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Aviation, Aerospace & Defense

IN COMMERCIAL DRONES, THE RACE IS ON

AVIATION'S FASTEST-GROWING SECTOR OUTPACES US REGULATORS

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BY 2035, THE NUMBER OF UNMANNED AERIAL VEHICLE OPERATIONS PER YEAR WILL SURPASS THAT OF MANNED AIRCRAFT.

Cover photo courtesy of 3D Robotics
Photo on this page courtesy of PrecisionHawk

US COMMERCIAL DRONE INDUSTRY PLAYS CATCH-UP

Now that the Federal Aviation Administration has proposed regulations for commercial drones, the US industry can finally start catching up with other countries in this growing industry. In Japan, farmers have been using drones for decades to inspect crops. In Canada, police use drones for search-and-rescue operations. In the UK, drones are used for commercial photography. In the US, all of those activities have been illegal without special permission from the FAA, which was rarely granted.

In February, the administration proposed rules that are a good first step to create a friendly environment for commercial drone operators to get off the ground. The rules are based on the actual risk that the small, unmanned aircraft pose. However, finalizing the rules will take a couple of years, and companies would have to operate commercial drones within the line of sight of the operator and away from people, leaving activities like package delivery out of bounds.

As the FAA has demonstrated through its 10-year effort to regulate the commercial use of drones, rapidly evolving technology can easily outrun the regulatory process. To keep up, regulators must take incremental steps that are risk-based and closely track developments in the industries they regulate. Nowhere is that more evident than with commercial drones.

Already, the US starts out behind in a growing industry as other countries have implemented and even revised their own rules. The delay and restrictions mean the commercial drone industry is developing elsewhere. And a few major US companies, like Google, are moving substantial portions of their drone research operations overseas. The US is leaving billions of dollars in economic growth on the table and giving other countries the benefit of coming to market first.

It is not too late to catch up. With reasonable and globally competitive regulations, the US could still become a leader in the commercial drone industry.

Yes, there are other hurdles for the US industry. The technology is probably too complicated for the non-aviation customers who might find use for it. The nascent industry must stake out selling channels and marketing approaches. And battery technology must improve for small drones to boost their capabilities to the commercial level. But until the US allows commercial drones, advances in those technologies will primarily benefit other countries.

Exhibit 1: Uses for commercial drones

PRECISION AGRICULTURE

- Precision agricultural uses are projected to make up about 80 percent of the commercial UAV industry – predominantly with remote sensing to detect crop health and determine fertilizer and pesticide needs.
- UAV systems could improve crop yields by 15 percent and reduce fertilizer use by as much as 40 percent.

PUBLIC SAFETY

- Public safety is projected to be the second largest market for UAV applications.
- UAVs offer public safety departments a wide variety of applications, including search-and-rescue, wildfire monitoring, barricaded suspects, and surveillance.
- High-performance UAVs fall within the budget of a police department – similar to the cost of a police squad car.

AERIAL PHOTOGRAPHY

- Photography is a relatively mature UAV application.
- Professional-quality cameras can be added to UAVs. Photos previously only achievable at high cost from planes or helicopters are now much more affordable.

OTHER APPLICATIONS

- Applications include mail, small package delivery, infrastructure monitoring, filmmaking and other media uses, wildlife conservation and meteorological research.
- Other applications are conservatively expected to rival the public safety market in size.
- Applications may take longer to develop because of technological constraints or regulatory difficulties.

Source: Oliver Wyman analysis and other sources (including AUVSI)

RISE OF THE DRONES

By 2035, the number of unmanned aerial vehicle, or UAV, operations each year will surpass that of manned aircraft operations, according to the Volpe Center, the US Department of Transportation research arm. That is a profound change in the composition of aviation activity.

Industry experts from the Teal Group to the Association for Unmanned Vehicle Systems International, or AUVSI, estimate the global drone market is worth $6 billion to $12 billion, and commercial drones account for about 10 percent. The Volpe Center forecasts the US commercial drone market will reach $5 billion annually by 2035. We expect the global commercial market will easily be several times that size for UAVs, sometimes called unmanned aerial systems, or UAS.

