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THE DRONES REPORT: Market Forecasts For Commercial Applications, Regulatory Process, And Leading Players

Marcelo Ballvé | February 26, 2015

BUSINESS INSIDER

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Key Points

- **The global commercial drone market will take shape around applications in a handful of industries: agriculture, energy, utilities, mining, construction, real estate, news media, and film production.** Within five years, drone use will be routine in these areas. The hobbyist and consumer market is a separate category, important mainly to a few firms focused on inexpensive systems and the smallest version of these aircraft, with aerial photography being an especially popular application.
- **Overall, most drone industry growth is on the commercial side, as the shift away from the military market gains momentum.** The market for commercial/civilian drones will grow at a compound annual growth rate (CAGR) of 19% between 2015 and 2020, compared with 5% growth on the military side. The average selling price of a commercial drone system, including software and hardware, is now ~$30,000, according to market research we have reviewed, but will come down gradually as new regulation opens up competition.

- **E-commerce and package delivery will *not* be an early focus in the drone industry.** Despite the hype around Amazon Prime Air and other high-profile research programs looking into delivery drones (DHL, etc.), this will not be a common application in the short- or medium-term. E-commerce deliveries would be focused in urban areas, where airspace is crowded and regulators will see too many hazards to approve routine drone activity.
- **Proposed US regulation would effectively end the ban on commercial drone flights within the next two years and would allow low-altitude flights of small drones within view of a ground-based pilot.** US government actions point consistently toward a near-term goal of deregulating small drones for specific and limited commercial applications, in strictly demarcated areas in which no members of the larger public would be exposed to drone overflights.
    - The proposed rules dovetail with the handful of "exemptions" that have been granted over the past couple of years allowing specific US firms to fly drones commercially.
    - The rules, including privacy safeguards, are unlikely to be finalized before early 2017, but we believe it is very likely that widespread commercial unmanned aerial vehicle (UAV) flights will become routine sometime that year.
    - The proposed regulations ban drone flights over populated areas and prohibit flights that don't maintain the drone within a pilot's line of sight. That puts a chill on applications such as advertising or e-commerce, which almost by definition would require overflights of crowded cities or towns.
- **Technology barriers are at once a roadblock and a huge business opportunity.** There are still thorny problems to be solved in terms of navigation, object avoidance, continuous flight, and remote piloting. The firms that innovate in software and hardware to solve these problems will become industry leaders. Advances in civilian drone software and hardware will also make it easier to convince the public and

regulators that drones can be safely incorporated into civilian airspace at scale.

- **Legacy drone manufacturers focused on mostly military clients do not have a natural advantage in the fast-evolving commercial drone market.** The broader commercial market, which includes business-to-business and business-to-consumer markets, is not easy for military contractors to shift to. They are accustomed to working with multiyear billion-dollar contracts and a handful of large clients, i.e., the world's major militaries.
- **Major commercial UAV vendors will most likely emerge from a large and fragmented field of private companies and startups,** which already boasts some pretty dug-in UAV vendors.
- **Many of the top commercial UAV manufacturers are emerging from outside of the US market,** and that could point to a future dominance by European and Asian UAV firms, especially if drone deregulation occurs more quickly in large markets outside of the US, as it has in Switzerland.
- **The commercial-drone industry is still young but has begun to see some consolidation and major investments from industrial conglomerates, chip companies, IT-consulting firms, and major defense contractors.** For now, the industry leaders are still a handful of early-stage manufacturers in Europe, Asia, and North America.

Click here to download the charts and data associated with this report »

Introduction

For the past several years, speculation has focused on when and how drones will come into wider commercial use. The answers to these questions are coming into focus, and they will be at the center of this report. Drone manufacturers — from startups to military-hardware manufacturers and consumer-electronics conglomerates — need to begin planning for the moment in which commercial drones are adopted for specific industrial uses.

Despite regulatory barriers, safety issues, and lingering privacy concerns — particularly in the US market — firms of different types are making significant investments in drone technology and are beginning to aggressively market aerial drone systems (which we'll refer to in the rest of this report as unmanned aerial vehicles, or UAVs).

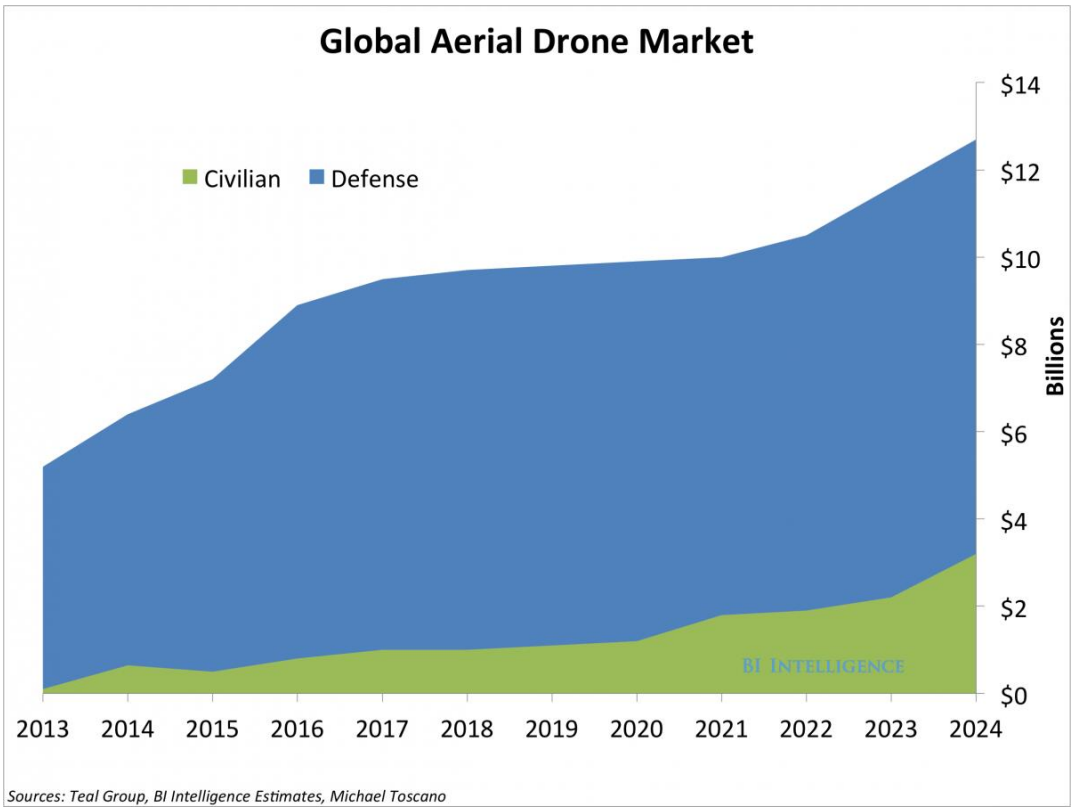
The most significant trend shaping the UAV industry in general is the shift from a focus on defense and military applications toward civilian use of drones, both by the public and private sectors. Outside of the US, UAV technology is already in use commercially, particularly in Western Europe and Asia but also Latin America.

