stratasys

SOLUTION GUIDE
DRONE & UAV

How 3D Printing of Drones and UAVs Meet Commercial and Defense Manufacturing Challenges

The Dynamic Drone Market

Industries as demanding as construction and defense are among those adopting autonomous drones and unmanned aerial vehicles (UAVs) at a rapid pace, and for good reason. With a diverse range of commercial applications, these aerial vehicles perform valuable services and reduce risk while saving on labor and other resources.

Drones and UAVs are a fast-moving market. Led by high usage rates in North America, the global commercial drone market is expected to exceed $583.5 billion by 2030 with a compound annual growth rate of 38.6% from 2023 to 2030, according to Research and Markets.[1] Cloud computing and 5G are among the technologies that are increasingly integrated into drones, providing high-speed internet connectivity which enable advanced functionalities such as command and control, media sharing, and autonomous flying.[2]

Yet another technology — 3D printing, an additive manufacturing solution — is also enabling fast and efficient development and production of drones.

Here are examples of some of the challenges solved by drones and UAVs:

Agriculture

Cameras and sensors on drones collect valuable data on crop health, water usage and soil quality to optimize crop yield and reduce water usage, providing greater sustainability and profitability. Additional uses include spraying pesticides and fertilizers more efficiently and monitoring the health and safety of livestock.

Construction

Drones are increasingly used to perform quality control inspections and provide real-time data on build progress. Used to survey hard-to-reach areas such as roofs, safety is maintained while reducing spending on expensive equipment that requires set-up such as scaffolding.

Defense

Aerial vehicles are used by the military to conduct surveillance and tactical missions. A wide range of UAVs are used to complement existing air power of manned aircraft, reducing risk to human operators. For example, lightweight small and medium-sized UAVs provide ground units with backpack deployable short-range reconnaissance capabilities or weaponized capabilities.

Energy

The inspection and maintenance of offshore oil rigs, power lines, wind turbines and solar panels reduces the need for manual inspections while improving worker safety and saving money. The surveying of potential sites for energy projects provides data on terrain, wind patterns and sun exposure.

Logistics

Large retailers and e-commerce companies are using drones to deliver packages and goods in urban areas. Drones are also deployed to deliver essential goods like medical supplies and equipment — even human organs — in remote or under served areas.

[1] Research and Markets press release.
https://www.businesswire.com/news/home/20230721993519/en/Global-Commercial-Drone-Market-Predicted-to-Surge-to-583.51-Billion-by-2030-Driven-by-Increased-Applications-and-Advanced-Technologies---ResearchAndMarkets.com

[2] Research and Markets report summary
https://www.researchandmarkets.com/report/commercial-drone

Conventional Manufacturing Methods

Traditional manufacturing methods for drones and UAVs include CNC machining, composites and welding as well as plastic fabrication practices such as injection molding and thermoforming. These methods are commonly used to produce parts such as frames, canopies, propellers, electronic components and landing gear.

While these conventional methods have evolved over time to meet the increasing demand for durable, high quality and efficient drone parts, they can drag down production times, adding inefficiencies to the supply chain while limiting the innovation that is possible with more agile development and manufacturing processes.

It is vital for drone and component makers to continue to test and upgrade their solutions for new markets and applications. Aided by 3D printing, companies are better equipped to innovate with advanced designs and materials that bring not only significant production efficiencies but improved performance of aerial vehicles.

Downsides of Traditional Manufacturing

Despite the possibilities from 3D printing of drone parts and components, conventional manufacturing approaches remain prevalent.

Let's take a closer look at a few of its disadvantages:

Longer Lead Times

Drones and UAVs are a competitive, fast-moving market. Particularly for subtractive manufacturing methods such as the CNC machining and welding, whether you outsource all or part of your manufacturing or perform it in-house, production times may span up to several days to several weeks or more, depending on the process and if backlogs are encountered.

Design Constraints

As suggested, design and development can be hampered with the time and processes required for conventional manufacturing. Machining and other fabrication methods can also limit the geometric complexity and surface accuracy of parts and components. In short, drone makers lose the agility and speed they need with the longer time commitment and greater resources consumed.

Higher Cost

Costs associated with machining, welding and other conventional methods are generally higher than 3D printing. In addition to the higher labor overhead of skilled trade workers of traditional manufacturing, costs such as capital expenditures for machinery and equipment as well as operational costs for maintenance and repair or outsourcing fabrication add up. Indirect costs include the lost opportunity of longer production lead times and development restrictions.