TECHNOLOGY DRIVING COMMERCIAL DRONES

Tens of thousands of hobbyists have flown radio-controlled aircraft and helicopters for many years, of course. But drones of commercial value are the result of recent advances in microprocessors, GPS, sensors, batteries, motors, lightweight structural materials, and advanced manufacturing techniques.

Advances in each of these technologies will influence the development of drones. The primary limiting factor for small UAVs is battery technology. Until researchers can make lighter-weight, higher-energy batteries, small, electrically operated UAVs will have limited range and flight duration.

Exhibit 2: Maturity of commercial drone applications and technology

Around the world, most commercial drone applications are in the early stages. Exceptions include precision agriculture in Japan and some aspects of border patrol. But other commercial uses are expected to develop rapidly.

	EARLY STAGE	MIDDLE STAGE	LATE STAGE
APPLICATION			
Aerial photography			
Border patrol			
Construction and real estate images and monitoring			
Emergency management			
Infrastructure monitoring			
Mail and small package delivery			
Filmmaking and other media uses			
Oil and gas exploration			
Precision agriculture			
Public safety			
Weather forecasting and meteorological research			
Wildlife and environmental monitoring			
TECHNOLOGY			
Advanced manufacturing techniques			
Batteries and other power			
Communication systems			
Detect, sense, avoid capabilities			
GPS			
Lightweight structures			
Microprocessors			
Motors			
Engines			
Sensors			

Source: Oliver Wyman

Many people are surprised to learn that by far the largest projected application for UAVs is in precision agriculture. AUVSI predicts that precision agriculture could account for approximately 80 percent of commercial drone use. Drones can identify differences in crop conditions, enabling farmers to reduce fertilizer use and increase crop yields. Using high-resolution imaging, they can provide more precise information at a much lower cost than available through aerial mapping with small planes.

Drones already make up more than 90 percent of crop dusters in Japan, according to Mary Cummings of Duke University's Humans and Autonomy Lab. There, the unmanned, 200-pound Yamaha RMAX helicopter (one of the relatively few commercial drones that weighs more than 55 pounds) has been used for more than 20 years. In the US, only in January 2015 did the FAA issue the first exemption permitting agricultural drone use outside of university research.

After agriculture, the next-largest drone application is expected to be public safety. Drones can assist police and fire departments to conduct search-and-rescue missions, assess dangerous conditions, and conduct surveillance. US fire departments are pushing for regulatory approval to use drones for better real-time images of wildfires. Following the nuclear accident at Fukushima, the Japanese are using drones to map radiation levels to determine which areas are safe to occupy. And one US firm wants to sell drones to serve as first responders to 911 calls because the aircraft can arrive at the scene before the police. In each of these examples, commercial deployment in the US has not been permitted, except in a few cases where the FAA has granted exemptions.

REGULATING SAFETY, PRIVACY, AND AIR SPACE

In the US, recreational use of small drones is permitted without FAA approval as a result of a specific directive in 2012 legislation. However, as the FAA worked to issue a comprehensive set of regulations "that encompassed the widest possible range of small" drone operations, it barred nearly all commercial use of drones. The move greatly frustrated drone manufacturers, users, and the elected officials eager to support a fledgling industry.

The rationale for the distinction between recreational and commercial drone activities mirrors the manned aircraft world, where commercial pilots are responsible for transporting large numbers of passengers safely in large aircraft, and therefore are held to the highest level of experience and training. Recreational pilots, while still flying aircraft with the potential to cause loss of life and property damage, are held to a lower standard of experience because of the lower potential for harm. However, small drones pose equal risk whether used for recreational or commercial purposes. In both cases, the pilot is not onboard and the risk of damage to people, property, or manned aircraft is low.