Most flights are conducted in industries such as agriculture, energy, pest control, private security, as well as property and land management. UAVs offer businesses the ability to monitor, manage, and map large territories at a relatively low cost.

A great deal of public attention has been devoted to the possible use of UAVs to deliver packages ordered through e-commerce sites such as Amazon's. But it has become increasingly clear that UAVs will first become prevalent in applications that allow for their deployment over sparsely populated areas of privately owned land (e.g., farming). This will help minimize concerns over public safety and privacy that would be triggered by routine UAV flights in crowded areas.

This report will gauge the size of the market for commercial UAVs globally, outline the regulatory landscape in the US (which is being closely watched by regulators in other countries), and offer an analysis of trends shaping this rapidly changing industry, with a focus on the key business opportunities emerging in the near term.

Sizing the UAV market



The aerial drone market is shifting steadily away from a near-exclusive focus on defense customers and toward commercial applications, with aerial mapping and photography-related applications leading the way. While regulatory challenges and public debate are still dampening potential on the civilian side, business adoption of UAVs will occur quickly in markets in which they are deregulated.

- **Spending on UAVs and related hardware will double over the next decade**. The Teal Group has forecast that annual spending on aerial drones, including civilian and military applications, will reach $11.5 billion in 2024. Our own estimate builds on Teal's numbers and that of other industry observers and comes up with a slightly higher forecast: nearly $13 billion in annual spending by 2024, up from $6 billion last year.
- **The civilian share of the drone market (which includes commercial applications and non-military government applications) will account for one-fourth of the drone market by 2024.** We believe the rapid development of relatively inexpensive UAVs for a wide range of commercial applications will lead to rapid civilian adoption, despite regulatory chokepoints in certain markets.

We believe some countries will allow drones in national airspace faster than others. In part, privacy and safety concerns will fade once UAVs garner public support by demonstrating effectiveness for certain applications, such as for public safety (i.e., monitoring wildfires or traffic/road conditions), oil-platform inspections, and environmental conservation.

We believe there will be $111 billion in total cumulative drone spending over the next 10 years to 2024 (2015 to year-end 2024), and $15 billion of that will be spent on commercial/civilian applications, including R&D costs, software, and hardware.

UAV system price trends

The price of a commercial UAV system based around a small drone will range widely from $500 for no-frills systems to $35,000 for full-featured UAV packages that may include sophisticated software, according to a report from September 2014 IBISWorld report and price cards available from top vendors.

However, some commercial UAV firms specialize in larger, heavier-duty aircraft, and these systems can sell for much more.

The Swedish firm CybAero recently signed a contract with a non-military Chinese government agency to supply it with 70 of its large helicopter-style drones over several years, for a total deal of ~$100 million (which would value each unit at more than $1 million).

But large drones like CybAero's that weigh above 55 pounds (25 kilograms) are a niche part of the market.

Switzerland-based senseFly sells its Swinglet UAV model for ~$12,000, but over 90% of that price goes to the image-processing software, according to IBISWorld. Many of the UAVs marketed by DJI, based in Shenzhen, China, are priced in the $1,000 to $2,000 range, which is within reach for consumers.

IBISWorld's estimate of an average selling price of $30,000 for a commercial-grade UAV seems reasonable given the large range of prices.

The main factor affecting average selling price in the future is whether further deregulation of small drone flights will open up new market opportunities.

Looser regulation will fuel greater demand for lower-cost, smaller drones, and average selling prices will come down.

Top applications

Precision agriculture: This term refers to the management of crops to guarantee efficiency of inputs like water and fertilizer *and* maximize productivity, quality, and yield. It also involves the minimization of pests, unwanted flooding, and disease.

Drones allow for constant aerial monitoring of crop or livestock conditions to quickly find problems that would not become apparent in ground-level spot checks. For example, a farmer might find through time-lapse drone photography that part of his crop is not being properly irrigated. One of the few commercial

drone uses to have been permitted by US regulators to date is for an agricultural-seed company to fly two small UAV models over farms to estimate biomass, yield, and crop health. One of these approved UAVs is the eBee Ag, manufactured by senseFly, a model marketed specifically as a precision-agriculture drone. SenseFly is owned by France-based Parrot, which manufactures low-cost drones for the hobbyist market.

Energy, mining, and utilities: All these industries have one thing in common — their operations involve large territories, often in inaccessible areas. For example, a utility may have power lines crossing many kilometers of rugged terrain, such as mountains, forests, or desert. Energy companies may also have important facilities in remote areas or offshore. Also, certain types of infrastructure, like an oil platform's flare stacks — the exhaust towers used to burn off excess gases — or a mine's slag heap, might be difficult to inspect without a remote device. These companies typically require fairly rugged and sizable UAVs.

- One US-based company, Virginia-based Total Safety, recently won regulatory approval to fly a 25-pound UAV to conduct safety inspections of oil platforms, refineries, and pipelines.
- The 286-pound unmanned helicopter marketed by Sweden-based CybAero lists power-line inspections as one of the aircraft's main applications.

Real estate, construction, and land development: Real-estate and property-development firms are also tasked with managing and mapping large swaths of land or collections of buildings. Without aerial imaging, would-be developers have to rely on the fragmentary information that is made available through satellite imagery or publicly available surveys. Even when covering small sites, drones create aerial imaging that can help developers and prospective buyers understand a property's surroundings. UAVs can also keep tabs on construction-site safety or inspect external walls and roofs of existing structures. One of the US exemptions that has been granted for commercial drone use was awarded to a construction company, Clayco, which planned to use

a 10-pound drone to monitor its 11.5 million square feet of construction sites across the US. Clayco would monitor video and image feeds sent by the drone for real-time monitoring of safety conditions and construction progress at its work sites.

