Drones
Drones have seen unprecedented market growth and rapid adoption across various industries, thanks to lower costs, easier manufacturing, and their effectiveness in a wide range of use cases.

Companies now use drones for mapping and inspections in agriculture, mining, and construction. Drones inspect dangerous and hard-to-reach places such as chemical weapons plants and erupting volcanoes. The emergence of COVID-19 and racial injustice protests accelerated the already-fast adoption of drone technology. Last year, UPS, CVS, and drone tech company Matternet launched a drone delivery pilot program that allowed Florida residents to shelter in place and receive medical deliveries including documents and blood samples. Controversially, government and citizen drones also tracked protesters and police during widespread marches for social justice, and monitored social distancing amid the pandemic in places including New York, Paris, Mumbai, and China.
Drones continued

**DISRUPTIVE IMPACT**

The use of drones allows us to work outside the limitations of the human body in a very cost-effective way. We’ll likely see a wave of mergers and acquisitions among flight service providers, hardware startups, drone and aircraft manufacturers, asset and flight path management software makers, and data processing platforms. The growing sector may give rise to a new “drones-as-a-service” business model akin to the car and scooter sharing industry, delivering access to drones without the intervention of specially trained experts. We’ll also see more government uses, including identifying terrorists and monitoring immigration. In 2017, U.S. Rep. Will Hurd (R-Texas) proposed the Secure Miles with All Resources and Technology (SMART) Act, which would employ a constellation of AI-powered cameras, biometric recognition systems, airborne unmanned vehicles, lidar, and mobile phone monitoring systems, to create a “smart wall” that conducts detailed surveillance, primarily for use at the Texas-Mexico border. The bill stalled in committee, but in the wake of recent public unrest, there’s renewed interest—and now, better technology—to make the proposal a reality.

**EMERGING PLAYERS**

- Zipline
- Anduril
- Terra Drone
- Hemav
- Matternet

Agricultural drones can manage crop health from the air.
DRONE SWARMS

KEY INSIGHT

Drone swarms, or fleets of networked drones capable of coordinated operations and communication, are being developed for military operations, surveillance, and other complex functions without human interaction. In a drone swarm, the collective functionality of the overall network becomes more important than each individual drone, and the group of drones can “learn” and adapt synergistically.

EXAMPLES

The U.S. Army is developing a Cluster UAS Smart Munition for Missile Deployment that would allow a swarm of small drones to fan out and destroy vehicles with “explosively formed penetrators,” or EFPs. The U.S. Navy Office of Naval Research intends to launch a swarm of Coyote drones, made by U.S. military contractor Raytheon, for intelligence, reconnaissance, and potentially weaponry. Turkey has deployed Kargu tactical kamikaze drones on the Syrian border via remote pilots. In October, China conducted a test launch of 48 “suicide” drones from a truck and helicopter. This follows a number of other larger swarm-drone experiments by the country in 2017. The U.S. Army plans to build an autonomous charging system that swarm drones could fly to for charging before redeployment. The Army is also working on a giant recharging drone called the Joint Tactical Aerial Resupply Vehicle, which is also intended to serve swarms.

Civilian applications include dazzling light shows and dynamic aerial artwork. Disney and Intel are creating a new type of light show that uses 300 drones with multicolored lights that fly in unison at Disney World.
Drones Swarms continued

**DISRUPTIVE IMPACT**

Swarms of drones would allow a single delivery truck to service a full neighborhood or multiple drones to work together in the manner of a school of fish. Ideally, future swarms will use what Nora Ayanian, a roboticist at University of Southern California, calls “leveraging diversity in the control policy,” in which each drone is programmed slightly differently so that the one best suited to the task teaches the rest of the swarm how to act. This could make drones more robust in unstructured and uncertain environments, such as in disaster response, environmental monitoring, and military applications.

**EMERGING PLAYERS**

- U.S. Navy Office of Naval Research
- U.K. Defence Science and Technology Laboratory
- China Electronics Technology Group
**KEY INSIGHT**

### Fleets of drones operating as air carriers will begin making package deliveries soon.

- The pandemic accelerated drone-delivery certification approvals, as many consumers avoided brick-and-mortar stores. Amazon received U.S. Federal Aviation Administration clearance last year to begin making commercial deliveries under a trial program. Amazon joined UPS and Google as companies certified to make autonomous deliveries. Google’s Wing, partnering with Walgreens and FedEx, began its tests last year. UPS now flies medical supplies between buildings on a Raleigh, N.C., hospital campus.

- Amazon has also filed patents for interesting drone-fleet logistics, including a gigantic beehive-like structure, where drones would dock and receive packages, and a laundry chute system attached to houses where packages would drop safely and tumble down to customers.

**EXAMPLES**

- Amazon
- Google’s Wing
- UPS
- FedEx
- Walgreens
- CVS

**DISRUPTIVE IMPACT**

**EMERGING PLAYERS**

- Amazon
- Google's Wing
- UPS
- FedEx
- Walgreens
- CVS
KEY INSIGHT

Car manufacturers, seeking to meet consumer preferences, are quickly adopting proactive safety functions that also provide the building blocks for full autonomous driving.