Exhibit 3: US Rules for Small Recreational Drones and Proposed Rules for Small Commercial Drones

UAV OPERATIONS	RECREATIONAL	COMMERCIAL
Allowed?	Yes – do not need FAA approval	When proposed rules become effective, subject to meeting the certification requirements
Main operational requirements	• Within line of sight • Below 400 feet • Away from airports (notify if within five miles)	• Within line of sight • Below 500 feet • Daylight only and not above people • FAA aeronautical knowledge test • Recurrent test every 24 months • TSA vetting • UAV aircraft markings

Source: Oliver Wyman

After struggling with this and other issues, the FAA found that the manned aircraft framework cannot be readily applied to commercial drones. The agency dropped the idea of requiring drone operators to hold pilot licenses. The FAA said in its February rulemaking that its "broadly-scoped approach to the rulemaking effort took significantly longer than anticipated," and the agency is proceeding with "multiple incremental UAS rules rather than a single omnibus rulemaking" focusing on the small UAS operations posing the least amount of risk "immediately instead of waiting until the issues associated with higher-risk UAS operations are resolved."

The FAA is moving in the right direction. This is the same lesson that other regulators have learned. The technology is moving too quickly; the field to be regulated is too new. Lower risk activities must be permitted sooner rather than later; and incremental regulations released when ready, and then improved, so that the technology can be introduced safely as soon as practical.

Still, the process is far from perfect, and the regulators' use of risk-based language is not always accompanied by a serious risk analysis and ranking of different types of drone operations. For example, how can the FAA justify stricter safety requirements for commercial drones than for recreational drones, when both involve exactly the same operations, unless the answer is simply that the law requires it?

Many countries distinguish instead between heavier drones (typically, those weighing more than 55 pounds) and lighter drones. The smallest drones, weighing less than 4.4 pounds, are treated differently in some countries because they pose a much lower safety risk than larger drones. Most commercial drones weigh far less than 55 pounds and operate below commercial airspace.

The technology poses other conundrums for regulators in assessing risk. For example, drones rely on shared, non-secure radio frequencies, and the radio link between ground-based controller and drone can be interrupted. Regulators worry about what could happen. Some manufacturers are addressing this by programming drones to hover while waiting for the link to be re-established and, if not, returning to home base after a set period. Regulators and manufacturers continue to study solutions to lost links.

Manned aircraft have rigorous quality and redundancy requirements developed over decades, and these are reflected in the price. Commercial drones, however, cost as little as a few hundred dollars and may be built from hobbyist-quality components. With the smallest drones, quality is less of a concern because the consequences of a crash from low altitude are primarily to the drone itself. But with larger drones approaching 50 pounds, and certainly for drones above that weight, the quality of the individual components becomes a greater concern. Regulators will have to sort through this issue.

Also, pilots have the ability to see and avoid other aircraft based both on the pilot's own senses and the use of collision avoidance systems. But such collision avoidance systems are not yet practical for small drones, and regulators are not convinced that ground-based operators have the equivalent of the see-and-avoid capabilities of a human pilot. Some drone manufacturers are working on first-person-view technology to give the operators robust, real-time visuals as a substitute for line of sight. For regulators to permit commercial drones to be used beyond the line of sight, they must accept that the technology has a high level of safety.

Meanwhile, the proposed FAA regulations conclude that the smallest, lightest drones (those under 4.4 pounds) traveling beyond the line of sight entail greater risk than heavier drones within the line of sight. But what are the true safety risks of the different size categories of drones? Instead of asking for comments on whether the smallest, lightest commercial drones should be regulated under a less burdensome set of rules, the FAA should classify them differently from the start. There is already a track record in Canada.

SAFETY REGULATIONS – THE CANADIAN APPROACH

Canadian regulators separate different weight classes to manage risk levels, recognizing that lighter drones pose less risk, both to people on the ground and property. Canadian regulators also recognize that, as a practical matter, users of the smallest, lightest drones are more likely to comply with simple guidelines than to meet burdensome administrative requirements. As with other countries, Canada's lighter-touch regulations, applicable to the smallest drones, evolved over time.

By taking this approach, Transport Canada, the Canadian regulator, is able to focus its own limited resources on the heaviest drones that pose the greatest risks. The one-page Transport Canada infographic and one-page rule sheet are considered industry classics in explaining reasonable, user-friendly regulation.