Labor Shortages

CNC operators and programmers, assembly workers and fabrication specialists are hard to find. In recent years, the skilled manufacturing trades have been especially hard hit with shortages due to lack of qualified, trained workers. The fast pace of technology advances also make it harder to find skilled workers. A study by Deloitte with the Manufacturing Institute (a partner to the National Association of Manufacturers) found the skills gap in the U.S. could result in 2.1 million unfilled jobs by 2030.[3]

[3] NAM article.
https://nam.org/2-1-million-manufacturing-jobs-could-go-unfilled-by-2030-13743/

The Added Value of Additive Manufacturing

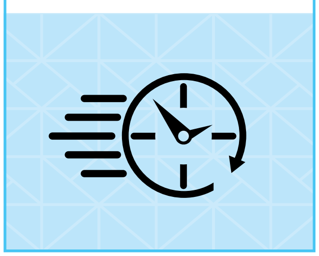
An established alternative to conventional manufacturing methods, 3D printing is no longer restricted to just prototyping and tooling. In fact, 3D printing is an accepted additive manufacturing solution for end-use parts and components, known for its faster time-to-market and production cost-savings.

Today's advanced 3D printers and materials provide design freedoms not found with traditional manufacturing techniques and materials. Drone and UAV makers are increasingly using 3D printing to accelerate their drone R&D and production schedule, dramatically changing the way they are manufactured. This means the structural design of unmanned vehicles can easily be optimized for weight, strength, and aerodynamics.

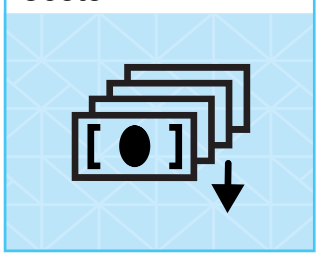
There are many types of drone parts that can be 3D printed including frames, canopies, propellers, camera and antenna mounts as well as electronic components. Drones, UAVs, land-based robots and other unmanned vehicles are often made in low-volume production runs, subject to customization and frequent product updates — all ideal use cases for 3D printing.

Benefits of Additive Manufacturing in Drone Making

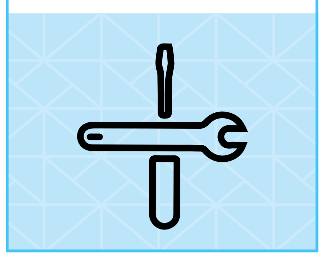
Rapid Prototyping



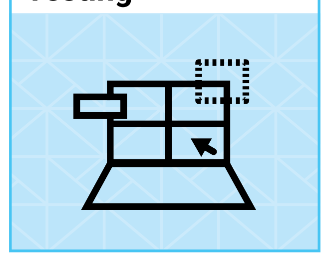
Low Development Costs



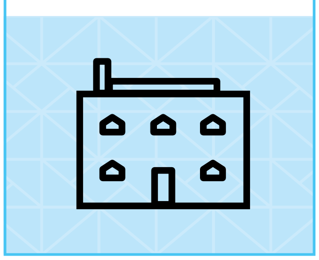
Production Parts



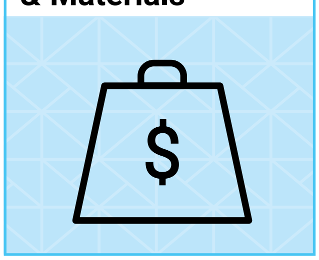
Software Stress Testing



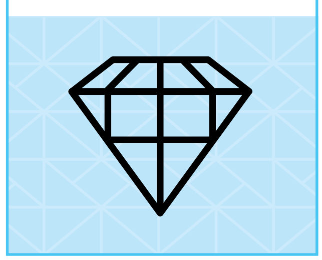
In-House Tooling



Save Weight & Materials



Exotic Materials



Speed Up Time to Market

Here is a closer look at a few advantages of 3D printing:

Rapid Prototyping

Starting with reduced design and development time, on through printing the first prototype and testing, design iterations are quickly produced with 3D printing. Unlike conventional methods, 3D printing a prototype typically takes hours. This flexibility and speed means optimizing for quality and performance with new design iterations within easy reach.

