The Drone Revolution is Hovering, Ready to Land

JABIL

Regulatory standards and proven performance are key to mass adoption.

No longer just for hobbyists, today's drones or unmanned aerial vehicles (UAVs) are highly sophisticated devices packed with technology such as electro mechanicals, advanced structural mechanicals, and complex integrated electronics systems such as sensors, communications, and power management. Industries as varied as entertainment, agriculture, disaster recovery, and critical utilities are deploying fleets of drones for photography, inspections, precision crop spraying, and security. Retail deliveries are on the rise and expected to reach one million deliveries annually as retailers, UAV manufacturers, and third-party logistics service providers work through the complications of last-mile delivery. The market is at a tipping point. Advisors at McKinsey report, "Regulations, customer acceptance, and cost will all determine whether the industry reaches its potential to disrupt global logistics or remains limited to isolated applications."[1] UAVs and their supporting ecosystems require complex capabilities involving sensor integration, electronics miniaturization, power management, safe autonomous functionality, structural efficiency for peak performance, and specifications related to regulatory standards. Growth of UAVs in the air will also grow the market for ground control station equipment requiring complimentary technologies such as power management, communications, ruggedized enclosures, miniaturization, light weighting, and software security.

Global Commercial Drone Market

$29.9B

Global Market Size

2022

Source: www.grandviewresearch.com

The global commercial drone market size is projected to grow to USD 47 billion by 2029 at a nearly 30% CAGR.[2] This growth must be supported by the development of a ground infrastructure that manages storage, charging, and maintenance of growing UAV fleets. While government and defense have been the largest buyers to date, commercial UAVs also expect major adoption in the near-term, with the industrials, logistics and transportation sectors leading.[3] Several countries are exploring UAVs for postal deliveries and large retailers like Walmart and Amazon have deployed and are testing UAV delivery fleets in the U.S. UAVs address many of the costliest, negative drawbacks of delivery today—they remove the weight and carbon emissions of gas-powered vehicles, reduce traffic on roads, and increase speed of delivery by flying over obstacles and traffic. And they do it with increasingly quiet devices capable of improved delivery accuracy. The company Zipline, for example, claims it has reduced its required landing radius to the size of a dinner plate.[4]

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The Anatomy of an Unmanned Aerial Vehicle

The complex workings of the UAV require a unique fusion of cross-discipline engineering and specific manufacturing capabilities. From optics and sensors to communications and power management, the technology and expertise required to build, integrate, and operate a UAV is complex and intricate. To address the challenges and opportunities in manufacturing a modern UAV, let's take a look at a sample vehicle:

- **Airframe** – airframe, fairings, landing gear, aero-dynamic devices, payload mounts
- **Flight Systems** – flight controls, motors, wings/propellors, camera gimbal, navigation LEDs, payload deployment mechanisms, safety systems
- **Power Management** – battery, chargers, weighting/balance, energy management, battery swaps, battery status, communication
- **Autonomous Operating Systems & Sensing** – collision avoidance, communications, cameras, LiDAR, radar, and infrared sensors, antennas, gyro stabilization, and GPS, GNSS, compass
- **Infrastructure** – ground support equipment, charging hardware, communication terminals, payload loading stations

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Power Management

Go Farther, Do More

From smartphones to electric cars, battery power and energy management are constant challenges. UAVs are also subject to this pressure—especially as their role in tasks operating Beyond Visual Line of Sight (BVLoS) increase. While battery improvements and battery density will be key to longer flights, there are other power management factors like weight, payload, and distance that play into the energy consumption models. To optimize these systems, UAVs may employ a hybrid power supply system architecture, defined as a product having two or more power supplies available for the propulsion and auxiliary system, to boost endurance and performance. Fuel cells, batteries, solar cells, and supercapacitors are examples of power sources that could be combined in a hybrid power architecture. To enable today's drones (and those of the future) to work efficiently, the appropriate energy management system must be selected based on optimal and accurate modeling techniques. Accurate modeling techniques could consider route planning, real time environment factors, battery state of health, payload prediction, and other factors.