Canada's current regulations categorize commercial drones by weight, with two categories for those that weigh less than 25 kilograms (55 pounds). The primary differences between the two under-55-pound categories are that the heavier category requires the drone to stay at least 150 meters from crowds, buildings, and vehicles; the operator to provide basic information about the drone and its operation to Transport Canada; and a fire extinguisher on site. The lighter category requires the drone to stay at least 30 meters from crowds, buildings, and vehicles, and no notification is required. In both cases, line-of-sight operation is only permitted up to 300 feet in altitude and during daylight hours in good weather, with a $100,000 liability policy required.

Only the over-25-kilogram category requires permission from Transport Canada in the form of a special flight operations certificate, the equivalent of a detailed flight plan. The Canadian authorities also created flexibility for this category. Once an operator builds a strong track record, Transport Canada may grant the operator a blanket Special Flight Operations Certificate for a specific geographic area or for a defined period.

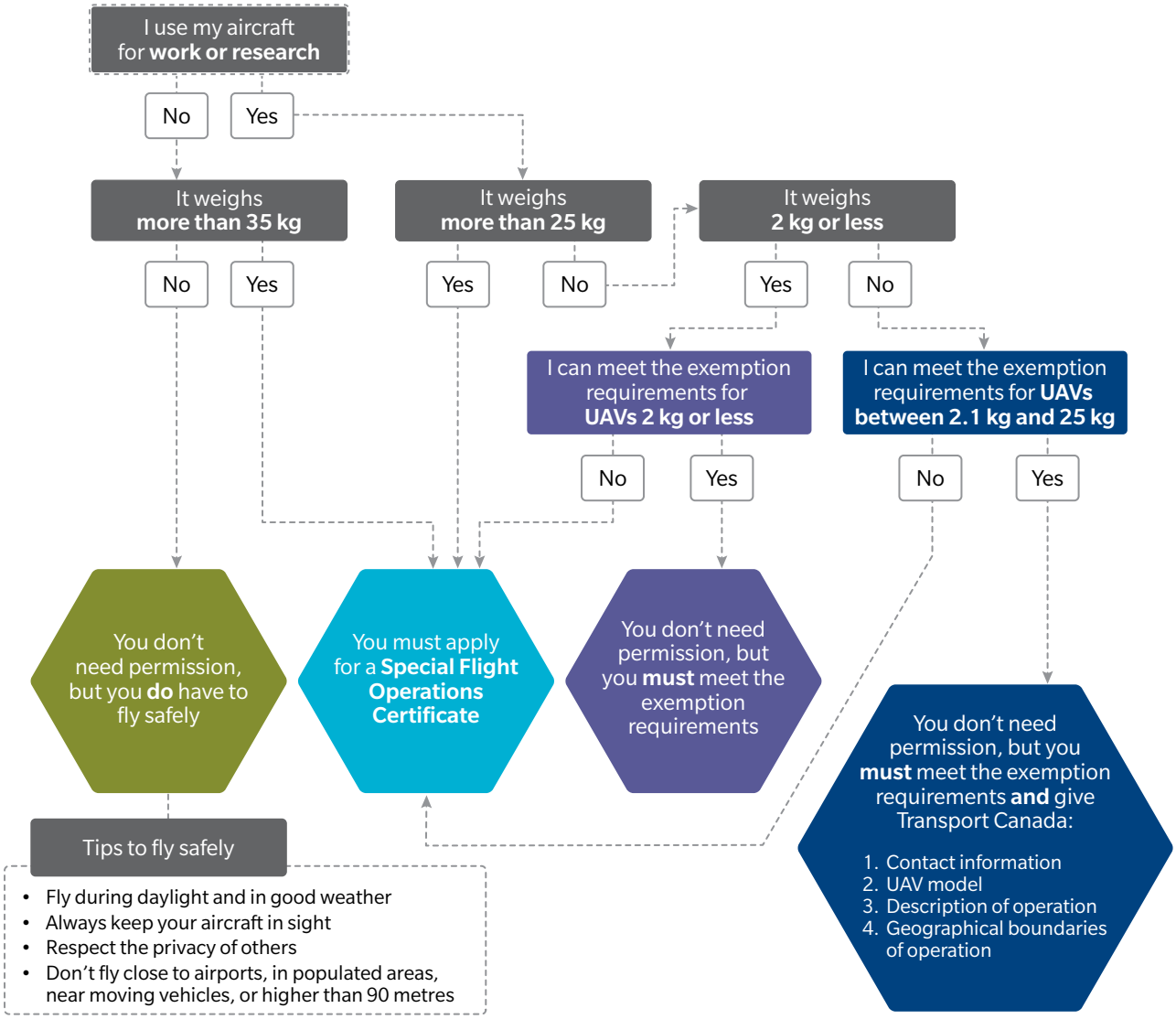
In a recent release, the Province of Ontario boasts: "For innovative young companies in the fast-growing unmanned aerial vehicles (UAVs) industry, Ontario's regulatory environment has helped them gain a multi-year head start over potential US competitors."