Faster Production

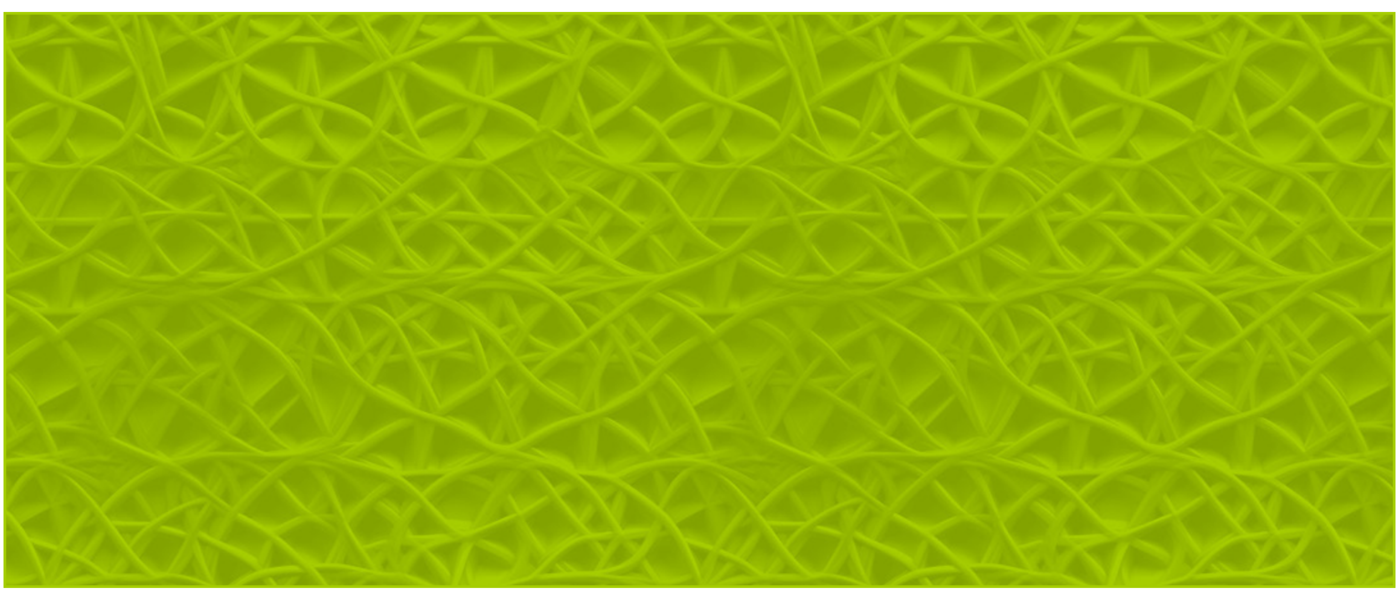
Following prototyping and testing, making an end-use part, including any finishing processes that may be required, can typically be accomplished in a matter of hours or a day, not days or weeks. Accelerated production means faster time to market and a more responsive quality feedback loop.

Lower Cost

All the efficiencies add up. Compared to many conventional manufacturing methods, 3D printing offers a reduced cost-per-part. Among the efficiencies that contribute to savings are the labor and material requirements of 3D printing which are generally lower. And additive manufacturing generates less material waste than other methods.

Scalability

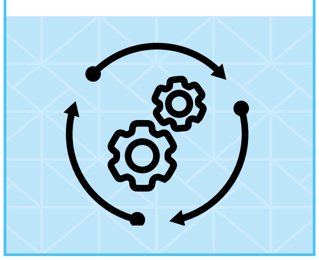
From the smallest of print runs to larger volumes, 3D printing is highly scalable. Companies often start with one part from a 3D printing service provider and then decide to integrate additive manufacturing capabilities into their own operations.



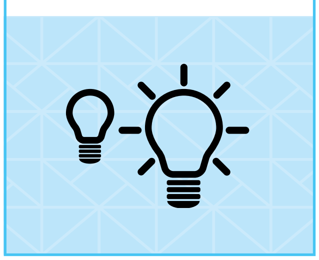
The Stratasys Drone Development and Production Solution

With a history of serving the defense, aviation and aerospace sectors, Stratasys is at the forefront of the drone and UAV market as a leading provider of additive manufacturing solutions for prototypes, end-use parts and components.