Media and entertainment: By far, the industry with the largest number of case-by-case approvals granted to US companies for commercial drone flights is the film-production category, earning these exemptions a nickname, "Hollywood exemptions." Film production has a clear advantage — similar to that enjoyed by mining companies and large agribusiness — in that UAV flights for these purposes typically take place in tightly controlled and demarcated territory (i.e., film sets). US regulators are also working with media companies, including the 24-hour news cable channel CNN, to establish ground rules and best practices for drone deployments by the news media.

Nonetheless, drones will be a niche technology for the news and entertainment media — few media companies will actually see a need to apply and pay for drones — and so this UAV market will be dwarfed by others, like agriculture, for which drones will play a routine role. However, entertainment *is* notable for being an early adopter. Many of the film-production UAVs approved for flights are proprietary models created and operated by a single production company. This is another reason why film production is unlikely to be a large commercial market: Each production house wants to use its own proprietary technology. The proliferation of custom designs *could* lead to innovations in UAV software or hardware.

Surveying/aerial imaging: Though it overlaps with many other areas, including mining and land management, UAV-assisted surveying and mapping is important to single out because it has so many potential applications across so many industries. This UAV-assisted surveying will be carried out most often by specialized contractors, typically engineering firms that often do this type of large-scale mapping work for private- and public-sector entities, including mining and energy companies, national and regional governments, and conservation nonprofits.

E-commerce and logistics: While package or mail deliveries to isolated rural areas would be a likely medium-term application for civil UAV flights, the widespread use of UAVs in e-commerce logistics seems to be a long way off. Regulators, particularly in the US, still are profoundly skeptical regarding the safety of UAV flights in congested areas, even if the UAVs in question are small and lightweight. There's the added complication that most logistics and delivery applications will be stymied by the requirement that pilots keep the drone within "line-of-sight," and this is still required for most approved commercial drone uses. It does seem likely that UAVs will play a very *limited* role in logistics in the near- and medium-term, but in niche situations such as rural delivery, courier services in remote areas, and emergency airdrops (see below).

Consumer: The current restrictions on drones in the US market do permit one type of activity: the use of drones below 400 feet (122 meters) in altitude by individual hobbyists and enthusiasts. This has given rise to a thriving, if fragmented, consumer-drone industry. This sector is focused mainly on lightweight and low-price systems. Some of the top marketers of commercial drones — China's DJI and France's Parrot — cater at least in part to this hobbyist market. Meanwhile, the US camera maker GoPro recently announced it was developing a UAV-designed product for photographers. If the latter application becomes popular, this market could explode very quickly, and that could lead to problems. There is already widespread concern about consumer drones invading privacy (e.g., neighbors spying on one another) and safety concerns around unauthorized flights near airports, stadiums, public parks, and government buildings.

Other: Entrepreneurs and aviation experts have also marketed drones for a wide array of applications, including foreign aid and medical-supply drops, pest control, private security, ecological monitoring, traffic monitoring, and even aerial advertising.

The regulatory landscape in the US — the tug of war in Washington, D.C.

For the past two years, would-be commercial UAV vendors have been watching the regulatory process in Washington, D.C., closely, hoping for promised policy that would end the ban on commercial drone flights in the US.

For the most part, they have been disappointed. The expected release date for draft rules on small commercial UAV flights was late 2014, but those rules were delayed for months.

This delay is a signal of how technically complex and politically fraught the process has become. Over the past two years, commercial UAVs have been the focus of increased media scrutiny, and there have even been committee hearings in the US Congress.

But in mid-February US regulators finally issued draft rules that will govern the commercial operations of UAVs weighing less than 55 pounds (25 kilograms).

There will be a public-comment period and more reviews before the draft rules become policy, and so the rules are subject to change. But the draft rules — along with case-by-case approvals, or "exemptions," that regulators have given to a handful of commercial UAV operations in the past couple of years — give the first clear glimpse into what the US commercial UAV industry will look like.

Draft rules

In the US, the civil-aviation regulator is the Federal Aviation Administration, or FAA.

A 2012 law instructed the agency to draft rules that would allow for the operation of small commercial UAVs in US airspace. The rules were to set policies in areas such as pilot licensing, UAV certification, flight restrictions, weight limits, pilot practices, etc.

The rules were finally published on February 15, 2015. Click here to read a PDF of the FAA's overview of the draft rules.

Publication of the rules opens them to a two-month period of public comment, after which they will again be reviewed and amended. We think it is unlikely the rules will become policy before 2017 (though some Washington, D.C., analysts believe it could happen earlier).

Congress could also create a law that could supersede the FAA rule making, but that is unlikely in the short term.

The drafted rules are relatively restrictive — they allow only for **commercial** flights by licensed operators within visual range of the aircraft (i.e., no remotely operated flights) and severely restrict where the flights can be conducted.

Here are the main points:

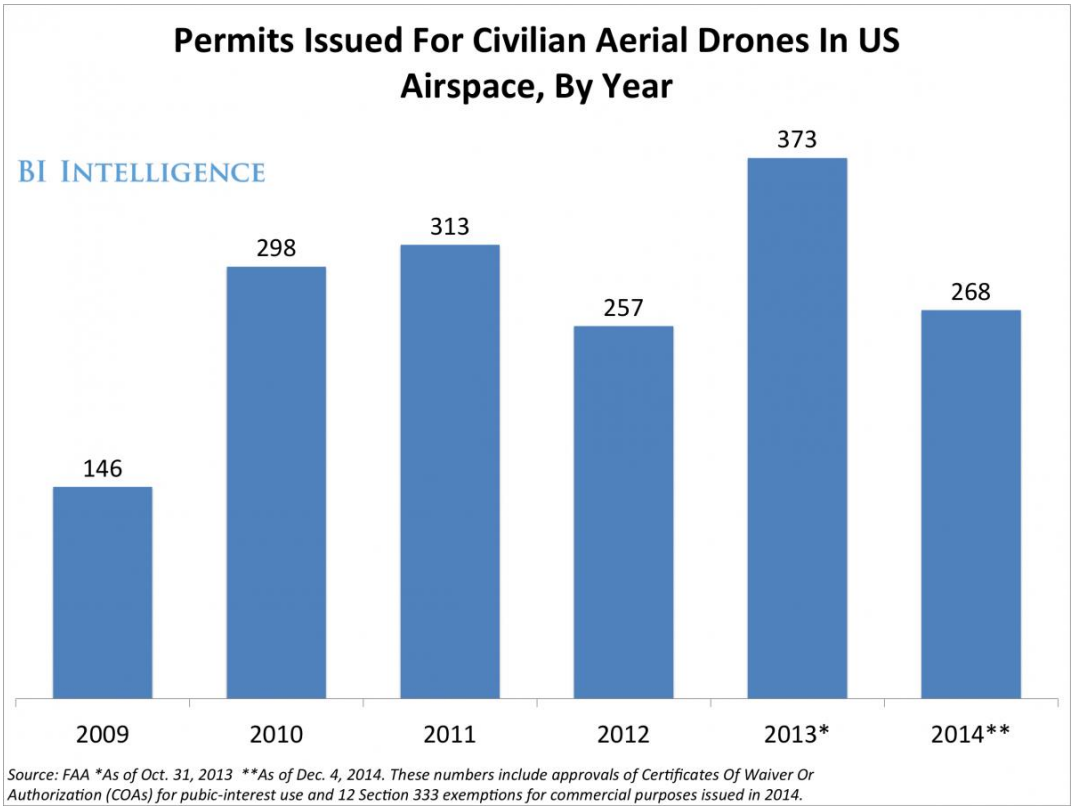
- The operator of the aircraft must be licensed as a drone pilot by the FAA, and the credential must be renewed every two years. The licensing process is not yet in place and is part of what needs to be detailed for the rules to go into effect
- The UAV may not weigh more than 55 pounds (25 kilograms)
- The pilot must keep the UAV within visual line of sight at all times during flight
- The UAV may not fly any faster than 100 miles per hour (161 kilometers per hour)
- Maximum altitude is only 500 feet (152 meters)
- UAVs cannot be flown above any people not involved in the flight or near restricted airport or flight areas (this effectively rules out UAV flights over urban or even sparsely populated areas)
- The flights must occur in daylight
- Other government agencies will need to study the privacy implications of the flights and propose a framework for industry self-regulation

There is some hint that regulators are unsure about whether they want to restrict flights as much as they have in the proposed rules. The FAA is asking the public whether separate policies should be carved out for commercial flights of UAVs weighing less than 4.4 pounds (2 kilograms), and whether the line-of-sight restriction should be relaxed.

Current policy

Meanwhile, the existing law must be followed.

Commercial flights are banned, but hobbyists can fly drones for recreational purposes below 400 feet in altitude and away from airports.



Until the new rules are in effect, the only way an aerial drone or UAV can be cleared for any other use in US airspace is to receive a special permit or exemption from the FAA.

These approvals fall into two broad categories:

- **Commercial use:** Operators of UAVs who want to conduct commercial flights can apply for individual exemptions from the existing restrictions. These are called "Section 333 exemptions," because of the section of legislation that provides for them. The FAA has a backlog of these exemption requests. It has granted more than 30 exemptions to businesses, including movie-production, construction, real-estate, aerial-imaging, and oil-services companies.
- **Public use:** The FAA issues Certifications of Authorization, or COAs, for limited UAV flights to public agencies and public-interest-oriented bodies. These include universities, police departments, and government agencies. COAs are also issued to commercially oriented private companies that want to conduct research and development at six designated UAV testing sites. As of December 4, 2013, there were 545 active COAs, according to the FAA. In 2014, 256 new COAs were issued.

A separate, more elaborate process of soliciting FAA authorization for flights of experimental aircraft can also be used to seek approval for UAV testing.

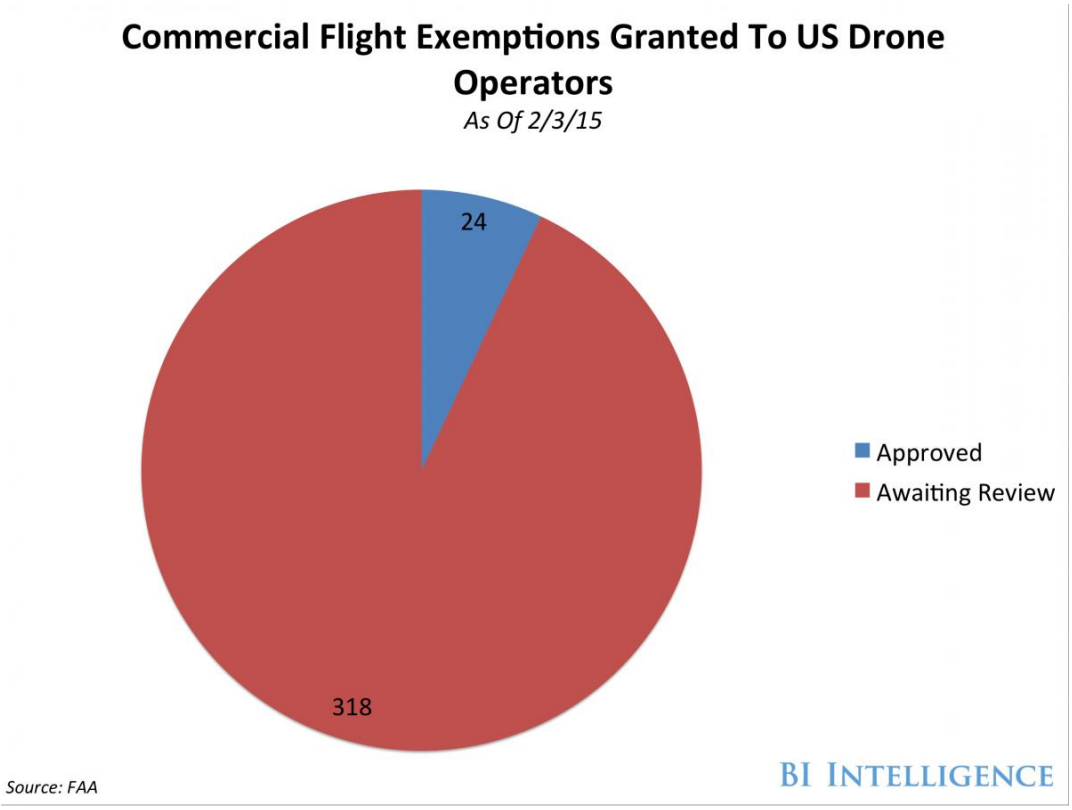
Exemptions granted to commercial UAV operators in the US

These exemptions were meant to speed up the commercial use of small UAVs in the absence of the long-awaited rules, and they are named after a specific section of 2012 US legislation mentioned above, which was enacted to streamline and modernize the FAA. (The FAA, which is part of the US Department of Transportation, has more than 48,000 employees.)