Photo courtesy of Ascending Technologies

Exhibit 4: Canada's approach to UAV regulations

Flying an unmanned aircraft?

You may need permission from Transport Canada



Source: Transport Canada

Note: This infographic was recreated from an official Transport Canada work, please refer to www.tc.gc.ca/SafetyFirst<http://www.tc.gc.ca/SafetyFirst>" for more information.

LOST OPPORTUNITIES FOR THE US INDUSTRY

Numerous reports conclude that US drone manufacturers and users are at a serious disadvantage because of their inability to test commercial drone applications in the US and the regulatory-driven absence of a US commercial market. US drone manufacturers and users have moved portions of their research and development to other countries.

In the emerging delivery market, Amazon reports that it has shifted some of its air delivery research and development overseas instead of flying UAVs indoors in the US. The company reacted to the FAA's February 2015 proposed testing rules by saying that the agency needs to expeditiously address the needs of Amazon's customers – a clear reference to the line-of-sight limitation. Google is conducting similar drone delivery research in Australia.

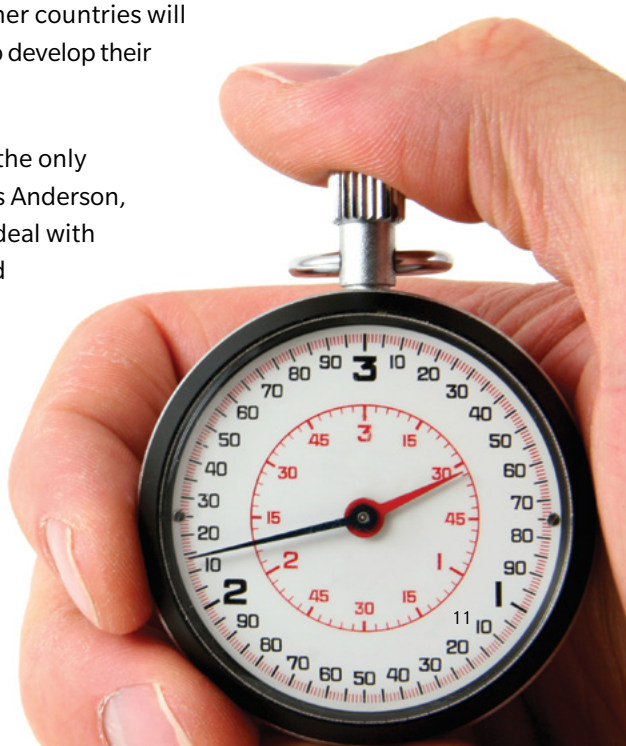
In France, commercial drone operations have been allowed since 2012. Bloomberg reports that more than 1,200 commercial drone companies operated in France as of February 2015; the UK's Civil Aviation Authority lists about 480 approved commercial operators as of January 2015. That figure increased 80 percent from January to October 2014. In both countries, the number of registrations is accelerating.