EXAMPLES

Netradyne makes AI-powered dash cameras that monitor real-time road conditions to reduce accidents. Companies can use the technology inside fleet vehicles to monitor driving behavior and teach commercial drivers how to be safer and more efficient drivers.

Comma.ai created Openpilot, an open-source software driver assistance system that uses a $1,200 camera and development kit that allows people to transform their cars so they steer, accelerate and brake automatically, as with Tesla’s Autopilot.

Comma.ai works with a large variety of car models and manufacturers via a customized Android cell phone mounted to the windshield and connected to the vehicle’s existing adaptive cruise control hardware.

DISRUPTIVE IMPACT

Vehicle manufacturers will continue to implement and tout active safety features to attract safety-minded consumers, with software representing the next wave of advances. Car manufacturer development cycles, historically occurring over a 10 year span, will accelerate as platforms become increasingly software-driven.

EMERGING PLAYERS

- Netradyne
- Driveri
- Comma.ai
- Tesla

Increasingly advanced safety features are laying the foundation for autonomous vehicles.
KEY INSIGHT

Autonomous delivery is becoming more common, driven in part by an increased desire for contactless interactions brought about by the pandemic. Delivery is an ideal testing and development ground for autonomous vehicles, as the hurdles for safely transporting food are lower than those for safely transporting humans.

EXAMPLES

Nuro, a startup founded by former Google engineers, is developing autonomous vehicles for last-mile deliveries, including take-out, groceries, laundry, and packages. JD.com has autonomously delivered more than 13,000 packages, traveling 6,900 kilometers in lockdown environments. Cenntro Automotive Group’s CityPorter electric vehicle will soon make urban deliveries, while General Motors launched a new last-mile delivery business called BrightDrop.

DISRUPTIVE IMPACT

A study from the World Economic Forum found that rising demand in e-commerce will lead to a 36% increase in delivery vehicles in the largest 100 global cities by 2030, and last-mile delivery will spike 78%. The first widely deployed autonomous vehicles likely won’t be transporting humans but rather familiar goods—like pizza. These sorts of autonomous deliveries will continue to gain momentum as a reliable, data-rich, and cost-effective solution for last-mile transportation with the potential to improve customer experiences. These relatively low-stakes deliveries will socialize autonomous technology in everyday society, easing the transition to autonomous vehicle systems for transporting people.

EMERGING PLAYERS

- Nuro
- Refraction AI
- Cenntro Automotive Group
- Arrival
- Rivian

Starship Technologies uses robots to deliver food and drinks to George Mason University students.
The proliferation of drones will lead to more aviation guidelines, including “air lanes” that will guide low-flying aircraft, both piloted and autonomous. Where and when these new aircraft can operate will significantly impact the built and natural environment, and managing the number of flying drones will be important to ensure safety and noise pollution.

**Examples**
The U.S. Federal Aviation Administration has updated its Part 135 certification process for package deliveries by drone and is creating new regulation for air safety and industry guidelines. UPS Flight Forward was the first to receive a Standard Part 135 air carrier certificate to operate a drone aircraft in 2019. The FAA is now working with industry as well as state, local, and tribal governments to inform future rules and regulations.

The FAA’s new BEYOND program will develop and scale drone delivery operations, establishing rules for infrastructure inspection and public operations. The program will also gather data and community feedback on the social and economic benefits of drones. Vodafone and Ericsson will work together to prove how safe flight path corridors can be created within existing cellular network coverage. Using network traffic data ensures that autonomous drones avoid areas of poor network coverage to guarantee connectivity from departure to destination.

**Disruptive Impact**
Regulators have an opportunity to preempt congestion, ensure safety, manage community perception, ensure privacy and learn from road and air travel if they proactively create aerial infrastructure along with key stakeholders. Cities and states will then need to develop regulation to ensure interoperability of drone lanes.

**Emerging Players**
- U.S. Federal Aviation Administration
- International Civil Aviation Organization
- European Union Aviation Safety Agency
- Civil Aviation Administration of China
- South African Civil Aviation Authority
- Civil Aviation Authority of Singapore

Proactive planning can help avoid an aerial overload.

Image credit: Flightradar24.
Flying Taxis

KEY INSIGHT

Compact, unmanned electric aircraft have moved beyond the concept stage, and now a flurry of prototype tests at companies worldwide could open the door for autonomous air travel services to take individuals and small groups short distances.

EXAMPLES

In 2021, Cadillac introduced a vertical take-off and landing (eVTOL) personal air taxi. It’s General Motors’ first foray into the increasingly crowded aerial mobility space. Hyundai, Aston Martin, and other carmakers announced plans to build their own eVTOL aircraft. But there have been setbacks: A fire inside a hangar destroyed a prototype by Germany-based Lilium; Boeing’s Aurora Flight Sciences prototype crashed; and Kitty Hawk’s one-person vehicle, Flyer, suffered fires involving batteries, electric motors, and wiring.