The FAA began accepting petitions for these "Section 333" exemptions in 2014.

It has not been very quick in approving them. According to our analysis, the FAA received close to 345 petitions as of early-February 2014, and it approved just 24 of them.

(See chart below based on early February figures.)



The process has also turned out to be complicated for some petitioners. One petition that has received scrutiny belongs to the high-profile company Amazon.

We reviewed the exchange, available on a US government website housing requests for exemptions and decisions, and overall believe it shows the FAA as reluctant to approve commercial flights in the area of e-commerce delivery absent further data that this application would be beneficial to the public. It is a case study of how cumbersome and involved the Section 333 process can be.

1. Amazon filed its exemption request on July 10, 2014, seeking permission to test its Air Prime delivery drone program in an isolated property it controls in Washington State.
2. The FAA replied on October 29, asking Amazon for more information on whether the UAV program would potentially result in any benefits for the US public and whether Air Prime would be better served by a broader permit given to experimental aircraft (although that authorization process is lengthier and more complex). "What data or analysis supports

Amazon's position that aerial delivery is in the interest of the American public?"

3. Amazon replied once more on December 7, insisting that its test flights in rural Washington State would fall in line with many of the safeguards required of petitioners and that an experimental aircraft authorization may consume more time than the 333 process. There has been no further action from the FAA.

Insight into FAA's regulatory preferences for drones

Looking at Section 333 exemptions that *have* been granted, we can begin to see the outlines of what the FAA views as the appropriate use of commercial drones in terms of size, flying speed, safety precautions, and types of applications.

- **Applications:** The FAA is clearly attempting to approve applications it believes can be encouraged in the short- and medium-term without causing too many difficulties for the US air traffic system. It has privileged drone applications that either do not contemplate the routine use of drones over crowded cities/airspace or those that require very brief, low-altitude flights over highly restricted areas.
- **Size and type**: Most exemptions granted were for drones weighing 15 pounds or less. The weight of a drone is important from a safety perspective, because a collision with an obstacle — another aircraft, a building on the ground, or a person — is far less dangerous if the UAV is small. The FAA did grant seven exemptions to film-production companies that operate drones weighing over 50 pounds, but these were for flights within tightly controlled outdoor film sets, and none of the UAVs weighed more than 55 pounds, which corresponds to the limit contained in the recently proposed rules.
    - **The FAA did not privilege any particular manufacturer in its exemptions.**Several of the major drone manufacturers were represented in the approved drone exemptions, including a few based overseas. Some exemptions went to proprietary drone designs developed by production studios and surveying firms.

Exemptions were given to drones with four (quadcopters), six (hexacopter), and eight rotors (octocopter).

- **Flying speed:** The FAA's exemptions restrict drones to maximum flight speeds of ~50 knots (roughly 90 kilometers per hour, or 60 miles per hour). The proposed rules allow for faster speeds, which may be an attempt to "future proof" the rules, because presumably UAVs will get faster even as they get better at avoiding obstacles.
- **Pilot credentials:** Some exemptions have gone to operators promising that the pilot in command has a private pilot's license (though not a commercial license, which is more difficult to acquire). Some have even gone to pilots promising only UAV-flight training and other model aircraft certifications. The proposed rules for commercial drones contemplate a new UAV pilot-licensing program run by the FAA.
- **Safety precautions:** In all exemptions, the FAA has mandated that drones be operated at low altitudes, far from airports or populated areas, for extremely short durations, and within pilot's line-of-sight.

The tables below offer snapshots of all the commercial exemptions recently granted by the FAA, and the model UAV involved:

US Companies Approved For Commercial Drone Flights

Applicant	Date Of Approval	Industry
Advanced Aviation Solutions	1/6/15	Agriculture
Aerial MOB	9/25/14	Entertainment
Aerial MOB	2/3/15	Entertainment
AeroCine	1/23/15	Entertainment
Alan D. Purwin	2/3/15	Entertainment
Astraeus Aerial	9/25/14	Entertainment
Asymmetric Technologies	2/10/15	Infrastructure Inspections
Blue-Chip UAS	2/10/15	Aerial Imaging
BOSH Precision Agriculture	2/18/15	Agriculture
Burnz Eye View	1/23/15	Aerial Imaging
Capital Aerial Video	2/13/15	Real Estate
Chevron UAS	2/13/15	Energy/Oil
Clayco	12/10/14	Construction
Douglas Trudeau, Tierra Antigua Realty	1/6/15	Real Estate
Flying Cam	9/25/14	Entertainment
Helinet Aviation Services	2/3/15	Entertainment
HeliVideo Productions	9/25/14	Entertainment
Pictorvision	2/3/15	Entertainment
Pictorvision Inc.	9/25/14	Entertainment
Picture Factory	2/18/15	Entertainment
Pravia	2/6/15	Agriculture
Pravia	2/6/15	Agriculture
RC Pro Productions Consulting	9/25/14	Entertainment
Shotover	1/30/15	Entertainment
Slugwear	1/30/15	Aerial Imaging
Snaproll Media	9/25/14	Entertainment
State Farm	2/13/15	Insurance
Team 5	1/30/15	Entertainment
Total Safety U.S.	1/30/15	Energy/Oil
Trimble Navigation	12/10/14	Aerial Imaging
VDOS Global	12/10/14	Energy/Oil
Viafield	2/9/15	Agriculture
Woolpert I	12/10/14	Aerial Imaging
Woolpert II	12/10/14	Aerial Imaging
Total Granted	**34**	