Putting a price tag on the lost opportunities in the US market resulting from regulatory constraints is difficult. AUVSI estimates that each year of delay has a $10 billion economic impact for the US. Even a small fraction of that is significant, particularly if foreign-based companies can sustain the advantage of lead time. And that is the fear of US-based drone manufacturers.

*AUVSI estimates that each year of delay has a **$10 billion** economic impact for the US*

Based on a framework developed by Fernando Suarez and Gianvito Lanzolla (*Harvard Business Review 2005*) to evaluate the likelihood of developing a durable first-mover advantage, our view is that non-US drone manufacturers will not sustain their initial advantage in the long term. The rapid technology changes and market growth of the commercial drone sector will enable US firms to catch up once (and assuming that) the FAA issues reasonable commercial drone regulations. This is not to say, however, that the first movers in other countries will not achieve important short-term gains. At a minimum, they gain time to develop their brands in the market.

While US regulatory constraints are undeniably important, they are not the only factor preventing the drone market from reaching its full potential. Chris Anderson, chief executive of 3D Robotics, said the drone industry needs not only to deal with regulatory constraints, but also to establish simpler selling channels and to offer solutions, as opposed to just selling complex drone technology. "Commercial users don't want a drone, they want a solution, a box with a button," he said in an interview with *VentureBeat* in January 2015. Other drone executives have drawn the same conclusion regarding the need to provide an information-based solution, as opposed to a novel technology.



A RISK-BASED APPROACH

To catch up with the global drone industry, US regulators must stick to their plan of incremental rule updates that are risk-based and closely track industry developments. The FAA's proposed rules are a start and need to be finalized and implemented quickly. Precision agriculture is an obvious candidate for minimal regulation because of the low population density, low altitudes, few structural obstacles, and few privacy concerns.

An important part of the regulatory process should be communication. Regulators must educate drone operators and the public about safe operation. No system of fines and prohibitions will replace the need for drone operators and the public to understand and support common-sense rules of operation.

And drone industry leaders should engage regulators. Without input from the industry, the regulatory tendency is to focus on what could go wrong as opposed to what the industry needs to be successful. Major high-tech companies, far from Washington, waited a long time before engaging with regulators and legislators, but now communicate on an ongoing basis. The commercial drone industry has learned this lesson early and has formed multiple coalitions aimed at promoting its interests.

NEXT DRONE FRONTIER: PRIVACY

This groundwork will be important as drone use becomes more widespread and the public begins to call for stricter parameters on a more high-profile topic: privacy. The most sensitive concern is that people will use drones for surveillance or to fly over private property and transmit images.

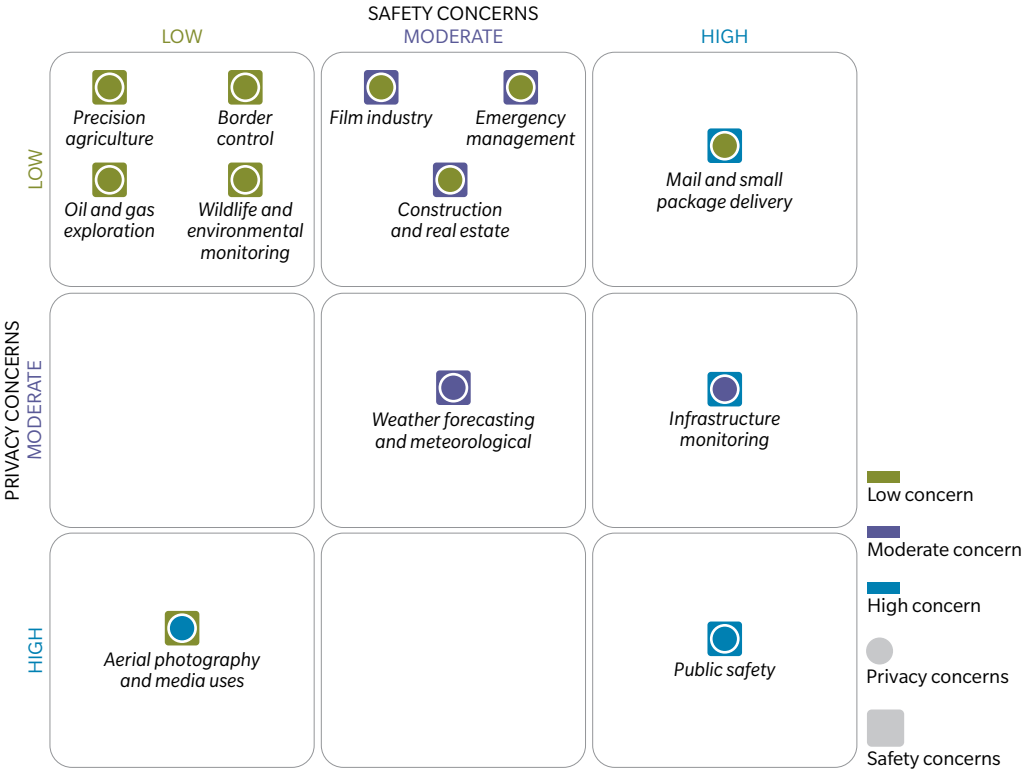
The core expertise of aviation regulatory agencies is safety regulation, not privacy, and at least in Canada, Australia, and the US, aviation authorities have asked to be removed from privacy decisions.

