead at Shapeways. "The series of steps involved in post-processing takes each drone model from that 'fresh out of the printer' state to a consumer-ready part."

Industrial drone designs are expertly calculated, and manufacturing is highly specialized to ensure quality devices are sturdy enough to withstand the rigorous use and the intensive work delegated to them.

> "At Shapeways, post-processing is an integral part of our entire production process for every material associated with 3D printed drones."
>
> - Zach Dillon, User Application Lead at Shapeways

About Shapeways

Shapeways makes world-class 3D printing more accessible to everyone through automation, innovation, and digitization. Our purpose-built software, wide selection of materials and technologies, and global supply chain lower manufacturing barriers and speed delivery of quality products.

Shapeways' digital manufacturing services have empowered more than 1 million customers worldwide to produce more than 20 million parts using 10 different technologies and 90 different materials and finishes. Headquartered in New York City, Shapeways has ISO 9001-compliant manufacturing facilities in Long Island City, N.Y., and Eindhoven, the Netherlands.

Contact us at www.shapeways.com to learn more.