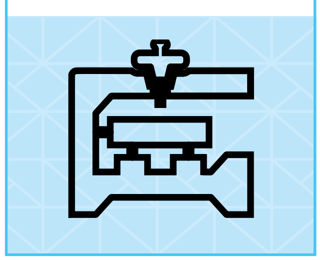
Production Level



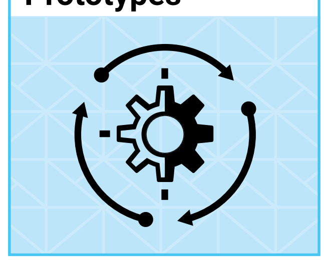
Concept Models



Jigs and Fixtures



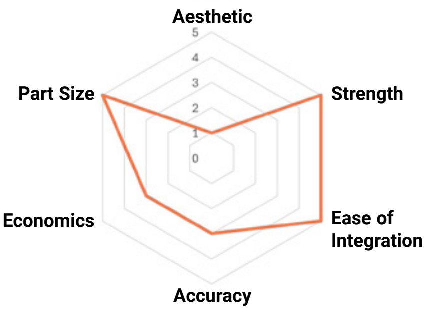
Functional Prototypes



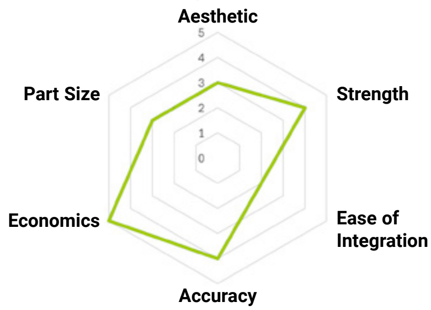
System Comparisons

Each Stratasys 3D printing technology has distinct benefits and your application requirements will drive the selection.

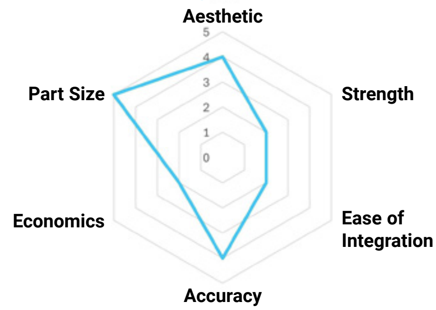
FDM



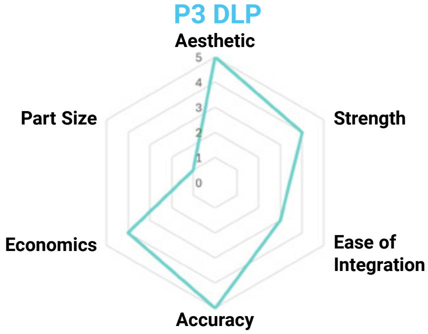
SAF



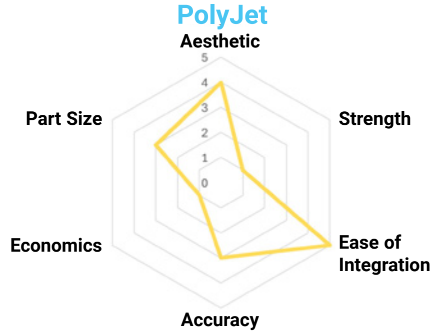
SLA



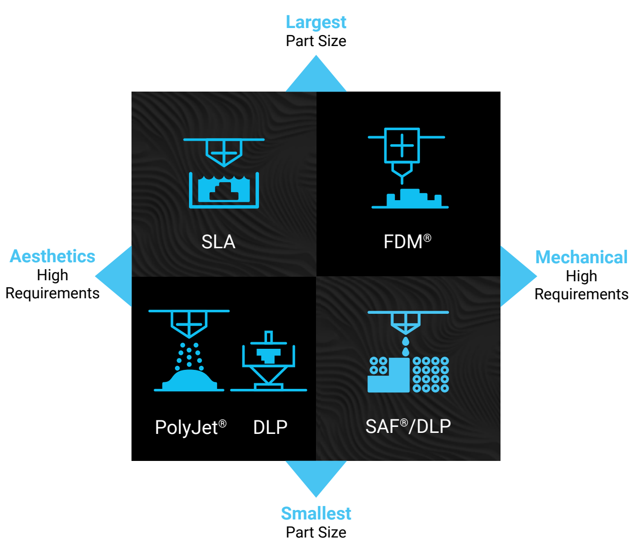
P3 DLP



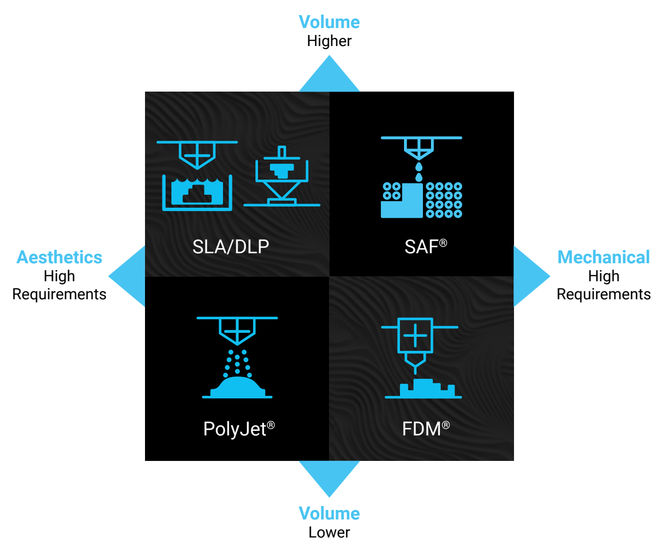
PolyJet



Stratasys has a system and a material to meet your part size requirements, volume of parts, and cost-per-part criteria.