Concurrently with the FAA's issuance of proposed rules covering commercial drones, the government issued an order requiring federal agencies "to take steps to ensure that privacy protections and policies relative to UAS continue to keep pace" with industry developments. The US Congress has already begun work on legislation to prohibit drone operators from capturing data in ways that would violate a reasonable expectation of privacy. Other proposed legislation would require drone operators to submit a "data collection statement" to the FAA, delineating, among other things, what data will be collected, how the data will be used and retained, and whether the data would be sold to third parties.

Exhibit 5: Safety and privacy concerns

SAFETY VS. PRIVACY

Many activities with lower safety risks also have lower privacy risks because they are conducted in remote areas. Aerial photography is an important exception. A true risk-based approach to commercial drone deployment would give early approval to activities with both low safety and low privacy risks.



Source: Oliver Wyman

Typically, activities with lower safety risks, such as precision agriculture, oil and gas exploration, and wildlife conservation, also have lower privacy risks because they are conducted in remote areas. However, aerial photography is an example of drone use with low safety risk and high privacy concerns. Our view is that, over the long term, privacy concerns will prove even more difficult to manage than safety. Creating a risk-based approach for regulations will be crucial as the industry faces this next challenge.

THE REGULATORY PATH FORWARD FOR COMMERCIAL DRONES

The regulatory travails of this emerging industry provide some important lessons for setting constraints on commercial drones and other industries.

- **Technology moves more quickly than the regulatory process.** Regulators need to recognize when it is better to put forth initial rules so the industry can keep moving forward, rather than delay until more complex and comprehensive schemes are developed. This also applies to privacy issues, which are complex and will take time to address.
- **Safety regulation should be risk-based.** In the US, small drones operated by hobbyists are allowed to operate with minimal regulation, while the same drones operated by businesses are prohibited. Under the FAA's proposed rules, the two will continue to be treated differently. That's clearly not a risk-based approach. The focus of limited regulatory resources should be on larger drones, with greater capabilities and higher risk.
- **New technologies require new regulations suited to the situation.** Applying manned flight regulations to govern small, unmanned drones will not result in regulations that fit the problems. Imposing a line-of-sight limitation on even the smallest drones does not support the technological advances in remote-controlled navigation.
- **An important part of the regulatory process should be educating drone operators and the public on safe operation.** No system of fines and prohibitions will replace the need for drone operators and the public to understand and support common-sense rules of operation, such as distances from airports and maximum altitudes.
- **Technology-based industries must engage the regulators.** Technology executives may have little interest in the regulatory process, but they must help regulators understand their issues and the urgency of addressing them. In the absence of external engagement, the regulatory tendency is to focus on what could go wrong as opposed to what the industry needs to be successful. The commercial drone industry has learned this lesson early and has formed multiple coalitions to promote its interests.

Photo courtesy of DJI

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