Jabil, as a large contract manufacturer, is currently working across several industries that require intensive power management. In particular, Jabil works with several electric car and robotics companies to optimize their systems for power management and autonomous features. "Electric vehicles are driving significant growth in energy storage products," said Dave Eckerson, Jabil's director of industrial engineering services.

"Vehicle manufacturers want a higher level of integration, they don't want separate power electronics, motors, and other mechanicals that they have to integrate into one system."

> **"Becoming a key global player in the EV charging market requires a supply partner that can deliver exponential growth and steep ramp-ups in production. In 2020, we increased production capacity by 300% with Jabil. And we were able to ramp up production there from zero to 5000 units/month within a 2 month period."**
>
> **MATTHEW FISH**
> Purchasing Manager at EVBox
> EVBox Case Study

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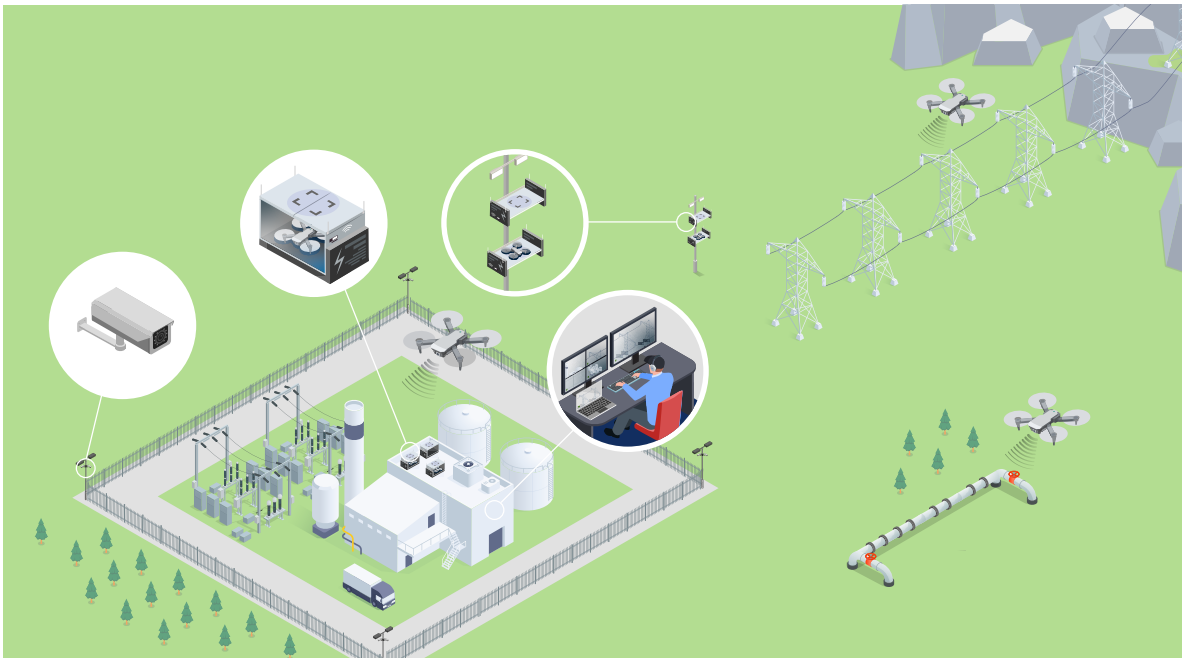
As UAVs are expected to carry more and travel farther, static on-board power will not be sufficient. To support critical UAV missions, an infrastructure of charging and storing stations will be required. Positioned atop power or lighting poles, UAV charging stations can fill in the gaps for long-range BVLoS flights like that illustrated below.