DISRUPTIVE IMPACT

Most designs use electric engines that allow for vertical landing and takeoff in urban spaces, enable short- to medium-distance trips, and rely on both piloted and autonomous formats. NASA Ames Research Center and the U.S. Federal Aviation Administration are currently working to create regulations for safety and air traffic control. The result could be hundreds of thousands of delivery drones and air taxis flying in urban and suburban airspace, opening up a new medium of travel for the mainstream passenger and impacting transit design, congestion, and travel times. The high rate of crashes in the helicopter travel industry, including the high-profile fatal crash of Kobe and Gianna Bryant and seven other people in 2020, highlights the need for increased safety in this burgeoning area.

EMERGING PLAYERS

- European Organisation for the Safety of Air Navigation
- New Zealand government
- EHang

General Motors debuted its concept eVTOL in 2021.
KEY INSIGHT
“Follow-me” functionality, whereby a drone is able to detect and pursue a moving subject, has burst onto the scene in personal drones for photography and videography, but it has potential applications in a range of settings and situations.

EXAMPLES
Many photo- and video-enabled consumer drones available today have "follow-me" and crash-avoidance functionality, enabling semi-autonomous flight, where a subject is kept in the frame of the camera without the need for a designated pilot. This is ideal for capturing solo activities like skiing, surfing, and dance. Most of these drones rely on GPS transmitter technology or recognition software, such as DJI ActiveTrack.

DISRUPTIVE IMPACT
The ability to automatically avoid crashes and reroute around obstacles greatly increases a drone’s safety and versatility. Autonomous conflict avoidance and follow-me functionality reduce stress and sensory demand on the remote pilot, making indoor flight easier and expanding the range of circumstances in which drones can be safely operated.

EMERGING PLAYERS
- DJI
- Skydio
- Yuneec

Follow-me functionality allows drone operators to capture the moment without worrying about piloting.
Inspection Drones

KEY INSIGHT

As natural disasters and extreme weather events become more common, drones will help with the rapid inspection and interpretation of critical infrastructure.

EXAMPLES

Drone inspections are being performed in almost every industry that requires visual inspections, in the aftermath of a weather event or as part of routine maintenance. Drones can capture visual data more safely than humans can—and AI systems process those data in real time. Carnegie Mellon University researchers are developing an AI system that will review amateur drone footage of damage from 2020’s Hurricane Laura so that it can perform rapid damage assessments in the future. The system would automatically identify buildings and offer preliminary damage assessments, increasing situational awareness and significantly reducing cost and human labor.

DISRUPTIVE IMPACT

Increasingly frequent extreme weather events will further strain infrastructure. As civil aviation authorities grant new certifications to allow flights beyond the visual line of sight, drones will gain access to remote gas pipelines, power lines, and other areas that are often only reachable by dangerous backroads.

EMERGING PLAYERS

- Carnegie Mellon University
- Neurala
- Optelos
- PowerVision Robots

Drones can inspect infrastructure in places that are too dangerous for humans.
KEY INSIGHT

Drones aren’t just for air and land. Underwater drones have been around since the 1950s, but in recent years the technology has improved dramatically due to better batteries, low-light high-definition cameras, and lighter control boxes and sensors.

EXAMPLES

The U.S. Navy first developed underwater drones, and such devices were used to discover the wreck of the Titanic in 1985. Modern drones are far more advanced. Today’s autonomous underwater vehicles are used to disable mines; to explore for oil and gas drilling; to inspect nets; to feed and stock fisheries; and to reduce costs for monitoring, building, and maintaining underwater assets. General Dynamics’ Bluefin-21 drone is known for its 2014 search for the wreckage from Malaysia Airlines Flight 370. Boeing’s Echo Voyager is the largest autonomous underwater vehicle, weighing 100,000 pounds, and it can also go the deepest. Boeing and Huntington Ingalls Industries are now developing the Orca drone submarine, designed for military combat, surveillance, and minesweeping. Lockheed Martin’s Marlin can create 3D models of its surrounding environment in real time. The navies of France, Japan, Russia, and China, meanwhile, are developing their own underwater technologies. Underwater drones have even become popular among consumer hobbyists and can be purchased online for $500 to $3,000.

DISRUPTIVE IMPACT

Underwater drones are changing the business dynamics of marine construction, potentially increasing underwater land usage. The potential of improved underwater surface mapping could also cut the costs of laying the transatlantic cables that serve as the backbone of the internet, enabling increased competition and connectivity. Military autonomous underwater vehicles could be used in both offensive and defensive capacities including intelligence, network infrastructure, port security, and more.

EMERGING PLAYERS

- Blueye Robotics
- Geneinno
- Youcan Robot
- Notilo Plus

Autonomous Underwater Vehicles could significantly help to maintain and inspect underwater structures.