Selecting the right Stratasys 3D printing technology and material will determine part performance.

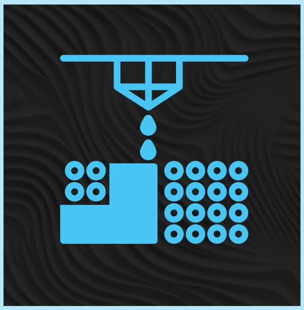


Examples of Stratasys solutions include:

- Small- to medium-sized parts using Selective Absorption Fusion® (SAF) or Origin P3™ (programmable photopolymerization) technology in quantities of up to the tens of thousands.
- Stiff, FST (fire, smoke and toxicity) compliant or ESD (electrostatic discharge) safe flight-certified parts, with FDM technology for larger parts and P3 DLP for medium-to-small parts.
- Metal castings using stereolithography technology on the Neo® printer series.
- Small-medium size parts that will be exposed to higher levels of UV, water, chemicals or extended periods of elevated temperature, using P3 DLP.

Stratasys Technology Highlights

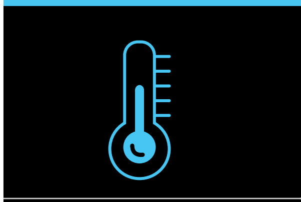
Stratasys SAF



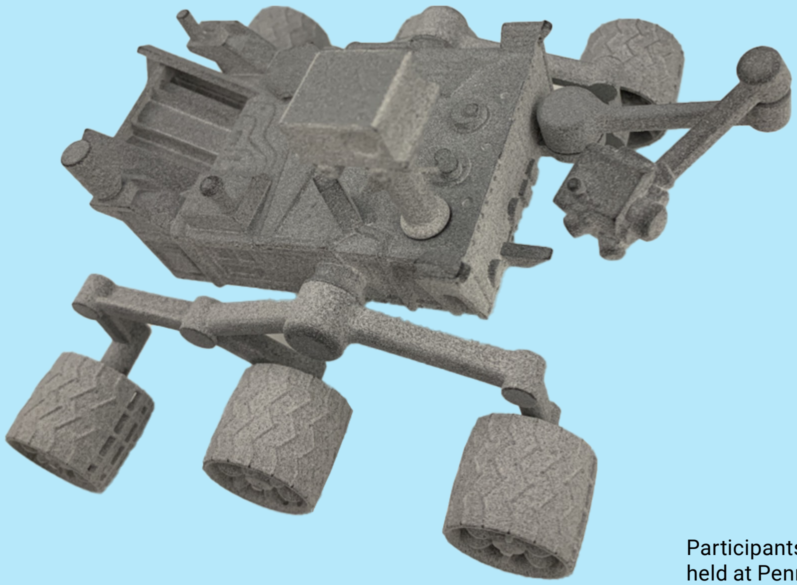
Stratasys SAF technology provides the accuracy, repeatability and control which is vital for consistent production and lower part costs.

SAF technology powers the Stratasys H350® powder bed 3D printer. SAF uses HAF™ infrared absorption fluid to fuse powdered polymer particles together in layers to build parts. Powder management is achieved with Big Wave® technology, which provides reliable powder distribution across the build area. Piezoelectric print heads jet the HAF fluid onto the powder, which is then exposed to infrared energy that fuses the powder together to form each layer of the part.

Built for higher-volume additive production volume that is tailored to short-run jobs, SAF technology renders greater thermal control over the build process compared to other powder bed technologies. The resulting benefits include consistent part properties regardless of nesting density, which ultimately provide higher yields and lower per-part cost. SAF technology employs features that best the competition on several fronts. Big Wave unidirectional powder management maintains a uniform print bed where all points experience equal temperatures, resulting in consistent print quality. Industrial piezoelectric print heads are non-consumable items, and the requirement for only one fusing fluid reduces ongoing maintenance and operational costs.

SAF — H350 Material Certifications — PA12, PA11 and PP		
	Mechanical properties tested at a wide range of temperatures	ASTM D638-22
	Chemical compatibility and mechanical properties tests for all common automotive chemicals and fuels, acids and bases	ASTM D543 – 168-hour immersion testing
	Fire safety testing	UL94 HB – Pass*

* Product is not currently UL Blue Card Registered.