UAV Ecosystem Supporting BVLoS Inspection Flights

Power utilities spend a significant amount of time and money to inspect their far-ranging power lines and pipelines. For power lines that run through mountain ranges and across other difficult terrain, inspections of the pylons are difficult, expensive, and carry high risk for the workers. It is much more efficient to send UAVs that can fly over traffic, examine, and document the state of pylons from head-to-toe, and send the images or video to headquarters for examination. Trials of these UAV utility inspections are already taking place in the U.S., Norway, Sweden, and the U.K. with only government regulations slowing their adoption on a larger scale. Wired magazine reports, "Instead of humans and helicopters, the vision is to have armies of drones inspecting and maintaining the electricity transmission grid using preprogrammed templates."[5]

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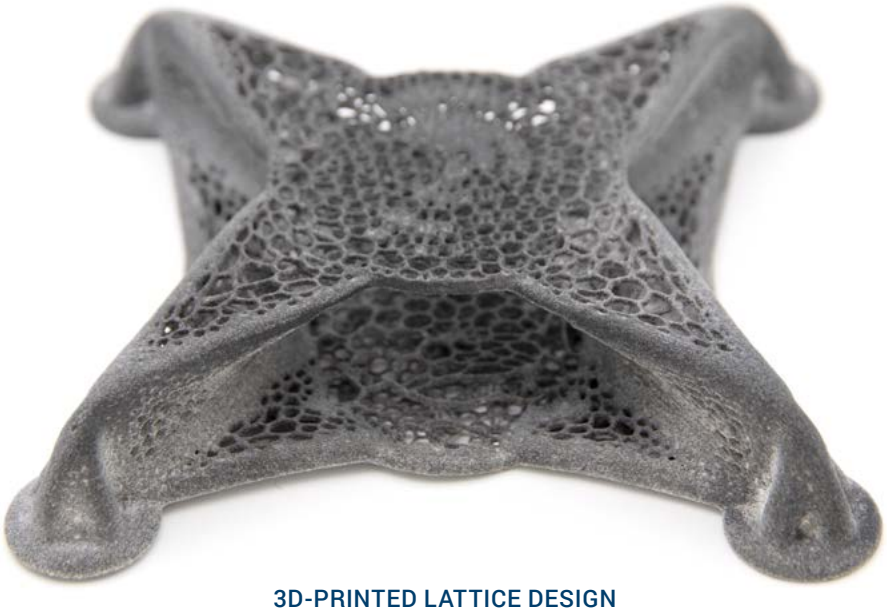
Structural Efficiency

The Growing Role of Materials Innovation

Optimizing a UAV system for energy efficiency goes beyond the battery. In fact, there's an acronym to address it: "SWaP" for Size, Weight, and Power. Material engineering and additive manufacturing (3D printing) can help reduce weight and create the most aerodynamic forms for the body, battery, cameras, and payload. The effect of each of these weight inputs can be minimized by unitizing multiple components into multi-functional components that reduce the part count and eliminate addition fasteners and bond lines. This all serves to streamline the UAV's shape to reduce aerodynamic drag as it moves through the airspace.

Achieving an aerodynamic, minimum operational weight is a priority in UAV design and production. "UAVs require a delicate balance between weight and power which kicks off a problematic cycle," explains Chris Huskamp, business unit director for Jabil. "Namely, they operate by battery, and while carrying payloads, they require greater reserves of power. To generate more power, they require bigger batteries. But bigger batteries add weight, which must be then counterbalanced with more power...it's an unforgiving spiral."

Additive manufacturing helps address the weight issue with the ability to print complex geometries, such as a lattice design as shown here. Lattices can dramatically reduce the weight of a component while retaining structural integrity. Additive manufacturing also enables parts consolidation and creating tight packaging of subcomponents.