Source: FAA

US Companies Approved For Commercial Drone Flights

Applicant	Make/Model Of UAV
Advanced Aviation Solutions	senseFly eBee Ag
Aerial MOB	HexaCrafter HC-1100, Halo 8
Aerial MOB	Aeronavics SkyJib 8 v.2 Heavy Lifter, Discovery Pro
AeroCine	Kopterworx Hammer X12
Alan D. Purwin	Gryphon Dynamics X8
Astraeus Aerial	Astraeus Aerial Cinema System V.3CS
Asymmetric Technologies	Microdrones md4-1000
Blue-Chip UAS	Sensurion Magpie MP-1
BOSH Precision Agriculture	Bosh Technologies Super Swiper
Burnz Eye View	DJI Phantom 2
Capital Aerial Video	DJI Model F550 UAS
Chevron UAS	Skycatch
Clayco	Skycatch
Douglas Trudeau, Tierra Antigua Realty	DJI Phantom 2 Vision+
Flying Cam	Flying-Cam 3.0 SARAH
Helinet Aviation Services	Gryphon Dynamics X8
HeliVideo Productions	HVP- 14301 Multi Rotor
Pictorvision Inc.	PV- 14817 Multi Rotor
Picture Factory	Tarot Oct-Copter X8
Pravia	Event 38 E384
Pravia	senseFly eBee Ag
RC Pro Productions Consulting	Coaxial Quad Multirotor VAO1-V1 and Coaxial Quad Multirotor VAO2-V2
Shotover	Gryphon Dynamics X8
Shotover	DJI S1000
Slugwear	DJI Phantom 2
Snaproll Media	SnapRoll Media SUAS
State Farm	Aerialtronics Altura Zenith ATX8
Team 5	Gryphon Dynamics X8
Team 5	DJI S1000
Total Safety U.S.	DJI S1000
Trimble Navigation	Trimble Navigation Limited UX5
VDOS Global	Aeryon SkyRanger
Viafield	senseFly eBee
Woolpert I	Altavian Nova Block III
Woolpert II	Altavian Nova Block III

Source: FAA

Regulation in Europe

In European markets, regulation of UAV flights is typically at a similar preliminary stage. Each national aviation regulator is in charge of creating rules for non-military small UAV or RPAS flights (remotely piloted aircraft systems, as they're often called in Europe). Larger UAVs are subject to stricter Europe-wide rules for larger commercial aircraft.

Numerous European authorities have taken the approach of certifying drone flights or operators on a case-by-case basis.

In early 2014, there were ~1,400 certified non-military UAV operators across the European Union, according to UVS-International, an industry trade group that tracks European regulations.

There are exceptions to the rule, and some countries have actually been more strict and more liberal: Switzerland, which is not a European Union state, has made all UAVs weighing less than 30 kilograms or 66 pounds subject to model-aircraft and visual-line-of-sight rules, which in effect lifted most restrictions on flights of small commercial UAVs, making Switzerland one of the least restrictive countries.

Technology challenges

UAV technology has advanced very quickly. The basic components of a typical UAV are straightforward, and some are shared with the larger aircraft industry:

- Metals — particularly aluminum — and plastic for the aircraft body.
- Battery packs, usually rechargeable lithium batteries, to power autonomous flight.
- Engine and aircraft parts that control flight.

- Software that directs flight, operates sensors, and guides behavior, including object-avoidance and safety capabilities such as "return-to-home" or automatic returns to a specific GPS coordinate if there's a problem.
- Sensors that collect images, data, and flight information.

As technology has advanced, UAVs have begun to carry more sophisticated and powerful processors to manage the software-based operations that control navigation, imaging, sensor controls, and autonomous flight. Some of these operations aren't pilot-initiated; they occur automatically and are algorithmically determined. For example, a sensor may detect a TV antenna on a home and direct the UAV to climb to a higher altitude. Like collision-avoidance tech in automobiles, which sometimes will decelerate a car automatically, without driver intervention, these technologies can allow the UAVs to respond "intelligently," when encountering certain issues or triggers.

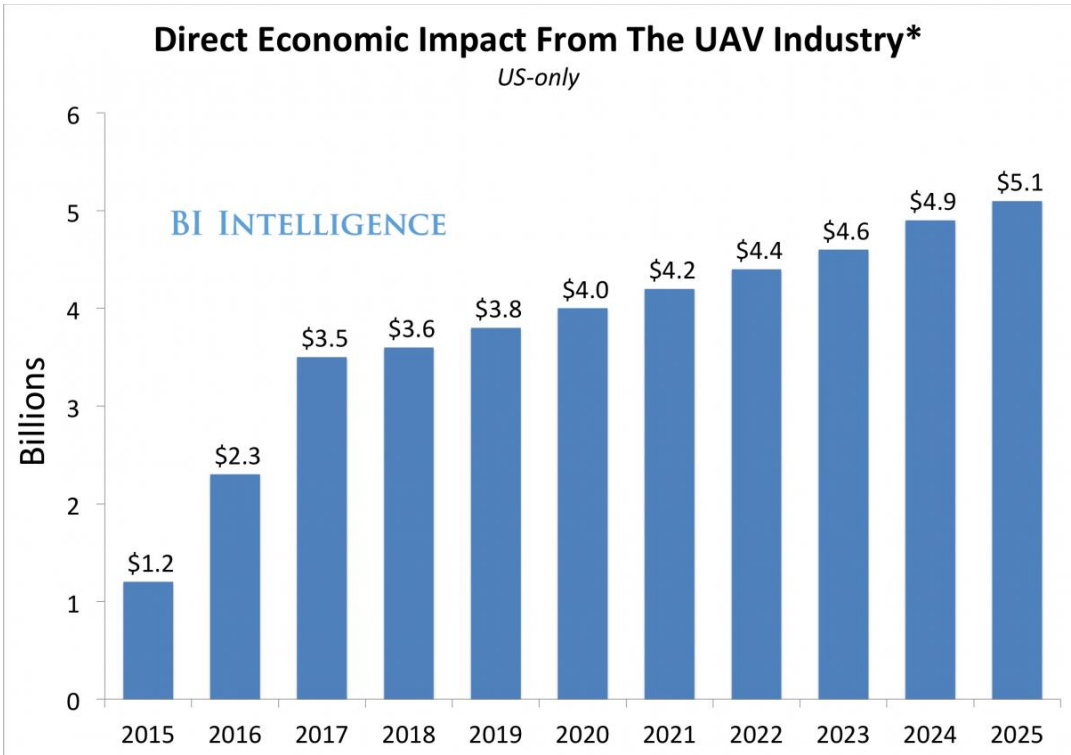
It is specifically around these software-based and sensor-based processes where UAV-focused tech startups have the most to contribute. We've identified a half-dozen areas in which drone research has the most opportunity to create new value.

- **Standard operating systems:** The operating system must house complex piloting software and process and relay data with almost no delays. Any latency could lead to a crash or inability to refine flight plans. Many early drone platforms were built on Linux or other open-source operating systems or were completely proprietary, i.e., military platforms built from the ground up as closed systems. 3D Robotics has its own open-source operating systems and flight software that it markets. Airware and Dreamhammer are also developing customizable operating systems and hardware that could serve as UAV platforms for a wide array of end users or drone vendors (much as the Android OS runs on smartphones made by different manufacturers).
- **Collision- and object-avoidance:** Startups including Ascending Technologies,SkySpecs, and Panoptes are focused on specialized sensors

and software-based technology that can help drones detect and safely avoid obstacles. One approach might be to use echolocation (as bats do) or image recognition.