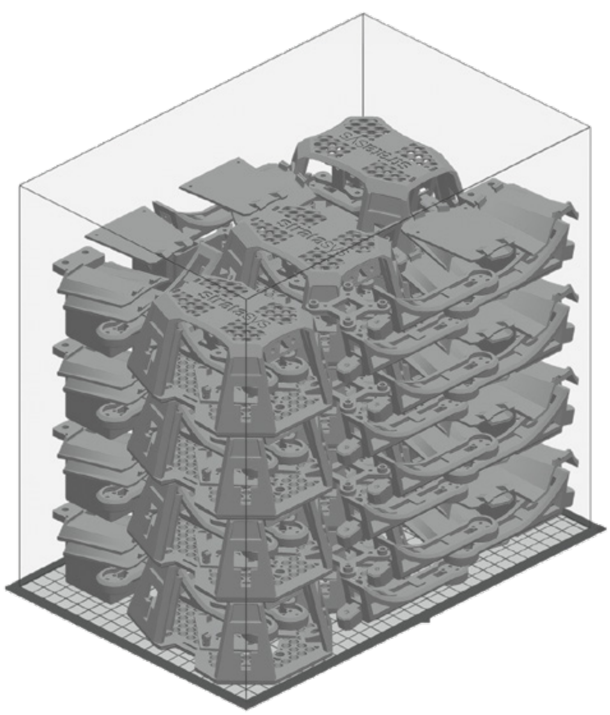
Participants at a girls' STEM career event, held at Penn State University in 2023, used the Stratasys SAF H350 printer to create multiple parts of this rover, including the body, brackets and wheels.

The UAV PA12 project was undertaken to demonstrate what can be achieved when using a SAF H350 system for production purposes and its potential for scalability.

H350 UAV PA12 Project

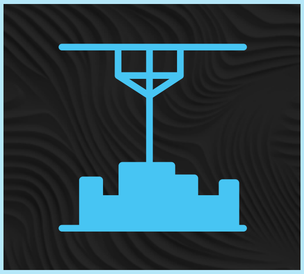
12 full models in 11 hours/26 minutes

Details	
Print Time	11 hr 26 min
PA12 (kg)	1
HAF (ml)	162
Total Model Volume (cm^3)	1,800
Models Nested	96
Build Density (%)	13
Pack Height (mm)	236
Cost Per Drone- Total ($)	31
Cost Per Drone- Material Only ($)	18



One Stratasys SAF H350 printer can produce 24 drones in a 24-hour period.

Stratasys FDM



Stratasys FDM (fused deposition modeling) technology offers valuable efficiencies over conventional manufacturing methods, bringing reduced production costs and shorter lead times for faster market entry. The broad material portfolio of FDM addresses a wide spectrum of applications, from functional prototyping to end-use parts.

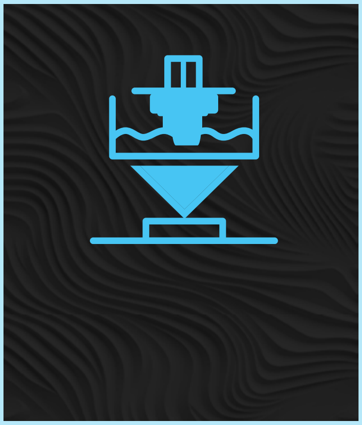
FDM technology is trusted for its precision, reliability and repeatability. From 3D printers used in the home or office to those found in industrial-grade platforms on the factory floor, FDM technology is one of the easiest 3D printing technologies to learn and operate. Material diversity opens your application space with capabilities ranging from engineering-grade plastics to high-performance polymers.

Material	HDT @ 264 psi	Elongation at Break (%)	Impact Strength Notched (J/m)	Tensile Modulus (GPa)	Density (g/cc)	Fatigue, UV, and Performance Data	Certifications
	XZ	XZ	XZ	XZ			
PC-ESD	144 °C	5.2	233	1.96	1.195	ESD 104 - 109 Ω*cm	
Nylon 12CF	154 °C	2.4	106	9.46	1.19	Impact of Temperature on High- Performance FDM Materials UV Exposure Fatigue data to 106 cycles	
Antero 840CN03	157 °C	12	45.8	2.94	1.27	ESD 104 - 109 Ω*cm Impact of Temperature on High-Performance FDM Materials UV Exposure Fatigue data to 106 cycles Chemical resistance	FAR 25.853 AIS
ULTEM™ 9085 resin	172.6 °C	5.4	88.5	2.52	1.27	ESD 104 - 109 Ω*cm Impact of Temperature on High-Performance FDM Materials UV Exposure Fatigue data to 106 cycles Chemical resistance	FAR 25.853 AIS
ASA	97.6 °C	5.9	43.1	2.14	1.08	UV Exposure	

Stratasys FDM technology is used to produce functional prototypes and end-use on-demand parts for the Altura Zenith commercial drone by Aerialtronics.