3D-PRINTED LATTICE DESIGN

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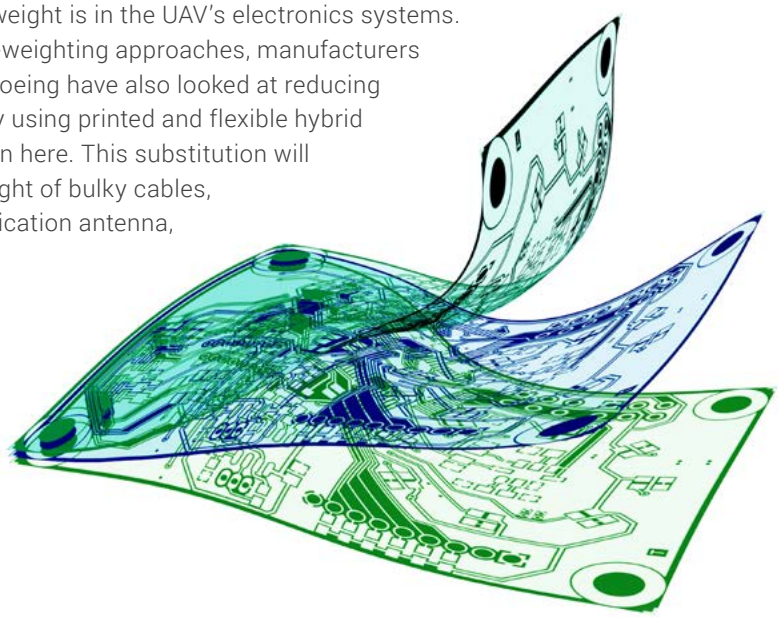
Today, almost all UAVs incorporate carbon fiber composite material. Although carbon fiber is a structurally efficient material option for general use, manufacturers need to consider a wide range of criteria during material selection. For one, the vehicle's structure must possess high structural stiffness to maintain its aerodynamic shape. Second, rotating blades such as rotors, propellers or engine fan blades and structures undergoing pressurization cycles require high stiffness or else the thrust distorts the blade profile, reducing propulsion efficiency.

As UAV use cases increase, manufacturers will need to explore innovative material options. Specialized use cases for UAVs usage may require certain specifications or characteristics that can be addressed by material engineers. For example, fire fighters can use UAVs to monitor and help control the spread of wildfires, or to deliver supplies or rescue equipment to fire fighters in the field. In this situation, it's necessary to use heat-resistant materials to avoid damaging the drone or creating an environmental hazard.

> **"The Alpine F1 Team is making great use of high-performance 3D-printed parts and materials in a way that I haven't seen other F1 teams or even other industries take advantage of—yet. And we're always working on new materials to extend the range of solutions that materials engineering and 3D printing can deliver."**
>
> **STEVE KUBIAK**
> Process Engineer at Jabil
> FI Alpine Case Study

Another area for reducing weight is in the UAV's electronics systems. Similar to mechanical light-weighting approaches, manufacturers like Lockheed Martin and Boeing have also looked at reducing the weight of electronics by using printed and flexible hybrid electronics like those shown here. This substitution will reduce or eliminate the weight of bulky cables, radar and cellular communication antenna, and flexible solar cells.



PRINTED & FLEXIBLE ELECTRONICS REDUCE WEIGHT

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Optics & Sensor Breakthroughs Drive Increased Autonomy

When people talk about "autonomous vehicles," they usually think of self-driving cars. As car companies begin testing autonomous driving, they (and the rest of us) are realizing just how complex, nuanced, and reliable the technology must be to ensure safety. It's not just a matter of better individual optics and sensors, these components must seamlessly integrate with the device software to respond or take evasive action. State-of-the-art perception systems capture scene information from a combination of multiple sensor sources, typically cameras, radar, and LiDAR. Artificial intelligence fuses these sensor inputs to identify objects, precisely localize the UAV in space, and plan the optimal path to reach the desired destination.