- **Image recognition:** This ability is tied to the above problem and other safety challenges. A drone would need to be able to distinguish a blimp from a low cloud if automatic safety features are going to work. Likewise, emergency-landing technology might depend on the vehicle's ability to identify safe landing areas (i.e., clearings, empty roadways, or helicopter landing pads).
- **Geo-fencing:** This feature would essentially prevent UAVs from flying beyond a certain set of coordinates, helping pilot-directed and autonomous flights avoid unauthorized airspace.
- **UAV-software security:** It will be important for commercial UAVs to demonstrate an ability to resist cyberattacks.
- **Virtual-reality piloting:** One potential way to control a drone outside the line of sight would be to immerse oneself in a 360-degree virtual-reality environment created by stitching together camera images collected by the UAV, mimicking the experience of directly piloting a drone.

Regulators will most likely be friendlier to routine commercial UAV flights if they are confident these safety and performance technologies will help minimize the risk of collisions and accidents.



Source: Association For Unmanned Vehicle Systems International, 2013
**Includes all UAV-linked spending on employees, construction, purchasing, development, investment in UAV technology*

Players

The civilian UAV industry is global and fairly well developed in some markets (e.g., Europe, Japan, etc.), and it has recently seen strong global competition emerge out of China.

Shenzhen-based DJI is thought to be the world's largest drone manufacturer, followed by France-based Parrot.

Here is a list of civilian/commercial drone-systems and aircraft vendors that have come to prominence in recent years. This list is not comprehensive. (One market research outfit, IBISWorld, has counted more than 60 UAV vendors operating in the US alone.)

- **3D Robotics:** Based in San Diego, 3DR has raised $35 million in venture-capital funds from backers including Richard Branson, the well-known airline and aviation entrepreneur. 3D is among the world's leading manufacturers of small UAVs. It has a factory in Mexico and 28,000 customers in over 60 countries, according to IBISWorld. Revenue is estimated at under $100 million.
- **Aerialtronics:** This Dutch company markets the Altura line of quadcopters. Among its clients are fire departments and emergency-rescue teams.
- **Aeryon Labs:** This Canada-based company has supplied drones to law enforcement, the Libyan air force, and VDOS, an oil-services firm that won approval for commercial UAV flights under an exemption granted by US regulators.
- **Airware:** This San Francisco-based company has built its strategy around creating an operating system and customizable hardware to serve as the foundation of drone programs. It has raised $40 million in venture-capital funds, including an investment from GE Ventures, Google Ventures, and Andreessen Horowitz.
- **Altavian**: This Gainesville, Florida-based company positions itself as a one-stop shop for UAV technology, consulting, and support services.
- **Amazon Prime Air**: Amazon operates drone research and development labs in Seattle and England. It has petitioned US regulators to allow it to conduct commercial test flights at an outdoor facility near Seattle, but so far it has not received an exemption from the ban on commercial UAVs that would allow it to do so.
- **Ascending Technologies**: This German firm markets the Falcon line of small UAVs and has also developed micro UAVs and drone-navigation tech with built-in safety features like redundant sensor systems (data can be cross-referenced to eliminate flight errors based on a single unit). Ascending also has received an investment from Intel.
- **Aeronavics**: New Zealand-based Aeronavics supplies UAVs and UAV components and support systems, mainly for photography and filming applications. It recently raised $1.1 million in funding for 15% equity in

the company on Snowball Effect, a Kiwi equity crowdfunding site. The raise values the company at $7.3 million.

- **AeroVironment**: This UAV-focused company, which also markets technology for charging electric vehicles, is publicly traded on the Nasdaq exchange and focuses mainly on US military clients. But it has won approval for its UAVs to be flown commercially by oil and gas companies under exemptions to the commercial-UAV ban, so it is clearly interested in the civilian market as well. The company recently signed a cooperation dealwith Lockheed Martin.
- **Boeing:** The aerospace giant operates Insitu (see below) as a wholly owned subsidiary focused on commercial and civilian UAV technology.
- **CybAero:** This Swedish firm focuses on a specific niche: large (at least by commercial-UAV standards) helicopter drones that have been used mainly in search-and-rescue, security, and public-safety applications. It is one of only a few publicly listed UAV-manufacturing companies in the world, announced $29 million in full-year 2013 sales, and has stated its goal of reaching $200 million in annual sales before the end of the decade. A recent ~$6 million deal was signed with China's customs agency. AeroVironment (see above) controls an 8.5% stake in the company.
- **DJI**: We believe this is the world's leading UAV manufacturer. It caters to commercial and hobbyist markets, emphasizing photography and video applications. The Chinese company based in Shenzhen is estimated to have annual revenue of $100 million to $200 million, according to a September 2014 IBISWorld estimate. We believe it will end 2015 above that range. While DJI has had trouble with bugs in its operating system, including some that allegedly led to "flyaways," uncontrollable flights that led to crashes, it is notable that several of the US government-approved commercial UAV operations under Section 333 will use DJI models.
- **Dreamhammer:** Like 3D Robotics and Airware, San Diego-based Dreamhammer's strategy revolves around an operating system that will make it easy for different drone vendors and users to operate UAVs and build apps for specific uses.

- **EHANG**: The San Carlos, California-based company has roots in China and markets a UAV under the name Ghost Drone. It got its start on the Indiegogo crowd-funding site and has raised $10 million in venture capital. Its drones, aimed at consumers and small enterprises, can be operated through a smartphone app (many commercial UAVs require a PC-based ground station for operation).
- **Facebook**: The social-networking and messaging company made what is thought to be a $20 million acquisition of the UK solar-powered, high-altitude drone company Ascentain early 2014. Facebook's intention is to put this UAV tech to work in the context of itsinternet.org project to bring free internet to billions of unconnected people.
- **Finmeccanica**: Through various subsidiaries, this defense-focused Italian manufacturer markets several small UAV systems aimed mainly at military clients. But the company's large trove of technology and hardware makes it a likely candidate to compete in the civilian-commercial space as well. In fact, its Agusta Westland subsidiary already works with civilian and commercial clients in public safety, fire-rescue, and energy categories. Agusta Westland is developing helicopter-style UAVs.
- **Google**: Google bought Titan Aerospace in early 2014, reportedly for ~$60 million. Titan makes solar-powered UAVs that fly at high altitudes. Google has also launched research into more conventional UAVs as part of Project Wing, part of the company's Google[x] research and development program, which focuses on "moonshots," or projects that will potentially have a huge societal or business impact but have a high risk of failing. Project Wing has tested UAVs for delivery of small items in a remote part of Australia.
- **GoPro**: At the time this report went to press, GoPro had not confirmed the rumor that it was developing drones to carry its popular cameras. In early February 2015, GoPro's CEO did not rule it out in an interview with Fortune. "What I can tell you [is] drones are great for GoPro, and GoPro is great for drones," CEO Nick Woodman was quoted as saying. "Whether or not we officially get into the business, the drone industry has been

fabulous for us, because it seems like most of them out there are carrying a GoPro."