Leptron used Stratasys FDM technology to make complex fuselage parts on its five-pound remotely piloted RDASS (rapidly deployed aerial surveillance system).

Stratasys P3™ DLP



Stratasys P3 DLP technology brings industrial 3D printing to a completely new level with unparalleled accuracy, proven repeatability, very tight tolerances, and superb smooth surface finish. The P3™ Programmable PhotoPolymerization is an evolution of Digital Light Processing 3D printing.

During the printing process light, temperature, pull forces and pneumatics are tightly controlled, resulting in repeatable injection-molding-like part quality and surface finish with high accuracy and tight tolerances. In combination with the broad range of performance materials -validated or open material system-, it enables industrial 3D printing across the widest range of geometries - from large bulky parts directly on the platform to the finest of features.

Due to its ability to consistently heat to and maintain the chamber at 60 °C, Origin is the only printer that has Blue Card certification with the 3955 FST material.

Matching injection molding precision and surface finish unavailable with other resin 3D printers, it is the most advanced 3D printing solution for industrial production.

Most Relevant P3 DLP Material Certifications

Material	HDT	Elongation at Break	Impact Strength	Water Absorption (24 hour)	Certifications / Specific Properties	Thermoplastic Analog
Loctite 3D 3955 FST	300 °C (572 °F)	2%	23 J/m (0.43 ft·lb/in)	0.3%	FST & UL-94 V0 at 3 mm thicknesses	Ultem, PBT
Loctite 3D IND3380™ ESD	200 °C (392 °F)	2%	12 J/m (0.22 ft-lb/in)	0.59%	ESD	PEKK
Somos® WeatherX 100	73 °C (163 °F)	19%	27 J/m (0.51 ft·lb/in)	0.4%	Resists exposure to higher levels of UV, water, chemicals and elevated temperatures (E Modulus: 1943 MPa (282 ksi); Viscosity 950 cP)	UV-stabilized thermoplastic

TE Connectivity chose Stratasys' Origin printer over other printers as it's the only system that meets the required <50 micron **accuracy, repeatability, surface finish and material properties**. With printed parts almost similar to injection mold parts, they see that some of our customers can't even tell the difference.

3D Printed Aerial Vehicle Success Stories

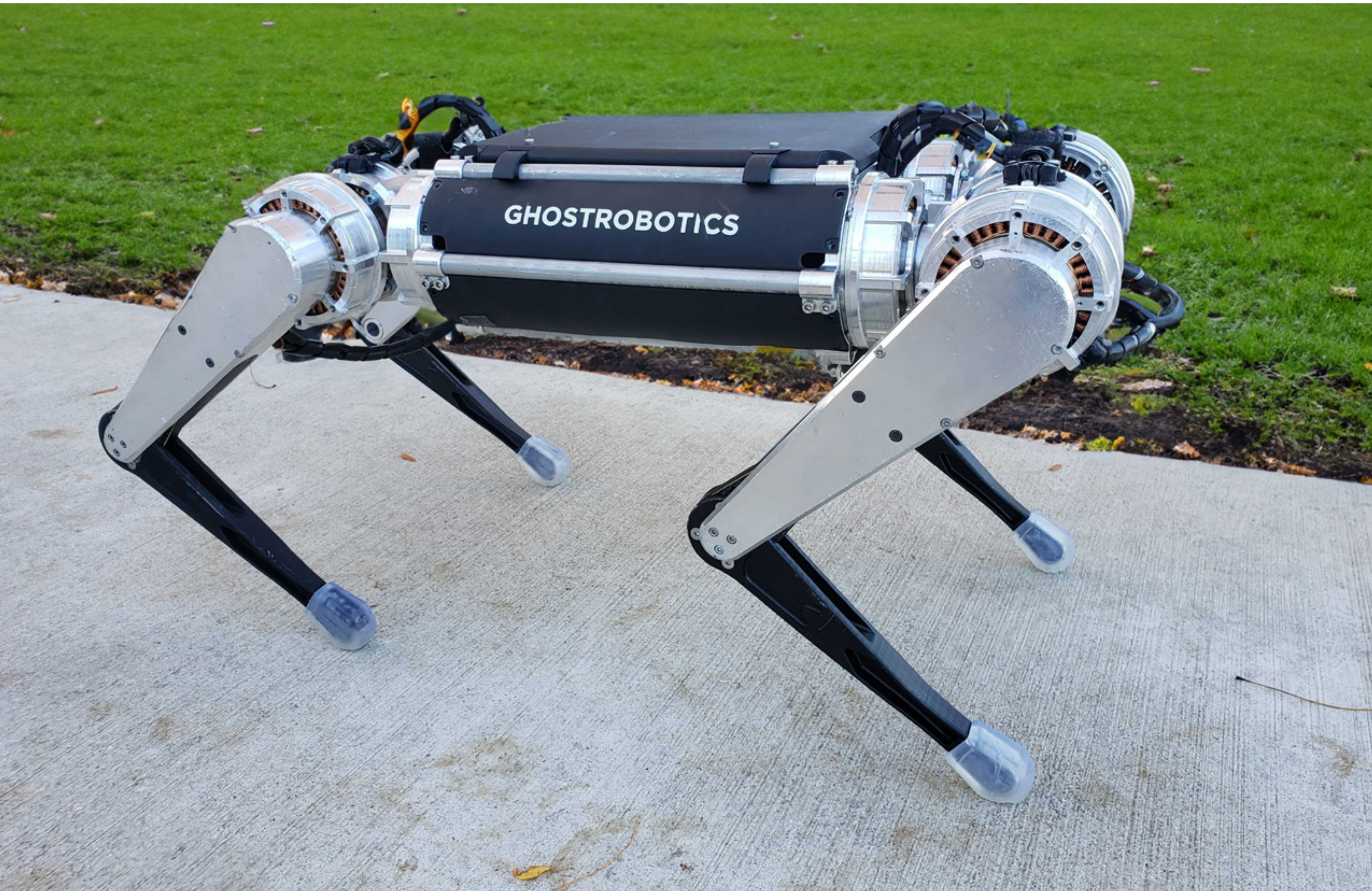
Here are a couple of Stratasys customer success stories from the logistics and defense sectors:

Ghost Robotics – Logistics

Ghost Robotics sought to accelerate production of its four-legged Spirit™ series robot with all-terrain stability. With a mandate to make lightweight, durable parts with a cosmetic surface finish, the company did not have to change the original design of its CNC machined parts when it switched to 3D printed parts, making the transition nearly seamless.

The company used Stratasys Origin One P3™ printer technology and accessed the Origin One materials network, selecting the most suitable materials to achieve the performance and surface accuracy it required for nine parts — including side panels, legs, and soft toes. Henkel's high-impact Loctite 3172 and ABS-like material Loctite 3843 had the optimal mechanical strength, durability, surface quality and price point.

In addition to significant production efficiencies, 3D printing gives Ghost Robotics the agility it needs to iterate new designs based on customer feedback.



General Atomics – Defense

Government defence contractors demand rigorous quality control from their partners. General Atomics Aeronautical Systems, Inc. (GASI), a maker of remotely piloted aircraft systems such as the MQ-9A Reaper and the MQ-9B SkyGuardian took a phased, hybrid approach to integrating 3D printing into its design and production. The company uses both in-house systems and vetted contract manufacturers such as Stratasys Direct®.

GASI used Stratasys FDM technology to bypass more conventional fabrication methods such as laminating composite material to make parts for a ground control station. By 2022, GASI's SkyGuardian program produced about 240 parts with 3D printing, saving $2 million in tooling expenses and more than $300,000 in recurring costs. Labor savings alone from making the tooling and bypassing the associated finishing processes such as curing and trim work have been significant.

The benefits go far beyond bottom-line savings when you consider the speed and flexibility of additive manufacturing to meet new design iterations and challenging contract schedules.

An aircraft duct 3D printed with ULTEM™ 9085 resin material.

Ground-support equipment manufactured with FDM additive technology.

Making the Business Case for 3D Printing

Aerial vehicles such as drones and UAVs are already revolutionizing the defense industry and many commercial sectors. With a diverse range of applications and form factors, aerial vehicles provide valuable data, improving safety and adding efficiencies. As drone technologies continue to advance, more and more uses for aerial vehicles will arise with a wider range of benefits.

As this guide has shown, additive manufacturing is playing a key role in the development and production of drones with tangible benefits over conventional manufacturing methods. With the capability to rapidly create prototypes and end-use parts, 3D printing gives drone and UAV makers the tools they need stay competitive and take advantage of market trends and opportunities. Don't miss out on its advantages.

What's Next?

Use the knowledge gained from this guide to take the next step to learn how 3D printing can benefit your operation. Whether you start with outsourcing one part to our Stratasys Direct on-demand service or want to develop your own 3D printing program with Stratasys solutions, we are here to help.

Discover how 3D printing with Stratasys improves efficiency and redefines the limits of manufacturing. Contact one of our experts today to learn more, whether to talk about specific applications or find answers to your 3D printing questions.

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