Addressing light differentials and weather conditions has guided autonomous devices to make use of sensor-fusion, or the use of multiple types of sensors for the same application. Typically, one type of sensor cannot safely monitor the conditions around a device in all situations. For example, cameras may not be able to accurately recognize other objects in low-visibility conditions, such as darkness, fog, or even blinding light. The types of sensors that benefit autonomous vehicles include:

- **Camera sensors** for video and still images are common types of optical sensors. Multiple cameras can provide a 360° view of the environment, which is vital for identifying obstacles. Camera sensors are equally valuable for autonomy in other environments, such as warehouses and stores.
- **Light Detection and Ranging (LiDAR)** combines unique software and hardware to transmit and interpret light waves that generate a precise 3D map of the UAV surroundings. Light is sent out to survey and measure the distance to surrounding objects and features.
- **Ultrasonic sensors** send out short ultrasonic impulses which are reflected by obstacles. Unlike LiDAR, they are able to "see" through objects, and unlike cameras, they are unaffected by low-light situations.
- **Radar sensors** use Frequency Modulated Continuous Wave (FMCW) radar to recognize both moving and stationary targets. These sensors are ideal for long-range detection and are not affected by extreme weather conditions.
- **Infrared sensors** provide images under low-lighting conditions, such as those in night-vision systems. With infrared sensors, UAVs can fly at night which is optimal with less ground and air traffic of other types.

In recent years, there have been several ground-breaking innovations in sensors and optics. Below are two that Jabil has recently developed to support work on autonomous devices like cars, robots, and UAVs:

- **Omnidirectional Sensor** – showcases an industry-first solid-state 3D camera combining a 3D time-of-flight (ToF) depth sensor with a custom 360° x 60° field of view optical assembly. This sensor earned the "**Best of Sensors Award**" from Fierce Electronics.
- **SWIR 3D Camera** – this first-of-its-kind 3D camera operates in the short-wavelength infrared (SWIR), at 1130 nanometers, solving a problem of capturing 3D images when moving between differentiated light levels, e.g., inside to outside. The 3D sensor data from these innovative depth cameras will improve obstacle identification, collision avoidance, localization, and route planning — key applications necessary for autonomous platforms.

> **"The Jabil omni-directional sensor is one of the most innovative implementations of the ADI depth-sensing technology we have encountered. Jabil's wide field-of-view, depth-sensing approach is opening up new possibilities for human interaction with robots."**
>
> **DONNACHA O'RIORDAN**
> Director, Analog Devices, Inc.
> Automation Magazine

"The new SWIR camera provides a glimpse of the unbounded future of 3D sensing where sunlight no longer impinges on the utility of UAV platforms," explains Ian Blasch, senior director at Jabil Optics. "As an example, integrating SWIR cameras with UAVs, will improve performance in several precision agriculture applications such as crop management, targeted resource allocation, and topographic map development."

Enabling a UAV to perceive the environment around it requires a variety of sensors including cameras, LiDAR, radar, and the software to integrate all of the inputs into meaningful directions for the device. Sensor fusion combines data from multiple sensors to provide higher quality information so that an autonomous system can make better, safer decisions. As all of these technologies and their integration continue to improve and prove themselves safe and effective in testing; the regulatory aspects of UAV development should also evolve and clear the way for wider adoption.

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Regulation is Key to Mass Adoption

Determining and establishing regulations for the UAV market is an active process for civil aviation bodies around the world. As of 2022, several countries are developing new regulations, ranging from BVLoS operations to unmanned traffic management (UTM) activities. Governments actively working on regulations include the US, the EU, India, South Korea, Japan, Australia, and several African countries. UAVs will likely be regulated by the civil aviation authority for a given country with most countries currently evaluating the best move forward, while appreciating the required speed to support adoption.