- **Gryphon Dynamics**: This South Korea-based manufacturer has several UAV models and has been a popular vendor to drone operators authorized to fly commercially under the FAA's exemption program. Four out of the ~40 UAVs approved to fly commercially have been Gryphon units.
- **Hexo+**: This company markets a $1,150 consumer UAV designed to hold a GoPro camera. The camera and drone are paired with a smartphone app.
- **Honeywell**: As a US military and government contractor, Honeywell has developed and is continuing to invest in key UAV technologies, including micro-UAVs and UAV sensors. Its focus has been the military and government markets, but as mainstream commercial applications gain in importance it could seek to exploit that opportunity. Given Honeywell's extensive work in the private sector, it may be better positioned to do so than other companies that have been focused on the more top-heavy airline and/or defense markets (e.g., Northrop Grumman, Boeing, Lockheed Martin).
- **Indra**: This Spanish engineering and consulting company struck a deal with CybAero (see above) to customize a helicopter-style UAV for sale to shipping clients.
- **Insitu**: This Boeing-owned company, based in Bingen, Washington, is another US-based leader in the commercial UAV market. It also markets systems to the US Navy, but its ScanEagle line is aimed at clients in agriculture, oil and gas, and emergency services.
- **Joby Aviation:** This Santa Cruz, California-based firm focuses on aircraft design and developing electric aircraft engines. Its products are particularly relevant to long-range UAV flights.
- **Kespry**: A Menlo Park, California-based maker of commercial-grade UAVs, it has raised $12.4 million in venture backing.
- **Matternet**: A small startup that appears focused on a single niche: the delivery of medical and aid supplies to out-of-reach populations.

- **Microdrones**: This Germany-based company has been manufacturing small UAVs for years. It has sold more than 1,000 units since 2006 and has more than 125 employees globally.
- **Parrot**: France-based Parrot markets a range of consumer-targeted devices (including small quadcopter UAVs), apps, and tech accessories. It also owns senseFly, a Swiss company that is an important business-to-business vendor of UAVs (see below).
- **PrecisionHawk**: This company has raised $11 million in venture funding and, unlike many other vendors focused on quadcopters, markets a small single-propeller airplane-like drone that weighs ~3 pounds, (1.3 kilograms). The company touts its artificial-intelligence software that can adjust flight plans based on in-flight information such as weather conditions.
- **Schiebel:** Like CybAero, Vienna-based Schiebel focuses on larger helicopter-type drones. However, Schiebel is focused on military clients and has a diverse product portfolio that includes mine detectors and specialized military-grade materials engineering.
- **SenseFly:** SenseFly, owned by Parrot, is based in Switzerland. It markets five UAV systems including the eBee Ag, which is geared to agricultural applications.
- **Sky-Futures**: This firm is specialized in UAV systems for oil and gas industry inspection services. Its head office is in Middlesex, England, but also operates offices in Norway and Malaysia.
- **Skycatch**: This firm markets a UAV system and support services for a self-piloting micro UAV that gathers spatial data on an hourly or daily basis for applications in construction, mining, agriculture, and solar farms.
- **Skydio**: Based in Menlo Park, California, Skydio says it wants to take the hassle out of UAV operations and open UAV usage to a broader audience and applications. Skydio launched with $3 million in seed funding from Accel Partners and Andreessen Horowitz.
- **Skyspecs**: This small startup, which includes two ex-members of Google's Project Wing, focuses mainly on technology to improve flight

safety and make it easier for pilots to operate UAVs without too much technical expertise.

- **SkyWard**: This Portland, Oregon-based company provides software and consulting services to companies operating UAV fleets. It appears to be the first US-based firm focused solely on UAV-related software and services (rather than hardware).
- **Verifly**: This company, launched by Jay Bregman, founder of the Hailo car-hailing app,wants to create a global verification system for drones so that UAVs don't enter areas in which they're not supposed to be flying. The company will have locations in Dublin and New York.
- **Zano**: This firm raised funds via Kickstarter and plans to offer tiny "nano" drones to the consumer market.
- Defense contractors: Northrop Grumman, Textron, Lockheed Martin, Airbus, Elbit, Aeronautics, LTD, and others have been providers of UAV systems to military clients and have either already become involved or are likely to begin offering services to non-military commercial or public-sector clients.

This list highlights a rising trend: investment by established industrial equipment and business-IT firms in up-and-coming drone companies, the first signs of consolidation in an industry that is still fragmented and heavily influenced by venture capital, startups, R&D labs, and small companies.

THE BOTTOM LINE

- **The global commercial drone market will take shape around applications in a handful of industries: agriculture, energy, utilities, mining, construction, real estate, news media, and film production.**
- **Most growth in the drone industry is on the commercial/civilian side, as the shift away from the military market gains momentum.** The market for commercial/civilian drones will grow at a compound annual growth rate (CAGR) of 19% between 2015 and 2020, compared with 5% growth on the military side.
- **E-commerce and package delivery will *not* be an early focus of the drone industry.**
- **Legacy drone manufacturers focused mostly on military clients do not have a natural advantage in the fast-evolving civilian drone market.**
- **Proposed US regulation would effectively end the ban on commercial drone flights and would allow low-altitude flights of small drones within view of a ground-based pilot.** The rules are unlikely to be finalized before early 2017, but we believe it is very likely that widespread commercial UAV flights will become routine sometime that year.
- **Technology barriers are at once a roadblock and a huge business opportunity.**
- **Many of the top commercial UAV manufacturers are emerging outside of the US market.**
- **The commercial-drone industry is still young but has begun to see some consolidation and major investments from large industrial conglomerates, chip companies, and defense contractors.**

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