"It's the chicken or egg scenario. These systems are not bleeding edge, so there's no problem rolling them out at scale and at cost, but the regulations need to get up to date," argues David Benowitz, head of research at Drone Analyst. "And there also needs to be change among the regulatory bodies like the FAA and the CAA to create the space for these more advanced systems to be developed and properly tested so that they can be proven to be safe."[6]

In order to complete more flights and prove their accuracy and safety, one company took their UAV fleet to Africa to provide much needed services to an underserved population as a critical need. In 2016, Rwanda's government signed a contract with Zipline to streamline blood deliveries to rural medical clinics. To-date, the experiment has exceeded expectations and for the past seven years, covered 80 percent of the country with unmanned flights speeding blood/medical deliveries over mountainous terrain and difficult roads that impede delivery by truck. This forward-leaning approach that Rwanda took to reach at-risk populations has enabled an environment to capture flight data that is now shaping regulations in countries such as the United States.[7]

The benefits of UAVs are acknowledged by most governments, and they want to regulate in such a way as to encourage the safe deployment of UAV fleets. The advantage of UAVs is that they can avoid obstacles and traffic jams on city streets. Moreover, increasingly urgent environmental goals regarding emission reductions and energy-savings are strengthening the value proposition of reduced vehicle use and roadway congestion.

"Jabil has a wealth of experience in regulated industries such as automotive, healthcare, and defense and aerospace," explained Zackary Matthews, senior sales director at Jabil. "In the current conversation around UAV regulation, Jabil supports decisive action so companies can continue to advance technology in a safe manner. The adoption of UAVs has the potential to address environmental issues, improve rural deliveries and services, strengthen infrastructure through inspections, support rescue missions by aiding first responders, and ultimately, improve our lives."

The regulatory situation is in flux and under pressure for movement. An industry survey by Drone Industry Insights shows consensus that regulation is the most important driving factor for mass adoption and common use.[8] Frost & Sullivan report that global regulatory constraints limit market growth.[9] In most of the world, a waiver is required to operate a UAV BVLoS, which usually involves a long bureaucratic process. While the abilities of optics, sensors, and software to safely pilot UAVs through space continues to improve, the main obstacle to growth is less about technology, and more about regulatory clarity.

Be Ready for the Tipping Point

In multiple market forecasts, the UAV market is consistently seen as a growth market with most predicting a double-digit increase in revenue this decade. Grandview Research forecasts that the North America region, which held the most significant market share in 2022, is expected to increase significantly over the next eight years due to developments in drone technology, favorable government efforts, and growing demand from enterprises across numerous industries.[10] Fleets and swarms of UAVs are coming. The benefits are too cost and environmentally effective to postpone when we could have integrated large-scale fleets of flying devices that do not require roads, gasoline, or pilots.

UAV functionality continues to evolve despite regulatory delays—and most of these advances support safety and consistent performance. Commercial UAV companies need to make sure they are ready to meet regulatory standards, operate with proven safety guidelines, and deliver on the promise of UAVs to reduce the number of risky, time-consuming, and fossil-fuel-dependent methods. From optics and sensors to motors and batteries, today's UAVs are highly advanced technological vehicles. A solid approach to creating powerful UAVs for mass adoption will be partnering with manufacturers that support your vision, deliver on the technology, maintain quality and regulatory standards, and incorporate all of this complex functionality into a unified whole.

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Footnotes & Resources

FOOTNOTES

1. Drone Delivery: More Lift Than You Think, ©2022 McKinsey & Company
2. Commercial Drone Market Size, Share & COVID-19 Impact Analysis, ©2022 Fortune Business Insights
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- Jabil Optics wins Best of Sensors 2021 for its Omnidirectional Sensor, ©2021 Fierce Electronics

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EDITOR

Mary Edwards

CONTRIBUTING AUTHORS

Ian Blasch, Senior Director, Optics

Greg Cramer, VP, Engineering & Technology

Dave Eckerson, Director, Industrial Engineering Services

Chris Huskamp, Business Unit Director, Defense & Aerospace

Zackary Matthews, Senior Director, Enterprise Sales

Brent Tompkins, Senior VP, Enterprise

Girish Wable, Senior Manager, Engineering Services

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